U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

VEHICLE TECHNOLOGIES PROGRAM

2011 Annual Merit Review

Results Report

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Prepared by New West Technologies, LLC
For the U.S. Department of Energy Vehicle Technologies Program

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Introduction

The 2011 U. S. Department of Energy (DOE) Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting (AMR) was held May 9-13, 2011 in Crystal City, VA. The review encompassed all of the work done by the Hydrogen Program and the Vehicle Technologies Program: a total of 298 individual activities were reviewed for Vehicle Technologies, by a total of 115 reviewers. A total of 1,236 individual review responses were received for the technical reviews.

The objective of the meeting was to review the accomplishments and plans for the Vehicle Technologies Program (VTP) over the previous 12 months, and provide an opportunity for industry, government, and academia to give inputs to DOE on the Program with a structured and formal methodology. The meeting also provided attendees with a forum for interaction and technology information transfer.

It should be noted that select DOE-funded projects, both oral and poster presentations, were not reviewed during the 2011 AMR. Generally, this was a result of subprogram preferences, including a rotation of projects that are formally reviewed one year, not reviewed the following year, reviewed the year after that, etc. Further, it was determined that all subprogram overview presentations would not be reviewed during the 2011 AMR. Another example is scheduling formal reviews based on project activity. For example, regulatory program activities tend to be ongoing, highly structured, and specifically directed by Congress. Thus, such VTP activities are typically evaluated on a less frequent basis. For those projects that were designated for review, the intention was to have a minimum of three reviewers. In a few specific cases, some projects had less than three reviewers due to medical emergencies, late cancellations, or other unforeseeable circumstances that impacted reviewer availability and subsequently, project reviews.

The reviewers for the technical sessions were drawn from a wide variety of backgrounds, including current and former vehicle industry members, academia, government, and other expertise areas. In the technical sessions, these reviewers were asked to respond to a series of specific questions regarding the breadth, depth, and appropriateness of the DOE Vehicle Technologies Program activities. The technical questions are listed below, along with the scoring metrics (if appropriate). These questions were used for all Vehicle Technologies Program reviews, including any American Recovery and Reinvestment Act (ARRA) reviews.

Question 1: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Question 2: Approach to performing the work: the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts. (Scoring weight for overall average = 20%)

Scoring: 4=outstanding (sharply focused on technical barriers; difficult to improve approach significantly); 3=good (generally effective but could be improved; contributes to overcoming some barriers); 2=fair (has significant weaknesses; may have some impact on overcoming barriers); 1=poor (not responsive to project objectives; unlikely to contribute to overcoming the barriers).

Question 3: Technical accomplishments and progress toward overall project and DOE goals: the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals. (Scoring weight for overall average = 40%)

Scoring: 4=outstanding (excellent progress toward objectives, suggests that barriers will be overcome); 3=good (significant progress toward objectives and overcoming one or more barriers); 2=fair (modest progress in overcoming barriers, rate of progress has been slow); 1=poor (little or no demonstrated progress toward objectives or any barriers).

Question 4: Collaboration and coordination with other institutions. (Scoring weight for overall average = 10%)

Scoring: 4=outstanding (close, appropriate collaboration with other institutions, partners are full participants and well coordinated); 3=good (some collaboration exists, partners are fairly well coordinated); 2=fair (a little collaboration exists, coordination between partners could be improved); 1=poor (most work is done at the sponsoring organization with little outside collaboration, little or no apparent coordination between partners).

Question 5: Proposed future research: the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways. (Scoring weight for overall average = 10%)

Scoring: 4=outstanding (plans clearly build on past progress and are sharply focused on barriers); 3=good (plans build on past progress and generally address overcoming barriers); 2=fair (plans may lead to improvements, but need better focus on overcoming barriers); 1=poor (plans have little relevance toward eliminating barriers or advancing the program).

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Responses: excessive, sufficient, insufficient.

Responses to the questions were submitted electronically through a web-based software application, PeerNet, operated by the Oak Ridge Institute for Science and Education (ORISE). Database outputs from this software application were analyzed and summarized to collate the multiple-choice, text comment, and numeric scoring responses and produce the summary report.

The report is organized by technical area. Responses to the questions are summarized in the pages that follow, with summaries of numeric scores for each technical session, as well as text and graphical summaries of the responses for each individual technical activity. A list of the activities (and page numbers) for each section appears at the start of each section.

1. Hybrid and Vehicle Systems Technologies

Vehicle and system research provides an overarching vehicle systems perspective to the technology research and development (R&D) activities of the U.S. Department of Energy's (DOE's) vehicle research programs, and identifies major opportunities for improving vehicle efficiencies. The effort evaluates and validates the integration of technologies, provides component and vehicle benchmarking, develops and validates heavy hybrid propulsion technologies, and develops technologies to reduce the parasitic losses from heavy vehicle systems. Analytic and empirical tools are used to model and simulate potential vehicle systems, validate component performance in a systems context, benchmark emerging technology, and validate computer models. Extensive collaboration with the technology development activities is required for success. The results of hybrid and vehicle systems activities are used to estimate the national benefits and impacts of DOE-sponsored technology development, and successfully transfer developed technology to industry.

In August 2009, the Department announced the selection of ten projects totaling $425 million for development, deployment, and validation of hybrid vehicles, and deployment of charging stations across the nation. ARRA-funded transportation electrification activities will aid in the deployment of technologies that help to reduce petroleum consumption. Activities include deployment of 18,000 public and private charging stations in major metropolitan areas across the country, and deployment of truck stop electrification infrastructure at 50 sites across interstate corridors. Additional deployment activities include development, validation, and deployment of light- and medium-duty electric drive vehicles.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

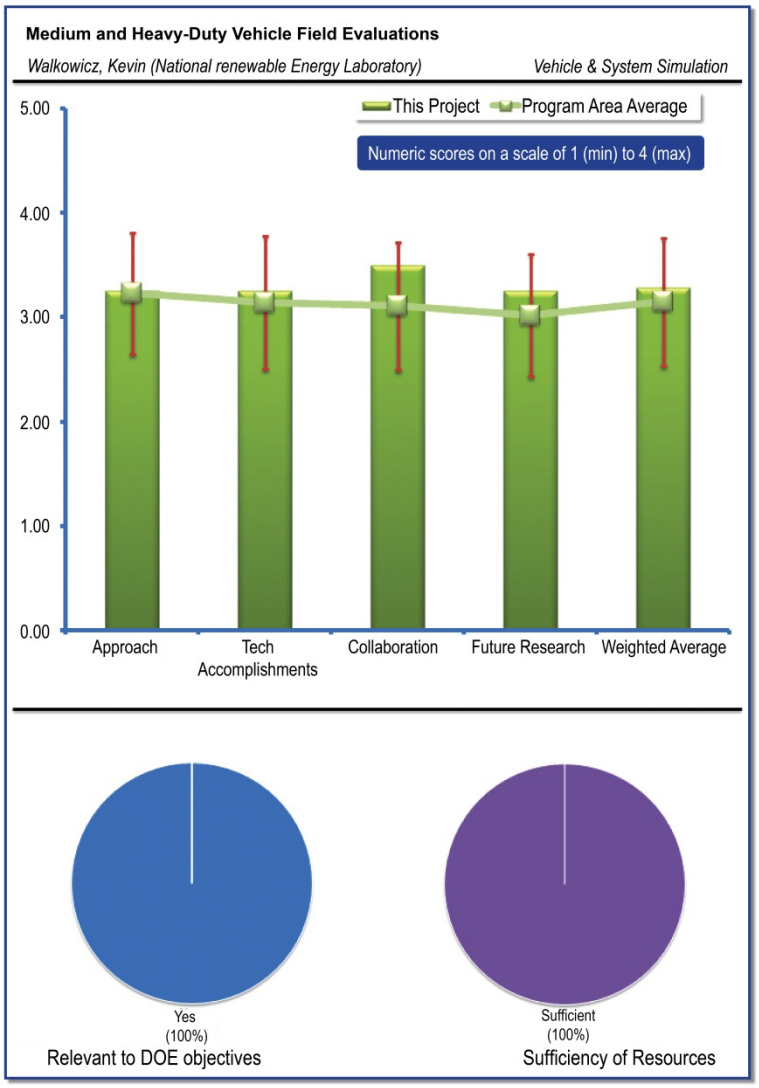
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Medium and Heavy-Duty Vehicle Field Evaluations	Walkowicz, Kevin (National Renewable Energy Laboratory)	1-4	3.25	3.25	3.50	3.25	3.28
Truck Duty Cycle and Performance Data Collection and Analysis Program	Knee, Bill (Oak Ridge National Laboratory)	1-6	3.25	3.25	3.00	3.00	3.19
Boundary Layer Lubrication Mechanisms	Fenske, George (Argonne National Laboratory)	1-8	3.25	3.50	3.00	3.25	3.34
DOE/DOD Parasitic Energy Loss Collaboration	Fenske, George (Argonne National Laboratory)	1-11	3.50	3.25	3.50	3.25	3.34
DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations	Salari, Kambiz (Lawrence Livermore National Laboratory)	1-14	3.25	3.25	3.50	3.50	3.31
Analyzing Fuel Saving Opportunities through Driver Feedback Mechanisms	*Gonder, Jeffrey (National Renewable Energy Laboratory)*	*1-17*	*2.67*	*2.33*	*2.33*	*2.67*	*2.46*
Autonomie Large Scale Deployment	Rousseau, Aymeric (Argonne National Laboratory)	1-19	3.60	3.60	3.80	3.20	3.58
PHEV Engine Control and Energy Management Strategy	Chambon, Paul (Oak Ridge National Laboratory)	1-22	2.50	2.50	2.75	2.50	2.53
Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity	Cesiel, Greg (General Motors)	1-24	2.80	2.40	2.60	2.40	2.53
Ford Plug-In Project: Bringing PHEVs to Market	D'Annunzio, Julie (Ford Motor Company)	1-26	4.00	3.80	3.80	3.40	3.80
Idaho National Laboratory Testing of Advanced Technology Vehicles	Francfort, Jim (Idaho National Laboratory)	1-28	3.75	3.75	3.00	3.00	3.56

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Development and Deployment of Generation 3 Plug-In Hybrid Electric School Buses	Friesner, Jan (Navistar, Inc.)	1-31	3.25	2.50	3.00	2.75	2.78
Advanced Vehicle Testing Activity	Karner, Don (ecoTality North America)	1-33	3.25	3.00	3.25	2.25	3.00
Advanced Technology Vehicle Lab Benchmarking - Level 1	Lohse-Busch, Henning (Argonne National Laboratory)	1-35	3.33	3.33	2.67	3.00	3.21
Advanced Technology Vehicle Lab Benchmarking - Level 2 (in-depth)	Rask, Erik (Argonne National Laboratory)	1-37	3.75	3.50	3.25	3.25	3.50
Electric Drive and Advanced Battery and Components Testbed (EDAB)	Carleson, Barney (Idaho National Laboratory)	1-39	3.00	3.00	2.75	3.00	2.97
Vehicle Systems Integration (VSI) Research Laboratory at ORNL	Smith, David (Oak Ridge National Laboratory)	1-42	3.25	3.00	3.00	2.75	3.03
Analysis of maximizing the Synergy between PHEVs/EVs and PV	*Kinter-Meyer, Michael (Pacific Northwest National Laboratory)*	*1-44*	*2.67*	*2.50*	*2.67*	*2.67*	*2.58*
CoolCab Test and Evaluation	Rugh, John (National Renewable Energy Laboratory)	1-46	3.67	3.33	3.67	3.33	3.46
Advanced PHEV Engine Systems and Emissions Control Modeling and Analysis	Daw, Stuart (Oak Ridge National Laboratory)	1-47	3.00	3.67	3.67	3.67	3.50
Plug-In Electric Vehicle Integration with Renewables	*Markel, Tony (National Renewable Energy Laboratory)*	*1-49*	*3.00*	*3.67*	*3.00*	*2.33*	*3.25*
Medium- and Heavy-Duty Electric Drive Vehicle Simulation and Analysis	Barnitt, Robb (National Renewable Energy Laboratory)	1-51	3.20	3.20	3.40	3.20	3.23
Analysis of Battery Wear and V2G Benefits Using Real-world Drive Cycles and Ambient Data	*Barnitt, Robb (National Renewable Energy Laboratory)*	*1-53*	*3.00*	*1.50*	*1.67*	*2.00*	*1.96*
LDV HVAC Model Development and Validation	Rugh, John (National Renewable Energy Laboratory)	1-55	2.50	3.25	2.25	3.00	2.91
Integrated Thermal Management for Electric Drive Vehicles	Rugh, John (National Renewable Energy Laboratory)	1-58	2.80	3.00	2.80	3.00	2.93
Real-World PHEV Fuel Economy Prediction	Gonder, Jeffrey (National Renewable Energy Laboratory)	1-61	3.00	3.25	3.25	2.50	3.09
Evaluation of Powertrain Options and Component Sizing for MD and HD Applications on Real World Drive Cycles	Rousseau, Aymeric (Argonne National Laboratory)	1-64	3.33	3.00	3.33	3.00	3.13
Evaluation of Ethanol Blends for PHEVs using Simulation and Engine-in-the-Loop	Shidore, Neeraj (Argonne National Laboratory)	1-66	3.00	3.00	2.75	3.00	2.97
Data Collection for Improved Cold Temperature Thermal Modeling and Strategy Development	Jehlik, Forrest (Argonne National Laboratory)	1-68	3.25	3.00	2.75	3.00	3.03
Advanced HEV/PHEV Concepts	*Gonder, Jeffrey (National Renewable Energy Laboratory)*	*1-70*	*3.67*	*3.00*	*3.67*	*2.67*	*3.21*
HEV, PHEV, BEV Test Standard Validation	Duoba, Mike (Argonne National Laboratory)	1-73	3.50	3.50	2.75	2.50	3.28
Codes and Standards to Support Vehicle Electrification	Bohn, Ted (Argonne National Laboratory)	1-76	3.50	3.25	3.50	3.00	3.31

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Green Racing Initiative: Accelerating the Use of Advanced Technologies & Renewable Fuels	Larsen, Bob (Argonne National Laboratory)	1-78	3.00	2.75	3.25	3.00	2.91
Testing and Validation of Vehicle to Grid Communication Standards	*Gowri, Krishnan (Pacific Northwest National Laboratory)*	*1-81*	*3.33*	*3.33*	*3.33*	*3.00*	*3.29*
CRADA with PACCAR Experimental Investigation in Coolant Boiling in a Half-Heated Circular Tube	*Yu, Wen (Argonne National Laboratory)*	*1-84*	*3.75*	*3.25*	*2.75*	*3.50*	*3.34*
Development of High Power Density Driveline for Vehicles	Fenske, George (Argonne National Laboratory)	1-87	2.40	2.40	1.80	2.60	2.35
Grid Interaction Tech Team	Hardy, Keith (Argonne National Laboratory)	1-90	3.50	3.75	3.25	3.50	3.59
Dynamometer Testing of USPS EV Conversions	Jones, Perry (Oak Ridge National Laboratory)	1-93	3.00	3.00	3.25	3.00	3.03
Wireless Plug-in Electric Vehicle (PEV) Charging	Miller, John (Oak Ridge National Laboratory)	1-96	4.00	3.75	3.50	3.75	3.78
The ArvinMeritor Dual Mode Hybrid Powertrain (DMHP): Opportunities and Potential for Systems Optimization	*Smith, David (Oak Ridge National Laboratory)*	*1-98*	*3.33*	*3.00*	*3.33*	*3.67*	*3.21*
Advancing Plug In Hybrid Technology and Flex Fuel Application on a Chrysler Mini-Van PHEV DOE Funded Project	Bazzi, Abdullah (Chrysler LLC)	1-100	3.67	3.33	3.33	3.17	3.40
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Jadin, Dennis (Navistar, Inc.)	1-102	3.50	3.25	3.50	3.00	3.31
*Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation	Karner, Don (Electric Transportation Engineering Corp.)	1-104	3.75	3.50	3.75	3.50	3.59
*Advancing Transportation Through Vehicle Electrification - PHEV	Bazzi, Abdullah (Chrysler LLC)	1-107	3.75	3.50	3.50	3.50	3.56
*Plug-In Hybrid Electric Medium Duty Commercial Fleet Demonstration and Evaluation	Miyasato, Matt (South Coast Air Quality Management District)	1-109	2.75	3.00	3.25	3.00	2.97
*Advanced Vehicle Electrification	Gosbee, Darren (Navistar, Inc.)	1-112	3.00	3.67	3.33	3.33	3.42
*Cascade Sierra Solutions: Transportation Sector Electrification	Lau, Sandor (Cascade Sierra Solutions)	1-114	3.00	3.00	3.00	3.00	3.00
*Advanced Vehicle Electrification and Transportation Sector Electrification	Cesiel, Greg (General Motors)	1-116	3.00	3.00	3.00	3.25	3.03
*Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification	Mackie, Robin (Smith Electric Vehicles)	1-118	3.50	3.75	2.50	3.25	3.47
* Electric Drive Vehicle Infrastructure Deployment	Carleson, Marc (Coulomb)	1-120	3.00	2.67	2.67	2.67	2.75
*Class 8 Truck Freight Efficiency Improvement Project	Rotz, Derek (DTNA)	1-122	2.75	2.75	3.50	2.75	2.84
* Demonstration of Highly Efficient and Clean Class 8 Trucks	Lawyer, Bruce (Peterbilt)	1-124	3.25	3.50	4.00	3.25	3.47
Overall Average			3.23	3.14	3.11	3.02	3.15

Note: Italics denote poster presentations. * Denotes ARRA-funded projects.

Medium and Heavy-Duty Vehicle Field Evaluations: Walkowicz, Kevin (National Renewable Energy Laboratory) – vss001



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that team had very precise measurement on MPG by technology. The second reviewer pointed out that prospective buyers benefited from unbiased evaluations so they can make informed choices to maximize fuel economy. The reviewer added that OEMs also have a learning opportunity, getting honest feedback from an external source, which allows them to improve their designs and maximize fuel economy. The final reviewer asserted that this work progresses the understanding of performance improvements for Hybrid vehicles in the various vocations.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that this is an ongoing project and that historic progress and recent progress both seem appropriate. The first reviewer added that it is good to see they are trying to incorporate more grade and load information which is useful information and should be captured. The mix of in-field data with some more detailed dyno testing is also nice. The second reviewer asserted that the approach is fleet specific so the use of the data is constrained by proprietary data within those companies. Other similar fleets would have to "just buy a couple and run them" to get real an understanding of benefit. This reviewer added that a way to reduce this work to a vocation type specific benefit range to provide to the "second" adopters would create more benefit toward petroleum reduction. The final respondent called the work interesting, but noted that it is perhaps regionally limited and with very few test case vehicles. The final reviewer questioned how these data could be widely translated to national fleet.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent pointed out that this is a fairly long running program and that the basic idea seems solid as does the implementation. The first reviewer added that the results seem consistent (each year) and useful. Another respondent noted that when measured against the reported objectives, the project is complete

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer indicated that the project is working with a number of alternative propulsion system developers and with fleet operators. Another reviewer added that long term relationships exist and are well coordinated for the project.

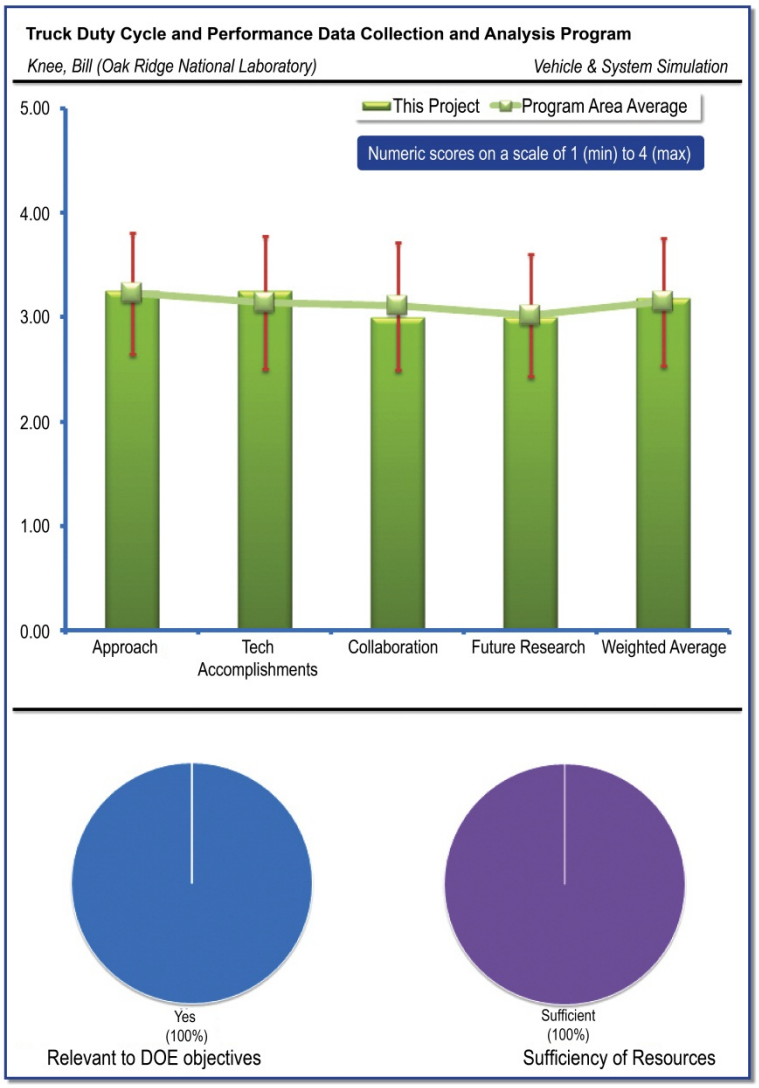
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first respondent included generally the same comments here as for accomplishments and indicated that the program output seems fairly consistent and appropriate. The reviewer noted that the data sharing mechanism is of particular interest and hopefully this will be publicly accessible, or at least some portions of the fleet data will be publicly accessible. The reviewer was also interested in the proposal to look at some off-road vehicles. The final reviewer added that the future proposals may be better than good.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The respondent indicated that this again is a fairly well established program and the resources needs seem to be well understood, leading to appropriate planned efforts.

Truck Duty Cycle and Performance Data Collection and Analysis Program: Knee, Bill (Oak Ridge National Laboratory) – vss002



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Four panelists reviewed this presentation. A first reviewer stated that the information being developed is suitable to show industry the FE benefits of various technologies. A second reviewer stated that to make informed decisions, designers and decision makers need to understand how vehicles are used and where the energy actually gets used. A third panelist said that the project has a very good validation processes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer thought that no real hard barriers seemed to exist. Another concluded that there are a number of tradeoffs that need to be made in deciding whether to get a more rich data set on a more limited number of vehicles/applications or a more restricted data set (per vehicle) across a much richer array of vehicles/applications. All in all, this reviewer agreed with the large scale approach; however, it seemed like there are still some missing details regarding various accessory loads. These type of data should be present in the data collected as part of the MTDC (richer data on a more limited number of vehicles). Pending the outcome of the final review of all the MTDC data, maybe some additional MTDC efforts are necessary. (However, having said that, this reviewer recognized that tradeoffs are needed. It would always be nice to have everything, it is rarely possible.)

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that progress to date seemed to be consistent with funding received to date. A second reviewer thought this project was definitely aligned and progressing according to plan, in line with the funding being delivered. The reviewer also suggested that this type of project could provide more benefit if it were expanded.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A first commenter saw lots of collaboration that seemed to be well coordinated. A second reviewer had detailed thoughts on specific research goals, having seen this presentation which included claims such as: "...driving tractive force, based on relatively simple assumptions, predicts total engine power quite well"; and "Fuel consumption during periods of positive tractive force correlates very well with the tractive force itself, even under very different driving conditions." The reviewer felt both of these statements suggested

that accessories are a small part of the puzzle. Further, the plans for the LSDC do not include any information regarding accessories. The reviewer recognized the need to limit bandwidth, but again the underlying statement is accessories are a small part of the picture. The reviewer said that immediately following this presentation this reviewer saw studies aimed at reducing consumption from heating, ventilating, and air conditioning (HVAC) accessories. This reviewer was unsure if there is an issue with this particular research, or the overarching research program. However, this would seem to be the program most targeted at discovering how operators really use their vehicles and there are a number of programs that look at reducing accessories. This reviewer did not know if some additional efforts are needed with the more complete data collection efforts. It would also seem that Idaho National Laboratory (INL) researchers might have some insights for the data collection.

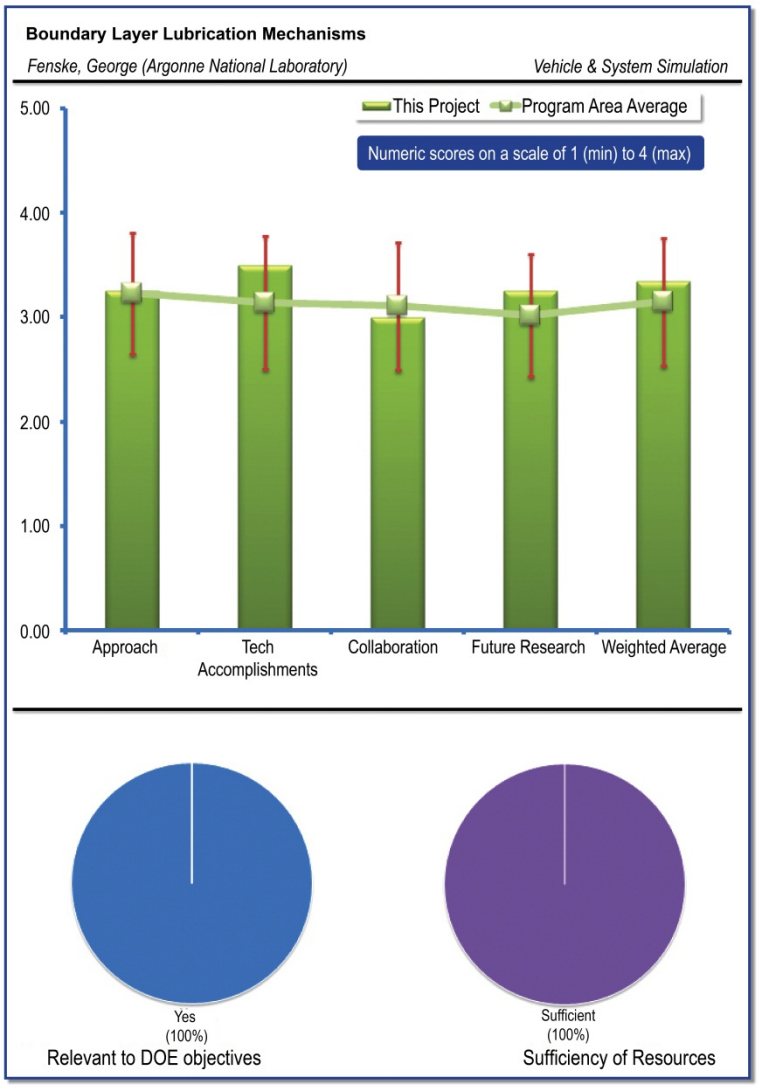
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A first panelist stated that this long term project has an ongoing plan, but could possibly be expanded to create more benefit. A second reviewer thought the general roll out of LSDC pilot seems to be fairly deliberate. Perhaps things could be accelerated slightly by leveraging INL's experience. This reviewer remarked that data buses are presumably much different between heavy duty vehicles and those on which INL typically collects data, but they do seem to have a lot of experience with a fairly large number of vehicles.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer saw pilot testing of large scale data collection as an FY11 target, but did not see any mention of pilot hardware.

Boundary Layer Lubrication Mechanisms: Fenske, George (Argonne National Laboratory) – vss003



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Four panelists reviewed this presentation. A first reviewer thought this project is in alignment with DOE objectives because improvements in lubrication will result in fuel efficiencies and overall reduction in fuel usage. A second reviewer believed that improving efficiency will clearly reduce energy/petroleum use, and friction reduction methods can offer improvements in virtually any powertrain configurations (newer configurations are not required). A third reviewer responded that this project clearly addresses the issue. Efficiency gain is largest possible gain for source of energy. Engine, transmission, axles can each cut fuel consumption by 2% to 4% by reducing friction. The fourth reviewer stated that high friction and high power density failures may occur in poorly understood boundary lubrication regime. The work directly contributes to our understanding of how to use lubricants to effectively displace petroleum usage, and as such, correlates 100% with the DOE mission. The Vehicle Technologies Program (VTP) facilitates environmental responsibility by advancing technologies to reduce passenger and freight emissions. A primary responsibility concomitant with oil dependence is reducing greenhouse gas emissions (primarily carbon emissions) from man-made activities such as use of oil for our vehicles. Neither petroleum reduction goals nor carbon emissions reduction goals can be achieved without new and more efficient vehicle technologies. More advanced fuels and lubricants as being studied in this project directly advance our understanding and responsibilities to reduce potential GHG emission and develop more efficient vehicle technology systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A first reviewer found the approach, which utilizes two parallel paths, interesting. The combination of both material and chemical film developments should result in a comprehensive prediction methodology. A second panelist thought that this project has a good technical approach, since the boundary lubrication regime is poorly understood. New tools and methods should enable new insights. ANL has unique tools (beam line X-ray analysis with minimal surface cleaning, electron micrographs for the film layers) that should help understanding of both materials and chemical films. Specifically, help understanding of boundary layer and film structures that build up on the surface, and tribochemical reaction layer analysis. A third panelist declared that the project addresses fuel savings by understanding and reducing frictional boundary layers in vehicle components and systems. There are constant advances in technology that may be contributing or averting frictional performance and impact. The third panelist commended ANL for using a basic research approach that includes computational models, design and simulation methodologies to understand tribological layers in various vehicle components. The work takes a components level and full complex systems approach. The work also considers test protocols in

this important area of research. The third panelist thought the experimental approach is a nice complement to the modeling and simulation work, and is nicely supported by basic materials science characterization of tribo films. The detailed information between with crystalline versus amorphous phases and their impact on friction is important to this field. The work may lead to a sustainable systems understanding for full vehicle friction management and reduction. This same panelist was thrilled to see the use of grazing incidence diffraction at APS. Nice example of power of photons. The final reviewer responded that all in all this is a worthwhile project and the progress seems good and appropriate with the budget. It is fundamentally a basic research program, so the lofty end goals that get discussed (2% improvement from axle, 3% from transmission, 4-5% from engine) more or less have to be ignored; at the end of this basic research effort no efficiency improvements should be expected. Rather the purpose is to understand the underlying mechanism so that a path to the improvements can be developed. The final reviewer thought this would be appropriate—basic research is important (although sometimes as a reviewer it is hard to reconcile the end goals with the program). However, this reviewer thought that any program does need to have some end goals defined/stated. It would be nice to see exactly what the end goals of this project really are (under questioning it seemed the 90% complete statement might have been a little optimistic).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A first evaluator thought that researchers seem to have made good progress in understanding boundary film and using this understanding to modify boundary lubrication. This reviewer commented that it would be nice to have some specification of end goals. A second evaluator acknowledged a novel idea to explore nature and use these theories in order to better understand how boundary layers are defined and characterized. The development of extremely low boundary frictions through modification of chemical film structure is an exciting find. A third reviewer considered this an excellent technical accomplishment. This reviewer remarked new scuffing model joining film and materials and design tools made available to OEMs are an excellent use of funds. Specific materials identified as well as pathways for future research. Use of crater created to expose film layers without damaging the layers is excellent experimental work. Understanding composition and structural changes in nm range of these layers is a solid advance. The final reviewer pointed out that the project began in 2004 and is 90% complete. This reviewer thought the project demonstrated significant development in sustainable friction reduction under boundary lubrication regime. The project also looked at temperature effects during sliding, and also failure/performance prediction methodology for lubricated components. The final reviewer described the project. The objective of the work this year included determining the mechanisms of boundary layer formation and loss rates as well as the film properties; determining the mechanisms of catastrophic failure by scuffing; developing integrated low-friction high power density interfaces; and determining the mechanisms of boundary layer formation and loss rates as well as the film properties. Technical accomplishments included the analysis of about a dozen tribochemical films, to establish a firm connection between the structure and friction behavior of the films. Further modeling and simulation is required. Findings: All crystalline films exhibits consistently higher friction; amorphous or mixture films consistently showed lower friction; produced tribochemical films enable boundary friction as low 0.03 instead of the usual 0.1 to 0.13 values.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer cheered good work with collaborators! Good hand off to commercialization! The second reviewer stated that interactions and collaborations include Eaton Corporation, Castrol-BP and Oakland University, but it was not exactly clear to the reviewer why these particular collaborators were chosen. A third panelist commented that the list of collaborators is comprehensive and includes representatives from all the main areas Engine, Transmission, Axle and Oil manufacturers as well as academia. The final reviewer felt that most of the collaborations seem to have been loose. This reviewer did not remember hearing much about the results of the academic (Oakland University) collaboration. The CAT collaboration does seem to have transitioned knowledge into industry, but it also seems like this was a few years ago.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

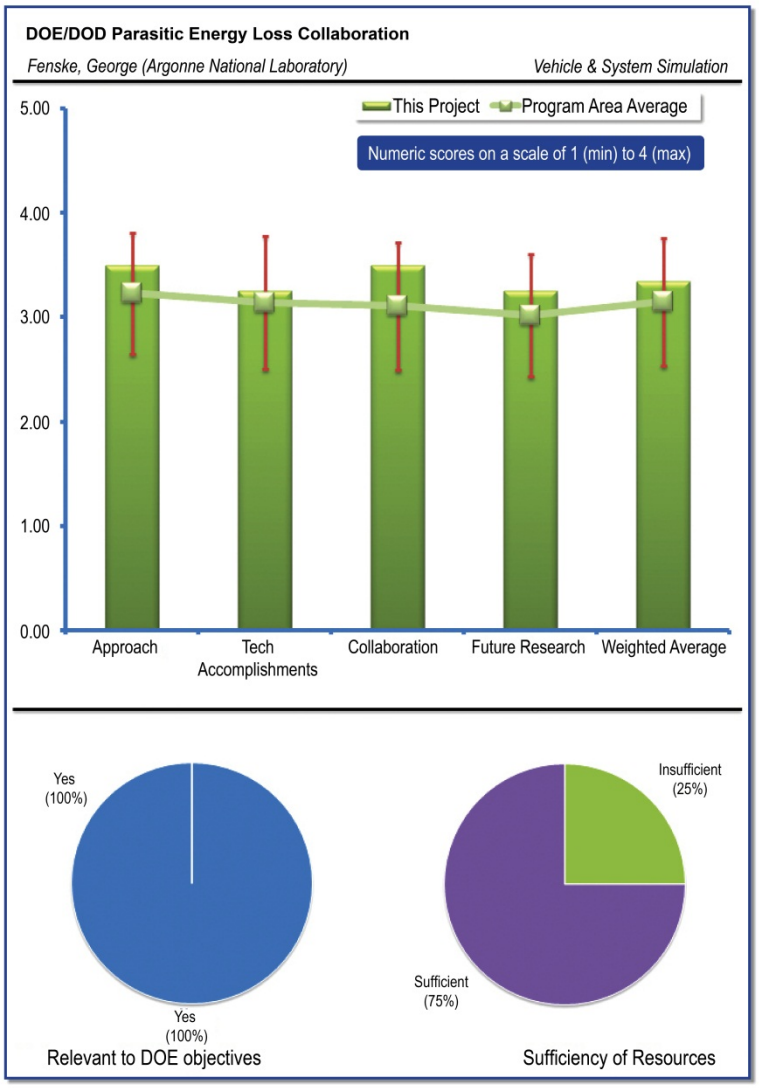
The first commenter found that future work appears to continue the exploration of friction reduction through material and film investigation. There has been some commercialization from work on this project but the reviewer believes that more opportunities

should be investigated. The reviewer is of the opinion that a follow on project is a must as the objective of turning this study in practical use must be achieved. A second commenter highly emphasized that work is needed on development of constitutive equation for the tibo-film mechanical behavior for input to the compressive friction modeling effort. The second reviewer said that future work should also include evaluation of the role of surface coatings on the behavior of tribochemical films, especially the low-friction ones, and continued development of compressive friction model. This panelist further suggested refining and optimizing the methodology for formulation and fabrication of the low-friction tribochemical surface films; conducting more work on real contact temperature; continuing nanomechanical and frictional properties of structurally different boundary films using a nanomechanical probe system; and providing a pathway for structure-properties relationship formulation for boundary layer films. The second reviewer pointed out that the presenter claimed that the "Potential for 5 -15 % fuel savings via efficiency gain is increasingly achievable," and further opined that the 15% was overly optimistic. A third evaluator felt that they all seem very good. The only thing holding this back from "outstanding" is that the evaluator was not fully clear on what parts of the "future efforts" represent future works under this program and what parts represent more general future efforts. Again, a clear statement of goals from this project would be useful. The fourth panelist stated that this project's goal is to design tribochemical film that gives optimum properties. The mechanism discussed was the sum of shear forces, ignoring wetting, flow viscous pressure in film layer and thermal. Scuffing initiation causes temperature rise not the reverse. Only shear force mechanism? Shear force increase of film layer is claimed as the dominant mechanism when in boundary layer contact regime. This is a logical explanation but further investigation to verify the assumptions may be fruitful. Crystalline versus amorphous analysis work coupled to nanoindentation is great, though the explanation should have been more thorough.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A first respondent thought that for the remaining scope, budget and timing the resources are sufficient. This respondent believes that project scope may have to be reduced to complete the project in the defined timeline, and that a follow on project is essential. A second reviewer thought that funding is sufficient to wrap up the project and elucidate the questions for a next stage of funding. The third reviewer requested a little more clarity as to what the milestones are in order to make a definitive assessment. This reviewer recognized this is more difficult with basic research, but a plan always exists—and it could have been a little more clearly stated.

DOE/DOD Parasitic Energy Loss Collaboration: Fenske, George (Argonne National Laboratory) – vss005



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally perceived that the project supports DOE objectives. The first evaluator concluded that this project directly contributes to DOE objective of petroleum displacement. The project targets specific VTP performance goals to achieve petroleum reduction, and supports the 21st Century Truck Initiative and both light duty and heavy duty vehicle technology goals by addressing details of parasitic losses in both commercial and ground vehicles. To achieve petroleum and GHG reduction goals, this project offers a strong support to the challenges and represent a unique opportunity for the U.S. to continue to evaluate, test and understand parasitic losses in VTP, to establish a sustainable energy infrastructure. A second evaluator claimed that improving efficiency will reduce petroleum used and reducing friction is broadly applicable to most powertrains. A third stated this project directly addresses fuel efficiency. Good use of resources. Friction consumes 10% to 15% of fuel in commercial vehicles. Reduced fuel use saves cost, reduces logistics and increases safety for military. Parasitic losses are large component of vehicle energy consumption. Good pulling together of resources and search for range of new technologies. There is a clear need for this type of work. New fuels and environmental regulations bring new challenges. The fourth reviewer thought that reduction in fuel usage for the military has a many benefits, from savings in overall cost associated with fuel delivery (due to lower demand), to reduction in convoys, is significant. This is aligned with the DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent commented that the modeling of parasitic losses to identify the magnitude and then identify pathways to improve fuel consumption is a logical approach. A second commenter deemed this type of DOD-DOE collaboration critical to accelerating VTP and VSS investments. The project should formally establish DOE/DOD collaboration that utilizes key facilities and expertise to investigate, model, and understand fundamental tribological phenomena that impact fuel efficiency, reliability, and durability. This particular project will develop and implement advanced tribological solutions (lubricant, materials/coatings, and surface texturing) to reduce fuel consumption, and will identify critical barriers related to parasitic friction losses, reliability, and durability common to commercial and military vehicles. The goal of the work is to improve vehicle fuel efficiency while maintaining/improving reliability and durability. The third respondent liked the rather detailed modeling of the engine losses showing the impact of changes in viscosity and reductions in boundary layer/asperity friction. This helped justify the focus on improving boundary layer friction by providing some grounded numbers that give some rigor to claims on what improved boundary layer friction can provide. The final respondent concluded that collaboration with DOD is an interesting approach to obtain severe environment data that is useful, but scarcer for

industry. Modeling parasitic losses to identify goals is well thought out as is use of bench top lab techniques to explore solutions: materials, textures, operating conditions. Are model validation phase and confirming testing on in use parts to come as later steps? or another project? Clarity here may improve the approach. There was one sentence on slide 20 "Establish test program ...". More depth here would be helpful.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer stated that the project is 25% complete. FY 2010 accomplishments included establishment of the MOU between DOD and DOE on this collaborative project on parasitic losses with DOD/TARDEC. Such an MOU may be considered a tremendous victory. The project is really just getting started. Preliminary work across agency needs and sampling was performed and acquiring driving schedules. Technically a small project on compression ring and oil control ring at low loads –to focus on simulating hydrodynamic regime where viscous losses are greatest was started. A second reviewer thought there was good progress on organization and building the approach. With oil on off testing, new work is just beginning. The presenter showed some of the same slides as previous presentation. Nice illustration but it was unclear what was the new bench work for this project. New slide hone results are getting the project off to a good start. A third reviewer thought that FMEP modeled as a function of boundary lubrication and viscosity is interesting, and that the use of both military and commercial drive cycles with real hardware and additives and then exploring the friction mechanisms under different load conditions should yield some interesting results. The fourth reviewer thought the presentation was a nice review of different driving conditions and impacts of friction reduction.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first panelist strongly stressed the excellence of the collaboration. Collaborators include TARDEC, Mahle, DOD Vehicle OEMS (NDA –protected) and Additive and Lubricant OEMs (NDA). Stakeholder breadth is commendable and appropriate. The second panelist thought that all aspects appear to be included and well covered. A third was impressed by the good outreach to DOD. The fourth panelist considered the project is in its early stages, and needs more work to expand partners to ensure commercialization of the results. This should be easy to pull in more industrial partners as the project gears up. The link to Mahle is a good start.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

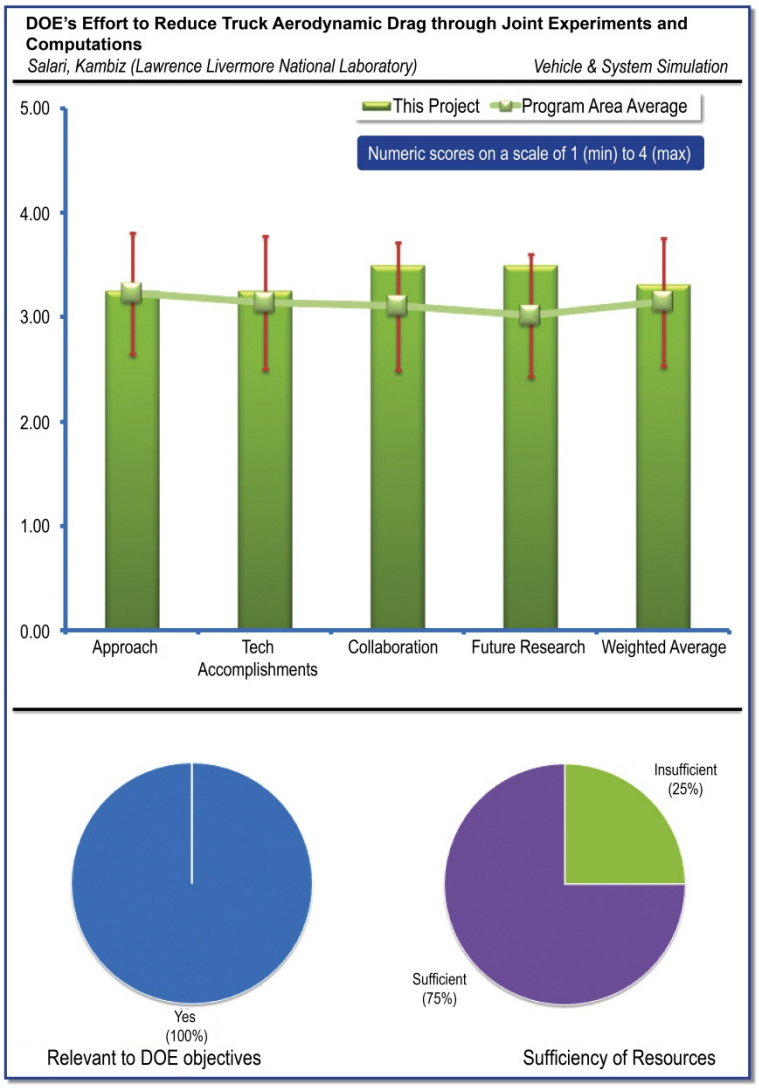
The first respondent thought the modeling efforts for diesel and gas engine work were clear, but asked, What is the new experimental work? This was less clear. A second respondent expected to see some good results from the modeling as well as the developments on engine and powertrain rigs. Alternative fuels were not covered in this project, but there is a follow on project that will explore this. A third respondent thought the next steps should include modeling the impact of low-friction strategies on vehicle efficiency – commercial and military ground vehicles, based on driving schedules (commercial vs. military). FY 2011 work should include: Applying driving schedules (engine maps) to predict changes in friction mean effective pressure (FMEP); scaling fuel economy to indicated mean effective pressure (IMEP); and initiating/extending studies on impact of additives and materials on vehicle efficiency (friction) and reliability/durability(wear and scuffing) –in progress. Findings to date include: Durability/Reliability–Maximum forces occur near top-dead-center where boundary/mixed regimes dominate –focus on high loads (˜50 N/mm). A fourth respondent appreciated the difficulties, but it would have been nice to see some efforts to look at the impacts on transmissions/gearboxes. The slide showing the impacts of friction reduction on net engine losses is very nice. It showed how reduced boundary friction enables lower viscosities and these two together give the some significant benefits and it puts some rigor behind the claims. It would be very useful to see something similar on the transmission side; otherwise the claims about potential reductions really do not seem to have a firm basis. Having said all that, given the funding level, this respondent thought the proposed work seemed very reasonable.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A first evaluator would increase this budget. The MOU has accelerated ROI when managed appropriately. When ANL works with DOE HQ VSS, this management and its results may work very well. A second evaluator concluded that more resources on more experimental work would be worthwhile. How will the work on the engine / drive train simulation rigs be funded? The FY 2011

funding is small compared to the goals. A third evaluator said resources appear sufficient. The final evaluator thought the first two items seem reasonable. The final item (test program with original equipment manufacturer [OEM]//Tardec) will rely on getting external support.

DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations: Salari, Kambiz (Lawrence Livermore National Laboratory) – vss006



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first evaluator was of the opinion that this project directly contributes to the overall DOE goal to reduce our dependency on petroleum for Class 8 tractor- trailer vehicles. The project objective includes reducing aerodynamic drag in Class 8 tractor-trailers by approximately 25% leading to a 10-15% increase in fuel efficiency at 64 mph. Class 8 tractor-trailers are responsible for 12-13% of the total US consumption of petroleum. A second evaluator acknowledged that aerodynamic losses on heavy trucks represent a significant amount of petroleum consumption. Moreover, some "add-on" devices and other enhancements can be implemented in the very near term. A third evaluator thought that a 25% drag reduction is aggressive and highly needed. The project directly addressed a key parasitic loss. Aero plus single tires seem to be a large near term impact. The third evaluator thought this project was producing great work to get solutions on the road in large volumes. The final evaluator stated that reduced aero drag improves fuel efficiency of tractors and trucks which take a large amount of the fuel used in the U.S.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A first respondent thought that this project's approach is sound. Full scale wind tunnel testing was matched with science-based AE modeling and road testing. Wind tunnel testing is expensive, but sound, and the industry collaboration is useful. The first respondent was not clear what the university contribution was, and thought that it could be easily expanded. A second panelist claimed that this year involved a lot of testing to help validate various claims and (presumably) to support CFD modeling efforts. Good focus on near term technologies that haulers would be likely to adopt (if the tests show merit). A third panelist thought that there was a great blend of pulling forward existing or proposed solutions and sorting them out to prioritize resources to accelerate to the market and in developing new solutions. This panelist also thought extending solutions from box trailers to tankers is a good step. A fourth respondent concluded that although the 2010 presentation did break down the drag by area of the tractor-trailer, and a drill down analysis was not given to show the aerodynamic drag currently on the tractor/truck vs. the cost to improve them. If that was done, it was not made clear this year. Even though both technologies help with fuel economy, wide base tires and aero improvements are pretty different topics. These technologies might be better served in separate projects. Analysis of the rolling resistance and how to reduce it (besides using Super Singles) was not shown.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewers had positive feedback about the technical accomplishments achieved thus far. A first reviewer commented that drag reduction estimations of the corrugated trailer drag, tanker trailer, and add on devices for van trailer are all valuable. LLNL's virtual testing environment should minimize wind tunnel costs. The non-proprietary results should be made as public as possible so drivers and fleets can use the information to make purchasing decisions. A second reviewer reported that identification of tankers was nice; a good opportunity for improvement and nice summary showing the influence of the gap. The second reviewer also liked the review of a broad range of offerings and efforts to summarize findings. The third reviewer thought that the ability to run full scale wind tunnel tests on tractor trailer was amazing. The work on corrugated trailers to identify low hanging fruit is a great result. Design guidance to trailer tails. The reviewer thought this project displayed great work with Navistar and extended team, resulting in really amazing progress over several years. This is an outstanding example of great use of DOE resources to really deliver advances important to the nation. The fourth reviewer stated that FY10 Accomplishments include full-scale wind tunnel test of Class 8 tractor-trailer combinations at NASA Ames Research Center, National Full-Scale Aerodynamics Complex (NFAC) facility. FY 11 accomplishments will include a focus on improving design/performance of existing drag reduction devices based the FY 2011 full-scale wind tunnel tests, and performing scaled experiments to validate the improved performance of redesigned aero devices. The ultimate goal of the work will be to design new aerodynamic drag reduction fairings for tanker trailers. The fourth reviewer concluded that the wind tunnel work is a strong accomplishment. What the team does with this date in the next assessment and design steps will be telling. Suggestions are trailer skirts, tail devices, and other AE devices. Findings include 405% FEI with wide base single tires.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first panelist thought that it was good to see interactions with haulers (Frito Lay and Praxair) in addition to manufacturers. A second panelist reported that partners include Navistar, Inc, Michelin, Freight Wing Inc., ATDynamics, Kentucky Trailer and Wabash National, Frito-Lay and Safeway and Praxair. A third panelist felt there was outstanding collaboration with a strong group including LLNL, Navistar, Michelin, NASA Ames, Wabash, Praxair, and Safeway. This panelist thought that communication through conferences and international outreach was outstanding, and that combining work on tires and aero to attack the two big parasitic losses is a unique approach. A fourth panelist believes that the collaboration with Navistar should ensure the devices are used, and that the collaboration with Praxair should allow improvements to be more easily adopted. The fourth panelist also stated that the guidance document referenced in the presentation should be easier to access for people who want to read it that are not on the project. LLNL took more than 10 days to be able to locate and send out the document upon request.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

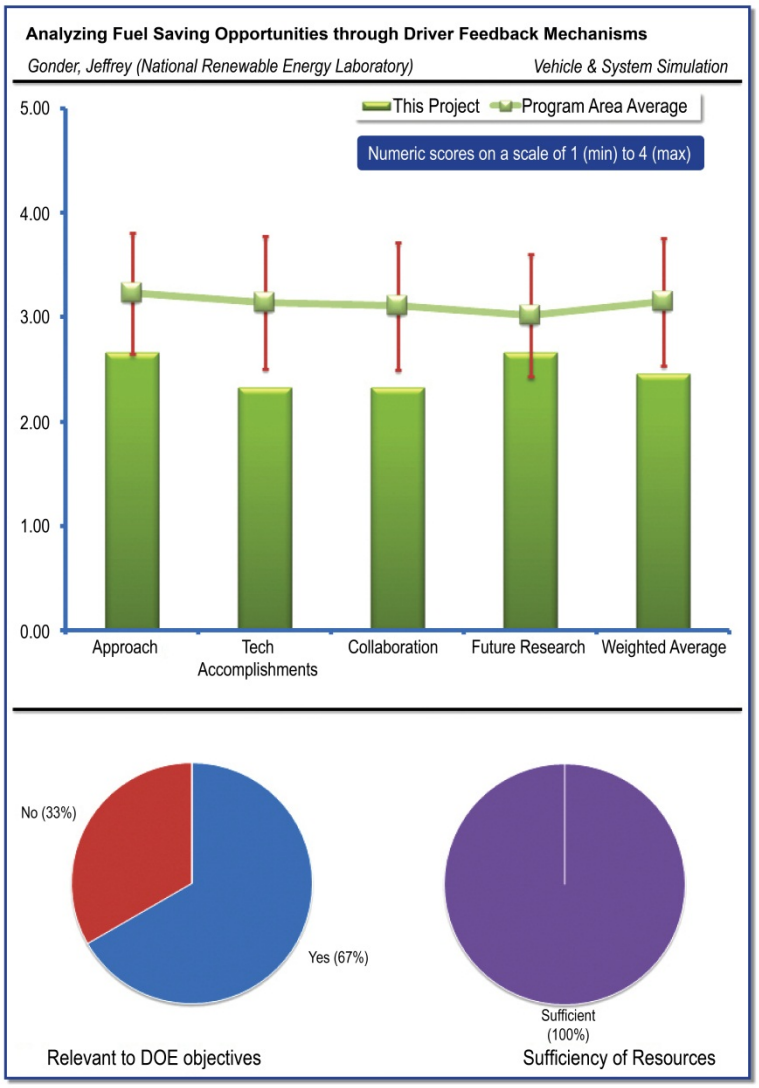
The first evaluator considered there to be potential for gains in efficiency for tanker trailers. Efforts to incorporate thermal (cooling system) aspects into aerodynamic studies seem nice. A second evaluator encouraged work to continue on tankers, aerodynamic devices, aerodynamic surface optimization, and integrated vehicle approach. This reviewer asked, what about through the engine aero losses? Is this a big next area? Will there be more types of trucks analyzed? Now that work is well advanced for long haul box rigs, should an analysis be done to identify next big areas to attack? A third evaluator reported that future work will include continued track work on AE devices and performance validation, and work with Praxair to design new aerodynamic drag reduction devices. Expanded work will include investigation of benefits of tractor-trailer integration for drag reduction (geometry, flow, and therma). This integration is the most compelling aspect of future work. A fourth evaluator thought the improvement on the tanker truck (to be measured) will be a key bit of information that would encourage use of aero devices in that application.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer thought that the money remaining in 2011 may not be sufficient to achieve all the future goals of the program for 2011. The team may need to prioritize which part of the plans should be funded. A second reviewer stated there was a great use of resources, that the project was an excellent value for the money, and that this project appears to have delivered more energy savings

for the money than any other DOE project they had seen recently. A third reviewer thought this program seemed to be fairly well established, with good coordination between various institutions.

Analyzing Fuel Saving Opportunities through Driver Feedback Mechanisms: Gonder, Jeffrey (National Renewable Energy Laboratory) – vss007



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers watched this presentation, and the third reviewed written materials. The first reviewer agreed that it is likely that providing the right feedback should effect some improvement in driving behavior, leading to lower fuel consumption. The question is, how much can be gained by this approach? The fundamental assumption is that it will take a long time to replace older lower technology vehicles, and significant reduction in fuel consumption can be had by trying to modify driver behavior. The second reviewer felt that modification of personal driving behavior has the potential to lead to roughly 5-10% improvement on average over the U.S. vehicle fleet. One the biggest problems facing improvement in vehicular fuel economy is the very large pool of legacy vehicles in the U.S. Fleet. These vehicles take 13-15 years to turn over and when coupled with the relatively slow penetration rates of new vehicular fuel efficiency technologies, the end result is a very slow improvement over time in the overall U.S. vehicle fuel economy. Technologies or fuel efficiency approaches that can improve the fuel economy of existing vehicles already on the road (more than 200 million), even only modestly per vehicle, can lead to dramatic savings when applied over the entire U.S. vehicle fleet. A third reviewer could not attend the session, so only reviewed the written presentation. This reviewer noted that this project has not yet enacted any of its planned tasks.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first evaluator saw a good combination of driver behavioral research and engineering aspects. Previous work from the National Renewable Energy Laboratory (NREL) has introduced the concept of kinetic intensity to evaluate different drive cycles. It may help to leverage some of that work and look at the derived benefit as a function of kinetic intensity. While it is not directly related to the project objective, it does bring some level of objectivity to the evaluation. The second evaluator stated that the approach is solid, consisting basically of quantifying fuel savings opportunities, identifying/understanding behavioral influences, and assessing various feedback mechanisms. Respectable and appropriate partners have been leveraged to appropriately assist with the task, with the possible exception of the lack upfront of automotive OEM participation. This reviewer expressed concern with the task becoming somewhat divergent. If work continues in the future, it may be beneficial to narrow and focus down to a few very promising implementation pathways with partners with the potential to be broadly implemented commercially. The third reviewer concluded the approach was not clear from written material.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first evaluator reported some interesting results from the study - even the negative results (only incremental cycle improvements achievable) provide valuable information. The second reviewer stated that this task has generated a respectable amount of technical progress and accomplishments, including analysis of and adjustment to real world driving samples, insights from literature reviews, identification of driving cycle considerations, and approach assessments. Several sound recommendations from the task have been made. The accomplishments basically make the case that a significant amount of petroleum displacement potential exists through modification of driving behavior. But, as always, modification of personal behavior can be extremely difficult unless there are strong incentives to change. The third evaluator concluded that there were no accomplishments shown in the written presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent thought that the task had respectable collaboration with several other entities including the Institute of Behavioral Science, Gloworm, Navistar, and Progressive Insurance. It would be beneficial to further expand collaborations with these entities, others like them especially on the commercial side, as well as with automotive OEMs. A second respondent stated that it was not clear from the presentation whether there had been any collaboration up to this point in the project. The slides on future work clearly indicate a list of collaborators. A third respondent surmised that collaboration and coordination was not clear from the written presentation.

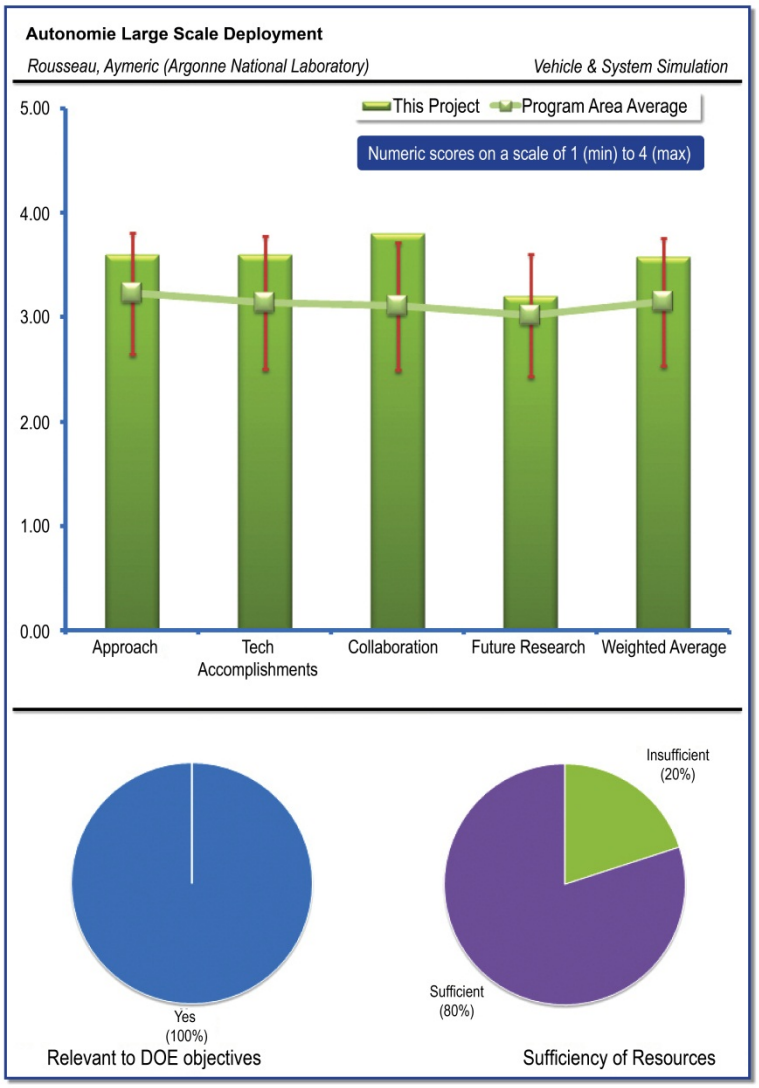
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first panelist commented that the project is largely coming to an end, but does appear to have the potential for continued follow-on benefits. For example, following up further on the idea of leveraging applications with enhanced incentives through commercial vehicle fleets and usage based insurance is promising. These areas could be taken further. It would probably be beneficial to get an automotive OEM involved from the standpoint of determining the feasibility of different driver feedback mechanisms from a driver receptiveness and cost standpoint. In the presentation, Recommendation 3 to "make it automatic" holds the promise for bigger gains but only much further in the future. A second panelist reported that the project's presented future work includes several recommendations along with collaborative work that is planned. It is not clear what the purpose of these recommendations is (with specific reference to future work). Is there anything planned that will study the impact of implementing these recommendations? The third panelist thought that the written presentation did not really clearly explain future research.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

A first commentator thought resources have been sufficient for the task. A second reviewer was unsure.

Autonomie Large Scale Deployment: Rousseau, Aymeric (Argonne National Laboratory) - vss009



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project provides software tools for vehicle manufacturers to be able to develop and field optimized vehicle systems architectures more quickly and cost effectively. Although this tool will not directly deliver petroleum displacing technologies to market, it will be an enabler to help automotive companies develop products more quickly. It is likely that the larger vehicle manufacturers who do not use Autonomie will already have alternative tools/methods that can achieve the same objective, but this package will be useful to the smaller manufacturers and ancillary companies and will help provide consistency in the marketplace. A second reviewer reported that Autonomie is the primary tool used by all the labs to evaluate fuel consumption of new powertrains or new control strategies, and it appears to have found significant use across many of the labs. A third felt that this project is highly relevant to accelerate the modeling of vehicle systems core to DOE objectives. Unknown overlap with other commercial off-the-shelf (COTS) solutions but availability without for-profit license fees can be key to labs, universities, etc. A fourth reviewer affirmed that the large scale deployment of Autonomie will accelerate HEV, plug-in hybrid electric vehicle (PHEV) and electric vehicle (EV) technology development and evaluation. It is easy to see that the program will have a high impact on work at both government agencies and industry. The fifth reviewer thought that a software program that provides plug and play integration of various engine and vehicle simulations program will be a valuable tool for the design of fuel-efficient vehicle and vehicle technologies.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A first panelist relayed that one of the stated goals in to have a commercial partner, which brought to their mind the ADVISOR experience. This panelist hopes the lessons learned from ADVISOR are kept in mind when seeking a commercial partner to work with on this project. A second panelist hoped that the approach will lead to a successful launch for the expanded user base, by commercializing the software package and taking significant efforts to ensure that the product will be robust and well supported in the market. This activity will be key to transitioning the software from a narrow range of “beta” users into the wider market. The wider market may be much less tolerant of developmental issues. The second panelist also thought the approach of bringing in a commercialization partner to manage those tasks, while leaving the government the responsibility for continuing produce development, looked very wise. A third panelist believed that the approach for the large-scale deployment of Autonomie to date has followed a systematic and well-thought out plan. Progress on automating software testing and distribution appeared to be working well. A fourth panelist is of the opinion that a virtual engineering approach, using tools for CIL and SIL are clearly the future. The

new website, links for entering and tracking issues, and other support activities are very useful for the large scale deployment effort. Establishing partnerships with industry is also commendable, as is automatic release generation process. Generation of public component libraries would enhance impact on work at academia and other agencies. A fifth panelist thought that perhaps the search for a commercial partner (for 24/7 support, etc.) was a little late starting, in that companies/users are already ramping up without the support contracted. From one question answered in review it sounds like there are easy migrations from Powertrain Systems Analysis Toolkit (PSAT) for models... these are key. So far there is no central "device" model library to enable efficient sharing without model reconstruction or extensive manual networking to other researchers/developers. A virtual tool (device) library should be strongly considered as an enhancement.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally perceived that the project is making progress. A first commentator said that it was good to see that Autonomie is being deployed for several DOE funded projects (quite successfully), many of which include HiL, PiL, and other configurations. This actually indicates the level of accomplishment and progress more than some of the slides in the presentation that address this specific issue. A second commentator thought that the commercialization effort appears to be progressing well, in a well thought out manner, and has hit several key milestones with respect to bringing in a commercialization partner. The package also appears to have added some key functionality over the last few years which has expanded its usefulness for the commercial customers. A third commentator judged that all critical tasks seem to be on target, the industry collaboration is very strong and attests to success in deployment. A reviewer concluded that the relatively large number of users suggests the product is well-received and useful. It would, however, be more valuable to track usage hours as opposed to the number of users to better evaluate Autonomie market penetration. A fifth commentator affirmed that the adoption and co-funding of the software by major OEMs and integration in a number of existing DOE projects are indications of its accomplishment/progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had positive remarks about the project's level of collaboration. The first respondent reported that it looks like there is excellent cooperation between ANL and GM, and ANL and the different software vendors that are involved. A second respondent thought that the great relationship with GM will help convince other companies including other manufacturers, GM suppliers, and other companies to use this package. This collaboration with a very critical user will have positively influenced the matureness and feature content of the product. A third respondent thought the collaboration to be, in short, outstanding. Other DOE entities, software companies, and OEMs are all involved…and the sheer number of users is impressive. A fourth respondent reported that there is good exchange between labs, OEMs, and Autonomie users. A fifth respondent thought that the project looks to be very well networked both with industry (co-developed with GM) and with other modeling system providers. Seems some additional commercial collaboration (OEMs/ suppliers) would be on-board and noted here unless agreement with GM restricted other commercial collaborators. "Marketing" or awareness to others should be proactive...maybe just not noted here.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

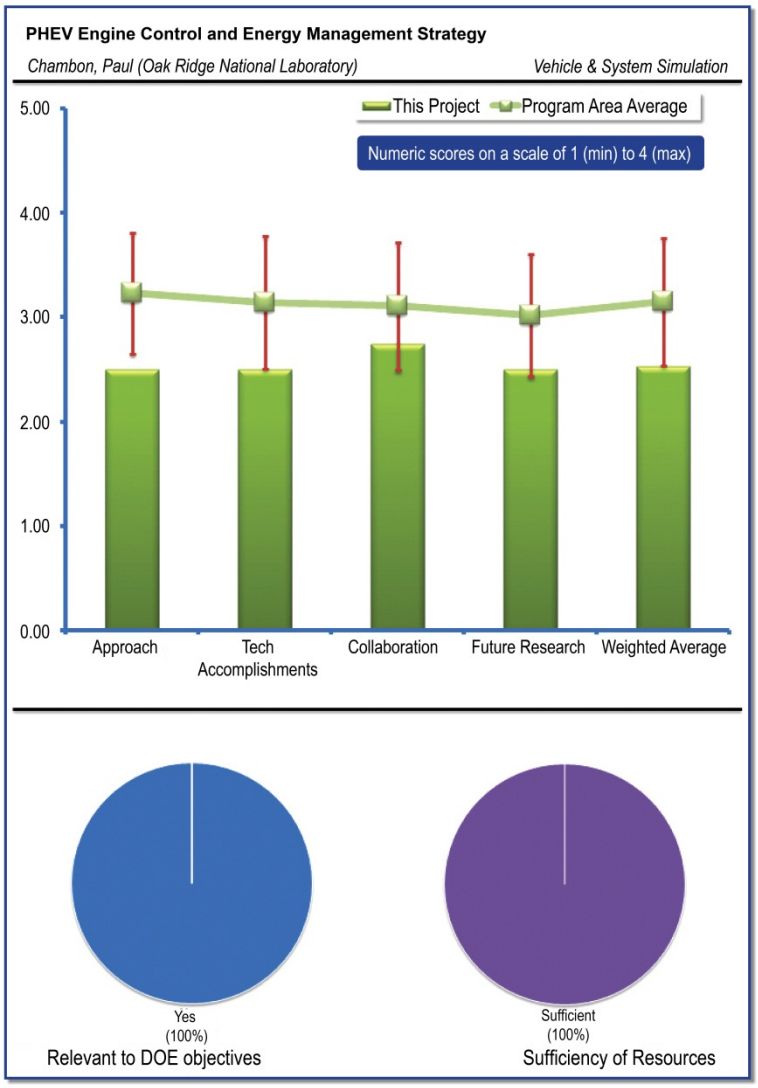
The first evaluator cautions careful selection of a commercial partner, based on the evaluator's experience with ADVISOR, related in the response on project approach. A second evaluator thought the additional feature content looks reasonable. Reducing simulation times for co-sim events may be key in making the adoption of the package a success - it was unclear from the briefing whether the current run times are acceptable or excessive - from experience this can often be a trouble area and should be looked at thoroughly. A third evaluator concluded the key element to future plans is to find a suitable commercial partner who could more effectively management the distribution and technical support of Autonomie. A fourth evaluator reported that the initial work on multi-controller optimization has been mentioned, and will be emphasized going forward. There will be a lot of important issues to address; this is an area that deserves a lot of attention. Industry standards for modeling and simulation (M&S) and support of simulation-based fuel consumption labeling and regulation for medium-duty (MD) and HD are both very relevant goals. A fifth evaluator thought the project did not provide much description of specific research/development areas to improve or enhance...a little of "it will be continuously

improved" based on feedback. However, the developers should have some more ideas of technically what is on the frontier. Maybe they do, just not communicated in presentation.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A first reviewer said that it seems like milestones are being met, and that planned future leveraging of a commercialization partner will be key to accelerate deployment. A second commented that the scale of the effort, impact, and further development of partnerships may merit increase in funding. Leveraging of GM funds helps achieve this at the moment and is commendable. A third reviewer thought that there appeared to be sufficient given progress and plans. No note of resource constraints in the project material and several partners engaged as well.

PHEV Engine Control and Energy Management Strategy: Chambon, Paul (Oak Ridge National Laboratory) – vss013



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer thought that this project supports overall DOE objectives indirectly, by addressing the cold-start emissions in PHEVs. Solutions will remove or reduce the constraints related to cold-start while optimizing the PHEV for minimum fuel consumption. A second panelist reasoned that increased penetration of PHEV can provide significant displacement of petroleum fuels. A third stated that the project does support DOE objectives but the relevance (compared to other initiatives) does not seem too strong. Cold start strategies are worked extensively through efforts with the U.S. Environmental Protection Agency (EPA),, the OEMs and tier suppliers to manage this transient event. It is not clear that there is a specific problem tied to PHEV that would not be addressed in the non-PHEV configuration. Yes, there could be more than one engine start event per drive cycle. However, the overall goal of DOE would be to avoid engine starts completely; or, if necessary, it would be to extend the range of the vehicle after the EV range is exceeded. This reviewer remarked that there are some configurations, modes, and duty cycles that may require multiple starts but is it a primary-enough expectation to put specific development funding into? How much more optimization would really occur above and beyond the baseline work already done for cold start?

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent thought the approach looked good overall but had one question: Does the PHEV set up include a motor/generator that could be used for stop-start? It is not clear from the presentation if that is so. Since the claim is that is expected to come from system optimization, it would seem that the motor/generator would play a big part in the system optimization. This would have a significant impact on emissions as well. A second respondent reported that the approach includes several tasks, four main tasks to be exact, and the planned activities are well defined in the context of stated objectives. However, the respondent's concern is whether the planned scale of the effort is realistic, particularly building the hardware setup and plans to carry out proposed experimentation. So far the engine testing has been completed, using a complete vehicle and chassis dynamometer. The on-going effort is developing engine-in-the loop capability at UT Knoxville, while there a planned parallel engine experimental effort at Oak Ridge National Laboratory (ORNL) on emissions and control system development. In short, the second reviewer was supportive of the effort, as long as the team keeps the focus on the main goal and initiates work on cold-start strategies on time. A third respondent asked: How would adding the hybrid controller into the loop really affect the cold-start performance? The material/presentation did not get specific enough regarding what control parameters/actions may enable optimization. The approach seems to be heavily dependent on tapping into the

tight control loop of the ECM (having an open controller). Without answering the question of a novel approach to cold start emissions, this effort seems redundant to every OEMs current activities. A fourth respondent criticized that establishing a partnership with Bosch (or similar) should have been a primary goal from the onset of the project as opposed to developing an open controller. In addition, there has been much research investigating various strategies to mitigate cold start emissions but the approach used in the present project does not seem to build off previous research, instead it reads as if "various strategies will be tried."

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that many of the issues that came up in 2010 have been well addressed. A second thought that since the partnership with Bosch had been established it appeared that the progress made on developing an open controller was diminished. A third commentator said that they understand the difficulty in getting the engine setup and then switching based on the new collaboration with Bosch. Again, is the potential benefit and available control levers actually worth all this time trying to directly control the engine? Perhaps the most valuable effort to the broader community is experience in modeling an engine system and PHEV vehicle level model in Autonomie. This should be well documented to benefit other initiatives. A final commentator concluded that engine characterization on ORNL chassis rolls facilities has been completed. The open source controller has been developed, to overcome the setback caused by lack of technical support from the OEM. The latter obviously caused delays, but the team seems to be in a better position after engaging Bosch as a new partner. The progress at UTK and ORNL related to engine test setups seems to be good, but effort so far has mostly provided enablers in terms of methodologies and experimental capabilities. Transition to actually pursuing main objectives will need to happen soon.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had a mixed assessment of collaborations, with three commending the collaborations and a fourth expressing concern. The first evaluator found significant improvement compared to last year, where the project appeared to be foundering. This evaluator also thought it was good to see Autonomie being put to use. A second evaluator concluded that collaboration with UTK and ANL good, engaging Bosch as the new partner should be very useful for controller development. A third evaluator reasoned that the partnership with Bosch should prove valuable to determine effective strategies to mitigate PHEV cold start emissions. The final evaluator said that it seems the project should have been suspended until a known collaboration partner giving desired control access was in place. Not at all clear if efforts are well-coordinated with EPA efforts at a project objective level...understanding that specific expert(s) with experience in cold start transient emissions are being leveraged. With this project there may be a high risk of redundant objectives.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

All four reviewers questioned future plans. A first stated that the details are lacking as to building a systematic test plan to determine the optimal strategy to reduce PHEV cold start emissions. A second thought that the list of strategies to be investigated seemed to be broad, and will require decisions soon. What will be the balance between work on vehicle level strategies (supervisory control) and engine-level strategies, e.g., air-fuel ratio (AFR) optimization or VVT retard? A third reviewer said that for FY12 the objectives included supervisory strategies and system optimization. The third reviewer asked: How is the sizing of components itself addressed here? Is there a trade-off involving vehicle performance as well? Battery capacity? What drive cycles will be used? A fourth reviewer deemed that the future work does not seem well connected to a future mainstream DOE effort. If future goals are realized (e.g., all-electric vehicles) will this problem be eclipsed/obsolete? Is this really a PHEV project or looking at approaches to improving engine cold starts in general. The FY12 proposed work of "Iterative concurrent emissions optimization of engine control strategies and hybrid supervisory strategies" would be very helpful to give examples of HOW this would be approached...what example "levers" specific to PHEV?

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One respondent answered that resources appear sufficient for stated scope.

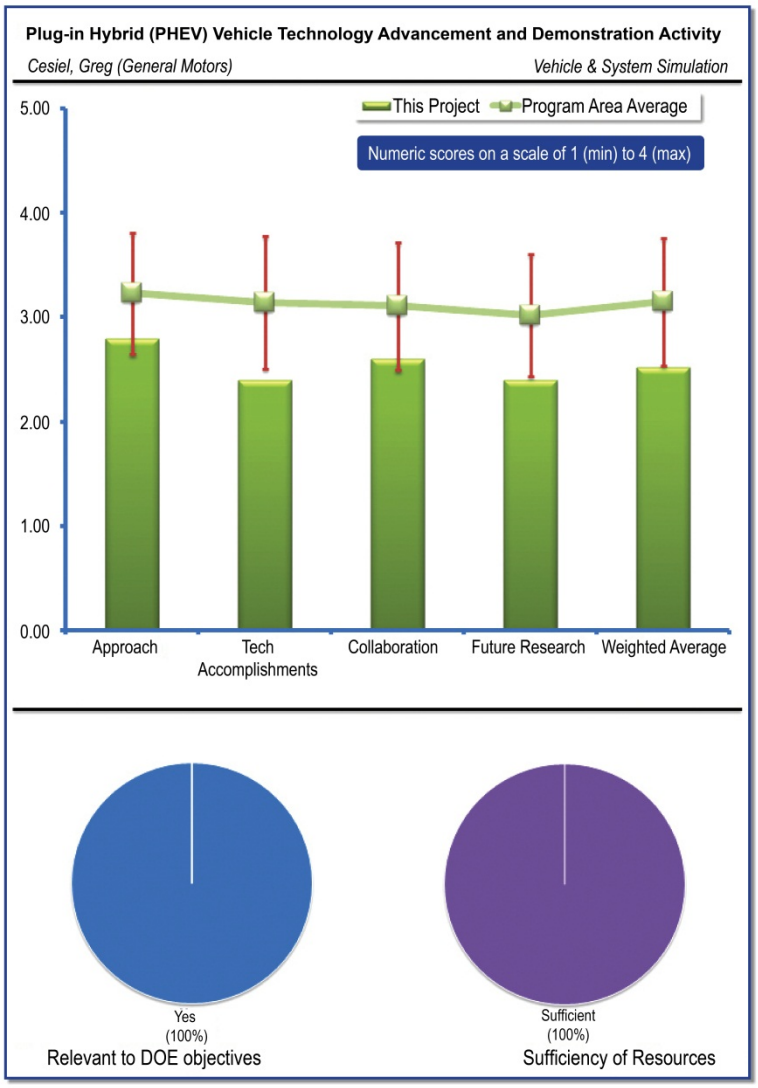
Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity: Cesiel, Greg (General Motors) – vss018

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer described developing and demonstrating advanced PHEV technologies as being very relevant to DOE's mission statement. A second commentator concluded that PHEVs are a proven way of reducing fuel consumption. Therefore, developing PHEVs and bringing PHEV to production is an obvious means to achieve petroleum displacement. A third commentator affirmed that PHEVs can be very effective in petroleum displacement. This project helps OEMs perform risky new development and deployment of PHEVs in the future. Real world usage and results are an important and expensive endeavor. Leveraging costs with OEMs is a wise choice. A fourth commentator acknowledged that introduction of advanced plug in technology (blended mode) will have significant impact on increasing fuel economy. A fifth commentator had a fundamental programmatic question, and doubted the program's ability to accelerate the penetration of plug-in hybrids into the U.S. fleet.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent offered that the presentation materials offer minimal technical details. The respondent could only guess that GM is addressing the barriers appropriately. The second respondent thought the approach was not very detailed, but that lack of detail made sense at this stage of the development process. A third respondent thought the approach was great, building off of previous 2-mode technology and expertise; is there plan for on-road fleet operation besides the development testing? The fourth respondent thought the presentation did not have much in the way of data, and was more of a high level overview. The fourth respondent would like to see specific data to understand petroleum displacement potential. The project is stated at 65% complete, but needed some data for review. A fifth respondent did not feel that this project was leveraging the Volt. Since it appears a project goal is to accelerate PHEV penetration into the national fleet, it seems maximized leveraging of the Volt would be logical.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first evaluator thought that good progress had been made. This evaluator thought that the presentation could have provided more details, graphs, figures, or results on progress. A second evaluator thought it hard to gage the level of progress since last year. Few details were given, and accomplishments seemed similar to last year. No measures were given to support refinement. A third evaluator

thought that, based on the presentation material, it seemed like very little progress has been made over last year (slide is identical to last year's presentation). Some of that can be explained by the change to a new vehicle platform that required porting the powertrain from the Saturn Vue. Still it was not made clear by the presentation material. DOE reviews were mentioned to assure us that milestones were achieved and demonstrated during those reviews but no evidence was provided during AMR. Are they being too secretive? A fourth evaluator reported that the project has been shown to function in cold and high altitude, and was said to be 65% complete; however, no data was shown to validate this claim. The fifth and final reviewer thought this project seemed to be behind Ford and Chrysler. There were no technical accomplishments or data presented. It appears the switch of vehicle platforms significantly impacted this project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A first reviewer found good collaboration with the University of Michigan, the Battery Coalition, UMTRI, and Argonne with testing. More collaboration with component and battery suppliers could help to strengthen PHEV development for the U.S. market. A second reviewer reported that partners were listed but no concrete evidence of by-products from those collaborations (except for ANL, but they are not listed as a partner). A third reviewer found that University and DOE lab collaborations were evident. A fourth thought the project had appropriate collaborations with government and educational institutions. A fifth reviewer only noted University of Michigan collaboration, and understood that the ANL test was required. Ford and Chrysler had municipality and utility partners on their teams, and this reviewer was expecting the same on this project.

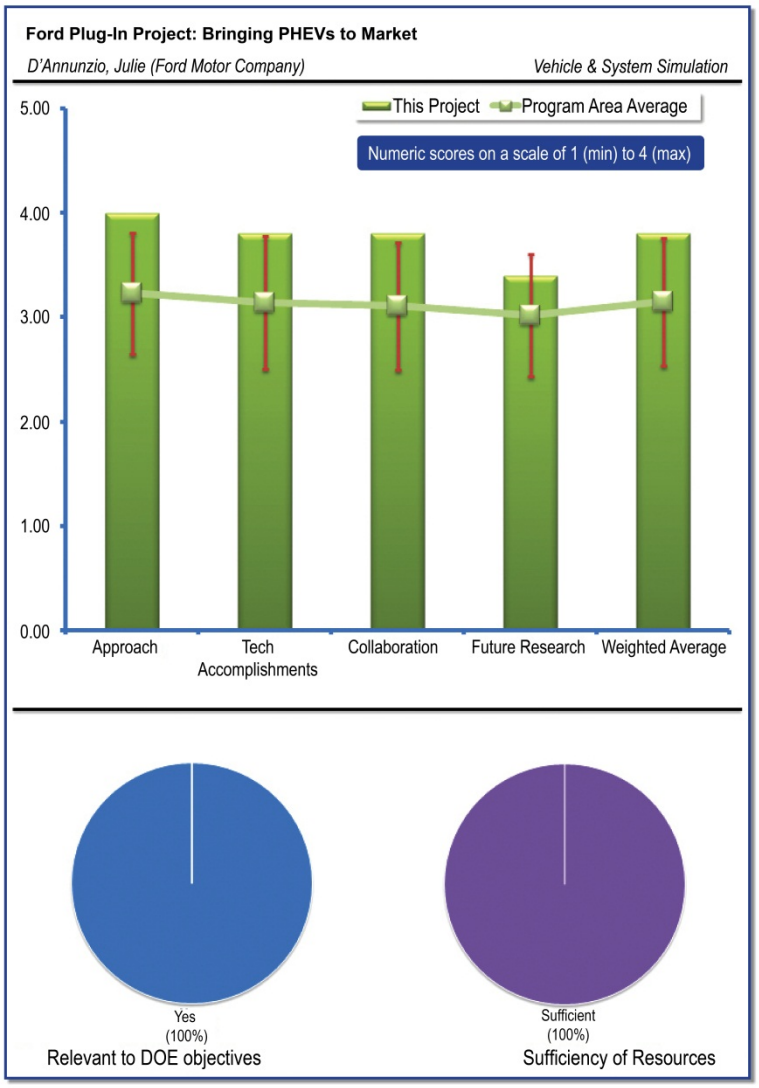
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first panelist saw good plans for continued development and demonstration through testing and on-road demonstration; including various charging power levels and charge / drive patterns. It would be interesting to include controlled charging studies (day of day control and/ or charge power level control through Smart Grid tech.) A second panelist thought the plan was fairly generic, but seemed reasonable. A third said the plan was adequate for the future year, but that it was hard to gauge if enhancements would be implemented. A fourth panelist agreed that there were no detailed specifics on the program in the presentation, but that the general idea was very good. A fifth panelist reported that program steps were presented, but it was not clear where GM is in the phases. A schedule would have been helpful and suggested for future AMRs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first evaluator suggested leveraging previous 2-mode technologies to enable low investment costs for this project in order to reach the goals of development and demonstration. A second evaluator was not able to assess the project based on presentation material. The second reviewer asked: Is this staffed appropriately, judging by the lack of (evidence of) progress? A third evaluator thought the resources to be sufficient, with the exception that in switching platform, there may be more expense than originally planned.

Ford Plug-In Project: Bringing PHEVs to Market: D'Annunzio, Julie (Ford Motor Company) – vss019



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers saw that this project supports DOE's objectives. The first evaluator thought that demonstration and deployment of more than 20 PHEVs from an OEM is very relevant to DOE's mission statement. A second claimed that plug in hybrid technology has high potential for drastically increasing fuel economy. This technology coupled with renewable fuel flex fuel capability furthers the potential for petroleum displacement. A third evaluator stated that flex fuel and improved mileage will support DOE's goals. A fourth said use of advanced technologies may enable electrified (GRID connected energy) transportation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Commenting reviewers remarked that the project has a very good design. The first reviewer thought this project had a great approach: multiple vehicles were deployed to a dozen utilities for on-road demonstration as well as dynamometer testing for baseline evaluation and data correlation. A second reviewer felt the design approach was very good, and should yield good results and insight into capabilities of PHEVs. A third reviewer said that this was a well phased program that allows for evaluation of systems and production likelihood, and proper in-use durability planned. A fourth reviewer affirmed that the approach seems solid. The next generation of improvements is being implemented in EU and China vehicles.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A first panelist thought that deployment activity looked very good. A lot is being accomplished. The panelist was interested in seeing the results after the 57 MPH calibration enhancement (a smart decision). A second panelist reported that there was good data thus far on over 500k miles for fleet, and that the data acquisition system and vehicles seem to be sufficient and effective enough to move forward. A third panelist stated that particular data not shown, only a high level overview. Progress and mileage accumulation is good (fleet ~400,000 miles); however, fuel economy potential not shown. The panelist thought there were interesting results on fleet driving behavior that was unexpected (higher rates of daily charging- fleet drivers not wanting to pay for charging at home). A fourth panelist confirmed that more than 20 PHEVs were deployed for on-road operation, accumulating nearly 400,000 miles, and serving as an outstanding demonstration of PHEV technologies. These increased EV operating region, and successfully demonstrated vehicle to grid communication (Smart Grid). A fifth panelist reported good technical progress, which identified status and issues, including program changes. The project identified changes in technology within partner community, including charging EVSE partners, and J1772 plug

upgrade. Key barriers to be addressed included energy storage system (ESS) controls improvements. Specific performance related to vehicle goals not reported.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers has positive feedback on collaborations. A first commentator stated that collaboration with a dozen utilities was great. They wondered if any portion of demonstration planned for private drivers as compared to business fleet usage since the driving, charging, and utilization patterns are quite different from business fleets to private drivers. A second commentator pointed out that of course the OEMs would be collaborating with its suppliers, but this project is exceptional because collaborating with utilities is a very important relationship. A third commentator was of the opinion that in addition to the technical partners in the development of the vehicle, the fleet/driver network they have created enabled a quick mileage accumulation, and outreach opportunity. INL data gathering and distribution was useful for proper information sharing. A fourth commentator thought utility collaboration is good, but that future partners could include private individuals to capture non-fleet application. A fifth commentator saw good collaboration with a number of regional energy authorities, government, and industry partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A first respondent said to continue the great work, and that any plans for further development, improvements, etc. should use lessons learned. A second respondent saw a solid project drawing to a close. A third thought that continuing field testing and evaluation of technology changes and controls changes is good plan, but no specific details were listed in the presentation as future work. A fourth respondent considered next generation technology planning to be logical (electric AC, higher speed EV). Battery life predictions based on improved EV usage could be added.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

A first evaluator thought that more than 20 PHEVs provided a large enough sample to demonstrate the technology on-road while still being small enough to keep costs down. A second evaluator found it hard to judge; it appeared that this project has not been slowed by funding. A third evaluator concluded that appropriate resources have been applied in this project, especially, and very importantly the outreach.

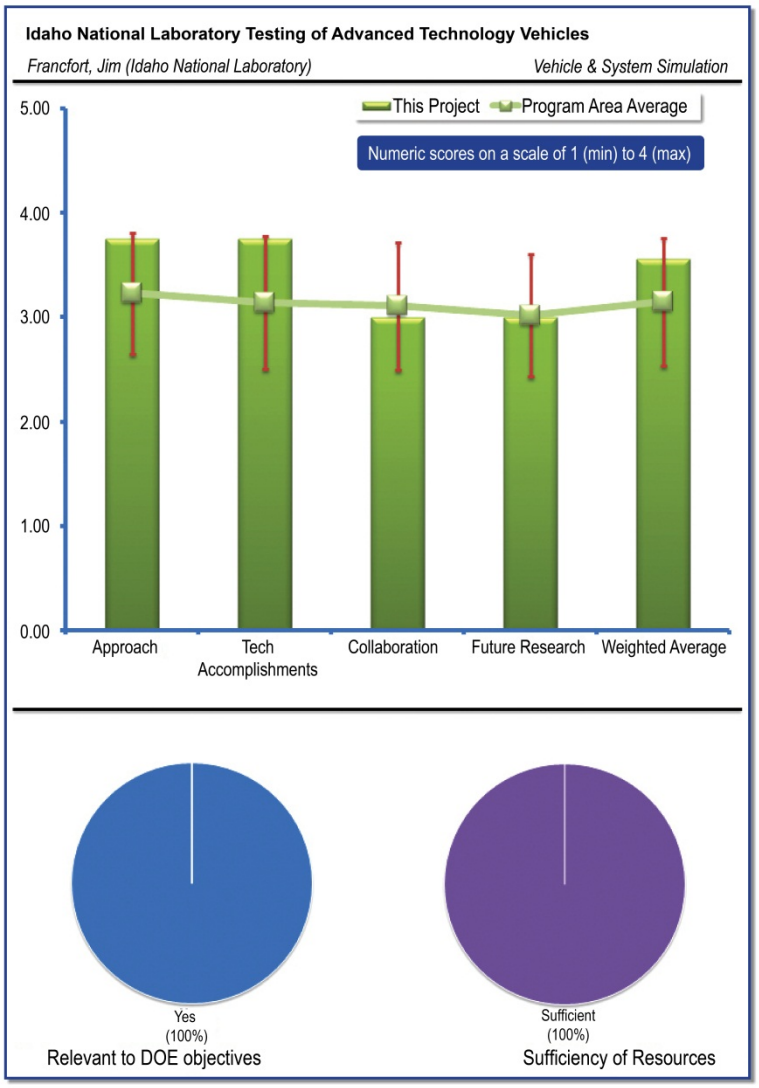
Idaho National Laboratory Testing of Advanced Technology Vehicles: Francfort, Jim (Idaho National Laboratory) – vss021

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that unbiased 3rd party vehicle testing helps to overcome end-user hesitance to acquire advanced vehicles, and helps manufacturers and suppliers improve the performance and reliability of advanced vehicles. A second stated that it is important to have some actual in use testing to provide a basis for all the modeling and projections. A third reviewer confirmed that independent, unbiased, and credible real world evaluation of advanced vehicles and fuels is essential for market acceptance of these technologies and to achieve significant petroleum displacement. Without broad, real world confirmation of advanced vehicle technology performance and costs, potential end-users—be they fleets or individual consumers—are not likely to consider their use. The final reviewer held that the U.S. needs real world testing of hybrid and electric vehicles to understand how much they are reducing fuel use and what some barriers for their use might be.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first panelist commented that, all in all, the data collection seems to be well done, providing some real feedback to decision makers. A second agreed that there is a lot of data being obtained by this project for little government investment. A third panelist reported that INL, in collaboration with other entities, has been performing the function of an independent real world tester of advanced light-duty vehicle technologies and fuels for nearly two decades. INL has developed a comprehensive and proven approach to need including development of test methods for each technology; conduct of actual testing on closed tracks, dynamometers, in the laboratory, and accelerated and fleet testing. INL analyzes and evaluates a number of vehicle and component parameters and infrastructure related elements under a broad range of environmental and driving conditions. The focus is to accurately and consistently document real world technical, maintenance, and cost parameters and to convey them in applicable formats to a broad range of users. The processes have been refined and honed consistently throughout the years. More recently, a significant emphasis has been placed on evaluation of electric drive vehicle infrastructure including charging equipment, charging/driving patterns, and interactions with the grid. A fourth summarized the approach and made suggestions on the presentation. This panelist listed: Collecting real-world and life cycle data on advanced vehicles; DOE program doing field testing of LD advanced vehicles; multiple testing approaches used depending on technology state and need; data review and cleaning; very clear graphical summaries in reports; and a battery testing mule vehicle. The fourth panelist thought that advanced vehicle testing activity (AVTA) is a very low-cost

project for the number of test miles and data accumulated, and the number of reports published, as all funding is highly leveraged via testing partnerships to provide maximum benefits to DOE and taxpayers. =Every testing regime has at least 20% cost share, and most testing cost-share is typically 50% or higher. Taxpayers receive independent information on emerging technologies and the associated amounts of petroleum used or avoided. The final panelist also advised that slide 14 is potentially confusing—although the color scales look to be the same, the numerical values the colors signify are quite different so the two graphs are not comparable to each other. Although some resolution could be lost, it would probably be best to use the same color scale for both graphs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A first evaluator thought the accomplishments generally good, as this was mostly about data collection, and this is a long running program that seems to be fairly well established. A second concluded that a lot of useful data are being obtained. The findings (such as the positive effects of the microhybrids) appear from the presentation to be given back to stakeholders for them to act on through reports. Hopefully feedback is obtained from the stakeholders on the format and content of those reports. How are data accumulated into larger groups, then analyzed and used? This is a huge amount of valuable data but it must be challenging to get analyze and then use it. The reports by vehicle were clear and helpful. A third evaluator agreed that the task achieves an impressive level of overall productivity, not just in the sheer number/variety of vehicles which have been tested over millions of miles, but the success to which a broad range of partners have been engaged, and contributed through a variety of means including most impressively the very high levels of cost share. Technical accomplishments also include battery specific testing, support for the United States Postal Service (USPS) electric long life vehicle effort, and the electric drive and advanced battery test bed vehicle project. The level of automation achieved in the data collection and reporting functions is also very impressive and undoubtedly contributes to high overall of efficiency of the project. A fourth evaluator summarized the accomplishments, including: Dyno testing of USPS conversions; testing li-battery PHEVs from 10 manufacturers (and one Pb-battery); publishing/presenting 3,000+ fact sheets, 26 formal reports, web-accessible reports; 22 HEV models (56 units) tested to date; 5 million HEV testing miles; and 12 H2 vehicles tested.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A first respondent thought that collaboration with researchers developing the models seemed like it could be a little tighter. The respondent also noticed mention of standards (two accomplishments) but no discussions of collaboration with ANL - who is also working on these standards. A second respondent concluded that it would help to explain more ways that the partners have used the data. The power companies' use of charging data makes sense, but it is a good idea to continue to look for how to provide value to OEM's just as it is beneficial to provide data for Autonomie. A third respondent reported that the project has extensive collaborations with other labs, EPA, multiple governmental fleets, and broad testing partners including utilities, county/city governments, automotive OEMs, military bases, universities, conversion companies, advocacy groups, and clean air agencies. Again, most impressively is the success to which these broad collaborators have been engaged and contributed through various in-kind and financial cost-sharing arrangements. A fourth respondent listed the collaborations as: Testing by INL and ECOtality; collaborating with USPS, major automotive OEMs, ANL, ORNL, NETL, EPA. The respondent noted that "Consumers" or "General Public" were conspicuously absent from the list of collaborations. While the last respondent would not expect the AVTA to truly collaborate with consumers, this reviewer felt there should at least be strong efforts at direct outreach.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commentator felt that future research should continue to focus on how data are analyzed and shared. A second commentator thought that charging infrastructure reports (not just vehicle) seem to be a newer focus and are a good idea. A third commentator stated that proposed future activities center on continuation of the testing, data collection, and analysis of electric drive vehicle technologies, energy storage systems, and supporting infrastructure in response to DOE's goal to reduce petroleum consumption in the transportation sector. Plans also are to continue to test as appropriate other advanced vehicle technologies such as hydrogen internal combustion engine vehicles. Plans are to end PHEV conversion data collection as increasing numbers of OEM PHEVs become available. A fourth commentator concluded that future plans to test electric vehicle supplemental equipment (EVSE)//charging

infrastructure are good, but presentation implies that this (rather than vehicle testing) will be the future focus of the program. Is it wise to de-emphasize vehicle testing? The last commentator also noted that NDAs and agreements in place to test Volt, Escape, Ram, LEAF, Coulomb (EVSE).

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first evaluator thought that, given the AVTA's numerous accomplishments over several years, the resources are at least adequate. Given the efficiency of the AVTA, the return on investment from increasing the program's resources might be significant. A second evaluator noticed total DOE share increases ($4.0M compared to $2.5M), and assumed the extra work for infrastructure reporting drives this. A third evaluator thought resources appeared sufficient and appropriate for the current activity given the very high level of cost share achieved. A fourth evaluator thought it looked like resources could be a constraint to do the quality control on the data. Does more of this function need to be done on the government side if the companies are having trouble with it?

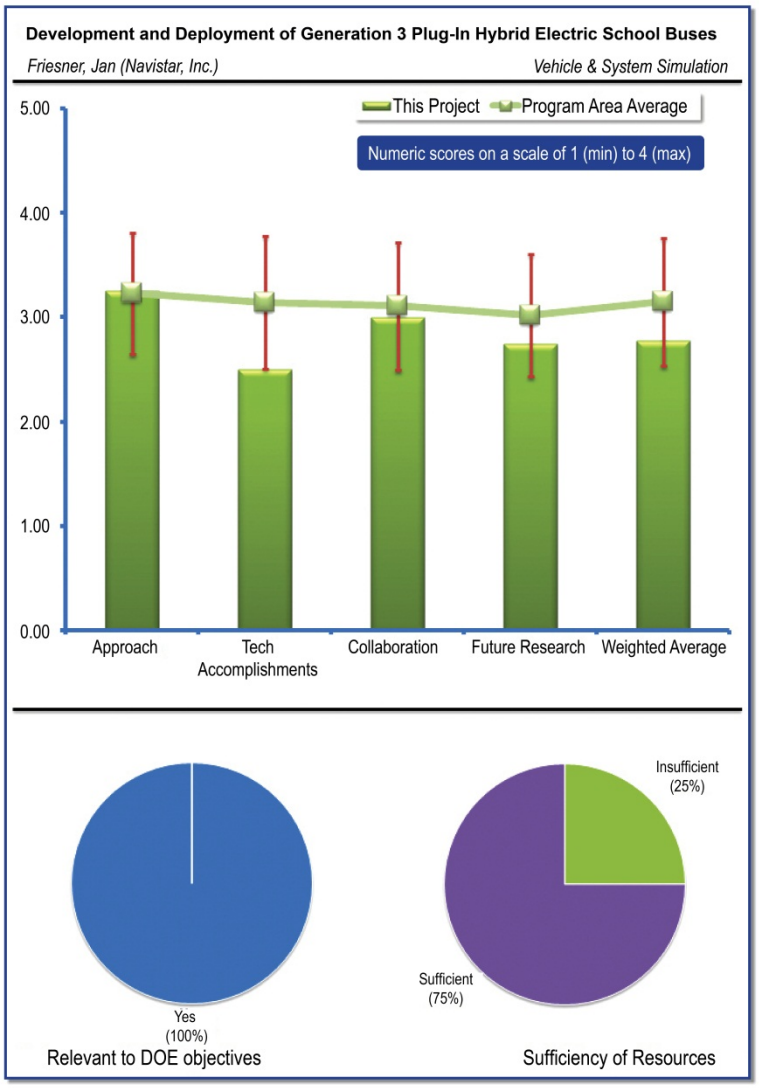
Development and Deployment of Generation 3 Plug-In Hybrid Electric School Buses: Friesner, Jan (Navistar, Inc.) – vss023

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that school buses are great candidates for PHEVs and PHEVs can achieve good petroleum displacement. A second panelist thought that the technology could be leveraged for other heavy duty class applications aside from bus usage, which could be very beneficial relative to large scale transportation. The project exhibited an interesting application of PHEV for busses, with two opportunities for charge and a transient operation—and benefits for air quality at schools. If seen to be successful, this could serve as a model for future school bus fleet decisions. A third panelist concluded that hybrid buses will displace fuel, but it will be small compared to light vehicle consumption. The presenter said there are 200,000 buses in the U.S. The LV fleet is ~ 240 million. Buses amount to less than 0.1 % of the LV fleet.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that this project had the right approach: performing upfront simulation work to identify the correct powertrain configuration as well as to size components before building the two best candidate platforms for real world evaluation. This will save iteration time and get a better end product. A second reviewer said there was a good approach and applauded the decision to adjust requirements based upon field data collection. A third reviewer felt it was unfortunate the original targets were unable to be attained. They stated the investigator's rationale for backing off on the targets was a little vague. A fourth reviewer considered the upfront analysis with cost benefit included to be appropriate for the market. The big question will remain the additional cost of battery storage and high power electronics being acceptable within the market (the biggest barrier).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A first respondent thought that it was unclear what portion of the work was performed by Navistar: DOE seems to have requested ORNL to perform simulations and NREL to do route analysis. Navistar seems to have done their own simulations but no results are available. The current progress does not line up with the February 2012 target to get running PHEV bus prototypes. A second respondent concluded that perhaps the project got a late start, but believed that doing the simulations (ORNL) and collecting the data (NREL) will provide a better design in the end. A third responded that after two years, modeling and simulation complete, but the

project has no hardware and much work to complete over next couple of years. A fourth reviewer affirmed that it seemed like progress was being made, but questioned if they were on schedule.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first commentator thought that there seems to have been some good interactions with ORNL and NREL. On the simulation side, no information was available to compare Navistar and ORNL results and to assess the coordination during that task. It would be good to have that information to learn what works and what does not. A second commentator felt that getting the help for initial design was a very good decision to take. A third said that to complete complex integration, relationships with other industry partners on the electrical powertrain/controls side would be beneficial (battery suppliers, high power electronics, motor suppliers, controls, etc.). A fourth commentator concluded that it seemed like ORNL and NREL have done a majority of the work thus far.

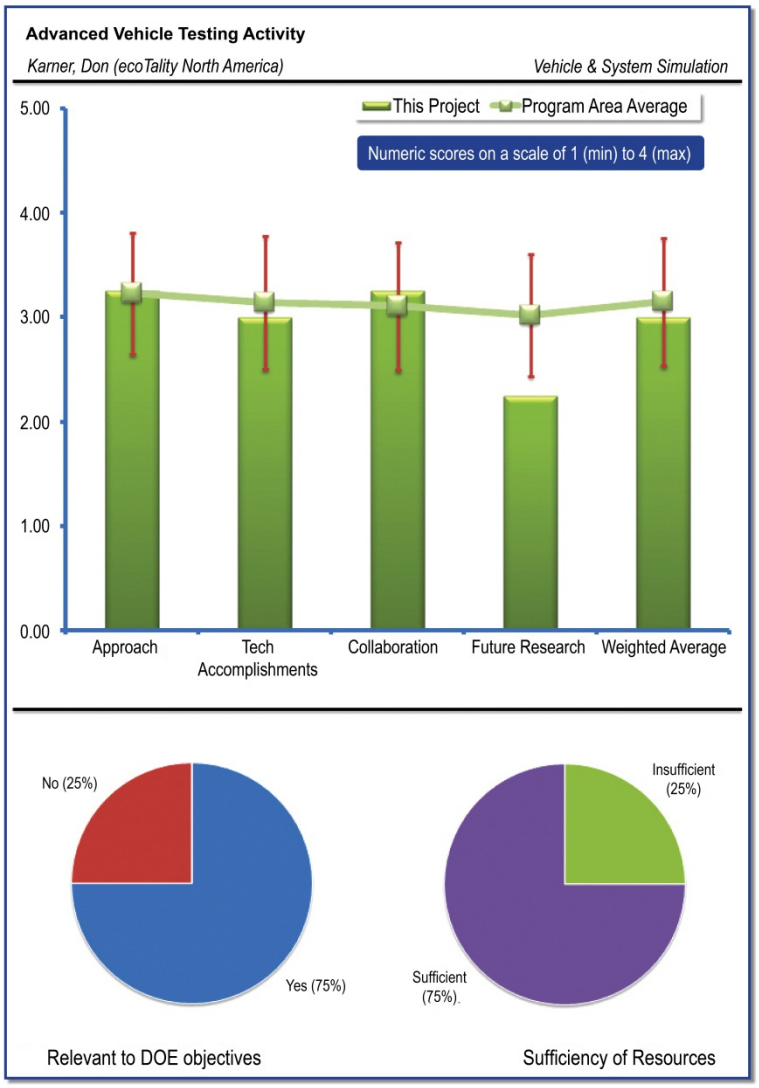
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A first evaluator thought that once completed, the testbesds should yield very valuable data. A second was of the opinion that it was still very early in the project. Once the first prototype is built, then it will be interesting to see what direction the program will take and how close the vehicle performance is to the targets. A third evaluator concluded that the timeline listed to deliver prototype buses in February 2012 seems unrealistic. It is lacking components and powertrain dynamometer testing: currently the powertrain component go right into the bus after procurement. Without testing the engine, hybrid transmission and battery pack first in a safe, controlled environment to iron out most integration issues and validate control strategies, the debugging on the vehicle might be difficult and time consuming with no guarantee to cover the whole operating envelope. The plan does not mention controls and integration tasks, they should not be overlooked, and the vehicle will not be built in one week as currently planned.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first panelist thought the budget appeared to be sound. A second felt there was not much detail on resources, but deeper collaboration with electric powertrain industry suppliers would be beneficial on a tight deadline. A third panelist reported that resources were not mentioned in the presentation but the aggressive timeline will require a very large, qualified team to deliver those buses.

Advanced Vehicle Testing Activity: Karner, Don (ECOtality North America) – vss029



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that this project has been helpful in characterizing vehicle performance, and in providing objective data with which to compare new technology vehicles to conventionally equipped vehicles. This reviewer noted that the accelerated testing has been particularly effective in that vehicle energy consumption trends can be evaluated over a number of duty cycles to result in a composite fuel economy. The same reviewer commented that the vehicle fleet testing accumulates 160,000 miles of service in less than two years and that this provides real world fuel economy data in a relatively short time frame. They feel that a lifetime of testing can be completed in less than two years' time. The availability of such data can guide OEM's and component and system suppliers with information to improve efficiency and durability of new technology vehicles, which will lead to greater market acceptance, and ultimately, reduced consumption of petroleum. The second reviewer felt that the work provides real world evaluation in a controlled environment to understand new technology effect on petroleum displacement. While the third reviewer said that this work directly evaluates energy use and petroleum displacement of advanced vehicles in real world testing. In contrast to three of the reviewers, the fourth reviewer commented that fuel displacement was not measured.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A single reviewer felt that the performance testing, which included vehicle acceleration, maximum speed, driving cycle range, braking, and gradeability, can be used to compare "new technology" vehicles to conventionally equipped units, and also provides an A to B comparison amongst new technology vehicles. This reviewer also felt that using the same driver over the same routes to eliminate the driver as a variable would allow the remaining variables to only pertain to the environment. This reviewer felt that it provides information on efficiency of such vehicles over the equivalent of a vehicle's lifetime. This reviewer also noted that it is important that total cost of ownership is calculated at conclusion of test program and felt that actual failure rates are very low as most testing is performed on production released vehicles. This reviewer also felt that with respect to component and sub system testing, battery tests are perhaps the most significant and that it provides invaluable information concerning degradation of battery performance over time.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the program has taken available specifications and combined them to form meaningful, comprehensive test procedures. This reviewer felt that one of the stated objectives, to develop lifecycle cost data for the vehicles which may have been developed during the course of fleet testing vehicles, had little information presented concerning this portion of the evaluation. During 2010, ten vehicle baseline tests were completed, and eight series of fleet tests began, with completion scheduled for the end of calendar year 2011. The reviewer said that the "most significant finding" according to presenter, is the excellent performance of batteries, which has been a large "unknown" for electric vehicles. The reviewer commented that batteries should last for the life of the vehicles, based on the experience of this program, and noted that looking at the total program since its beginning, 175 testing tasks were completed, with 10 million test miles accumulated to date. Six different fuels were evaluated. According to the reviewer one of the stated objectives was to develop lifecycle cost data for the vehicles. This may have been developed during the course of fleet testing vehicles, but little information was presented concerning this portion of the evaluation. Overall the first reviewer felt this program has provided a significant volume of data that can be used to rate production available vehicles and can also serve as a basis for identifying and exploring technical improvement opportunities. A second reviewer said that because this is a testing program over 5 years it seems to be well conducted and has had ongoing improvements. This reviewer felt that the number of vehicles over this time period seems to be quite efficient. The third reviewer commented that the fleet testing has a very limited in scope.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented that the project team has worked closely with Idaho National Labs (procedure development and data analysis) as well as Argonne (procedure development and dynamometer testing) and that the project team has also worked with Roush Industries on vehicle development and regulatory compliance, as well as special testing. The same reviewer also felt that EZ Messenger, a courier service, is ideally suited for mileage accumulation and variation of routes. They stated that EZ Messenger has been a willing partner for conducting fleet tests and designing test routes. A second commenter said the work is very tightly tied to ANL and INL. This reviewer was not sure about how partnering has worked.

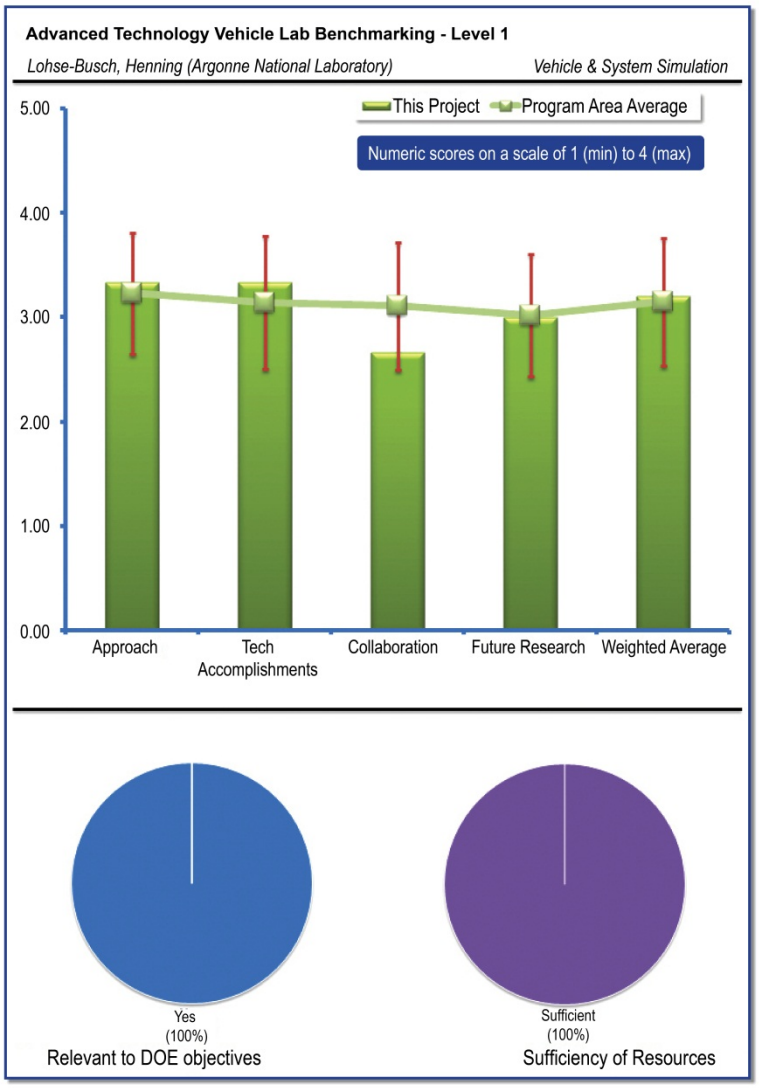
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated testing will be winding down by end of calendar 2011. Fleet testing and report completion will follow (presumably during the first half of 2012). The program is scheduled to end at that point. The reviewer also stated that one of the presented objectives was to develop lifecycle cost data for the vehicles. They thought that this may have been developed during the course of fleet testing vehicles, but little information was presented concerning this portion of the evaluation. The reviewer recommended that total life cycle costs be a prominent portion of the final report, and that all costs (fuel, electricity, routine maintenance, necessary repairs) be delineated. The buying public will be most interested in a so-called "cost of ownership." A second and third reviewer said that work was scheduled to continue on the 5 year program according to the schedule and that the program ends in December 2011. It was their understanding that no future work was been described. The third reviewer assumed that the project would be proposing for follow-on work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer stated that the resources appear to have been appropriate as all project objectives have been or will be accomplished.

Advanced Technology Vehicle Lab Benchmarking - Level 1: Lohse-Busch, Henning (Argonne National Laboratory) – vss030



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the program has taken available specifications and combined them to form meaningful, comprehensive test procedures. This reviewer felt that one of the stated objectives, to develop lifecycle cost data for the vehicles which may have been developed during the course of fleet testing vehicles, had little information presented concerning this portion of the evaluation. During 2010, ten vehicle baseline tests were completed, and eight series of fleet tests began, with completion scheduled for the end of calendar year 2011. The reviewer said that the "most significant finding" according to presenter, is the excellent performance of batteries, which has been a large "unknown" for electric vehicles. The reviewer commented that batteries should last for the life of the vehicles, based on the experience of this program, and noted that looking at the total program since its beginning, 175 testing tasks were completed, with 10 million test miles accumulated to date. Six different fuels were evaluated. According to the reviewer one of the stated objectives was to develop lifecycle cost data for the vehicles. This may have been developed during the course of fleet testing vehicles, but little information was presented concerning this portion of the evaluation. Overall the first reviewer felt this program has provided a significant volume of data that can be used to rate production available vehicles and can also serve as a basis for identifying and exploring technical improvement opportunities. A second reviewer said that because this is a testing program over 5 years it seems to be well conducted and has had ongoing improvements. This reviewer felt that the number of vehicles over this time period seems to be quite efficient. The third reviewer commented that the fleet testing has a very limited in scope.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that the general approach is to use chassis dynamometers for controlled evaluation of hybrid and electric vehicles, as well as major components and systems. They point out that this testing is supplemented by track testing and coast down testing performed by INL. Following dynamometer testing, vehicles may subsequently be subjected to accelerated fleet testing. The reviewer said that the project scope is continuous improvement of test capabilities and instrumentation and that this contributes to Argonne's reputation as a leader in vehicle and drivetrain evaluation capabilities. The same reviewer also said that both Level 1 (basic) and Level 2 (more extensive instrumentation) are performed. While this project covers Level 1 activity, the reviewer felt that much information can be garnished from this Level 1 testing in a short period of time, including analysis of parameters such as driver aggressiveness and accessory loads. A second reviewer said that improvements would be to develop an understanding of driver behavior range so that the

real world performance range can be mapped via a straightforward set of drive cycles. The reviewer elaborated by saying standard test cycles run for FE or emissions are not adequate to define real world performance range

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

According to the first reviewer among the accomplishments sited for this period were: (1) Quantified effects of driver intensity (aggressiveness) on fuel economy. (2) Quantified effects of air conditioning on fuel economy. (A/C has a major impact on fuel usage). (3) Studied effects of idle stop on fuel economy, and showed that this feature is far more significant in city based start-stop driving (which would be expected). Also studied and quantified benefits of idle stop feature. (4) Examined in-vehicle battery performance. The reviewer felt that the findings are significant because they were conducted on several different brands of vehicles. Thus, the general conclusions and observed trends should be applicable to other vehicle types. A second reviewer said that in the areas and on the cycles tested, this is very good. See question 2 for improvements.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that collaborations include INL, SAE, and cooperation with several other DOE funded programs, including: (1) HEV, PHEV, and EV Test Standards Development, (2) Codes and Standards Support, (3) Data Collection for Improved Cold Temperature Thermal Modeling, (4) Autonomie Development, (5) Vehicle Demonstrations conducted at INL, (6) Integrated Thermal Management of Electric Drive Vehicles. The reviewer also remarked that the recent evaluation of an EV was discussed, in which testing identified significant technology improvement opportunities that were subsequently shared with the OEM. The reviewer felt that this feedback and close collaboration with OEM's is deemed to be particularly important, as the OEM is in the best position to use this data to drive improvement in these advanced technology drivetrains. The reviewer suggested that to ensure that such close collaboration and working relationships are carried out on a consistent basis. It was not clear that this sited example was "typical" of OEM/Lab interface. The reviewer also noted that collaboration with SAE is occurring regularly to facilitate standards development (based on some of the test results achieved). A second reviewer recommended that the project seek further collaborations with fleets for new drive behavior information. The final reviewer felt that more standardization on battery systems should take place. In particular connections should be standardized between battery management systems and the controllers.

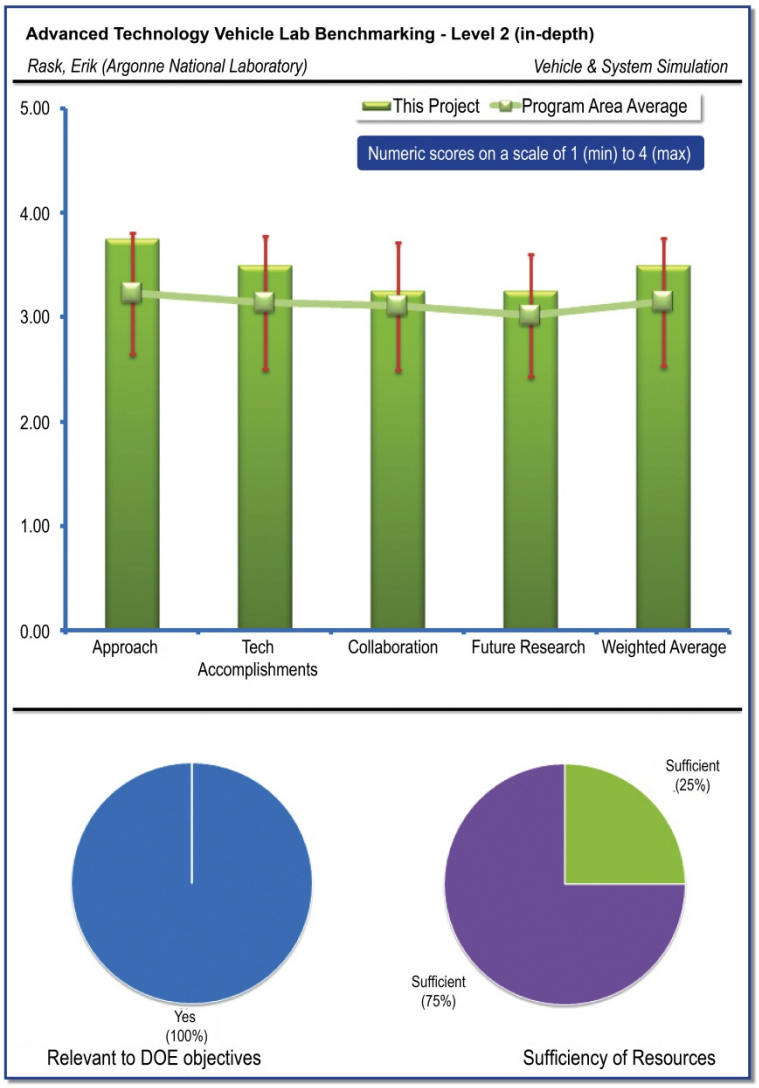
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the projected activity includes evaluations of Nissan Leaf, Toyota Prius, Hyundai Sonata and that it is unclear how vehicles are selected for evaluation or how work is prioritized. The reviewer felt that it would be helpful to better understand this process. The reviewer also noted that the project will perform Level 2 analysis on DOE selected vehicles and will continue support of standards development. They have also planned a facility upgrade to the 4WD test cell (installation of climate control for testing under extreme conditions). The second reviewer felt that the project should include new tasks for question 2 comments.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer said that resources appear to be sufficient and that current and future work seems to have been planned based on resources available, so there is a good match. Another reviewer simply stated that the project is getting by.

Advanced Technology Vehicle Lab Benchmarking - Level 2: Rask, Erik (Argonne National Laboratory) – vss031



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally commented that the project supports DOE objectives. The first reviewer said that there was a very in depth testing on thermal effects of the systems. The second reviewer felt that the project is helping government and industry to understand current state of technology and that the information learned is fed into simulation programs, which facilitates design and spec'ing of hybrid and electric systems. The reviewer said the information can also be used by OEM's and suppliers to identify and act upon improvement opportunities and that the result is more efficient cars that will be more in demand, and result in a reduction of U.S. petroleum consumption. According to the reviewer the information is often times more detailed and comprehensive data than the OEM's themselves might generate. The third reviewer commented that this benchmarking work directly evaluates the potential for advanced vehicles to displace petroleum energy in controlled, repeatable conditions.

The final reviewer said the relevance will show better after some other vehicles are evaluated and felt that a sample of 1 is very hard to evaluate.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said that the level 2 testing involves more comprehensive measurement of vehicle operating parameters, including complete power flow assessment. This is extremely helpful in understanding current state of hybrids and EV's and may identify opportunities to reduce wasted power. This reviewer said that this is clearly "systems level" testing, understanding how all components and systems function together. Examples include EGR, waste heat recovery, and electrification of accessories. The reviewer also said that this testing also seeks to evaluate individual component performance, understand component duty cycles, and evaluate component operating temperatures. Furthermore the reviewer said that the instrumentation and parameter measurement is extensive (more than 100 parameters measured in each test). Detailed thermal data are obtained (understanding coolant temperature at all points of the engine). The second reviewer said that there may be already in place but getting real evaluation methods from OEM's and creating a number of evaluations against varying evaluation protocols would provide a greater value to industry.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer remarked fuel economy results were obtained that compared a 2010 Prius versus the 2004 version. Among the notable differences: there is a significant improvement in "engine off" time in 2010 version in the city. The reviewer also said that cold start strategy features controlled fuel flow rate during warm up (not warming up as quickly as possible, but as efficiently as possible). Another feature evaluated is the coolant warm-up using exhaust heat. They also noted that the project evaluated usage of exhaust gas recirculation (EGR) valve, traction motor characterization, and generator characterization. They noted that obtaining data that can provide insight into brake blending strategy. Sounds like this will be given more attention in the future. The reviewer stated that testing showed battery de-rate versus temperature. The reviewer concluded that such detailed testing as this can provide invaluable information to both OEM's and component system suppliers. The data help to define duty cycles, operating requirements, and effects of component or system design on fuel efficiency. The reviewer said that this kind of detailed understanding is an enabler for initiatives to improve performance while lowering cost. The second reviewer said that the project is still learning but on a good track and felt that outcomes so far are very good.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer noted that collaborations include: (1) Advanced Vehicle Testing Activities with INL and DOE, (2) SAE (testing procedure development), (3) Cooperation on DOE technology evaluation requests, with NREL, ORNL, and INL, (4) United States Council for Automotive Research (USCAR) and OEM's (sharing of test plans, data and analysis), (5) Developers of Autonomie (also located at Argonne). The reviewer felt that the extent to which data are reviewed with OEM's is not completely understood. This reviewer strongly encourages Argonne to work closely with OEM's as a means of fostering and accelerating identification and implementation of improvement opportunities. The second reviewer said that the project provides great to support internal DOE initiatives like Autonomy, but is not really sure how good the industry collaborations are.

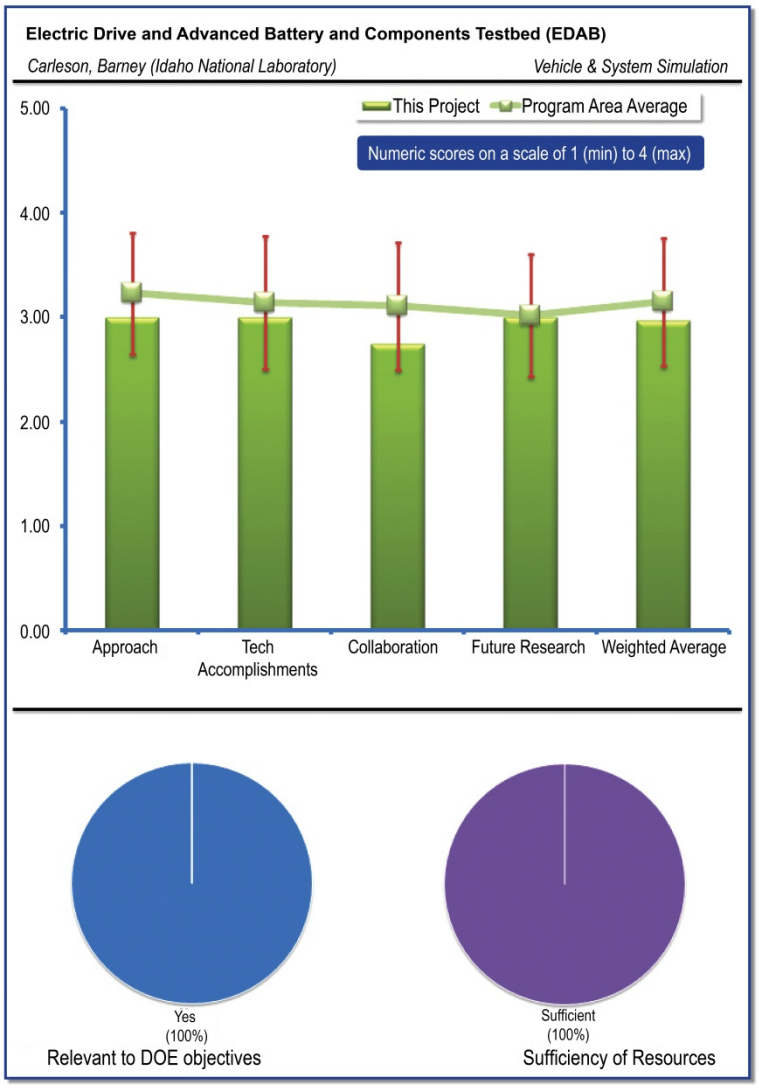
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer said that short term projected activity is to continue Prius evaluation, including hot and cold temperature performance. Upcoming work includes Level 2 evaluations of the Volkswagen Jetta, Hyundai Sonata, Chevy Volt (2011).The reviewer pointed out that the means of selecting vehicle candidates for evaluation was not provided in the presentation and the project should consider providing information on this process in the future. The second reviewer felt that adding more vehicles will solidify the approach and add to outcomes.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer commented that resources appear to be adequate for planned testing and that the lab facilities and technical expertise at the Argonne Labs appears to be outstanding. The reviewer felt that the labs are very well equipped to handle this comprehensive Level 2 vehicle testing. The second reviewer said that from what is being done, the project may need more resources to expand collaborations. The third reviewer pointed out that 5-cycle testing will require more resources, and that it is important to evaluate hot and cold performance for advanced vehicles. This reviewer felt that data and testing from APRF supports many other important areas, including standards.

Electric Drive and Advanced Battery and Components Testbed (EDAB): Carleson, Barney (Idaho National Laboratory) – vss033



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally saw that the project directly support DOE objectives. The first reviewer commented that testing energy storage systems (ESS) in realistic environments will help identify and resolve ESS performance, reliability, and durability issues to facilitate deployment of petroleum-displacing PHEVs and EVs. The second reviewer commented that battery technology is essential to successful implementation of electric drive vehicles on a broad commercial scale. While advances are being continually made, much still needs to be understood about the way various battery technologies behave under different driving and environmental conditions. This reviewer felt that in order to further develop battery technologies, prioritize resource allocation for R&D, and gain additional insights it is important to have a reliable base of real-world performance data from a broad cross section of advanced battery technologies. Similar to the first two reviewers the third reviewer said that hybrid electric and electric vehicles are often discussed as one way to reduce petroleum consumption and energy storage systems represent a major technological hurdle to be overcome if EVs and HEVs are to more widely penetrate the market. This reviewer felt that the project's efforts to understand how energy storage systems are used and the impacts this has on the systems directly support the overall goal of petroleum displacement. The fourth reviewer points out that this presentation covers two projects - Electric Drive and Advanced Battery and Components Testbed (EDAB), and Baseline Testing and Fleet Data Collection and Analysis of USPS eLLV (2nd project). This reviewer said that the score is only for EDAB but the comments cover both projects. If possible, the reviewer recommends against having two projects in one presentation in the future. The reviewer realizes that both projects needed review and there was probably only one timeslot. For EDAB, the fourth reviewer felt that industry and users need to know how electric vehicles and their storage systems perform to see how designs can be improved. For the USPS eLLV project the reviewer said that on-road testing is needed to see how various designs perform in real world conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated the project is developing an energy storage system (ESS) test "mule" vehicle and is focused on small blended "advanced" (i.e., - not yet commercially available) PHEV batteries to full-size EV batteries; not smaller batteries for mild hybrids. They also stated that the project is unseeing combination of chassis dynamometer, lab, and on-road testing. The reviewer wondered if it is premature to test all sorts of exploratory ESSs on-road and that perhaps it would be more effective to screen them first with hardware-in-the-loop testing in a more controlled (lab) environment. This reviewer felt that it was unclear if that has already been

done, or is being done separately. The first reviewer also mentioned that they did not hear a discussion of how the one ESS to be tested first was selected and that it is a topic reviewers might have liked to review and comment on, but in general, the level of detail of this presentation was a bit thin. The second reviewer also said that the presentation was in two parts: (1) one related to development of a battery test bed and (2) the other related to the data collection from a USPS fleet. The bulk of this will focus a little more on the first. For the EDAB project the second reviewer was not completely sure if a mule vehicle is really the best use of DOE's time/funds. The reviewer felt that building a mule is what OEMs do best and a dedicated hardware in the loop testing center is more what they would expect out of a National Labs. The second reviewer elaborated by saying that the addition of "real world" conditions is nice, but they did not know the value of one set of conditions, such as vibration seen in a custom configuration (which is not likely to be duplicated) and thermals seen with custom configuration in one environment. The reviewer recommends that perhaps additional instrumentation could be added to vehicles INL tests under other projects and that the collected data could be used to drive lab cycles (no need for mule vehicle). The second reviewer also commented that given the requirement of a vehicular test bed, the series electric seems a reasonable design decision. For the EDAB project, the third reviewer felt that this part of the project is needed to characterize the ESS. The reviewer recommended that the project may want to consider more than 3 years or 100K miles for end of the 1st life and asked, what is end of life criterion? While 30% was mentioned as a reason for 3 years or 100K miles the reviewer felt that it should be checked that the packs really have lost 30% at 3 years or 100K. The reviewer remarked that the packs may not have degraded that much and so could be tested longer if budget allows. The third reviewer said that the test cycle used is a valid cycle and noted that the environment will definitely factor into how the packs perform. The fourth reviewer said that the approach is sound, encompassing three overall components including chassis dynamometer testing, energy storage system testing in the Laboratory, and on road testing. They feel a good decision was made to base the ESS testing pattern on trends determined from previous PHEV household fleet data. A reviewer also said that it is confusing for reviewers to review the on-road USPS long-life vehicle (LLV) testing together with the EDAB mule vehicle. It seems this reviewer that the EDAB mule vehicle is different enough that it should have been the main focus of this presentation. For the second USPS project the third reviewer commented that the data for how ESS will perform is important to the learning gained from this project. The reviewer felt that the fact sheets are a good overview of the whole vehicle but hopefully there is more battery use data being given back to the companies that made each vehicle and to the public where allowed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that the "First" ESS to be tested has been selected and purchased and the ESS control system developed. They also noted that the EDAB mule vehicle conversion nearing completion. One reviewer felt that the program seems to be on track. While the second reviewer felt that appropriate progress is being made for this stage of the work. The second reviewer stated that actual ESS testing needs to begin in July in order for significant results to be achieved before the end of the year. For the second USPS project, the second reviewer commented that it is good to look at charging effectiveness as this project is doing. The third reviewer said that technical progress has been good based on a FY10 project start date. The reviewer elaborates that the principal value of the project is that it provides in-depth real world information encompassing effects of vibration, temperature extremes, stop/start conditions and so fourth into the analysis of energy storage systems.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers saw a high-level of collaboration, and also suggested additional collaborators. One reviewer felt that the project team consisting of INL, ECOtality, ORNL, and AVL is certainly capable, but feels the project could be more effective if there was collaboration with battery manufacturers, component suppliers, and/or vehicle OEMs. Similarly, another reviewer felt that AVL and ORNL are good choices, but that it would be nice to see some more collaboration with potential end-users of this data (e.g., those modeling or designing the systems which will be tested). The third reviewer also commented that it should be examined who can use data from the ESS's and how it can be broadcast to those interested (keeping confidentiality where necessary). Another reviewer sated that the level of collaboration is largely reasonable and appropriate for this task. It included ECOtality for testing, ORNL for control system development, and AVL for vehicle integration. The reviewer questioned if any coordination with ANL or NREL would be in order and appropriate. Another reviewer remarked that getting five vehicles out of this project for the budget allotted is a good value. For the second USPS project, a reviewer commented that there is good coordination with an energy storage group that will facilitate the use of the packs in a 2nd life.

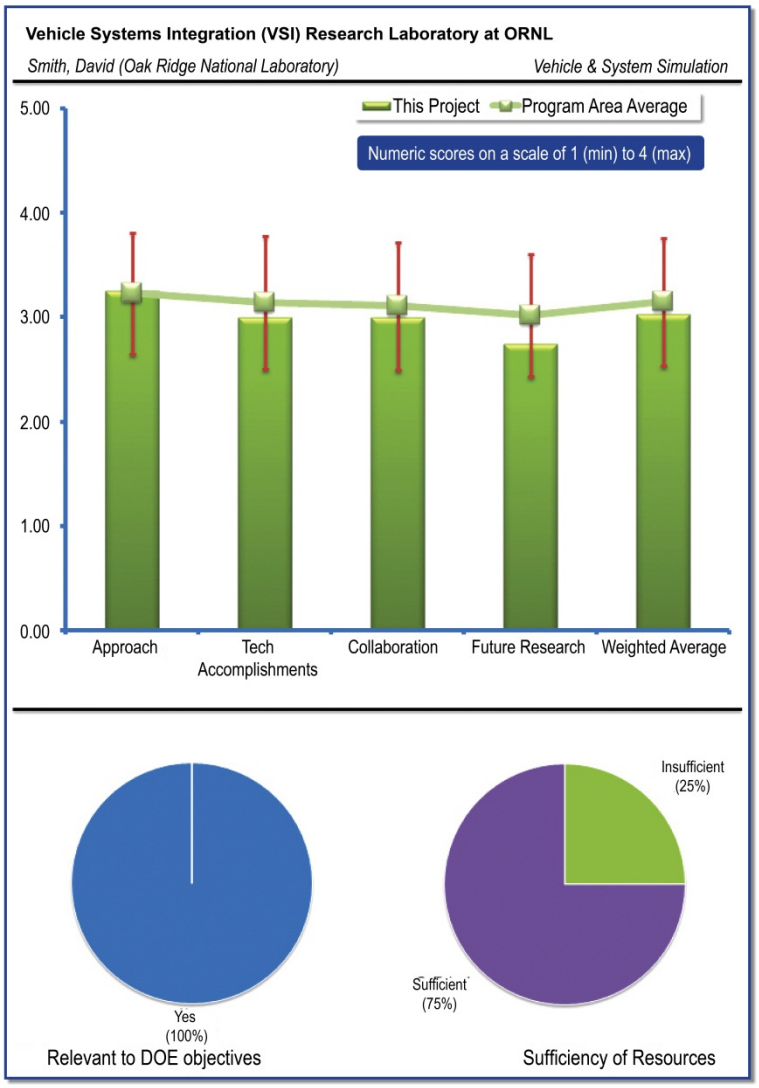
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer commented that tracking of temperature with battery performance and life will be valuable and that for all the testing recommended, some 2012 budget would likely be necessary. Another reviewer said that sufficient information was provided on future work activities. Another reviewer was not completely convinced that a specialty vehicle is the best approach for "real world" data, as opposed to instrumenting a number of actual vehicles and then using the data to drive test cycles on variety of battery packs, so the reviewer is not convinced that four specialty vehicles are needed. A third reviewer said that sufficient information is provided on future work activities including testing various energy storage systems with various chemistries, testing of a variety of motor and power electronics technologies, as well the potential build of 2-4 additional test platforms to build after successfully demonstrating on-road testing capabilities and flexibilities of the current prototype. For the second USPS project the data for one year will be good on the postal vehicles but data for 2 or 3 years as packs could perform differently long term would be better.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer felt that both projects will likely require funding in 2012. Similarly a second reviewer commented that the EDAB project may need funding in 2012 to complete testing and the second USPS project would benefit from longer term data on the ESS's than just 1 year. This reviewer felt that the USPS project should not need too much to continue testing - just resources to download and examine the data and possibly for maintenance. A third reviewer stated that resources appear sufficient for this task.

Vehicle Systems Integration (VSI) Research Laboratory at ORNL: Smith, David (Oak Ridge National Laboratory) – vss035



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said that this new facility described will bring state of the art testing capability for MD and HD trucks, which are very much needed. Another reviewer remarked that testing facilities that can support heavy duty powertrains are in short supply and having a good facility will help development efforts bringing better technologies to the market in less time. The third reviewer felt that the facility will provide the ability to understand integration effects of various technologies.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer likes the expandable facility concept. The second reviewer said the lab seems to be a nice facility, including two dynamometers which can offer very large total torque capability when joined. The third reviewer pointed out that the facility is behind schedule and now expected to be commissioned in about a year.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer pointed out that the project seems to be a little behind schedule, but breaking ground and getting construction started is a real and significant step. The reviewer felt that the net summary for this project as a whole would seem to be that it will be a useful facility and construction is underway, albeit slightly behind schedule. The second reviewer said that the design of the site is good and constrained by funding and other limitations.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer pointed out that the facility already has one commercial system scheduled for testing. Another reviewer commented that there is not a lot of collaboration right now and that they only have one industry partner lined up.

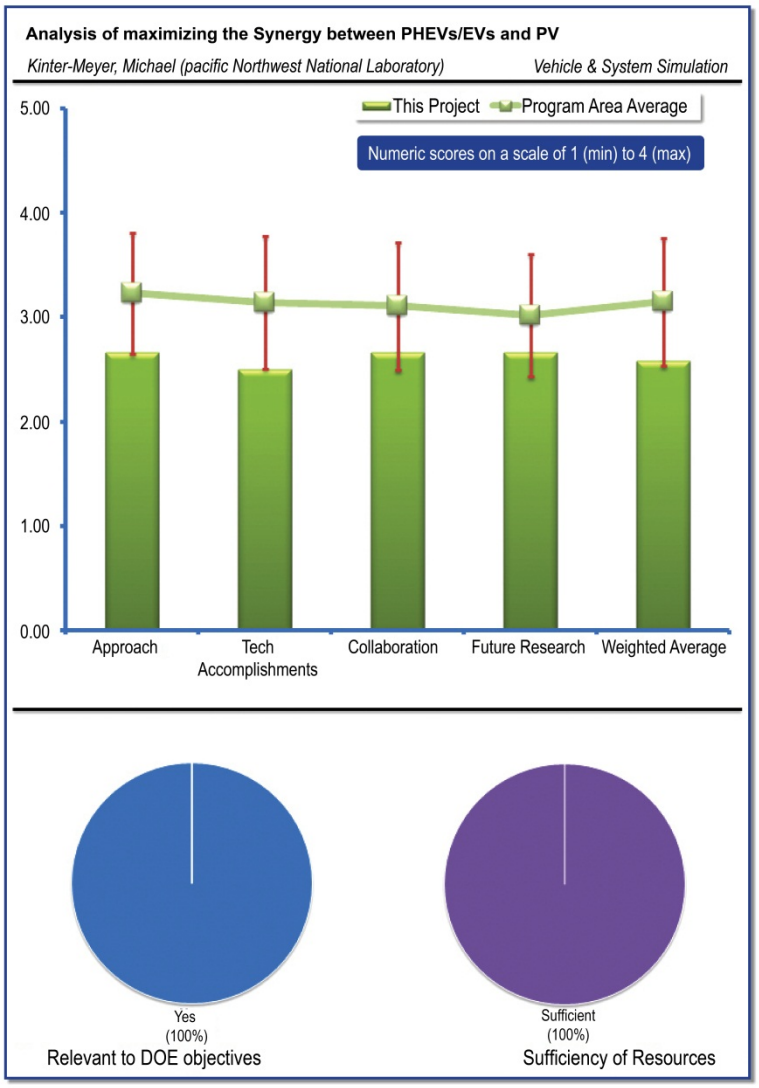
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said that it is hard to say much about this, the facility is still under construction and will likely be in construction or development for a portion of next year. A second reviewer elaborated by stating that the facility needs to be built and commissioned before future work can be solicited and planned.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer again pointed out that things seem to be a little behind schedule. Another reviewer viewed the schedule lag as an indicator of insufficient resources.

Analysis of maximizing the Synergy between PHEVs/EVs and PV: Kinter-Meyer, Michael (Pacific Northwest National Laboratory) – vss036



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer commented that PEVs and renewable energy have a strong synergistic potential to reduce petroleum consumption in the transportation sector. Advances in one area can enable further advances in the other. In order to capitalize on these opportunities, close coordination, communication, and harmony needs to be achieved between the demand scenarios of PEVs and supply profiles of renewable energy sources. The reviewer pointed out that the project is focused on the effectiveness of PEVs providing grid services as a function of public/private charging, as well as determining the market value of grid services that can be captured.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer pointed out that the technical approach explained in detail what needs to be done, but there is not a lot of information on how this will be done. Another reviewer remarked that this task is largely focused on the synergistic opportunities of coupling solar photovoltaic (PV) electricity generation with plug-in electric vehicle demand and that it will follow essentially the same approach previously conducted for wind energy by Pacific Northwest National Laboratory (PNNL). This targets overlaying solar insolation profiles onto vehicle driving patterns to determine the number of PEVs required to meet balancing services for grid friendly charging strategies, including as a function of public/private recharging stations.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two reviewers noted that the project has not yet started and it is a new start for FY11. It was not clear what rating should be given.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said that based on proposed plan it looks OK. This reviewer questioned, should collaborators include utility companies as well? A second reviewer stated that collaboration exists with NREL for PV arrays and plug-in electric vehicle (PEV) charging with smart charger controller and that collaboration also exists within PNNL with the Environmental Molecular Sciences Lab. The second reviewer said that it would be beneficial to broaden collaborative efforts to utilities and industry to gain additional insights, understanding of industry thinking and direction, and potentially lead to cost-sharing should concepts emanating from this project prove to be attractive.

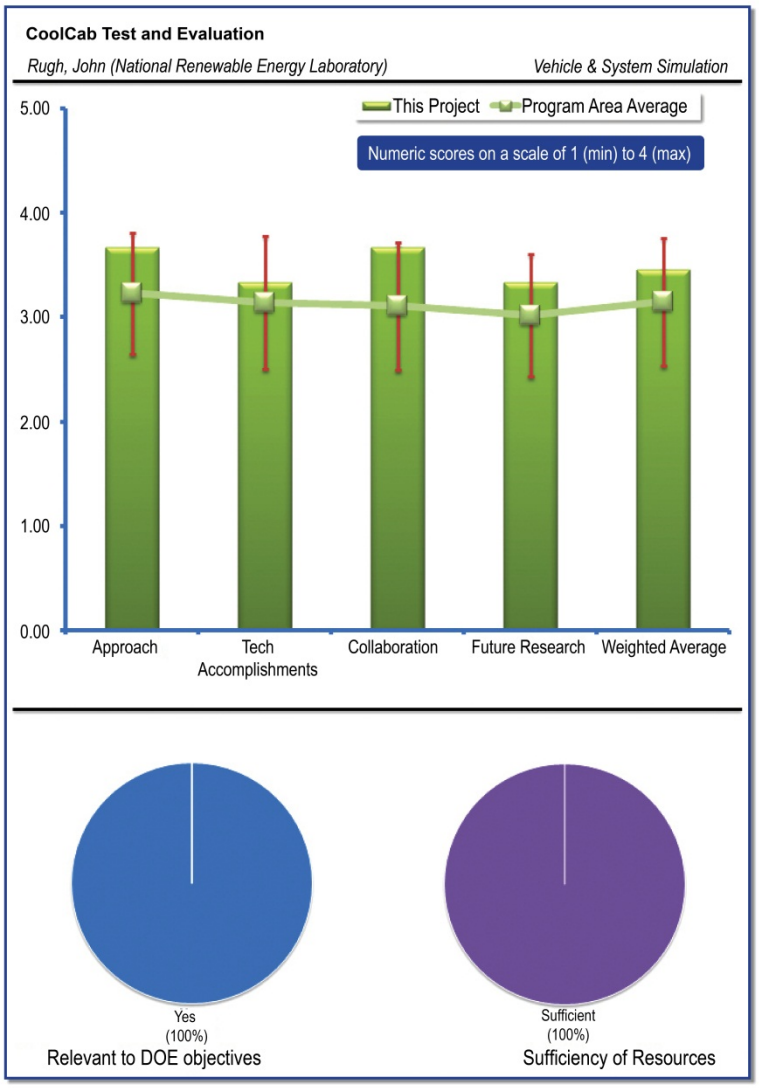
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer commented that it is a relatively short duration project. They felt that a time line of activities would help in understanding the scope of the work involved. Another reviewer said the proposed future research is somewhat undefined but appears to focus on concept demonstration in FY12. It would be beneficial to get industry involved in FY11 as a precursor to an FY12 demonstration.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Based on one reviewer's understanding of the proposed work, it should be sufficient. Another reviewer said resources are sufficient for this task, especially as it is largely a follow-on to a very similar effort with wind energy.

CoolCab Test and Evaluation: Rugh, John (National Renewable Energy Laboratory) – vss037



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer said that the project had an excellent approach to a very big problem of cabin temp control. A second reviewer stated that idle reduction saves fuel. Another reviewer felt that the project was relevant; however, more detailed fuel saving data must be presented.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer commented that the projects estimation of potential 30% reduction in idle fuel use by providing tools for design evaluation of alternative technologies fills a gap in the engineering process. This reviewer felt that this is an excellent way to attack the problem on a systematic basis.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer commented that how to take the tool to the next steps was shown to be clearly understood and that the collaboration with vehicle producers will enable early adoption and ongoing use.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said this certainly seemed like it is a well-coordinated effort with industry and the Autonomy group.

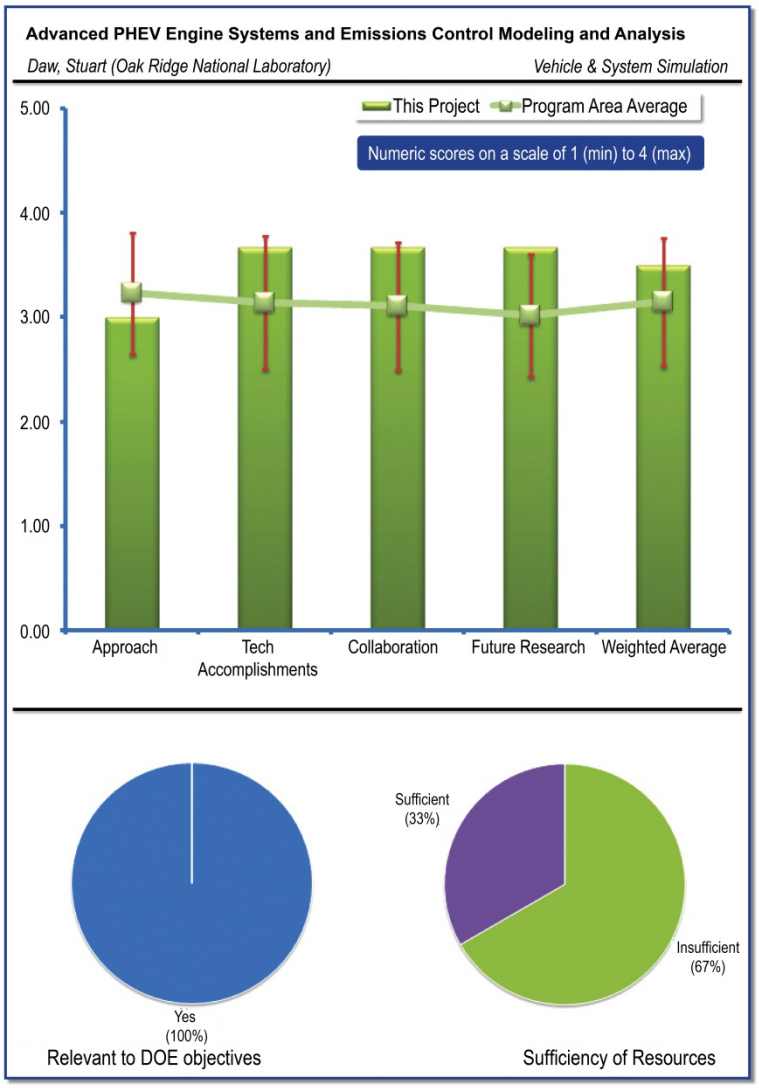
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer expressed that this project is a logical extension of current work and coordinated with the industry partners.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

A reviewer said that the development to the next level may require more resources.

Advanced PHEV Engine Systems and Emissions Control Modeling and Analysis: Daw, Stuart (Oak Ridge National Laboratory) – vss041



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that this project is definitely relative. They elaborated by saying modeling of powertrain emissions directly supports the development of high-efficiency powertrains. A second reviewer said the project is emissions related but to the extent it enables hybrids to meet emissions laws, it furthers the use of fuel saving hybrids. A third reviewer agreed by saying that topics are highly relevant to DOE objectives and enabling development in the industry. Publication to industry is understood to be essential.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that modeling transients is critical for PHEVs and HEVs that routinely operate their engines in start-stop modes. The reviewer said that emphasizing component models rather than maps along with low-order model can allow exploration of more concepts and tradeoffs within available time and project resources. The reviewer also remarked that promising concepts identified with the low-order model should then be verified with higher-order modeling. Furthermore the reviewer said that the project has been going for six years and finish is listed as "ongoing". The reviewer can believe there is still significant work to do, but is there really no end foreseen for this PHEV engine and emissions modeling effort? The third reviewer said there is still a lot to evaluate for one project. They also said that tying together various programs (as this project does) will help get usable results from the programs involved. Coordination will continue to be very important. The third reviewer said that the premise is that multiple engine on/off will generate higher emissions. The third reviewer questioned how do those emission spikes balance with engine off time when no emissions are generated? A fourth reviewer said that the approach appears very sound and communication of sequence of activity/priorities would be helpful...otherwise it appears as a bit of a shotgun of activity. They understood that this may not be the case, just the appearance.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers saw significant technical accomplishments. The first reviewer said the accomplishments appear extensive and address project objectives. Insulated selective catalytic reduction (SCR) shown to keep temperatures high enough to mitigate impact of cold starts, though it may accelerate aging. They also pointed out that the diesel oxidation catalyst (DOC) model appears to be closely predictive of actual component performance, as does cold-start three-way catalyst (TWC) model and data. The first reviewer also

commented on linking component models together to simulate aftertreatment systems. The second reviewer said that the transient hybrid drive cycle simulation results have been accepted for publication. Multiple entities should be able to use them. The second reviewer felt it would be good to know the tradeoff between start/stop emissions and keeping the engine running. A third reviewer remarked that significant results and publications have occurred given the funding level.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that there were extensive collaborations with appropriate contributors and stakeholders. A second reviewer said that there is a lot of info coming into the project and then needs to be assimilated into the project results. The third reviewer said the results look to mostly be used by Arvin. The third reviewer also asked if there other companies that could benefit from the results, and how can the results be brought to them? The fourth reviewer said that major collaborations are obviously in place, both within national labs and industry. The fourth reviewer questioned if there were any comments back from industry on relevance and alignment with future work priorities?

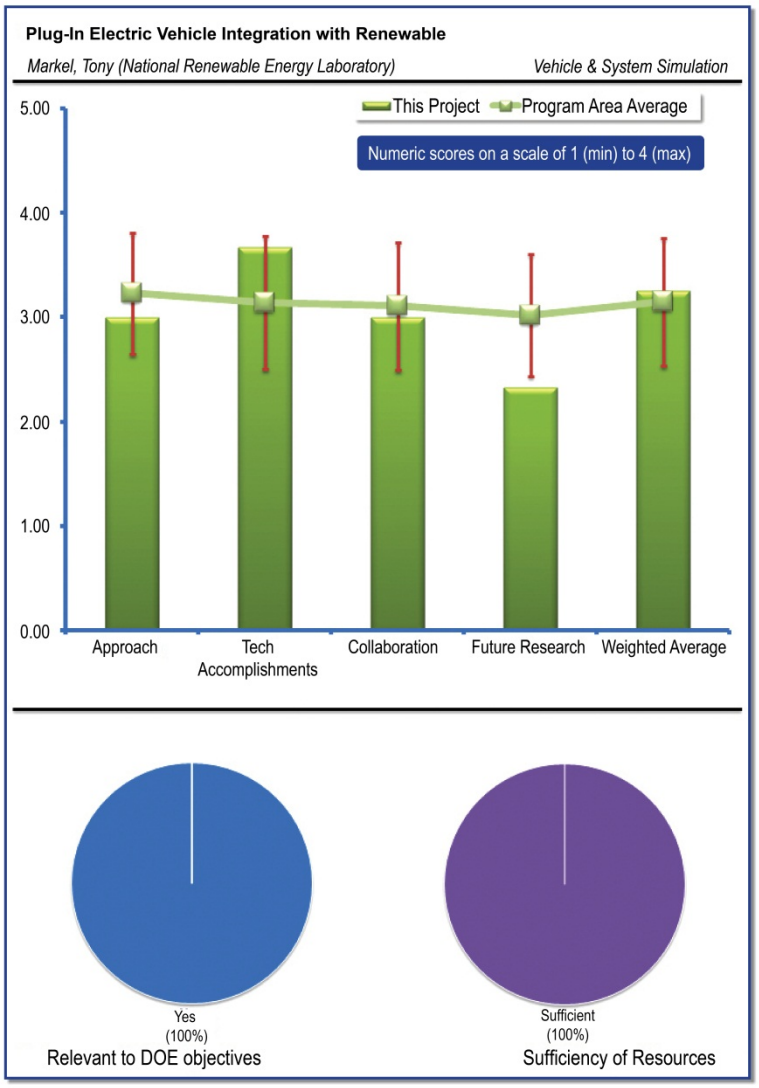
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the presenter stated that this task will end this FY and the results will be migrated; the reviewer did not catch where they will be migrated to. Consequently, many of the "future activities" cited on the slide will not occur. Notwithstanding that, future modeling efforts should probably examine effects of using up to E15 fuel in gasoline engines, as is currently under consideration for nationwide approval. A second reviewer felt that it will be good to get the models into Autonomie for use by the Autonomie user community. A third reviewer said that the project had a good list of future activities and appreciate the comment of PRIORITIZED by category.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer felt that this work appears very important and effective, yet resources shrank every year. The second reviewer commented that there still seems like a fair amount of work to be completed before the project is wrapped up this year. A third reviewer said that the project team has demonstrated successfully managing scope based on funding received. Will threshold future activities based on priority and funding level.

Plug-In Electric Vehicle Integration with Renewables: Markel, Tony (National Renewable Energy Laboratory) – vss042



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said that there is a high relevance to DOE objectives for integration to grid and potential load-leveling strategies through 2-way communications. A second reviewer said that the PEVs and renewable energy offer synergistic opportunities to reduce petroleum consumption in the vehicular sector. According to the second reviewer, working together, PEVs and renewable energy can help lower barriers to acceptance of respective technologies as they play to each other's strengths. This task aims to help with integration and synergistic growth between PEV's and renewable energy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer questioned, Does the approach makes the work visible to industry and utilities directly? The reviewer felt that it was not obvious if progress/observations are distributed...last publication noted was one year ago at an MIT conference. The second reviewer said the objective is pretty clear: to identify opportunities for alternative value streams for PEVs through integration with renewables and support the definition of the infrastructure needed to enable these opportunities. The second reviewer felt the approach is reasonable within the overall objective framework of the project, but would be improved if it were more structured and quantitatively defined. Additionally, it may be beneficial to further assess the appropriate role for a National Lab (whether it be that of an integrator, convener, facilitator etc.) for the development of the concept of a "green signal".

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that based on stated objectives, very good progress has been made. A second reviewer said accomplishments appear to match plan. Noted participation in industry standards development (via SAE) is KEY! The second reviewer suggested referencing the publication frequency question in the Approach section. A third reviewer said that there has been solid progress specifically with regards to literature review and assessment, as well as published results of communication analysis scenarios. Delivery of the definition of "Green Signal" for charge and discharge management of PEVs is due in FY11. The third reviewer also commented that it would be beneficial if the project had quantified milestones within the context of the overall project objective.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said that the industry standards and National Labs were noted. The reviewer questioned direct connection to utilities (e.g., via the Electric Power Research Institute [EPRI]) and smart charger industry (e.g., General Electric)? A second reviewer said this project is collaborating with PNNL, SAE, and the NREL strategic energy analysis and distributed energy integration groups. They felt it may be beneficial to also include other industry and utility entities in collaboration on the "Green Signal". The concept of a "green signal" impacts multiple parties and the sooner everyone is brought on board the better.

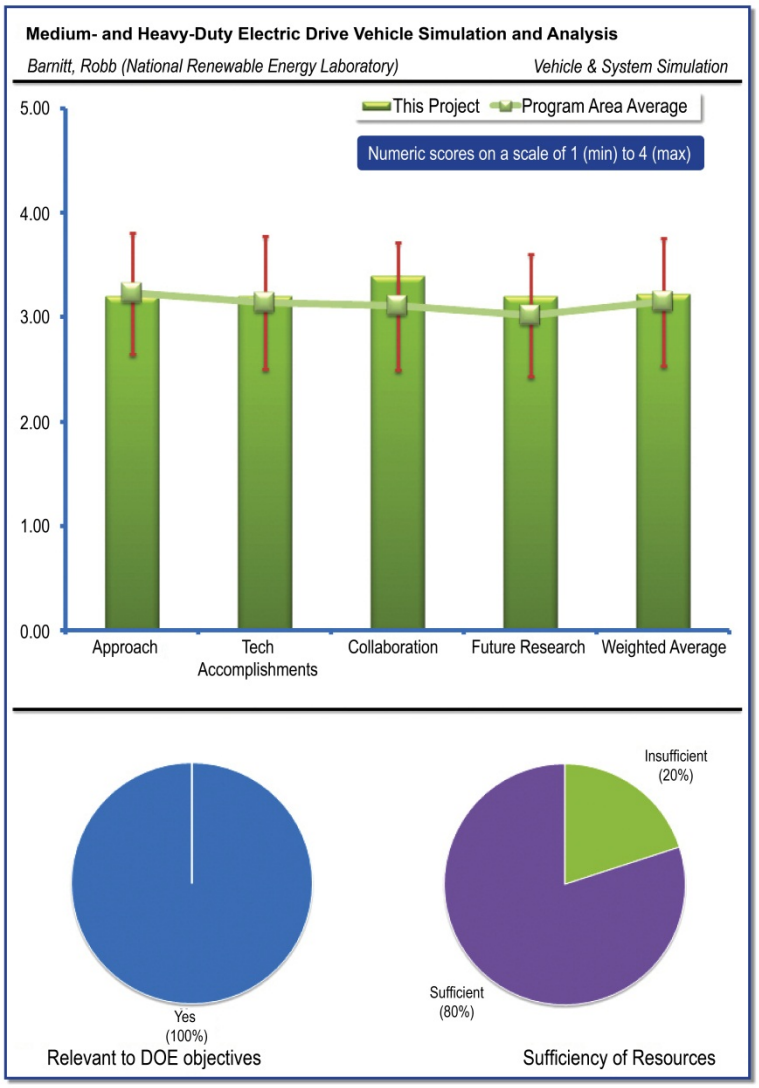
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer said that nothing has been proposed, not clear what the rating should be. A second reviewer agreed, stating that the project was thin on description here as to what is intended to be done next, such as what is project specific barriers to address next. The third reviewer said that plans for FY12 include implementation of a field demonstration and analysis of results. Ostensibly, NREL is underway planning with an industry partner in this endeavor.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that there are no budget disconnects apparent from description. A second reviewer said that the financial resources appear roughly appropriate for the scope of this task.

Medium- and Heavy-Duty Electric Drive Vehicle Simulation and Analysis: Barnitt, Robb (National Renewable Energy Laboratory) - vss043



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer remarked that this is a good project topic with clear potential to positively (or negatively) influence fleet adoption of more efficient/petroleum displacing vehicles. They felt it was nice to see a medium duty project since this sector does not get that much attention. A second reviewer said that the project addresses questions pertaining to plug-in hybrid technology for an important vehicle segment, medium and heavy trucks. A third reviewer commented that the project is highly relevant analysis for industry consideration in matching applications to drive cycles. A fourth reviewer said that the methodologies to address industry and end-user expected benefit is extremely valuable to accelerate acceptance and deployment of PHEV vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said the overall approach looks good; however, there are concerns with the lack of grade information in the drive cycle. Grade imposes a higher demand on the battery output, and also allows for more regen during coast, and essentially changes the battery charge-discharge behavior. It may also change the trade-offs that are arrived at, based on drive cycles that do not involve grades. Another reviewer said that the simulation based approach with significant physical test data to build/correlate models should provide a very robust and defendable solution. Interesting "intensity" analysis approach for comparing driving cycles – it is absolutely correct to focus heavily on the driving cycle as this has a tremendous influence on whether technologies make commercial sense for a particular application. This reviewer felt that perhaps the commercial assumptions around future pricing for motors/batteries etc. could be developed in more detail - these will have a big impact on commercial viability, and they believe the government has invested more heavily in modeling/predictions of these items that has been adopted so far in this project. A third reviewer said that among the strengths are model validation with experimental measurements using the FedEx vehicle and the usage of a set of diverse driving cycles in the analysis. Also, the approach to considering battery and fuel cost support the main objective of providing the guidance to the MD and HD sector. The third reviewer felt that the weakness is a relatively crude battery modeling with two arbitrary selected max power levels. A fourth reviewer remarked that there was a good sequence of combining real-world data, dynamometer data and correlating analytical tools for broader use case application. Title including "Heavy-Duty" seems confusing with specifically medium duty package delivery being current scope. The fourth reviewer also felt that the questions asked in Project Relevance section also seem broader than intended activities would address (e.g., warranty implications). The fifth reviewer commented that utilizing "real" drive cycle data as model data input is an excellent approach. It would have been useful to conduct parametric studies of model assumption to assess different scenarios, e.g.,

increase in battery power density, varying cost of electricity, etc.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer said that the results of the research have allowed a better understanding of economics of electric drive vehicles and the relation to the drive cycle. It would be good if the grade information could be incorporated. A second reviewer commented that the project appears to have achieved significant amounts of progress within relatively limited funding limitations. The third reviewer said that the analysis of the fuel and ESS cost for the FedEx vehicle, for a set of daily distances and various PHEV system configurations, has been completed, and that is good. However, it is hard to judge the rate of progress since the planned timeline was not available to them. The milestone of publishing one paper is not sufficient for judging progress. The third reviewer did note that plans for future include a much more extensive list of tasks. A fourth reviewer simply stated that there were good and clear presentation of results. The fifth reviewer said that the model results provided a very valuable tool to assess long-term (15 years) economic input. As stated above, a parametric study of model assumption would have strengthened the results.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said that there are great partners, particularly the fleet partner who will be able to implement recommendations. A second reviewer also felt that there was a good selection of partners. The third reviewer remarked that the collaboration with direct participants is good. To gain perspective on the OEM questions (and approach to answer), perhaps an OEM should be a collaborator. Another reviewer said that the collaboration with FedEx to acquire "real" drive cycle data was extremely valuable.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said it may be worthwhile to explore the CARLOS “real world” cycle that was developed by a consortium of auto companies and suppliers in Europe to represent passenger car and truck usage. While this is meant primarily for durability studies, it should be applicable for fuel economy studies as well, especially if it is truly designed to represent “real world”. A second reviewer said that the reporting out of the currently available findings and recommendations was quite confusing - in order to meet DOE's aim of displacing petroleum, the results and recommendations will have to be clearly and concisely described for fleet customers to interpret and be able to make purchasing decisions. Reviewer three would be keen to see a very clear message that could be presented at commercial truck conventions to fleet owners, as well as to product developers. It appears that there are already enough data available to tell this story, although the future planned effort certainly will help mature the fidelity of the results. This reviewer said that if the results are not easy to interpret in these types of forums, the government may consider implementing a “fleet advisory service” to meet with fleet owners and review their drive cycles against the data results to provide them one-on-one guidance for various investment scenarios. If budget can be found for this it could be a great method to accelerate adoption in the right areas so that fleets find good financial return on investment and implement wider adoption. A third reviewer said that the proposed future task form an extensive list, and answers will be relevant to the MD and HD sector. The equality of results will depend on some of the new models, such as the battery life model. Real-world driving is also important. The fourth reviewer remarked that the proposed future work is specific and seems a logic extension of current results.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that good progress seems to have been made, although the split of task completion over time was not clear in the briefing. Another reviewer said that the funding level is not excessive, but increase for FY11 is not explained. A third reviewer said that the budget appears light to wrap up project with intended future work scope in FY11. This reviewer questioned, perhaps future work partially spills into a future request for FY12?

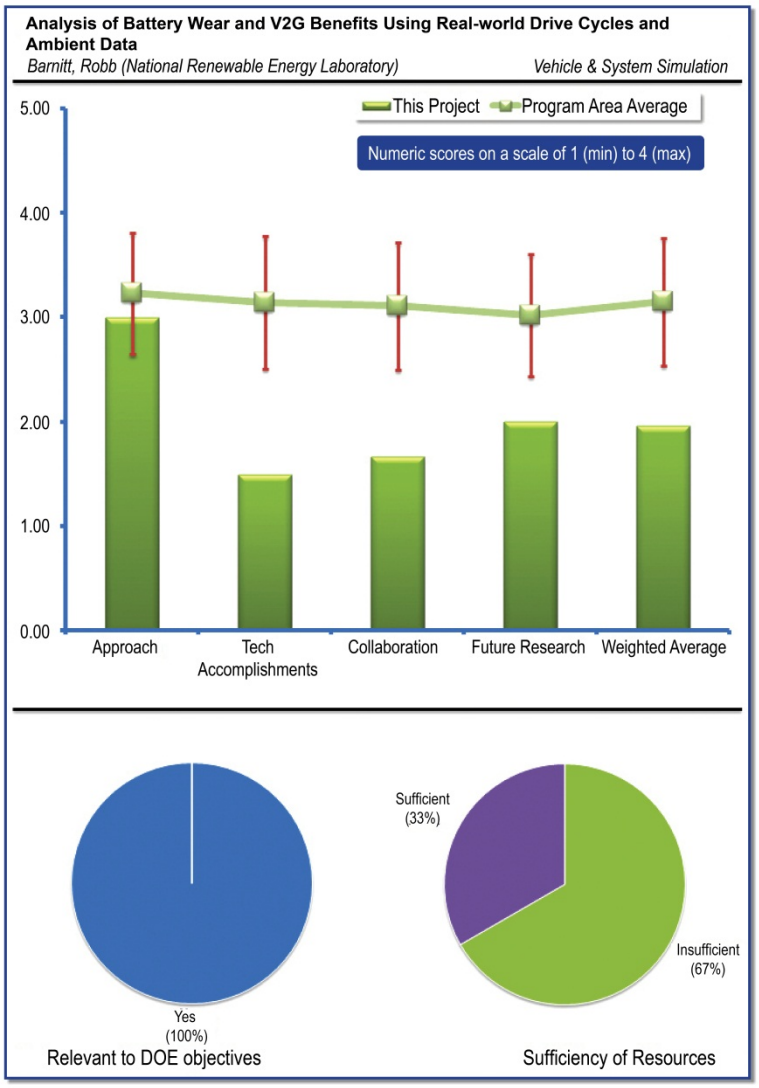
Analysis of Battery Wear and V2G Benefits Using Real-world Drive Cycles and Ambient Data: Barnitt, Robb (National Renewable Energy Laboratory) – vss044

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers were generally of the opinion that the project supports DOE objectives. The first reviewer said the potential for saving fuel, especially when the drive cycles are repeating (as in school bus routes) is quite significant, and this project addresses some of the ways of achieving this. Another reviewer said that ambient temperature effects on battery wear/life is a major industry commercial risk element, thus a clear barrier to faster adoption of EVs/PEVs. A third reviewer felt that the plug-in electric vehicles offer the potential to displace significant amounts of petroleum. The principal barriers to plug-ins are range and cost which are largely governed by battery technology. The third reviewer said that these challenges can be mitigated somewhat through improved battery life and vehicle battery applications in support of peak grid demands. A better understanding of factors determining battery life (operating and ambient temperature) and exploration of vehicle-to-grid applications for vehicular batteries can lower life cycle cost barriers.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

In general, the first reviewer felt the approach that is being used to evaluate battery life etc., is good. An issue that appears in all of the projects that involve simulating "real world" cycles is the lack of grade information in the drive cycle. Grade imposes a higher demand on the battery output, and also allows for more regen during coast, and essentially changes the battery charge-discharge behavior. However, the reviewer felt that it looks like incorporating grade information in the description of the real world drive cycles is a much harder task that they imagined, because of unreliable GPS elevation data and several other issues. Another reviewer said that the approach is sound for scope of project. A third reviewer remarked that the objective of this project is to ascertain holistically the value/utility of large energy capacity PEV school buses with usage profiles that may be conducive to vehicle-to-grid services. The third reviewer notated that this project follows a three layer approach: (1) Use of an existing NREL simulation tool determining battery life as a function of depth of discharge, temperature, and voltage, (2) Overlaying ambient temperature profiles, (3) Followed by overlaying driving and vehicle-to-grid usage profiles. This reviewer felt that the focus of this task should be more narrow and targeted such as focusing on a specific PEV school bus application in a targeted area that is fertile and has qualified industry and fleet partners and attractive local vehicle-to-grid applications. The overall approach is too broad and diffuse and has no upfront industry/commercial/private sector pull.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer said they cannot say much here, since no funds have been allocated. This reviewer was unsure if a fair rating is appropriate either. Two other reviewers noted that this is a new start project and the question is not applicable, the funding only recently confirmed.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer said that the presentation does not list any collaborators, though this could very well be because of a lack of funding. This reviewer also mentioned that on the lack of road grade data that was discussed earlier in the presentation, they will look into it at their company and see if it can offer any ways of measuring the relative elevation changes. This reviewer felt that is should help make the "real world" cycles more real. The second reviewer said that no collaboration was noted outside NREL; however, short term of project may be reason for less collaboration. Seems this project would have a battery supplier involved (and possibly EPRI?). A third reviewer felt that this project is currently only coordinating with other NREL activities including the NREL energy storage team and electric vehicle grid integration team. As alluded to under question two, this effort should be working upfront with several local fleets, industry, and utility partners to maximize synergies, and to ensure that project objectives are salient, and the approach and results are useful for the private and public sectors.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said that since nothing has actually been accomplished yet, this reviewer assumes that everything outlined in the presentation is actually future work. The approach looks good. The second reviewer said that this question was not applicable as the current work is still being planned and aligned to budget, there was no future work framed. A third reviewer said that in discussions with the Principal Investigator, future work is to include climate control studies, which may be apropos given the significant impact of ancillary loads on PEV range, battery discharge profiles and by extension battery life, and ultimately life cycle costs.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated that the PI indicated funded at 50% of scope; re-evaluation of scope and approach required. Another reviewer said that resources are sufficient for the proposed task. If the task is more narrowly defined and targeted, the current resources may be excessive. Another reviewer commented, No funding??

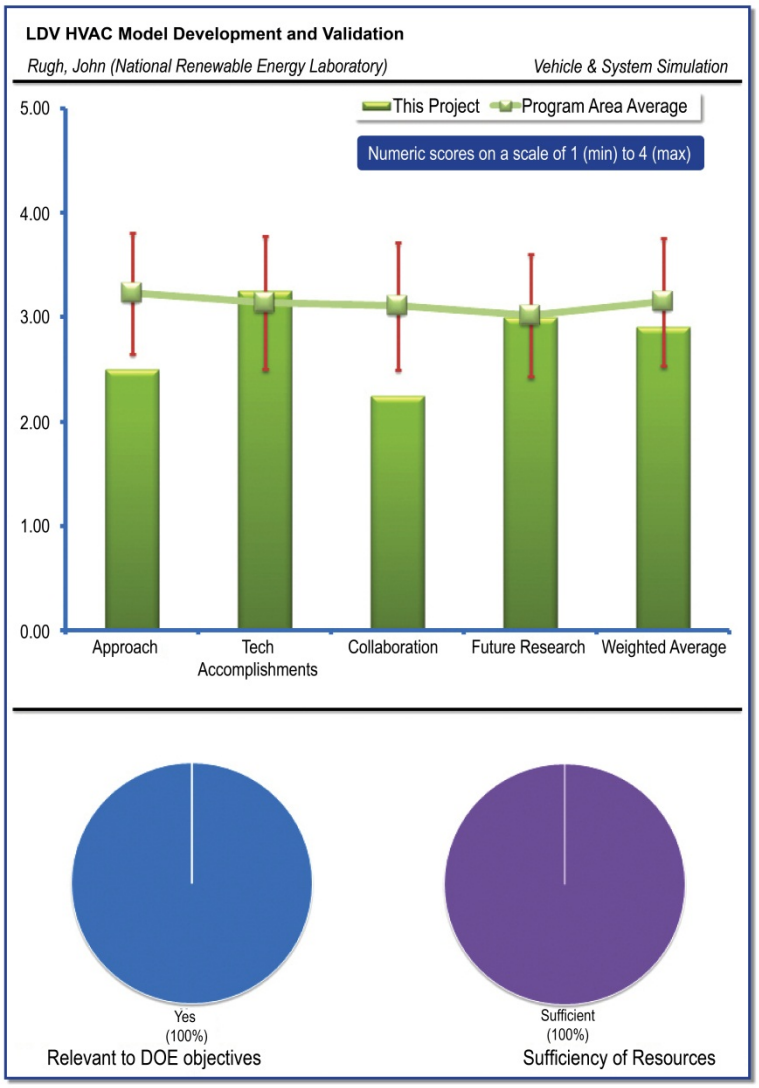
LDV HVAC Model Development and Validation: Rugh, John (National Renewable Energy Laboratory) – vss045

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally saw that the project supported DOE objectives. One reviewer said understanding and reducing HVAC loads, often the largest accessory load, is a key enabler for greater acceptability of battery-dominant vehicles. Another reviewer remarked that air conditioning power demands can substantially affect fuel economy and the range of electric vehicles. Five percent of all fuel consumed by light duty vehicles is attributable to the A/C system operation. This reviewer said that creating a modeling approach that can lead to improvements in the efficiency of air conditioning systems can provide a significant fuel efficiency benefit to all vehicles, but particularly electric vehicles. This program seeks to create a modeling approach and to validate that methodology. The third reviewer stated that HVAC takes a large share of the fuel for light duty and even a sizable part of the HD and MD trucks. Also it drastically affects the fuel efficiency of hybrids. The fourth reviewer commented that it is important to have the Autonomie model available for numerous energy modeling activities. As such a high parasitic loss factor, every modeling activity should account for HVAC losses (both A/C and heater use).



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said that this project builds on previous development of CoolCalc and that there was good attention to detail with including the momentum equation (for the flowing refrigerant) in the model. They also feel that Matlab/Simulink-based HVAC model interfaces with Autonomie, enhancing the model's power and usefulness. 1-D model is probably fine for refrigerant lines; however, it may be an oversimplification for heat exchangers. For example, multiphase flow and cooling fins do not appear to be considered in the model; presumably the cylindrical heat exchanger model elements use an average coefficient for the heat transfer to the air. The "Future Work" slide suggests that validating and "adding detail" to the model may be addressed in FY12. A reviewer asked a good question during the presentation—how does this work not duplicate modeling that Visteon and other AC suppliers or EPA must be doing already? Answer: Integration with Autonomie is new and valuable; NREL is not aware of any EPA models. This reviewer did not find these answers totally convincing. The second reviewer said that Matlab/Simulink will be used to model the A/C system. This makes the model easily interfaced with Autonomie, commonly used for overall vehicle simulations. Compatibility with Autonomie is apparently a primary objective of this program, since it is believed that a number of models already exist for conventional vehicle air conditioning systems. The reviewer stated that components will be modeled and built up to form a complete system and that this model will subsequently be used to build a model for heavy duty vehicles. According to the reviewer, the presentation did not provide

details of the experimental verification of simulation results. This is obviously a key element of the program. A third reviewer felt that the approach of integrating with Autonomie is excellent. It seems like models of HVAC systems should be pre-existing (especially when working with a partner like Visteon), even if they are not in Simulink. Can they not be translated or transferred manually into Simulink? The deriving of the models appears to have taken resources and time. For something like microtubes perhaps new models have to be developed since Visteon is likely not using them. A fourth reviewer felt that the model appears very simplistic versus state-of-the art tools already in use by Tier 1 suppliers and OEMs. Presentation seemed to frame a fundamental vehicle system routinely modeled as if it were leading edge development. The reviewer pointed out that fidelity/usefulness of the model may later be called into question if key decisions on overall vehicle efficiencies or target setting hinges on its use. This reviewer suggests a high level of commenting by HVAC experts at OEMs and suppliers before going too far with this project. The reviewer also pointed out that only A/C is modeled but title of project is HVAC…should heater loop be supplemented to the modeling effort?

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that this is a brand new project this year and is about 25% complete. Progress appears reasonable so far, but noted that none of the modeling has been validated yet, but it is in the future plan. The second reviewer said that the work looks to be on track. The modeling for the system and components is done and now needs to be integrated into Autonomie. While the third reviewer stated that given the approach and framing, sufficient progress seems to have been made to date. The final reviewer commented: (1) Detailed component models developed, (2) Phase Diagrams developed, (3) Conservation equations developed and introduced into simulation, (4) A/C system performance was demonstrated. The reviewer acknowledged that the significance of this simulation is that it will be compatible with Autonomie program, which is used extensively to simulate advanced vehicles. Other simulation programs are currently available, but they are very expensive and are NOT easily integrated with Autonomie. The reviewer pointed out that missing to date is the experimental validation of modeling results. Apparently this will be included as part of the overall program and Visteon will assist in this effort.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer pointed out that NREL is working with Argonne and Visteon, and commented that there was not much detail on the nature or extent of such collaborations. The second reviewer pointed out that this modeling approach is being developed in conjunction with Visteon. It is anticipated that Visteon will take the lead in experimental verification of the model. This reviewer suggests that Visteon be asked to provide simulation results obtained from the current Visteon analysis tool. This will provide additional confidence in the validity of this newly developed modeling approach. An open question is whether or not one of the other National Labs would be able to perform the experimental validation more effectively than Visteon. Another reviewer said that the project has strong partners. In the presentation it was not clear on what was being shared with them but from the Q&A it sounds like there are plans to share with them. It looks like Visteon has given parts and info on those parts. The reviewer commented that it would help if they would share their models if they can be convinced to do so. Model comparison would be valuable. The final reviewer encouraged a robust conversation with the National Highway Traffic Safety Administration (NHTSA) and EPA to determine any redundancies with fuel economy efforts tied to modeling this significant parasitic loss. Also, Visteon HVAC team is likely to already have more sophisticated models of this in use...granted, possibly not in Autonomie.

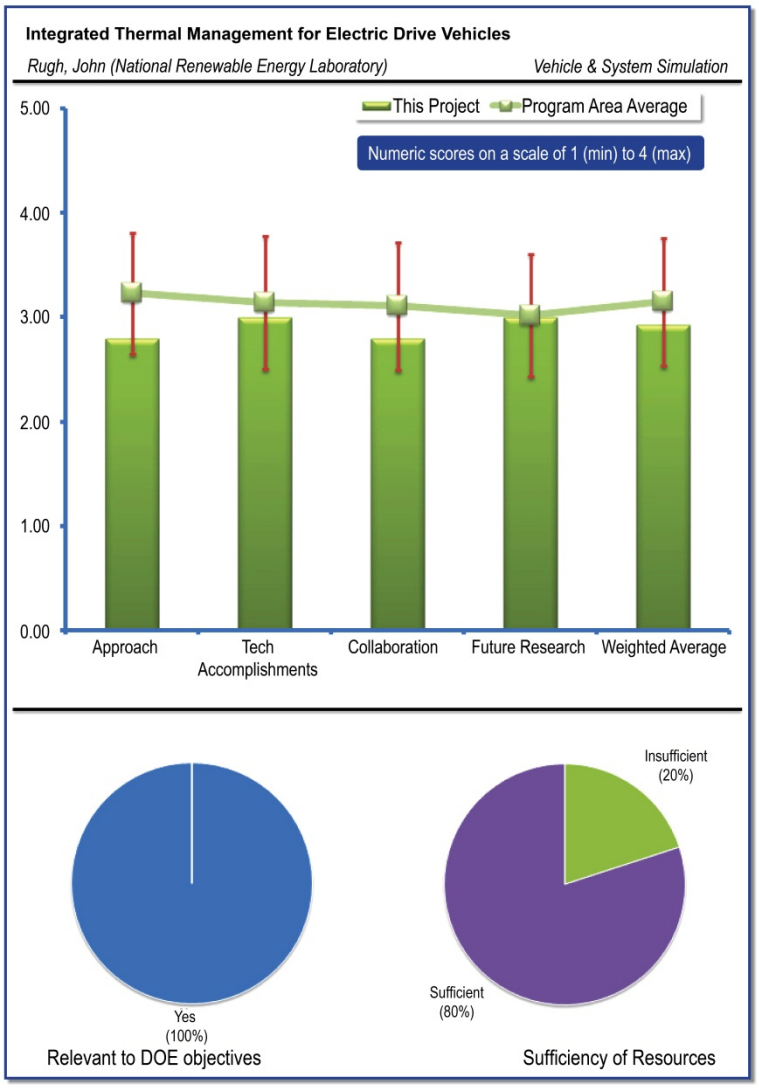
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said that this project builds logically on prior work. Not much detail provided. Another reviewer said that it will be good to validate with the model with the system as built. The third reviewer said that future plans call for evaluating and modifying the simulation model as required, and to add additional detail to the simulation as required. Details of the experimental validation plan were not provided, but during Q&A, it was learned that Visteon will take responsibility for this. The idea to do the work for HD trucks in a follow up project is a good one since it accounts for 1% to 5% of the fuel use depending on the cycle. A fourth reviewer thinks the team should have a more definitive roadmap of whose work is benefiting from this model and what/when that work will be. This reviewer questioned, is this primarily a tool for the National Labs to have a vehicle HVAC Autonomie model or beyond that?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer noted that the resources appear to be sufficient. A second reviewer felt the same way given the relatively simple scope. As noted, Visteon will apparently provide resource for experimental validation of the simulation. Another reviewer commented that per the slides, budget in 2012 will be needed to complete the goals of the project.

Integrated Thermal Management for Electric Drive Vehicles: Rugh, John (National Renewable Energy Laboratory) - vss046



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said it is quite possible that integrated thermal management can offer some level of fuel economy benefits to even conventional vehicles by using smart warm-up strategies. So it should be able to offer more significant benefits in the case of PHEVs and EVs. A second reviewer said it is clear that thermal management systems have a significant influence over the range performance of electric vehicles, and therefore optimization of these systems from an energy perspective will be a key component of the consumer's willingness to adopt the technology. The second reviewer remarked that the effect will contribute to hybrid powertrain vehicles efficiency also, but the effects will be more pronounced on fully electric battery vehicles. A third reviewer remarked that the work examines opportunities for reducing energy consumption related to cooling and thermal management of a PHEV or EV; the goal is to improve range by reducing the losses related to cooling circuits for electric components. There may be indirect benefit in reduced complexity and cost of cooling circuits. A fourth reviewer said this is a very relevant topic to address barriers in industry. Thermal management has become a complex and costly subsystem within EV/PHEV vehicles. A fifth reviewer said that owing to a lack of waste heat, the energy required for heating and cooling of EV can represent a significant fraction of the overall energy input to the system. Therefore, the reviewer said optimizing the HVAC systems in EVs is critical to optimize energy efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt the approach is good, with a focus on cost as well as increasing component (battery) life by using appropriate warm-up strategies. However, one piece of the petroleum displacement problem that should also be addressed is the effect of these warm-up strategies on reduced/increased parasitic losses in some of the components (e.g., bearing friction within the electric motors, increased electrical resistance in motor winding) which could lead to reduced/increased fuel consumption. The reviewer said this would be particularly true for conventional vehicles, where the dependence of parasitic losses on temperature is probably more significant, but it should have some effect on PHEVs as well. Additional simulations with temperature dependent parasitic loss maps should easily quantify this effect. A second reviewer said the definition around early stages of the project seems to be robust, however the maturity of the plan for the later stages of the effort seems like it still needs to be matured. For example: Key design operating points need to be defined so that any conclusions reached on combining cooling circuits with stand up to industry critique. An OEM partner willing to share system level requirements would be very helpful here. Selecting only “moderate” severity operating points (although they do represent a large proportion of the use profile) may undermine the credibility of the results—the performance of the

system during more severe load points should be confirmed, otherwise the system is not viable. Also the second reviewer recommend that the project team use a simple mass/energy and/or cost saving metric as a measure of success, rather than using those savings to "fund" a larger battery pack in the vehicle and predict the increased range; the latter, which was suggested to be the path forward during the questions, maybe confusing. The third reviewer commented that the approach is based on a 1-D modeling of the cooling circuits, and simulation of component (and cabin) temperatures and power required running ancillary systems. The reviewer noted that the project is in the early stage, nevertheless the direction needs better justification. Namely, it was repeatedly stated that the researchers will use the model to look for chances to combine cooling circuits in the EV or PHEV and reduce losses. However, the temperature setpoints for the battery, the motor, the power electronics, and finally the engine are typically very different, and that imposes fundamental constrains. The PI should use the preliminary results to address this and define the scope better. The fourth reviewer says that the approach looks sound to address assessment of combined cooling loops. Relevance charts (and title) indicate a broader "thermal management" scope which would imply cabin heating as well. Clarification that project is assessing A/C and Advanced Power Electronics and Electric Machines Program (APEEM) and ESS cooling would be helpful...assuming that is the case. If not, it was not obvious that approach addresses cabin heating work. In addition, this reviewer felt that declaring analysis ambient condition assumptions for analysis (based on typical industry extremes) and delta "T" rates for cabin cool-down would give more confidence that conclusions are linked to industry/customer expectations. The reviewer also noted that it is not clear what the Go/No Go Decision point in June 2011 is for. The fifth reviewer said that the 1-D thermal model using KULI is a good first approach to modeling HVAC systems in an EV. The leveraging of DOE tools is an efficient use of resources.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that good progress has been made in developing component and subsystem models. Results showed good correlation with test data. The second reviewer commented that it is difficult to judge since the program is in such early stages. This item certainly could be a "3" if funding was only recently made available. Another evaluator said that there is good progress with development of the 1-D model for thermal/cooling analysis and a cabin thermal load model. The selection of the software package KULI was not elaborated enough, as there are other options. The reviewer wondered even more about the selection of FAST for vehicle simulations rather than Autonomie. Cabin thermal model is a strength and its impact will be interesting going forward. The fourth reviewer stated that there has been significant accomplishments setting up the necessary models and correlating to test data. The final reviewer said the results to date look reasonable though much works need to be done regarding optimizing the thermal management systems.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The majority of reviewers commented that the project may benefit from partnering with OEMs. The first reviewer said that Visteon and EE Tech team are named as collaborators on this project. Obviously, Visteon has been involved quite heavily in this project, providing component design data, etc. It was unclear from the presentation how much the EE Tech team is involved. In the future, the reviewer felt that it would perhaps be helpful to mention their part in the project as well. The second evaluator stated that it this program could really use an OEM partner who can provide full vehicle cooling/heating system requirements; while Visteon may be able to do this, the presentation suggested there may be some holes in the areas of design operating points (worst cases) and appropriate evaluation cycles. Another reviewer stated that the collaboration with Visteon and EE Tech is definitely a plus. The fourth reviewer remarked that the link to industry (Visteon) and coordination across DOE VTP areas is good. The reviewer felt the project may consider sooner link with OEM to best understand customer cabin comfort expectations (shown occurring in FY12). The final reviewer also said that the project could benefit by fostering strong partnerships with OEMs.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

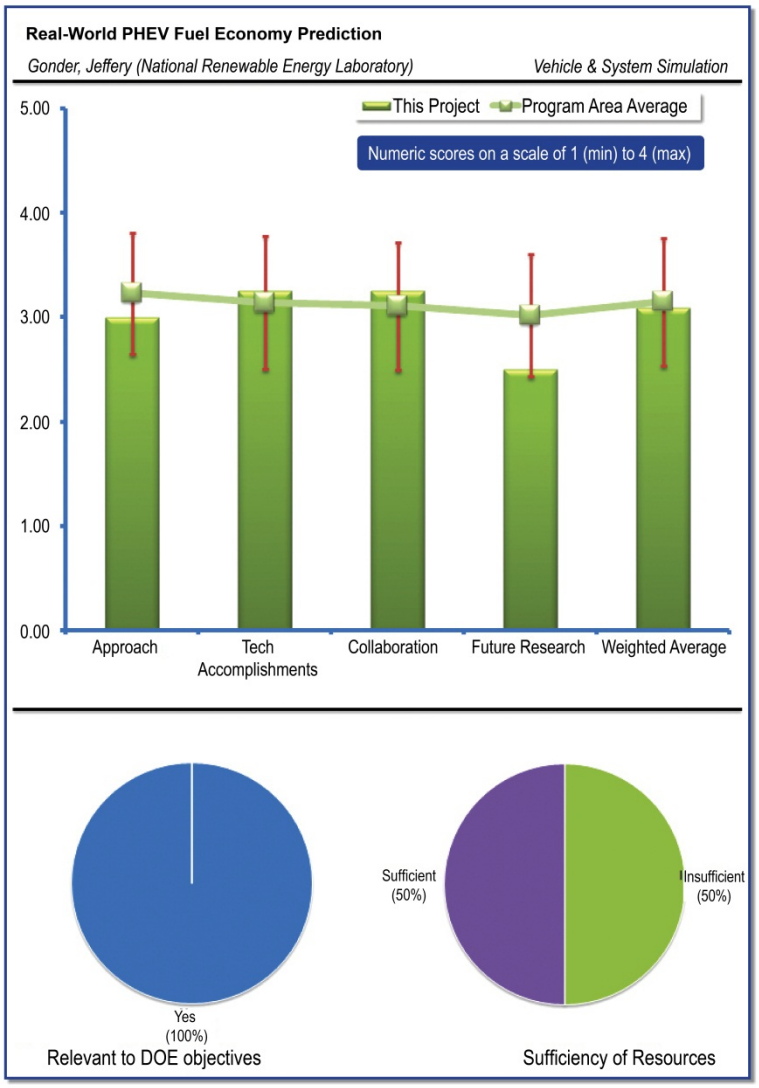
The first reviewer stated that the scope of the future work that has been outlined seems reasonable and achievable. A couple of considerations from the reviewer: Many of the other projects talk about evaluating fuel consumption benefits based on "real world" cycles. It appeared to this reviewer that only the federal test procedure (FTP) cycles are addressed in this project. It would be helpful

to understand the effect of these strategies on fuel consumption in "real world" cycles as well. A second reviewer said the project team may want to consider coupled 1D and 3D flow analysis (underhood airflow) to achieve a higher fidelity approach in later stages, after the initial direction is determined through the current approach. A third reviewer commented that including the battery cooling and examining the behavior of integrated system to detect opportunities for energy savings and reduction of system(s) complexity will be a critical next step. The project team should plan to evaluate the potential opportunities by looking at only a small section of certification driving schedules makes me worried though. Cooling systems and components have to be designed for critical conditions, hence extreme conditions or duty cycles should be considered too. A fourth reviewer said that the next steps on this project are outlined, perhaps expanding to include the cabin heating question in future work (as shown in relevance charts)? The final reviewer said that the planned work to quantify thermal challenges and to optimize (based on vehicle range) the thermal systems appear sound.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A reviewer said that resources are sufficient based on the stated objectives. If some of the suggestions here are addressed, it may turn out that more resources are needed. Another reviewer said resources seem to be adequate, success in achieving the milestones will be determined by other factors. The third reviewer stated resources appear sufficient given current project scope. The final said this program is just in the very early stages, but it is presented as being completed in FY13 - in many ways the program should be fairly straightforward to execute, and therefore it seems like a great candidate to be significantly accelerated in order to reach conclusions more quickly and influence more products sooner. This reviewer would prefer to see this program executed in full and published within 12 months.

Real-World PHEV Fuel Economy Prediction: Gonder, Jeffrey (National Renewable Energy Laboratory) – vss047



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers perceived that the project supports DOE objectives. One reviewer said that PHEVs have tremendous potential to reduce petroleum use and that this work is helpful because methodologies for determining PHEV fuel economy in blended driving are not as clearly defined as those for either conventional vehicles and charge-sustaining HEVs, or purely charge-depleting EVs. A second reviewer commented that the availability of an improved, standard approach for evaluating PHEV fuel economy will help industry project potential fuel economy improvements offered by new PHEV drivetrains, allow comparisons of various PHEV's, and provide a means of evaluating design changes made to PHEV drivetrains. This ability to project vehicle performance will accelerate improvements to PHEV technology, and ultimately make these vehicles more attractive. This in turn will promote greater petroleum displacement on a national level. The reviewer felt that the goals of this program are thus very appropriate: Evaluate the current means of projecting PHEV fuel economy, assess the pros and cons of each, and recommend a preferred approach. A third reviewer said the metrics for fuel economy that the public believes, will be key to them understanding the benefit to them in terms of fuel savings. A fourth reviewer remarked that the calibration of customer expectations to real-world fuel economy projections is relevant to advancing DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said the real-world, GPS-derived driving cycles and the Transportation Secure Data Center where they are stored and can be accessed are both very useful. The reviewer did have a comment that was directed more at EPA than at DOE or NREL: The extreme sensitivity of PHEV fuel economy to use and driver behavior may make it less valuable (or potentially misleading) for EPA to state a single value as the official fuel economy for PHEVs. Rather, the reviewer felt it may be more useful for EPA to report (e.g., on the window sticker) several discrete efficiency values on separate driving cycles reflecting charge-depleting, charge-sustaining, and a few standardized representative blended cycles. The second reviewer felt the general approach has been described as follows: (1) Review and revise PHEV calculation methods for standard test cycles, (2) Identify currently available options for projecting fuel economy, (3) Confirm that simulations provide reasonable estimates, (4) Evaluate against available "real world data" (either from OEM's or from national labs), (5) Identify and summarize pros and cons of each approach, (6) Recommend preferred approach. The second reviewer commented that not all of the specific "calculation methods" under evaluation were identified. The "simplified" calculation method (which eliminates the need to conduct full 5-cycle tests) and the "blending" of charge sustaining and charge

depleting (CD) modes were discussed in some detail. A third reviewer stated that the approach to use simulation and then real world results to check current methods for determining fuel efficiency is a good one. A fourth reviewer commented that the approach indicates several scenarios for adjusting numbers from standard drive cycles and acknowledges the complexity from both standard cycles and predicting real-world fuel economy. This reviewer recommended that this would encourage a more specific analysis with regional variation given how extensive the impact on ambient temperature conditions are to real-world performance. The reviewer commented that it may be time to allow the consumer to understand how energy consumption for cabin comfort significantly impacts their EV efficiency/range. Attempting to converge on a singular approach across temperature regions may not provide much value to the consumer except in an "average" region which is not where many of the first EVs/PHEVs will be deployed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted two SAE standards and two reports, that the blended constant-depletion method appears to correlate well with actual PHEV data - in one case. The reviewer also noted that "Leverage on-road drive cycles for PHEV evaluation" (on the Technical Accomplishments slide #15) is valid, but it is more of an approach than an accomplishment. The second reviewer said it appears that some of the results included in the presentation are based on existing analysis methods, or based on previous work in other programs. The project may be in the early stages of evaluating current methods, and there has not been sufficient time or resource to complete improvements or down-select most promising approaches. This reviewer noted that there was information presented showing that actual fuel and electricity usage was similar to values projected by the "adjusted" estimation method. Based on one analysis, the simplified calculation method appears promising. In general, the reviewer felt that it appears the project is on the right track to yield more accurate and representative methodologies for energy usage prediction (fuel and electricity). A third reviewer remarked that progress on simulation has been good. Correlation with real world results may need some work to finish by the end of project. The fourth reviewer said that progress in understanding breadth of approaches, simplifying assumptions and performance drivers seems substantial.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer remarked that NREL is collaborating with ANL on procedures and dynamometer testing, the SAE J1711 task force on procedures, and with INL on field evaluation results. The reviewer also noted that the project is also providing feedback to EPA on proposed rulemaking. The second reviewer said that sited collaboration activities include: (1)Working with Argonne on procedure development and chassis dynamometer testing, (2) Participation on SAE J1711 task force, (3) Sharing proposed approaches with EPA and commenting on proposed rulemaking, and (4) Fleet evaluation data sharing. The reviewer said it was not mentioned whether the prediction methods use Autonomie or other simulation programs. There may be an opportunity to collaborate with Argonne personnel in modifying or refining simulation methods. Another reviewer commented that hopefully some more of the real world data coming in from other DOE projects can be utilized before the end of this project. The final reviewer also noted that extensive collaboration is evident from industry, national labs and EPA.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the project was a bit light on details. The reviewer recommended that DOE/NREL consider developing a user-friendly "app" that car dealers and/or individuals can use that would use NREL and/or EPA test data to allow prospective car buyers to input their actual typical driving patterns (e.g., 15-mile round-trip commute every weekday, 50 miles on weekend days, and a 150-mile trip once a month) and calculate the estimated fuel usage/economy they'd actually achieve with a particular PHEV (or any vehicle). Another reviewer said that the remaining work is described as "complete remainder of project plan", "deliver milestone to DOE" (report on "Real World PHEV Fuel Economy Prediction"?), and "recommend preferred prediction approach(es)". If the work plan had been described in more detail, this description of projected activity may have been adequate, but it is difficult to get a feel for what specific activities remain. A third questioned wondered if there is time to complete the remainder of the project plan, deliver the milestone and select the preferred prediction approach in 2011? The final reviewer said that the future work did not propose more

accurate predictions based on non-traditional parameters, one potential was previously mentioned as a regional-specific prediction due to ambient temperature variations. Seems there would be more future work potential in this space than reflected.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that the project would likely need additional resources to develop the app discussed in #5 above. Another reviewer remarked that given the uncertainty of what actually remains to be completed, it is not obvious that resources are sufficient to meet the end of year targeted project completion date. The reviewer elaborated by saying this is not a criticism of the Principal Investigator necessarily, but the required resources originally projected for this effort may have been under-estimated. The work performed to date looks promising, but perhaps additional time and manpower will be required to bring the project to a successful completion. A third reviewer said that the time might be insufficient unless more resources are added to the project. The final reviewer said that funding appears on the lean side given scope. This reviewer senses that this may create constraints to exploring and documenting sufficient options on adjustment approaches.

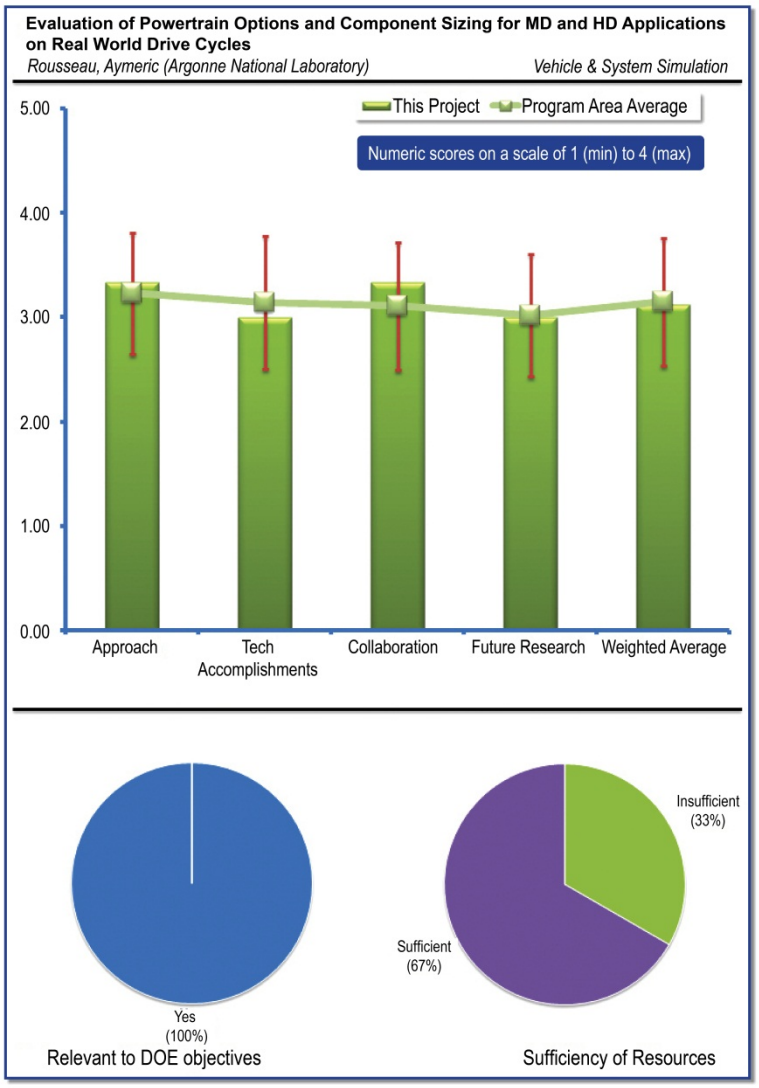
Evaluation of Powertrain Options and Component Sizing for MD and HD Applications on Real World Drive Cycles: Rousseau, Aymeric (Argonne National Laboratory) - vss048

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that getting the size of components right will optimize efficiency. The first reviewer also said that transit bus manufacturers in particular, and probably truck manufacturers to some extent, tend to offer the engine size(s) specified by customers rather than an optimized engine size. The second reviewer said the right powertrains and component sizing are important for the cost of the systems and the benefit they provide. Lower cost systems (with optimized components) will help with implementation of fuel saving hybrids and quicker adoption of hybrids. The final reviewer said that the activity supports ability for DOE to see fuel consumption effects generically across vehicle segments in medium and heavy duty trucks through simulation.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that there was good validation of models with actual vehicles (e.g., errors less than 2% for power). The reviewer also commented on the Q&A about constraining component size outputs to actual available products (e.g., engine hp) vs. identifying exactly what is needed. This reviewer suggested that the latter approach may be more valuable to the MD/HD vehicle OEMs because they tend to be less vertically integrated than LD auto manufacturers - some MD and most HD OEMs typically purchase their powertrains from a discrete list of supplier offerings rather than optimize and build them themselves. The second reviewer remarked that the approach of examining components and determining models for them to put into system models is a good one. It will allow engineers to see the effect on performance and fuel efficiency from different components. The third reviewer said that the general approach seems as good as it can be given complexity of product offerings across OEMs as current state. Discussion of attempting to factor specific engine existence, (near-term versus long-term) is not recommended. This reviewer commented that it is far too complex of an analysis and would be very difficult to maintain current data (also cannot account for production capacity constraints, etc.). For DOE directional guidance, the reviewer felt that fidelity of an "average" analysis across a segment should be sufficient.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer stated that the project is just ~15% complete, but it looks like the they have already made some progress in collecting drive cycles. A second reviewer commented that the development of component models has been done and that vehicle performance has been measured as well. The braking event histogram that was done will be helpful in sizing battery packs. The reviewer said it appears that a fair amount of work is still needed for the sizing algorithms and incorporating in the road data before the program is complete by the end of fiscal year 2011. The third reviewer commented that an example analysis was provided but the reviewer was unclear about how many classes of vehicle are now (and projected to be) complete by end-of-project. This appears to be a huge task to collect and manage the data but difficult to see exactly how far along the gathering and assessment of the data is currently.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said that ANL is partnering with OEMs (Navistar, Paccar, John Deere, Cummins, and more), NREL, ORNL, and West Virginia University. The reviewer said that the proposal cites "close relationship with truck manufacturers, suppliers, universities and national laboratory" and says "Value of data obtained through partnerships valued at several million dollars;" however, details of the collaborations are sparse. A second reviewer said there are many and varied partners that are giving data for the project and thought it will be good for the partners and other companies where possible to get the output (when it is available) as well. The third reviewer stated that this activity appears to have broad support and engagement in labs and OEMs.

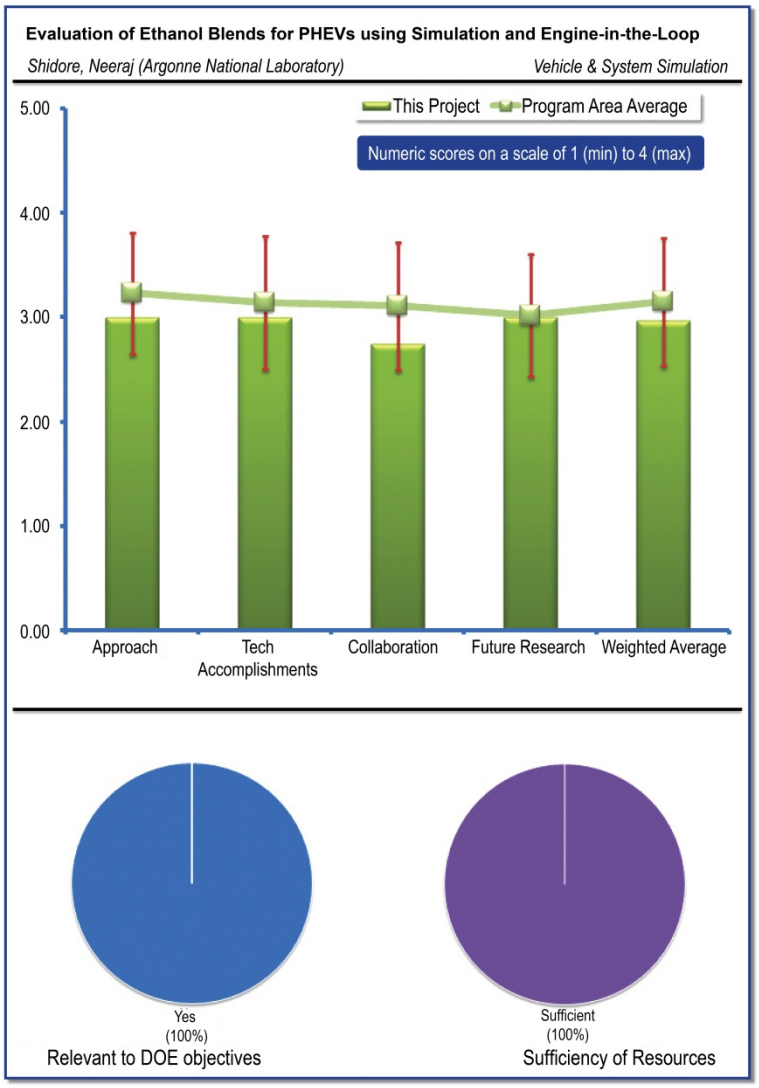
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer remarked that the future research is more of the same, plus ANL will "expand" collaborations and support future MD/HD labeling in Europe. The second reviewer commented that for this project, determining the improvement from hybrid systems is still a large task and for next projects, it makes sense to expand the scope to get into other improvements such as aero improvements. The final reviewer stated that much of the future activities seem to be a restatement of the current activities. They felt it was not clear what the future MD and HD labeling in Europe is for.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said it could be difficult to accomplish all the goals this fiscal year. The milestones are important ones for the truck industry so hopefully sufficient resources can be found to complete the program. Another reviewer felt it is difficult to judge scope relative to funding and that it appeared to be high potential for "ongoing" activity versus wrapping up a project at end of FY11. Wrapping up in FY11 would probably conclude insufficient resources.

Evaluation of Ethanol Blends for PHEVs using Simulation and Engine-in-the-Loop: Shidore, Neeraj (Argonne National Laboratory) – vss049



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Commenting reviewers were unanimous that the project supports DOE objectives. The first reviewer felt that the project was relevant and that other fuels, such as ethanol, natural gas, electricity with storage, and biodiesel, can also provide attractive means for reducing oil use through fuel displacement. The project VSS49 seeks information to better understand use of ethanol – gasoline blended fuels for PHEVs. Barriers to ethanol blends include cold start issue and energy density/fuel consumption. A second reviewer said that the use of alcohol based fuels to displace petroleum fuels is in-line with the DOE objectives. Unfortunately, the challenges with ethanol blended fuels require further study and understanding before robust implementations can be deployed. The final reviewer stated that both PHEVs and ethanol have the potential to reduce petroleum consumption in the vehicle fleet.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer explained that the project provided a very modest "seed" effort of $100K (started in FY 2011 and 50% complete) to start some simulation evaluations. The topics addressed- density, latent heat, knocks, and their impact on fuel/VSS-- are quite interesting and valuable data to have for those interested in alt fuels, and alt fuels engines, for example. The research objectives include data on optimization and areas of improvement, very interesting data to have for the community. The approach to the work is sound, and leverage existing resources at ANL Advanced Powertrain Research Facility (APRF). Approaches use appropriate fuel blends of interest (gas, E50, E85), standard drive cycles, and conventional and power split PHEV systems. This reviewer said that other reviewers have some load questions and presentation of data clarification is needed, but overall project (and such "seed") funding, is commendable. The second reviewer stated that the approach of pure gasoline (E0) through 50% (E50) and 85% (E85) ethanol blends is a good one as it covers the spectrum of ethanol based fuels currently available. The reviewer commented that with the addition of the Series Generator and Power Split device the reviewer would like to see the project investigate the use of E100 as the engine can now be run-up and started at much higher speeds than normal (idle vs. crank). The final reviewer said that this project makes very effective use of existing facilities and expertise to address a unique issue.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that the findings include important data for hybrid operation and load management. Fuel economy in ethanol blends may be optimized by vehicles control strategies. The data show an energy density penalty - in quantified detail of E50 and E 85 for conventional vehicles, and demonstrates the impact and improved comparative efficiency of hybrid operation, same fuel blends. The reviewer felt that continued work on PHEV operation will be interesting to follow. Another reviewer commented that the modeling of data appear to accurately capture the performance of the engine with the three fuels.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said that the collaboration with OEM and EU could be improved. A second reviewer stated they would expect to see an OEM become more involved than just providing the ethanol fuel blend calibrations.

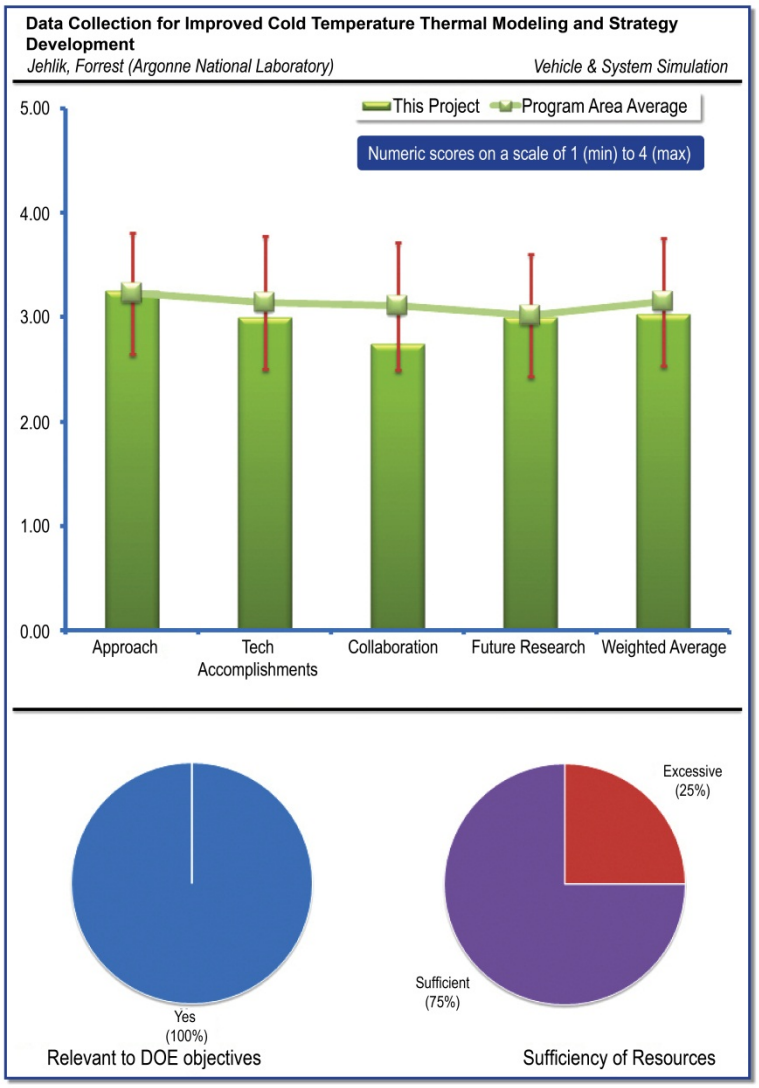
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said the project is taking next appropriate data sets and plans more collaborations with OEMs. The reviewer also said that the project plans to share data with USCAR. Future work will take into account driver behavior, which is important for energy efficiency/density studies. Work has found energy density penalties because of NO_X properties; the reviewer felt there will be room for improvement and new data here. The reviewer pointed out the catalysts did not change or impact findings, this could be further exploded from a DOE Basic Energy Sciences (BES) perspective. The reviewer also commented that the team may consider looking at E100 and loading vs. exhaust temperatures. The second reviewer said that completing the project as defined is appropriate and an extension to the project to explore system level optimization opportunities for ethanol fuel blends in a PHEV/HEV application would be of interest. They also stated that a true flex-fuel PHEV/HEV would be logical progression of today's technology paths. The reviewer wonders who will be first.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer remarked that the team has made some nice accomplishments and provided interesting data on a limited, seed funding. This reviewer commented that this is excellent work on the modest budget. The reviewer felt that if the project can continue the work based on the same modest budget, excellent. Before expanding the budget, the reviewer suggested bringing in a few other collaborators to strength the translation and impact of results, to other consultants or OEMs. Another reviewer stated that resources appear sufficient.

Data Collection for Improved Cold Temperature Thermal Modeling and Strategy Development: Jehlik, Forrest (Argonne National Laboratory) - vss050



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All commenting reviewers agreed that the project supports DOE's objectives. The first reviewer remarked that this project is relevant and that it directly supports DOE's overarching mission "to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions." The work directly supports the overall DOE VTP goal to achieve petroleum displacement by investigating cold temp thermal modeling and mitigation for energy savings. The project is developing engineering solutions for petroleum use reduction. The second reviewer said that the project brings to the front, a void in analysis that represents the majority of our transportation climates. Another reviewer commented that cold starts and cold temperature operation have a significant impact on the quantity of fuel consumed by internal combustion engines. This reviewer said that finding a solution that minimizes this fuel consumption is directly in line with DOE objectives. The fourth reviewer felt that this work addresses cold engine fuel consumption for many different hybrid powertrains.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt the project team is looking at the impact of cold operation on vehicle operation and energy efficiency. Team developed a fuel map based on experimental load of Hymotion Prius, and matches it to an urban dynamometer driving schedule (a UDDS)/ / UD 60 model. The second reviewer said consideration of other temperature locations has been included in the approach but additional locations should also be explored (e.g., cylinder head and valve bridge) as these may offer a different perspective to oil and coolant.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that the work provided a focused data set for cold temp impact on fuel economy, but the data are limited with respect to its potential. They felt that the project demonstrates improved procedures for model development and testing UDDS, but the data and its results are modest with respect to potential implications. A second reviewer stated that progress appears to be as per the plan.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer does not understand why Environment Canada is the only partner. However, this reviewer commented that the project is good use of ANL APRF, and future collaboration planned with NREL. The second reviewer was surprised to see that there was not an OEM involved. This particular reviewer was aware of previous OEM studies in the European Union that explored cold start fuelling and would have expected to see an OEM play a key role here.

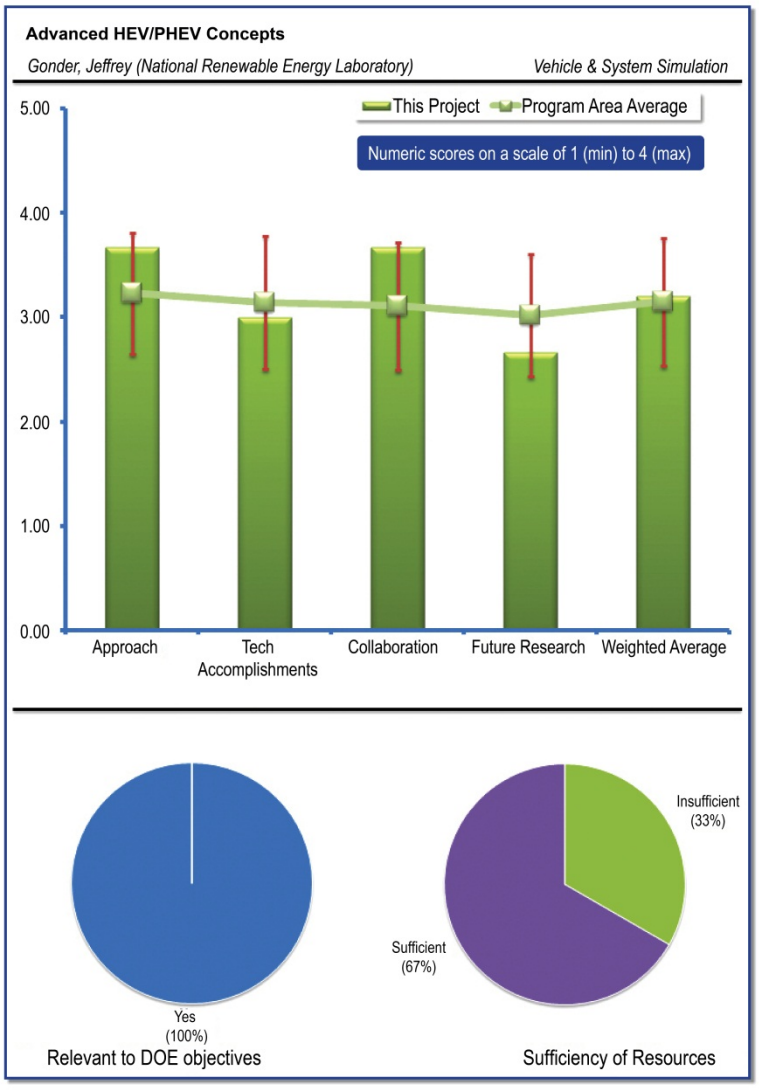
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer remarked that this is an important project but funds are small and limited. Future work includes new collaborations that will help expand the work. The reviewer said that new proposed work may incorporate creature comfort features into modeling effort (NREL) or light off features into modeling effort (ORNL). The reviewer suggested working with EPA. The second reviewer stated that improving the response surface methodology (RSM) is important especially with the addition of alternative temperature signals. A third reviewer commented that a future project should take these results and apply them to a real engine in order to validate the overall fuel saving opportunity.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A reviewer stated that funds are small, but so small they are not sure the impact of data are useful without a full blown comprehensive and coordinated effort. The reviewer felt that these very preliminary results show the study of cold temperature/thermal management with respect to the UDDS cycle, they thought it was important to study and has potentially significant impact on petroleum displacement. However, this reviewer also felt that data are sparse, so sparse that they are not sure about the investment, unless the project is truly managed and expanded and there is a strong relative return on investment. The reviewer stated that the current resources are a start, but not compelling as presented. Another reviewer stated that resources appear sufficient.

Advanced HEV/PHEV Concepts: Gonder, Jeffrey (National Renewable Energy Laboratory) – vss051



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project explores three different approaches for enhancing the performance, efficiency, and cost effectiveness of hybrids and plug-in hybrid vehicles. Evaluation of these advanced concepts will help to decide whether major development programs should be undertaken. They also said that the project could lead to significant improvements in hybrid vehicles, thereby improving their market attractiveness and leading to increased market penetration. Putting a greater number of hybrids on the road clearly addresses the national goals of reducing emissions, and dependence on foreign oil. The second reviewer commented that all three thrusts are relevant. The first focuses more on reviewing whether some major barriers (the high costs of large battery packs) can be removed. The other two thrusts offer a preliminary review of potential fuel efficiency gains from advanced controls or infrastructure. The third reviewer remarked that the project includes three advanced concepts between lower energy ESS, Route-Based Control, and Drive-on charging. They also noted that route-based control (RBC) has enough substance to split-off as its own initiative. Lower energy ESS seems to be concluding and drive-on charging could also be split off. RBC should be fed now for good near-term feasibility to the DOE mission, the reviewer elaborated by stating that both for fixed routes (commercial) and for less-fixed (consumer) based on GPS/NAV. The reviewer also pointed out that DOC is longer-term R&D that may be eclipsed ultimately by fuel cell strategy. This reviewer commented that it is less obvious for DOE focus if MAJOR infrastructure investment required realizing nationwide benefits. Ability for vehicles to pick up charge may just offset battery size savings.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers provided extensive details and suggestions relating to all three areas included in the presentation. One reviewer commented that this project includes three different work streams so each are addressed separately: (1) Energy Storage Project – Using simulation, this project will evaluate the effect of storage capacity on fuel economy. The reviewer commented too small a capacity results in lost opportunities to capture regen braking energy and too large a capacity drives up the cost, a significant factor considering that batteries are the single most expensive component in an HEV or PHEV system. In addition, the project explores which duty cycles ultimately drive the battery size. If a smaller battery is acceptable for the overwhelming majority of duty cycles encountered, then a scaled down storage capacity may be an effective tradeoff between fuel economy and initial cost. The reviewer felt that the technical approach is sound, and should establish a methodology for selecting storage capacity that represents the best compromise between acquisition cost and weighted average fuel economy. (2) Route Based Control – This project seeks to understand the benefits of using duty cycle

information to "anticipate" the demands a particular route may place on the hybrid system, and then modify control strategy accordingly to optimize efficiency and/or performance. The reviewer stated that the approach calls for data collection along repeatable routes, then using this information to modify control strategy (one or more variants). These modified controls are then placed in the vehicles for performance and fuel economy testing. The units with modified controls are compared to baseline vehicles to determine benefits. The reviewer felt that the technical approach is sound, and can offer a significant benefit to hybrid vehicles that travel a particular route or group of routes on a recurring basis. (3) DOC Charging – The reviewer felt that this project appears to be a "technology search" to understand various options for charging the vehicle's battery while the vehicle is in motion. In essence, potential technologies will be identified, coasted out, and a calculation made of potential overall fuel savings. The reviewer remarked that the project will compare the total cost (vehicle, fuel, battery, battery replacement) of various charging options including drive-on charging, plugging in at home, plugging in at destination, etc. The second reviewer said that all three projects seem to be well organized with specific goals and a clear plan to meet the goals. (1) Energy storage system represents a big part of the hybrid system cost. Better defining the cost vs. benefit tradeoff can help lower barriers to implementation. (2) More advanced powertrains most likely can exploit the extra information which is available to further improve efficiency. The reviewer felt that it is good to understand the boundaries of these benefits and to review different implementations. (3) The reviewer felt that the high level modeling and simulation review of the potential gains from drive on charging is a useful step. Again, this has the potential to improve fuel efficiency; studies to better understand this is completely appropriate. The third reviewer remarked that it is difficult to understand allocation across three initiatives. They also felt that the research team seems well organized (internally) but scoping is complex for outside review. Lower Energy Energy Storage System (LEESS) approach and project seems pretty complete. For RBC, the reviewer recommended a broader approach to capture potential of consumer market (not just commercial fixed route). A scenario where GPS knowledge of consumer location and destination could optimize control, may create a larger petroleum savings as PHEVs rollout to consumer market and GPS-enabled vehicles and/or mobile smart phone device are commonplace. Approach to analysis of drive-on charging was least defined.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that this project includes three different work streams so each will be addressed separately: (1) Energy Storage Project –As might be expected, there are diminishing returns with regard to sizing the battery. Simulation results (UDDS duty cycle) suggest a decreasing rate of fuel economy improvement as the battery size gets larger. An analysis of regenerative energy captured shows that reducing the peak power requirements of the battery from 30kW to 20kW results in only a small loss of regen energy. The reviewer sated that battery manufacturers have indicated that peak power is one of the key cost and size drivers. The reviewer felt that good progress has been made so far in understanding and "quantifying" the tradeoffs in performance vs. cost. (2) Route Based Control – the reviewer pointed out that some simulations work has been conducted to understand effects of control strategy changes on fuel consumption and battery usage. The "New European Drive Cycle" was used for initial analysis work. In addition, runs have been made to understand how driving style can affect fuel usage and battery state. The reviewer remarked that it appears that driving type (not surprisingly) can affect how effective a particular control strategy is. The reviewer remarked that some good work has been done to date to understand interrelationships between control strategy, fuel usage, and battery condition; however, it is not clear that the vehicle data collection and subsequent creation of modified control strategies has yet been initiated. (3) DOC Charging – An analysis tool for comparing various technologies has been completed. This is an Excel-based, homegrown, easy to use tool. The reviewer said the analysis results show that "externally powered" hybrid electric vehicle has the lowest cost of operation, which seems to make a case for further evaluation of DOC concepts. The second reviewer commented that the conclusion that smaller battery pack could offer similar efficiency gains is interesting. The reviewer is also interested in the fast running excel model. The reviewer pointed out that recently the EPA has proposed their own simulation tool for medium/heavy duty regulations. The reviewer understands one of the concerns was that the model was perhaps too complicated or required too much data entry. This reviewer remarked that something along the lines of what seems to have been developed here might be appropriate. (The EPA seems to want to have a model that captures engine torque/speed-- not just power-- which might be beyond the simple excel model. However the level of detail the EPA wants seems consistent with a simple fast model. Regardless of this discussion, it might be too late for working with the EPA, but the tool would be useful to others.) The third reviewer said that LEESS had most progress as

principal activity to date and seemed pretty much done. RBC and DOC activity to mostly begin now and there are limited accomplishments to date.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers thought that collaborations were extensive, and also provided comment about opportunities for possible future collaboration. One reviewer stated that the Energy Storage Project collaborations and information exchange have occurred with Ford, Chrysler, and GM. In addition, NREL's recommendations have now been adopted by USABC. The first reviewer also noted that for the route based control the collaborations have been primarily with bus and component manufacturers, including ISE, Navistar, and Allison Transmission. Also for DOC charging the same reviewer said that significant interactions have occurred with a number of organizations, including the Partnership for Roadway Electrification & Automation (PREA),, University of Auckland, Korea Advanced Institute of Science and Technology (KAIST),, ORNL, University of California-Berkeley (Partners for Advanced Transportation Technology), Utah State University, and the Aerospace Corporation. The second reviewer remarked that there is a number of good collaborations, but it would be nice if another collaboration could validate the conclusions of the LEESS study (similar to the previous work with GM looking at ultracaps instead of a battery pack). The reviewer remarked that some OEM collaboration would be useful to confirm prototype devices deliver full HEV fuel savings. This reviewer believed that a lot of people would have use for a simple and fast fuel economy model, especially one that could run in Excel; this reviewer pointed out that Matlab is now fairly common in engineering circles, but almost all engineers have access to MS Excel. This reviewer mentioned the EPA above, but there might a wide range of other researchers. Another reviewer stated that the collaborations seemed extensive and sufficient.

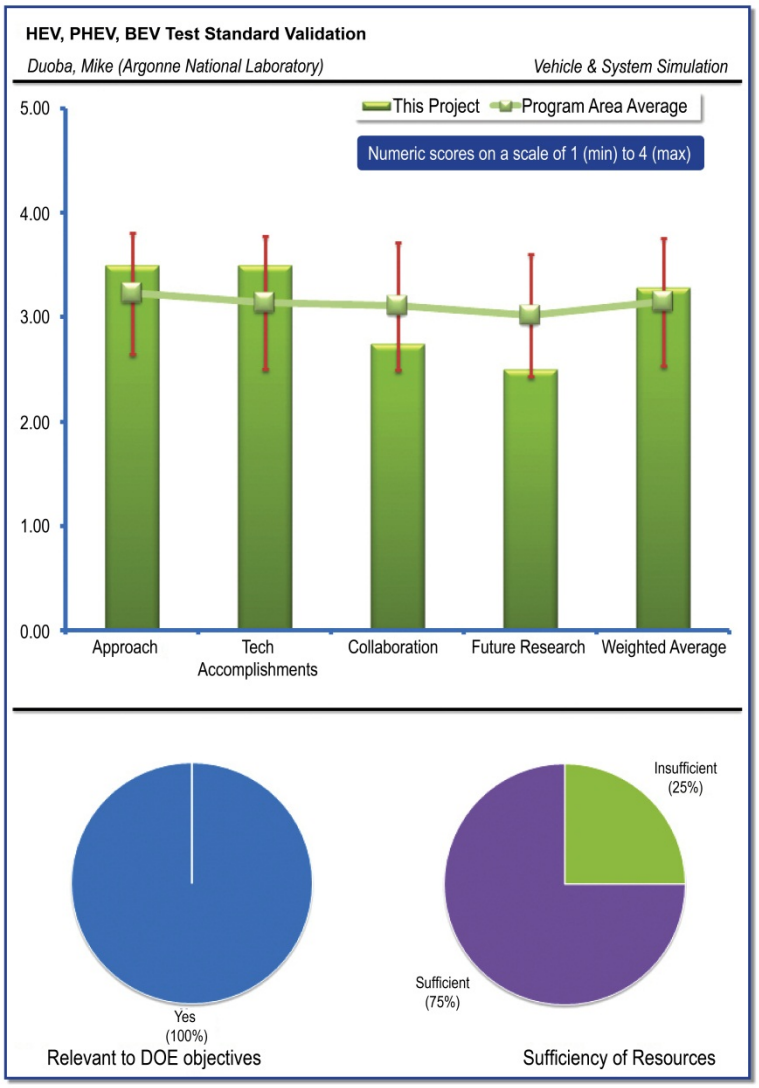
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that for the energy storage project, the future activity is focused on assessing performance of newly specified equipment as it becomes available to determine if simulation results have accurately projected vehicle performance. The reviewer points out that this will be conducted over a wide variety of drive cycles. For the route based control the same reviewer points out that data collection and subsequent "tuning" of control system is yet to be completed. Actual vehicle results will be compared against baselines to determine the effectiveness of the control strategy changes. The reviewer also commented that further analysis work will go beyond fuel savings and also consider battery life and emissions. The reviewer also stated that this work was done on buses, but it is desirable to transfer methodology to light vehicles (more vehicles, more fuel savings potential). They point out that a light vehicle partner will be sought. For the DOC charging project the first reviewer stated that the project will continue evaluation of charging options including when parked, at stops, "on the move" on roads, or over designated "charging routes." Additionally, cost analysis program will be refined. The reviewer pointed out that a hardware demonstration is anticipated, although budget limitations may not permit this except on a scaled down level. A second reviewer said that all 3 fronts offer interesting and useful future efforts. The reviewer again repeated that a simple and fast fuel economy simulation could have a lot of use. The reviewer felt that some consideration of additional efforts to develop this tool for public release would be worthwhile. A final reviewer commented that overall scope seemed fragmented. It was not clear to the reviewer that next steps for RBC and DOC were very focused.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer said that it is somewhat difficult to assess the adequacy of resources and that this is really "three projects in one," so the $350K funding total seems light. In addition, the reviewer said the principal investigator seems to have a number of activities to track and coordinate. This all leads the reviewer to the impression that perhaps plans for all three programs are too ambitious to be covered with existing funding and resource levels. Another reviewer stated that Task 1 discusses confirming that prototype devices deliver full HEV fuel savings, but that his would seem to require physical testing, including in vehicle testing. The reviewer felt that it intended budgets will not support this. Similarly the reviewer points out that Task 2 would seem to be heavily dependent on collaborating with hybrid system developers and end system users (various transit authorities).

HEV, PHEV, BEV Test Standard Validation: Duoba, Mike (Argonne National Laboratory) – vss052



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers remarked that the project supports DOE objectives. One reviewer said that standards are often underappreciated, but they are one of the most important pieces of the puzzle to commercializing complex systems like electric-drive vehicles. The second reviewer felt that this project is relevant. The reviewer also points out that project VS052, as will other standardization ANL projects (O59, 053, 052) directly support the DOE mission and the DOE VTP responsibility to develop new technologies to increase energy security in the transportation sector. The reviewer acknowledged that the project provides validation and testing of critical component for electric drive vehicles (EDV) including HEVs, PHEVs, and BEVs that will help reduce our national dependence on petroleum. Alternative non-petroleum based fueling options for ground transport vehicles – especially EDV—are critical to help support stable energy economy for the nation. Another reviewer stated that this work enables electrified transportation to displace petroleum energy. The final reviewer commented that the development of appropriate and timely standards is essential to the successful market adoption of electric drive vehicles. Procedures to test and validate standards during the development process are necessary to achieve robust and broadly applicable and accepted standards.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer remarked that it is a great idea to develop a quick version of SAE J1634 test procedures to enable faster development of extended-range EVs and PHEVs. This reviewer pointed out that the project will need to be careful if battery behavior at varying state of charges (SOCs) is significantly non-linear. This reviewer also felt that standardizing terms (J1715) is very helpful. Defining end-of-Charge-Sustaining (CS)-operation is very important for comparing PHEVs. This reviewer commented that developing and promoting standards is one of the most cost-effective and highly-leveraged investments DOE can make in bringing electric-drive vehicles to commercialization. The second reviewer commented that this project has been on-going since 2006. The reviewer said the approach is a nice complement to other VSS projects led by ANL and others DOE labs toward standardization. The project leverages the ANL Powertrain Research Facility resources and communicates results with INL AVTA appropriately. The final reviewer pointed out that this task involves leading and providing technical input to standards development largely with SAE, as well as performing supporting testing and validation activities primarily on the dynamometer. ANL's long history of vehicle and battery testing is being tapped to support this process. The reviewer said standards development and supporting validation procedures are by their very nature evolutionary and time consuming. They point out that one way to speed up the process somewhat is to have dedicated personnel who

cross the standards stakeholder boundaries and are in the position to provide important supporting technical information, while maintaining a neutral overall position. The reviewer felt that this appears to be largely the situation in this case. Another important aspect is efforts to simplify test procedures to lower costs to OEMs and accelerate the testing process once a standard is completed. The reviewer remarked that efforts to simplify and short cut test procedures (especially J1634) are in evidence here. Overall, the reviewer felt that the approach is sound and should be continued. However, given the high importance of the timeliness of standards development, the reviewer pointed out that continued efforts should always be made to further accelerate and simplify the standards development process, without of course compromising validity.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that the project made important contributions to at least five significant SAE and International Organization for Standardization (ISO) standards. This reviewer remarked that the proposed vehicle technology map on slide 12 needs review. For example, "idle-stop" should overlap with PHEVs and CS-HEVs. This reviewer questioned if EREV should overlap with BEV. Furthermore, the first reviewer pointed out that on slide 14, title refers to "ISO 23274-2 Support Harmonization of PHEV Procedures" but the graphic shows a standard for "non-externally chargeable [hybrid electric] vehicles." The second reviewer said the scope of work for FY 2010/11 includes J1634 and is 90% complete. The reviewer also stated that the work focus is J1634 and includes dynamometer validation for BEV. The reviewer noted that the accomplishments include dynamometer test procedure “short cut” findings. The reviewer commented that test metrics for dynamometer tests seems critical; however, how likely is it to have such metrics fully accepted internationally and how fast? This reviewer questioned, ISO standards require years, yes? The reviewer concurred that you have to start somewhere. The third reviewer felt that the level of technical progress and accomplishments for this task are good. Progress has been made on a number of fronts including leading standards committees, development of supporting vehicle/component testing and validation on the dynamometer, and HEV terminology clarification.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers provided input about other possible collaborators. One reviewer stated the presenter mentioned numerous other labs, OEMs, suppliers and DOE. This reviewer was unable to hear or see DOT listed in collaborations; this reviewer remarked that slide 16 vaguely refers to "regulators," which may or may not include all relevant modes of DOT. The reviewer mentioned that work with MD/HD standard (J2711) just started and that the project should seek collaboration with DOT generally and the Federal Transit Administration in particular as this standard will likely be important to the transit bus industry. A second reviewer said that it would be nice to see other dynamometer experts engaged in this project, outside of ANL, such as SwRI. Another reviewer stated that this coordination can be a difficult proposition! The final reviewer felt that solid collaboration exists with SAE and foreign equivalents, automotive OEMs and suppliers, California Air Resources Board (CARB), and the Progressive Automotive X-Prize Competition (X-Prize) entities. This reviewer questioned as to whether other manufacturers (Chinese and Korean) should be coordinated with as well.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

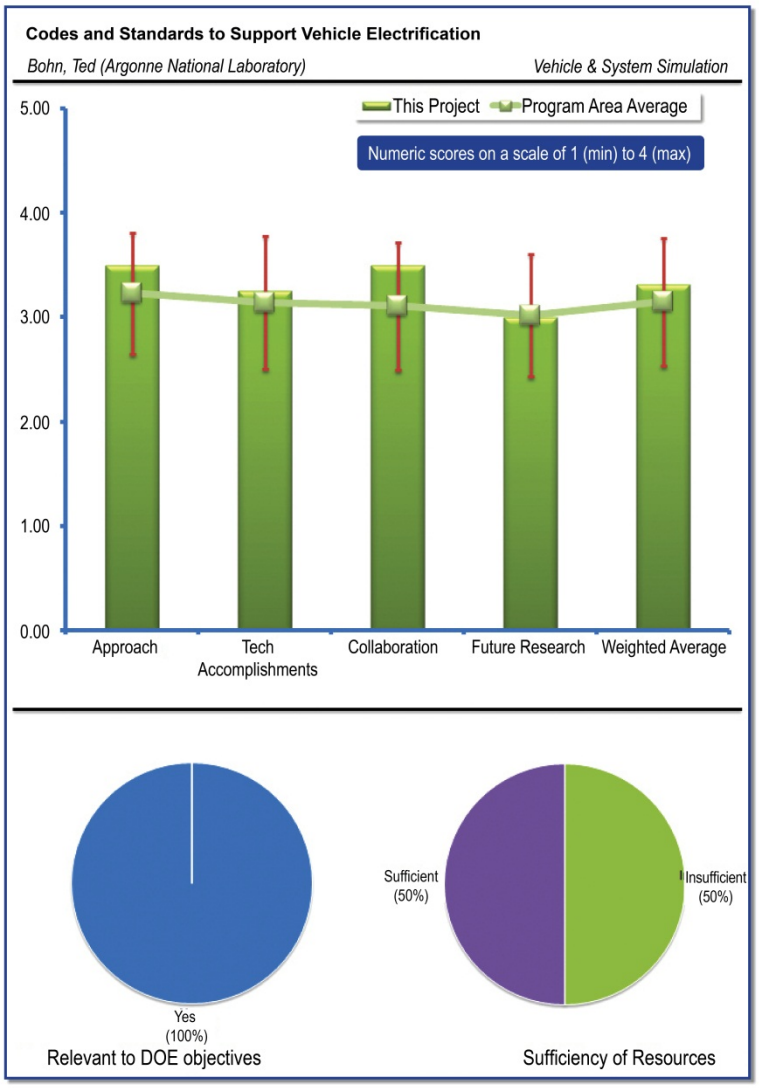
The first reviewer wondered if they missed part of the discussion, as they did not hear anything on proposed future research or see it in the slides; this reviewer gave this question a 3 out of 4 on the understanding that the important standards development coordination work will continue. The reviewer also commented that the project should ensure that the final standards include realistic assessments of accessory loads. These loads are even more important in vehicles with limited on-board energy reserves. The second reviewer said there was good use of APRF. The reviewer would like to see it expanded to other dynamometer test facilities for validation. The third reviewer felt that there was not much information provided on future efforts with the exception of J2711, but it is implicit that it would entail similar supporting activities for standards development as they arise and are prioritized.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer said to continue funding at least the same level if not more. The second reviewer said that the budget is modest and that ANL uses OEMs resources well for vehicles testing. The third reviewer stated that currently, financial and human resources in

support of this task appear adequate and appropriate. The fourth reviewer went into more detail by saying the leveraging of APRF support means that the support of APRF must be maintained or expanded. In particular, the reviewer believed that 5-cycle evaluation of EVs and PHEVs will require much testing in APRF, and this testing will be required for standards.

Codes and Standards to Support Vehicle Electrification: Bohn, Ted (Argonne National Laboratory) – vss053



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Commenting reviewers agreed that this project supports the overall DOE objectives. One reviewer stated that this is important work on development and harmonization of standards to enable and facilitate wider deployment of grid-connected vehicles. The second reviewer felt that the project is relevant and that the project supports the DOE and VTP missions directly to reduce the nation's dependence on petroleum but enhancing the infrastructure for vehicle electrification. The reviewer felt with a modest budget (for multiple DOE lab collaborators), the project addresses a specific aspect of codes and standards related to PHEV-grid interaction that is necessary for EDV infrastructure, and SAE J2907 Motor ratings. The reviewer noted that at present there are not straight forward standard for HE and BEP systems. This reviewer remarked that this would be a nice contribution. A third reviewer commented that grid electric energy for transportation can displace significant petroleum fuel energy and that this work enables grid connected vehicles along with vehicle electrification components. The final reviewer said the establishment of timely codes and standards, including harmonization regionally and globally, are of critical importance to the successful implementation of plug-in electric vehicles. The reviewer remarked that codes and standards are essential to universal PEV connectivity and to maximize synergies with development of the unfolding smart grid.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that the project is providing support and leadership in standards development efforts and on applicable committees. The reviewer felt that given ANL and DOE are not in a position to impose standards, standards are more effective with full industry input and buy-in; it is hard to see how the approach could be made more broadly effective. The reviewer stated that the project is addressing codes and standards requirements to enable wide-spread adoption of electric-drive transportation with Smart Grid Interoperability. Developing and promoting standards are among the most cost-effective and highly leveraged investments DOE can make in advancing the commercialization of advanced vehicles. The reviewer noted that the project is pursuing worldwide harmonization of standards. A second reviewer felt that the approach to the work that includes the Institute of Electrical and Electronics Engineers (IEEE), National Fire Protection Association (, NFPA) and NIST is commendable. However, the reviewer wondered how much the National Institute of Standards and Technology (NIST) is actually participating? It appeared to the reviewer that that the NFPA collaboration is very active. The reviewer also remarked that the technical approach that uses four focus modes is good, (i.e., end use measurement device [EUMD]//energy management system [EMS]/home area network [HAN]/human machine

interface [/HMI]).). The third reviewer felt that it is somewhat difficult to assess the approach as this task covers a lot of ground over diverse areas including technical support for codes and standards, technology concept development, lab and verification experiments, benchmarking, and liaison and facilitative support across broad stakeholder groups. This reviewer felt that it may be beneficial to explore an alternative management approach, including delegation components, to lighten the load on the PI.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that there has been good progress. The reviewer heard some frustration with the "herding cats" nature of getting industry to agree on standards. The reviewer pointed out that some people on standards committees are much more motivated than others. The second reviewer commented that the defined accomplishments are sound here in this project, but in general, the work here in standardization and “harmonization” still has an enormous way to go. The reviewer noted that this project contributes a baby step, but there seem to be many baby steps ahead. The reviewer agreed that it has to start somewhere, and nice to see EU, China and Japan awareness and communication, but for example, Japan includes SAE J1772 AC charge system as standard, direct current faster charger for batteries (CHAdeMO) DC is still unique. However, the reviewer believed that it still seems there is a mountain of work ahead to standardize, with numerous political pulls that may be the biggest barriers. A third reviewer stated that the task has demonstrated significant technical progress on multiple fronts in support of codes and standards development, technology concept development, testing / benchmarking, harmonization, and overall coordination. The fourth reviewer felt that the project has a very significant bang for the buck.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer mentioned that ANL is collaborating with an extensive and relevant set of stakeholders including SAE, IEEE, NFPA, Underwriters Laboratory (UL), National Electrical Code (NEC),UL, NEC, NIST, Utilities (DTE Energy, Southern California Edison, Communications technology vendors), EVSE suppliers (Clipper Creek, Coulomb, SPX, Leviton, ECOtality, General Electric, Schneider), Vehicle OEMs (Ford, General Motors, Chrysler, BMW, Fisker), and National Labs (INL, PNNL, ORNL). The second reviewer stated that most areas of the task appear to incorporate significant collaboration with other government and industry organizations. However, the reviewer pointed out the very broad and aggressive nature of the task along with the rapid evolution of the technology domain, dictates the need for a continual effort to reevaluate and assess the need for new/additional collaborative partners as efforts proceed. The reviewer felt that this is especially true on the technology vendor front. The final reviewer wondered how OEM collaborators were chosen as they seem to serve as “peer” reviewers.

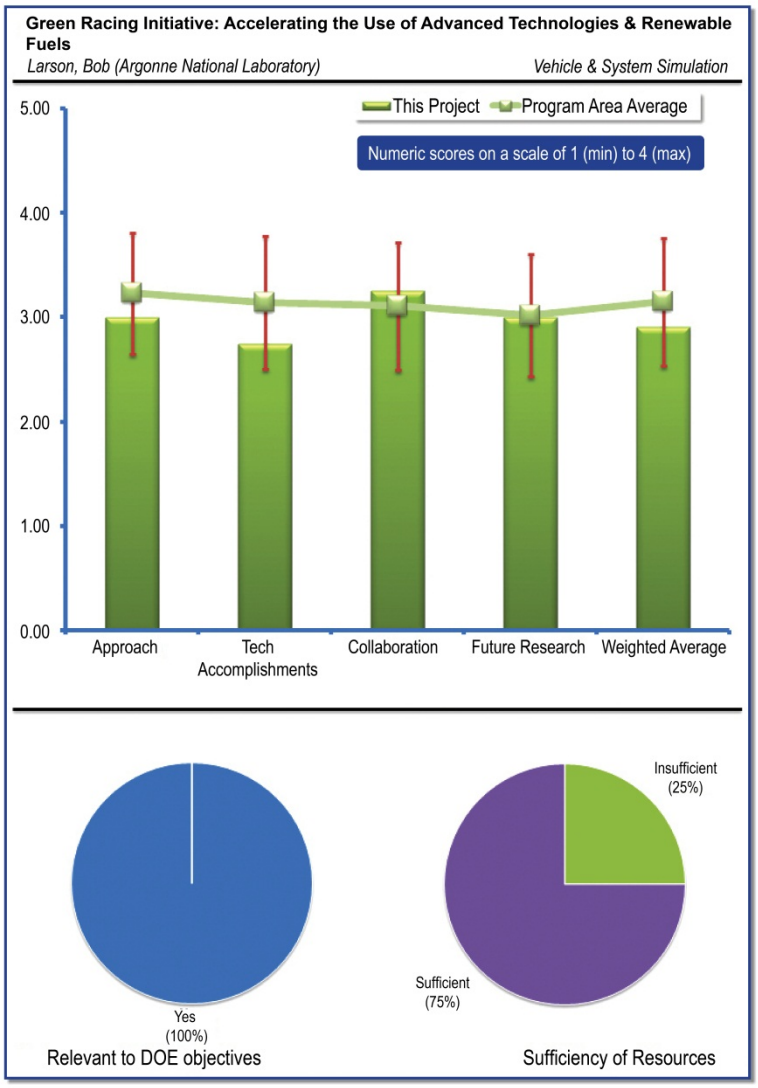
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer mentioned that the budget is $300K, modest but appropriate to provide standards data for this very defined scope of work. $400K is appropriate to achieve the FY 2011 goals. Another reviewer noted that benchmarking hardware to support codes and standards validation is planned for next year. A third reviewer said that the proposed future research is sound and in line with on-going activities. One reviewer was confused by the milestones slide as it implied the project is in year 3 of 3 and is nearing completion, yet the timeline on the second slide is silent on when the project will end (or be renewed), and then there was a slide listing several activities for next year.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that this is a very important and broad task with timeliness considerations. The reviewer commented that strong consideration should be given to expanding funding resources to enable the addition of at least one more technical human resource. Another reviewer wondered if there are technical (as opposed to administrative) reasons why these standards are managed and reported separately from those under VSS052.

Green Racing Initiative: Accelerating the Use of Advanced Technologies & Renewable Fuels: Larsen, Bob (Argonne National Laboratory) – vss054



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers commented that the project supports DOE's objectives. One reviewer remarked that this project is definitely supportive of DOE objectives. The reviewer pointed out that provided that the rules are structured to encourage it (which is generally true in this case), racing drives rapid innovation, serves as a showcase, and builds acceptance of advanced technologies. A second reviewer felt that project 054 is a unique complement to the VSS portfolio to support the DOE and DOE VTP missions in reducing our nation's dependency on petroleum. The project provides an outreach and education/training component for the nation, through an exciting and engaging venue, to increase awareness of alternative vehicle technologies. A third reviewer noted that besides the direct displacement of petroleum energy and component development in motor sports, the outreach effect from this project can have a much larger impact. The fourth reviewer stated that barriers facing widespread adoption of advanced vehicle technologies and fuels are not only technical in nature but often more so surround the issues of awareness and perception. The reviewer felt that broadly increasing general consumer understanding and acceptance of advanced vehicles and fuels can go a very long way with regards to achieving petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a very mixed evaluation of the project's approach. One reviewer said they were actually excited listening to the presentation of this project. This reviewer also felt that the presentation had a good intro, citing Secretary Chu's acknowledgement that racing pushes development much faster than development of production vehicles. The reviewer noted that the project is highly visible, especially to knowledgeable, enthusiastic, and often early-adopting consumers. This reviewer also pointed out that it encourages a historically resource-intensive sector to think about being "greener." Sponsoring racing leverages DOE investment very highly and the majority of actual investments are made by the racing teams and their sponsors. The reviewer remarked that the project cannot set, but can influence racing rules set by sanctioning organizations. Another reviewer said that Green Racing is an innovative way to greatly increase consumer awareness, understanding, and acceptance of advanced vehicle technologies and fuels. The reviewer felt that the racing industry offers the ideal venue to expose large numbers of people to the benefits of these technologies and dispel attitudes with regards to reliability, suboptimal performance, and costs, while providing a test bed if you will for automakers to performance test the technologies. The reviewer pointed out that through Green Racing a naturally vehicle-oriented audience can be

reached and dramatically leveraged. Additionally, since some alternative fuels are considerably cheaper than racing fuels, costs can be lowered opening the industry up to new entrants while saving further petroleum.

The first reviewer remarked that the slides comparing race car petroleum consumption on a track to passenger car petroleum consumption on the FTP were kind of pointless and could be misleading. The same reviewer also pointed out that the project needed to be careful of risk that the "bleeding edge" nature of racing innovation and the far more severe duty cycle than for highway vehicles could lead to failures of the green technologies that could inadvertently hamper their adoption. A second reviewer felt that this project is an important DOE VTP investment; however the initial investment of almost $500K for FY 2010 and $800K for FY 2011 may be managed more effectively. The reviewer stated that the approach to the work at present, and as presented, appears very POOR. While the reviewer acknowledged that it may simply have been the presentation as delivered to the reviewers, after multiple questions to the reviewer, it still was completely UNCLEAR, as to what DOE VTP VSS is actually supporting scope-wise in the Green Racing project. The reviewer stated that this needs to be defined for a comprehensive review. A third reviewer stated that it was not clear as presented orally or in PowerPoint form, which aspects of the Green Racing circuit DOE is actually funding. The reviewer felt it would it be better suited to find a stronger management team for this project. As presented, the ANL management team does appear to be managing the funds correctly or to their full potential. A fourth reviewer said that the project team at ANL stated the work is addressing barriers in technology risk and aversion, data collection and “constant technology development” but no data collection or risk aversion was presented. The reviewer stated that “Constant technology development” means nothing to them and that they need data. The reviewer felt that this presentation was VERY disappointing. Green Racing is an excellent topic that merges very well to VTP and VSS interests and would normally provide an exciting opportunity to unique engage the VSS players and stakeholders in community outreach and engagement through technology development, EV issues, and even standards, but this engagement was not presented. The reviewer felt that perhaps some of the information was not delivered as presented. The reviewer mentioned that the project slides state “enhance DOE image”. This reviewer highly recommended that DOE headquarters change the project manager if they wish to enhance, let alone maintain, the DOE image on this project. The project as presented does not enhance DOE’s reputation on the work. The reviewer stated that the project is not delivered with any oversight, management, accomplishments or goals and that this is a disappointment to the community. The reviewer felt without a management change, to one that understands spending tax payer money appropriately, with defined, specific goals, and demonstrating accomplishments, the reviewer would not support further budget on this scope of work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers offered a range of opinions about the project’s technical accomplishments. One reviewer said there is good penetration and visibility of a variety of advanced powertrain and fuel technologies, including race wins by those cars. The reviewer also commented that the green racing simulator appears very effective at educating and engaging the general public. A second reviewer stated that solid progress has been made in advancing the use of biofuels (especially ethanol and biobutanol) into the American Le Mans Series, as well as the beginnings of introductions of HEV racing technologies. The reviewer noted that progress has also been made in advancing Green Racing to Circle Tracks which have enormous outreach potential, and developing a well-received Green Racing simulator. The third reviewer stated that the list of “Technical Accomplishments” under this budget do not make sense. The reviewer pointed out that as listed, DOE claims to have (1) Reduced American LeMans Series (ALMS) petroleum use by 42% at PLM with better competition; (2) Incentivized switch to E85 by all major OEMs in ALMS GT category; (3) Introduced Porsche 911 GT3 R Hybrid in DC; (4) raced at Road Atlanta; (5) Awarded second season-long ALMS Green Racing Championship Awards; (6) Green Racing Champions receive invitations to 24 Hours of Le Mans; (7) Deployed HEV E85 racing simulator at multiple ALMS events; (8) Circle Track Project GREEN car tested using E85, fuel injection, with catalysts; (9) Project GREEN car raced at national event and was competitive; (10) Revamped, improved web presence with expanded media outreach. This third reviewer asked how on earth the DOE budget was actually spent, specifically to ‘”accomplish” such grandiose goals? The reviewer also asked, what website? The reviewer stated that the technical “Progress” on advancing biofuels, as presented, seemed to take credit for the entire Green racing circuit. The reviewer remarked that this is not an appropriate presentation for DOE funding resources. The third reviewer also asked did DOE funds go to develop the Argonne National Laboratory (ANL) “simulator”, as the reviewer still does not know. However, the third reviewer did comment that there were VERY cool pictures of cars.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

A reviewer said there was a huge list of highly relevant collaborations. The reviewer also stated that supporting racing engages a large community of "collaborators" in ways that few other projects can. A second reviewer said that significant and ostensibly appropriate collaboration exists across the racing, automotive, and engineering communities. The reviewer felt that the sky is really the limit here, and as such continued strong efforts should be made to forge further collaborative activities and expand outreach and awareness. This reviewer remarked that it is important to continue and expand strong collaborative efforts with the media (TV, radio, and print) as force multipliers. The reviewer continued to point out that the entire concept of Green Racing has the potential to help "pull" into the market broad acceptance of advanced vehicle technologies and fuels. A third reviewer stated that the collaborations are expansive and felt that it may be better served to have DOE headquarters or another lab collaborator manage this project, if DOE VSS is to continue the investment.

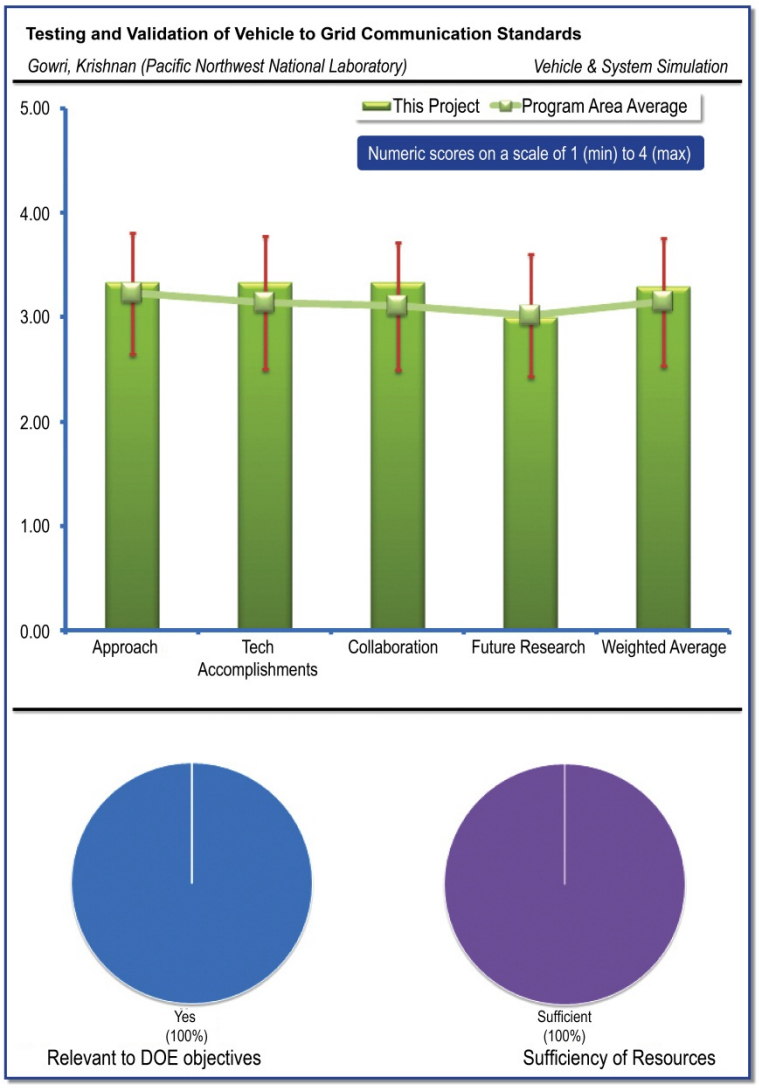
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that the proposed future research was great. The reviewer stated that more of the same successful approach, plus increasing electrification, hybridization, use of biofuels, and possibly energy budgets (e.g., limiting fuel flow and/or quantity). The first reviewer remarked that they would have liked to hear more about the simulator. The second reviewer said the proposed future research is solid targeting further expansion of biofuels into Green Racing, development of new HEP ALMS prototypes in 2012 and beyond, and expansion of renewable fuels to Circle Track racing. This reviewer felt it is important to look hard to the media to maximize positive press coverage and dramatically expand exposure. As stated above, the third reviewer stated that the project slides state “enhance DOE image”. The third reviewer highly recommended that DOE headquarters change the project manager if they wish to enhance, let alone maintain, the DOE image on this project. This reviewer felt that the project as presented does not enhance DOE’s reputation on the work. The reviewer said that the project is not delivered with any oversight, management, accomplishments or goals and that it is a disappointment to the community. Without a management change, to one that understands spending tax payer money appropriately with defined, specific goals, and demonstrated accomplishments, the reviewer would not support further budget on this scope of work.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that the project had great accomplishments and leveraging of the available resources. A second reviewer remarked that they could not evaluate because no clear milestones were demonstrated in the presentation either verbally or in PowerPoint form. A third reviewer felt that the resources are sufficient and appropriate for this task.

Testing and Validation of Vehicle to Grid Communication Standards: Gowri, Krishnan (Pacific Northwest National Laboratory) – vss055



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented that this project directly supports the DOE objectives of petroleum displacement by advancing management of vehicle-to-grid (VtG) communication codes and standards. The reviewer felt that such management and optimization will enhance productiveness of the anticipated 1 million EDV on the road in the U.S. by 2015. A second reviewer said that as PHEV's become more accepted, a significant number of charging stations will be required, and a heavy demand will be placed on the grid. The reviewer felt that it is clear that an effective, and hopefully common communication methodology should be established to assist in billing for power, determining how much energy the vehicle requires, and providing information that could help the utility "level out" power requirements by managing the charging time and charging rate of vehicles. The second reviewer also commented that improving vehicle to grid communications makes the entire process more efficient, which will facilitate growth of PHEV sales, and reduce petroleum usage on a national level. The reviewer went on to say that this project is intended to develop prototype communication modules to determine what is possible and practical, and then to propose communication standards and validation procedures for these communications. The third reviewer felt that plug in hybrids and electric vehicles offer a strong potential to displace petroleum. However, to realize this potential, the charging infrastructure must be established. They feel that this work represents a key part of developing the charging infrastructure.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that the objectives of the work include development of testing and validation procedures for vehicle to grid communication (VGC) standards and technologies based on SAE Documents J2847 and J2931. The reviewer stated that to do this, the project team is building a "VGC Virtual Testbed" and prototype communication modules to establish performance requirements for vehicle and charging station OEM adoption. The reviewer noted that the approach to the bed takes into account an appropriate breadth of communication line options for vehicle to grid (VtG) and vehicle to charger (VTC). The reviewer remarked that the team has chosen communication pathways and architectures that support SAE standard development with the committee input and EPRI requirements documents. The reviewer felt that this is a logical approach to the task. Also, the reviewer remarked that this project leverages work funded by the DOE Office of Electricity Delivery and Energy Reliability (OE). The reviewer complimented that this project is excellent, it would be nice to see more OE-Office of Energy Efficiency and Renewable Energy (EERE) VTP joint projects in VSS. A second reviewer commented that the general approach was to set up a lab test bench procedure to evaluate data

transmission capabilities, using the battery, charger, and EVSE. The second reviewer noted that since currently available EVSE equipment does not include all the capabilities that are likely to be required/desired in the future, a prototype communication module was designed, built and tested. The reviewer pointed out that this was intended to demonstrate the potential communication capabilities that should be included in any future communication standards. The reviewer stated that based on the above test results, recommendations will be made to SAE regarding VGC communications. The third reviewer had a very hard time getting the full big picture view of this program. At the highest level, the reviewer understood the end goal and was in full agreement with it. At the low level the reviewer could see how the testing that was discussed would generate data that would help to achieve the end goal. However, the reviewer could not quite get a clear definition of what specific problem this work would solve or what part of the overall puzzle this work would provide. The third reviewer did note that the level of funding did not seem to be inconsistent with the work being done. However, this reviewer felt the level of funding is clearly not enough to achieve the end goal; this is appropriate, because the project in itself is not supposed to achieve the end goal. But again, the third reviewer could not determine exactly what part of the puzzle this work was supposed to provide.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said the project accomplishments leverage a matching project funded at OE and that it is fantastic. The reviewer also noted that technology development under this award included completion of the laboratory test bed, development of two programmable logic controller (PLC) module prototypes/tested and HMI tested with the PLC modules. The second evaluator remarked that given the relatively short duration of this program, good progress has been made. This reviewer stated that communication test and validation procedures have been developed, as well as the test bed for communication devices. The reviewer pointed out that several vehicle to grid (V2G) systems have been evaluated, and a prototype communication module has been developed to evaluate potential future communication capabilities. Throughout the program, SAE has been advised or progress, and a technical paper was co-authored with several members of the SAE committee that deals with communication standards development. Several sets of recommendations and inputs have been provided to SAE regarding communication standards. The third reviewer's understanding was that the net funding was $375K. For the level, the third reviewer felt that funding the results seemed appropriate. Given that the reviewer could not quite get an understanding of what specific end goal this project has, the reviewer cannot really assess progress towards that specific end goal.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers saw excellent collaborations, and also suggested possible future collaboratiors. One reviewer felt that the partners are appropriate and include SAE, Echelon, MAXIM and Hymotion. Considering the OE awards, partners also include Toyota and Coulomb. This reviewer felt it was outstanding to see OE EERE/VTP VSS "joint" effort funding and felt that there should be more of it. The second reviewer said that significant collaboration and communication has occurred with SAE, as related to V2G communications standards development. This reviewer pointed out that other industry organizations include NIST and EPRI. Furthermore, collaborative efforts have extended to two manufacturers of communication technology, Echelon and MAXIM, as well as a battery and charger manufacturer (Hymotion). The second reviewer remarked that although collaborative efforts have been effective, there appear to be several other DOE sponsored programs that at least touch on the subject of vehicle to grid communications. An improvement opportunity is for DOE to identify potential opportunities for collaboration amongst these various programs. DOE is in the best position to identify such opportunities as they have access to information on all such programs. The reviewer felt that this seems like a missed collaboration opportunity. The final reviewer simply stated that the project had a meeting with both SAE and EPRI.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

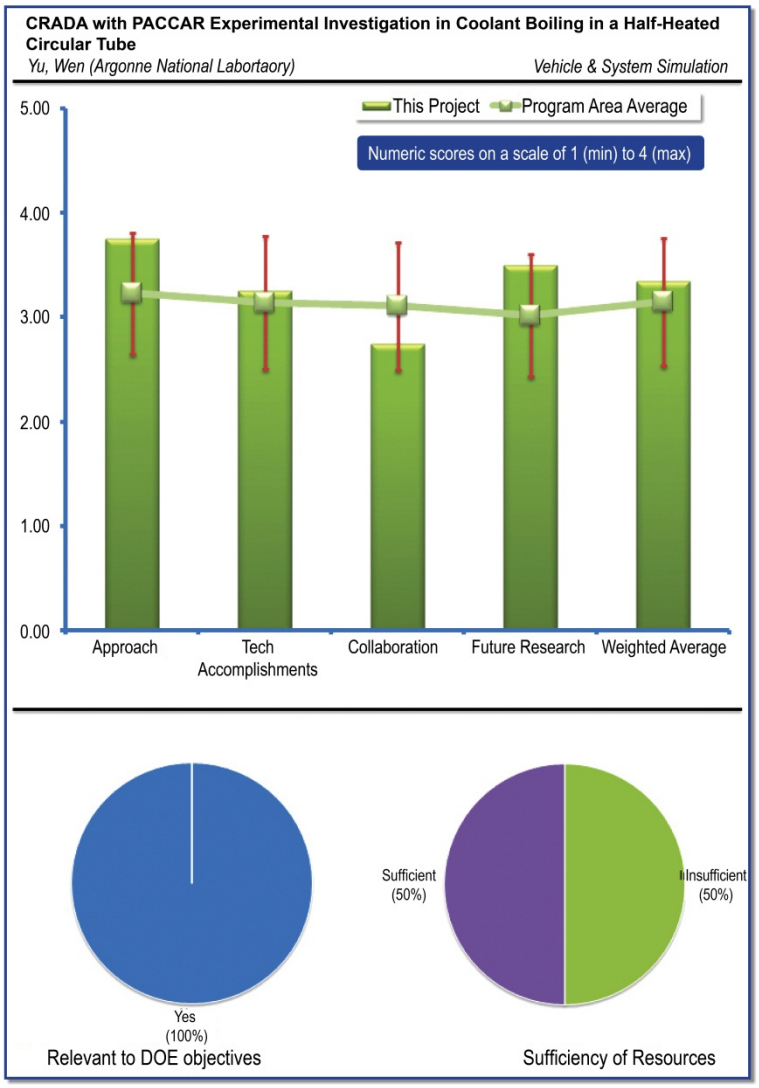
The first reviewer commented that the future work included work with SAE and contributing to J2931 document development. The reviewer pointed out that future experimental development work includes design and development of power line communication module prototypes for control pilot communication (three new modules will be developed based on SAE needs and EPRI

requirements documents). The reviewer said that the team will implement Smart Energy Profile (SEP) 2.0 application layers in the prototypes to test the latency, data rate and error rates. The work joins ANL and PNNL research teams and brings important communication VTG and VTC data to the public. The second reviewer stated that the project will be wrapping up in September 2011 and that the remaining effort will be involved primarily in summarizing work completed to date and continuing to assist SAE committee in development of communication standards. A third reviewer stated that they are essentially repeating previous comments, but thinks the work is good and worthwhile; however, what is really lacking is a clear plan of what the exact end goal of this work is. This reviewer commented that this should be addressed (i.e., some thought should be given to exactly what the end goal is and how that addresses the big picture of providing an integrated grid).

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer said that this project appeared to accomplish much in a short period of time and with limited resources. In that sense, the project team was very efficient in carrying out their tasks to meet key project objectives. The second reviewer thought the resources are appropriate for the work they seem to be doing. Again, this reviewer really had a hard time understanding the big picture plan.

CRADA with PACCAR Experimental Investigation in Coolant Boiling in a Half-Heated Circular Tube: Yu, Wen (Argonne National Laboratory) – vss057



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project directly supports the overall DOE objective of petroleum displacement by investigating and quantifying engine coolant boiling heat transfer in heavy-duty trucks for engine system efficiency and overall optimized thermal control management. The reviewer perceived that such work may influence fuel efficiency and petroleum displacement by reducing parasitic energy losses, reducing size, weight, and pumping power of cooling systems, increasing engine thermal efficiency and improve engine temperature gradients for HD trucks. A second reviewer remarked that this project is indirectly supporting the DOE objective of improved fuel economy and the resulting reduction in fuel consumption on a national level. The reviewer acknowledged that the objective of the program is to better understand and quantify heat transfer capabilities of a cylinder head of a diesel engine. The reviewer pointed out that better understanding of heat transfer capabilities at critical points of the engine allows optimization of the cooling system, including, but not limited to: (1) controlling (hopefully reducing) radiator size; (2) reducing coolant flow rate and also parasitic losses from water pump; (3) limiting hp loss due to cooling fan; and (4) improving power density of engine (allow engine to run at higher hp without concerns over cooling capabilities. Furthermore, the reviewer stated that each of these items will directionally improve efficiency and thereby reduce fuel consumption. A third reviewer noted the project is intended to assist engine analysis/design tools, which will ultimately lead to more efficient engines and cooling systems. The final reviewer was unable to attend the session Monday evening, but based only on reviewing the slides they stated that boiling heat transfer limits efficiency of a wide range of energy consuming devices (computers that use liquid cooling, air conditioning, refrigeration, industrial heat transfer devices and automotive intercoolers and radiators). The reviewer felt that the specific work here on heavy truck engines brings much needed knowledge that is applicable to other fields.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the project takes both an experiment and theoretical approach to the work. The reviewer also pointed out that the work includes experimentally determination of boiling heat transfer rates and limits in the head region of heavy duty truck engines; and mathematical models for boiling heat transfer coefficient and development of engine computer codes for heavy duty trucks. A second reviewer acknowledged that a test fixture was developed to simulate the critical heat transfer point of a cylinder head. The heat transfer coefficient was experimentally determined, using a matrix of coolant temperatures, simulated cylinder head temperatures, and coolant flow rates. The reviewer pointed out that with this information, an effective heat transfer coefficient can be calculated over a

broad range of conditions. This heat transfer coefficient will become an input parameter for a complex CFD model that will be used to ultimately optimize cooling capabilities through geometry, flow, and coolant temperature parameter changes. The first reviewer also had a question concerning the technical approach as whether the results are "transportable" to other critical geometric points of the engine, or if it is very specific only to the cylinder head section that was the model for this experimental set up. The reviewer pointed out that this potential lack of flexibility would limit the broader use of these experimental data to evaluate other portions of the engine. A second reviewer said this was one of the better cases where the presenter could clearly explain how his piece fit into the big picture. The reviewer stated that ultimately the "impact" slides that are shown are always at a very high level, while the research programs are often fairly small. The reviewer pointed out that here the researcher could clearly explain where the work fit and how it helped to achieve the big picture. The reviewer pointed out that they are always trying to get this information, but have very mixed success. The final reviewer was unable to attend the session, but based only on reviewing the slides the reviewer stated the project is a well-organized study, with solid experimental design and construction of equipment that appear well-adapted to measure regime of engine operations. Furthermore this reviewer pointed out that the materials, material surface preparation and material surface characterization weren't noted other than "cast iron material". The reviewer understands this may be proprietary information of PACCAR but inclusion of this information will improve the quality of the work. Also, the reviewer noted that understanding influence of manufacturing variation and of processes to modify surface characteristics may be important to ensure that results measured in the laboratory hold up in on vehicle performance evaluation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that the experimental development and design is creative and built on a modest budget. The reviewer pointed out that the facility is a new addition to the ANL APRF. The reviewer remarked that Labview is used to implement and track facility data, and remarked that technical accomplishments are impressive, fast and performed on a very modest budget. A second reviewer commented that the efforts to date have focused on planning the test, designing the bench test set up, and procuring and assembling components for the test bench. The test fixture is nearly ready for checkout and initial data collection. The reviewer noted that no data have yet been collected. The reviewer remarked that the results of effort to date are acceptable, although it appears to have taken a longer than expected time to generate the test plan and design and build the test set up. A significant portion of the effort to date appears to have been devoted to selecting appropriate instrumentation for measurement of test parameters. A third reviewer stated that the laboratory work seems to be well developed and an appropriate test rig has been built. The final reviewer was unable to attend the session, but based only on reviewing the slides, this reviewer stated that it is early in the project but advancing nicely.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented that there is an increase in project collaboration to extend the range of the work and PACCAR is the primary collaborator through a Cooperative Research and Development Agreement (CRADA). The reviewer remarked this is a nice opportunity for university outreach, graduate work and/or thesis. A second reviewer stated that collaboration has primarily occurred with PACCAR, the CRADA partner. This reviewer pointed out that given the length of time devoted to "designing the test plan," as well as designing and building the test bench, one wonders if there was expertise elsewhere within Argonne or at one of the other National Labs that might have facilitated this effort and accelerated the process. The third reviewer simply stated that the project is working with an OEM. The final reviewer was unable to attend the session Monday evening, but based only on reviewing the slides they felt the division of experimental work at ANL and computational work at PACCAR is logical. The final reviewer pointed out that the final phase of interpretation and evaluation is unclear as to how the heat transfer code will be cross checked compared to experimental results. However, the reviewer noted that the project has not advanced to that phase.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

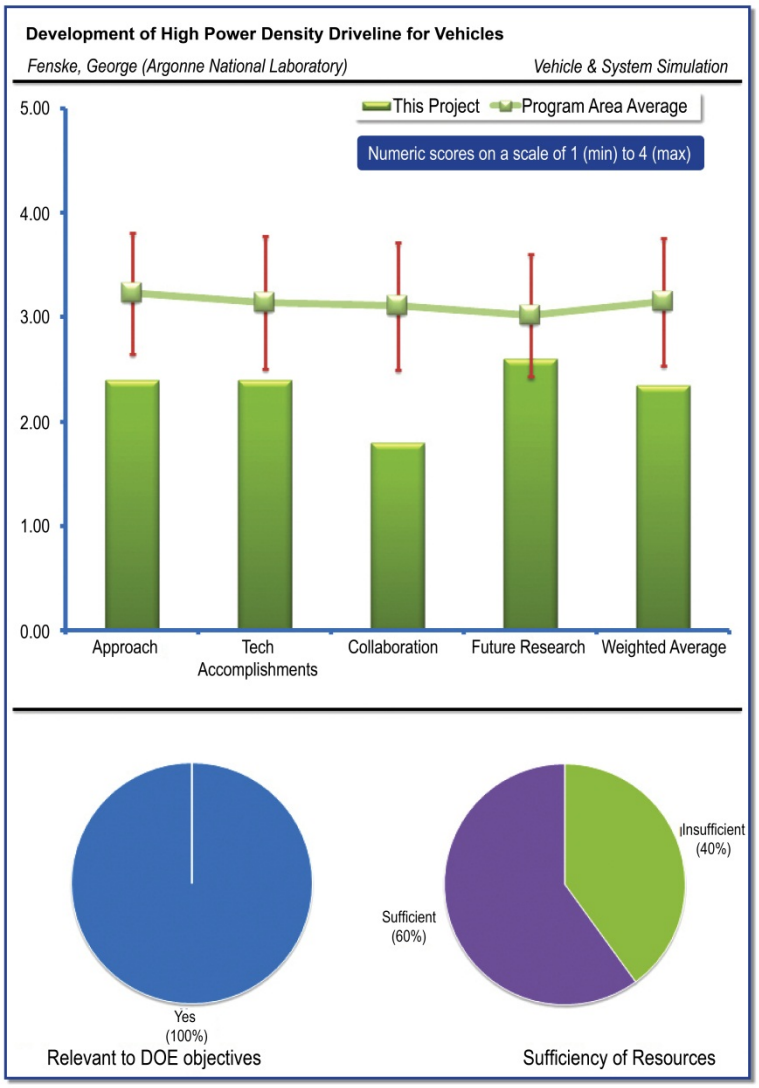
The first reviewer remarked that the project is well-positioned for its future work now the testing prototype is built. Future work includes experimental facility verification, detailed boiling heat transfer tests and experimental data comparison, interpretation, and correlation. Furthermore, the reviewer pointed out that theoretical work includes computer code optimization and validation. The

first reviewer felt that the approach to future work is logical and results will be telling. The second reviewer stated that future work will be focused on (1) checkout of the experimental test set up; (2) data collection; and (3) use of results to modify/refine heat transfer model. The reviewer noted that an opportunity for improvement in the presentation would have been a visual that showed the complete matrix of testing to be completed. Such a matrix would have shown all parameters to be varied and the range of variation. The reviewer pointed out that it is perhaps somewhat surprising that the future work noted will take approximately two years to complete; it is not clear from the presentation what percentage of the time will be devoted to testing versus using the results to complete the heat transfer modeling analysis. A third reviewer stated that the remaining work seems appropriate with funding level and general vision of what this work is to accomplish. The final reviewer was unable to attend the session, but based only on reviewing the slides they noted that the future research addressed existing materials and surface finishes and appears to assume that all future improvements will come from design changes to the coolant boilers (radiators, intercoolers, etc.) or perhaps change of water/ethylene glycol ratio. This reviewer said that it appears that the study could be easily extended to investigation of surface roughness, coatings and similar technologies to enhance heat transfer coefficient of the cast iron surface.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer was unable to attend the session Monday evening, but based only on reviewing the slides they remarked that funding appears minimal for the study to advance quickly. Elaborating, the reviewer stated that the funding looks like enough to cover equipment and perhaps 1/4 to 1/2 of a lab technician and engineer. The reviewer felt that with additional funding it appears the project could advance 2 to 4 times faster. A second reviewer said that the project should extend the scope of project; with a further detailed scope of work, and extended collaborators, DOE may consider increased funding. Another reviewer felt that with four individuals contributing to this program, there appears to be sufficient resources to carry out the project plan. The reviewer said that the time to complete all activity seems relatively extended, given the resource availability. The final reviewer stated again that this seems to be a well-designed project that is on track.

Development of High Power Density Driveline for Vehicles: Fenske, George (Argonne National Laboratory) – vs058



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. The first reviewer believed that this project directly supports the overall DOE objective of petroleum displacement. The reviewer pointed out that various projects have shown that 2% to 5% fuel savings may be accomplished by a 10% reduction of vehicle weight (in all classes of vehicles/impact variable per vehicle). The reviewer pointed out that this project investigates weight of the vehicle driveline that is approximately 20% of total vehicle weight. The reviewer pointed out that of course, safety, durability and reliability must be maintained. The second reviewer noted that weight reduction and subsequent reduction in fuel consumption does support DOE objectives. Furthermore, the reviewer commented that in the commercial arena the reduction in weight yields opportunities for increased payloads and subsequent reduction in vehicles on highway which has additional benefits. The third reviewer felt that the project is relevant if the stated goal (increase power density of transmission components) could be achieved; lighter weight subsystems could be produced, leading to lighter weight vehicles and reduced fuel consumption. A third reviewer stated that the project directly addresses parasitic frication losses and weight reduction. The reviewer elaborated that lightweighting in structural, frame and body, attacking the heavy drivetrain weight is needed but durability risks are higher. The reviewer pointed out that there is a clear need for this work as transmission, axles etc. are a large portion of vehicle weight. This reviewer noted that "Power density = higher load through smaller surfaces". The reviewer also questioned, Is not a lighter powertrain also higher performance? (inertial responsiveness, etc. more to performance than just friction). A fourth reviewer remarked that smaller components should need less energy to turn where stopping and starting are involved because of rotational inertia. Also, vehicle weight savings-saves fuel.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the project proposes to reduce driveline size by increasing the power density of the systems, and takes a look at various components (and various aspects of these components). Furthermore, the reviewer stated that the project proposes to use high power density gearing and bearings to reduce the size of the planetary gear system, and thus begin to study materials and engineering aspects of such components (wear, scuffing, and contact fatigue (pitting)). The reviewer noted that the team considers the effect of integrated materials, surface and lubricant technologies that may impact results. The first reviewer pointed out that collaboration with OEM partners, ANL proposed to develop and evaluate prototype HPD gearbox for transportation vehicles. The first reviewer remarked that while it is nice to see the topic, and the "concept" of the approach is excellent, the approach to the work is very broad with SO MANY engineering variables, let alone the materials variables, that the approach seems somewhat disparate, as

presented. In some sense, the approach is too broad. The approach to the task does not appear as systematic as it could, in both materials and engineering aspects of the work. The second reviewer felt that the approach to explore and evaluate integrated materials, surface and lubricant technologies and create models to determine kinematics is a logical plan. Unfortunately, the reviewer pointed out that this approach is only focused on an automatic transmission, and does not consider other non-planetary gear sets. The third reviewer stated that collectively there seems to have been three projects leveraging the tribological knowledge/expertise of Argonne researchers. The reviewer noted that as a whole the the projects represent a fairly modest budget and as a whole, the work seems to have been very good and very worthwhile. However, the reviewer points out that this particular project does not seem to be well conceived. Researchers/lab seem to be suited towards conducting basic research and there is a need for basic research. However, the reviewer again points out that this program seems to try to look at more applied research and seems to be struggling. A fourth reviewer stated that there was a good approach to an area that has been quiet: planetary gears and bearings with focus severity of contact for scuffing and fatigue. The reviewer pointed out the integrated materials, surface and lubricants approach. The reviewer commented on the approach of (1) modeling of size and weight vs. contact forces, (2) State of art search for technologies capable of meeting requirements, (3) Develop new if needed and integrate with others, (4) Then prototype with OEM and eventually hand off. The fourth reviewer also noted that cost and economics will play heavily in the eventual commercial adoption. This should be better addressed in the approach. The final reviewer stated that the material and lubricant paths are viable ones, but the path to gear tooth redesign could be explored more.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that most of the work accomplished includes gear box modeling and planetary size reduction assessment. This reviewer said that with the gear geometry and parameters unchanged, results show planetary gearbox size reduction will result in substantial increases in contact and bending stresses and reduction in lubricant entrainment velocity. The reviewer acknowledged that the new severe contact conditions in gears and bearings as and result of size reduction will have significant effect on gearbox reliability and durability. The second reviewer felt that the lack of participation from an OEM/Tier 1 supplier and limited access to proprietary software from the OEMs appears to have had an impact on accomplishments. The third reviewer felt that most of the work is to be done since the project has only been underway a few months, as was mentioned. The reviewer pointed out that the calculations and results of the increased stress in the gears are valuable. A fourth reviewer pointed out that this is a new project just organizing and that there are nice analyses to understand the problem. The reviewer felt that the project is off to a solid start, but more work may be needed to identify technologies used in other industries that could be applied here. The reviewer also noted that clarification of needs between bending fatigues, contact stress and boundary layer sliding speed is a good approach to begin an optimization. Optimization with known technologies using improved modeling techniques may allow project to meet goals. However, the reviewer said that identification of new technologies is likely necessary. Technologies to improve contact fatigues (coatings) are available (racing, aerospace) but may be too expensive. The reviewer asked if there should be an economic/business case component to the project to help understand markets that may best use the results. The reviewer recommended that some sort of cost/benefit analysis be added. This reviewer suspected that this is an area that can afford to spend much more on coatings than current OEMs accept. The fifth reviewer stated again that the basic project does not seem well designed. This reviewer pointed out that comments from last year suggest more OEM involvement was needed and that this does not yet seem to have happened, so it seems that researchers spent a lot of time in areas slightly outside of their expertise (trying to "fill in" for OEM). The reviewer stated that researchers have been trying to understand tradeoffs gear designers make in balancing gear life based on various failure criteria—bending strength, contact strength, wearing, scuffing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers suggested additional collaboration. The first reviewer said that the partner is General Motors. Concur it would be nice to collaborate with DOE Wind TP. The team needs to invite more partners. The second reviewer stated that there is no OEM at this time, only General Motors was approached with no response. The reviewer was surprised that Allison transmission was not involved as they are solely a manufacturer of planetary gear set transmissions. The third reviewer pointed out that reviewer comments from last year stressed the need for collaboration. The reviewer noted that collaboration with General Motors is mentioned, but the reviewer did not believe much has occurred to date. This reviewer's comment for this year is to repeat comments from last year: collaboration is needed. The reviewer is concerned that researchers will not be able to establish this collaboration given their current path. The

reviewer stated that it would seem that the researchers want OEMs to fully outline their methods for balancing gear life, based on all criteria, in a public forum. The reviewer is not sure anyone will sign up for this. A fourth reviewer stated that the project is just starting and there are no firm partners yet. The reviewer felt that the project will accelerate with the right OEM partner and that it is a key risk for the project. The reviewer said that bringing in aerospace partner is good approach and that more work is needed in this area. The reviewer stated that a racing engine partner, oil and gas, biomedical, coating partner or a fluid power partner may bring new ideas from industries that now may much more for their surfaces than automotive applications. The final reviewer noted that as was mentioned by the presenter, a committed partner to provide a target gearbox would be helpful. It would help to have more concrete collaborations from other gearbox makers (such as for the mentioned helicopter) that need to minimize weight.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the project will look at the effect of load, speed and lubrication on performance on the gearbox and develop and integrate materials, surface and lubricant technologies to meet and perhaps exceed tribological performance targets for smaller and lighter HPD gearbox for transportation vehicles. In theory, this project's future work is great, but it is not clear yet how the work will be accomplished and seriously optimized. The reviewer felt that the project seems to need further refinement on approach so results do not digress. The reviewer quoted the presentation: "Technology transfer and adoption the ultimate end result"; the reviewer stated that this project seems a long way off with limited budget to accomplish tech transfer. Another reviewer remarked that there is still a lot more modeling and development to be done before this project can demonstrate a commercializable opportunity. The third reviewer said that IF an OEM comes on board with a specific program then all will be well, but this reviewer was very concerned that this will not happen. Instead the reviewer thought that maybe something more basic (general questions to OEMs about improvements that could increase power density, freeing researchers to perform more basic research) would help; alternatively other government labs may be able to help (perhaps NASA Glenn Research Center in Cleveland, OH). The fourth reviewer stated that OEM involvement to help guide and direct is crucial and that applying technology from engine and other areas, and conducting experimental and modeling validation is great. This reviewer was concerned ANL will experience a steep learning curve if OEMs cannot be brought in an effective manner. The final reviewer stated that more material on paths to gear redesign would be helpful.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

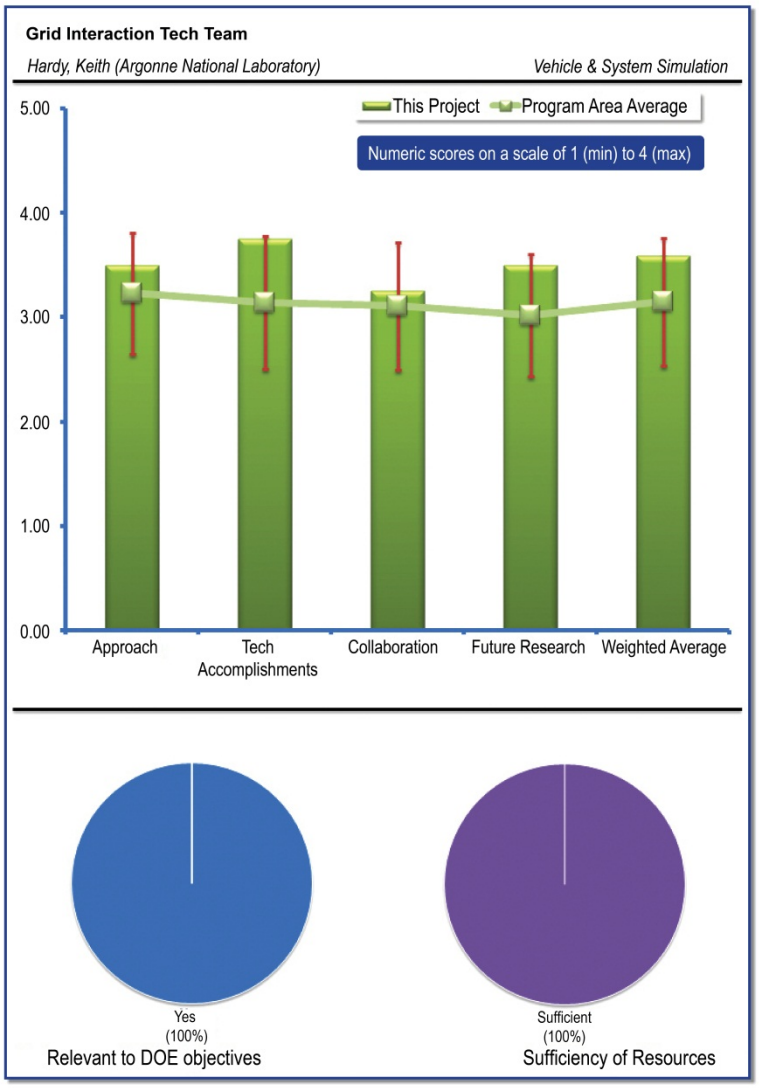
The first reviewer stated "see above". Another reviewer remarked that funding is small on this project and that without the support of a transmission manufacturer this project has limited opportunity for success. A second reviewer stated that the researchers and lab are very good; however, this project seems to have moved out of their core area of expertise. The reviewer felt that some small changes in approach could get things on track. This reviewer felt that they should really not have to give a low score when the research done in the lab is good, needed and the overall budget is quite reasonable. The reviewer requested that the project please try to fill in the gaps that seem to be present. A third reviewer remarked that resources appear sufficient to start investigation but will need to ramp up if OEMs join the effort. The final reviewer agreed with the third reviewer by stating that the resources are sufficient this year. This project would likely need to continue into the following year to achieve its goals.

Grid Interaction Tech Team: Hardy, Keith (Argonne National Laboratory) - vss059

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?



Reviewers perceived that this project supports DOE's objectives. One reviewer stated that the project promotes implementation of and overcomes barriers to grid-connected vehicles that can use electricity in place of petroleum for some or all of their driving. A second reviewer felt that this project is relevant and pointed out that it is led by K. Hardy (ANL) and directly supports DOE's overarching mission "to ensure America's security and prosperity" by addressing its energy, environmental, and nuclear challenges through transformational science and technology solutions. The reviewer remarked that the project VSS 059 directly supports the mission of DOE's VTP program to develop more energy efficient and environmentally friendly highway transportation technologies that enable the United States to use less petroleum. The long-term aim is to develop "leap frog" technologies that will provide the United States with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment. The reviewer noted that this project addresses a critical aspect of electrification transportation infrastructure (grid interaction) and its development, and addresses key challenges to make Electrification Transportation and EDV systems a standard in the U.S. and abroad. The reviewer felt that a fully loaded EDV and grid interaction system for the United States could provide energy efficient and environmentally friendly solutions that could greatly reduce the nation's dependence on petroleum. A third reviewer felt that grid electric energy can displace significant petroleum fuel energy and that this work enables grid energy to be effectively used for transportation. The fourth reviewer stated that the advances in the vehicle/grid interfaces including interoperability, communications, harmonization of connectivity standards, and cost reduction of technology is critical to the successful implementation of plug-in electric vehicles on a mass scale. The reviewer noted that this is a new and rapidly evolving area involving many stakeholders including automotive OEMs, EVSE manufacturers, utilities, and HAN suppliers, as well as potentially renewable energy providers. The reviewer noted that failure to adequately address vehicle/grid interface challenges in a timely manner has the potential to significantly impede or even prevent the successful implementation of PEVs in the relatively near term. The reviewer stated that successfully addressing these issues and staying ahead of the technology curve can accelerate implementation of PEVs in the consumer market as well as facilitate earlier and wider implementation of renewable energy sources in support of PEVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that there was an appropriate focus on development of standards and enabling technologies. The second reviewer said that the project has produced significant results and reached numerous performance goals since its inception of funding (~ $900K in FY 2010), including creating a national permitting standards template for EVs that was transitioned to Clean Cities. The reviewer felt that the approach is widespread and comprehensive and includes appropriate stakeholders to achieve results. A third reviewer stated that this area is difficult to work in effectively, but the team has done a very good job. The final reviewer commented that the approach is sound, tapping input and recommendations from a broad range of stakeholders, although it is not readily apparent how specific tasks are chosen. The reviewer assumed that it is a consensus process among grid integration tech team (GITT) members. It appears the immediate GITT team and project consensus process does not include industrial communications/networking/software firms. The reviewer commented that maybe it can be inferred they are implicitly included via the utility and automotive OEM representatives on GITT. If not, the reviewer points out that it may be an avenue for consideration.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked that the National EVSE Installation Permit Template will make it easier for consumers, fleets, and cities to deploy plug-in vehicles. The reviewer stated that the standards validation and work on communication between EVSE, EVs, home and metro area networks, and grid are key enablers. This reviewer said that prototyping of the low-cost End User Measurement Device (EUMD) that can replace the need for a second smart electric meter for a home vehicle-charging circuit is a very useful accomplishment. Another reviewer said that working with OEM partners, and key supplier partners, the project team has future work planned and is appropriate and on-schedule, and uses the budget appropriated adequately and efficiently. The reviewer noted that hardware and software development (test capability to evaluate SAE J2847 messages) across the vehicle-grid connection between the vehicle, EVSE, home gateway and utility, and representative human-machine interface (HMI) to facilitate the evaluation. This reviewer noted that second generation will transition to third generation at the end of FY2011 with the necessary field integration in FY2012. This reviewer said that OEM and utilities collaborators are appropriately engaged. International partners are appropriately engaged. UMAN and Compact Metrology projects are logical, approach is sound, and on schedule. The final reviewer stated that the technical accomplishments are basically in several areas, including enabling technology development, support for codes and standards, and facilitation of international harmonization. The reviewer said that significant hardware and software progress has been achieved for metrology and communication technologies. The reviewer said the project focuses on key enabling technologies to support the vehicle/grid interface system and may serve as a forcing function to accelerate advances in the commercial sector. Overall, the technical progress is good to impressive given the start date in 2009 and resources devoted to this task.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers provided suggestions about possible future collaborators. One reviewer noted that collaboration includes electric utilities, PNNL, NREL, NIST, EU (through NIST), and China. The reviewer also pointed out that collaboration includes U.S. Big 3 automakers, but apparently not any other automakers with a U.S. presence. The reviewer stated that it seems like it would be stronger if coordination/collaboration efforts included those as well. A second reviewer noted that all of the standards organizations are difficult to coordinate, but the team has done very well so far. While a third reviewer said that the overall collaboration is good across utilities, automotive OEMs, and the government including National Labs. As alluded to earlier, the reviewer went on to state that it may be beneficial to expand direct cooperation and involvement with commercial communication, software, networking firms. The final reviewer responded with four questions: (1) Why is Nissan not an OEM partner on this project, given the extent of Nissan on the ECOtality American Recovery and Reinvestment Act (ARRA) award and its importance as a stakeholder in this field of integration and standards? (2) Why/how is NREL collaboration on this project, to share its work in renewable integration? (3) How does GITT now fit into U.S. Drive, and is this seamless with the new initiative? The reviewer assumes, but will/should Tesla now be engaged in this project as a collaborator/stakeholder? (4) How well is NIST actually involved? Could they assist more?

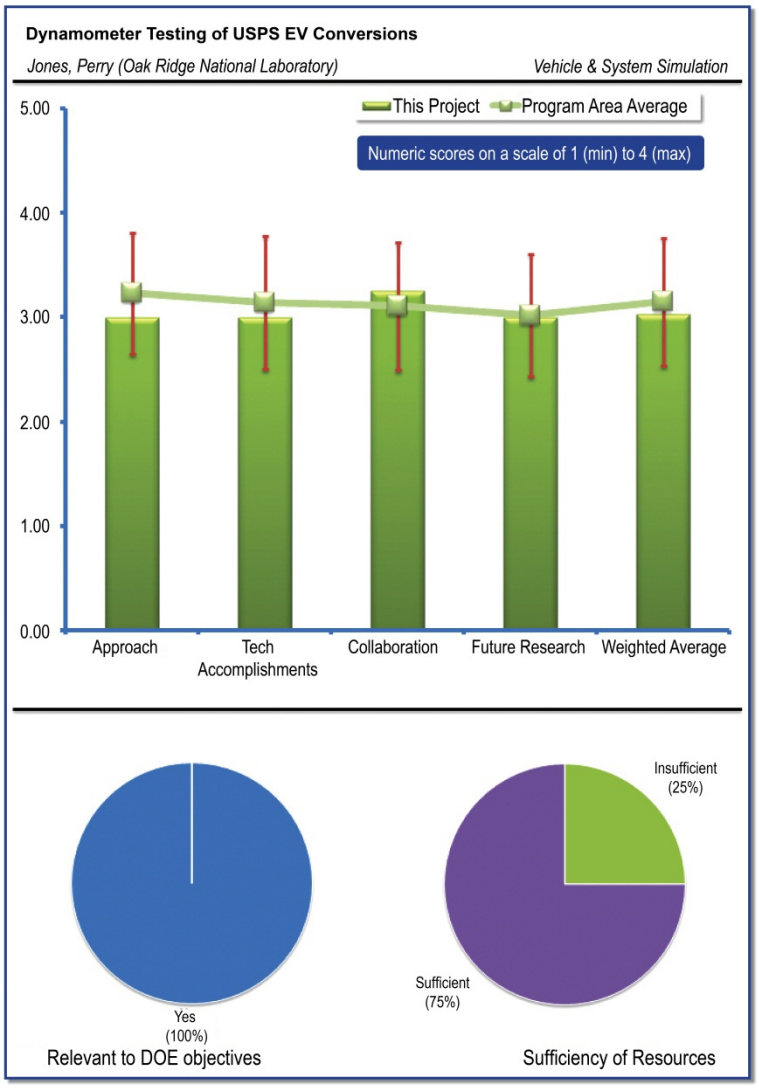
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The reviewer remarked that development of smart-grid communications architecture is appropriate and will be valuable. The reviewer remarked that (International) standards harmonization is a key enabler for leveraging large-scale private investment in vehicle and support equipment development and deployment. Another reviewer said that joint work with DOE OE is commendable, but must be expanded. Cost targets are a start at collaboration, but this topic should eventually be a strongly supported OE effort with VTP. Interoperability remains an outstanding challenge for this field, and should continue to take a front seat for support, scope and budget. The reviewer also suggested that attention be paid to lowering cost charging infrastructure, plus international collaborators, plus OE wireless fast charging. For interoperability, the reviewer felt that the field and stakeholders need to better communicate data and standards to accelerate standard development. This reviewer questioned, this may not happen fast enough for OEMs? The final reviewer noted that future activities are projected to include development of advanced communication architectures for the Smart Grid, compact metrology development and testing, assessment of cost reduction technology for charging infrastructure, inductive charging, and harmonization of standards. The reviewer remarked that all are important areas and efforts may be needed to systematically prioritize (if have not been already) all these important areas and consider if some elements could be delegated more heavily to the commercial sector.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that this project should continue to be supported at its maximum requested levels. This project topic is critical to the national energy security environment and reducing the nation's dependency on petroleum. The reviewer said that the team leading the project is skilled and well-versed in leading a project of this scope and breath. The reviewer stated that the budget is reasonable, however if more funds become available, an increase may be suggested. Another reviewer stated that the financial resources appear relatively sufficient but additional human resources may be appropriate given the technical nature and breadth of activities under this task.

Dynamometer Testing of USPS EV Conversions: Jones, Perry (Oak Ridge National Laboratory) – vss060



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project supports product developments and acquisition decisions that could lead to large-scale deployment of EVs to replace gas-guzzling USPS LLVs. The presentation claims that the overall USPS fleet is "the largest non-military fleet in the world" and LLVs are a substantial portion of that fleet. Another reviewer said that this project does help support the USPS's efforts to electrify their fleet. A third reviewer stated that electric vehicles, which may replace petroleum-using vehicles, will need dynamometer testing regimes for design as well as to understand their benefits.A final reviewer stated USPS is the largest non-military fleet in the world using 650 million gallons of fuel in 2010. The reviewer pointed out that USPS is very sensitive to fluctuations in fuel cost and is facing an enormous competitiveness challenge with regards to costs. The final reviewer stated that electrifying the USPS has the potential to save significant amounts of petroleum fuel, dramatically increase visibility for electric-drive vehicle technologies, improve the economic bottom line, and enhance driver working conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the project is using dynamometer testing of USPS electric-drive LLVs using standardized procedures. The reviewer also commented that use of USPS's "worst-case" cycle is valid, but it might have been more relevant to run more typical USPS cycles and sensitivity analyses too. The reviewer felt that the lack of HVAC loads may make data less useful. The reviewer understands that USPS directives may have constrained what tests were done and how. A second reviewer said the only real shortcoming seems to have been customer imposed. Ultimately drive cycles and accessories make a big difference when evaluating fuel economy and range. It is really too bad the USPS did not leverage the expertise in various DOE labs (e.g., NREL, ANL, and ORNL) when it comes to the collection and analysis of driving cycle data and generation of appropriate drive cycles. Again, the reviewer felt that it is hard to really hold this against the project. (The customer already had a drive cycle and wanted to use their drive cycle). A reviewer asked if a Volt or Leaf is not an option but would more standard vehicle being "mass produced" be possible? Is there nothing like the Ford Ranger based-USPS vehicle of the past? The reviewer thought it would be interesting to know how five different up-fitters were picked and the criterion for picking them. This reviewer also felt that it is valuable to get the drive cycles from real world data. The final reviewer stated that this project encompasses baseline dynamometer testing of five USPS long life vehicles converted to electric drive using various battery technologies. The reviewer said the approach is solid if conventional and electric vehicles utilize the SAE J1634 test procedure coupled with development of a USPS worst-case delivery cycle; conducts vehicle track

characterization; conducts dynamometer testing; and compares and validates with field usage data at INL. The reviewer pointed out that no accessory (A/C nor heat) loads are incorporated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that it is a small project and started 11/10, now complete. The reviewer commented that it seems like a good characterization of the vehicles given the small resources, sample size, and constraints. The reviewer noted that selection of the drive cycle to use appears to have been challenging, but they feel the dynamometer testing itself appears straightforward. A reviewer stated that it seems a suboptimal choice was made for the driving cycle. The reviewer felt that not much time was spent reviewing possible cycles and selecting appropriate cycles. However, it also seemed that this was a customer choice. The second reviewer stated that the energy cost per mile and regenerative braking effectiveness are good data with which to make component and system choices. Production system payback time would also be helpful. The reviewer said that it will be helpful for future designs to have representative delivery cycle. This reviewer commented that the results pointed out charge time to USPS and the need for Level 2 charging. The third reviewer said technical accomplishments are completed and in-line with task scope. The reviewer thought that it is interesting how test results vary by conversion vehicle /battery technology, leading to impressions that different vehicle/battery configurations are most appropriate for different routes as some rather significant differences in efficiency are demonstrated. The reviewer noted that differences in regenerative braking effectiveness are even more pronounced. The reviewer commented that drive cycle cost as low as $0.10/mile is demonstrated based on electricity at $0.12 per KWh AC. The reviewer felt this indicates significant potential fuel savings exist at economically viable conditions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that ORNL worked with USPS, INL, and ECOtality. The reviewer went on to point out that there actually quite a lot of collaboration for such a small project. Another reviewer commented the project work was carried out with other labs and the USPS and is well-coordinated. The third reviewer stated that collaborations are relatively narrow but appropriate for this task. Collaborations are with USPS and INL/ECOtality for vehicle prep and field data collection and analysis. A final reviewer remarked that some extra modeling would seem to have been very useful. The reviewer did gather that the modeling was begun at ORNL; it would have been nice to have seen a little more, although the reviewer was not aware if there was much funding to support this. The final reviewer commented that there was good collaboration with INL and end customer (USPS).

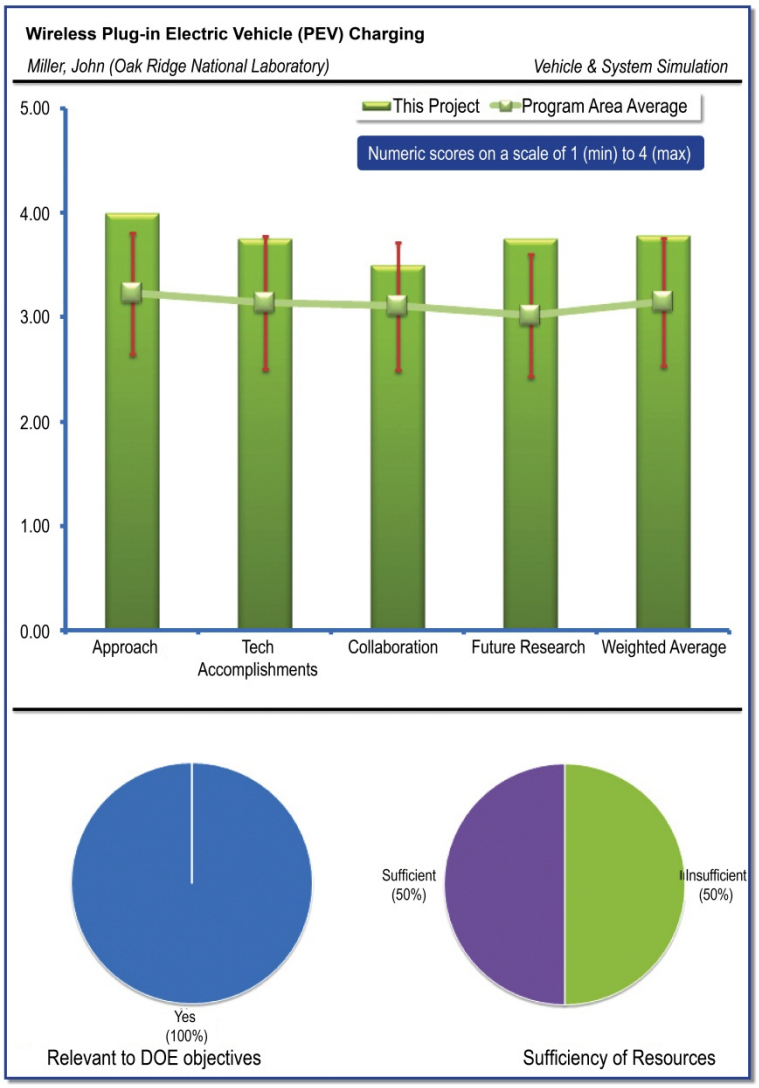
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer stated that the project is reportedly complete and there is no more funding, yet several follow-up activities are described. The reviewer felt it is unclear how these follow-up activities fit into the overall project timing or funding, but assuming the follow-up activities occur they seem good. The second reviewer commented that they liked the proposed use of "in-use" drive cycle information and more extended use of modeling and simulation. The reviewer remarked that both seem to be appropriate (and help address the only real shortcoming of this project, which again does not seem to have been the choice of the researchers on this program.) A third reviewer stated that the other DOE project will correlate the projects dynamometer work with road testing. This reviewer asked if the work will guide other vehicle choices in the future. The final reviewer remarked that the proposed future work is to tap results to further assess drive cycle impacts on technology applicability, establish a baseline vehicle as a platform for architecture sensitivity studies, and to use modeling to achieve the maximum regeneration scenarios. The final reviewer said that using results from this project (and possibly others) as a basis, it may be beneficial to conduct simulation studies of various battery/powertrain/regenerative braking combinations for eLLVs under a variety of drive cycle scenarios to optimize identification of the efficiency sweet spot.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that there were good ideas for future work but the project is completed. A second reviewer stated that the project is complete. A third reviewer stated that the current phase of project is completed. Resources were sufficient and appropriate.

Wireless Plug-in Electric Vehicle (PEV) Charging: Miller, John (Oak Ridge National Laboratory) – vss061



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers thought that the project supports DOE objectives. The first reviewer felt that the project was relevant and directly supports overall DOE objectives of petroleum displacement by supporting advanced technology in EDVs. The overall project is development of a wireless charging system for PEV stationary and dynamic conditions. A second reviewer stated that this is one of the most phenomenal projects that they reviewed in the VSS area. The reviewer stated that they would never have dreamed of such high efficiencies could be accomplished in non-contact space. The reviewer stated that they can only imagine how many challenges lie ahead (durability, political on a local basis, every imaginable angle). A third reviewer stated that the development of Wireless Plug-in electric charging system is a significant step towards greater acceptance and hence deployment of electric vehicles. The reviewer felt that this is in-line with the DOE's objectives. A final reviewer stated that this work is an enabling technology for adoption of PHEVs to reduce petroleum fuel consumption.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that this team and its approach is outstanding. The reviewer remarked that the performance goals and objectives are clear and well defined. The reviewer pointed out that the team will demonstrate 90% transfer efficiency from plug to battery at SAE J1772 Level II power of 3.6kW to 19kW. The work complies with SAE J2954 Wireless Power Transfer (WPT) emissions guidelines of 500uT in active zone and <62.5mG outside the active zone. The project Target for Vehicle application: Level III >60kW to vehicle in motion. The reviewer said that the team is working with RF power experts and ORNL fusion research teams to accelerate the innovation. A second reviewer felt that the use of field shaping and magnetic resonance is an interesting approach and does offer a robust solution to coil misalignment and power transfer. The reviewer commented that it does not require that the PHEV/EV operator to precisely park the vehicle over the charge pad, making it more acceptable for the general public. The final reviewer stated the project had a very good plan for exploratory work and milestones.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated the three completed milestones: (1) Completed three iterations of antenna design, (2) Completed skin and proximity effect model and simulation to understand power loss mechanisms, and (3) Completed current sensor scale calibration. The reviewer said that the initial focus of the work is on efficiency, not power. The reviewer also said that the physical effects have proven

most challenging, such as resistance in transmit coil and capture coils. The reviewer stated that the team now has a much better understanding of the parasitics. The reviewer also stated that the team had to calibrate sensors, optimize coil shape excreta, and plans a demonstration in 2012. A final reviewer remarked that the three iterations of coil designs and the lessons learned so far clearly shows solid progress and technical accomplishments.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer remarked that the project cannot get a stronger, more experienced team for the work and that it was nice to see BMW participating. A second reviewer stated that they were surprised that there is no commercial company participating in this project. This reviewer stated that an infrastructure company that could commercialize this technology would be a key asset to this project.

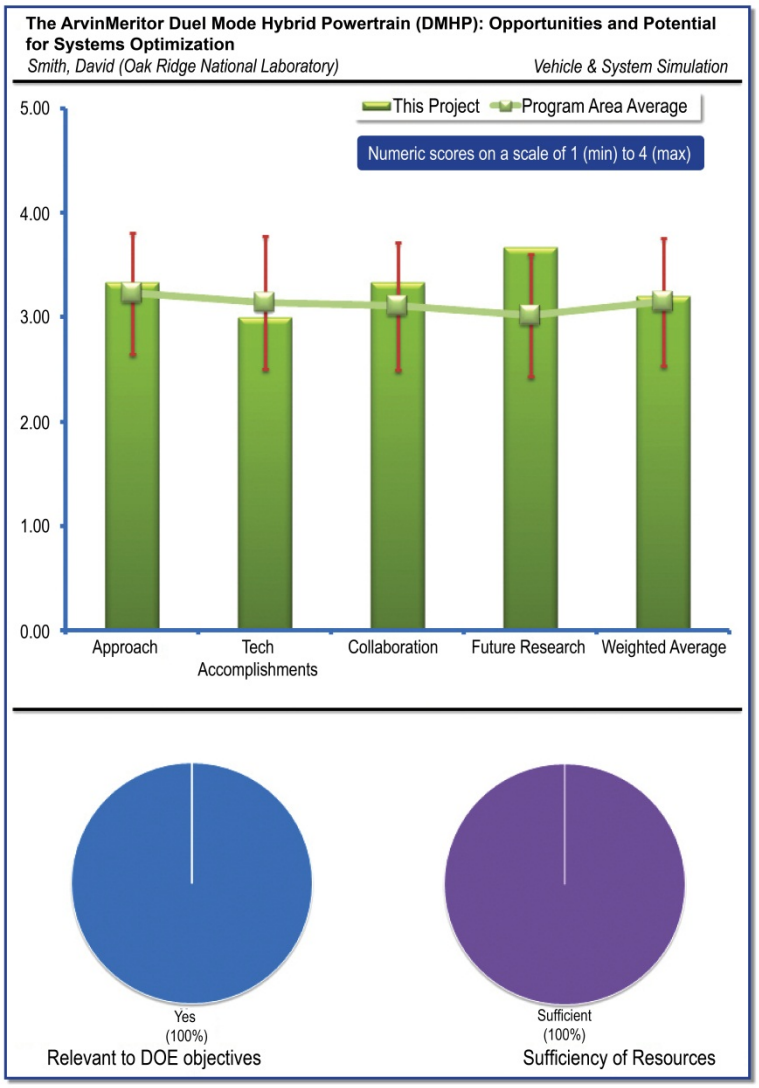
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer stated that the future work will need more efficient power inverters, more communications and controls along with security protocols. The reviewer pointed out that continued work includes design, model, simulation and fabrication of strip line power cables, characterization of antenna shielding effect in proximity to concrete and vehicle chassis floor pan galvanizing, and refinement of design for vehicle integration and stationary vehicle charging demonstration. This reviewer stated that the project is awesome and that it has an experienced team at its helm to see to reality. The reviewer stated “INVEST in this project”. Another reviewer commented that continuing the antenna design and development towards an efficient energy transfer system is critical. They also felt that turning this energy transfer system into a stationary charging demonstration is the logical conclusion of this project for 2012.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated to “triple the budget”. A second reviewer said resources appear sufficient

The ArvinMeritor Dual Mode Hybrid Powertrain (DMHP): Opportunities and Potential for Systems Optimization: Smith, David (Oak Ridge National Laboratory) – vss062



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that this project is relevant and that it directly contributes to the overall DOE objective of petroleum displacement by optimizing dual mode hybrid powertrain (DMHP) for fuel savings and energy efficiency. The reviewer pointed out that the project has only just begun (0% complete) but results will be important for reducing petroleum consumption for Class 8, HD trucks through advanced powertrain hybridization. The reviewer noted that hybridization of the Class 8, HD powertrain is inherently challenging due to expected long-haul driving and limited opportunities for regenerative braking, which is an excellent target for ROI. A second reviewer said that the program is relevant and that it involves further research and development of an advanced technology powertrain. This powertrain has been designed and developed to reduce fuel consumption. A third reviewer said that it is important to explore opportunities for hybrid powertrains in Class 8 long haul trucks based on the amount of fuel consumed in this vehicle class. This reviewer stated that the project is directly relevant to DOE objectives

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said the work WILL study systems optimization through model-based design and simulation of the ArvinMeritor Dual Mode Hybrid Powertrain (DMHP) specifically for Class 8 long haul trucks. The reviewer stated that the approach appears a sound planned balance between theory and experiment. The reviewer acknowledged that the results will be used to estimate improvements in drive-cycle energy efficiency, fuel mileage and emissions. The second reviewer stated that this is a controls development program. The reviewer felt it was a good idea to properly characterize engine as a first step of testing. The second reviewer would like to see some more discussion about how the proposed process would allow for different engines to be used with a minimum of additional work. (i.e., the new engine would require another characterization. But once that was done the new characterization could be "dropped" into the controls software or dropped into some pre-processor allowing the controls software to be seamlessly updated.) A third reviewer stated that the project seems well defined to exploit modeling, dynamometer work and on-road data collection.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

A reviewer commented that it is extremely challenging to score based on 0% complete. The reviewer pointed out that the CRADA was just signed. However, ArvinMeritor funded preliminary and exploratory studies where accomplishments included (1) full vehicle model with DMHP powertrain in Autonomie modeling environment, (2) proprietary engine data used for representative 2007 emissions compliant HD engine, (3) prototype electric machine (traction motor and generator) integrated into overall model, (4) well-structured supervisory control model architecture created and integrated into model, (5) vehicle model simulated over standard and "real world" drive cycles, and (6) standard heavy vehicle drive cycles were exercised to confirm expected operation of the DMHP, as well as baseline comparison for data found in the literature. This reviewer is LOOKING FORWARD TO DOE results. The reviewer said that DMHP warrants much deeper research and development efforts. The second reviewer pointed out that it is fairly early in the overall project and maybe simulations could have been a little further along, but again it seems very early in this project. A third reviewer stated that pre-funding progress toward objective (via Arvin-Meritor funding advance work). The reviewer went on to point out that the CRADA was still being finalized per presentation and that there is no confirmed project roadblocks for progress but risk identified for on-time completion of ORNL Vehicle System Integration Lab and procurement of engine and controls.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

For collaboration one reviewer simply mentioned the ArvinMeritor CRADA. The second reviewer went into more detail stating that the project has a final user for actual use testing, in addition to a powertrain supplier with an advanced transmission concept. The final reviewer felt that there was good collaboration with Arvin-Meritor and within ORNL, but has concern over diesel engine manufacturer not being engaged to assure availability of engine and controls. The reviewer points out that this has slowed some other DOE VTP projects.

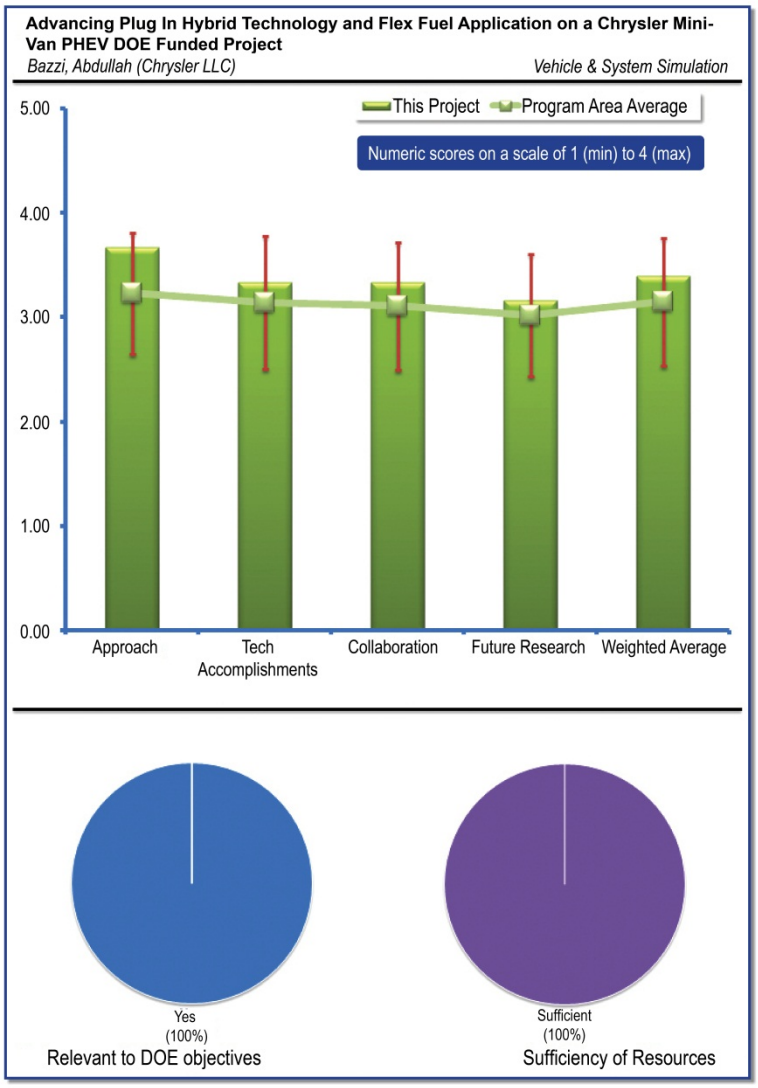
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that this is hard to assess based on 0% complete and that there is much future work planned and if accomplished, the work will be very important data and findings for DOE and the trucking community. A second reviewer stated that it seems to be a good research program leveraging modeling and simulation and testing to develop controls and assess fuel economy. The second reviewer also pointed out that heavy duty transmissions often have to work across a wide range of applications and with a wide range of engines. The reviewer stated that there might have been plans to address this, but if there were the reviewer missed them. Also the reviewer noted that the infield testing has to focus on a given engine/application, but modeling and simulation could allow exploration of other cases. A final reviewer stated that future work was well described through FY2013.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer said that having subsequently heard about some delays in the dynamometer facility, there may be some issues with completing any dynamometer testing (including characterizing the engine). The second reviewer felt that the project appears well funded if projections are accurate for out-years (FY2012 & 2013). The reviewer also pointed out that resources sound potentially dependent on (uncertain?) commitment by Arvin-Meritor to fund the on-road testing phase as implied by "Critical Assumptions and Issues" slide.

Advancing Plug In Hybrid Technology and Flex Fuel Application on a Chrysler Mini-Van PHEV DOE Funded Project: Bazzi, Abdullah (Chrysler LLC) – vss063



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that through their direct use of electricity for a substantial portion of the driving, and increased fuel economy over the rest of the operation, PHEVs have the potential to substantially displace petroleum consumption. A second reviewer commented that the demonstration and deployment of 25 PHEV is very relevant with DOE's mission statement. The third reviewer remarked that PHEVs can be very effective in petroleum displacement. The reviewer said that this project helps OEMs perform risky new development and deployment of PHEVs in the future. A fourth reviewer said that the combination of plug in hybrid coupled with renewable fuel use very pertinent to goals of DOE. The fourth reviewer felt that there are multiplicative effects of renewable fuels and electrification greatly additive in petroleum displacement. Another reviewer said that flex fuel maximizes efficiency impact of PHEV in petroleum displacement. The fifth reviewer said that 14 vehicles are re-lease content, and would highlight programs capability to displace petroleum from in-use data .The final reviewer stated that this project will improve the efficiency of a Chrysler minivan and will also be flex fuel capable.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer pointed out that Chrysler is developing a PHEV flex-fuel minivan, 25 of them on a 2-year demo, to get real-world data and evaluate customer expectations and acceptance. This reviewer had wondered aloud for years why no OEMs were offering PHEV minivans - the potential fuel cost savings, duty cycles, and buyer demographics seem very favorable. The first reviewer mentioned that the project is targeting 53 mpg in charge-depleting mode. The reviewer felt that 22-mile all-electric range seems an appropriate tradeoff and that Chrysler is treating this as a production program rather than R&D (in terms of decision making). The reviewer was a bit surprised that Chrysler chose to use a 290 hp 3.6-L V6 engine, perhaps this was chosen to allow minimal changes to the base model and use an engine already flex-fuel certified, but such a large, powerful engine seems somewhat excessive. A second reviewer stated that the project had a good approach starting with a currently available platform to keep cost down while still effectively demonstrating the technology on-road. The second reviewer recommended the project utilize analysis to maximize architecture impacts, for conversion from conventional vehicle to PHEV including crash compliance and customer utility. The second reviewer suggested addressing different ESS technologies and subsystem impacts on economy/efficiency. This reviewer felt there was good use of appropriate milestones in development phases - using production cadence requirements implies commitment to program

feasibility. A third reviewer commented on the overall approach for system architecture. While using an existing powertrain mated to a charge depleting battery pack and hybrid drive system will allow for a quick demonstration of the technology, the optimization of the system will enable better market penetration and fuel savings. The reviewer also said that simulations of new engine and hybrid drivetrain components to optimize fuel economy, cost and range should be pursued. A fourth reviewer said the powertrain selection (engine) is not as conducive to demonstrate petroleum displacement potential (oversized). However, for demonstration purposes the reviewer felt it is a good program. A final reviewer said the component selection (namely engine) is weak. The reviewer pointed out that the object given of the study were to develop a PHEV with flex fuel capability. The reviewer stated that the study will address the original objectives but because the design is not well optimized, it will not be useful in revealing PHEV capabilities and expectations of petroleum displacement of this technology in the field; the reviewer expressed disappointment as a result.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that 21 vehicles have already been built and rigorously tested in laboratory, on-road, and severe environments. The reviewer pointed out that 25 EVSE built and delivered to partner organizations. The reviewer said that the project appears to have a reasonable likelihood of leading to mass-produced practical PHEV minivans. A second reviewer felt that there was good progress towards charge control demonstration and showed EAER meeting goal (> 20 mi) future plans to test mpg and Wh/mi and emissions. The second reviewer wondered if there is opportunity for engine downsizing. A third reviewer felt that it was hard to judge progress as the presentation was weak on performance expectations and results could have been better described. A fourth reviewer stated that the project is on track, mules completed, and already tested on road. A fifth reviewer commented that there was a wide list of technical accomplishments listed, but unclear where the project was in regards to the status of some of the technical areas. The final reviewer felt that the project seems to be on track.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer said that Chrysler is collaborating with Austin Energy, Behr, Electrovaya, INL (for data processing and reporting), SMUD, and the State of Michigan. The second reviewer felt there was good collaboration with a few utilities, but wondered if any vehicles will be driven by non-business fleet drivers (i.e., private drivers)? One reviewer stated that suppliers and DOE labs are involved, and another reviewer said appropriate partners were on board. A fourth reviewer said that there was good collaboration with DOE's INL lab for information distribution and existing collaborations with other OEMs.

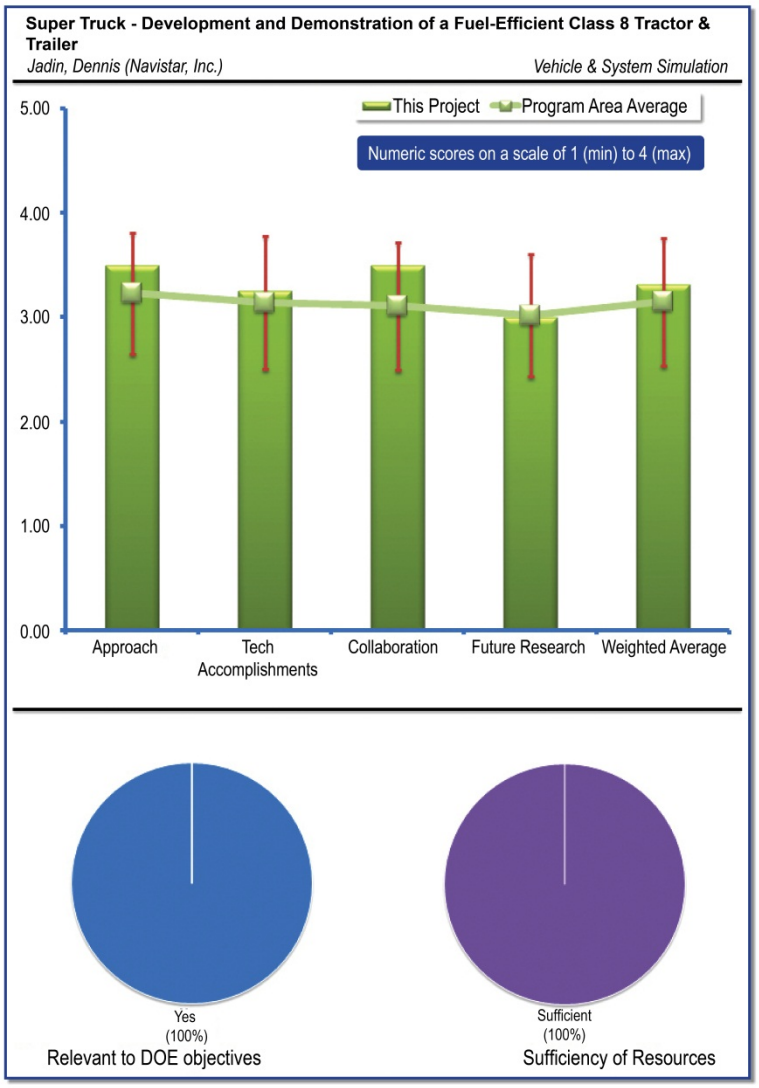
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the project was a very detailed project plan with FMVSS testing. A second reviewer stated that thorough demonstration from simulation results to dynamometer testing to on-road operation across a wide range of temperature and operation. A second reviewer stated that the plans for deployment and data collection are adequate. A third reviewer stated that it would be nice to better understand the possibilities for this program to lead into a production vehicle application. The final reviewer said the next steps to improve system cost, performance should be pursued and system optimization studies could be helpful

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer commented that 25 PHEVs are a good sample size and that it is large enough to get a good sample set of data yet small enough to keep project efficient. A second reviewer said the project is leveraged with Chrysler's own engineering activities. The reviewer felt that it is very likely that the project will be completed on time. A third reviewer acknowledged that it appears that Chrysler had allocated appropriate resources to meet the objectives of the program. The final reviewer said that the resources are sufficient to integrate existing technology into a vehicle, but new components may require additional resources

SuperTruck – Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: Jadin, Dennis (Navistar, Inc.) – vss064



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said that the project is relevant and directly addresses fuel savings. A second reviewer said the goal of 50% reduction is appropriate. A third reviewer commented on the stated program goals and objectives and that they agree with SuperTruck objective of demonstrating 50% improvement in freight efficiency. The final reviewer pointed out that Class 8 application is a significant portion of the overall on-road fuel consumption

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer said that work seems to be appropriately holistic with systems approach to integrate various subsystem improvements. Argonne has superior modeling expertise. However, the reviewer is unsure of ANL's heavy vehicle expertise. A second reviewer felt that the approach was clear, well planned and gives confidence that the project will meet or exceed the goals. Also, the second reviewer said that early vehicle demonstrations are great and that they like the down select stage. The reviewer commented that the project is planning to have more solutions than they need so that they can select based on economics or fleet acceptance criteria. The reviewer also felt that component integration across suppliers is really novel if they can pull this off. The reviewer commented that the moving 5th wheel is quite novel. A third reviewer felt there was a reasonable approach to successful program including model based design, prototype vehicle development, and testing. The reviewer stated that the plan is to attack 50% improvement through structure approach. The reviewer also pointed out that the assumption that each technology is purely additive on the path to 50% improvement is questionable. A final reviewer said that fleet input, modeling and simulation driving down selection of technology seems ideal.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that there is minimum progress towards overall goals. However, the reviewer pointed out that the project is only 6 months in and anticipated project length is 5.5 years. A second reviewer commented that there have been strong accomplishments in six months and that this gives strong confidence that the project will meet or exceed the goals. The reviewer remarked on the good simulation and hardware in loop studies with nice simulation of ton-mile/g results. The reviewer felt that there has been an impressive amount of work completed and impressive work to get things on test vehicles so quickly. The second reviewer said that there is a wonderful demonstration of innovation and willingness to test really new things (hybrid options, 5th wheel moving,

etc.). A third reviewer said there is significant progress exhibited with prototype vehicle development near completion (almost 2 trucks). The reviewer remarked that there is good work shown in modeling and evaluation of various concepts. The reviewer felt that the movable 5th wheel concept interesting but safety/vehicle dynamics are a concern. The reviewer thought that there is more work with the movable 5th wheel concept and wondered what the cost implications for this technology are versus improvement in freight efficiency? The final reviewer stated that the mule vehicles are close to completion and testing with project only six months in thus far.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that there is a good balance of partnerships. While a second reviewer said there is a great team that has partners to address all of the key areas, with good inclusion of National Labs, fleets, and a wide range of suppliers. A third reviewer commented that there is a very good mix of partners including trailer manufacturer, tire manufacturer, materials suppliers, and national laboratories.

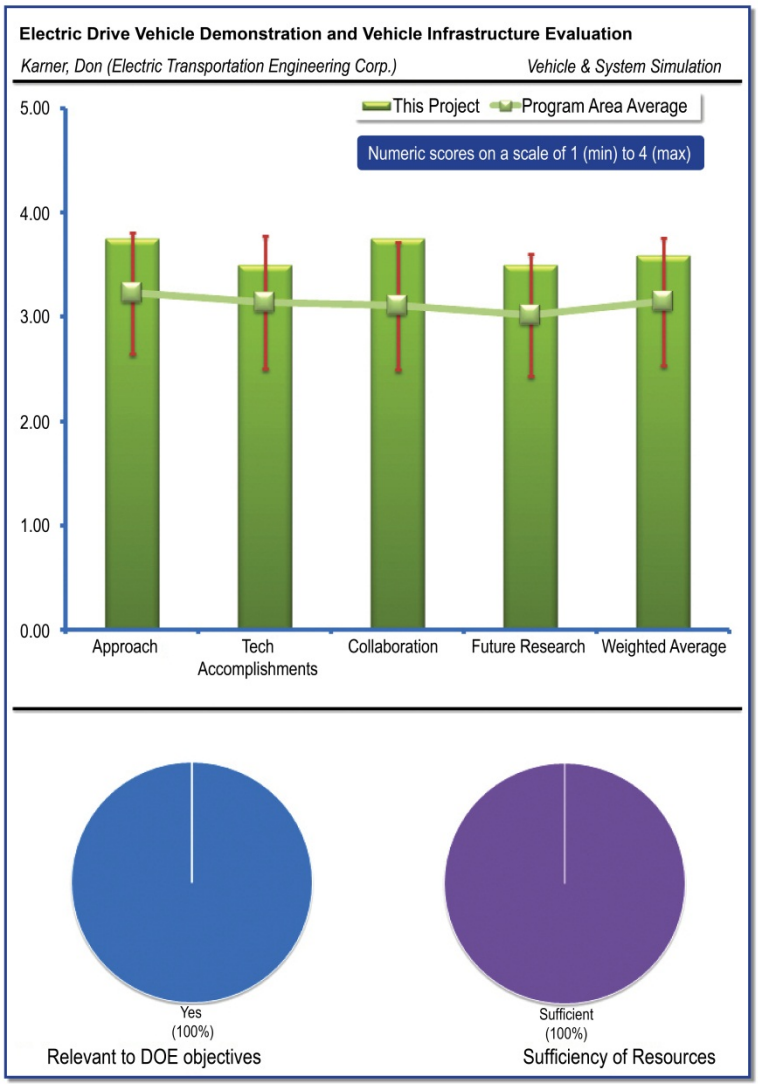
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that the project truck design down-select process and timeline seems appropriate. The reviewer stated that assuming 2,000 lbs. hybrid system penalty is appropriate, but assuming future truck penalty will be "much less" my be risky. The reviewer felt that the dual mode hybrid drive is interesting and may provide significant future fuel savings. However, the reviewer pointed out that futuristic approach for Class 8 trucks may prove risky. The reviewer also thought that component integration and packaging may be difficult. The first reviewer said that moving fifth wheel dynamics and strength requirements may make success difficult and will surely aid weight. The second reviewer felt that there is a clear plan that gives confidence the project will get there. The reviewer said that the project plans to overshoot and down select. A third reviewer commented that the timelines presented are reasonable, although somewhat high level (a little vague). The third reviewer said that the direction of research is logical. The final reviewer said that the voice of the customer activity is good and thought that fleets should be named. The final reviewer thought that future fuel economy testing will be valuable, but the method should be defined better.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer said that the DOE spending level verbally stated of $8 million is 22% of total DOE budget, while project progress is only at 9% raises flags. However, the reviewer understands that it may just have high start up costs, but felt consideration should be given to tracking this closely. The second reviewer said that ramp up is a bit slow $5.4M (verbally said $8M to date) versus $89M over 5 years. $8M for 6 months puts them about on track. The third reviewer stated that the resources presented appear sufficient. The third reviewer said that the aerodynamic work (full scale wind tunnel) could borderline on excessive. The reviewer felt that CFD and physical demonstration will prove out concepts. The final reviewer felt that spending vs. allocation seemed appropriate.

Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation: Karner, Don (Electric Transportation Engineering Corp.) – arravt066



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that yes, there will be savings but there is not a measurement tool in place. Another reviewer noted that this was the big picture definition. The third reviewer asserted that in order for electric vehicles to reach their full market potential, a robust, standardized charging infrastructure must be in place, including provisions for both in-home charging and public charging facilities. This project seeks to explore infrastructure alternatives and make recommendations for future deployment. The reviewer added that a sound, standardized, cost effective infrastructure will accelerate acceptance of electric vehicles, which obviously results in reduced petroleum consumption. The final reviewer indicated that this is the largest EV and infrastructure deployment effort in U.S. history. It will cut across essentially all the critical areas identified as barriers to deployment of light duty electric vehicles. Overcoming infrastructure barriers, including fully understanding charging profiles, consumer use patterns, improving bidirectional communications from the vehicle to the grid, development of sustainable business models, and so forth are essential to the successful commercialization of electric-drive vehicles to the broad consumer market.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent stated that this project seeks to deploy over 8,000 electric vehicles, install charging devices (including home, commercial and fast charging commercial units), collect data on said vehicles and charging units to understand charging practices, and ultimately make specific recommendations on future infrastructure requirements. Data analysis is being conducted by Idaho National Labs. The reviewer added that the large number of vehicles in the study was deemed necessary to create an appropriate "density" of electric vehicles in order to gain insight on charging and infrastructure requirements. The original quantity of over 5,000 vehicles (1,000 cars clustered in 5 metro areas) was expanded to accommodate two additional metropolitan areas. This aspect of the program appears to have been well thought out. This reviewer continued that the project also seeks to determine the merits of a smart charging system that can reduce peak demand and level off power requirements.The reviewer pointed out that an open question is whether or not the project could have been just as successful with fewer overall vehicles, which would have substantially lowered overall project cost. In summary, this reviewer felt that this project appears to be a very well thought out. The creations of "high density" EV areas should prove to be a very successful model for projecting future charging habits and infrastructure requirements. All aspects of EV charging and deployment are being explored in this program. Though overall program cost is extremely high, the amount of

information to be garnished from this comprehensive study should prove worthwhile for planning the next phase of higher volume EV deployment and infrastructure creation.

The final reviewer indicated that a significant amount of upfront planning has gone into the development of this project, including the development of 10 year plans and EV micro-climate studies. A significant amount of work has gone into infrastructure planning including the organization of regional stakeholders and the development of certified contractor networks, as well accommodations for ADA requirements. This project includes broad residential and public installation of charging infrastructure, including fast charging.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that it would be hard to say what exactly is contributable to the project and other market forces. The second reviewer noted that much has been accomplished to date including project management infrastructure set up and staff hired, "High Density" EV locations were identified, with the intent of installing the required charging infrastructure at these locations, both the EVSE and Fast Charger units are now being manufactured and deployed, a communications network and data collection network established, with all acquired data being funneled to INL for analysis, and barriers and "open issues" (ADA requirements, charge station signage, utility demand and overloading, setting standards for fast charge connector) have been identified and are being addressed. The reviewer added that a summary of each area was provided in the presentation, and there seems to be an approach to address each item. The fourth reviewer asserted that the project appears to be largely on schedule and has a litany of notable accomplishments, including completion of ten year plans and micro climate studies, completion of residential and commercial UL listed EVSE level-2 equipment, development of a communications network, and infrastructure barrier identification.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent acknowledged that there are many collaborators on this program including utilities, city governments, and EVSE manufacturers, as well as Idaho National Labs. It is clear that such cooperation was absolutely critical to obtaining meaningful results from the program. A key addition to the team was Underwriters Labs, who are playing a major role in certifying EVSE units and fast chargers. This is one of several projects dealing with current and future infrastructure and V2G communication needs for electric vehicles. There appears to be an attractive opportunity for collaboration amongst these DOE sponsored programs, which could either reduce aggregate cost, accelerate learning, or both. DOE is encouraged to look for these opportunities. The final reviewer agreed by adding that extensive collaborations exist with OEMs, 18 cities, multiple cities and universities, and UL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the proposed future work includes completion of deployment of all vehicles, EVSE's, and fast chargers. Data collection (including both vehicle utilization data and charger utilization) will continue and all data will be fed to INL for analysis and report out. The data collection effort is expected to greatly assist in projecting future charging needs and in designing the grid to accommodate the expected ramp up of electric vehicles. Also planned is the development of business models for production of EVSE units and for commercial charging. This information, coupled with usage data discussed above, will assist in the creation of a recommended approach for infrastructure design and deployment in major metropolitan areas. The second respondent pointed out that the proposed future work includes continued expansion of EVSE deployment to 8,300 grid connected vehicles and 12,000+ EVSE systems, including 200 DC fast chargers. Future work will also include increased data collection and reporting, analysis and projections of demand response, business model development, and compilation of lessons learned from peripheral areas including signage. Future work may also want to consider methods to tap ideas from EV customers to expand receptivity to EVs outside the domain of first adopters.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer felt that this is a very relevant project. Another reviewer pointed out that this is very large, well-funded program and there appears to be adequate resources (human and financial) to complete the project per plan. Success will depend, however, on

effective collaboration with the utilities, metropolitan governments, and national labs. The final reviewer noted that the resources are currently appropriate and sufficient.

Advancing Transportation Through Vehicle Electrification - PHEV

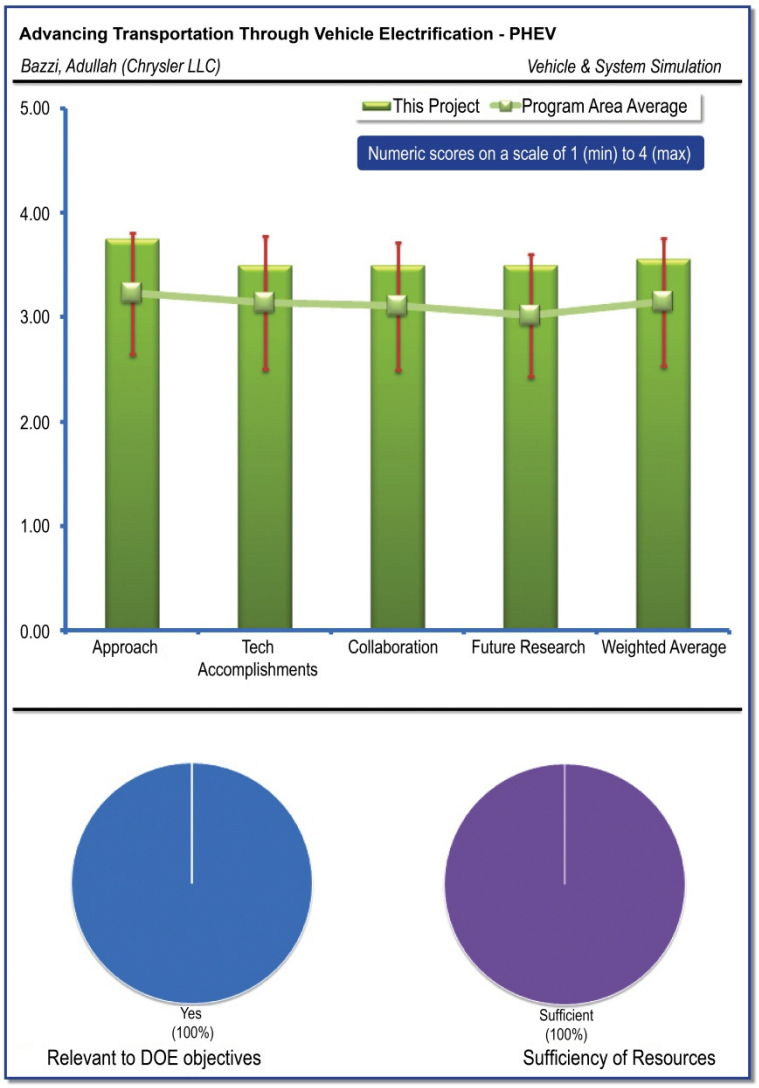
: Bazzi, Abdullah (Chrysler LLC) – arravt067

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that there was significant fuel savings achieved during charge depleting mode. Fleet deployment will be large enough to expose many potential customers to plug in electric technologies. The second reviewer asserted that the project is relevant as it extends the capabilities of hybrids to utilize grid power, further reducing the dependence on fossil fuels and supporting the federal government drive for energy security. Another reviewer confirmed that in order for fuel saving hybrids to gain market acceptance, an understanding is needed of how fuel saving hybrids actually perform in the field and how much fuel they save in the real world applications. The final reviewer indicated that this project addresses battery performance for real world environmental conditions as well as charging system integration. The reviewer added that these are very important topics for a widespread launch and integration of PHEVs.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that the team has clearly a strong commitment to engineering a production ready solution, including significant durability testing prior to deployment. Great targeting of a market that will enjoy vehicle feature content that is enabled by the hybrid transmission and battery pack (on-board power generation).Also comforting that crash certification activities were complete prior to deployment. The second reviewer thought that the project had a very thorough and structured approach utilizing the latent skills of an established organization and demonstrating new focus. The third reviewer felt that much of the vehicle had to be designed although it looks like the 2-mode hybrid transmission was "stock." Money could have been saved if a more predesigned vehicle and systems could have been used (if they existed.) On the positive side, following the Chrysler Development System will let it go to production if that decision is made. There should be a sizable field support budget as at least a few issues will probably come up that were not found in the initial 12 truck fleet in 2010. A tiered release of the 140 truck fleet (if schedule can be modified to allow it) would help identify issues so the same problem does not need to fixed in 140 trucks. Another reviewer pointed out that the project includes demonstration across diverse environments and that it is extremely important to understanding technology potential under extreme conditions. This reviewer added that three phases seem logical and there is a reasonable amount of detail for a presentation of this length. However, the reviewer found it hard to determine whether approach matches funding level just due to brevity of talk. The reviewer added that the

mix of current and existing components seems reasonable and cost effective and the deployment partners and vehicle allocation is excellent.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that significant technical hurdles appear to have been overcome. Although the most complicated system (the hybrid transmission) was a commercially available item, this project still includes a reasonable level of technology development (battery pack, inverters, power panel, charging). This reviewer also noted that it seems like the project is a little behind in terms of completion of the vehicles compared with the original plan, but the situation appears to be recoverable and reasonable progress has been made. Another reviewer felt the technical accomplishments were good given the resources but expected more innovation. The third reviewer pointed out that technical accomplishments were met or are scheduled to be met shortly. The final reviewer assumed that the 20 miles electrical drive range was part of proposal package. It seemed like more range in the 30 or 40 miles would be more relevant. This reviewer added that the comments by speaker indicated that it could go 40 to 50 miles before the engine would engage, but this will, of course, depend on a lot of conditions. There was good progress on fuel economy, exceeded target, and substantial compared to gasoline vehicle. The reviewer noted that the data are available to national laboratories and partners and that this is important for further understanding of customer interactions with technology. Finally, this reviewer noted that it needed more detail to understand technical accomplishments and progress and thought more detail could have been included in this time frame.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that there was a good selection between key sub-system vendors, academia and deployment partners. Having the OEM run the program lends significant credibility to the solution. The second reviewer noted that because of the company brand and resources this will not have been a problem. This reviewer had hoped to see some smaller innovative organizations taken under their wing but no real risk or development of smaller companies was evident. Another reviewer confirmed that it makes sense to cooperate with the utility companies to monitor charging and modify the charge schemes to keep from grid going down. Collaboration list and roles seem suited and coordinated for this project. More information on roles and interactions would have been very useful and the participation level of everyone it is not clear.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted the focus on deployment, field testing, and addition of key (and interesting) functionality with regards to smarter charging and interaction with the grid and added that these items will be important to enable large scale deployment. The second reviewer indicated that the future research is well thought through and relevant not only to this project and vehicle platform but also capable of significant impact in other business areas. The third reviewer mentioned that the nonproprietary field data should be released to the public. Also nonproprietary components could be released in industries which do not compete with Chrysler such as the charger or on board AC power. The reviewer added that there should also be an ROI calculation (for the customer) done on the product in production if it has not been done already. The final reviewer felt that the future seems consistent and focused with plan.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer noted that it appears to be a little behind, but with significant progress over the last 12 months. Another evaluator noted that there was no lack of resources. The third reviewer felt that it is quite a few trucks for initial startup testing and they will require a fair amount of field support personnel. The final reviewer indicated that the internal and external resources appear to be sufficient to meet milestones and that it has been demonstrated with progress to date.

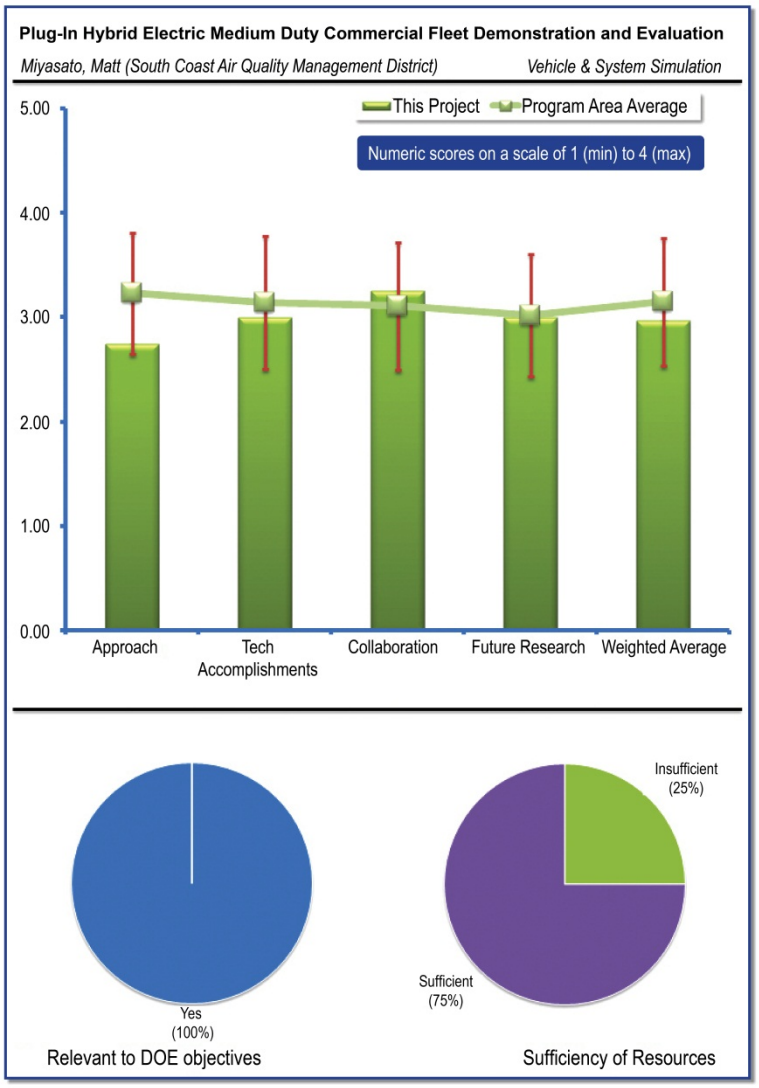
Plug-In Hybrid Electric Medium Duty Commercial Fleet Demonstration and Evaluation: Miyasato, Matt (South Coast Air Quality Management District) – arravt068

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that this project is focused on a quite small component of the overall market, but selection of utility industry as one of the primary targets will likely lead to a more accepting customer base than a typical commercial entity. The second reviewer pointed out that this reduces idling requirements for these types of vehicles within service applications and the use of fossil fuels. The third reviewer asserted that the hybrids will save fuel and the project will point out field issues that when solved will help larger scale acceptance. The final reviewer pointed out the focus on MD PHEVs, which is good match for this technology due to drive-cycle and range of many of these applications. The reviewer also stated that it was good to see "cost" mentioned in objectives which is very important to wide spread acceptance, and noted that "smart charging" is very important to use with existing grid system.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer noted that it is unclear what the route to production implementation of this package will be and that maybe the body builder partner will manage integration and assembly, but this would be significantly more complex than typical 2nd stage assembly activity (transmission replacement, changes to body in white, high voltage system integration). The role Ford is playing in the program appears to have diminished over the last 12 months (although this was not clearly described during the briefing). This could be lead to a significant increase in the difficulty of fielding the product of this project as a production vehicle. Eaton seems to have been heavily leveraged during the development phase. It is unclear how much of the development was funded by the program, since much of the system was already commercially available. The level of robustness that the full systems integration tasks (cooling, electrical system etc.) have been executed with was difficult to assess. The reviewer also added that the deployment plan was not very clearly presented, other than “it's defined and includes utilities around the U.S.” The second respondent thought that the technical approach is good, especially the idea of using an Azure system that is already proven. It also makes sense to try two different approaches (Eaton and Azure Dynamics) and pull the best aspects of the two systems forward into production. This reviewer added that the project approach of releasing so many vehicles up front is risky for potential field issues. This reviewer realized that the schedule calls for certain money to be spent in certain time periods, especially since recovery funds may be used for this project. However, time should be made to allow for a staged release would greatly lessen the risk of having issues with all 280 vehicles. Large issues on release would decrease market acceptance of hybrid vehicles. This reviewer added that there is a good selection of relevant vehicles for this size

class. Electric powered auxiliaries make sense for 550. Specifications in approach but would like to see more detail in terms of timeline, decision points, etc. The reviewer questioned where the deployment will be and what the approach to securing deployment partners is.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that the cost and schedule control of key (unnamed) hybrid sub-systems has obviously been a significant issue on the program, leading to a very significant reduction in the planned size of the fleet and delayed deployment. The reviewer expressed that this is a real shame and it has to lead to questions around the robustness of the proposal submittal planning. The reviewer also pointed out that the F550 system is stated as having a blended regenerative braking system, but the presenter stated that this system has no iteration with the brakes other than through removal of regeneration during ABS events. The reviewer did not view the system as implemented to be a blended system, which typically bypass the base brake systems for initial applies. This is a shame on a project with a significant budget. While it is easy to understand the risk reduction measure (this reviewer has been involved in similar strategies for one-off technology demonstrators), development of a true blended system with a brake system vendor partner would have been a major "win" for the project because nothing exists in this vehicle sector currently, this is an opportunity lost. The second reviewer indicated that given the partnerships, this reviewer felt that they should have made greater progress. Another reviewer stated that the systems as designed appear to be sufficient for the applications and also look to be cost effective designs. The three different vehicle calibrations for the F550 should maximize the fuel savings in different applications. The final reviewer noted nice accomplishments so far. As with the approach, would be nice to see where you are compared to where you intend to be at this time. This reviewer added that the discussion of accomplishments was nice and the reviewer realizes that time is very limited but the project did convey a sense good progression. This reviewer noted that the project team showed three calibrations for the F550, and questioned how the decision will be make on which to deploy and if they all work effectively with same hardware technology package, questioned if they have material orders for 50 F550s, how many F550s they intend to build and deploy, and if orders are already placed, does it mean that the design is finalized.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer pointed out that it was not clear what Ford's role in the project is, it certainly appears that it would be beneficial for them to have had a more significant role than was implied in the briefing. Also a braking system partner developing a hybrid blended brake system would have enabled higher efficiencies to have been gained. It is unclear what the path to production would be for this project when the DOE effort is completed. The second responder acknowledged that the partners for this project have large resources and good technical knowledge of which the project makes use. The third respondent noted excellent collaborations and appreciated the description of the nature of each collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

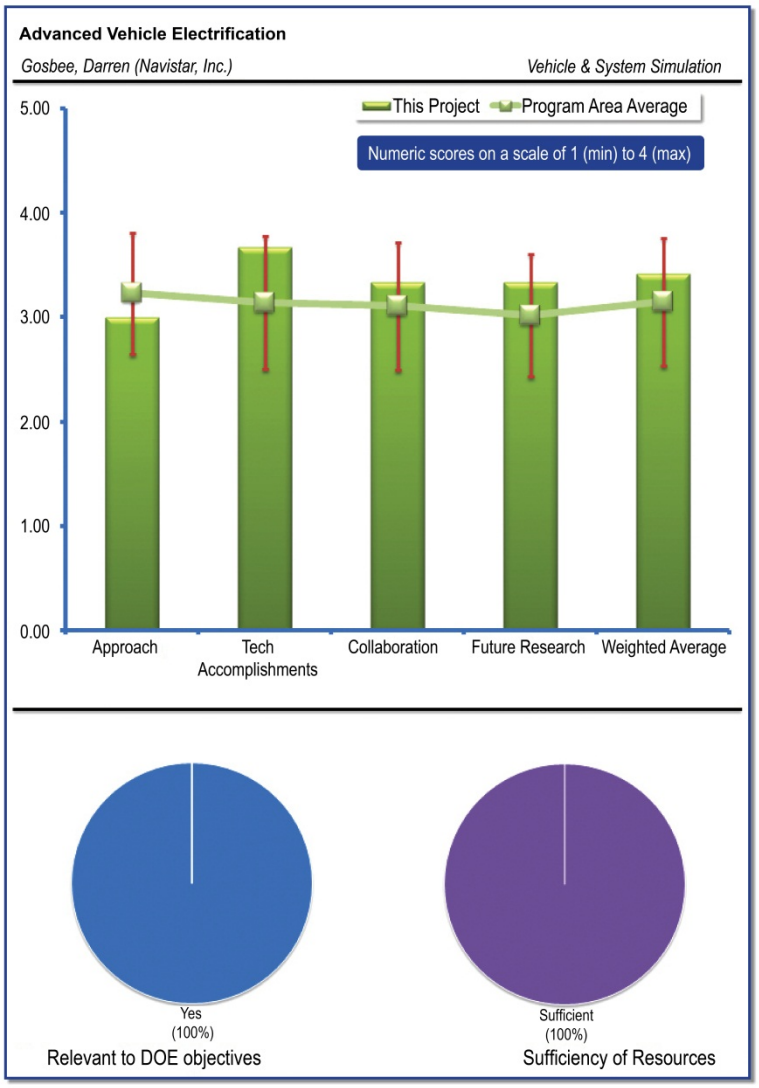
The first reviewer stated that the completion of the system development, builds, deployment and data acquisition and analysis will be a major accomplishment for this project. The second asserted that efforts should be made to share the designs with non-competing industries such as class 6 and 7 trucks that would be able to use the F-550 hybrid design or slightly upsized versions of it. The battery packs should have a 2nd life planned if possible for when they do not meet energy or power specs after a few years. The final reviewer noted that future plans look reasonable but questioned where the vehicles will be deployed for evaluation and how they will be deployed and tracked.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer indicated that the project appears to be at risk of overspending and is delayed. The reviewer added that DOE should maintain close watches on progress to make sure the deliverables are not diluted to the point of no longer adding the value that would be expected for the significant levels of investment. The second respondent expressed that extensive field support resources may be needed if there are field issues. Resources should be sufficient unless there are many field issues which is a possibility with some of

the newly designed components. It appears the budget did not cover the initial field test estimate of 378 vehicles. The reviewer questioned if studies where done to see where the discrepancy was between planned budget and actual cost of components.

Advanced Vehicle Electrification: Gosbee, Darren (Navistar, Inc.) – arravt069



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the estimated savings of 1250 gal/yr. per eStar vehicle across a 950 vehicle fleet will lead to substantial petroleum displacement. The second reviewer pointed out that it will save fuel by having vehicles run off electricity instead of petroleum. The final reviewer asserted that this is a development and launch of zero tailpipe emissions EVs but added that the presentation also included estimates of fuel savings. Overall, project appears to be on target. However, more information in presentation would have helped this reviewer to better evaluate although this reviewer realized that these are brief presentations due to time constraints. The reviewer also added that the Q&A was very helpful.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that adapting an existing UK-market battery-electric truck to the U.S. market speeds time to market and reduces costs. The multi-year plan to grow capabilities of local suppliers in order to increase the domestic content of later-production vehicles appears to be a powerful strategy. The first reviewer added that as an ARRA-funded project, goals are not just petroleum displacement but also creation and/or preservation of domestic jobs. Navistar reports that some potential eStar customers do not require a 100-mile driving range and would prefer a reduced driving range version of the vehicle in order to meet their actual driving needs with a less costly vehicle. The third reviewer felt that the use of the previous design is a good way to save resources. Up front battery and vehicle cost estimation and ROI for the customer might have pointed to challenges in sales. The final reviewer noted well defined near-term milestones but was unclear on the duration of project, when starts, and when it ends. The final reviewer was unclear on specifications of vehicle which is being transitioned to the U.S. but thought it was a decent approach to make use of some existing technology.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer indicated that this project has introduced a new medium-duty battery-electric truck into the U.S. market (by bringing a production EV over from the UK). Navistar adapted the eStar vehicle to use a larger A123 battery pack in order to meet the grant requirement of a 100-mile driving range. The reviewer added that vehicles are rolling off the line with 75 or 80 are currently deployed. The target for full 950 vehicle deployment by September 2011 is being reassessed. The project team is working with local suppliers to significantly increase the domestic content of the eStar vehicles and leveraging existing Navistar dealer network to train sales and maintenance personnel. The reviewer also noted that the team added Canadian homologation to previously-achieved Federal

Motor Vehicle Safety Standards (FMVSS), EPA and CARB. The second reviewer pointed out that with reported Price of $150K from Navistar it may be difficult to get the amount of customers the program planned. Subsidies or further subsidies may be needed to get significantly more vehicles into the field or close to 950 in the objectives. Durability life testing that was completed and sufficient data from R&Q fleet over time will be the key to ensuring product quality of production release. The final reviewer mentioned that it was good to see estimates of actual vs. project job creation but was not clear of assumptions and job accounting. Navistar has identified an extensive list of participants to train for field and also makes use of Navistar's extensive dealer network. The reviewer added that the 100 mile range is outstanding and has been demonstrated. Overall, 75 to 80 vehicles have been deployed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer pointed out that the project team is collaborating with A123 on development of larger-capacity battery pack and lighter pack housing. They are also collaborating with NREL on data collection, analysis, reporting, and dissemination. The reviewer also indicated that they are developing relationships with utilities, local suppliers, local & state governments and participated in/presented the eStar at numerous industry events. The reviewer also stated that one Navistar comment near the end of the presentation indicates potential trouble with the planned approach: "The industry supply base has not progressed at the development rate required to support electric vehicles, technology is still young. As a result [Navistar has] continued relationships with existing suppliers until such time as domestic cost, quality, and durability targets can be met." Continued issues with developing domestic suppliers could diminish the project's fulfillment of ARRA goals (though that won't affect the project's impact on DOE petroleum displacement goals). The second reviewer confirmed that all collaboration reported is appropriate. However, the plan to address the bankruptcy of Modec and any new challenges that it adds (or does not add) to the program should be better explained. The final reviewer asserted that the collaboration and role with A123 good but was unclear on the status of developing relationships. The reviewer added that data collection sharing with DOE is important.

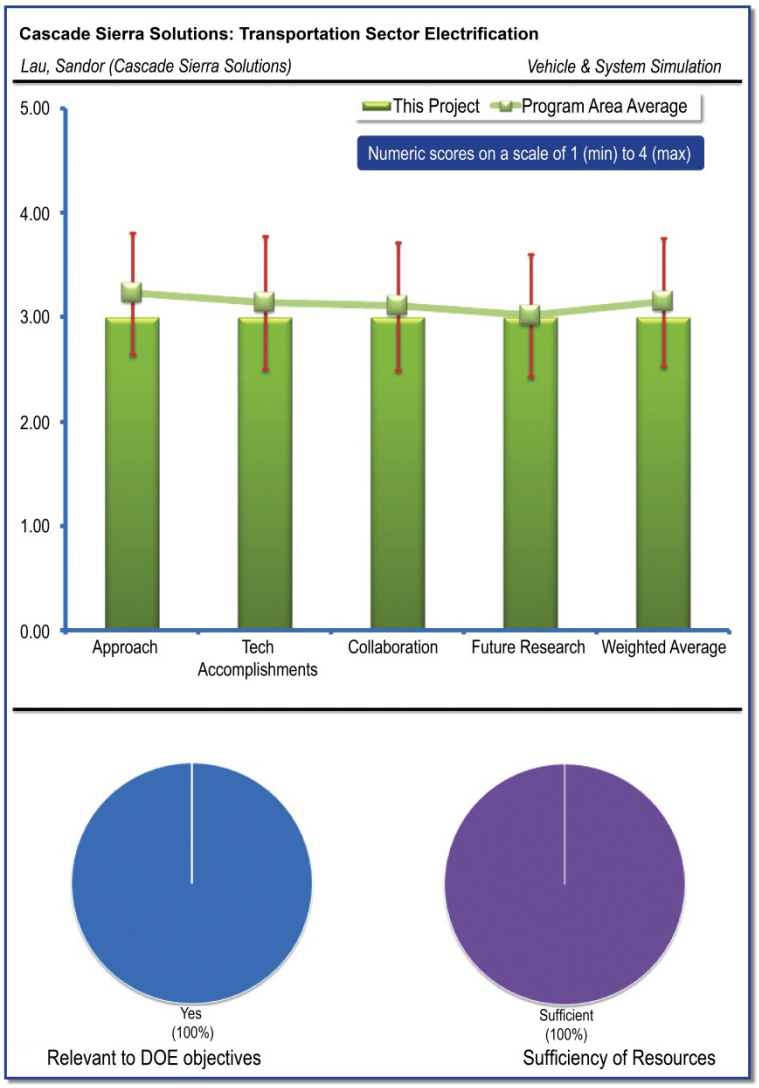
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer's comments include noting that the project team is working at cost reduction and development of local supplier base and will explore range alternatives (reduced range to lower cost). Current customers are averaging 23 miles/day meaning that many could be satisfied with 75 mile vehicle range. This reviewer also noted that they will be looking at how to replace unique motor/axle with components that interface with existing Navistar line so that EV versions of other vehicles can be offered, developing and adding numerous product improvements, and plan to seek Canadian homologation. The second reviewer confirmed that the costs savings for the components will be key to long term savings from the truck. It appears like release of all the vehicles is slower than planned which may be advantageous as issues are found and addressed. It is a good realization that a smaller battery pack will help and the grant requirement should be modified. Customers will need to see an ROI for them to invest in the technology. With a high cost battery on a $150K vehicle it will be hard for them to get an ROI. Extensive dealer training is and will be important to address the field issues that will likely arise with a new product. The final reviewer noted that cost is important and good to see. Most of proposed work with a few exceptions appears to be focused on more conventional vehicle issues. If 70-80 vehicles have been launched, this reviewer quested if the remaining "future" research issues are necessary within this activity.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer pointed out that if project results in deployment of proposed 950 eStar electric trucks, DOE investment per truck will be about $41K, which seems reasonable for the truck alone. Adding in the value of significant petroleum displacement, the development of hundreds of direct and indirect U.S. jobs, and the example of commercial viability to other potential U.S. electric truck manufacturers, this project appears to be achieving a very favorable return on investment. The reported slower-than-expected development of domestic suppliers is a concern however, and may argue for targeted investments in developing supplier capabilities. The second reviewer asserted that appropriate field resources will be needed, as will possible subsidies, to sell a sufficient number of vehicles to get the field data desired. Possibly the subsidies could be increased by reducing the number of vehicles from 950.

Cascade Sierra Solutions: Transportation Sector Electrification: Lau, Sandor (Cascade Sierra Solutions) – arravt070



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project addresses a key enabler to reduce idle time of the heavy truck fleet, and provides grants to promote adoption of more efficient technologies into the legacy fleet. The second reviewer asserted that this was clearly an application that this reviewer had not considered and is a well thought out fuel saving application. The third reviewer expressed that it will improve the fuel efficiency of the many vehicles in the field to be able take electricity from truck stops and not have the trucks idle or run diesel APU's. The final reviewer pointed out that the project supports DOE objectives from enabling infrastructure perspective and addresses very challenging barriers.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that there appears to have been a very robust selection process around the locations of the targeted truck stops. The fact that truck owners still have to pay a significant portion of the technology costs may reduce uptake, but will ensure commitment from those that do participate that should lead to higher quality results overall. Good combination of working with truck stops and fleets both and an interesting project addressing lack of plug-in infrastructure for commercial vehicles that will certainly restrict adoption of anti-idling technologies. Another reviewer felt that the idea of leveraging the grant funds to encourage the drivers and truck stop operators to install equipment is a good one. Getting the drivers (fleets) and truck stops to sign on will be key and the incentives will need to be sufficient for them. The data collected on the chargers and the trucks will be valuable to understand driver's habits. Having a small convenient power charging device will help adoption. The final reviewer comment on several aspects of the project, including indicating that the project spans 2010 to 2014, working with SmartWay is good approach, identified potential truck stops with plans for 50 installations, 25 connections per site, opportunity to monitor utilization and patterns of use for diesel fuel displacement, job creation through installations at truck stops and truck installations, and milestones are well-defined and appear to be on target.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer expressed that the project spend rate has been quite low, but it appears that a significant amount of planning and preparation work has been completed and it's perceived by the reviewer that the spend rate should significantly increase as installation activity at the truck stops ramps up in the near future. No mention of any testing/validation of the truck stops pedestals was mentioned

- DOE may want to ensure that this is a fully validated product before installations are completed (this was not questioned during the session). The second respondent noted that higher voltage chargers are accomplished and the portable A/C design and manufacturing contracting is done. The approximately 25 truck stops to date is important progress towards the key milestone of 50 stops. This reviewer added that fleet participation is also necessary and it is not clear how many of the 5,000 trucks have signed up. The final reviewer confirmed decent achievements to date with fuel and CO_2 savings, and further suggested that more information is needed here. Need more information here. This reviewer added that the Milestones are well defined and appear to be on target. However, it was hard to judge whether accomplishments are good progress. Not sure how much funding has been spent to date and need more information. Good to see commitment from large chain as well as others and it should be more than enough to meet target of 50 sites.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer asserted that there appears to be strong interaction with fleets and truck stop facilities, and also equipment vendors and financing partners. Another reviewer expressed that the university partner's role in data analysis will be very helpful and important, and also mentioned that it sounds like the follow-on of the other chains (in addition to the one that was mentioned) to sign up will be important and the drivers will need to have an incentive to participate. The final reviewer was not clear on details of collaborations and noted that it would have been good to have more detail but realized that time does not allow.

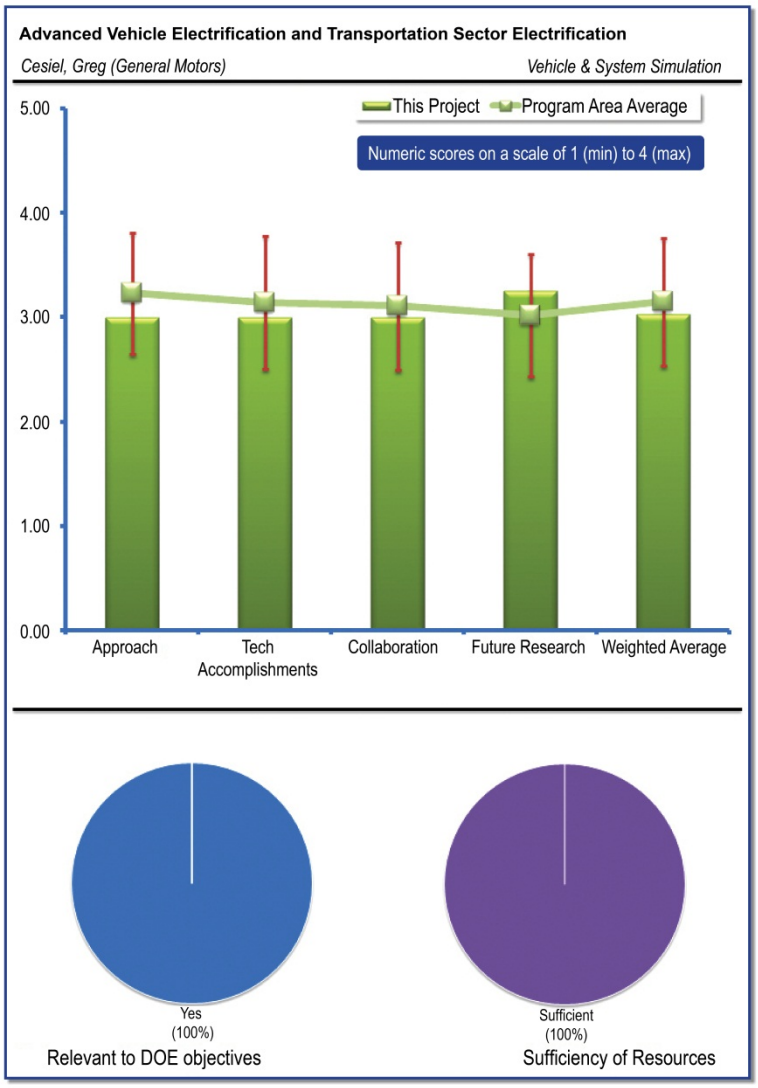
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the business case around ownership of the pedestals and purchase of time/energy still appears to need maturing, which is probably ok at this point in the project. The truck stops will likely need to pull revenue in to offset fuel sale losses. There was limited discussion around capturing data from the initial fielding fleet and this area should be examined so the level of success of the project can be measured. The second respondent believed that the work plan for 2013-2014 makes sense but more could be done to plan how to bring other drivers and truck stops on board. The final reviewer thought that plans forward seem on track and consistent with objectives but added that more detail would have been good.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer felt that the project was off to a slow start, but that it would be expected based on the level of planning and coordination being performed in the early stages and that it should increase quickly from this point forward. The second reviewer indicated that there is a possible tradeoff to consider if drivers are not using the stops and devices. Money could be increased to encourage drivers to use the improvements at the stops and less of the actual devices/stops could be financed.

Advanced Vehicle Electrification and Transportation Sector Electrification: Cesiel, Greg (General Motors) – arravt071



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that this project does reduce fuel usage. The second reviewer pointed out that the Chevy Volt development has generated significant interest in electric vehicles, due to its extended range capabilities, which neutralizes one of the major concerns about electric vehicles, getting stranded without the ability to replenish onboard power. With this vehicle, and with the adoption of this technology by other OEM's, the acceptance and deployment of electric vehicles should accelerate and thereby reduce national dependence on foreign oil. Extended range EV's bridge a gap between gasoline powered cars and full electric vehicles. The extended range concept is a potentially game changing technology. This technology appears to give a U.S. based company the technological lead in the electric powered vehicle arena, which should result in job creation within the U.S. The specific focus of this project was to support the final validation of the vehicle (already designed before the start of this project) and to support the data collection and analysis efforts. In the latter case, the objective is to learn more about how the vehicle will be driven, and the charging habits of users, while also gaining an understanding of future grid requirements as the population of electric vehicles grow. The final reviewer indicated that a full understanding of the electric vehicle consumer market, including data on vehicle performance and infrastructure under real world conditions is essential. This is a large, far reaching project utilizing the Chevy Volt as the electric vehicle of choice to push the envelope on development of a sustainable and growing electric-drive market for the general consumer.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A respondent asserted that the approach is generally sound, characterized by a multi-year, comprehensive development program, with strategic collaboration with utilities, and an extended vehicle test program in key metropolitan areas in the U.S. Program included development of key systems and components (batteries, generator, engine) followed by system integration and complete vehicle testing. Final validation depended heavily on feedback from selected users in the general public. Vehicle usage and charging data are now being collected on deployed vehicles with data transmitted by OnStar. The reviewer added that it appears that the project was focused on two separate, but nonetheless related areas: (1) final validation of the vehicles (through extensive field testing); and (2) acquiring vehicle and charging data to understand driving habits and charging requirements. It seems that the project will yield very useful information in both areas. The final respondent indicated that the basic approach is to launch the Volt in select markets starting in December 2010 and expand to across the country by the end of 2011. GM is working with utilities to install charging stations in

residential and public locations in support of the Volt roll out. Data from charging station activity will be used to assess consumer behavior and inform future technology and infrastructure activities, including integration with the Smart Grid.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer pointed out that battery standardization needs to be considered in these early deployments. The project team needs to ensure that the second purpose or afterlife of lithium ion batteries is useful and not regarded as hazardous waste. The second respondent stated that the Volt had been already been designed, developed, and extensively tested prior to the start of this project. Under this current project, vehicles are now being deployed, and charging stations are being installed for both private and public use. Beginning in the fall of 2010, data have been collected and sent to Idaho National Labs for analysis and summary. It is somewhat unclear how much of the final component and system validation was conducted under this program versus with GM internal funding. The final reviewer expressed that insufficient detail is provided to gauge technical progress and no hard milestones and little technical detail is provided. One interesting development is the Smartphone app by OnStar to assist driver's connection with the Volt.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first respondent indicated that data are being collected and sent to Idaho National Labs for data reduction and summary in a format accepted by DOE. GM has looked to EPRI for encouraging the involvement of key utilities to deal with the issue of charging facilities in metro areas. A total of nine large utilities are involved in the program so far. This project is similar to several other DOE programs that attempt to understand vehicle driving and charging patterns, and to project future infrastructure needs. A key opportunity is for DOE to facilitate cooperation and information exchange between the principals of the several programs. Another reviewer confirmed that sufficient collaboration appears to exist primarily with EPRI, various utilities, and INL for compilation and amalgamation of driving and vehicle data.

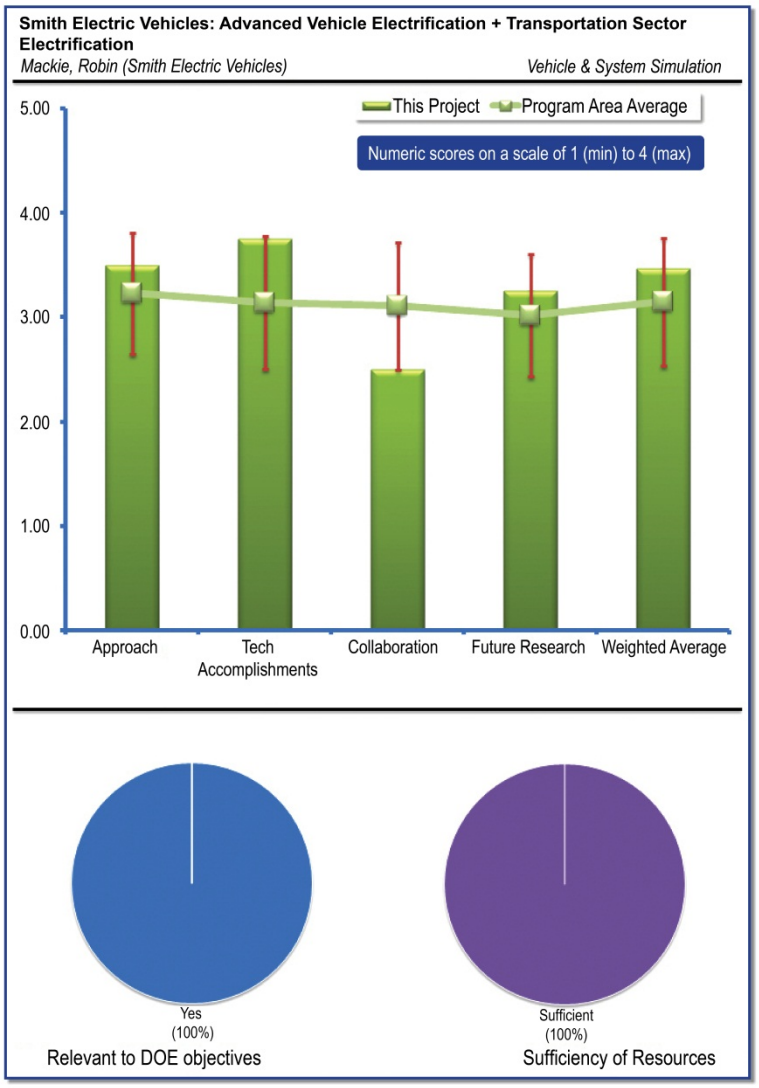
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer noted that the future work will be centered on additional charging station installations and continued data acquisition and analysis. A number of future development opportunities have been identified. (See Special Projects). Most significant activities include support of fast charging development and data collection activities, and support of efforts to develop "smart" charging capabilities, which includes among other things, effective vehicle to grid communications. Another reviewer stated that the proposed future work is a logical extension of existing activities and will include data gathering on charging installation and use, as well as special projects to support fast charging, smart charging and secondary battery use.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The reviewers indicated that the resources appear to be sufficient. One reviewer did point out that it is unclear whether the "special projects" summarized in the presentation are funded under the current project budget.

Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification: Mackie, Robin (Smith Electric Vehicles) – arravt072



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer pointed out full EV 100% fuel reduction and that the team will capture data in the future. Another reviewer asserted that the development and release of full electric commercial values obviously supports the national initiatives to decrease petroleum usage and reduce dependence on foreign oil. A cost effective version of this vehicle promises to be well accepted in the light vehicle commercial markets whose duty cycles feature limited daily mileage. The deployment of 500+ vehicles and subsequent data collection will provide invaluable information to guide next generation development, focused on cost reduction. It was reported that up to 225 new jobs will be created as a result of this program. The third reviewer confirmed that while the biggest and most attractive arena for electric drive vehicles is the light-duty market, applications also exist in the medium-duty delivery market. The medium-duty market is commercial in nature often with well-established urban driving routes and centralized charging which provides some natural advantages to electric drive vehicles. Establishment of a sustainable medium duty electric vehicle market and manufacturing base can help create jobs and pull electric-drive vehicles further into the mainstream.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer pointed out that the program used technology transferred from Smith U.K. The U.S. technical contingent has been built up to support next generation development. Homologation of the vehicle was required to meet all U.S. requirements. Using data collection (from Smith developed telemetry) and lessons learned from vehicle launch, a Gen 2 development is now underway. A conventional drive axle is used, which directionally will reduce powertrain cost. The second reviewer indicated that Smith U.S. has a well-thought-out approach capitalizing initially on the technical expertise and long experience of Smith U.K. This includes the conversion of the Newton platform to DOT requirements, R&D of second generation vehicle systems emphasizing performance and cost reduction, as well as telemetry systems. This project includes the development of a new manufacturing facility, enhancements to the supply chain, and a requirement that customers agree to participation in a 2-3 year data collection program. The overall approach is multi-faceted, currently utilizing battery technology from Valance and A123. The one area that is not ostensibly noted is strong efforts at visibility and awareness. Consideration should be given to ways to highlight the visibility of these vehicles through the media in local communities.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first respondent noted that homologation was successfully completed and that the vehicle has been launched in the marketplace. Supply base in the U.S. in several areas has now been established, though much more work is required to fully develop a U.S. supply base. Approximately 247 units have been sold, with 147 vehicles delivered to date. This reviewer added that the project team has worked to obtain NREL approval of Smith Data Acquisition System. The next phase (and most challenging) is to develop a cost reduced Gen 2 version. This was a very rational, logical approach, building on existing proven technology to produce a U.S. version of the Smith vehicle. The final reviewer indicated that the project has clear milestones and appears largely on track for achieving them. To date, notable technical accomplishments have been achieved across the board including transfer of the Newton platform, institution of successful localization of the supply base, initiation of second generation product development, establishment of a manufacturing facility (leading to 95 new jobs), successful implementation of a Smith telemetry system, and confirmed orders for 235 vehicles (about half of the project target total).

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer stated that primary collaboration has been with Smith U.K. and all technology has now been purchased by Smith U.S. Smith U.S. has developed relationships with key suppliers and is currently working to increase U.S. supply base for a wider range of components. It is suggested that Smith reach out and become involved in one or more of the initiatives to develop standardized charging facilities and vehicle to grid communications. The second reviewer felt that the collaboration is responsible but appears largely limited to within Smith U.S. / U.K. other than some first generation suppliers and university contacts for technology R&D and education and training. Smith is working closely with customers to specify product improvements. There may be opportunities working with NREL to identify additional optimal medium duty applications for the Smith Technology. NREL has done numerous studies and conducted modeling activities examining attractive medium duty applications for advanced vehicle technologies. There may also be some opportunities to team with other vehicle manufacturers who have readymade platforms for specific medium duty electric vehicle applications. The final reviewer pointed out that the presentation was kind of vague in the presentation as to "collaborators" including customers, suppliers, and institutions.

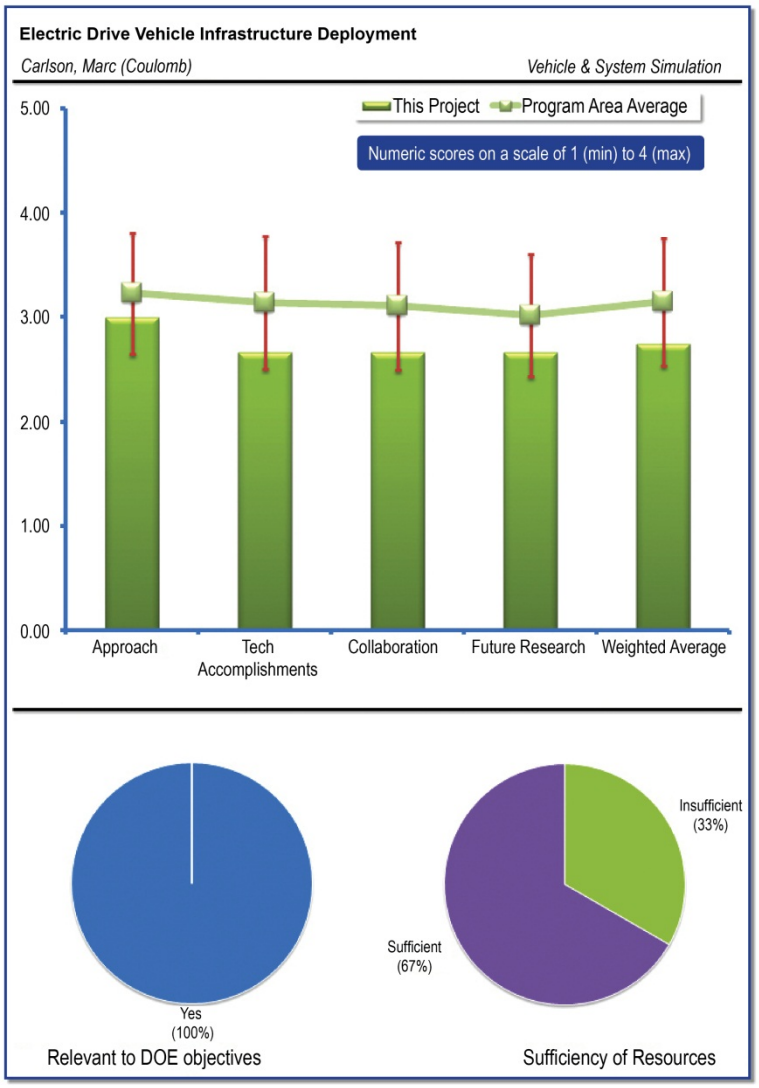
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first respondent pointed out that future work includes full deployment of 510 vehicles, continuation of data collection and development of Gen 2 systems. In addition, more development of manufacturing and assembly processes is required in anticipation of complete vehicle assembly in the U.S. This reviewer thought that their approach is logical, and the emphasis on cost reduction for Gen 2 is well placed. The vehicle cannot likely achieve attractive production volumes without a strong business case for owner, which mandates a modest premium over the cost of a conventionally powered vehicle. The final reviewer felt that the proposed future work is a logical extension of Smith current activities to improve the technology and manufacturing processes, strengthen the supplier chain, expand training of the work force, and reduce costs. Smith believes they may be able to sell 4,000-5,000 electric medium duty vehicles over the next 3 years. Again, as part of this project, efforts should be made to highlight visibility in local communities.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that this was a very relevant project and resources appear to be adequate, although based on verbal comments during the presentation, Smith is still ramping up both their production and technical areas. The final reviewer expressed that this is a large ARRA task ($32M) of which most (88%) of funding passes through to the vehicle purchasers. The task is sufficiently funded for now. If significant success is achieved, costs are dramatically reduced, and notable vehicle sales are achieved after removable of incentives, consideration should be given to additional funding to further accelerate penetration of the medium-duty vehicle market.

Electric Drive Vehicle Infrastructure Deployment: Carlson, Marc (Coulomb) – arravt073



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that in order for electric vehicles to reach their full market potential, a robust, standardized charging infrastructure must be in place, including provisions for both in-home charging and public charging facilities. This project seeks to demonstrate the viability and benefits of an EV charging infrastructure. A sound, standardized, cost effective infrastructure clearly will accelerate acceptance of electric vehicles, which obviously results in reduced petroleum consumption. Another reviewer indicated that overcoming barriers to charging infrastructure for electric drive vehicles is essential to market implementation of electric vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer asserted that the focus of this project is to demonstrate the viability of an electric drive vehicle charging infrastructure. The project will provide approximately 4,600 public and private Level 2 charging stations from which data will be collected and forwarded to INL for compilation and analysis. Efforts are being made to coordinate OEM EV deployments (GM Volt and Ford Transit Connect and FOCUS BEV, as well as smart EV) with charging station installations to maximize usage. The project will leverage other company efforts and infrastructure. The project is also working with the local press to expand awareness and receptivity. The second respondent acknowledged that under this project, approximately 4,600 charging stations (both public and private) will be deployed in 10 metropolitan areas. The project includes three OEM partners (GM, Ford, and SMART Car). The first phase of the program, which began in June 2010, involves the deployment of the charging stations, with a targeted completion date of December 2011. Phase 2 will have a two-year duration, during which time data will be collected concerning the times of highest charging, charging rates, and load on the grid. This program does not appear to be quite as well organized as several other DOE-sponsored projects with similar objectives. The lack of detail in the presentation and the apparent delays in charger installations are two indicators. The reviewer added that all data will be forwarded to Idaho National Labs for analysis and summary.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent expressed that charging station installations have begun and are scheduled to be completed by the end of 2011. This phase of the program appears to be significantly behind schedule. Of the 4,600 stations to be installed, only 1,000 units have been built, and only 500 installed to date. Completion by December seems ambitious at this point. This reviewer added that data

are now being collected and forwarded to INL. Early observations point to the fact that requirements may vary by region. General knowledge of EV's and charging facilities differs by region. The challenge in densely populated metropolitan areas is the lack of parking spaces, where public charging stations could be installed. Some metro areas are opting for "free parking and charging" as a means of stimulating interest in and acceptance of EV's. Other metro areas will provide charging on a fee basis. According to this reviewer, no hard data were shared during the presentation and it is not known if there is sufficient data yet available to form the basis of a summary report. Another reviewer stated that not much information is provided beyond a high level on the technical progress of this task which appears to be somewhat behind schedule based on shipped and installed units. Some early insights and observations are noted as to differences across regions, business models, charging hosts. Some early policy recommendations are provided that largely correlates with current conventional thinking surrounding the development of a viable electric vehicle charging infrastructure.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer pointed out that partnerships have been formed with GM (Volt), Ford (Transit Connect vehicle) and SMART Car (EV version). In addition, ten metropolitan areas have been selected for charging station installations. To some extent, installations are being patterned after EV sales in a particular region. As noted, INL is handling all data analysis and summary. The reviewer added that this project is similar to several other DOE sponsored programs exploring current and future EV infrastructure requirement, and also strongly recommended that DOE find a means of facilitating collaboration amongst these several projects, to the benefit of all. The final reviewer noted that little specific information was provided as to existing and future planned collaborations outside of obvious connections with the automotive OEMs. Reference is made to multiple "matching sources" but is not clearly elucidated.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent stated that future work involves completion of charging station installations and continuation of data collection and analysis. Another reviewer indicated that little information was provided to assess proposed future activities outside the ultimate deployment target of 4,600 stations.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Based on delay in charging station installations, there is some indication that resources may be lacking. This was not specifically addressed in the slides or during the verbal presentation. The final reviewer felt that the resources are sufficient for this task.

Class 8 Truck Freight Efficiency Improvement Project: Rotz, Derek (DTNA) – arravt080

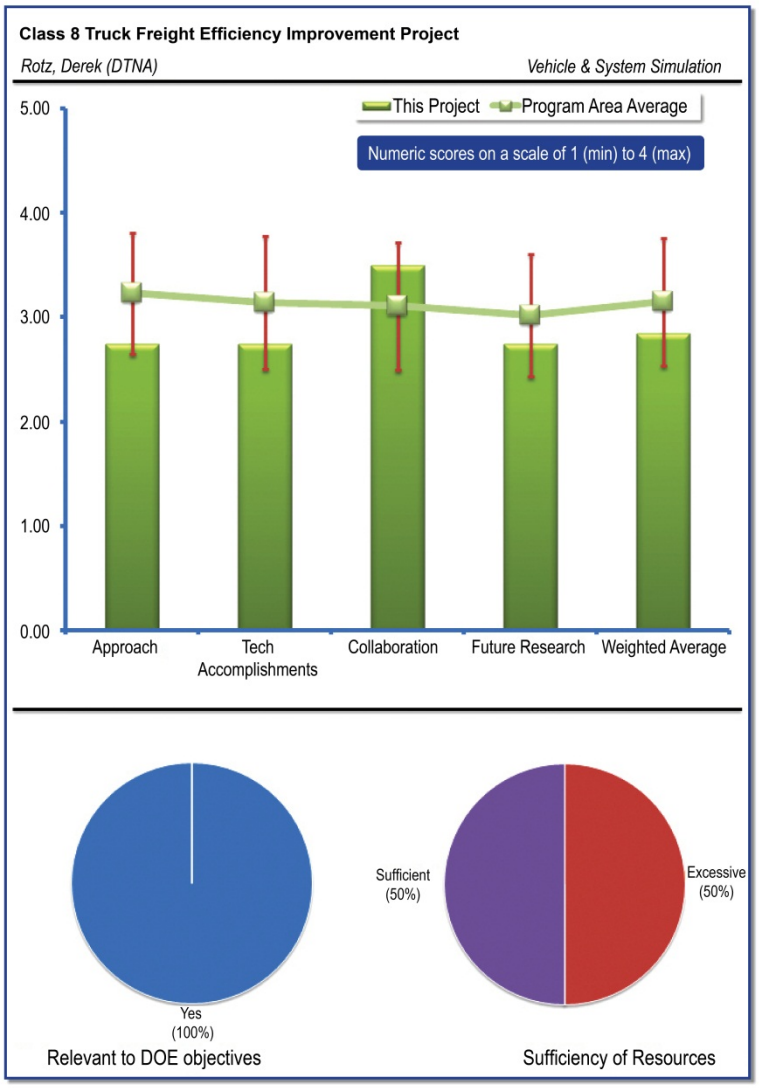
Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally thought that the project supported overall DOE objectives. The first reviewer pointed out that this is the direct study of fuel use reduction in heavy trucks. Another reviewer felt that the stated program objective supports the overall SuperTruck goal of a 50% improvement in freight efficiency. Multiple advanced technologies are being considered and integrated into the demonstration including hybridization, weight reduction, and aerodynamic improvements. The third reviewer stated that Class 8 trucking is a significant portion of on-highway fuel use and that a 50% improvement in freight efficiency would enable petroleum displacement. The final reviewer noted that the goal is 50% increase in fuel efficiency. However, given the five year time line, success is difficult to evaluate with this only being the first year review.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?



Reviewers generally provided a positive assessment, and offered suggestions. The first reviewer indicated that the approach to holistic fuel use reduction is good. They are trying to integrate multiple subsystems and the interaction between each subsystem and have a good approach to developing baseline drive-cycle. Only criticism would be limited hours and miles documented, in a limited region of the U.S. Drive cycle documentation does not include middle America prairie routes, nor Rocky Mountain basin range cycles. However, wind tunnel testing hours seem appropriate. Another reviewer asserted that this was a logical approach but some partners are missing versus claims for performance improvement (tires, axles, ...). Michelin is tire partner that was answered in questions. The reviewer also added that the torque limiting and energy management solutions are novel but questions if there are safety risks with it. The third reviewer confirmed that a structured approach was presented and appears to be followed. Good use of model based design and simulation to evaluate candidate technologies and their respective impacts on the overall goal of the project. The final reviewer asserted that the approach includes analysis of options to improve freight efficiency, but there was no mention or acknowledgement of past experiences and/or constraints based on user expectations and paybacks. Understanding that this is a “demo/development” project, it is acceptable that there will not be a commercial product as an output, but there could be better acknowledgement of past fleet trials (tires, aero and hybrid) to avoid demonstrating technologies that fleets will not implement. If it is a technology that has shown significant implementation barriers, then an effort should be made to improve this in order to gain acceptance.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewers saw evidence of progress in the early stages of the project. The first reviewer pointed out that the project is only 20% complete on a time line basis, so success to final goal cannot be expected to be high. However, on this basis, progress appears to be significant. The second reviewer asserted that less than $3M has been spent in $80M project and good work to establish baselines on baseline vehicles but appears to be little work to date on advanced technologies, and also pointed out good simulations and computation done by the project. They are hiring new employees to gear up for this effort and thus expect technical efforts to accelerate in future years. Other reviewers indicated that the project appears to be on suggested timeline and making good progress. The budget YTD seems reasonable for work presented, presumed to significantly ramp out when prototype hardware builds begin.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers saw a high-level of collaboration, and also suggested additional partners. The first reviewer expressed that the project has very good partner profile, including a university, two engine manufacturers, two large truck fleets, truck OEM, and two trailer/aerodynamics companies. Michelin needs to be identified as a partner, given the potential fuel savings from tire design changes. Waste heat recovery system partner needs to be identified. Another reviewer pointed out that this is the smallest of the three teams, some critical partners seem to be missing compared to claims for performance. From the response to questions it sounds like Daimler is working with a number of supplier partners (Michelin, axle, ...) that are officially on the team and perhaps are not participating in team meetings. It is unclear if there is true collaboration or if Daimler is simply passing requests along to suppliers. The third reviewer confirmed that the team had a good mix of partners to successfully complete and demonstrate technology. The reviewer added that the universities and fleet identified, as well as trailer manufacturer and aero improvements company. The final reviewer felt that interaction with Fleets should be highlighted better to show a “customer acceptable” solution.

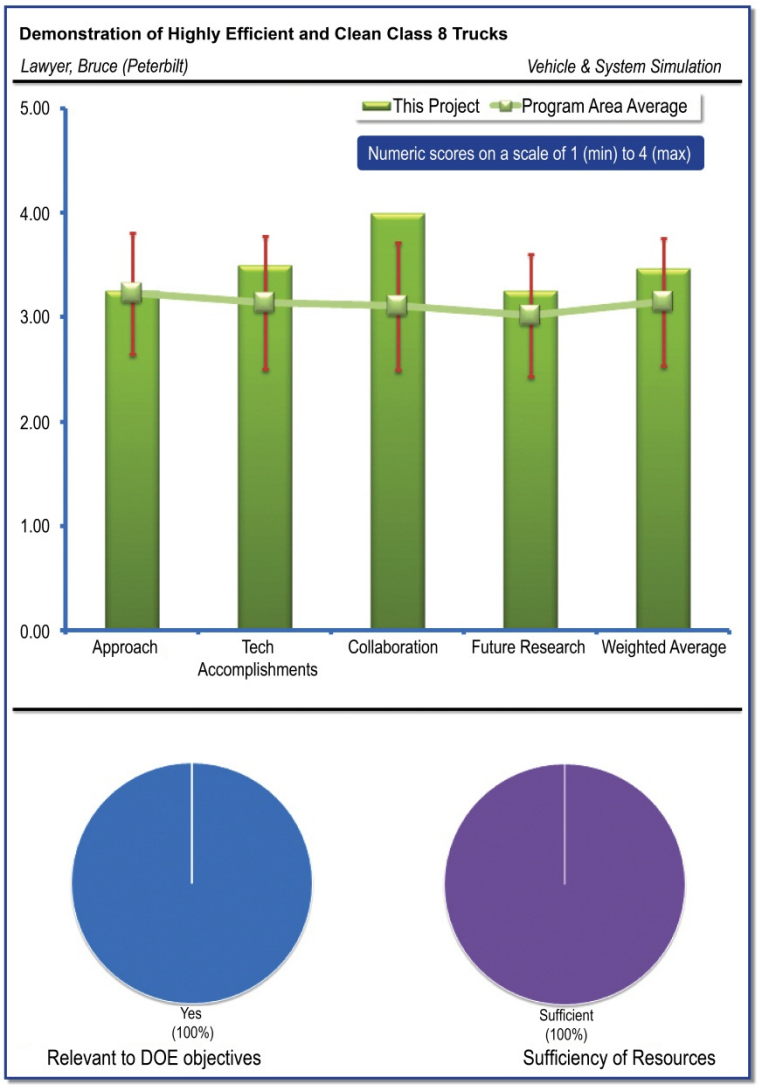
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer acknowledged that the future work was presented as a natural progress to completed work to date. Detailed timeline developed and presented supports logical progression to completion. The second reviewer confirmed that the decision points based on simulation, data and builds seems logical**.** The third reviewer thought that the research is too preliminary to require decision points, as all research to date indicates positive potential fuel use reductions. Continuation of holistic systems approach is positive at this point in this project. Hardware, design, and control systems research, including potentially limiting driver toque demands is good approach. The final reviewer noted that the engine goals of around 10% do not appear to be aggressive enough compared to amount of money being spent. This reviewer also observed a lot of work on parasitic, aero etc., but engine work appears too limited. The engine work is being presented separately so this may be addressed later. A few areas appear to rely more on hope than on a clearly defined plan (tires). Tire baseline appears to be dated technology; that is perhaps half of projected tire gains are already commercially available (singles).

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer indicated that the project had $79 million total budget, or $16 million per year, which seems to be a very reasonable budget for work envisioned. Another reviewer stated that the program demonstrated sufficient resources are being employed. Vehicle prototype integration plans not fully presented which is critical to success of program. The third reviewer stated that the distribution of expenditures versus the tasks and the work / resources proposed versus gains expected is unclear. The third reviewer pointed out that the team has spent less than $3M of 5 year/$80M project. If linearly scaled up, they should have spent around $16M and are now hiring to ramp up to spend later. The reviewer questioned if actions are necessary to ensure that the funds will be used and that the targets will be achieved. The final reviewer indicated that the $40 million budget is less than 5% spent, so available resources seem excessive.

Demonstration of Highly Efficient and Clean Class 8 Trucks: Lawyer, Bruce (Peterbilt) – arravt081



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer indicated that the goal of 50% is appropriate, and a second reviewer commented that the project directly addresses fuel consumption. Another reviewer pointed out that powertrain focus coupled with aero and rolling resistance reductions are used to focus on fuel efficiency benefits. The final reviewer asserted that the project properly baselined their test case and evaluated against commercially viable technologies which meet the Super Truck #2 objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally responded positively to the approach, while also providing comments about addressing technical barriers. The first reviewer stated that the initial modeled results are showing 24 hour duty cycle results very positive to date. Another reviewer noted well planning, an aggressive approach, fast launch, and a good use of resources. The reviewer also added that the project had a comprehensive approach including CO_2 and pollution analyses as well as fuel and weight issues. This reviewer indicated that adding route performance partner (Garmin) and research is quite innovative. The targets are believable by technology area. They are starting with a baseline that is already at an aggressive level for fuel economy (2009 model). The third reviewer pointed out that the project is in early stages, modeling completed. This reviewer expressed a need to see how project progresses to determine if approach and technical barrier issues are addressed. The final reviewer stated that the program identified categories for energy losses which allowed for technology focus areas including cooling and Waste heat recovery, weight reduction, RPM reduction, Trailer Aero, and communication speed from Vehicle to Trailer/system. A basic project schedule was shown, but prioritization or recognition of the difficulties in the different categories was not addressed. There was attention to the impact/ (value of program goals) from the different categories.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers saw evidence of progress towards meeting goals. The first reviewer indicated very strong accomplishments to date based on fuel reductions to date against current year goals toward final project goals. The second reviewer saw strong progress, particularly with the aero work, and that the results to date give confidence they will meet the goals. The reviewer questioned if too much weight is assumed to come from the trailer, but utilities and Alcoa give confidence they will achieve this. The reviewer added that overall weight gains are impressive and there was nice work on vehicle and systems communications system, and pointed out that the trailer is

built, the transmission has been designed, and the APU and heat recovery systems have been designed. The reviewer also noted that all team members appear to be contributing. Another reviewer confirmed that the project has met all milestones to date (design phase, computer intensive). The final reviewer confirmed the list of technical accomplishments and noted simulation versus initial test results (3-5%) variance. However, mentioned that the accomplishments were not listed as a % of goal achieved for specific categories, only overall truck system. The reviewer also stated that no discovered technical barrier issues were discussed, though in question and answer the comment regarding Solid Oxide Fuel cell issues for warm-up.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers were complimentary about the collaboration and coordination with other stakeholders. The first reviewer expressed very good partnering group from supplies to trailer manufacturer, end-user fleet, and OEMs and added that there does not appear to be a missing partner. The second reviewer pronounced them a great team and stated that they have all the right partners to address the key issues and a great plan. The reviewer indicated that the team members and plan provide confidence that they are working together and collaborating. This reviewer was given the impression of strong team work rather than an OEM dictating targets to suppliers. There was also validation by running vehicles in fleet with partner (U.S. Express) during the program is a plus. Other reviewers commented on the long list of pertinent industry collaborators to achieve goals and the excellent partnering network, to properly distribute work with subsystem experts.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer asserted that to date, results are exceeding current goals, suggesting good planning, with both excessive weight reductions and fuel savings. The anticipation of on road testing of second truck is appropriate. This reviewer also indicated good real world research lead by a company that understands need for final research to produce an economically viable product. Another stated that the project's very clear and logical approach gave this reviewer confidence that this team will meet the goals and deliver some breakthroughs along the way. The reviewer added that there are plenty of options to ensure that some can fail and they will still meet or exceed targets. The final reviewer asserted that the future work is in an alignment with the overall plan, but does not list the weighting factor of the future work versus the "to date" in the ability of the modifications to meet the over program goals. The final reviewer questioned if they have knocked of the low hanging fruit and now will be struggling to meet the goals of the next phase.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer confirmed that resources appear to be sufficient as measured by funds spent to date and fuel reduction progress to date. Another reviewer felt that the project's resource level was great and the project had a fast ramp-up and good use of resources to aggressively achieve the plan. The final reviewer pointed out that the partnership list appears to be capable of delivering on the project deliverables. The reviewer added that the next steps in validation of the upfront analysis, will truly determine if the proper resources have been applied by each of the partners.

2. Energy Storage Technologies

Energy storage technologies, especially batteries, are critical enabling technologies for the development of advanced, fuel-efficient, light- and heavy-duty vehicles, which are critical components of the U.S. Department of Energy's (DOE's) Energy Strategic Goal: "to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy." The program's vision supports the development of durable and affordable advanced batteries covering the full range of vehicle applications, from start/stop to full-power hybrid electric, electric, and fuel cell vehicles. Much of this work will transfer to energy storage for heavy hybrid vehicles as well. Energy storage research aims to overcome specific technical barriers that have been identified by the automotive industry together with the Vehicle Technologies Program. These include cost, performance, life, and abuse tolerance. These barriers are being addressed collaboratively by the DOE's technical research teams and battery manufacturers.

In August 2009, the Department announced the selection of 26 projects totaling $1.5 billion for developing the manufacturing capacity of advanced batteries and advanced battery components. ARRA-funded energy storage technology activities support the establishment of a domestic capacity for batteries, which will help develop the market for advanced electric drive vehicles. Twenty ARRA activities are for developing the manufacturing capacity for advanced batteries and battery components, including the production of lithium-ion cells and polymers; production of polymer separators and other components; and battery recycling. Six additional activities are for the creation of new battery facilities, or the upgrading of existing facilities, that will enable researchers to test batteries, improve battery safety, and increase the throughput of specialized thermal testing. For this merit review, these 26 ARRA-funded projects were not evaluated during the 2011 Annual Merit Review.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
PHEV and LEESS Battery Cost Assessment	Barnett, Brian (TIAX LLC)	2-6	2.88	3.13	2.00	2.63	2.86
A High-Performance PHEV Battery Pack	*Alamgir, Mohamed (LG Chem, Michigan)*	*2-10*	*3.33*	*3.17*	*2.50*	*3.00*	*3.10*
USABC HEV and PHEV Programs	*Yoon, Steven (A123Systems)*	*2-13*	*3.17*	*3.17*	*2.00*	*2.83*	*2.98*
JCS PHEV System Development-USABC	*Engstrom, Scott (Johnson Controls-Saft)*	*2-15*	*3.17*	*3.33*	*3.33*	*3.00*	*3.25*
Advanced Cathode Material Development for PHEV Lithium Ion Batteries	*Gardner, Jamie (3M)*	*2-18*	*3.67*	*3.83*	*3.67*	*3.33*	*3.71*
USABC Battery Separator Development	*Smith, Ron (Celgard)*	*2-20*	*3.00*	*2.83*	*2.83*	*2.80*	*2.87*
Multifunctional, Inorganic-Filled Separators for Large Format, Li-ion Batteries	*Pekala, Richard (Entek)*	*2-23*	*3.67*	*3.50*	*3.83*	*3.50*	*3.58*
Hybrid Nano Carbon Fiber/Graphene Platelet-Based High-Capacity Anodes for Lithium Ion Batteries	*Jang, Bor (Angstron Materials)*	*2-25*	*3.80*	*3.20*	*2.80*	*3.20*	*3.30*
New High-Energy Nanofiber Anode Materials	*Zhang, Xiangwu (NC State/NLE)*	*2-27*	*3.33*	*3.83*	*3.50*	*3.33*	*3.60*
Stabilized Lithium Metal Powder, Enabling Material and Revolutionary Technology for High Energy Li-ion Batteries	*Yakovleva, Marina (FMC)*	*2-29*	*3.29*	*3.43*	*2.00*	*2.86*	*3.14*
Protection of Li Anodes Using Dual Phase Electrolytes	*Mikhaylik, Yuriy (Sion Power)*	*2-32*	*3.43*	*3.29*	*2.86*	*2.71*	*3.20*
Process for Low Cost Domestic Production of LIB Cathode Materials	*Thurston, Anthony (BASF)*	*2-35*	*3.00*	*2.83*	*2.67*	*2.67*	*2.83*

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Engineering of High Energy Cathode Materials	Amine, Khalil (Argonne National Laboratory)	2-38	3.00	3.00	3.00	3.00	3.00
New High Energy Gradient Concentration Cathode Material	Amine, Khalil (Argonne National Laboratory)	2-40	2.00	3.00	3.00	3.00	2.75
Design and Evaluation of Novel High Capacity Cathode Materials	Johnson, Christopher (Argonne National Laboratory)	2-42	3.00	3.00	2.00	3.00	2.88
Evaluation of Li2MnSiO4 Cathode	Belharouak, Ilias (Argonne National Laboratory)	2-43	2.00	2.00	2.00	2.00	2.00
Development of High-Capacity Cathode Materials with Integrated Structures	Kang, Sun-Ho (Argonne National Laboratory)	2-44	4.00	3.00	3.00	4.00	3.38
Developing High Capacity, Long Life Anodes	Amine, Khalil (Argonne National Laboratory)	2-46	2.00	2.00	3.00	2.00	2.13
Develop Improved Methods for Making Intermetallic Anodes	Jansen, Andrew (Argonne National Laboratory)	2-48	2.00	2.00	3.00	2.00	2.13
Novel Electrolytes and Additives for PHEV Applications	Abraham, Dan (Argonne National Laboratory)	2-49	--	--	--	--	--
High Voltage Electrolytes for Li-ion Batteries	Jow, Richard (Army Research Laboratory)	2-50	--	--	--	--	--
Development of Advanced Electrolytes and Electrolyte Additives	Zhang, Zhengcheng (Argonne National Laboratory)	2-51	--	--	--	--	--
Development of Novel Electrolytes for Use in High Energy Lithium-Ion Batteries with Wide Operating Temperature Range	Smart, Marshall (Jet Propulsion Laboratory)	2-52	--	--	--	--	--
Novel Phosphazene-based Compounds for Enhancing Electrolyte Stability and Safety of Lithium-ion Cells	Gering, Kevin (Idaho National Laboratory)	2-53	--	--	--	--	--
Screening of Electrode Materials & Cell Chemistries and Streamlining Optimization of Electrodes	Lu, Wenquan (Argonne National Laboratory)	2-54	3.50	3.00	3.50	3.00	3.19
Scale-up and Testing of Advanced Materials from the BATT Program	Battaglia, Vince (Lawrence Berkeley National Laboratory)	2-56	3.00	2.00	3.00	3.00	2.50
Fabricate PHEV Cells for Testing & Diagnostics	Jansen, Andrew (Argonne National Laboratory)	2-57	3.33	3.67	3.67	3.00	3.50
Electrochemistry Cell Model	Dees, Dennis (Argonne National Laboratory)	2-59	3.00	3.00	3.00	3.00	3.00
Diagnostic Studies on Li-Battery Cells and Cell Components	Abraham, Dan (Argonne National Laboratory)	2-61	3.67	3.33	3.33	3.00	3.38
Electrochemistry Diagnostics of Baseline and New Materials	Kostecki, Robert (Lawrence Berkeley National Laboratory)	2-63	3.33	3.33	3.33	2.67	3.25
Diagnostic Studies to Improve Abuse Tolerance and Life of Li-ion Batteries	Yang, Xiao-Qing (Brookhaven National Laboratory)	2-65	3.50	3.50	3.50	3.50	3.50
Develop and Evaluate Materials and Additives that Enhance Thermal and Overcharge Abuse	Amine, Khalil (Argonne National Laboratory)	2-67	3.50	3.00	3.00	3.00	3.13
Evaluation of Abuse Tolerance Improvements	Orendorff, Chris (Sandia National Laboratories)	2-69	3.00	3.00	3.50	3.00	3.06
Overcharge Protection for PHEV Batteries	Chen, Guoying (Lawrence Berkeley National Laboratory)	2-71	3.00	2.50	3.00	3.00	2.75

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High Energy Density Ultracapacitors	*Smith, Patricia (Naval Surface Warfare Center)*	*2-73*	*3.43*	*3.00*	*3.29*	*3.00*	*3.14*
In-situ characterization and diagnostics of mechanical degradation in electrodes	*Daniel, Claus (Oak Ridge National Laboratory)*	*2-75*	*2.67*	*2.67*	*3.33*	*2.33*	*2.71*
Low Cost SiOx-Graphite and High Voltage Spinel Cathode	Zaghib, Karim (Hydro-Quebec)	2-77	3.00	3.00	3.00	2.75	2.97
Design and Evaluation of Novel High Capacity Cathode Materials	Thackeray, Michael (Argonne National Laboratory)	2-79	3.75	3.25	3.50	3.25	3.41
The Synthesis and Characterization of Substituted Olivines and Layered Manganese Oxides	Whittingham, M. Stanley (SUNY-Binghamton)	2-81	3.00	3.00	3.33	3.00	3.04
STABILIZED SPINEL AND POLYANION CATHODES	Manthiram, Arumugam (University of Texas at Austin)	2-83	3.00	2.67	2.33	3.00	2.75
Olivines and Substituted Layered Materials	Doeff, Marca (Lawrence Berkeley National Laboratory)	2-85	4.00	3.50	3.00	3.00	3.50
First Principles Calculations and NMR Spectroscopy of Electrode Materials	Ceder, Gerbrand (University of Cambridge)	2-86	4.00	3.00	4.00	3.50	3.44
Development of High Energy Cathode Materials	Zhang, Jason (Pacific Northwest National Laboratory)	2-87	2.80	3.00	2.60	3.20	2.93
Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes	Henderson, Wesley (North Carolina State University)	2-89	2.75	2.75	2.00	2.25	2.59
Molecular dynamics simulation and ab intio studies of electrolytes and electrolyte/electrode interfaces	Smith, Grant (University of Utah)	2-91	3.00	3.33	3.67	3.00	3.25
In situ Characterizations of New Battery Materials and the Studies of High Energy Density Li-Air Batteries	Yang, Xiao-Qing (Brookhaven National Laboratory)	2-93	4.00	4.00	4.00	3.67	3.96
Search for New Anode Materials	Goodenough, John (University of Texas at Austin)	2-95	3.33	3.33	2.67	3.33	3.25
Electrolytes - Advanced Electrolyte and Electrolyte Additives	Amine, Khalil (Argonne National Laboratory)	2-96	4.00	4.00	3.00	3.00	3.75
Development of Electrolytes for Lithium-ion Batteries	Lucht, Brett (University of Rhode Island)	2-97	3.00	3.00	3.33	3.00	3.04
Bifunctional Electrolytes for Lithium-ion Batteries	Scherson, Daniel (Case Westerm Reserve University)	2-99	3.00	3.00	2.67	2.67	2.92
Studies on Oxide Cathode Crystals	Chen, Guoying (Lawrence Berkeley National Laboratory)	2-101	3.00	3.33	3.33	2.67	3.17
Investigation of critical parameters in Li-ion battery electrodes	Cabana, Jordi (Lawrence Berkeley National Laboratory)	2-103	3.00	3.50	3.25	2.75	3.25
New Electrode Designs for Ultrahigh Energy Density	Chiang, Yet-Ming (Massachusetts Institute of Technology)	2-105	3.00	3.00	3.33	3.33	3.08
Fundamental Approach to Electrode Fabrication and Failure Analysis	Battaglia, Vince (Lawrence Berkeley National Laboratory)	2-107	2.50	2.00	3.50	2.50	2.38
Modeling-Thermo-electrochemistry, Capacity Degradation and Mechanics with SEI Layer	Sastry, Ann Marie (University of Michigan)	2-109	3.50	3.50	1.50	3.00	3.19

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
The Role of Surface Chemistry and Bulk Properties on the Cycling and Rate Capability of Lithium Positive Electrode Materials	Shao-Horn, Yang (Massachusetts Institute of Technology)	2-110	3.50	4.00	3.50	3.50	3.75
Interfacial Processes - Diagnostics	Kostecki, Robert (Lawrence Berkeley National Laboratory)	2-112	3.25	3.75	3.25	3.50	3.53
Performance and Degradation Modeling of Batteries	Srinivasan, Venkat (Lawrence Berkeley National Laboratory)	2-114	3.00	3.00	2.67	3.00	2.96
Polymers For Advanced Lithium Batteries	Balsara, Nitash (Lawrence Berkeley National Laboratory)	2-116	2.50	3.00	1.50	2.50	2.63
Electrolytes - R&D for Advanced Lithium Batteries. Interfacial Behavior of Electrolytes	Kerr, John (Lawrence Berkeley National Laboratory)	2-117	3.00	3.00	3.00	3.00	3.00
Advanced Binder for Electrode Materials	Liu, Gao (Lawrence Berkeley National Laboratory)	2-119	3.50	2.50	3.50	2.50	2.88
ATOMISTIC MODELING OF ELECTRODE MATERIALS	Persson, Kristin (Lawrence Berkeley National Laboratory)	2-121	2.33	2.00	2.33	2.33	2.17
Intercalation Kinetics and Ion Mobility in Electrode Materials	Daniel, Claus (Oak Ridge National Laboratory)	2-123	3.33	2.67	2.33	2.33	2.75
In-Situ Electron Microscopy of Electrical Energy Storage Materials	Unocic, Ray (Oak Ridge National Laboratory)	2-125	3.67	3.33	3.33	3.00	3.38
Diagnostic Testing and Analysis Toward Understanding Aging Mechanisms and Related Path Dependence	*Gering, Kevin (Idaho National Laboratory)*	*2-127*	*3.00*	*3.00*	*3.00*	*3.00*	*3.00*
Overview and Progress of United States Advanced Battery Research (USABC) Activity	Snyder, Kent (Ford Motor Company)	2-129	3.33	3.17	3.83	3.00	3.27
Progress of DOE Materials and Manufacturing Process R&D Grants	Johnson, Chris (National Energy Technology Laboratory)	2-132	3.29	3.43	3.43	3.29	3.38
Computer-Aided Engineering for Electric Drive Vehicle Batteries (CAEBAT)	*Pesaran, Ahmad (National Renewable Energy Laboratory)*	*2-135*	*4.00*	*3.60*	*3.80*	*3.60*	*3.73*
Electrolytes and Separators for High Voltage Li Ion Cells	Angell, Austen (Arizona State University)	2-137	2.80	2.60	2.60	2.20	2.60
Integrated Lab/Industry Research Project at LBNL	Cabana, Jordi (Lawrence Berkeley National Laboratory)	2-139	3.25	3.00	3.75	2.75	3.13
Integrated Lab/Industry Research Project	Vaughey, Jack (Argonne National Laboratory)	2-141	3.75	2.75	3.75	3.25	3.19
Hard Carbon Materials for High-Capacity Li-ion Battery Anodes	Dai, Sheng (Oak Ridge National Laboratory)	2-143	2.40	2.00	1.20	2.00	2.00
Carbon/Sulfur Nanocomposites and Additives for Li/Sulfur Batteries	Liang, Chengdu (Oak Ridge National Laboratory)	2-146	2.75	2.75	1.50	2.75	2.59
Studies on the Local State of Charge (SOC) and Underlying Structures in Lithium Battery Electrodes	Nanda, Jagjit (Oak Ridge National Laboratory)	2-148	3.00	2.67	2.67	2.00	2.67
Perfluoro Aryl Boronic Esters as Chemical Shuttle Additives	*Hunt, Adam (Enerdel)*	*2-150*	*3.29*	*3.00*	*3.29*	*3.29*	*3.14*
Numerical and Experimental Investigation of Internal Short Circuit in a Li-ion Cell	*Kim, Ge-Heon (National Renewable Energy Laboratory)*	*2-153*	*3.60*	*3.60*	*3.80*	*3.40*	*3.60*

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Battery Thermal Modeling and Testing	*Smith, Kandler (National Renewable Energy Laboratory)*	*2-155*	*4.00*	*4.00*	*4.00*	*3.75*	*3.97*
PHEV Battery Cost Assessment	Gallagher, Kevin (Argonne National Laboratory)	2-157	3.38	3.00	3.00	3.38	3.14
Novel Composite Cathode Structures	*Johnson, Christopher (Argonne National Laboratory)*	*2-160*	*3.00*	*3.50*	*3.00*	*3.00*	*3.25*
Overall Average			3.18	3.07	3.01	2.94	3.07

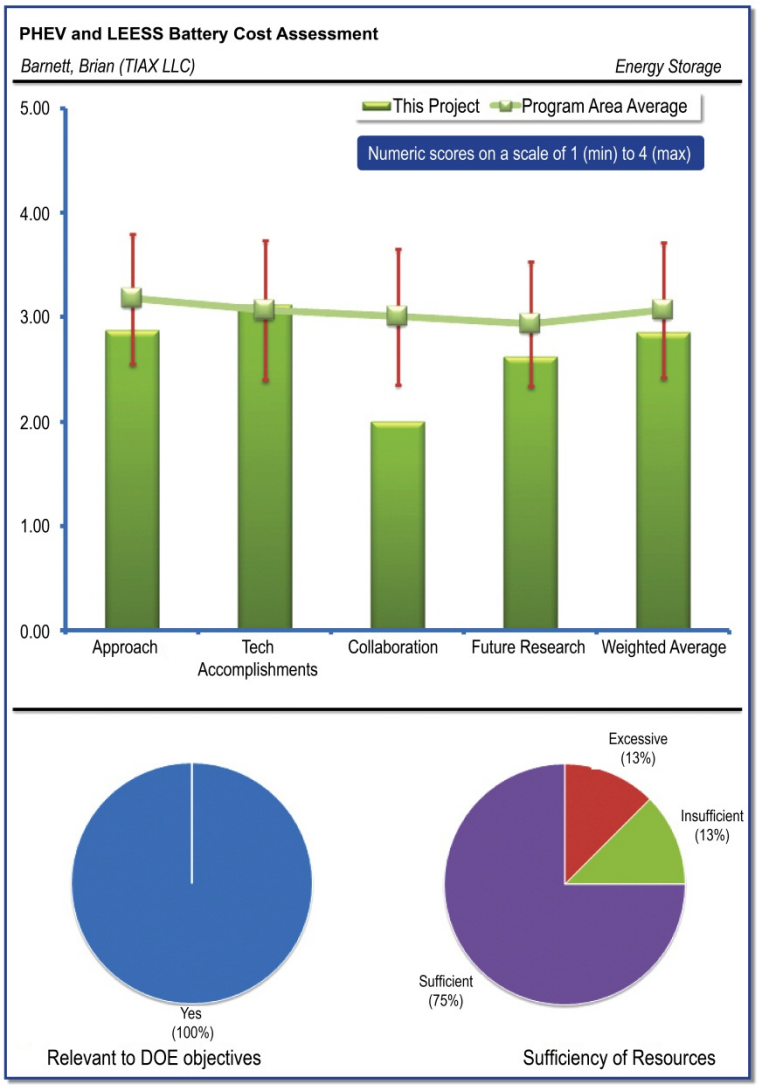
Note: Italics denote poster presentations.

PHEV and LEESS Battery Cost Assessment: Barnett, Brian (TIAX LLC) – es001

Reviewer Sample Size

This project had a total of eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?



Responses to this question were all positive, but with a few suggestions for improvement. One reviewer commented that the project provides battery cost comparisons and observations which may be useful on a relative basis. Another person had similar comments about the importance of cost, stating that the cost analysis of the batteries for profitability is very important. Another reviewer reinforced that cost is a key issue in the commercialization of new technology for EV, HEV and PHEV. They added that to be successful, a business must be profitable. This careful study provides the basic business information needed to construct a business plan for success in building lithium (Li)-ion batteries for transportation. Another person had detailed comments, affirming that this project is quite relevant to the overall DOE goal of partly replacing the conventional vehicles with hybrid or electric vehicles to minimize the national dependence on petroleum resources. The (high) cost of batteries for PHEVs is a serious issue from the manufacturers' perspective and thus requires considerable attention. The overall objective is to develop cost assessments based on appropriate models, for various chemistries and designs to identify the specific technology areas that need to be improved to mitigate the high costs. These studies, if successful, will assist in overcoming the cost barrier for Li-ion batteries for vehicular applications. The reviewer concluded by observing that successful implementation of the battery technologies in vehicular applications would in turn reduce the petroleum consumption, and pave the way towards petroleum replacement. One commenter explained that cost is the biggest barrier to the introduction of hybrid vehicle technology capable of providing substantial reduction in vehicular petroleum consumption. The reviewer felt that this work provides useful information on the impact of recent lithium ion battery technology on cost; both the absolute and relative information is useful. Another reviewer felt that the project will provide the appropriate information showing the cost benefits of using electrochemical electrical energy storage systems to replace petroleum for use in vehicle transportation. The reviewer also agreed that the project as outlined will also provide helpful directional information for choosing the optimum type and size system for automotive OEMs to significantly improve fuel economy. Another person stated that the cost models, if realistic, provide some forward business planning necessary for product development and marketing. It would be great to see a detailed comparison of variables between the TIAX model and the Santini/Gallager/Nelson model. The final person emphasized that the cost assessment is crucial in adequately addressing the DOE objectives and identifying clear limitations and challenges of Li- ion technology to fully exploit their potentialities in real applications. The reviewer added that on the other hand, the specific project objectives are not well described and commented with few information about budget and effective efforts.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

Reactions to this question were mixed, with most being positive. One person stated that the approach is realistic and complete. Another person pointed out that the approach involves the comparison of LEESS requirements with cell count of Prius IV nickel-metal hydride (NiMH) cells required to meet requirements is a useful observation and metric on a relative basis. One reviewer applauded the carefully thought approach which includes all of the elements and the parameters involved in commercial production. The reviewer added that the results can be trusted; Dr. Barnett has significant experience in this area (20 years or more) and understands the nuances of building a cost structure for a new product. Another person had very detailed comments, stating that in the past, TIAX performed the cost assessment for different chemistries in PHEV applications, which led to the expected conclusions that materials with high power and long life, electrodes with less surface area and methods facilitating rapid electrode coating help the cost. In the present work, a similar assessment has been made for LEESS applications, which have higher power needs, with three different approaches: i) parametric analysis of different Li-ion systems; ii) experimental characterization of different chemistries; and iii) extrapolation from the performance data of commercial systems. The reviewer added that the results indicate that, unlike for PHEVs, the majority of the cost comes not from cell materials, but from materials in the battery components (pack electronics) and cell casing, and the cell formation and aging processes, such that reducing the number of cells can lead to lower overall pack cost. Though not entirely unexpected from the increased power needs of the LEESS, the present analysis clearly provides some insight into the cost components. The reviewer concluded by asserting that the project is well-designed and integrated with other developments in materials and cell fabrication. One person commented that the selected approach is adequate in the definition and development of cost models and cell design determination, but it is questionable in including an internal coin cell preparation and testing for model validation. The reviewer felt that this approach strongly reduces the general applicability of the developed model to the rest of the Subprogram, because apparently there is no connection with the chemistries, cells, modules, and battery designs largely investigated in other projects. Another reviewer said that the cost analysis work seems logical and well organized and based on sound assumptions and methods. The reviewer pointed out that the assumed production volume is not indicated clearly. The reviewer also noted that the effect of production volume and the dependence of cost on production maturity are not explicitly addressed. The reviewer concluded by stating that it would be useful to estimate when these costs would be achieved. Another reviewer felt that the amount of material presented within the time restraints was excellent and that the work seems to be proceeding in a way that would provide useful information to the various automotive OEMs. The reviewer stated that they would like to see a summary slide showing how the different cell/system parameters clearly drive the system toward meeting the performance requirements relative to the cost implications. The reviewer also remarked that system voltages and current limitations should be included as they can/will drive chemistry selections, system size, cell count, and consequently system cost. Another reviewer offered that for high power-to-energy ratio the supercapacitors are more important and may meet the U.S. Advanced Battery Consortium (USABC) cost goals. The reviewer added that even though the approach is well thought out, it lacks the analysis for LEESS based on high power to energy ratio. The reviewer concluded by offering that supercapacitor may meet the USABC cost goals for the system. The final reviewer cautioned that specific use of coin cells for power estimation and area-specific impedance (ASI) determination may lead to significant inaccuracies in values.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments to this question were mixed. One person commented that the work shows good progress in state of the art Li-ion batteries towards cost goals and shows design approaches to reduce costs. The reviewer thought that there was very good insight on how design effects cost for PHEV and LEESS cases. The reviewer also thought that good credible tools developed both for estimates and relationships of variables effecting costs for complicated applications. Another person offered that this is the first time a study has been conducted with this scope. They added that the study is based on facts and not wishful hope that all will be okay. The reviewer added that this study is one of the basic needs for a viable business plan. The reviewer stated that the other need is a business model with markets, penetration path and profit-loss calculations. The reviewer concluded by remarking that once the costs are known, the credible business plan can be constructed. Another reviewer had detailed comments, stating that reasonably good progress has been achieved in carrying out the cost analysis for the batteries for LEES applications and the results are not contrary to the expectations, for a power-based application. In short, a chemistry that can support high power loads will have less electrode area and less number of

cells, and thus is a preferred option. The project is well designed, but the approach is not as relevant and robust. It is based on in-house test data from the coin cells (far from reality) and the values for the electrode loadings, fade rates and SOC ranges are rather arbitrary and may not relate to those adopted in the industry. The loading, for example, may not be uniform across different chemistries, differing in tap densities. The coin cell data are particularly suspect, especially with the impact electrolyte conductivity had on the power characteristics, and it is hard to predict the behavior of large capacity cells form the coin cell data. Also, there may be several variations from the materials and the electrode design parameters that TIAX used for these cells. The reviewer concluded by suggesting that a more direct collaboration with the manufacturers of one or two representative chemistries in terms of using their electrodes/cells data will add credibility to these analyses and to the conclusions from this study. Another reviewer had similar comments, stating that the technical achievements are interesting and valuable, but only of limited acceptability because they are strongly conditioned by the approach restricted to the in-house cells. The final reviewer felt that a great deal of work was done in the selected areas. However, the reviewer mentioned that they would like to have seen more costing information on the electrolyte and separator costs as they may contribute more significantly to the cell cost depending on the chemistry. It was not clear to the reviewer that this issue was fully addressed. The reviewer concluded by hoping that the final program outcome will provide a clear "overall" system cost range for the various current cell technologies, with respect to the different cathode material.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question revealed that there was limited, if any, collaboration. One person stated that the presenter did not elaborate upon this in the PowerPoint presentation. Another person noted that in order to get the information for the study, Dr. Barnett has had to establish a trust in the investigator to present the results carefully and protect proprietary information. One commenter stated that there are no collaborations mentioned in the presentation, though they would presume that the principle investigator (PI) would have had some discussions/interactions with the battery manufacturers or other researchers on the material properties, electrode design aspects, etc. Another reviewer agreed, stating that the collaboration is not clearly addressed and is considered extremely important with need for some coordination with other projects for improving expected results. Another reviewer mentioned that there was no indication of collaboration or coordination with other institutions. This reviewer suggested that particularly, there could have been some outside measurements for verification of power vs. electrode loading from national labs and/or battery developers. Another reviewer had similar comments that they did not see any significant collaboration with other partners. The reviewer emphasized that they would like to have seen some collaboration with others to support larger format cell builds. The final reviewer commented that it was not obvious who is validating the database and models because the process is held confidential.

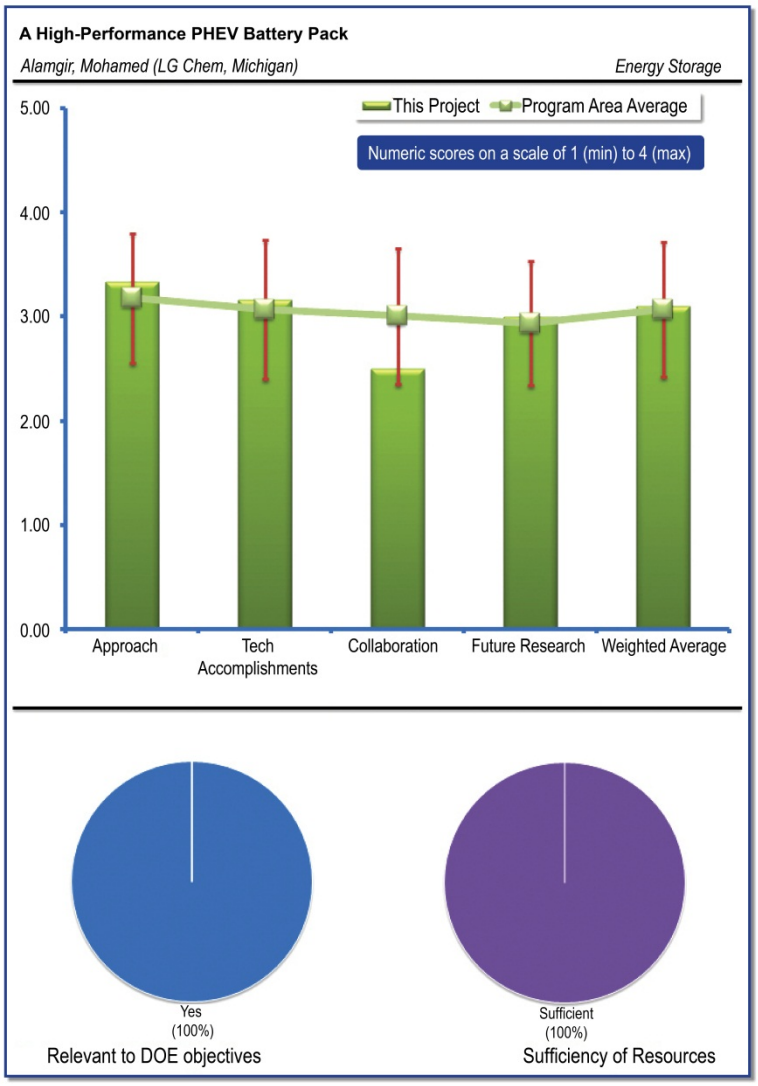
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments state that the future plans are not clear. One person observed that the proposed research for Fiscal Year (FY) 11 is to update the models and databases to place all assessments in a common basis and to investigate the tradeoffs between HEV performance, fuel economy, and battery cost. Another reviewer commented that each new material and process for making materials and cell assembly will require a new calculation on cost. The reviewer felt that this model should be able to accomplish updated costing with a minimum of effort, provided only minor changes in cell assembly processes are made; once constructed, the model can be updated on a regular basis. One reviewer commented that the program outlines future work for the LEESS program in extremely broad terms; more definition is needed. The reviewer added that the program does not say anything about the future PHEV effort. The reviewer concluded by stating that it was felt that one future plan for the PHEV program should be similar to the very broad future plan for the LEESS program - investigate the tradeoffs for the various PHEV systems, with respect to fuel economy and battery cost. Another person asserted that it was not clear if the running activities are the final ones, or there is a lack of information about prosecution of work, which is not adequately analyzed with extension to lithium commercial systems. Another commenter stated that the future work description was minimal and vague. This reviewer also felt that information on the project start and end date timeline was missing, to the point that they were unclear whether the contract had ended or not. The reviewer concluded by requesting that if there will be new projects, that more info on future work would be useful. One person asked whether the 2014/2015 timeframe assesses a time far enough forward for OEM projections (should be focused 5-10 year forward). The final person commented that the future research continue based on the perception of the successful last two years; however, the validation of success is lacking.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Comments all pointed to the fact that the presenter did not provide sufficient information. One reviewer commented that the lack of information made it hard to give clear justification to this criterion. Another person agreed with this assessment, stating that resources and funding for the project were not disclosed in the presentation. One commenter indicated that the budget information is not provided here, but recalled from discussions at the meeting that it is approximately $150,000; if so, the resources are adequate for the planned effort. Another reviewer also had similar comments, explaining that budget and cost information is missing. The reviewer criticized that omitting this for only this project makes it look like there is some special relationship or favoritism to this contractor. The reviewer concluded by stating that verbally it was stated the cost was $150,000 per year; if so, this was actually a great value for the investment. Another reviewer commented that based on the scope of the study the resources provided by DOE are marginal; therefore, the reviewer was sure that TIAX provided considerable support in the gathering of the data. The final person commented that TIAX appears to have the needed expertise and financial support to accomplish stated and recommended goals in the program's time frame.

A High-Performance PHEV Battery Pack: Alamgir, Mohamed (LG Chem, Michigan) – es002



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person stated that the project clearly addresses key elements for Li batteries functional to the DOE objectives. Another person agreed that the project is aimed at improvements in performance and cost of batteries for PHEVs that can substantially reduce petroleum usage for passenger vehicles. The reviewer added that the work spanned battery cells, modules, and packs addressing energy, power, life, and safety performance. Another person had detailed comments, describing that this is a project, ongoing for the last few years, initially aimed at developing a PHEV-10 mile battery pack system based on Li-ion cells with 5,000 cycle-life and 15-year life, as targeted by USABC, and accompanied by a highly efficient thermal management system. The reviewer explained that the current objectives are to develop cells for a PHEV with a 40-mile range on a single charge (PHEV-40), using next generation high capacity cathode materials, to develop battery packs and to further optimize the thermal management system. The reviewer's comments concluded by affirming that the project objectives are quite in tune with the DOE goals of reduced greenhouse gas (GHG) emissions and petroleum consumption through the use of hybrid and electric vehicles. One commenter noted that LG Chem (LG) is a large company that supplies Li-ion batteries for use in powering EV, HEV and PHEV now under development. The reviewer stressed that successful deployment of the vehicles hinges on a viable source of high energy batteries. The final reviewer commented that battery and component development are necessary enablers to successful deployment. The separator advancements by LG have been essential for safety and tolerance abuse.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed. One person was not clear on the approach or even what program was under review. The reviewer noted that three are covered included two that appear complete and one that just started this month, so they were not clear what we are supposed to be reviewing. The remaining reviewers did not hold this opinion. One person described that the design, construction, and production of flat, prismatic cells for incorporation into battery packs is essential for powering these PHEV vehicles. The reviewer concluded by stating that the design has been carefully qualified for performance as well as safety. Another commenter reported that the project has been well prepared and organized with focus on various key components of the Li battery. The reviewer felt that the project is well based on previous projects results and open issues. Another person observed that the approach is believed to be driven by the current production environment (GM); LG has shown significant gains in battery development in a short timeframe. The final reviewer had detailed comments, explaining that the approach is based on improving the cell performance characteristics by optimizing the composite cathode (spinel/layered), carbonaceous anode material, electrolyte composition, and more

importantly a proprietary ceramic–reinforced separator in a laminated package cell deign. The spinel manganese oxide is a good choice to meet the life and cost target and the laminated packaging helps in improving the specific energy and reducing the cost, while the use of ceramic-reinforced separator will provide additional safety to the battery during any abuse. Thermal control of the battery pack through the circulation of chilled air is easy to implement and may be cost-effective as well. The reviewer concluded by stating that the overall project is well designed and well integrated with the materials developments, under the other DOE projects related to lithium batteries.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed. One reviewer commented that they were unsure what was supposed to be reviewed. This reviewer added that however, in all cases, progress is not clearly presented. The reviewer concluded by suggesting that a USABC gap analysis would be a useful way of showing progress. One person reported that the results of previous projects are very good and the progress of the last project is still too limited. Another reviewer mentioned that LG provides batteries that are reliable, have high performance characteristics that are essential for the success of the PHEV in the U.S. market. One person had detailed comments, acknowledging that considerable improvements have been made from Gen 1 to Gen 3 cells in all the desired characteristics (i.e., cycle life, high temperature resilience and the low-temperature cranking) to meet the targets of the USABC program. It was difficult, however, to quantify in the absence of units on the graphs; possibly the relative improvements could have been mentioned in the charts. Likewise, it was difficult to gauge how well the specific energy (40 mile range) requirements have been met, in the absence of actual numbers for Watt hour (Wh)/kilogram (kg). The packs designed and delivered appear to meet the performance targets and are equipped with efficient thermal, and probably compatible, design based on circulating chilled air inside the battery. The reviewer added that the developed results in performance thus achieved here look quite promising and it is possible that further improvements in the specific energy and reduction in the cost of the thermal management will emerge from this effort that can benefit PHEV-40. The final reviewer remarked about the interesting comparison of air- vs. liquid-cooling; and asked how this refrigeration system is going to help meet the cost targets of <$200/kilowatt hour (kWh).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed, with some reviewers stating there was no collaboration, while others felt the collaboration was good. One reviewer commented that the design, qualification and performance have been carried out in-house at LG. The suppliers of critical parts have worked alongside LG to arrive at the final design and the suppliers of critical electrode, electrolyte, and packaging assure a high quality product. Another person indicated that there is good ongoing collaboration with the National Laboratories in terms of testing and verifying the performance of the cells and packs emerging from this project, as well as the thermal management scheme developed here. Another reviewer, however, felt that the collaborations of the research community are well selected and appropriate. Probably, the type of effort with significant activities on materials, system engineering and cost reduction would require the involvement of materials producers and thermodynamic modeling & engineering contributions. The final reviewer stated that the work occurred all inside LG, but even though they are capable, this lacks the rationale of collaboration.

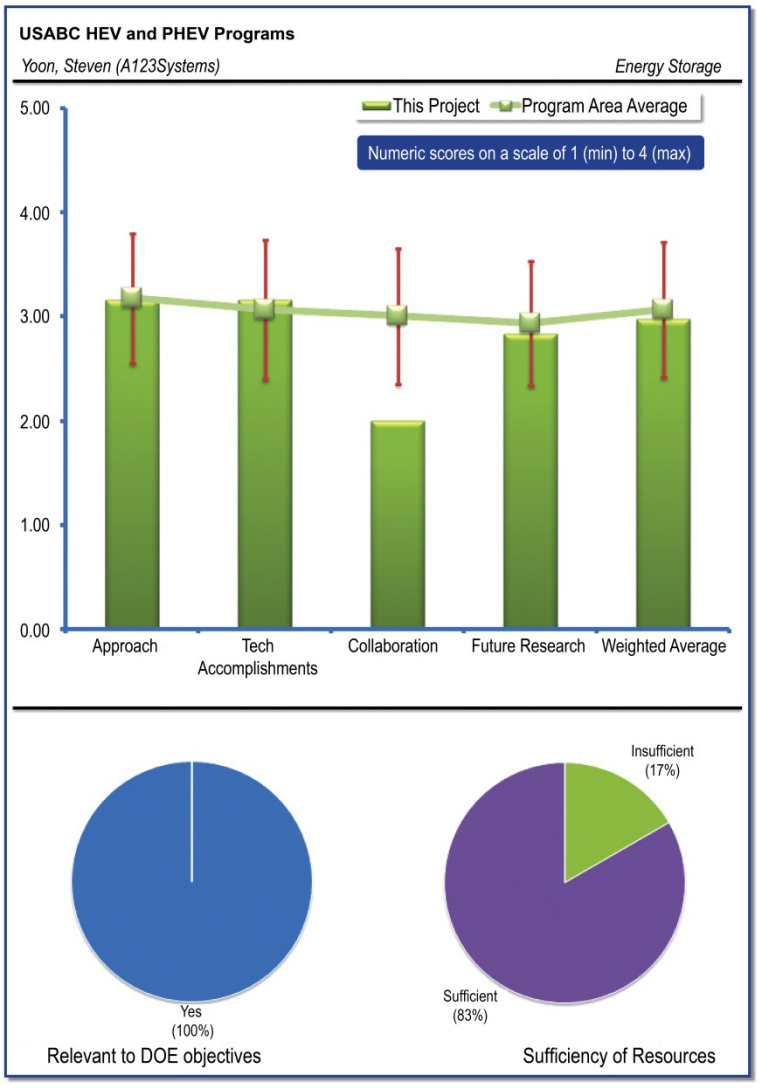
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were again mixed. One person stated that they were unclear about the future plans. Another reviewer reported that no future research plans were requested to the best of their knowledge. One commenter stated that future work is part of the presented project just started and it is relevant in terms of planning. The final person commented that the future plans include developing cathodes of higher specific energy to meet the needs of the PHEV-40 in terms of energy density and optimizing the thermal management system to reduce the overall cost of the battery packs. The reviewer concluded by stating that future work is thus planned in a logical manner and not many serious barriers are expected in this improvement for PHEV-40.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers to comment indicated the resources were sufficient. One person stated that the budget seems adequate. Another person explained that sufficient resources were provided to carry out the project. The final reviewer commented that the resources are adequate for this project to achieve the objectives.

USABC HEV and PHEV Programs: Yoon, Steven (A123Systems) – es003



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person stated that the project provides the cells for 10- and 40 mile PHEV vehicles. Another person explained that the project is aimed at improvements in performance and cost of batteries for PHEVs that can substantially reduce petroleum usage for passenger vehicles. Specifically, the work aimed at development of pouch cells with potential for higher energy density and lower cost. Another reviewer agreed that the project is focused on advanced Li battery for EVs, well supporting DOE objectives. The final reviewer had detailed comments, asserting that the project is consistent with the DOE goals of reducing petroleum consumption and GHG emissions by using battery-powered hybrid and electric vehicles. This project is aimed at: i) developing Li-ion battery packs comprising prismatic pouch cells using A123 Systems (A123) doped nanophosphate chemistry for PHEV (10 and 40 mile); and ii) developing low-cost battery modules for HEV hybrid battery systems. These programs thus align with the goals by addressing the relevant technical barriers such as life, safety and cost. Owing to the higher power and enhanced safety characteristics of this battery chemistry (using lithium phosphate), this system would be an excellent candidate for the HEVs and PHEV-10, though, it may be challenging to meet the 40-mile range, due to its lower specific energy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments to this question were generally positive. One reviewer noted that a traditional approach was taken in the design of the cells for battery packs. Another person commented that the project is well organized with clear objectives, milestones, and deliverables conveniently related to the identified technical barriers. However, the proposed solutions are described in a generic manner making hard to evaluate the effective level of innovation introduced. Another commenter mentioned that two complex and comprehensive programs were included with a reasonable organized approach, but the reviewer thought the presenter could have provided more detail. The final reviewer had detailed comments, stating that the approach is based on addressing the key technical barriers for this technology for its applicability in PHEVs and HEV. The approach thus consists of: i) developing high energy materials, optimize electrode and pouch technology in new cell designs (20 ampere-hour [Ah] prismatic) with long cycle life; ii) optimizing thermal management through cell and module design for good calendar life; iii) improving energy density through efficient module / pack design; and iv) reducing cost through high energy materials and improved deigns. Similar goals for the HEV are being achieved through improved electrode and hardware design. The overall project is well designed, looks feasible and well integrated with the materials developments, under the other DOE projects related to lithium batteries. The only barrier that this technology may find it

difficult to meet is the high-energy specific energy requirement for PHEV-40; these cathodes (either iron [Fe] or Mn phosphates) are unlikely to meet the energy needs and no additional information was provided in support of the high energy density characteristics from these materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that the results are very interesting with good progress with respect to the objectives. Another reviewer commented that high-performance battery packs based on a pouch cell configuration were designed and fabricated but performance fell short. Another reviewer had similar comments, stating that though aggressive, the USABC targets of cost and calendar life were not reached (very important). The next reviewer acknowledged that the project included comprehensive and complex programs with challenging hardware and testing tasks. The reviewer felt that the gap analyses showed excellent progress to USABC goals and also mentioned that the programs will be completed late with no-cost extensions. The final reviewer commented that the technical accomplishments and progress achieved in the two parts of this project, i.e., for the PHEVs and HEVS, are impressive, though there must be considerable leverage from the other in-house efforts. Specific accomplishments for the PHEV program include setting up the production facility for 20 Ah (pouch) prismatic cell for PHEV and completing the fabrication and testing of two generations of cells, with the latter meeting the energy and power needs, and likely to meet the life target, but still falling short in the cost goal. In the HEV category, the accomplishments include development and delivery of 10-cell module, comprising 32113 cells, which meet HEV power and energy targets and are to comply with the life requirements. In addition, a 6Ah HEV Prismatic cell was developed and delivered with expected improvements in cost, energy, and power targets. The reviewer criticized that once again, as with other USABC–sponsored developments, it is hard to know how well this project is pacing towards the PHEV or HEV goals, in the absence of any quantitative data. This project has delivered several forms of hardware (cell and packs) at various stages for testing at the national laboratories.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers all stated that there was no collaborations, but the reactions to this were mixed. One person commented that the work occurred all inside A123, so it does not meet the goals of collaboration. Another person commented that coordination and collaboration was as would be expected. Another reviewer mentioned that no partners or collaborations were included in the project, though they surmised that this does not seem to negatively impact the program. One commenter expressed that there is no formal collaboration in the development of these technologies, but there is ongoing collaboration with the National Laboratories in terms of testing and verifying the performance of the cells and packs emerging from this project. The final reviewer had similar comments, stating that there are no collaborations planned and used; it should be better to have at least the contribution of National Laboratories for at least optimizing and clearly confirming the results.

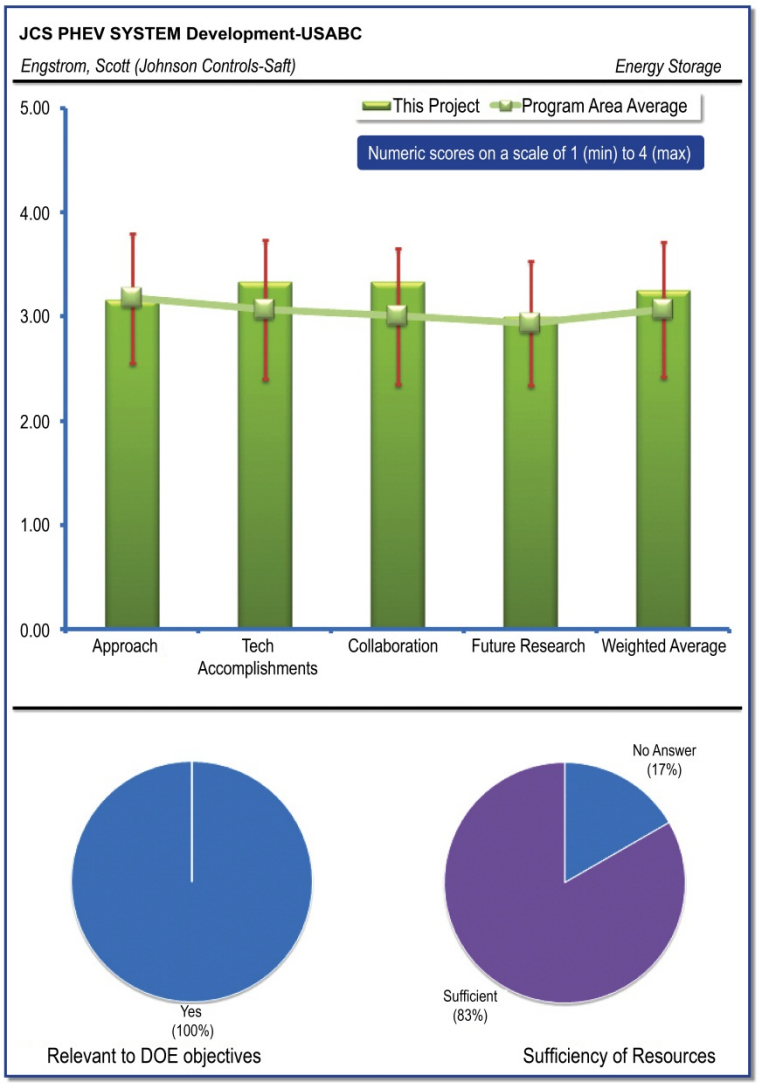
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed, with some believing that the project is completed while other felt that there is work remaining. One reviewer commented that the limited work left is correctly related to the previous results. Another reviewer offered that the future plans are to continue the testing of Gen 2 1.5 Ah prismatic cells and packs for the cycle life and calendar life and cold cranking requirements and to deliver a pack based on these cells. Therefore, the future work appears logical with no anticipated risks. Another person stated that there was no extension to the contract. One reviewer reiterated that this is a no-cost project extension, but added that the project is essentially over. The final reviewer commented that the project is essentially complete and seems generally successful with exception of cost, which is challenging and may be addressed through manufacturing development activities.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented that the resources are adequate for this project to achieve the objectives. Another person stated that the budget seems okay. The final reviewer expanded on this, stating that the cost extension required to complete the project was denied.

JCS PHEV System Development-USABC: Engstrom, Scott (Johnson Controls-Saft) – es005



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person pointed out that the project is aimed at improvements in performance and cost of batteries for PHEVs that can substantially reduce petroleum usage for passenger vehicles. The reviewer added that the work spanned battery cells, modules, and packs addressing energy, power, life, and safety performance. Another person affirmed that the design and construction of experimental cells is an essential part of arriving at the best cell design for a particular purpose. One reviewer remarked that all advances to progressing cell materials in the technology are important. Another reviewer acknowledged that the project is well in line with DOE objectives. The final reviewer had detailed comments, agreeing that the project is consistent with the DOE goals of reducing petroleum consumption as well as GHG emissions by using battery-powered hybrid and electric vehicles. The reviewer explained that this project is aimed at developing, fabricating and qualifying 20 Ah prismatic cells for PHEVs for 20-mile (PHEV-20) and 40-mile all-electric range applications, and optimizing the battery system designs meet the USABC performance goals. The reviewer concluded by explaining that this project is thus attempting to overcome the technical barriers of energy density, cycle life and cost of the present cells for the PHEV applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviews to this question were mixed, with some reviewer providing criticisms, while others described the approach. One reviewer stated that the project is organized to improve existing Li technology with a detailed, but generic, approach with limited indication of the real innovations. Another person commented that the researcher's presentation of the approach was disorganized and confusing, but the reviewer acknowledged that the project is a comprehensive and a large body of work. One reviewer explained that the project approach included that cells were constructed and built with specific applications in mind, e.g., PHEV-20 or PHEV-40. The reviewer highlighted that the choice for cathode is a critical part of the activity. The commenter also noted that all the constructions need to be cycled, and tested according to a pre-prescribed regime. Thermal management and other safety features are incorporated into the cell packs. A thermal model was developed and testing for performance and abuse tolerance was carried out. The reviewer concluded by mentioning that a cost model was developed for experimental purposes. The final reviewer described that the project approach is based on: i) utilizing the existing Saft prismatic cell manufacturing equipment and technology for the wound or stacked cell design; ii) evaluating advanced cathode materials (nickel manganese cobalt [NMC]) for improved energy densities [compared to nickel cobalt aluminum oxide (NCA)-based systems]); iii) redesigning the cell mechanics to meet the targeted 30 Ah capacity; and iv) developing and delivering a battery system with series/parallel combinations of these prismatic cells. The reviewer concluded by explaining that

in addition to performing tests to assess the improvements in capacity, cycle life and calendar life, detailed tests were conducted to demonstrate the safety tolerance of these cells to various abuse test conditions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed. One person stated that the researchers met all goals and targets. Another reviewer noted that the cells and packs were assembled and tested according to prescribed regimes to confirm the cell design and that several iterations on the design are made to respond to the testing results. The reviewer concluded by mentioning that a final design was established and further testing of performance, safety, etc. was carried out. One reviewer had detailed comments, acknowledging that good progress has been achieved in improving the specific energy in the 20 Ah prismatic cells for PHEVs with 20-40 miles range. The reviewer described that other project accomplishments include: i) optimization of cell fabrication methods for improved robustness and manufacturability; ii) optimization of NMC chemistry to improve cell performance; iii) development of prismatic cell building capability for both wound and stacked prismatic cells; iii) fabrication, testing and delivery of a prototype system; iv) development of a thermal simulation model, which was later verified through experiments; and v) carrying out various abuse tests to demonstrate the safety. The reviewer observed that once again, as with other USABC–sponsored developments, it is hard to know how well this project is pacing towards the PHEV goals, in the absence of any quantitative data, though it is clear that there is notable improvement from Gen 0-Gen2 versions. This reviewer concluded by mentioning that the project has delivered several forms of hardware (cell and packs) at various stages for testing at the National Laboratories. Other reviewers had similar comments about the difficulty in gauging the progress. One reviewer noted that the results achieved seem interesting, but are substantially incomplete to give a clear evaluation of the progress. The reviewer also criticized that most graphs had numerical indication of the involved quantities. The final reviewer agreed with others that there seems to be significant progress in development of prismatic cell hardware with NMC chemistry. The reviewer explained that it is evident that a lot of work was done, but that it was difficult to judge the status with respect to USABC goals. The reviewer suggested that a gap analysis chart would have been helpful. The reviewer concluded by mentioning that the program is complete but at least three deliverables are past due.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were generally positive. One reviewer commented that the use of National Laboratories is a plus. Another reviewer noted that the presenter mentioned the collaboration with Saft and Entek. Another reviewer noted that Johnson Controls Inc. (JCI) worked closely with Entek for separators and BASF for NMC materials and USABC for contract issues. Another reviewer had similar comments, indicating that there was some collaboration with the separator developer, but this is ongoing collaboration with the National Laboratories in terms of testing and verifying the performance of the cells and packs emerging from this project. The final commenter felt that the collaborations are reasonable, but that there is no collaboration with other subprogram participants. Particularly, there is no clear indication of the possible role and contribution of independent testing laboratories.

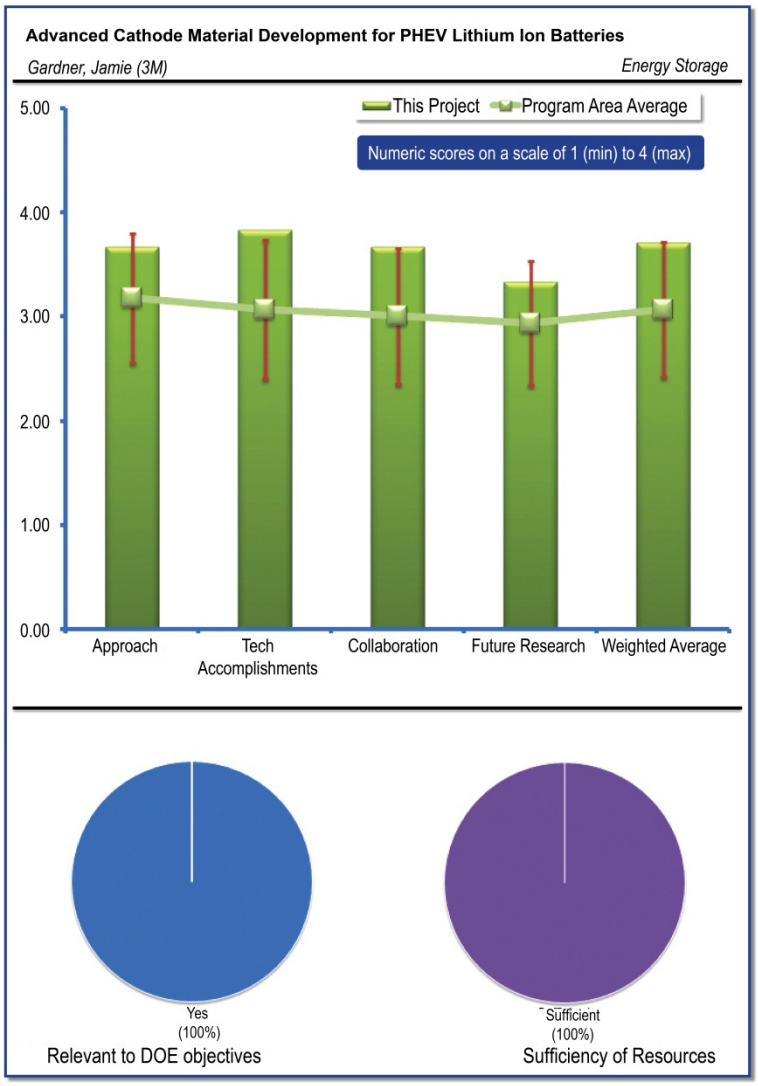
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments to this question were mixed, with some reviewers describing the future plans and others stating there were no future plans since the project is over. One person felt that the next steps are appropriate and well related to the previous work. Another reviewer commented that the future planned studies are logical, look feasible and include fabricating and delivering improved prismatic cells and the 20-mile battery systems for multiple lab evaluations, and develop designs for low-cost 40-mile battery system. One reviewer indicated that the program path was established and followed and that the contract is almost finished. Another reviewer, however, stated that the future plans presented are sketchy and not quantitative. Another commenter reported that additional work was not discussed, while the final reviewer stated that the question was not applicable.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reactions to this question were mixed. One person stated that the financial resources were adequate for the contract requirements. Another person agreed, commenting that the resources are adequate for this project to achieve the objectives. The last reviewer expressed that it was very hard to make revision on a so large budget with limited information.

Advanced Cathode Material Development for PHEV Lithium Ion Batteries: Gardner, Jamie (3M) – es006



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive, although only two reviewers out of four specifically mentioned the project's support of DOE objectives. One person described that the project provides new high-energy cathode materials for use in cells and battery packs for transportation applications. Another person explained that the project provides for lighter weight and lower cost cathode materials providing higher specific energy and lower cost batteries particularly for EV and PHEV applications. Another reviewer emphasized that the project absolutely supports DOE's petroleum reduction goals; advanced cathode and other cell core components will be essential for technology success. The final reviewer commented that this project is aimed at developing advanced cathode materials with enhanced capacity (10%) and reduced cost (15%), with no loss in cycle life or thermal stability compared to the state-of-art metal-nitrogen-carbon (MNC) (111) cathodes. Low specific energy and high-cost are the two deterrent factors for the PHEV-40 batteries and new electrode materials are required to overcome these barriers, so successful development of these materials will increase the viability of Li-ion batteries powering the PHEVs and electric vehicles, which, in turn, will reduce the petroleum consumption as well as decrease the GHG emissions, as desired by DOE.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers provided various summaries on the researcher approach. One person mentioned that the approach followed traditional approach to identify materials, scale-up pilot plant and construct 18650 cells to verify performance. Another reviewer explained that the project is based on a combined approach using statistical models to identify and select cathode materials, followed by experimental work. The reviewer felt that the selection of technical issues with quantitative targets is a sign of good planning. Another reviewer also felt that the project utilized a good, well-organized, and detailed approach to target both compositional modification and process improvement to achieve cost reduction. Another reviewer had similar comments, stating that the approach utilized known methods the project scope was well defined with an achievable target. The final reviewer had detailed comments, stating that the approach is based on developing new cathode materials from the layered-layered composites of Li_2MnO_3 and $LiMO_2$, where M=Mn, Ni or Co. The reviewer agreed that this approach is the most likely solution to increasing specific capacity of the cathode materials beyond 170 mAh/g, as is also being attempted by several other laboratories. The range of compositions (Mn-rich) being focused here will duly address both the technical barriers of energy and cost, without compromising with the thermal stability or cycle life. Further, the efforts to scale up the cathode synthesis and validate its performance and abuse tolerance in sealed cells are consistent with the project

goals. The reviewer concluded that the project is thus well-designed, looks feasible, and well-integrated with the other material development efforts under DOE.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses to this question were all positive. The first reviewer commented that the results are close to the defined targets with an excellent progress. Another reviewer remarked about the excellent noted achievement on all defined barrier goals. The reviewer added that noteworthy is "cost" which seems difficult in most projects and is essential if not the key to market success. One commenter highlighted that the researchers achieved increased specific capacity and lowered material costs in accordance with goals. Detailed characterization confirmed comparable, or better, performance across all gap analysis criteria. Another reviewer had similar comments, acknowledging that the project was completed, including developed cathode materials with lower cost and higher performance, and sent cells for evaluation in DOE labs. The final reviewer described that the project progress achieved in developing new material, i.e., optimizing the cathode material composition (from about 50 samples), is quite reasonable. The improvements in capacity meet the initial targets, even though these improvements are not as significant as the reviewer expected. Subsequently, however, the material has been successfully scaled up to 25 kg and assessed in detail for its electrical performance and abuse tolerance in 18650 cells. These tests indicate that the 18650 cells containing this advanced cathode materials have met the performance targets, from the “gap analysis”. Further confirmation of the benefits for this material will, of course, have to come from the cells fabricated by a battery manufacturer. The reviewer concluded by affirming that this project has delivered a few cells to the DOE laboratories for the assessment of performance and safety.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All reviewers noted the good collaboration with National Laboratories. One person acknowledged the good collaboration with ANL and Sandia. Another reviewer mentioned that the researchers collaborated with Sandia and Argonne and supplied cells for testing. One reviewer commented that the project is well-integrated in the subprogram with good collaboration with National Laboratories. Another reviewer applauded that Sandia is an excellent test partner for independent abuse testing. The final reviewer affirmed that there is good collaboration with the National Laboratories in terms of testing and verifying the performance, and demonstrating the abuse tolerance of the 18650 cells with the advanced cathode material.

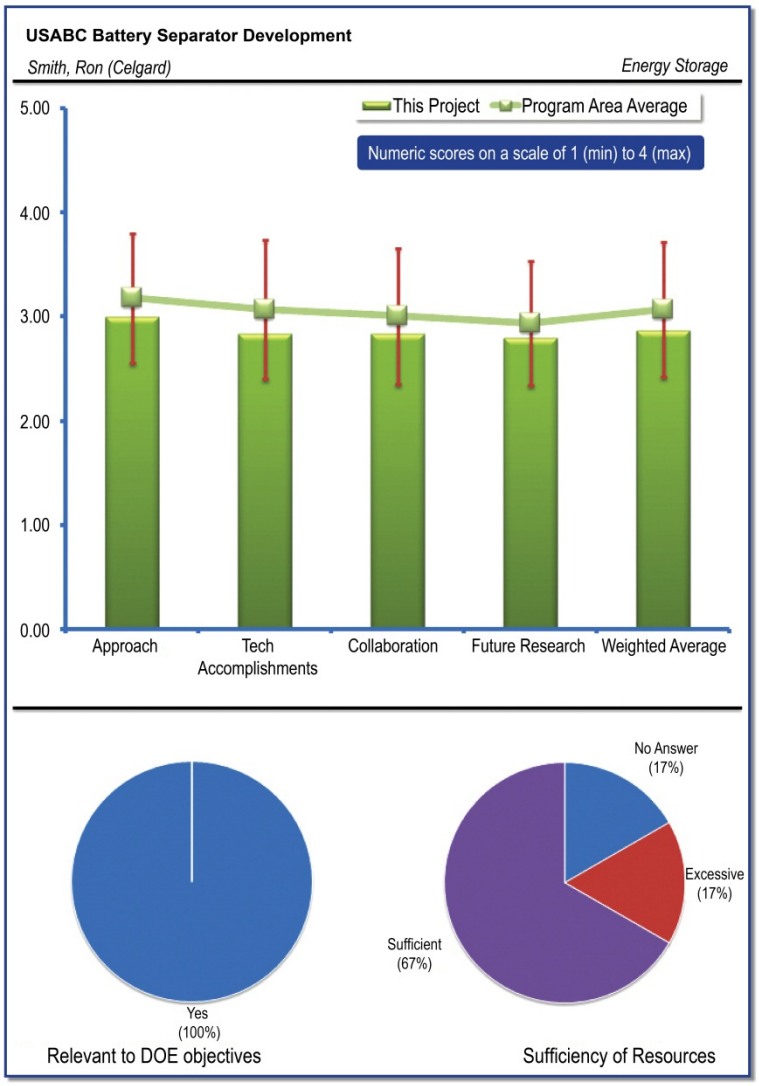
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed, with some people stating that the project was completed with no proposed work, while others described future work plans. One reviewer commented that as the project is winding down this year, the plans for the rest of the year are to continue the life tests on the cells in-house and to collaborate with the National Laboratories to complete performance verification in 18650 cells. Another person commented that the project was successfully completed, but would be nice to share plans to utilize new materials in products. Another reviewer, however, felt that the future plans were well-connected to the running and previous work. Another reviewer had similar, but brief comments, stating that the work proposed is reasonable. The final reviewer requested that DOE keep this project going into large cell format.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers felt that the resources were adequate. One person stated that there was no mention of resources issued, while another reviewer felt the resources are okay. The final reviewer to comment stated that the resources are adequate for this project to achieve the objectives.

USABC Battery Separator Development: Smith, Ron (Celgard) – es007



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One reviewer commented that the work on separators can give support to DOE objectives, even if these objectives are not clearly described in the presentation. One commenter affirmed that the robust separator is essential for long life and high performance. The reviewer also pointed out that Celgard supplies a high percentage of separator materials for the Li-ion industry. Another person explained that the project's goal is to develop procedures for battery separators for improved safety for lithium ion batteries for EV, HEV, and PHEV applications. One reviewer highlighted that separator development is a key safety enabler in the automotive market. The final reviewer commented that this project is aimed at developing a standard testing protocol for evaluating high temperature melt integrity (HTMI) properties of lithium-ion battery separators and to design and develop a separator product that demonstrates HTMI criteria. Mechanical failure of separators through shrinkage at high temperatures is a known failure that ultimately leads to cell thermal runaway, should there be any thermal abuse condition within the cell. The shrink-resistant separator being developed here will greatly improve the safety of Li-ion batteries, which is a major technical barrier for the viability of Li-ion batteries powering the PHEVs and electric vehicles to reduce petroleum consumption as well as decrease GHG emissions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person explained that a test method was developed to confirm the performance of a new separator material; the project then developed a new material with improved performance. Another reviewer commented that the overall research plan is reasonable; however, approach details are missing. One reviewer had detailed comments, explaining that the approach is based on developing test standards for the HTMI properties of the separators, both on the films as well as on the cells containing these separators. The film tests include dimensional rigidity (stability) under hot conditions of 150-200° Celsius (C) as well as shutdown properties (increased resistance with temperature) of the polymer. The reviewer criticized that the shutdown requirement was not part of the current project. New separators being developed in this project include polymeric component as well as ceramic filler for improving the mechanical properties. The reviewer concluded by indicating that the project is well-designed and looks feasible to develop new mechanically robust and thermally resilient separators for Li-ion cells. One person remarked that the approach includes an interesting metric of separator "withdrawal" from the hot tip. The final reviewer commented that there is an acceptable understanding on technical barriers of Li cell separators with the development of specific testing procedures; however, it is not fully understandable why a novel separator must be developed to validate the procedure: other commercial separators should be used. The reviewer added that work on novel

separator development cannot be simply focused on preparation of materials for testing validation, but it should have more practical and technical objectives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses to this question were mixed. One person reported that the researchers met the goals of developing a new material that meets to goal and a method to test the separator materials to conform performance. Another reviewer expressed that any advancement which at least minimally delays the onset of runaway is a success, perhaps however if the delay or initial internal short can be detectable by the BAS. If detectable, the system may have a small amount of reaction options to the rest of the pack so as to avoid catastrophic failure. One reviewer had detailed comments, describing that new test standards have been developed in this project for the separator materials, based on: i) hot-tip test for the melt integrity; ii) temperature-dependent resistance for the shut-down property; and iii) dimensional stability under load at high temperatures. In addition, the hot-box tests on the cells provide correlations with the dimensional stability and shut-down property of the separator. New separators were developed based on impregnating the polymeric separators with ceramic fillers, as is being done in the other laboratories. Three versions of such composite separators were developed and demonstrated to have improved dimensional stability at high temperatures. The reviewer added that interestingly, the HTMI coating did not prevent cell failure in the nail penetration test, but would delay exotherm onset. The reviewer concluded by indicating that this project has delivered two rolls of the new separators to DOE laboratories for further assessment. Other reviewers had more critical comments, with one stating that the results are only partially addressing the targeted objectives. The final reviewer criticized that the results are not impressive. Additionally, this reviewer observed that the procedures developed were not clearly identified or explained. The reviewer felt that none of the separators appear to pass Z-direction strength test. Further, this reviewer continued that the work also does not appear comprehensive or creative. The reviewer concluded by cautioning that neither the test procedures, nor the separator research and development (R&D) work, appear to provide much value towards new separator products.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments all point to fact that the only collaboration is with a National Laboratory (Sandia). One reviewer stated that Celgard is the sole contractor. Another person indicated that Celgard had delivered samples for National Lab testing. Another reviewer indicated that there is ongoing collaboration with the National Laboratories in terms of providing external validation of the developed HTMI materials. A reviewer felt that the collaboration has been improved with Sandia National Laboratories' involvement, but it has not fully investigated the possibility to validate the test procedure in other organizations and on other separators. The final reviewer reinforced that they always encourage including Sandia as an abuse partner, since their core abuse knowledge is superior and growing.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed. One person pointed out that the plans include developing manufacturing methods for the new separator. Another person indicated that the proposed future research is focused on continuing the evaluation of ceramic-based coatings for HTMI battery separators in terms of cost-benefit ratio and examining alternative, long-term technologies. Others did not share these opinions, with one reviewer stating that the proposed future plan is very limited with a generic focus on barriers. Another reviewer commented that future plans are vague and indefinite, so the reviewer was left to believe there may be no outcome other than to consider this as a future R&D direction. One reviewer stated that this question does not apply since the work had been completed. The final reviewer commented that the presenter's response to this question was not totally understood, but for lack of any other place for the reviewer to comment, this reviewer questioned the inclusion of the defensive posture from the 2010 AMR comments in the presentation.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed. One reviewer stated that the researchers had sufficient resources available. Another person agreed, commenting that the resources are adequate for this project to achieve the objectives. Others were more critical. One reviewer

commented that the presented activities are not really consistent with the planned budget. The final reviewer explained that it does not look like this project was worth the money spent. The reviewer found it hard to believe that $2M was spent on this project.

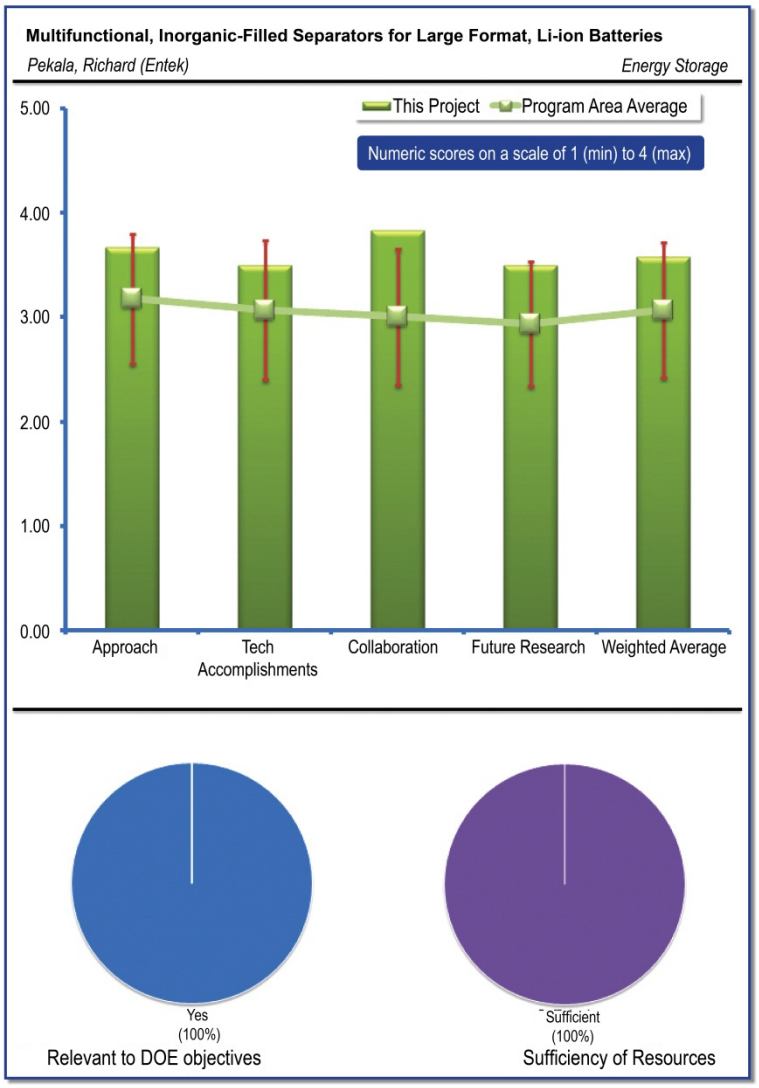
Multifunctional, Inorganic-Filled Separators for Large Format, Li-ion Batteries: Pekala, Richard (Entek) – es008

Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One reviewer commented that the project focused on developing procedures for battery separators for improved safety for lithium ion batteries for EV, HEV, and PHEV applications. Another person stated that separators are essential for good cell operation. One reviewer had detailed comments, stating that high temperature mechanical and dimensional stability of the separator, with or without shutdown, is the key to ensure adequate safety of Li-ion cells and batteries. Safety is indeed a major technical barrier for the viability of Li-ion batteries powering the PHEVs and electric vehicles, which would reduce the petroleum consumption as well as decrease the GHG emissions from automobiles. The reviewer remarked that this project is aimed at developing multifunctional, inorganic-filled separators and demonstrating their performance in 18650 cells. One person reinforced that anything which improves fade rate characteristics of cells is a plus for the economics of EVs. The final reviewer agreed that the project addresses key objectives functional to DOE needs.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were all positive. One reviewer commented that the approach is based on developing freestanding, dimensionally-stable, separators filled with silica and/or alumina to achieve less than 5% shrinkage at 200°C, low impedance and also with no adverse effects on the electrical performance. The latter is being verified in 18650 cells fabricated by the collaborator, American Lithium Energy Corporation. The tests performed thus far address only the electrical performance but not the improvement in safety, which is primarily the expected benefit with these ceramic-reinforced separators. These separators do not have the shutdown properties, which, though not listed in the current USABC goals, is a desired property. The reviewer concluded by stating that overall, the project is well designed and looks feasible to develop new mechanically robust and thermally resilient separators for Li-ion cells. Another reviewer pointed out that the approach addressed abuse tolerance, high temperature, life and cost drivers using silica filled polymer separator material with biaxial orientation with good high temperature stability. One person commented that the approach is good with clear indications of the technical issues and objectives and the project is rationally organized to meet the targets. Another reviewer explained that the researchers have developed a comprehensive and well-organized approach with adequate detail. The reviewer added that the approach includes a good plan for matrix design or samples and excellent step wise test plan. The final commenting reviewer stated that the approach is a very good comparison between control sample and test.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer described that the researchers developed a process to produce inorganic filled separators with improved performance and abuse tolerance. Another person had detailed comments, describing that several separators filled with inorganic materials (e.g., silica and/or alumina) were developed, which met the USABC goal in terms of high temperature stability (i.e., less than 5% shrinkage at 200°C). The reviewer added, these separators also have excellent electrolyte wetting property and show low impedance even at low temperatures. In order to verify the compatibility of these separators with the electrode materials, several 18650 cells were fabricated with different inorganic fillers and tested for different characteristics (i.e., cycle life, self-discharge at 60°C and low temperature performance). It was clear to the reviewer from these tests that there is no evidence that inorganic-filled separators have adverse effects. Cell performance is generally better than for controls: longer cycle life, less self-discharge, and higher rate capability. The reviewer concluded by stating that the project progress accomplished towards the project goals and the overall DOE goals is quite satisfactory. Another reviewer commented that the results are interesting with good progress with respect to the technical barriers. The reviewer felt that the comparison with target is very promising and also the insurance about the cost targets. The final reviewer remarked about the good comprehensive results with multiple samples meeting targets. This reviewer added that the separator seems to provide other improved properties beyond improved safety and that the program is on track for very successful conclusion in June.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Comments to this question were very positive. One reviewer acknowledged the good cooperation with American Lithium and JCI and the overall good responsiveness to needs. Another reviewer had related comments, stating that there was good collaboration with appropriate partners including suppliers, testing, and customers. Another reviewer agreed, emphasizing that there is an integrated network of collaborations, well selected, and really needed to have a complete view and evaluation of the technical results, combining private and public bodies. One reviewer described that there is ongoing collaboration with American Lithium Corporation for the fabrication of 18650 cells with inorganic filled separators and also with a few other non-DOE collaborators for separators characterization and raw materials. The final reviewer commented that they were pleased to see such a wide-ranged cell build up in process with different cell manufacturers.

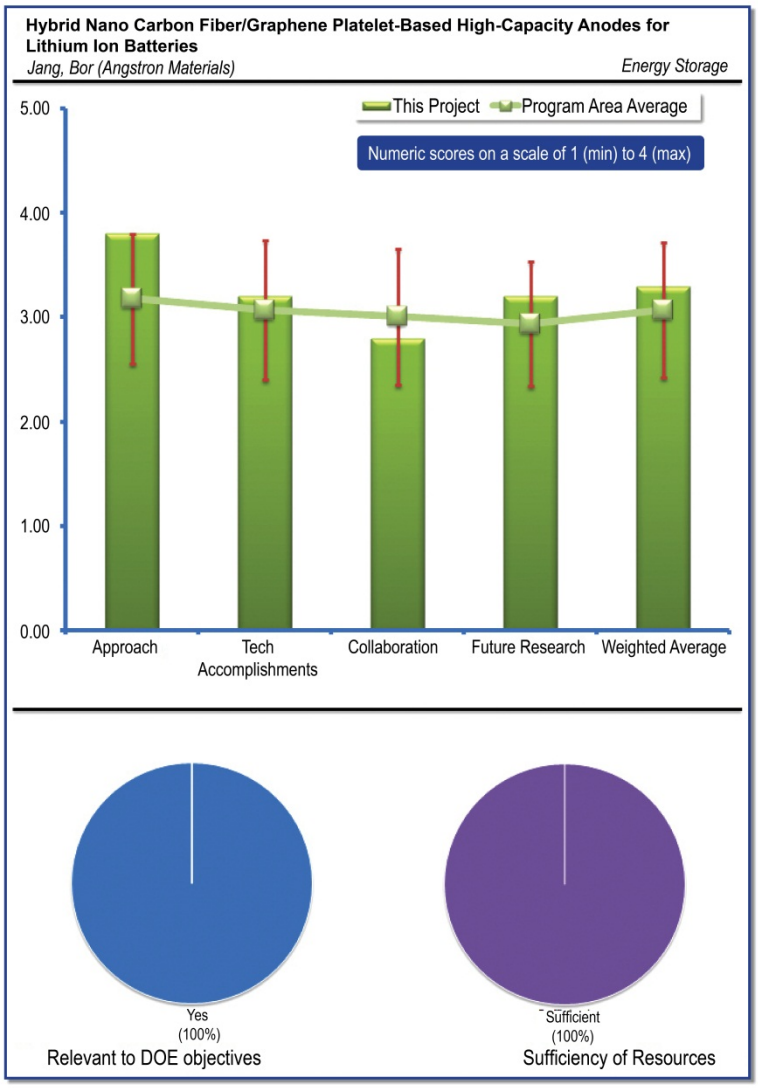
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Responses to this question were all positive. One reviewer commented that the project is proposing a logical prosecution with clearly identified and explained tasks. Another evaluator pointed out the good detailed list of future plans, most of which are in progress, with excellent prognosis of successful completion. Another reviewer remarked that abuse testing is essential and scheduled and that test samples have been distributed to other cell assemblers including JCI, Dow-Kokam, and A123. The final reviewer reported that there are clear plans for future research to: i) continue 18650 cell performance testing for cycle life and 60°C storage; ii) conduct abuse tests on cells; iii) continue pilot production of silica-filled separators; and iv) send separator samples for large format cell builds, e.g., A123, Dow-Kokam™, and JCI-Saft.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The responses to this question were mixed. One person commented that the resources are adequate for proposed/ongoing effort. Another reviewer agreed that the resources are adequate even considering the established collaborations. One reviewer expressed that the project was a great value to DOE for minimal investment. The final reviewer commented that the contract looks to be completed with present funding.

Hybrid Nano Carbon Fiber/Graphene Platelet-Based High-Capacity Anodes for Lithium Ion Batteries: Jang, Bor (Angstron Materials) – es009



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person stated that the project is relevant to DOE objectives. Another reviewer noted that the energy density and specific energy will be improved with a high energy anode. One commenter explained that this project offers an approach to higher specific capacity anode materials that could increase the specific energy of lithium ion batteries for electric vehicles and/or plug-in electric vehicles. Another reviewer commented that like other core materials of the battery, the anode development to increase range or reduce cost for equivalent range is essential. The final reviewer indicated that the result of the project is a new silicon based anode system. The technical feasibility of the material has been demonstrated. The nano-graphene base surrounds the silicon spheres and limits/minimizes the volume changes on charge and discharge. Significantly higher cell energy density is possible.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the approach is challenging and innovative with proposed breakthrough on Si-anode preparation. The project is well organized and feasible with typical risk of advanced research. Another person agreed that this is certainly a leading edge application of carbon nano-fibers (CNF) technology, but the reviewer questioned how durable this is. One reviewer applauded that the use of conductive carbon nanofibers onto the copper foil to produce a laminated electrode structure was very creative. The reviewer added that the graphene sheets prevent aggregation of the nanoparticles during the charge-discharge process. Another reviewer agreed that using nano-graphene and nano-silicone is a good match for conductivity and prevention of fracturing active material. Other reviewers offered criticisms and suggestions. One evaluator commented that the technical barriers are provided, but not in priority order. It was not clear to this reviewer how this project will address high production cost. Pulverization is not a barrier itself but contributing to low cycle life barrier. The reviewer concluded by surmising that by low capacity the reviewers mean low specific capacity and really the barrier is low specific energy. The final reviewer indicated that it would be useful to have an estimate of what pack of at least cell level specific energy and energy density improvement could be achieved by using this material in an optimally designed cell. The reviewer warned that doubling the specific capacity of the anode material does not double the cell specific energy. Similarly, estimates of the effect of implementation of this material on cell and pack cost would be useful to fully assess the value.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One person commented that a chemical vapor deposition (CVD) apparatus has been installed to mass produce the silicon coated conductive web. Small lab cells have given excellent stability and steady capacity on charge-discharge regimes. The remaining comments suggest that approach improvements are needed to improve the project results. One commenter stated that the results are very promising and some cost analysis should be included to the experimental work to estimate final cost. Another reviewer commented that the cycle life at 70% SOC window may not be sufficient. The reviewer also suggested that the cost goals do not match the automotive industry expectations for profitability. The final reviewer commented that there is evidence that a lot of fancy materials work has been done; however, quantitative progress towards 2011 targets of 1000 mAh/g capacity with 750 cycles, about 70% SOC swing, and less than 20% of capacity fade is lacking. The summary value proposition with the optimistically favorable cost prognostication is not convincing. The reviewer felt that actually it is doubtful with two expensive materials this anode approach can be cost acceptable.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Only two reviewers responded to this question. One acknowledged that the researcher's work with Angstron, Nanotek, K@, E-one Moli, Honda, and Nissan should lead to rapid incorporation of the invention into the commercial world. The other reviewer indicated that there is appropriate collaboration from outside the subprogram. The reviewer suggested that some collaboration inside the subprogram (e.g., National Labs for validation in various lab cells and different cathodes) is recommended.

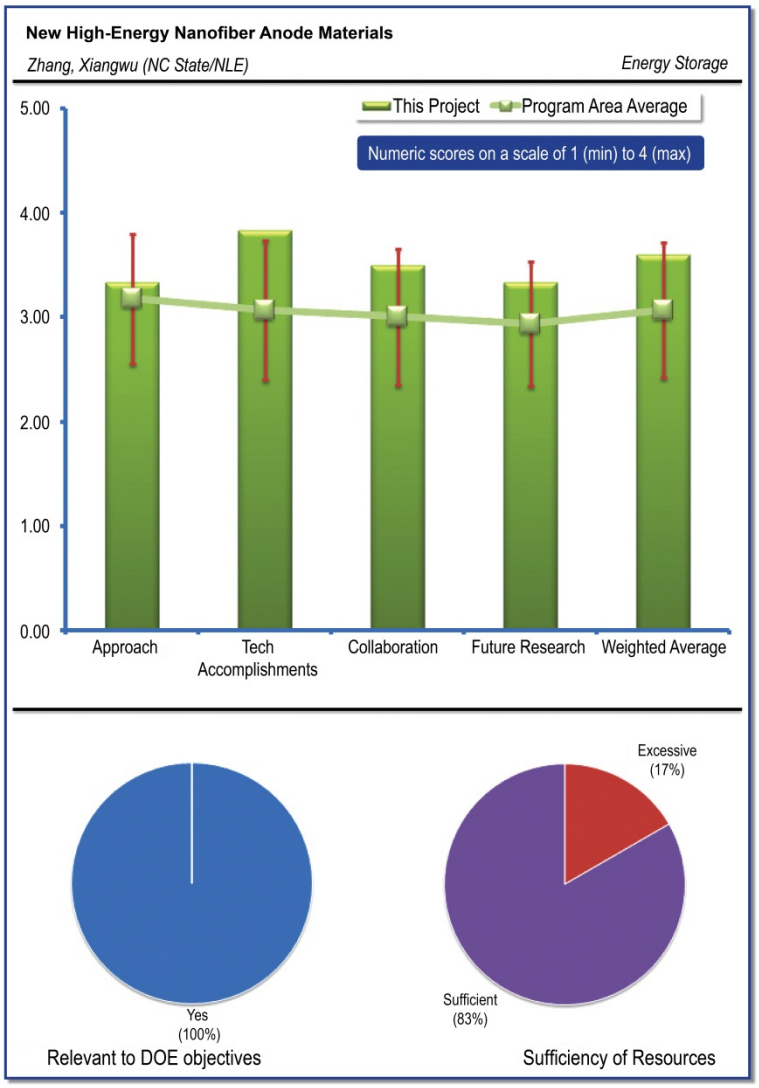
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One person noted that the future plans include expansion of the processes into larger electrode sizes as well as improving the process steps are in order. A reviewer commented that the proposed plan for the prosecution of the activities is reasonable and well based on the previous results. The proposed cell testing does not clearly specify the selection of cathodes and electrolyte components. Another reviewer stated that they are interested to see results on a larger format application. Two reviewers had suggestions for the future research direction. One reviewer suggested that future work should focus on meeting specific capacity and cycle life targets and showing acceptable cost is achievable. The final reviewer indicated that the proposed research should be focused on developing low-cost anode about $10 - 15 per kg. The cycle life testing window should be widened to 80%.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers provided comments, both positive. One person stated that the funding level seems adequate. The other person commented that the funding was consistent with the progress and speed of development.

New High-Energy Nanofiber Anode Materials: Zhang, Xiangwu (North Carolina State University/NLE) – es010



REVIEWER SAMPLE SIZE

This project had a total of six reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

Responses to this question were all positive. One reviewer remarked that the project is useful to support DOE objectives, even if it only partially addresses key needs. Another reviewer stated that the project involves new high-performance anode silicon materials. A reviewer asserted that all core cell material development is essential to reaching battery objectives. One commenter explained that the carbon anode in Li-ion batteries has limited specific energy and this advanced nano-fiber will increase the battery energy density. The final reviewer described that this project offers an approach to higher specific capacity anode materials that could increase the specific energy of lithium ion batteries for electric vehicles and/or plug-in electric vehicles.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

All reviewers had positive comments to this question, with some reviewers providing suggestion for project improvements. One reviewer had detailed comments, indicating that the project is well focused on increasing the specific capacity over graphite materials while developing high cycle life relative to silicon anode materials. The targets have been adjusted appropriately upward to be relevant for both EV and PHEV applications. Aggressive materials cost targets have also been set. However, according to this reviewer, it would be useful to have an estimate of what pack of at least cell level specific energy and energy density improvement could be achieved by using this material in an optimally designed cell. Further, this reviewer added, doubling the specific capacity of the anode material does not double the cell specific energy. Similarly, estimates of the effect of implementation of this material on cell and pack cost would be useful to fully assess the value. Another reviewer agreed that the project uses a sound approach. The reviewer offered an additional improvement to the current program would be to investigate and report on initial and ensuing irreversible capacity loss with the anode materials. The reviewer concluded by emphasizing that further improvement to the current program or potential future program should include some focus on optimizing/minimizing initial and ensuing irreversible capacity loss. Another reviewer mentioned that the approach included developing a new method to produce anode materials using an electrospun process to combine lithium and carbon into nano-fiber materials for Li-ion cell anodes. One commenter indicated that the project is interesting and well-organized with clear tasks and milestones. The reviewer also thought that the electrospinning preparation of Si-anode was promising. The final evaluator noted that combining Si and carbon (C) will significantly improve anode specific energy.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All reviewers had positive comments to this question, with some reviewers providing suggestion for project improvements. One reviewer expressed that the progress is excellent with very promising results in terms of stability and specific capacity. Another reviewer reported that the researcher developed a Si/C nanofiber with a capacity of over 650 mAh/g. Established a base performance for the new material with a capacity of over 600 mAh/g. Another evaluator emphasized that the simultaneous progress towards specific capacities approaching 1,000 mAh/g and 750 cycles is impressive. The reviewer also thought that the progress towards process development resulting in a start-up company with promising cost projections was also very impressive. One reviewer indicated that the obvious thermal expansion life-cycle barrier will be challenging. The final reviewer explained that the automotive cycling depth of discharge (DoD) should be 80% or higher.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had positive comments, with one posing a question. One person acknowledged that the researchers are working with several companies including American Lithium, Ted-Cel, ANL, and Indiana-Purdue universities. Another reviewer explained that the collaborations have been satisfactorily improved with respect to last year. One evaluator stated that the project includes outstanding collaborations with several organizations. The last reviewer noted that they were curious as to collaborative partners versus supplier status of the groups included in the project.

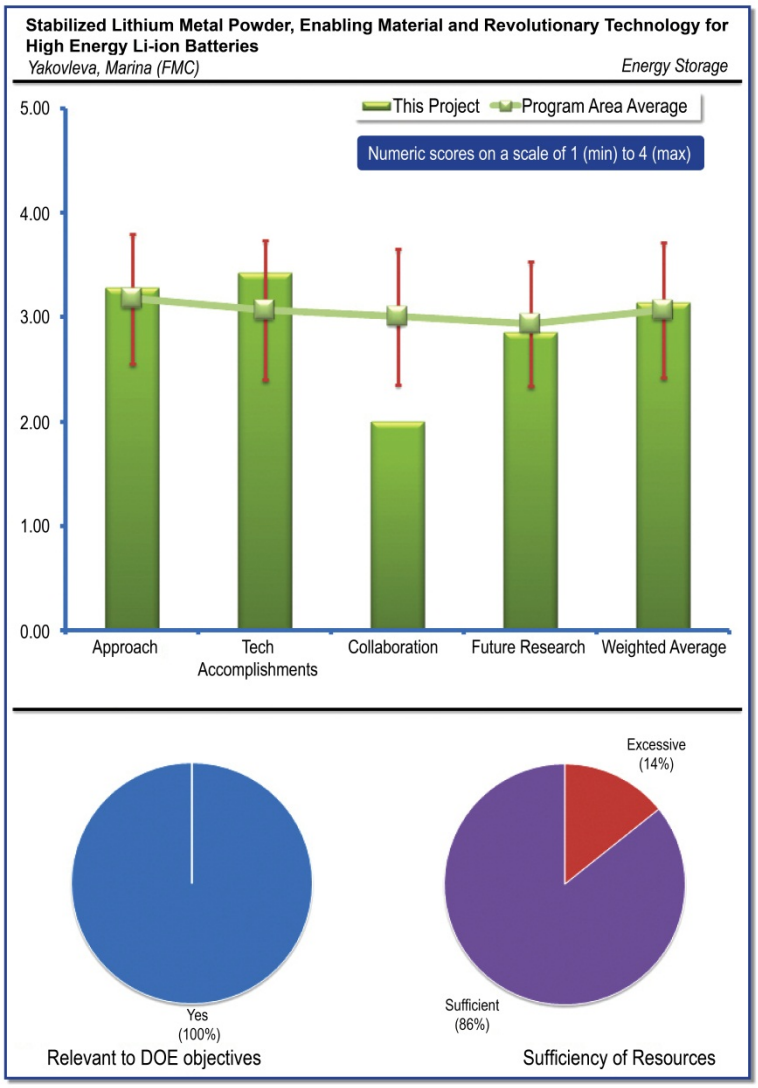
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers all had positive comments, with some offering suggestions to be included in the future plans. One reviewer stated that the researcher presented excellent and aggressive future plans. Another person commented that the plans include further improvements to the capacity by adjusting process parameters and that the project will deliver 18650 cells to potential customers. One reviewer indicated that the work planned for the next period is well-focused on the barriers even if there is no good indication of the effective progress awaited with the proposed innovations. Several reviewers provided suggestions for improving the work plan. One evaluator suggested that some focus on irreversible capacity loss characterization, reporting, and optimization should be included. Another person asserted that collaboration with an existing high-volume consumer electronics cell producer should be strongly pursued. The final reviewer offered that the work plan should include the cost justification of the advanced anode by comparing with the conventional anode material and should meet USABC cost goals.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed. One person commented that there was no mention of money problems. Another person stated that the budget seems adequate. The final evaluator, however, expressed that without further expansion of the scope, the funding level seems excessive compared to other similar programs.

Stabilized Lithium Metal Powder, Enabling Material and Revolutionary Technology for High Energy Li-ion Batteries: Yakovleva, Marina (FMC) – es011



Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were generally positive. One reviewer commented that the project addresses a key element of Li battery with relevant impact on DOE objectives. Another person pointed out that there is potential for cost reduction with the novel method of intercalating carbon anode. Another reviewer had similar cost reduction potential comments, stating that the lithium metal in powder form may be a lower cost anode for EV applications. One person indicated that the project provides new material for design and manufacturing flexibility providing potentially for improved specific energy and cost reduction for batteries EV, HEV, and PHEV applications. One reviewer had detailed comments, stating that lithiated metal oxides or phosphates serve as cathodes and also as lithium source in Li-ion cells. These cathode materials, however, have low specific capacities, compared to the anode counterparts, and thus limit the specific energies for the cells. In addition, some of the non-lithium cathodes, which may have better specific energies and safety, cannot be used in the present form, unless there is another form of lithium source that could be added in conjunction with such cathodes. The objective of this project is to develop cost-effective manufacturing processes for stabilized lithium metal powder (SLMP), which will function as an independent source of lithium. The overall objective is to integrate the SLMP Technology into the Li-ion cell for PHEV application, and support high volume production of Li-ion batteries and to make available commercial quantities of SLMP that will enable higher energy, safer, environmentally friendlier and lower cost lithium batteries. Such batteries will contribute to the success of PHEVs, which would in turn reduce the petroleum consumption and the GHG emissions in automobiles, and pave the way towards petroleum replacement. The final reviewer had a slight hesitation on answering "yes" without understanding DOE's expectations of a material supplier of lithium. Any improvements in efficiencies and or customer needs in this area could logically take place in the competitive marketplace. However, the reviewer indicated that they have certainly learned a few things from the PI and encourage DOE's objective pursuit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer explained that meeting DOE goals will require higher-energy anode material, so the powdered lithium metal may be the best solution. The "slump" powdered lithium metal has the potential to lower production cost and yield higher performance than the present carbon anode materials. Another reviewer had detailed comments, stating that the approach is to develop a process and design a commercial unit to scale-up the production of SLMP dispersion. The reviewer explained that there are two approaches for integrating SLMP into the Li-ion chemistry. First, SLMP may be added to the anode to compensate for its irreversible capacity, such

that the lithiated cathode efficiency might be improved. Alternately, SLMP might be used even to lithiate the carbon anode such that it may be combined with non-lithiated cathodes, which may have better safety compared to lithiated cathodes. In either approach, the amount of SLMP required to be added is considerably less, due to its high Li content, approximately 98%. The approach involves the development of a process and prototype unit for the commercial production of dry SLMP and the integration of SLMP Technology into a Li-ion system [e.g., mesocarbon microbeads (MCMB)/$LiMn_2O_4$ system] to demonstrate the improvements both in the capacity as well as cycle life upon SLMP addition. The reviewer concluded by remarking that the approach is well-designed and feasible and addresses the technical barriers of performance and cost targets of Li-ion batteries for PHEVs. Another evaluator commented that the project is well structured with clear objectives and well- identified barriers; however, there is a lack of clarity due to the absence of quantitative technical and economic targets. The final reviewer commented that coated lithium metal powder provides additional flexibility for the design and processing for lithium-ion batteries, greatly reducing some detrimental effects of irreversible capacity. The reviewer added the suggestion that the potential effect on specific energy and cost should be quantitatively estimated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to the question were mixed, some positive and some providing work plan suggestions. One reviewer stated that the project seems to be tracking the timeline defined two years ago. Another reviewer reported that the vendor delivered equipment for fabricating "slump" anode and the site has been prepared. The reviewer added that Kureha was selected to supply anode material, Toda the manganese spinel materials, and that the project is still on the original schedule. One reviewer had detailed comments, stating that the progress achieved within last two years is consistent with the project plans as well as with the DOE goals. The reviewer indicated that the researchers had completed the design, purchase, installation and commissioning of a commercial-scale unit for the production of SLMP dispersion. Also, the research team completed the experimental runs with the new commercial-scale and the optimum dispersion conditions were determined. SLMP can be applied uniformly using micro-gravure method onto the pre-fabricated electrode or transferred to electrode surface through a carrier film. The benefits of the SLMP Technology have been successfully demonstrated in a Li-ion cell with Kureha hard carbon and Toda $LiMn_2O_4$. Improvement in the capacity with comparable cycle life was demonstrated with SLMP additions to the anode. The reviewer felt that it is, however, surprising that the use of SLMP has not been accepted yet by industry, even after years of its development, and the associated problems (e.g., potentially electrolyte stability) need to be understood and resolved. Another commenter acknowledged the good progress towards goals, including testing material in real cells showing beneficial effects on capacity as well as no detrimental effects on power and cycle life. The reviewer concluded by adding that the presentation was not well organized and could be more clear and concise. One reviewer stated that the results are very promising with very good progress; however, the reviewer still has some concerns about the cost impact. One evaluator indicated that an evaluation in a graphitic carbon based system should be, or should have been, included. The final reviewer explained that the accomplishment should track cost of the material and should be analyzed for a business case.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One reviewer indicated that the researchers are working closely with equipment and materials vendors to meet program goals. Another reviewer had a conflicting view, stating that there are no partners on this project; however, FMC Corporation (FMC) has been involved in collaborations outside this project in support of material development for Li-ion cells. Another reviewer suggested that collaborators from inside the subprogram should be identified. The commenting reviewer stated that it was not obvious if the Li-ion cell developers are benefiting from the developed material, and if so, how the cost of the batteries is improving.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

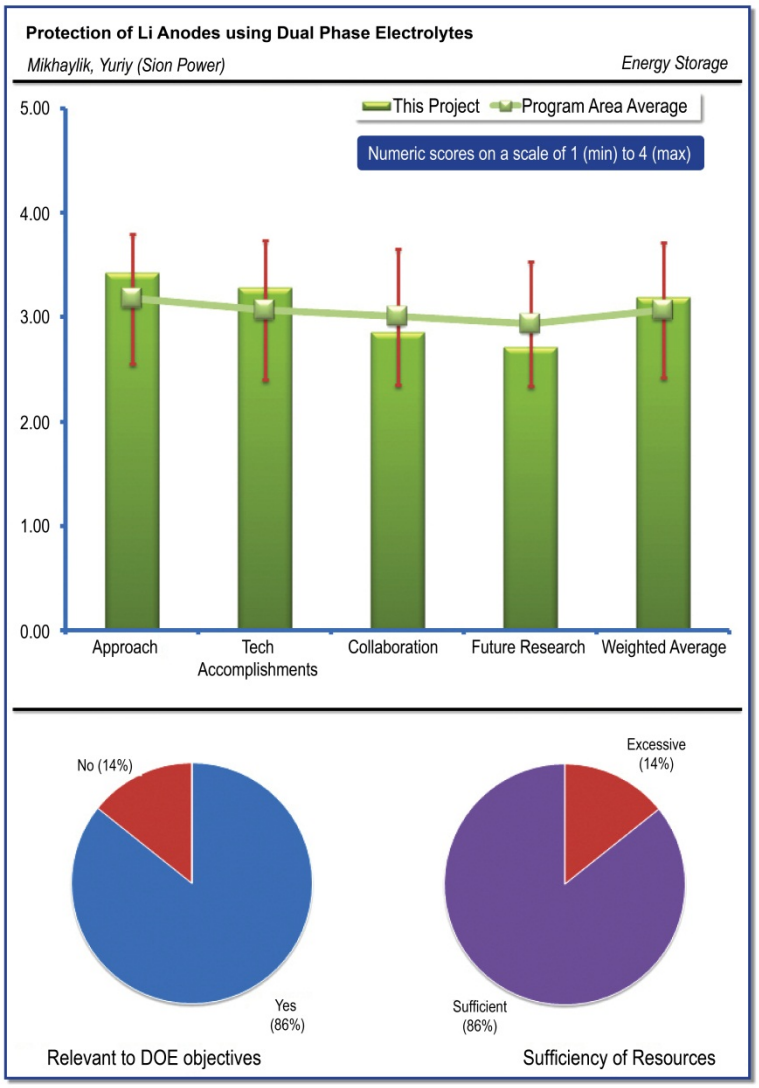
Reactions to this question were mixed. One reviewer indicated that the project is mainly equipment-oriented to produce new anode construction in Li-ion cells. Another person felt that there are clear plans for future research to: i) explore the use of pilot scale alternative unit to produce dry SLMP powder directly from battery quality lithium metal, which will be cost-effective; and ii) integrate SLMP Technology into the Li-ion cell using $SiO/LiCoO_2$ system. Another reviewer, however, stated that no future research plans

were shared. Another evaluator, however, felt that the future work is very poorly described, but it seems adequate and consistent with the previous work. One reviewer suggested that an evaluation in a graphitic carbon based system should be included. Another person mentioned that a collaboration with an existing high-volume consumer electronics cell producer as a direct and included element of this project should be strongly pursued. The final reviewer commented that the future work should include cost study and life testing.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Responses to this question were mixed. One person commented that funding is adequate. Another reviewer agreed, remarking that the resources seem adequate. A reviewer commented that the resources are adequate for this project to achieve the objectives. The final reviewer, however, asserted that the resources for the project are excessive for a program within this category.

Protection of Li Anodes Using Dual Phase Electrolytes: Mikhaylik, Yuriy (Sion Power) – es012



Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the project is relevant to DOE objectives. Another reviewer provided detailed comments, describing that the lithium-sulfur (LiS) system offers high gravimetric and volumetric energy densities, due to the high specific capacity of the sulfur (S) cathode. However, its advantages have not been realized yet due to the solubility of polysulfides from the cathode in the electrolyte migrating to the anode and affecting its cycle life. The objective of this project is to develop an electrolyte system with two immiscible electrolyte solutions for the anode and cathode compartments, each with adequate chemical/electrochemical stability and impermeability for the polysulfides towards the anode and finally, stabilization of the Li anode. The overall objective is to incorporate such an electrolyte system in large format cells and demonstrate the improvements in anode and cathode function, cycle life, and increase in thermal runaway temperature. These studies, if successful, will lead to high specific energy Li batteries for PHEVs, which would in turn reduce the petroleum consumption and GHG emissions in automobiles, and pave the way towards petroleum replacement. Another person had similar comments, describing that the development of a new electrolyte that provides two separate liquid phases would open new opportunities to develop unique constructions where each electrode chemistry has its own unique electrolyte yet functions as a normal cell construction. The reviewer added that the system has good potential as a rechargeable, metallic lithium system. Another person expanded on the previous comment, noting that the electrolyte, like all core battery materials, requires development for long-term success. One reviewer mentioned that the lithium-sulfur chemistry has one of the highest energy densities. Another reviewer commented that the project involves the development of high specific energy batteries for EV applications. The final reviewer commented that there is no evidence that LiS systems can ever provide appropriate performance for automotive applications, although the reviewer felt that they may have potential for other applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer expressed that the project is challenging with a well-organized structure and clear approach to technical solution to innovative Li/sulfur cells with novel dual-phase electrolyte and cell design. Another reviewer had detailed comments, explaining that the approach is based on a dual-electrolyte system with different electrolytes immiscible into each other and tailor-made to anode and cathode environments. The anode electrolyte is immobilized in a polymeric gel, which is stable towards Li preventing the Li dendrites and also functioning as separator. More importantly, it does not dissolve polysulfides from the cathode. The catholyte, on the other hand, is tailored to improve the sulfur cathode performance with high polysulfide solubility. The demonstration of this LiS system

with dual-phase electrolytes will be further demonstrated in large format 2.5 Ah cells after optimizing the cell design in terms of electrode sizes, substrate thickness, active material loading and depth of discharge and developing the production of larger gel-polymer coated anodes and cathodes. Even though the approach looks feasible from the improvement in cycle life, the reviewer felt that it is not realistic to assume that the anode will be free of dendrites with the proposed gel electrolytes in ether solutions, based on the vast number of studies with Li metal rechargeable systems in the past. The reviewer concluded by highlighting that the safety issues associated with this system are still to be answered, and offering uncertainty as to how increasing the thermal runaway temperature to 165°C would help with the Li metal anode. Another reviewer commented that for the development of the new construction, a LiS battery system is proposed. A Phase 1 gel electrolyte for the lithium side (where Li_2S_2 is insoluble) and a different composition Phase 2 electrolyte (where it dissolves polysulfides for the sulfur side of the cell) is used in a large format prismatic cell construction. The reviewer also mentioned that the concept has been demonstrated in small 0.25 Ah cells where 140 cycles have been demonstrated. One evaluator commented that the approach seems reasonable, but might rely too much on modeling. The reviewer suggested that stepwise experiments for cell size scale-up might be beneficial in view of many variables involved with this complex and challenging technology. The final reviewer noted that the use of LiS as a base technology for this development (acknowledging that Sion Power uses this technology) is aggressive, but is probably key to getting the high energy LiS into automotive sized batteries. The reviewer concluded by stating that there are still questions around the safety and cycle life goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed. One evaluator stated that there is a really good progress with promising results. Another reviewer described that the 2.5 Ah cell has been cycled over 100 times with only a slight decrease in capacity on each cycle. The gel polymer is mixed with a silica filler. The mixture could be coated with slot die techniques in the 2 to 10 micron thickness. The Li anode did not show mossy lithium deposits after cycling. It is expected that 500 to 1,000 cycles can be obtained with the new construction using a uniform pressure on the cell, the dual-phase electrolyte, and solid-electrode interface formation on the lithium from the Advanced Research Projects Agency-Energy (ARPA-e) project. The reviewer concluded by mentioning that the dual-phase electrolyte eliminated thermal runaway on 50% of the cells tested at end-of-life. One commenter felt that reasonably good progress has been achieved within the last couple of years, consistent with the project plans as well as with the DOE goals. The reviewer mentioned that improvements in both cycle life, beyond the modest target of 50 cycles to about 140 cycles without Li dendrites, with twice the anode capacity, and a marginal improvement in thermal safety have been demonstrated in small pouch cells with the proposed two-component electrolyte system. The researchers completed the design of large-format 2.5 Ah cells and developed the hardware system for the production of gel-polymer coated anodes and initiated the production of cells. The reviewer concluded by stating that surprisingly, there were no cell level data presented here to support the claims of improvements in cycle life and rate capability in full cells. The final reviewer highlighted that last year's impressive results were presented again this year, perhaps from poster slides, but progress since then seems slow. Some modeling results were shown but may or may not represent reality in physical cells. The poster discussion indicated that the first 2.5 Ah cell was built and 250 Wh/kg specific energy was achieved with other testing underway. The reviewer stated that from discussions, the program seems to be on track and that this is very challenging work with breakthrough potential.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One person mentioned that collaboration with BASF has significantly increased the effort on the project. Another reviewer indicated that the collaborations are limited, but seem adequate in this Phase. A reviewer suggested that it could be beneficial to collaborate with National Labs and others. One evaluator pointed out that there are no partners on this project; however, Sion Power has been involved in collaboration outside this project with BASF for the development of materials for Li-S cells. The last reviewer commented that the project needs to include additional collaboration with ionically conductive anode coating developers.

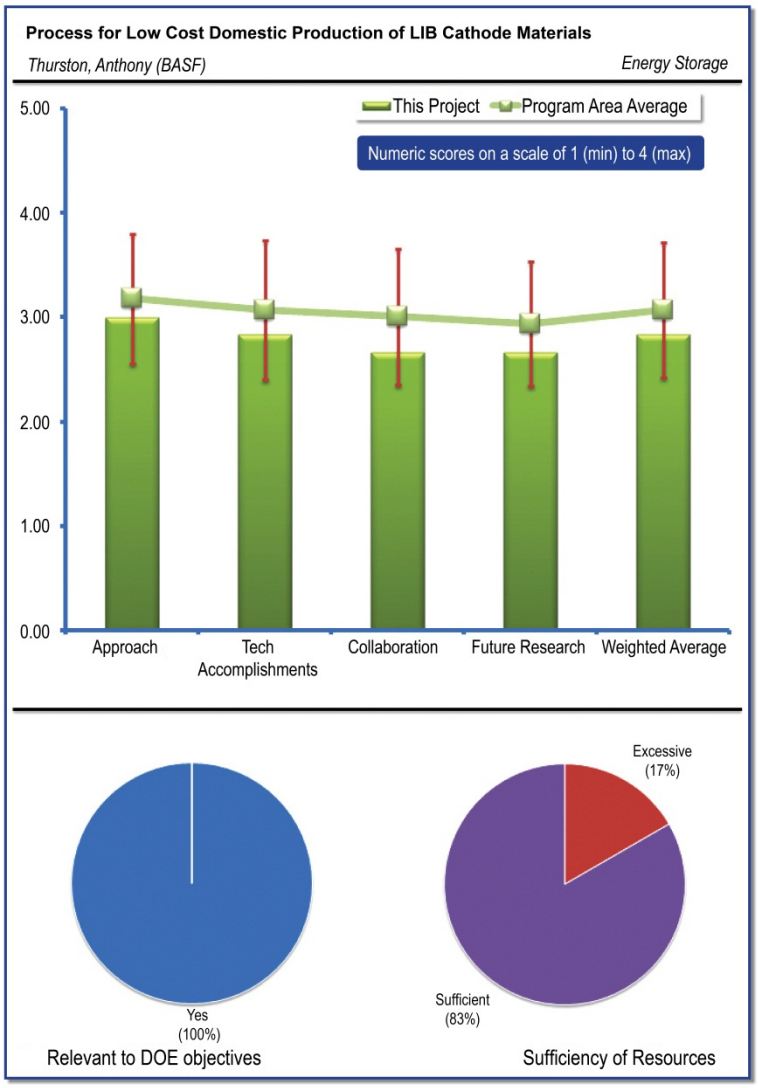
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Responses to this question were mixed. One person commented that there are clear plans for future research to: i) finalize the design of 2.5 Ah cells, fabricate them and test under USABC test conditions; and ii) demonstrate their high energy, improved cycle life, and safety. The reviewer felt that these plans are consistent with project objectives. Another reviewer commented that the demonstration of good cycle life of the 2.5 Ah cells by August 2011 will be a key to the viability of the system. One reviewer commented that the proposed work is consistent with the achieved results, but cautioned that the researchers need the cell testing results to be fully validated and fixed for future work. The reviewer also observed that additional collaboration on anode and electrolyte structural characterization inside the subprogram would better verify materials characteristics. Another evaluator felt that there were not much details or explanation of how the results were used to adjust development path. One reviewer cautioned that the program should not move to large format cell stage, but should focus on advancements at a more fundamental (small or lab-cell) scale, if the program is continued. The final person asserted that the cycle life goal of 1,000 cycles for an EV application should not be compromised.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All reviewers agreed that the financial resources are adequate. One person stated that they are okay. Another reviewer expanded somewhat, indicating that the resources are adequate for an exploratory project. The final reviewer commented that the resources are adequate for this project to achieve the objectives.

Process for Low Cost Domestic Production of LIB Cathode Materials: Thurston, Anthony (BASF) – es013



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers had positive responses to this question. One person provided detailed comments, stating that this project is quite relevant to the overall DOE goals. It is important to develop low-cost production methods for cathode materials being developed under the Batteries for Advanced Transportation Technologies (BATT) and Advanced Battery Research (ABR) programs, and BASF is well positioned to undertake these studies. The objective is to produce two cathode materials, suitable for electric vehicle application, using BASF's existing assets and low-cost production process and to validate their performance in cells and battery packs. Also, there are plans to work with auto OEMs to ensure that the cathode materials being produced meet the standards. Specific objectives for this year include: i) reduction of processing time by 25%; ii) increase in production capacity by 25%; iii) increase energy density of cathode material (Ah/kg) by 25%; and iv) initiate pilot plant production of NCM materials at a greater than 100kg level. The reviewer felt that these studies, if successful, will lead to the incorporation of high-energy and low-cost cathodes in Li-ion cells for enhancing the PHEVs, which would in turn reduce the petroleum consumption, and pave the way towards petroleum replacement. Another reviewer remarked that the availability of a high performance, low-cost cathode material produced in the U.S. is essential for a viable EV, PHEV and HEV domestic production. One commenter affirmed that the project properly addresses economical and technical aspects of Li cathode material production functional to DOE objectives. Another person commented that the low-cost cathode materials from domestic and global suppliers are needed to meet the battery cost goals. Another reviewer pointed out that the project provides for the development of materials and processes to provide higher specific capacity and lower cost cathode materials. The final reviewer reported that the project is an excellent example of technical progression of manufacturing efficiencies.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Responses to this question were mostly positive, with one reviewer providing criticisms. One reviewer provided detailed comments, describing that the approach is to utilize BASF's production and R&D facilities in U.S. to develop low-cost production process for the cathode materials developed in DOE laboratories and to ultimately produce them at a few ton levels. This approach also involves the selection of proper starting materials and adopting suitable blending methods and calcing schedules. In addition, BASF will work with Farasis Energy, Inc. (Hayward, California) to evaluate these materials in 18650 cells and with commercial partners such as automotive OEMs and Tier I suppliers to validate BASF's cathode materials and finally test a Li-ion battery pack containing BASF's cathode materials. Typically, manganese-rich mixed metal (NCM) oxides are being developed which provide considerable cost savings

together with enhanced specific capacities. The reviewer concluded by remarking that the project looks feasible and well designed and integrated with the material development efforts in the DOE laboratories, especially with the licensing of ANL cathode material technology. Another reviewer expressed that the project is clearly designed with well selected production steps. The reviewer added that the preparatory cost analysis gives also quantitative savings. One reviewer commented that the researchers had developed a good approach to target both compositional modification and process improvement to achieve cost reduction. One reviewer explained that the project will develop production capability to produce two cathode materials for electric vehicle applications. The reviewer added that the project will identify and qualify starting materials as well as evaluate new materials for performance in small test cells. The final reviewer stated that the approach does not evaluate the process cost of the conventional cathode production material and does not have any process cost targets, which are important for the success of meeting battery cost goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reactions to this question were mixed. One reviewer provided detailed comments, stating that impressive progress has been achieved within the last two years, consistent with the project plans as well as with the DOE goals. Cathode materials of various formulations were synthesized in the NCM category, some with high rate capability (10ºC) and some with high capacity (approximately 170 mAh/g). Significant improvements were made in the synthesis of NMC-111 cathode, with the process changes resulting in reduced processing time and increased potential production capacity, while maintaining product performance. Several of these cathode materials showed performance comparable to the state of art materials. Among these several formulations successfully synthesized and evaluated, there is the class of high-energy cathode materials (with low Co and Ni) that shows impressive performance characteristics of about 280 mAh/g and good rate capability. The reviewer highlighted that this is indeed a notable accomplishment, considering their inherently poor power characteristics. Another person commented that there had been good coupled improvements in specific capacity and materials cost $/kg. The reviewer suggested that the researcher should also report $/mAh and estimated effect on specific energy and battery $/kWh cost. The reviewer felt that the project seems to be on target with milestones and plans and that there was good progress and credible that objectives will be met at end of program. One reviewer offered the opinion that NCM 226 is the lowest cost NCM with the highest specific capacity. The reviewer added the suggestion that the cathode should be characterized for the cycle life, calendar life, energy density, low temperature performance, safety, etc. to focus on the low-cost material. Other reviewers were more critical, with one evaluator commenting that there is more evidence with respect to the previous year about the progress achieved on cathode materials. The reviewer added that the progress is more appreciable, but with no clear evidence of a substantial breakthrough in material research and in preparation process. However, still some concern remains about the real transferability of the process to other cathode materials. The final reviewer simply stated that the progress to develop process and production capability has been slow.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question were generally positive, but with some criticisms. One evaluator indicated there was good collaboration with Farasis and plans for further collaboration with others in future. Another reviewer, however, stated that the collaboration was more of a supplier arrangement than as a collaborator. One reviewer acknowledged the collaboration with Farasis to evaluate the BASF shows reasonable performance in cylindrical and pouch cells. The reviewer was concerned that the appearance of the pouch cells is less than satisfactory; any bubbles in the outer packaging material is not good and indicated non-uniform pressure on the electrode stack. Another reviewer acknowledged that there is ongoing collaboration with Farasis energy to assist in the assembly and testing of 18650 cells and packs from BASF-produced NCM cathode materials and to provide guidance for design modifications in order to meet customer requirements. The reviewer also mentioned that there is collaboration with ANL via technology transfer. One person criticized that the collaborations are still limited to cell preparator while other collaborations were announced, but were not disclosed and not even justified in term of needs. The final reviewer commented that the collaborations should include a mature cell producer to assess the acceptance of the low-cost cathode material.

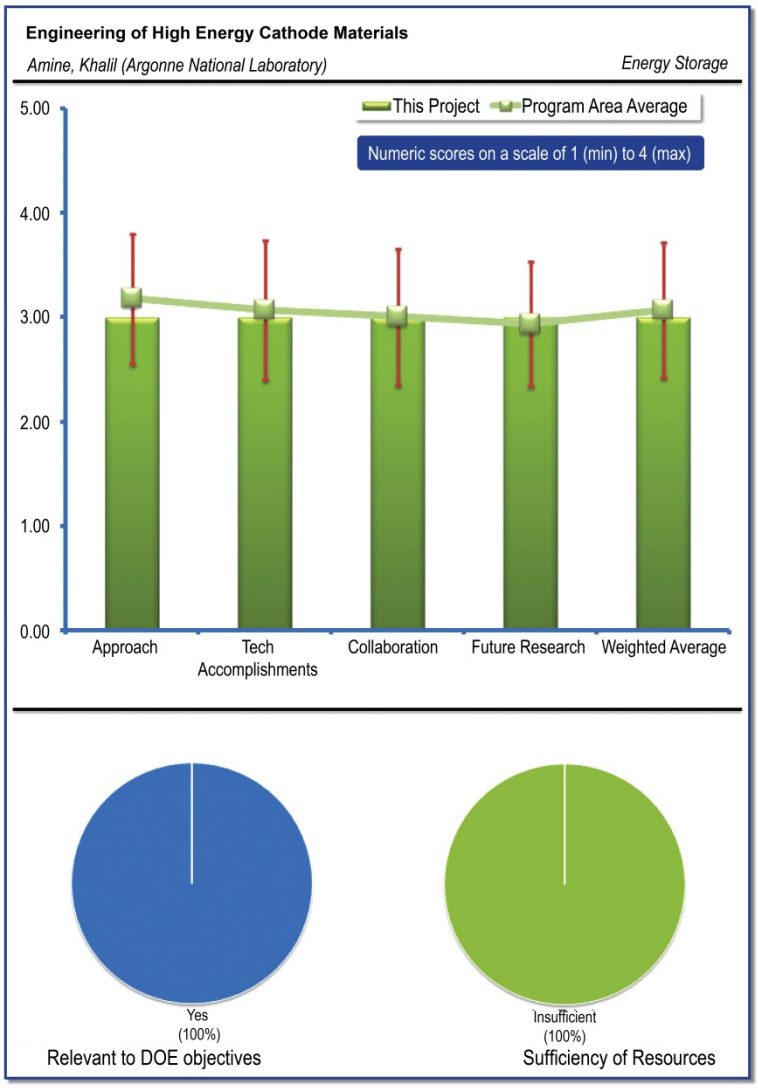
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Responses to this question were mixed. One reviewer stated that the proposed future research is well planned and the future plans are consistent with the overall goals and include: i) pilot production of 1 MT of NCM in pilot plant; ii) pilot production of 100 kg of high energy NCM in pilot plant; iii) verify the quality of the HE NCM materials;, and iv) evaluation of Li-ion battery pack with the cathode materials produced here. Another person agreed that researchers have a good plan, but suggested that it should be flexible about whether goal should be 2, 1, or 4 new materials since even one significantly improved material with substantial cost reduction would be a success. One reviewer commented that the fact that the researchers have a 25% improvement objective for processing time and production capacity as well as a 25% improvement in energy density is an indication that the process still needs definition. The reviewer added that the cost estimations should have been clear by this time in the project. Another reviewer expressed that the proposed work is generically consistent with the achieved results, but remarked that there is no indication on the way the next steps and improvements will be reached. The final reviewer asserted that the future research should focus on the cost analysis as soon as possible to assess the success of the development work and DOE's support.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reactions to this question were mixed. One evaluator commented that the resources of about $5 M with approximately 50% cost-share over three years are consistent with the project scope in terms of developing low-cost production methods for the next generation cathode materials for their incorporation in Li-ion batteries. The remaining reviewers were more critical. One evaluator commented that BASF has had sufficient resources to accomplish their goals, but the reviewer was disappointed in the progress made by this international company that should be a leader in this field. The last reviewer expressed that they are significant efforts and resources in relation to the product improvement effort that hardly justifies a 50% cost sharing.

Engineering of High Energy Cathode Materials: Amine, Khalil (Argonne National Laboratory) – es015



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer affirmed that the project has a strong emphasis on the cathode capacity, the bottleneck for a higher energy range battery.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer remarked that the researchers had developed an innovative approach and that it was interesting to see the graphene approach applied on these materials. The use of graphene is interesting, it seems it provides higher conductivity as well as a lower reactivity towards the electrolyte. It is hard to see how the tap density is affected after using graphene. In the future, the reviewer suggested that it should be important to report some of the capacity data in mAh/g total electrode weight. Some of the powders maybe excellent at the active material level, but require too much conductive additive or may not load well.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer cautioned that at some point, before the authors go too deep into one particular approach (such as carbon coating), they should test their material in a more industrial oriented battery. The reviewer felt that is also important to study how stable is Mn in these structures, in particular towards Mn dissolution.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer expressed their understanding of the difficulties in finding collaborators from industry based in the U.S.; however, the authors should go an extra mile toward that goal.

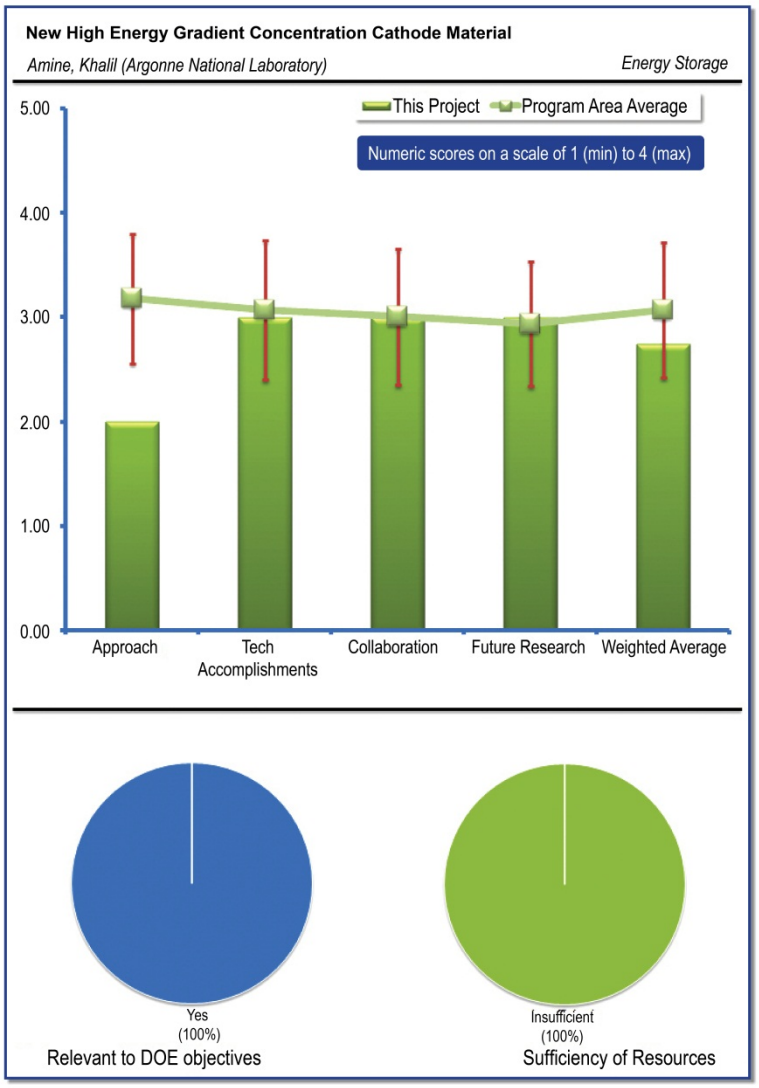
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer stated that they would like to see more full battery data of the commercial type. The reviewer acknowledges that this is difficult, and there is a lot of intellectual property involved, but collaborations with the U.S. industry are badly needed.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The reviewer commented that the financial resources are sufficient at the moment; however, if the authors move into industrial battery testing they may need additional resources.

New High Energy Gradient Concentration Cathode Material: Amine, Khalil (Argonne National Laboratory) – es016



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer agreed that the project is very relevant as the authors concentrate their efforts on cathode capacities.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer provided detailed comments that the gradient approach is a very creative idea; however, the reviewer had the impression that the practical feasibility of the process is not yet certain. The precipitation process is continuous but only for a few hours. After a few hours the precipitation process has to stop. Furthermore, since the metal cations concentration is varying over time, the precipitation process never reaches steady state. This lack of steady-state produces a variety of different materials, and unfortunately too much powder out of specifications, or with powder that shows lower performance. The powder that the authors have shown yield high capacity, but the reviewer had the impression that other powders, coming from the same lab, may have higher potential in the practical arena.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer observed that based on the cross-section analysis, it seems that some of the particles are not very dense at the center. At some point it would be important to disclose the mAh/g unit in terms of total electrode weight. At the moment, it seems that the authors are considering only the weight of the active powder.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer acknowledged that participants in this field of study know that is difficult, but additional efforts with industrial partners based in the U.S. should be pursued.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

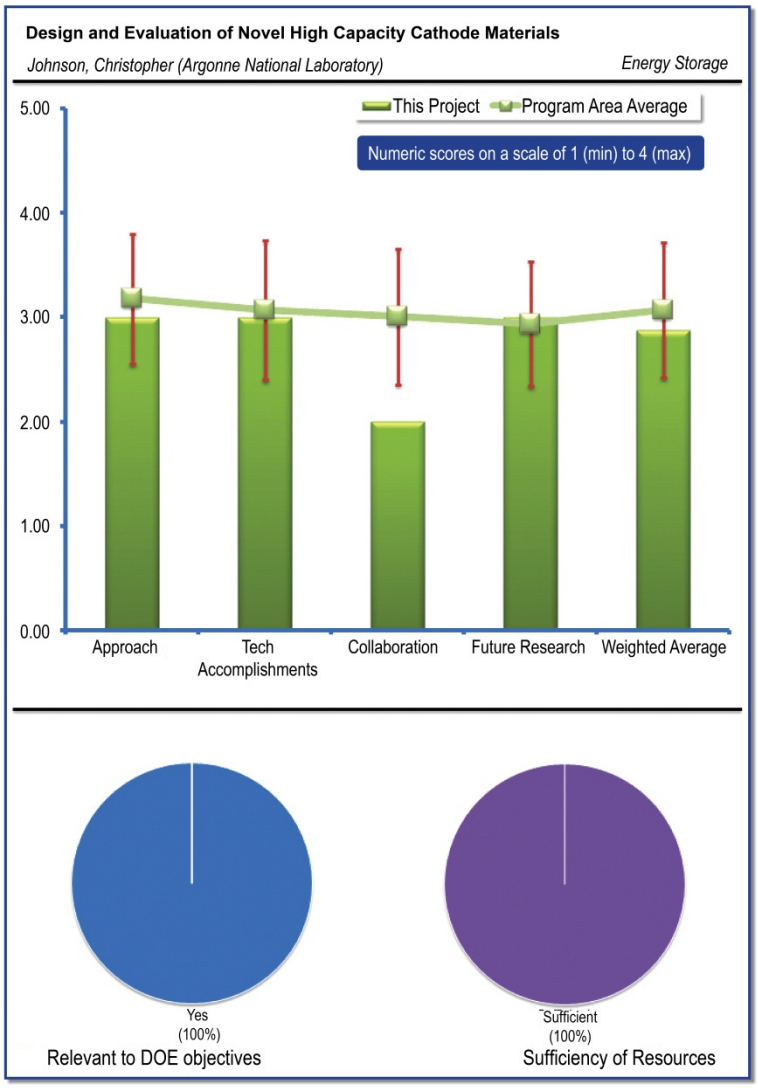
The reviewer suggested that in the future the authors may try to concentrate in the industrial synthesis of these gradient powders. The researchers should try to mimic the very successful gradient approach but with a method that generate a more uniform powder quality.

The reviewer acknowledged that this can be very challenging and require additional creative efforts. However, if the powders are showing very promising results in industrial battery, it may be worth trying.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The reviewer stated that the resources may be insufficient if the authors explore the performance of their powders in industrial batteries.

Design and Evaluation of Novel High Capacity Cathode Materials: Johnson, Christopher (Argonne National Laboratory) – es017



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer observed that it concentrates the efforts on high-energy cathodes which are critical if we want to increase the battery range.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer offered that it is an interesting approach in an area that is risky and that it seems that there is a lot of chemistry at the electrode level. However, the reviewer added, if the authors managed to resolve some of the issues (such as reforming the Li_2O to form nanoscopic Li_5FeO_4) we may have a very high payoff in terms of cathode capacity.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer explained that it is a difficult system, an area of research that involves a lot of synthetic efforts. The reviewer added that in order to judge better the potential of these materials, the capacity should be reported also in terms of mAh/g total electrode. The reviewer felt that maybe the capacity values may decrease substantially, but improvements in this area are very important.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer commented that the project seems to be in a development phase, more concentrated in basic research, the collaboration with industry may not be strong at the moment.

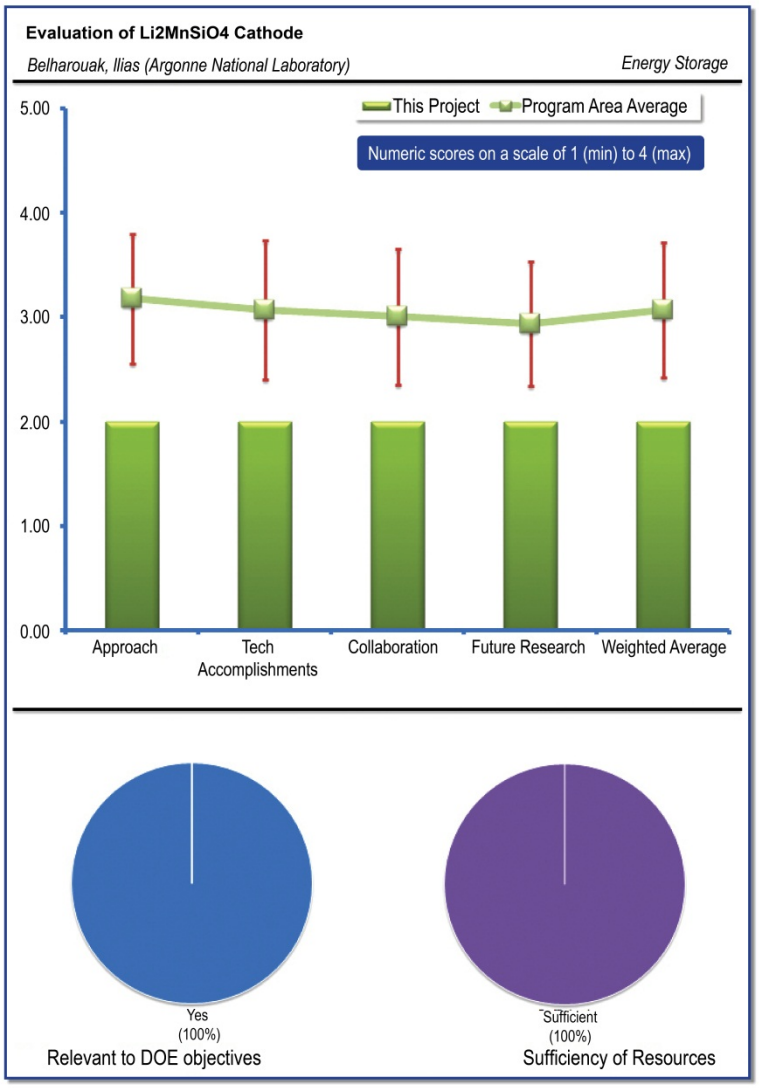
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer suggested that in the future, the authors should also study the possibility of Fe being lost into the electrolyte. The reviewer had the impression that iron dissolution (from the electrode or from iron impurities) will have a very negative impact on cell performance.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewer did not provide a comment to this question.

Evaluation of Li_2MnSiO_4 Cathode: Belharouak, Ilias (Argonne National Laboratory) – es018



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer stated that this research is supportive of the DOE overall objective as it concentrates the efforts on a high-capacity cathode.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer stated that the approach was an interesting attempt to improve the Li_2MnSiO_4 performance; however, it seems, the authors were confronted with too big of a challenge. The reviewer mentioned the discovery of crystallinity on a charged electrode was important and interesting.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer observed that it seems it was hard to move this study forward.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer explained that apparently the collaboration with other institutions was not strongly pursued.

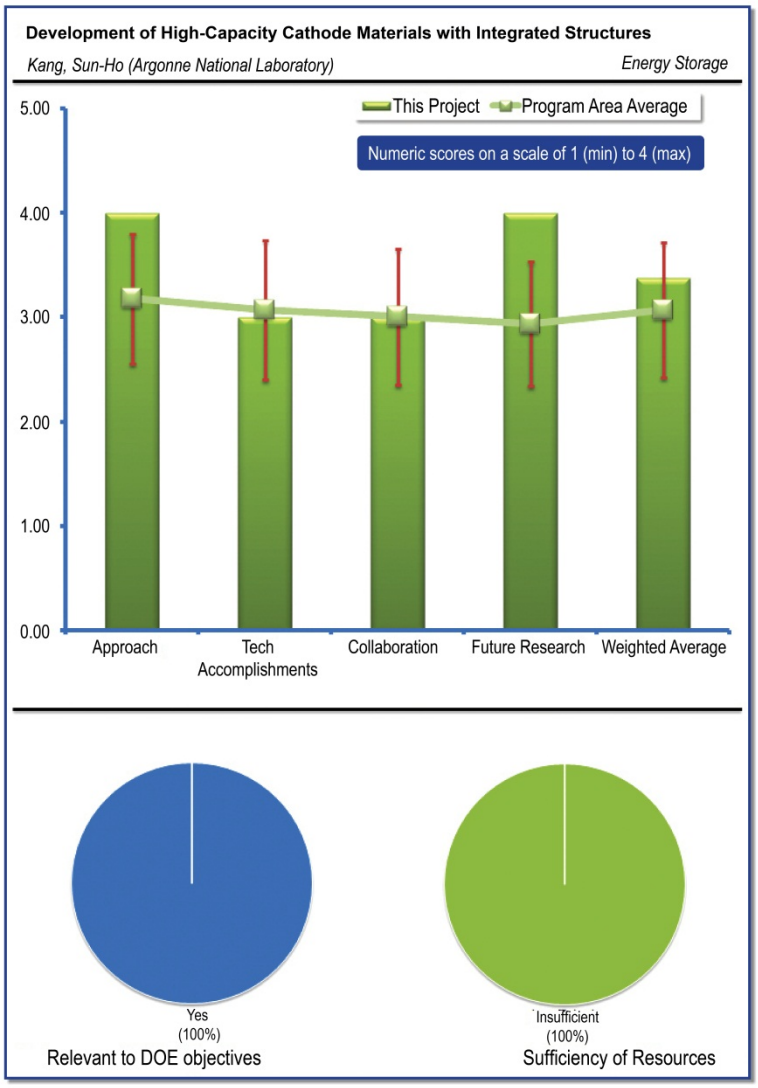
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer noted that it seems that the project is being discontinued.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewer did not provide a comment to this question.

Development of High-Capacity Cathode Materials with Integrated Structures: Kang, Sun-Ho (Argonne National Laboratory) – es019



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer stated that the work is very related to the overall DOE objective; the electrode capacity is critical in this case.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer agreed that the approach is very focused on technical barriers, mainly Mn dissolution and the voltage shape change. The reviewer suggested that maybe the authors should also indicate the electrode capacity in terms of mAh/g total electrode weight. The reviewer also explained that if the powders require large amounts of conductive additives, or if they do not load well (low tap density), that should be an area where the authors should strongly focus their effort also.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer stated that the authors have shown good progress and they seem to be trying to build a strong bridge with industrial partners. The reviewer also agreed that the researchers are also downselecting the best two most promising cathode chemistries to be tried in full batteries.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer felt that the collaboration with other institutions seems to be moving in the right direction.

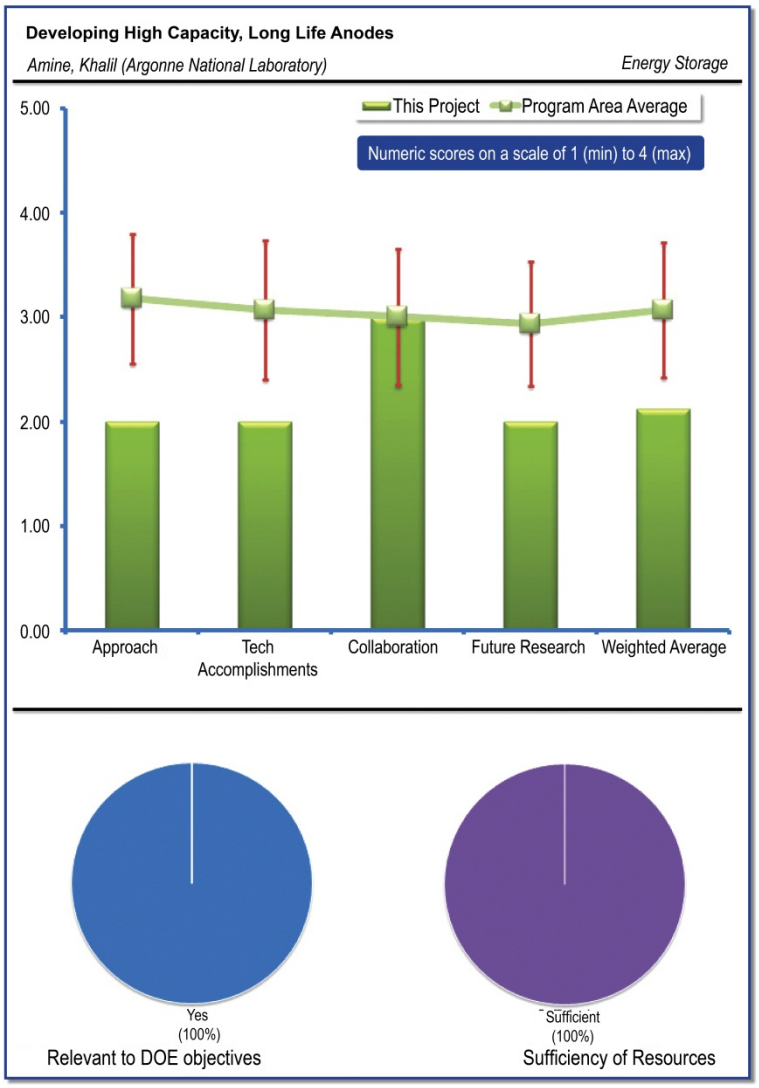
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer stated that it seems that the authors are focused in building a bridge between their basic research findings and industrial batteries. They have clearly indicated their commitment to additional efforts with U.S. companies. It may not be easy to overcome barriers such as intellectual property, but that type of collaboration is badly needed.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The reviewer felt that the researchers had insufficient funding if the authors strongly pursue industrial collaborators.

Developing High Capacity, Long Life Anodes: Amine, Khalil (Argonne National Laboratory) – es020



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer stated that anodes with improved performance over current graphite anodes are desirable. The reviewer continued, noting that considering that very little progress has been made on increasing the reversible capacity of cathode over one electron per cation, the next large performance improvement of Li-ion cells may come from using anodes beyond graphite.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer observed that the project focuses on using mostly engineering approaches. The reviewer felt that shifting away from the old titanate anodes is a step in the right direction, but the researchers still need to consider revolutionary approaches to solving the reversible capacity and low cycle life of the new anodes with large volume changes during cycling.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer observed that all of the materials shown in the presentation are still far away to be competitive against current graphites in actual cells in many aspects even though they may have some advantages here and there.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in response to this question.

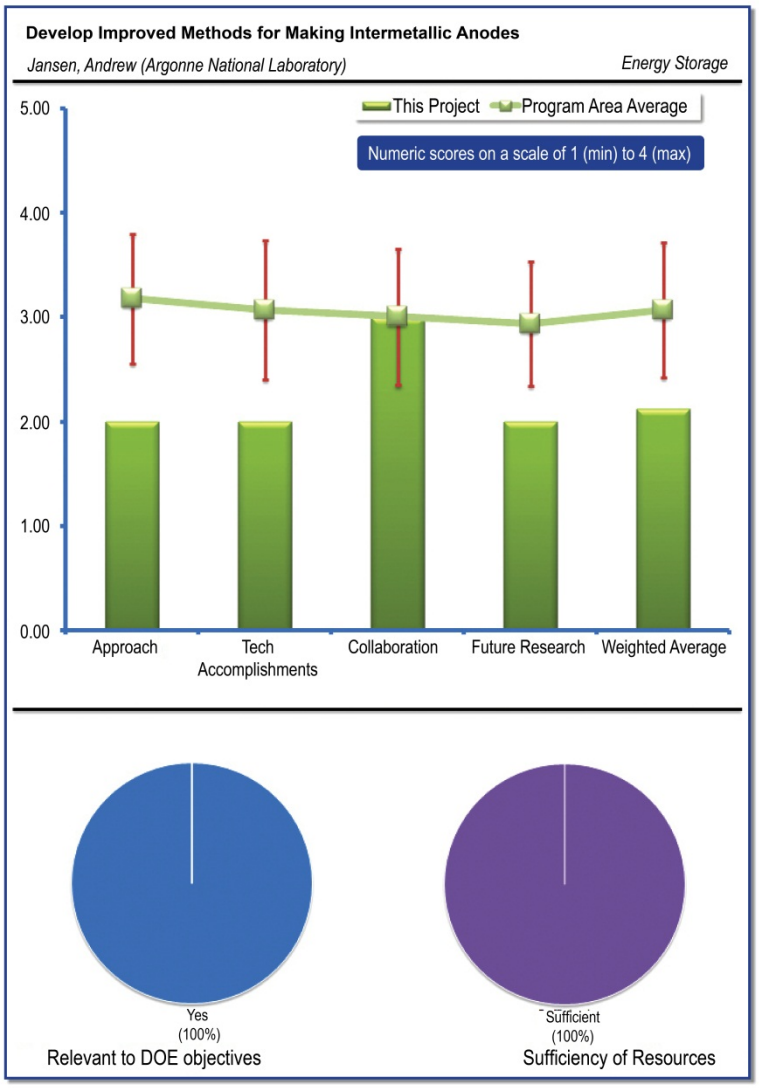
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer indicated that the failure mechanisms for this type of anodes have been well studied in the past. The reviewer emphasized that the researchers need new ideas to overcome the large irreversible capacity during first cycle and low cycle life of these new anodes.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No comments were received in response to this question.

Develop Improved Methods for Making Intermetallic Anodes: Jansen, Andrew (Argonne National Laboratory) – es022



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

No comments were received in response to this question.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer stated that the researchers need new ideas to make the Cu_6Sn_5 type anode with large volume expansion work. The reviewer felt that the current approach in controlling particle size and using new binders did not seem to work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer remarked that it was good to expand the exploratory type work beyond Cu_6Sn_5. The reviewer felt that some results from WildCat seemed to show some promise.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in response to this question.

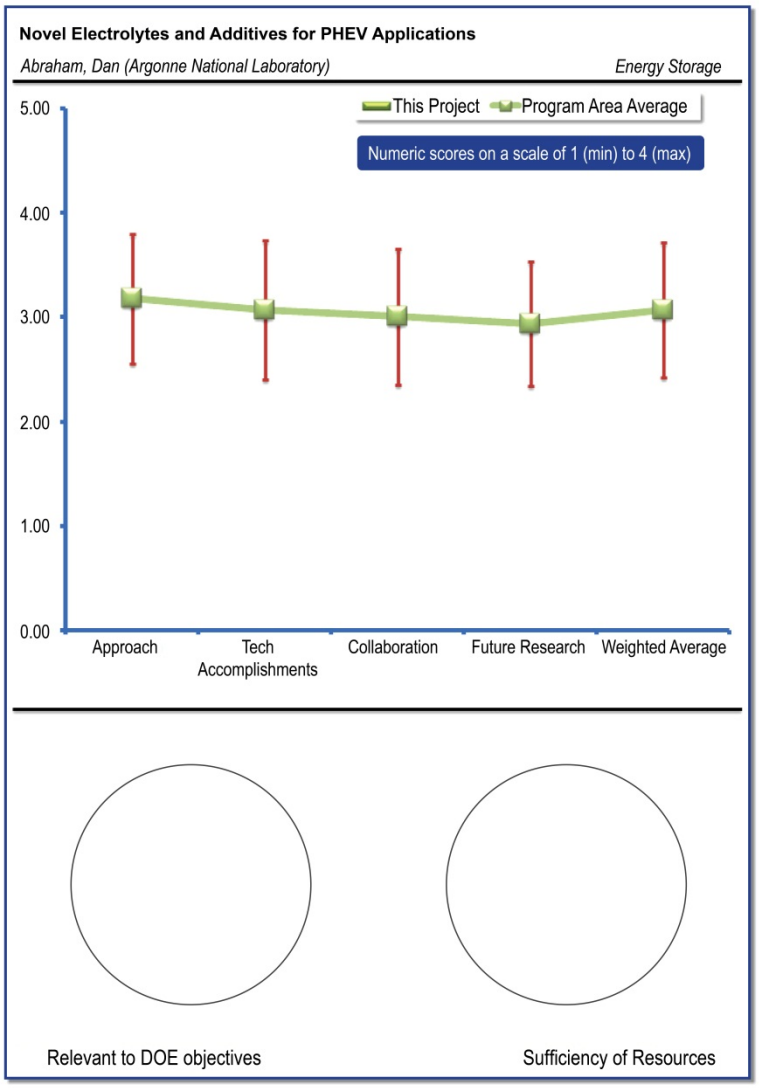
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer suggested that more binder does not seem to be able to control the expansion of the anode. The evaluator added that the researchers need to confirm that the metal oxides like $Fe_2O_3$and Li_5FeO_4 are promising before doing much. They concluded by offering that these materials will need pre-lithiation first to overcome the irreversible capacity first.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Novel Electrolytes and Additives for PHEV Applications: Abraham, Dan (Argonne National Laboratory) – es023



Reviewer Sample Size

This project had a total of zero reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

No comments were received in this section.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments were received in this section.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

No comments were received in this section.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in this section.

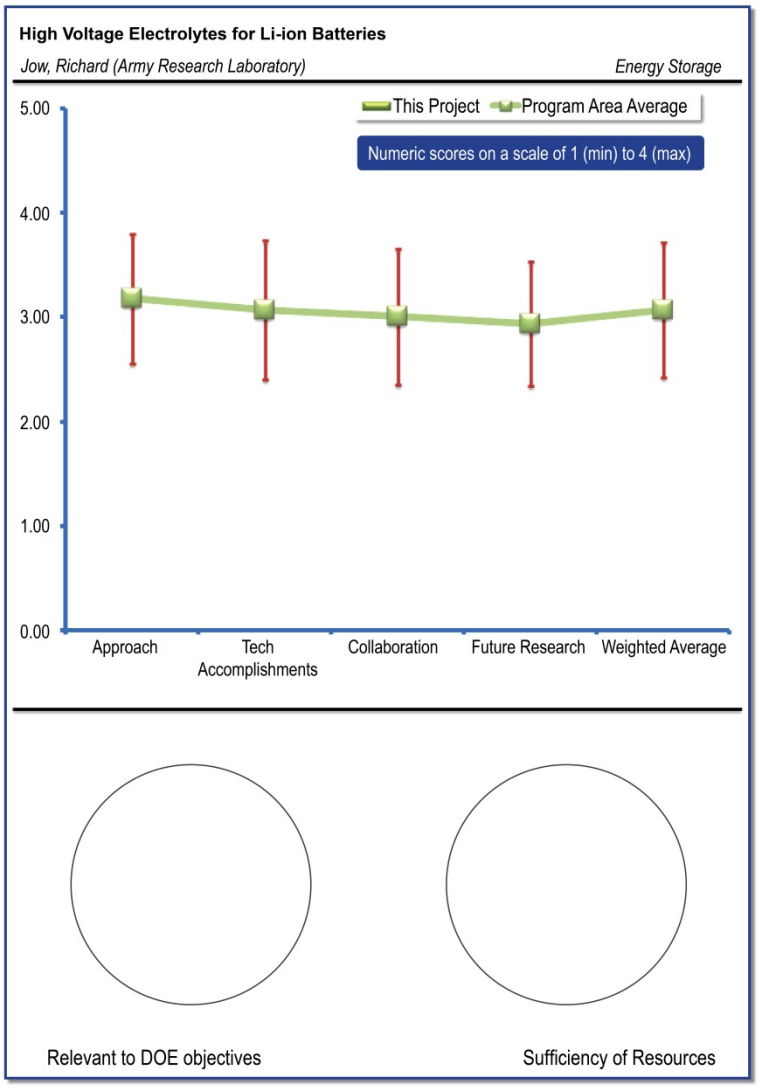
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

No comments were received in this section.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in this section.

High Voltage Electrolytes for Li-ion Batteries: Jow, Richard (Army Research Laboratory) – es024



Reviewer Sample Size

This project had a total of zero reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

No comments were received in this section.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments were received in this section.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

No comments were received in this section.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in this section.

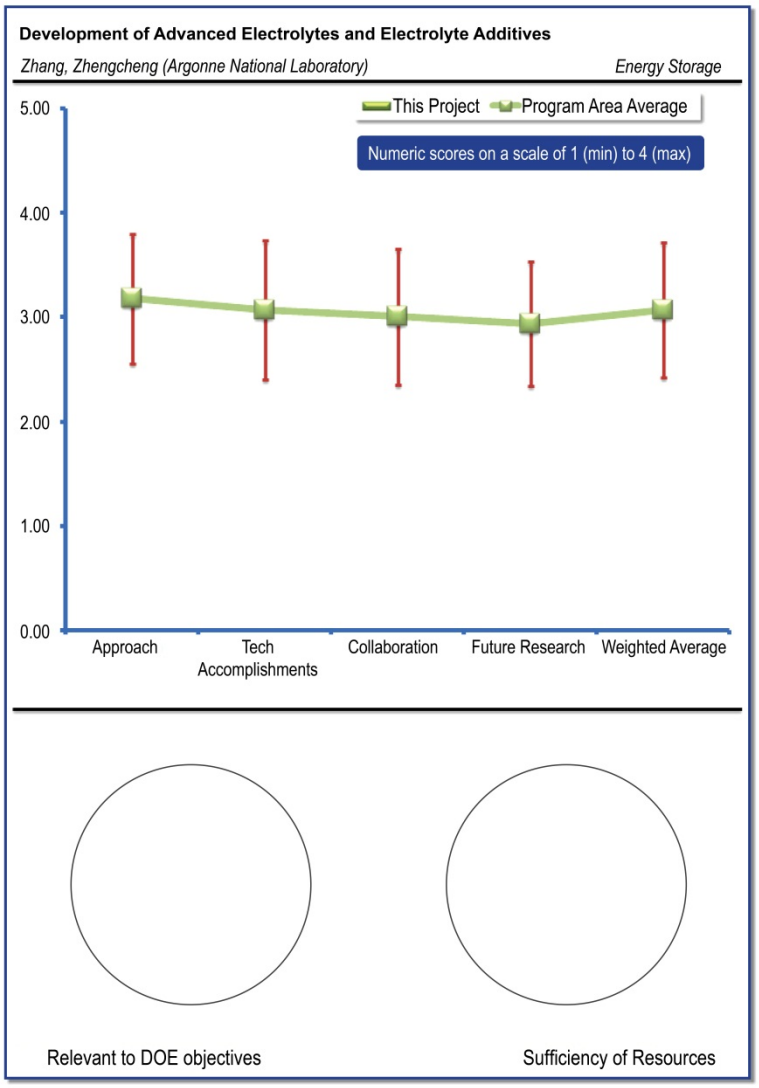
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

No comments were received in this section.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in this section.

Development of Advanced Electrolytes and Electrolyte Additives: Zhang, Zhengcheng (Argonne National Laboratory) – es025



Reviewer Sample Size

This project had a total of zero reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

No comments were received in this section.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments were received in this section.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

No comments were received in this section.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in this section.

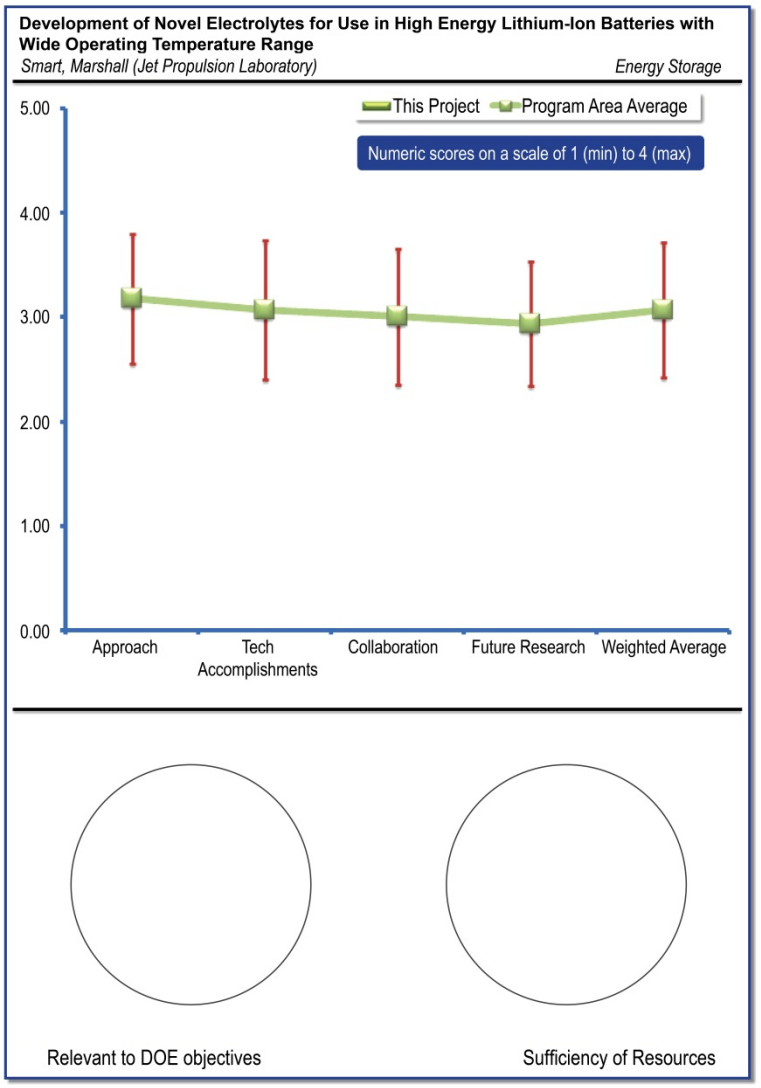
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

No comments were received in this section.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in this section.

Development of Novel Electrolytes for Use in High Energy Lithium-Ion Batteries with Wide Operating Temperature Range: Smart, Marshall (Jet Propulsion Laboratory) – es026



Reviewer Sample Size

This project had a total of zero reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

No comments were received in this section.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments were received in this section.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

No comments were received in this section.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in this section.

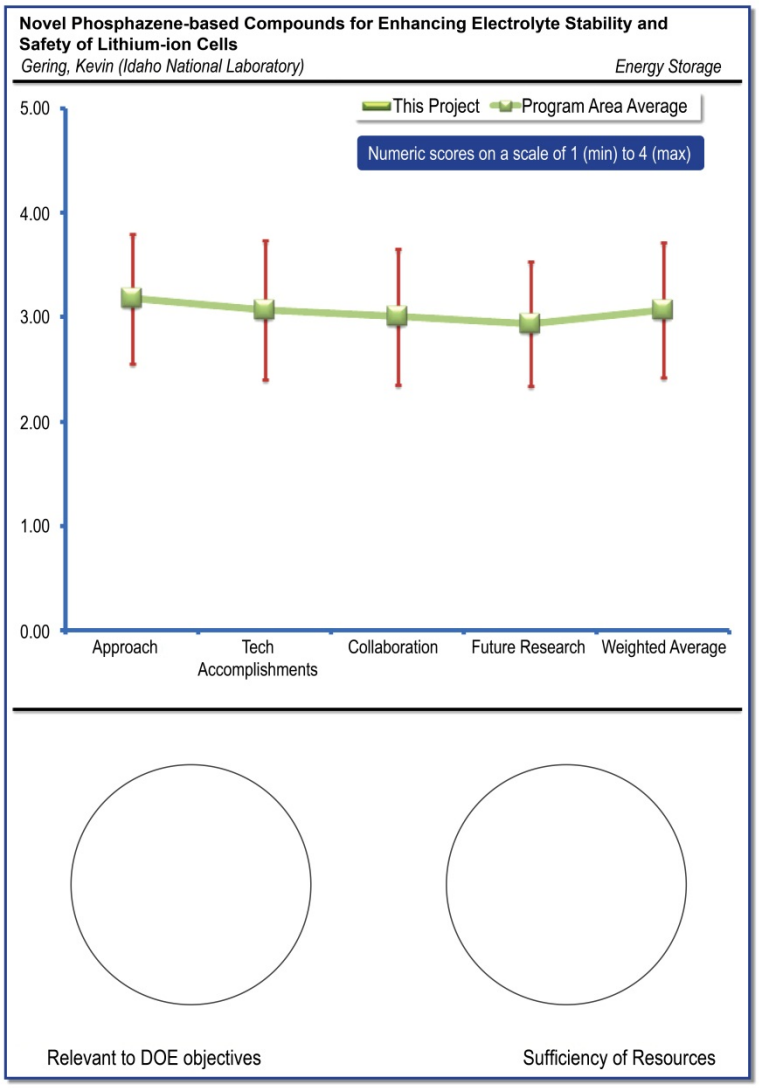
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

No comments were received in this section.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in this section.

Novel Phosphazene-based Compounds for Enhancing Electrolyte Stability and Safety of Lithium-ion Cells: Gering, Kevin (Idaho National Laboratory) – es027



Reviewer Sample Size

This project had a total of zero reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

No comments were received in this section.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments were received in this section.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

No comments were received in this section.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in this section.

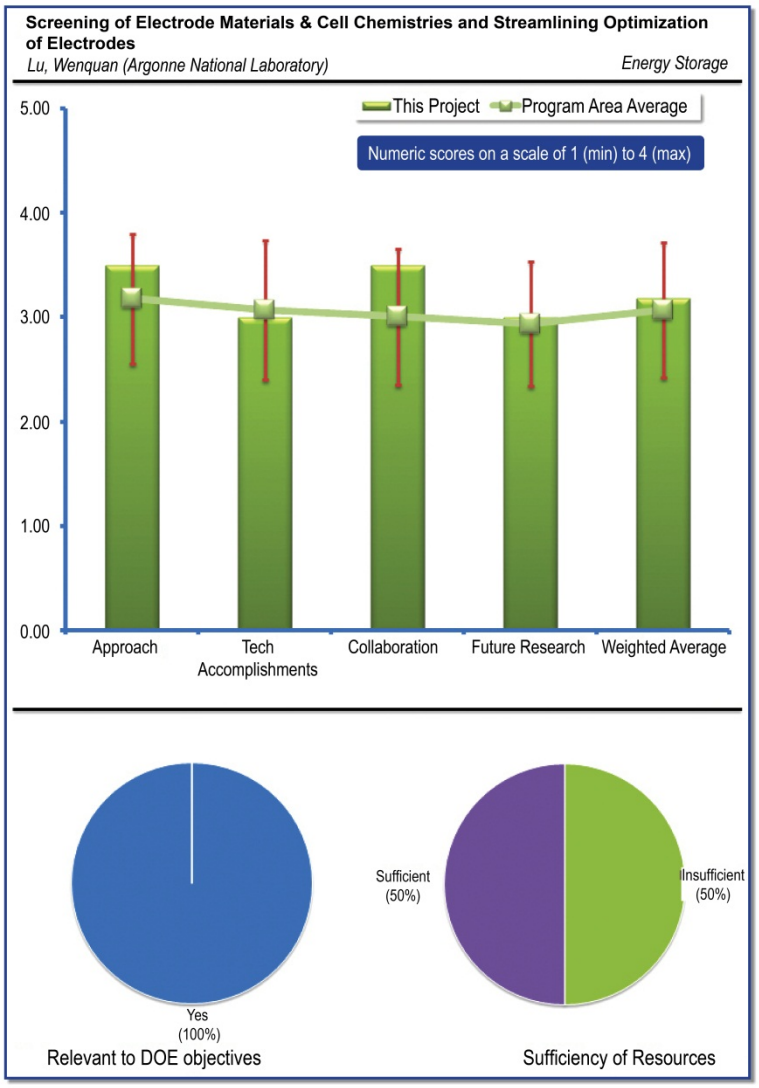
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

No comments were received in this section.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in this section.

Screening of Electrode Materials & Cell Chemistries and Streamlining Optimization of Electrodes: Lu, Wenquan (Argonne National Laboratory) – es028



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer observed that this is sort of advance screening of materials in many ways similar to what battery manufacturers do routinely. The reviewer suggested that it may be helpful to have some strict guidelines to show what are the parameters for screening and what filters are used to screen the materials ahead of time; in other words, the reviewer asked what the minimum pass criteria was for the screening. Another reviewer felt that the work is very relevant to DOE objectives and that the high energy cathode materials, electrode fabrication, and new electrolytes are extremely important when we try to increase the range of an HEV.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reactions to this question were mixed. One reviewer was critical of the approach, stating that, by and large, general industry practice has been employed to screen materials; more is expected from a National Lab. The other reviewer felt that the approach was very focused on technical barriers and that it seems that the authors are focusing in very practical issues. This person mentioned several high points of the approach, including: i) that voltage depression of the composite cathode material seems to be a critical component; ii) the work on fluorinated electrolytes is also very important; and iii) optimization of the electrodes is also critical.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

According to one reviewer, some of the technical findings tend to sound trivial and fully expected [e.g., poor particle connectivity in the electrode can be improved by increasing carbon black (CB)]. For such matters to become of value, the optimal composition and trade-offs are to be discussed and explained. Another reviewer remarked that it is important to move to the more realistic unit of mAh/g total electrode weight as opposed to mAh/g active material weight. This is important because the study suggest that carbon coating of the cathode powder increases the electronic conductivity; however, tap density may go down.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that the authors should try a stronger collaboration with industrial partners. This person offered that their techniques may help improve the life of the battery.

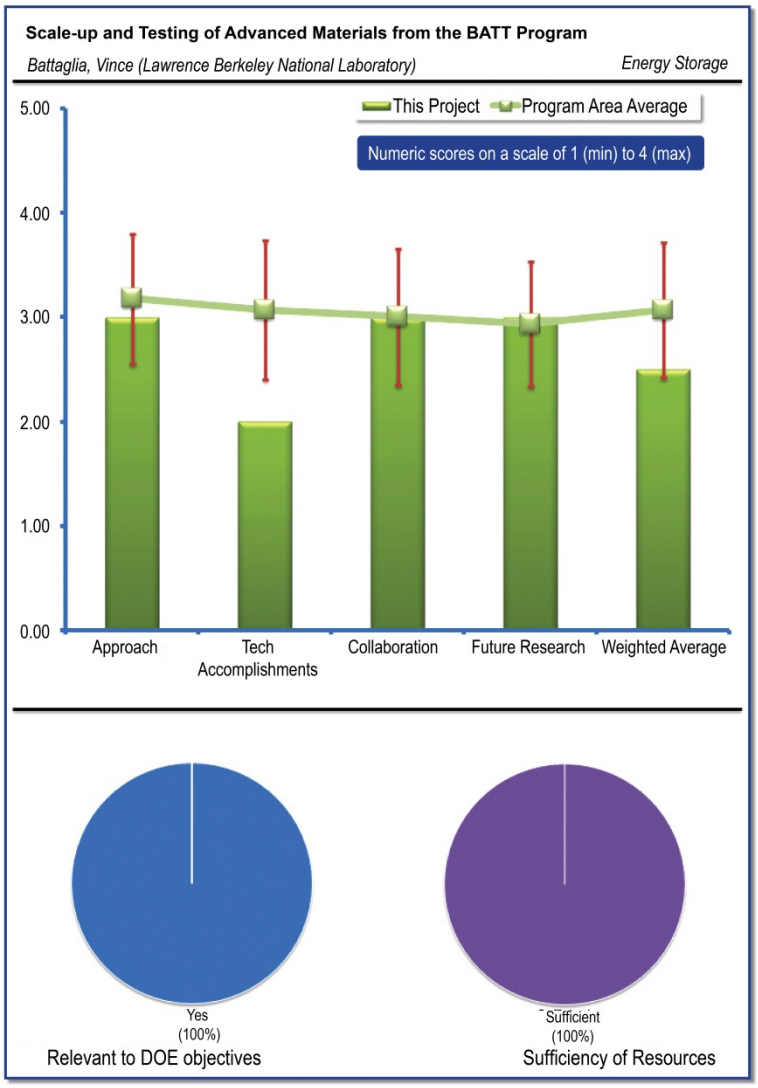
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer suggested that the authors should also focus on the analysis of failed batteries. The reviewer asked whether the researchers could a) measure the conductivity of electrodes taken at the end-of-life and b) use the nanoelectrical imaging of electrodes as a toll for predicting cycle life. This evaluator also thought that it could be of great interest to put together a model, using their variety of measuring techniques, that could explain certain failure mechanisms in commercial batteries. The reviewer concluded by asking whether the failure mechanisms are being addressed by the new materials or electrode compositions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer stated that the project should be expanded towards a stronger interaction with American companies (the reviewer acknowledged that this is not an easy task) and study commercial Li-ion batteries.

Scale-up and Testing of Advanced Materials from the BATT Program: Battaglia, Vince (Lawrence Berkeley National Laboratory) – es029



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that it is important to have a third-party as a central place for evaluations of various new materials at bench scale so that the performance can be compared on the same basis. The reviewer also asserted that it is also important that the central place can recommend materials for the next phase (e.g., scale up) if the same types of materials are supplied by various labs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments were received in response to this question.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

No comments were received in response to this question.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

No comments were received in response to this question.

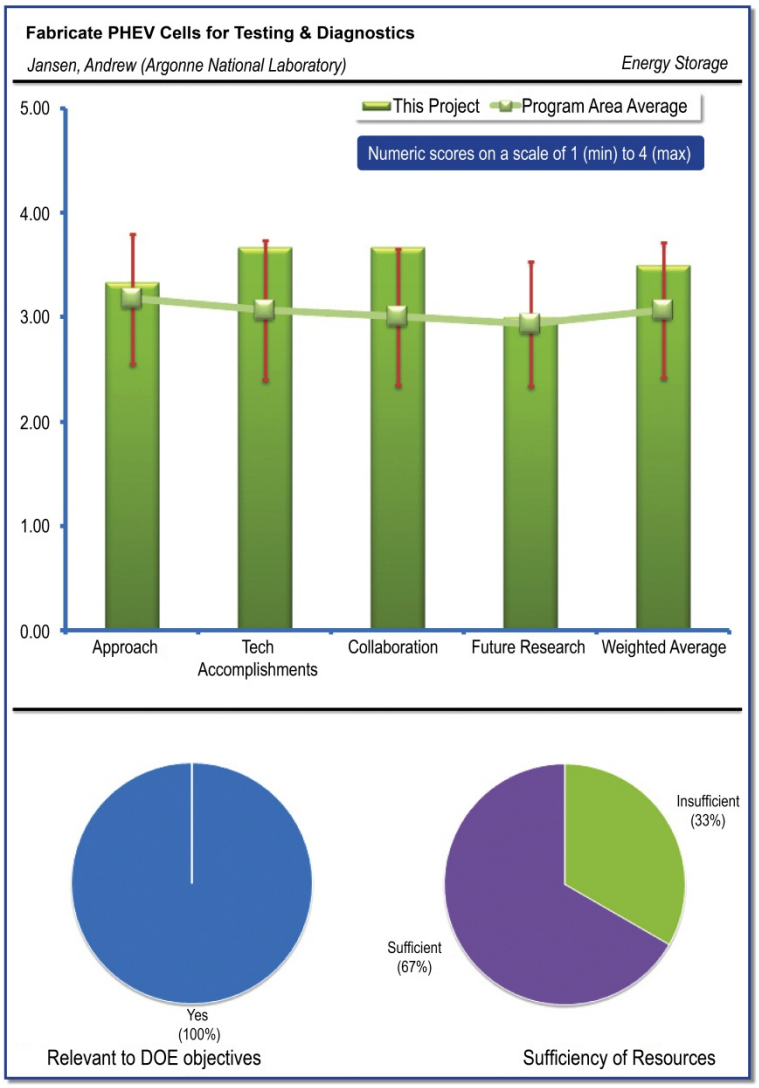
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer stated that besides testing the intrinsic capacity and rate capability of the new electrode materials, the performance of electrode (not the active material) using optimized formations is important from practical applications and should be evaluated.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Fabricate PHEV Cells for Testing & Diagnostics: Jansen, Andrew (Argonne National Laboratory) – es030



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One evaluator asserted that it is very good for one key DOE lab working Li-ion cells to have the adequate capability on making full cells (at least the 18650 size) at a pilot line scale. Another reviewer expressed that electrode and cell fabrication play a big role in performance and life. The reviewer also pointed out that scale up is a critical step in transitioning R&D into pilot/production processes. The final reviewer agreed that the project is very relevant, particularly if the authors direct their efforts toward the understanding of the failure mechanisms of commercial batteries. The reviewer indicated that data should be compared with the results obtained on batteries assembled using new materials and electrode compositions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that using industry and experts to guide the fabrication processes is a smart approach. Another reviewer felt that the project is very relevant and that it will bridge basic research and industrial batteries. The reviewer emphasized that the cell fabrication facility is critical; there are not too many places where batteries, similar to commercial cells, can be assembled in the U.S., so this is very important. The reviewer concluded by acknowledging that the installation of the cell making equipment, for cylindrical cells, was an important milestone.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person commented that the PI reported excellent progress with a clear execution path. The reviewer suggested that as far as test results go, the researcher should consider other parameters that might impact results (e.g., in measuring material capacity, tap density is a critical parameter that could change the results, sometimes dramatically). Another reviewer highlighted that this is a very important facility that should help bridge the gap between research and development work, as well as industrial cells. For this reason, the reviewer thought that it is important to report some of the capacity data in mAh/g total "electrode" weight and not only mAh/g total "active" weight. Another person remarked that the equipment and machines seem to be adequate for ANL's plans to produce full cells from scratch. It was not clear to the final reviewer how many tools and means that ANL has for property measurements and controls for cell making. The reviewer suggested that the areas needed to control and measure are mix uniformity, slurry rheology,

electrode thickness and variations, electrode integrity, tension of the webs during winding, electrode alignments, dust, separator properties, and so on. The reviewer added that having a standard operating procedure (SOP) for all key steps is critical.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reactions to this question were positive. One reviewer commented that it is very good for newcomers to learn the know-hows from industrial companies. The other reviewer to comment noted that it seems the authors have strongly emphasized interaction with industry. The reviewer acknowledged that this is difficult, and not too many U.S. companies are available; however, the authors should keep working toward that goal.

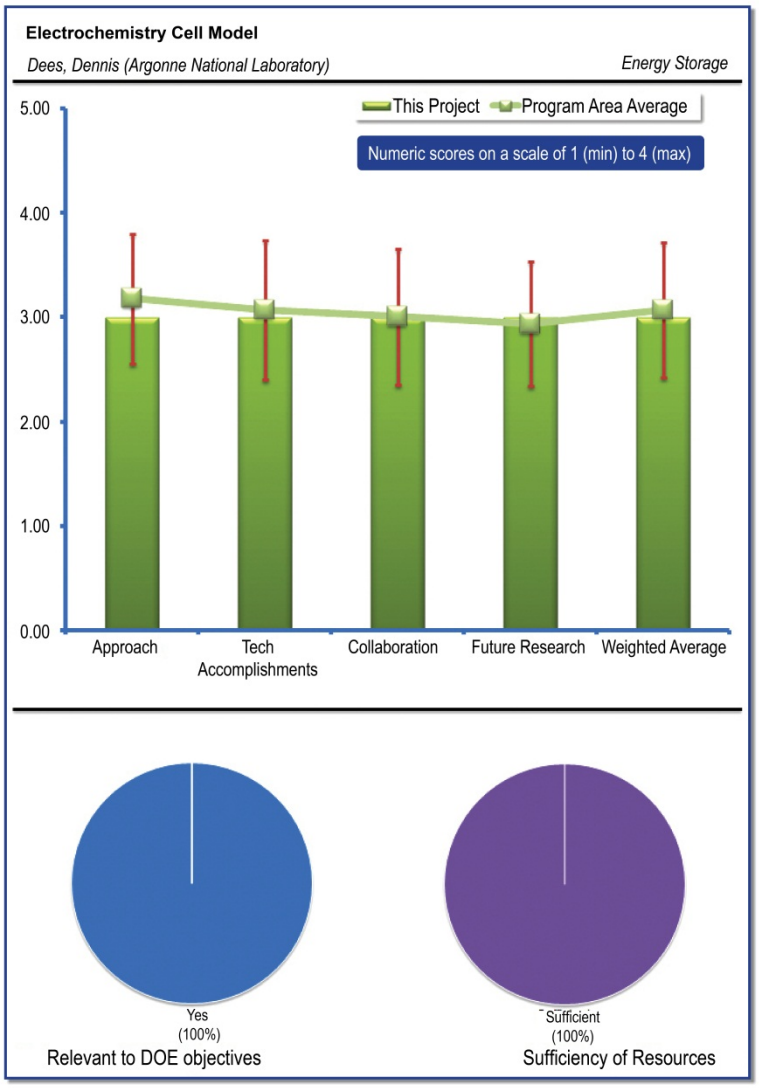
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers offered suggestions for improving the future work. One reviewer suggested that the researchers need to consider the impact of extraneous factors (e.g., the stack pressure in the case of pouch cells, since they may also impact performance/life data). Another person noted that failure analysis can give important hints on cycle life performance and active material issues that may not show up in standard tests. The reviewer added that the breaking-in of the batteries (formation) is also very important; there is too much "black art" in this area so the reviewer was glad to see efforts in that direction and referenced Slide 15 in the author's presentation. The final reviewer suggested that the researchers need to keep in mind that there are still some differences between the cells made on pilot scale and production scale. So at some point, this project needs to demonstrate that cells made on the pilot scale can match the cells made on production by a reputable battery company.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The only reviewer to comment stated that maybe the project needs more funding depending on a stronger interaction with industrial partners.

Electrochemistry Cell Model: Dees, Dennis (Argonne National Laboratory) – es031



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer commented that electrochemical modeling work is useful for providing insights and detailed information on cell performance that are difficult or impractical to obtain experimentally.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The respondent stated that, in the past 10 to 20 years, a significant amount of work on Li-ion cell modeling has been published by several groups (e.g., Newman, While, Wang, and many others). The use of new differential equation solver software seems very helpful for solving the complex models (coupled partial differential equations). However, this reviewer wonders if the PI has examined many other commercial solvers and compared the pros and cons of using Process Systems Enterprise Limited (PSE) advanced process modeling (gPROMS). This reviewer added it is a good approach to develop a model based on experimental observations (solid electrolyte interface [SEI] and micropores inside the particles).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer felt many parametric studies provided useful information.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer said it appears that this group is capable of doing sophisticated modeling work all by themselves. Therefore, there is little need to collaborate with other modelers working on the DOE projects. However, some kind of coordination with the Lawrence Berkeley National Laboratory (LBNL) group is recommended to ensure that they will compare results if these two groups are modeling the same phenomena. This reviewer added that some overlap is good to double check the results.

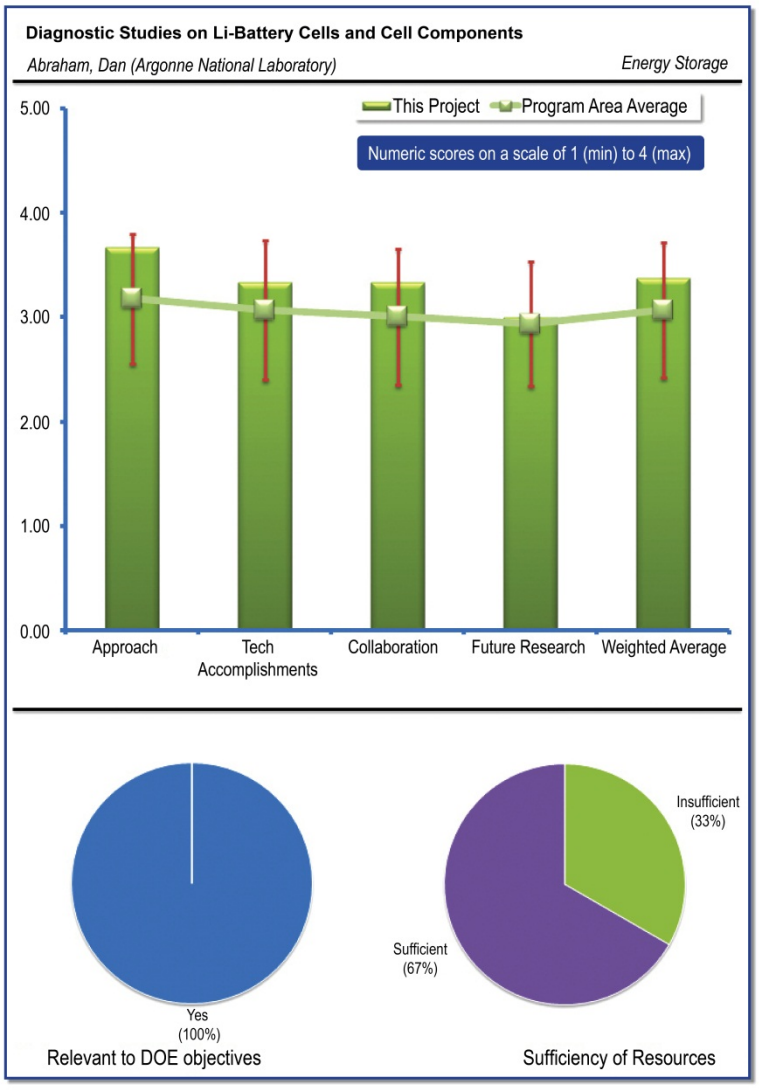
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer commented that, at some point, the PI needs to verify experimentally the key modeling results and new discoveries. This reviewer refers to the verification part to be carried out by other groups and done at the end of project. After the model is ready for distribution, this reviewer added, the PI should try to promote the usage of the model by select cell designers and material developers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewer said the resources were sufficient. There were no additional comments.

Diagnostic Studies on Li-Battery Cells and Cell Components: Abraham, Dan (Argonne National Laboratory) – es032



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer said effective diagnostic tools are always useful. A second reviewer commented that understanding aging and failure mechanisms will eventually lead to longer life and economically viable solutions. The final reviewer commented the project was very relevant, adding that diagnostic studies and aging of the electrodes are critical if we want to increase the range and the life of a Li-ion battery.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section, with reviewers offering a few further suggestions. The first respondent noted that the approach of using multiple techniques like X-ray diffraction (XRD) (long range structure), X-ray absorption fine structure (XAFS) (local structure), X-ray photoelectron spectroscopy (XPS) (surface film oxidation), and referenced cell (individual electrode effect) by the PI and co-workers is very effective on diagnosing the failure mechanisms. Another reviewer noted a nice combination of pure and applied research, and added that the latter should be emphasized further. The voltage profile observed in layered-layered oxide seems to be an important issue that should be studied further. The final reviewer stated that good insights were gained on aging mechanisms. This reviewer also observed a well-organized and systematic approach to problem solving, and a very good and clear analysis. Some questions remain on the interpretation of data (e.g., it is suggested that capacity loss is mainly due to Li-consuming reactions in the anode but in fact the anode's impedance suffers a lot less than the cathode). This reviewer went on to note that the evidence provided shows that the cathode capacity is by and large maintained. Finally, this reviewer questioned where the consumed Li came from and the evidence for supporting that.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers offered a number of suggestions in this section. The first reviewer said progress has been excellent, and added that maybe additional work to include the role of electrolyte and separator will strengthen the work. A second respondent, as mentioned earlier, would like to see more capacity data focused in mAh/g total electrode weight; in particular, when the authors try to bridge the gap between pure and applied research. The final reviewer commented that the diagnostic tools used by the PI and co-workers have indeed provided some insights into the failure modes. The authors indicated that the capacity fade of the baseline cell appears to result from

Li loss during graphite SEI dissolution/reformation. This might be true, but it needs to be confirmed by checking the cycled anode and cathode separately. This can be done by pairing the cycled anode with a fresh cathode and the cycled cathode with a fresh anode and then cycling the cells again.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The lone respondent commented the authors have shown strong collaboration with other institutions. This reviewer stated that although difficult; the group should keep trying for a stronger interaction with the U.S. battery industry.

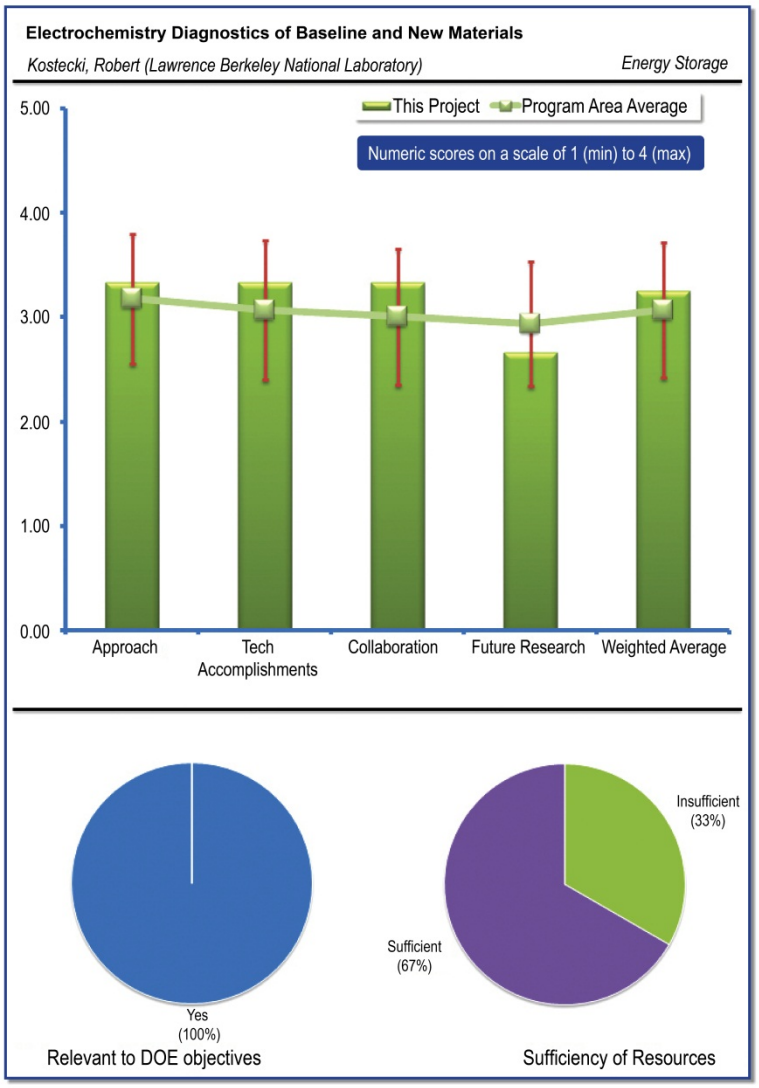
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers offered a number of suggestions in this section. The first said include the role of electrolyte and separator, and added that the solid-electrolyte interface changes during aging are critical. A second reviewer commented the aging experiments are very important; they should probably emphasize the analysis of failed batteries (autopsy), of commercial and more advanced cells. The final reviewer noted that, in addition to the proposed future research, one electrochemical diagnostic tool that the PI and co-workers can consider is to develop a referenced cell for the 18650 size, as ANL has the capability of making 18650 cells as the testing vehicle for many applied researches.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The lone respondent commented that resources may not be sufficient, depending on the strength of collaboration with U.S. companies (battery or chemical companies).

Electrochemistry Diagnostics of Baseline and New Materials: Kostecki, Robert (Lawrence Berkeley National Laboratory) – es033



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated high-voltage cells are presenting one of the few viable options to reach high energy and low cost. The other respondent commented it was very relevant, adding that the study towards understanding the degradation mode of active materials is critical if we want to lower the cost and increase the range of a battery.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent commented the PI has clearly demonstrated an obstacle (i.e., oxidation of electrolyte and PF_6- intercalation into conductive carbon additives) and presented a feasible solution to overcome the problem with evidence. The other reviewer commented that, now that the authors have identified some of the problems associated with degradation and failure of carbon, for example, they should try to identify which of these degradation mechanisms is playing an important role in commercial batteries, or even advanced batteries that are still under consideration.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated important progress has been demonstrated, adding that more data related to full batteries are also necessary. The other respondent liked the citation of the previous work on PF_6- interaction into carbon materials. This reviewer has seen in some cases the researchers do not refer to previous work performed by others. This reviewer added that the amount of work presented seems to be insufficient to justify a $600,000 project. Only three carbon materials and the effects of heat treatment and surface treatment were investigated using cyclic voltammetry (CV) and Raman. Finally, this reviewer queried whether there were any other major accomplishments in the past years that did not get reported in this postal presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that the authors have shown strong collaboration with other institutions, and added that a stronger interaction with U.S. companies, which is not easy, should be strongly pursued. The other reviewer commented a proof of concepts presented at the full cell level would have strongly reinforced the findings.

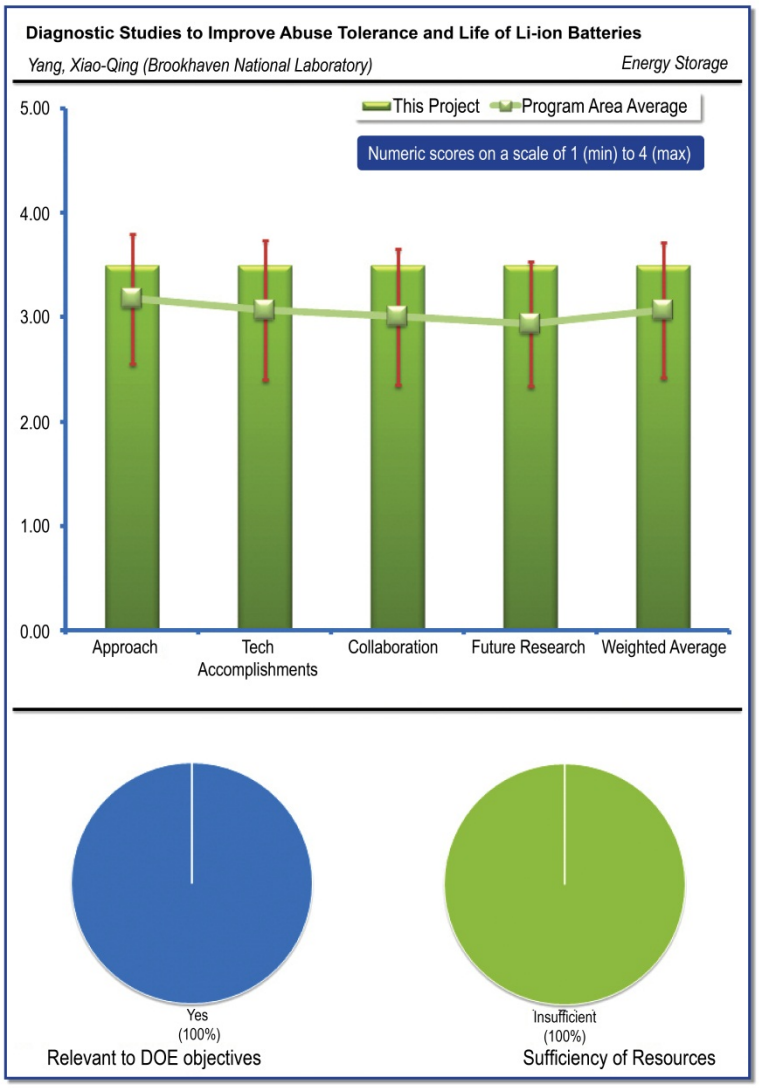
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Reviewers offered a number of suggestions in this section. The first respondent said to extend the study to include electrolyte oxidation on the high voltage (HV) oxide particles, adding that it seems more intuitive if electrolyte oxidation occurs primarily on the oxide particles rather than conductive carbon particles. Extend the study to use HV solvents (e.g., sulfones). That would be more relevant than carbonaceous solvents. A second reviewer stated, as mentioned earlier, diagnosis and the analysis of the failure mechanism associated with these batteries is strongly recommended. The authors may try to analyze commercial batteries in an effort to identify key issues that may need particular attention now. The final respondent commented the group needs to be more specific on the areas to focus on. Because the project is on electrochemistry diagnostics, this reviewer would like the PI to focus on a specific area and provide in-depth scientific understanding of a few key items.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said the resources were sufficient, while one said the resources were insufficient. The lone commenter said the authors may need additional resources depending on how strong their collaboration is with U.S. companies.

Diagnostic Studies to Improve Abuse Tolerance and Life of Li-ion Batteries: Yang, Xiao-Qing (Brookhaven National Laboratory) – es034



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said safety is an absolute must-have, especially in the transportation sector. This reviewer added that insights into what might lead to thermal runaway are invaluable. A second reviewer said the work is very relevant, adding that abuse tolerance, cell capacity and power fading are critical issues that, if improved, will translate into a higher battery range.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent said the PI has mastered the art of advanced imaging techniques and attacks the problem directly and with authority. The other reviewer stated the in-situ transmission electron microscope (TEM) studies are clearly important and have produced a better understanding on degradation issues. In-situ studies are very close to real life conditions. It should be important to study the Al_2O_3-coated electrode in a full cell to see if additional issues (good or bad) show up.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted excellent insights with clear explanation of the underlying phenomena, while the other respondent commented interesting work. This reviewer added that safety-related issues are critical in Li batteries. The coating of an electrode with Al_2O_3 has to be tested also in cylindrical cells. The in-situ XRD measurement in collaboration with Proctor & Gamble was very interesting. It would be important to know the tradeoff of a coated electrode or powder. This reviewer added the thermal decomposition mechanism of Gen2 and Gen3 powders was an important achievement.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The lone respondent stated that the respondent understands that is not easy to find U.S. companies ready for collaboration, but added that the interaction with Duracell, Dow chemical, and GM R&D Center should be strongly pursued.

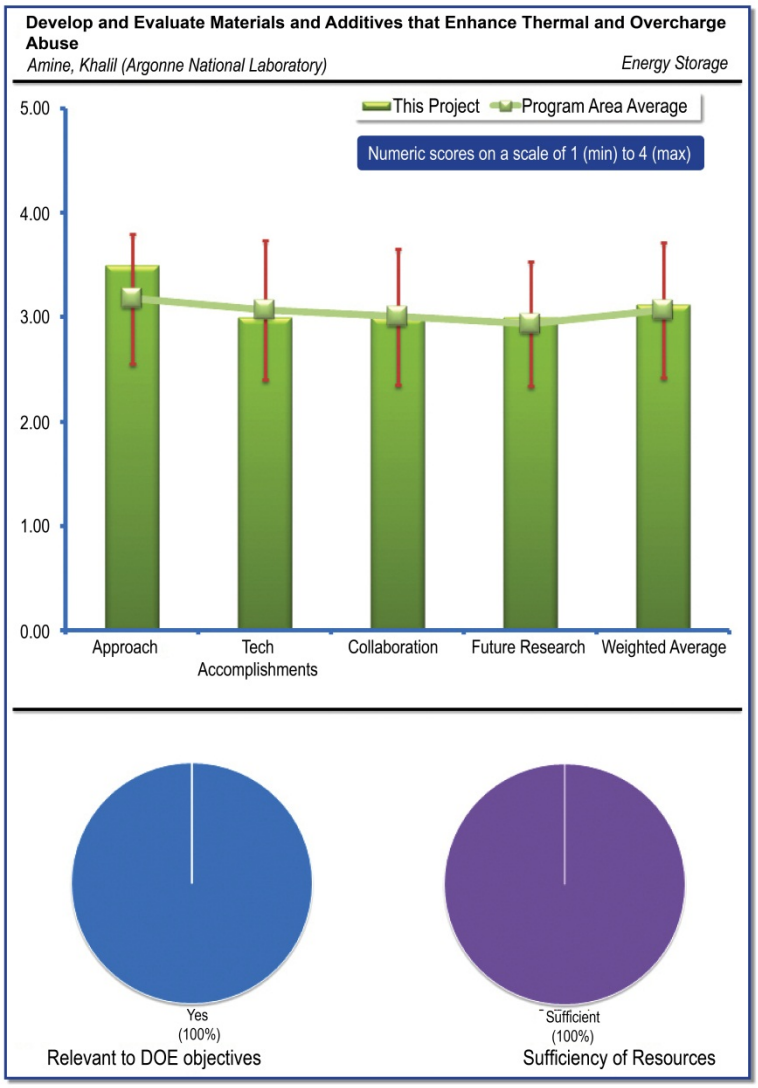
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The first reviewer would like to see these studies extended to newer cathode materials (e.g., Li-rich layered-layered) and compared to more established cathodes (NCA, NMC, etc.). The other respondent said, as mentioned earlier, further experiments with commercial batteries should be tried. This reviewer added so far the results are promising; therefore, tests performed on commercial batteries seem to be a natural avenue to explore.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said more emphasis on using advanced imaging techniques will produce richer output, while the other reviewer said the resources are insufficient if a stronger interaction with U.S. companies is pursued.

Develop and Evaluate Materials and Additives that Enhance Thermal and Overcharge Abuse: Amine, Khalil (Argonne National Laboratory) – es035



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer commented that batteries are the viable near-term option for vehicles. Safety is a critical issue in adopting the lithium-ion technology for vehicles, and this project focuses on it. The other respondent noted the 3.9V redox shuttle (ANL-2) could potentially be useful as a redundant safety feature and capacity regulator for a $LiFePO_4$-type cathode that has an upper charging cut-off voltage at or below 3.9V.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent indicated the researchers focused on identifying and solving the problem. The other reviewer commented this project focuses on developing and evaluating electrolyte additives and materials that can enhance the thermal stability and abuse tolerance of lithium-ion batteries. This reviewer added that electrolyte additives and redox shuttles can help to improve safety, so the approaches and direction are reasonable.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted electrolyte additives to form better SEI layers on graphite have been developed. Two redox shuttles have been identified. Also, scale-up of the materials developed is being pursued. This type of work has been occurring with the PI with a large amount of resources for quite some time now, and it is not clear what is new this time. This reviewer questioned whether any of these materials can make a breakthrough or game change in the industry. The other respondent indicated the performance of the ANL-2 as a redox shuttle is good. However, this reviewer added, ANL-2 by itself as the sole protection method for overcharge is not likely to be sufficient for the cathode with excess capacity over 3.9V. Issues that still need to be addressed include variation of the cut-off voltage as a function of discharge rate and temperatures. Additionally, this reviewer commented, the high-rate capability at room temperature, and especially at low temperature, may be decreased substantially if the concentration of ANL in the electrolyte is 0.2 or 0.4M.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The lone respondent in this section noted the collaborations are with Sandia National Laboratories and EnerDel: the usual people the PI has been interacting with in the past.

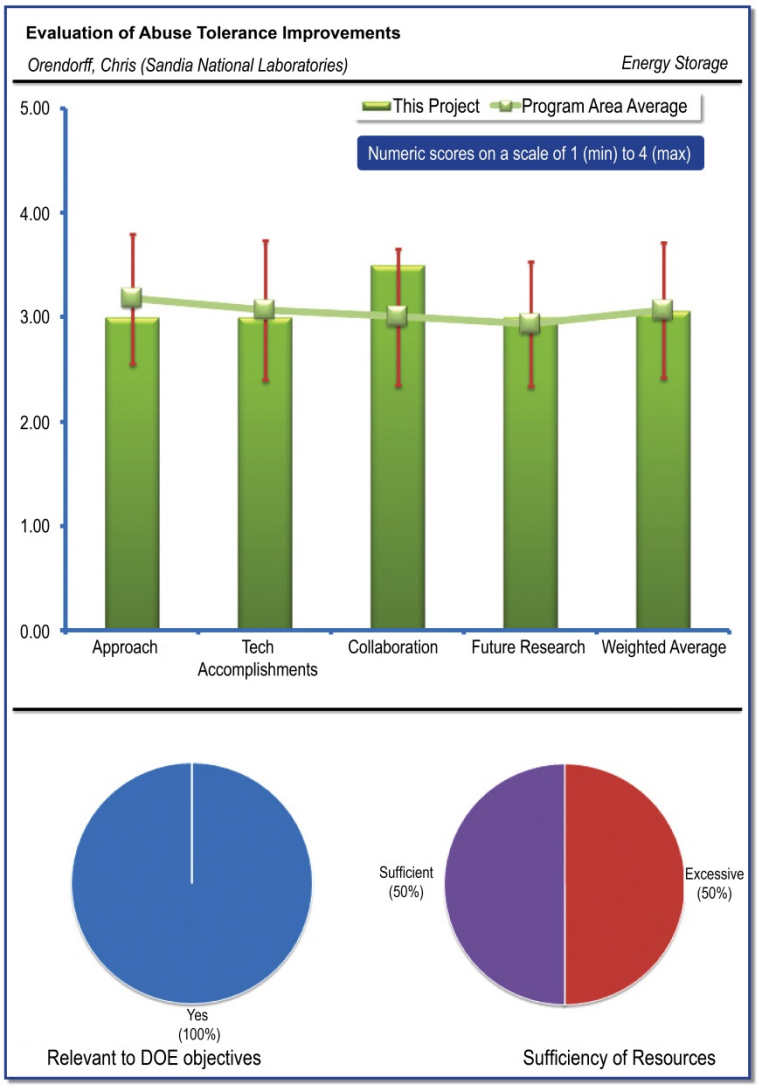
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer acknowledged that the future work is focused on carrying out more characterization and exploring new redox shuttles, which are natural extensions. The other reviewer would like the group to thoroughly investigate the potential drawbacks of the ANL-2 in the following areas: (1) effect of ANL on high rate capability at room and low temperatures; and (2) effect of ANL on cycle life (need to test to 60-70% of the initial capacity for the control) at room and elevated temperatures. This reviewer added that, after sufficient work is done to characterize ANL-2, then the group can expand their research effort into other items outlined by the PI and co-workers. They need to focus the effort on something that shows promise rather than doing general research work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented the resources were sufficient for fundamental and applied research work, while the other agreed the resources are sufficient for the level of effort on the project.

Evaluation of Abuse Tolerance Improvements: Orendorff, Chris (Sandia National Laboratories) – ess036



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer wrote battery safety is a critical area for consumer and EV Li-ion cells. The other respondent commented that safety and abuse tolerance are critical issues in successfully adopting the lithium-ion technology for vehicle applications. This project addresses these important issues.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

This first reviewer said the project focuses on identifying the mechanisms of heat and gas production in lithium ion cells during charge-discharge. Such an understanding can help to develop appropriate materials systems for safer lithium-ion cells. The project also focuses on developing materials that will minimize gas and heat generation. The second respondent noted the author certainly has successfully applied a key technique (Accelerated Rate Calorimetry [ARC]) for characterization of several materials and a few full cells in the past year. As long as the equipment is available, the testing itself is straightforward. This reviewer added that characterizing commercial cells is important for baseline establishment. For full cell thermal testing, this reviewer added, the PI needs to collaborate with the groups in other DOE labs (e.g., NREL) on modeling using the thermal parameters generated from the PI's work. This will help understand the failure mode of the full cells on thermal abuse.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated good results and good correlation between component testing and real cell testing have been obtained. The other person noted that software and hardware have been upgraded for accelerated calorimetry tests. This reviewer added that a few cathode materials with chemical coatings have been assessed. Chemical coating with AlF_3 has been found to enhance the thermal stability. This is as one would expect since the highly reactive cathode surface is not in direct contact with the electrolyte when the cathode is coated with inert AlF_3. Attempts to develop thermally stable electrolytes seem to cause other problems such as decreases in conductivity and capacity. It may be a tough problem to tackle to have all the parameters in a favorable position.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer indicated the work involves extensive collaboration with several people: other national labs, universities, and industry. This is a big plus for the project. The other respondent indicated a need for some modeling work to understand the causes of thermal runaway of cells using the improved materials under select key abuse tests.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said the future work focuses on an extension of the ongoing work to develop both better understanding and to develop better materials. The other reviewer made a few individual comments: (1) Understand the interactions of individual components on cell safety on thermal abuse for a few select key designs; (2) Establish the baseline of the safety characteristics of a few select commercial batteries (e.g., 18650 and large format PHEV or HEV batteries from a few large companies) on thermal abuse; and (3) besides thermal abuse, how does the new/improved material perform in cells on a few select mechanical and overcharging abuse tests?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said the resources were sufficient while the other said they are excessive. One reviewer stated the current funding for this project is on the high side, and added that $1.3M per year is a large amount of funding.

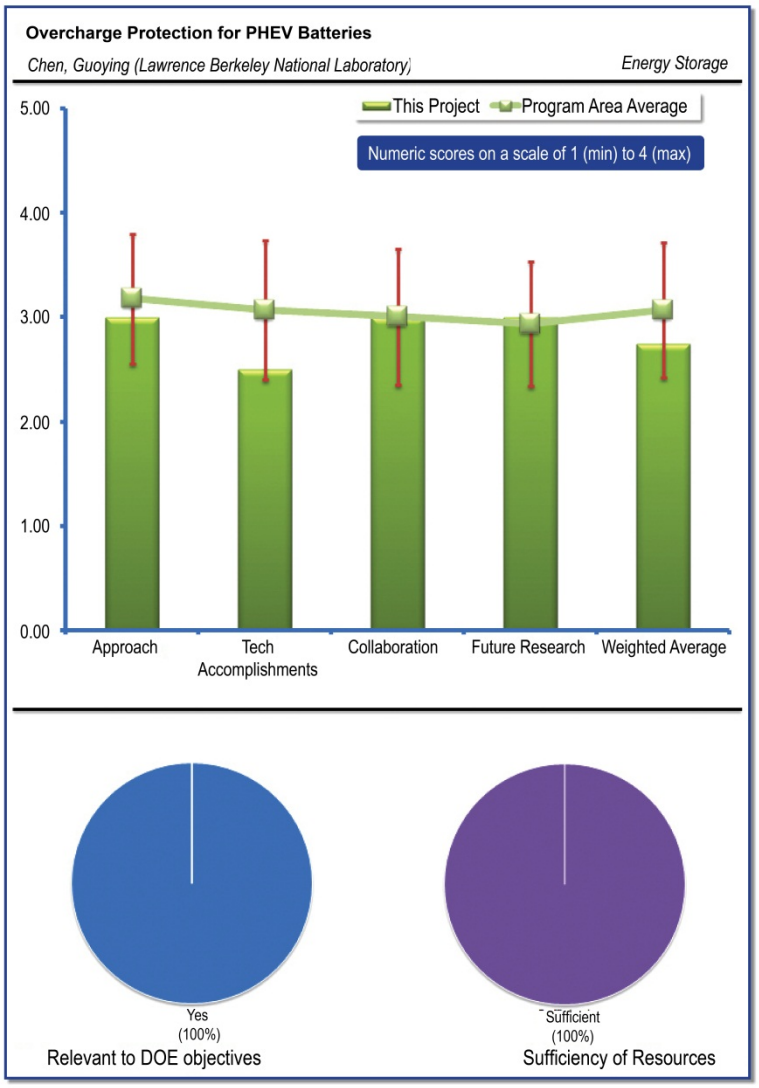
Overcharge Protection for PHEV Batteries: Chen, Guoying (Lawrence Berkeley National Laboratory) – es037

Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented PHEVs and EVs are attractive options to displace petroleum use in the U.S. This project focuses on developing over-charge protection for lithium-ion batteries so that the technology could be successfully applied to vehicle technologies. The other respondent acknowledged it is relevant fundamental research work for the SE program. However, this reviewer added, the importance of developing an internal overcharge protection for improving Li-ion safety is low because current electronic circuits can provide adequate overcharge protection for individual Li-ion batteries. In terms of cost reduction, the PIs need to compare the cost for the integrated circuit with the estimated cost for the internal overcharge protection system (material and production cost) for several assumed volumes to determine if the cost reduction assumption is valid.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The lone respondent indicated this project focuses on the development of electroactive polymers for internal self-actuating protection. It is a viable approach. It has the primary goal of increasing the cycle life and rate while lowering the cost.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted a high-voltage polymer has been found to provide improved stability at low voltages. This reviewer added that it could be applied to various battery chemistries. It has been found to carry large currents. The PI may want to increase the activities to accelerate the developments. The other respondent noted the technical barriers related to (1) the onset voltage, (2) the effect of the charging rate on the onset voltage, (3) the temperature on the onset voltage, and (4) cycle life, have been addressed to certain degrees in the project progress report. However, this reviewer would like the PIs to expand the tests to include (1) capacity retention on charged cells (i.e., capacity loss at room and elevated temperatures) and (2) overcharge protection capability for the best-bet system measured at different rates/temperatures and at different voltage cuts for the gen-2 cathode $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ or another cathode that will have excess capacity on overcharge.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first respondent commented that developing an internal overcharge protection system that will be able to be implemented requires a significant amount of resources and funds. This reviewer suggested the work be done just within the fundamental stage. Unless a material/separator system can resolve all the concerns related to cell performance and safety, the PI's should not attempt to do any scale-up work. This is because the likelihood of success on replacing the current external integrated circuit by an internal method for overcharge protection is really low. If there is anything, one may consider using both for the cases where the cathode has extra capacity available during overcharge. The other reviewer noted the collaborations are mostly with the scientists/engineers at Lawrence Berkeley National Lab, and added the PI could extend the collaboration outside LBNL to get a better perspective and enhance the productivity.

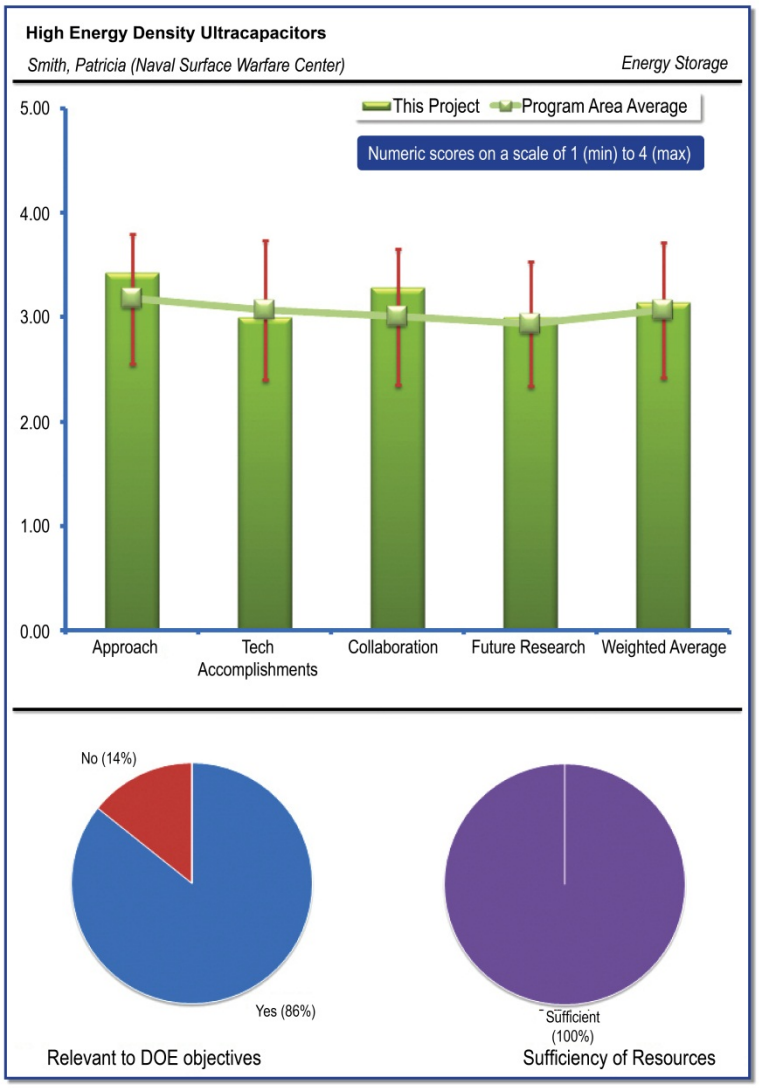
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer remarked the future work is exploratory with an aim to identify other polymers, characterize them, and explore in different cell configurations. This reviewer added it could be broadened in collaboration with others at universities. The other respondent made a number of comments. This reviewer said that in general, this is really fundamental research work. If there is any intention that the PIs plan to move the project into a next phase for scale-up, then the PIs need to develop specific goals for this project. For example, the onset voltage is x.xx volts with certain standard deviations on various discharge rates and temperatures for a given material developed and construction used. If not, just concentrate on the fundamental side of the project and identify any potential pitfalls of the best-bet systems and the means to overcome them. This reviewer added that, besides looking for new materials with the onset voltage higher than 4.4 (vs. Li), the PIs need to provide additional data on the best-bet system to address the following questions: (1) How precisely can the internal overcharge protection control the onset voltage and the capacity removed from the cathode for gen-2 cathode (or a cathode with excess capacity on overcharge) on different rates and at different temperatures when the best-bet internal overcharge protection system is used? (2) What is the capacity retention of a fully charged cell at room and elevated temperatures after one, three, and six months for the best-bet system? (3) What is the effect of the best-bet internal overcharge protection method on cell rate capability and long term cycle life?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said the resources were sufficient. One reviewer commented that the resources were sufficient for fundamental work, while the other reviewer stated the current funding level is adequate for the level of activities.

High Energy Density Ultracapacitors: Smith, Patricia (Naval Surface Warfare Center) – es038



Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer commented the project well integrates technical aspects useful for the achievement of DOE objectives. A second respondent stated ultracapacitors with high energy density could become a viable approach for vehicles, and thus the project is relevant with respect to the objective of displacing petroleum use in the U.S. Another reviewer noted the ultracapacitor may replace the batteries for power-assist automotive applications because they have the potential to be cheaper than the batteries. A fourth respondent indicated that, though capacitors are not generally viewed as a high potential long term solution to EVs, they have a genuine place in HEVs and in an electrically hybrid application with a battery. They can bring certain safety solutions as well as other safety risks. This is a good project for the goals of DOE. Another reviewer said ultracapacitors have the ability to absorb and release large amounts of energy almost instantly. For instance, this reviewer added, in regenerative braking, huge energy bursts are created and a battery has trouble handling the bursts while ultracapacitors by their nature have a very fast response time. One person commented that supercapacitors offer advantages over batteries for power assist HEV applications in terms of cycle life, safety, and low temperature performance. Modest improvements in specific energy might enable supercapacitors to meet HEV energy storage application requirements with a superior solution to batteries. In contrast, the final reviewer indicated that, with the recent advance of high rate lithium-ion batteries, the need for a hybrid system using regular Li-ion batteries combined with ultracapacitors to run HEVs and PHEVs is questionable. That being said, this reviewer added, for fundamental research, the project still has some value in terms of understanding the limits of the Li-ion capacity and discovering new systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section. The first reviewer remarked the approach is the correct one: identify the high capacity/capacitance electrode materials and the appropriate electrolyte composition then select the best combination for further qualification. This reviewer added the pouch cell construction is best for screening. The lithium negative gives a significantly higher voltage system than the usual carbon-carbon capacitor construction. Another respondent said this project is probably the only one looking at hybrid supercapacitors (or battery-like supercapacitors) by combining the best of Li technology with the best of electric double-layer capacitor (EDLC) technology. The project is well organized with good prospects of feasibility, because of the clear technical targets. A third reviewer commented the project is focused on developing high energy density electrodes and compatible electrolytes for lithium-ion ultracapacitors. This reviewer added that identifying electrode materials with high energy density is the

bottleneck for ultracapacitors, and this project focuses on it. Another person felt characterizing the newly developed capacitors for energy is a good start. However, it needs to be balanced with the conventional power available at all temperatures. This reviewer added there is a need for increasing energy density without reducing power density and cost. If we do not meet the power, cost, and energy goals, it will be difficult to compete with batteries. One final commenter said good focus on specific energy, but it was not clear where 15 Wh/kg came from as a goal. It was not quite clear to this reviewer why this particular asymmetric supercapacitor approach was chosen since comparison to other approaches is not discussed. Cost is key barrier to supercapacitors for this application and was not discussed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments tended to be positive in this section. One reviewer stated the best combination was identified and a more intense evaluation on the characteristics of carbon and positive electrode was carried out to qualify the selection of carbon positive electrode and electrolyte. This reviewer added that safety issues were addressed. A second reviewer said the results are very encouraging and well-focused towards the objectives, and added the investigation will have been better integrated with structural analysis to better understand material modifications. Another respondent noted good progress in demonstrating specific energy and characterizing performance including safety testing results. This respondent also observed an interesting, favorable result about improved charge retention over the symmetric supercapacitor. One final respondent noted carbon-based materials are pursued. However, this reviewer added, carbon-based capacitors have been widely investigated. It is not clear what the significance of the work is compared to what is already known. The PI may want to focus on other materials that promise to increase the energy density.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent stated the collaborations are appropriate and well-selected. A second reviewer said the collaborations involve other universities and companies. This reviewer added that the interaction with companies like Maxwell is very beneficial to the project. The final reviewer noted the group has collaboration with Cabot, the University of Massachusetts, and Ener2 for the next generation evaluations, as well as Hunter College for nuclear magnetic resonance (NMR) evaluation to identify lithium in the SEI layer.

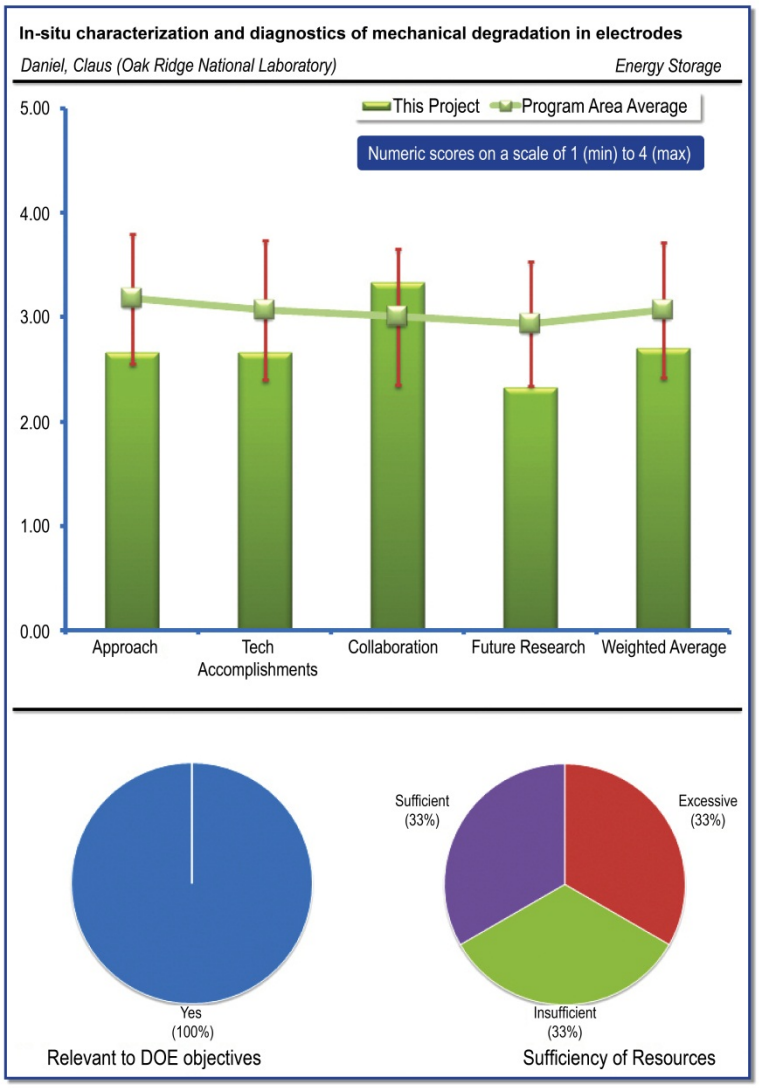
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers offered a number of suggestions in this section. The first commenter stated the plans for continued study have been clearly identified for new electrolyte system studies and performance evaluations. Another reviewer commented the planned activities are very well-connected to the previous work with clear steps. A third respondent was not sure about the need for further solvent investigation, but thinks cycle life measurements are critical for application. Another reviewer said future research should not compromise in the -30°C power capability of the conventional ultracapacitors and the cost should be half of the cost of the batteries per kW power. Another said future work is focused on a continuation of electrolyte investigation and their characterization with NMR, differential scanning calorimetry (DSC) analysis, and stability measurements. The PI may want to focus on other electrode materials systems since carbon capacitors are already being developed by industry. One person emphasized the need to talk to car manufacturers that have developed HEVs, PHEVs, and EVs to determine the voice of customers first for the actual need of the hybrid system and understand its technology pitfalls. This is because the premise of the project is established on the conceptual advantages of the hybrid system. One final reviewer questioned whether any car companies would plan to use the technology considering the additional cost associated with making the UCs and integrating them with the batteries, if the performance goals are achieved at the end of the project. Additionally, this reviewer offered a query regarding the energy efficiency of charging the UCs after they are depleted by the batteries.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All seven reviewers said the resources were sufficient. One reviewer commented they have adequate resources for the study, while another agreed the resources seem adequate. One final reviewer said the funding level is adequate for the efforts.

In-situ characterization and diagnostics of mechanical degradation in electrodes: Daniel, Claus (Oak Ridge National Laboratory) – es039



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were mixed in this section. One reviewer commented that the project is very relevant, and added that the study of mechanical/chemical degradation of the electrodes and the active materials should help prolong the battery life. Another person indicated the project should help shed some light on determining the mechanical cracking and phase-change induced stress on particle fracturing during cycling. The final reviewer is not sure about the relevance, nor could this reviewer see how this technique could shed light on the underlying mechanisms of mechanical failure.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were mixed in this section. One reviewer said the integration of acoustic emission with x-ray diffraction is accomplished well in this project. Another reviewer commented that it was a very novel technique, and added it would be interesting to try the in-situ X-ray measurement on industrial batteries. In contrast, a third reviewer stated the acoustic emission for detecting particle cracking has been used many years before; it is not a new method as suggested by one reviewer in 2010. A final reviewer did not see the results supporting the benefits of acoustic measurements.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted page 13 of the presentation shows a very important plot where anode and cathode are analyzed in-situ and at the same time. This reviewer acknowledged that it is difficult to establish collaboration with industry; however, the authors should try to analyze, using their technique, commercial batteries. It should be of great interest to understand the failure mechanism of commercial batteries using this technique. The second reviewer requested the results to help this reviewer better understand how mechanical failures occur, where or when it happens, how to prevent it, or shed light on the mechanisms of failure. One final reviewer indicated the acoustic emission (AE) method has been shown to be effective in identifying the key particle cracking steps for Si-based anode by the PI. However, this reviewer added, for the common cathodes and graphite anodes used in Li-ion cells, the particle cracking does not seem to be the key failure mechanisms for cycle life.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The lone respondent acknowledged how difficult the interaction with industrial partners is. IP issues and confidential information are important barriers; however, this reviewer added, the authors should try hard towards that goal.

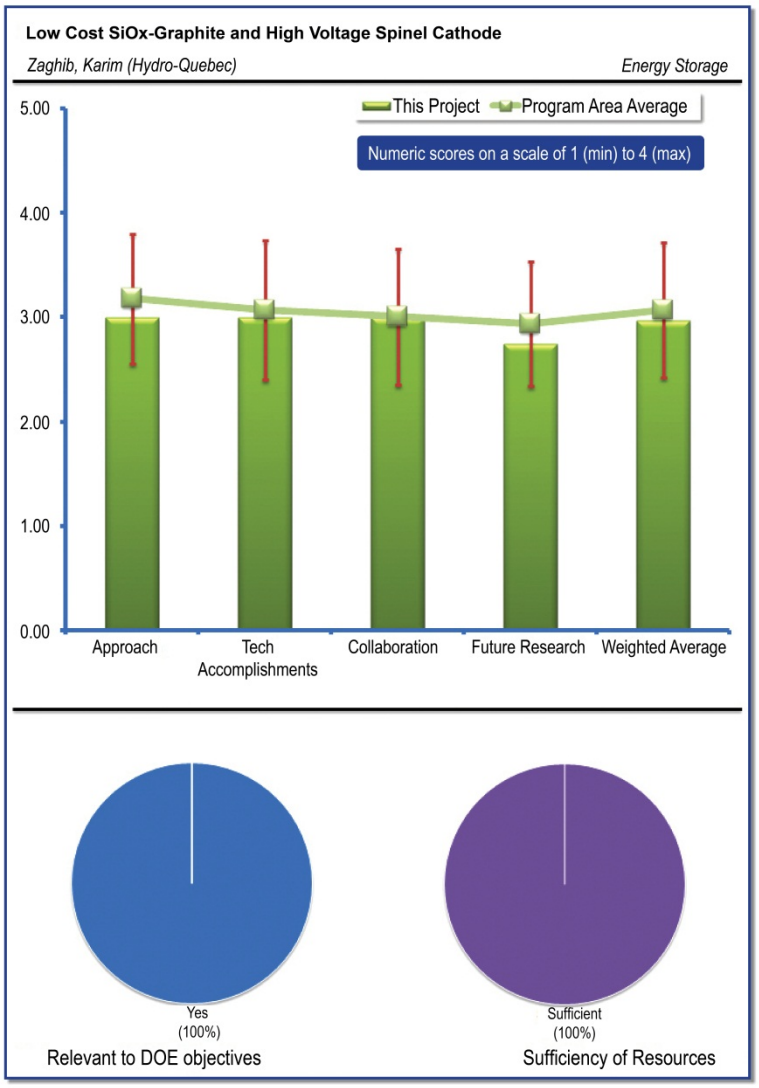
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers offered a number of suggestions in this section. One reviewer commented the authors should explore creative ways to bridge the gap with industry, particularly with the U.S. industry. A second respondent emphasized the need to include a model cathode that has almost zero strain on cycling and different particle size in the study for assisting data interpretation. Another person commented understand the relationship between particle cracking with other physical properties of the electrode beyond the particle size. One final reviewer commented that the future work sounds like doing more of the same. The reviewer further questioned what the expected findings and benefit would be from this technique.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said the resources were sufficient, one said the resources were insufficient, and one said they were excessive. One respondent said insufficient if the authors strongly pursue further interactions with U.S. companies.

Low Cost SiOx-Graphite and High Voltage Spinel Cathode: Zaghib, Karim (Hydro-Quebec) – es048



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer said improvements in cathode and anode materials will increase the extent of fleet electrification. Another person indicated those materials are considered for the next generation for Li ion batteries. A third reviewer noted that two aspects limiting Li-ion technology are clearly identified and functional in addressing DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were mixed in this section. The first respondent indicated the technical barriers are well analyzed and approached in a convincing manner with acceptable development on anode and cathode materials. This reviewer added the investigation on the defined material is complete and acceptable. Another reviewer commented the passivation approach of lithium nickel manganese oxide (LNMO) and silicon anode work is promising and being approached logically. A third reviewer noted it might be good to see how the feedback from the collaborators under the BATT program influences the material development and helps to focus on the objectives to improve poor cycle/calendar life. One final reviewer stated it is not clear how the PI could achieve the low-cost SiOx. These materials were studied for more than ten years.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. One reviewer felt the achievements are excellent with clear indications of the next steps and the technical limitations of the selected materials with good prospects for improvements. Another reviewer has not seen the SEI layer analysis that was addressed in the approach slide, and added the idea for carbon-coated silicon is very old and, also, the results are not new. A third reviewer made two separate comments: (1) Regarding Si anodes, the work shows results comparing different binders and the effect on 1st cycle efficiency and reversible capacity, but does not address cycling life and calendar life. In-situ studies of the Si anodes confirmed the literature data. (2) The coating of the high voltage spinel material results in not only better cyclability, but also in higher capacity. This reviewer asked what the amount was of the coating component. The final reviewer made a number of specific comments. Regarding the Silicon anode material, is it possible to benchmark compare their performance against 3M or Mitsui Mining? Regarding Slide 9, it seems predictable that a 13um material would crack. What is the particle size distribution (PSD) of the Si nanomaterial? The in-situ anode scanning electron microscope (SEM) movie was very impressive. This reviewer added, in general, polyimides are considered an expensive resin family. Has there been any comparison with what sort of cost impact there would be

versus the existing polyvinylidene fluoride (PVdF) or styrene butadiene rubber (SBR) /carboxymethyl cellulose (CMC) costs? Continued this reviewer, regarding the lithium iron phosphate (LFP)-coated LNMO, is the process based on mechanical milling? The SEM doesn't show a smooth coat. Regarding Slide 14, after about 4C (i.e., 8C or greater), the LFP doesn't seem to contribute any capacity based on the LFP voltage plateau region; the slopes of the coated and uncoated seem similar at these rates. Instead the 8C rate with LFP starts its discharge around 4.5, while the non-coated starts around 4.1 and yet still provides slightly greater capacity due to a shallower curve. LFP is not electrochemically active in this region, so is it the prevention of resistive film build-up on the cathode or some other mechanism? The AC impedence (ACI) results on Slide 15 suggest the same, but why is the LFP inactive at above the 8C rate? From the SEM, the particle sizes seem rather small; what is the extent of carbon coating on the LFP? What are the electrode/cell details of these rate tests (loadings, thickness, porosity, additives, etc.)? This reviewer added, regarding Slide 29, low temperature oxide (LTO)/LFP work was only mentioned in the technical back-up slides; is this being continued? Ozuku-sensei proposed this system years ago for sealed lead acid (SLA) replacements; is this being pursued by Hydro-Quebec? Regarding Slide 30, why was a different amount of adiponitrile (22%) used than the other two nitrile (50%) attempts?

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were mixed in this section. One commenter remarked the project is well integrated with BATT activities, with good support and collaborations in place with other project participants and external institutions. A second reviewer noted it will be beneficial to see the effect of the collaborative effort on the design of the future work. Another respondent noted the presentation mentioned collaborations with Vince and Venkat on silicon, and added it would benefit from a collaborators slide. One final reviewer commented that the PI did not use new materials and thus needs to collaborate more to investigate the material from different aspects.

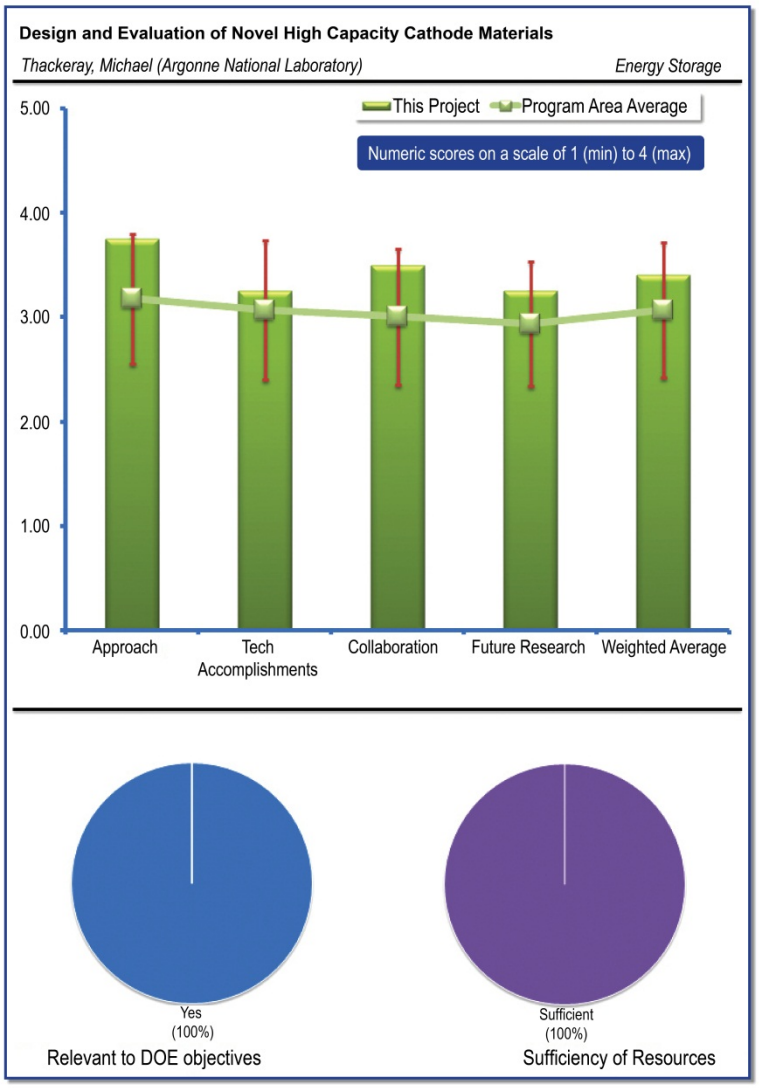
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments were mixed in this section. One reviewer stated the planned future steps are well justified by the achieved results and by the aim to solve the identified problems. A second reviewer indicated the proposed future work seems reasonable, and would encourage Hydro-Quebec to share more of its future collaboration plans. Another person noted the future activities are planned well. More focus should be on the understanding of the effect of the binder on the performance of the Si anodes vs. mere comparison. One final reviewer commented that the PI needs to review the approach and results. This reviewer does not see they are aligned.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers said the resources were sufficient. One reviewer commented that there was great progress on the 18650 facility development and utilization. A second reviewer stated it seems that there are sufficient resources. One final reviewer said the consistent budget is considered adequate to the work presented and the achieved results.

Design and Evaluation of Novel High Capacity Cathode Materials: Thackeray, Michael (Argonne National Laboratory) – es049



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer indicated the project is clearly in line with DOE objectives, while a second respondent noted that high-capacity cathode material is considered one of next generation materials. The final respondent commented that the two materials highlighted within this research show either appreciable specific capacity, increased operating voltage, or both. The focus extends to rate capability and durability. The reason for the selection of these materials is due to the relatively low cost of the metal oxide formulations selected. All of these aspects of the project are directly in line with the PHEV-40 battery goals which, in turn, is directly in line with the DOE objective for petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section. One person said the approach is defined well to solve the issues, while another commented the project is well addressing clearly identified barriers on the materials under investigation. This second reviewer added that the combination of experimental and theoretical is well combined. A third reviewer stated the approaches are systematic, adding that, while selection of some routes over others were not comprehensively covered, the selected approaches were well communicated and could be aligned with each technical barrier that needed to be addressed. This reviewer added that rate capability was addressed verbally, but this is one of the themes for the balance of the program. The final reviewer indicated there is a very clear understanding of the technical issues and a very methodical approach in addressing them. This reviewer noted the constant search for new ways of doing things.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated the results are excellent, with clear progress that is well related to the planned work and expectations. A second respondent noted good progress on a new family of the composite materials and new sonication technique to improve the stability of the surfaces of the electrodes. This reviewer asked if the effect of the impurities that could be brought with the coating reagents, such as SO_4, were considered on the calendar life of the electrode in the full cell. Another reviewer commented the barriers of specific capacity and high voltage appear to have been overcome. Durability/cyclability shows significant improvement, and shows promise that this can be addressed, at least to a minimal goal. This reviewer added that rate capability still needs to be addressed; processability and cost issues have been addressed, and show significant promise in meeting goals. One final reviewer commented that

there are more experimental data. However, this reviewer added that the presenter needs to provide more information about the test methods.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted excellent coordination between all collaborators. Another person commented some collaboration exists, while the final respondent said the collaborations are reasonable and adequate to the need of the project.

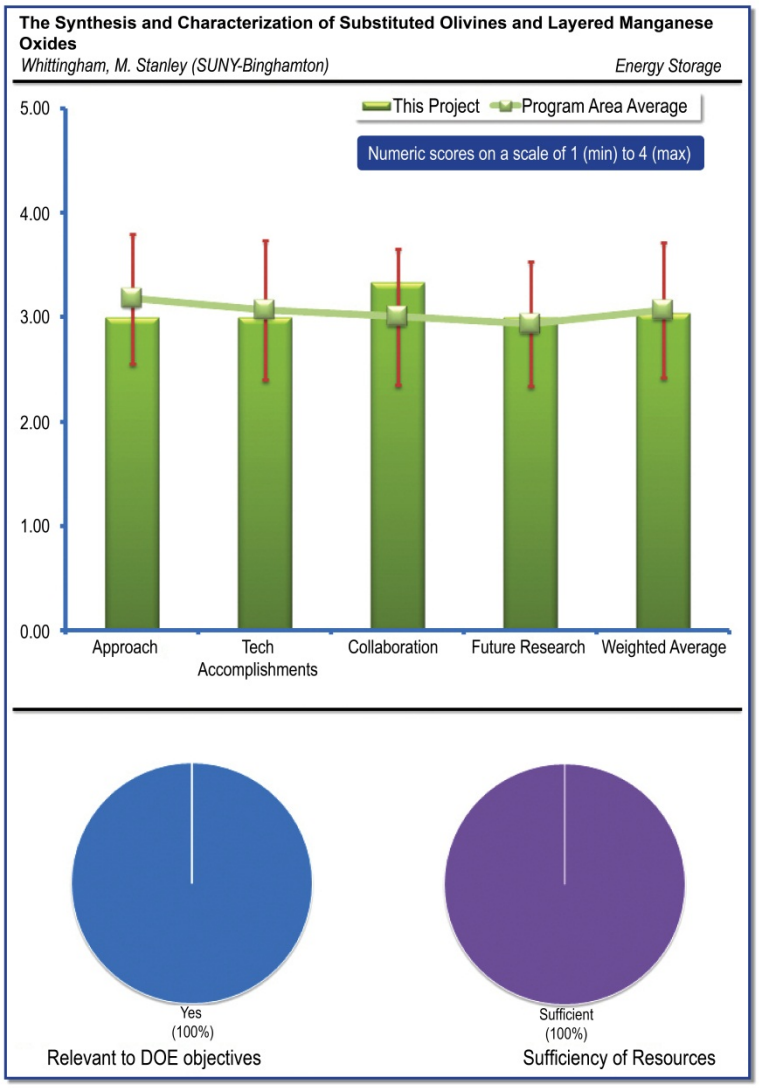
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments were generally positive in this section. The first respondent said the plan is well-defined and this reviewer looks forward to seeing the results for the surface design next year. Another reviewer indicated the proposed plan for the next-period activities is reasonable, with well-identified steps to solve the open issues. A third person acknowledged that the focus is on improving upon the work done to date and on developing fundamental tools. The final respondent highlighted the group's very clear understanding of the high capacity composite material challenges and clear path forward to address them.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four respondents said the resources were sufficient. Two reviewers indicated the resources seem to be sufficient, while a third commented the project has been very successful to date. This third reviewer added it appears likely that all barriers will be addressed, although some may require additional future work in order to be adequately overcome (specifically durability and rate).

The Synthesis and Characterization of Substituted Olivines and Layered Manganese Oxides: Whittingham, M. Stanley (SUNY-Binghamton) – es050



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One person indicated the relevance of this study is clear, while another stated cathode developments will enable further fleet electrification. The final respondent said the project well addresses key aspects of Li-ion cells for meeting DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were mixed in this section. One reviewer indicated there is a clear view and comprehension of the barriers with a very good approach to try to solve the identified problems; the main questions are efficiently answered proposing and verifying scientific and technological solutions. A second commenter felt that the structural characterization, including defects and morphology, is good but was not addressed in this study. The final reviewer made a number of comments. This reviewer noted the comment was made during the presentation that this project is targeting moderate PHEV rates of 1 to 3C. These rates are more appropriate for EVs, not PHEVs. The USABC targets for PHEV High P/E and High E/P designs target between 3 to 13C. The PI was requested to clarify which battery type is the target of this program. Regarding Slide 3, if the goal is 200 Ah/kg, some of the materials currently pursued seemed surprising. Stoichiometric NMC cycled at low voltage due to self-identified electrolyte limits and olvine and its derivatives seem unlikely to achieve this goal. Since higher voltage NMC cycling would be needed, it seems that this program would benefit from more electrolyte work. The iron pyrophosphate has a theoretical value of 220 mAh/g and is interesting work that should be continued; however, if the researchers do not feel they could access this capacity without higher voltage electrolytes, then they should work on this or collaborate with someone who does. Regarding Slide 13, researchers should not worry about targeting more than one lithium materials. This reviewer added that, although a system with multiple plateaus is more complicated to engineer around at the vehicle level, the potential benefit to energy far outweighs this concern, especially at the research stage.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. One reviewer commented that the results are outstanding, even the negative ones, because they allow us to better clarify the behavior and performance limitations of some of the materials. The modifications and innovations proposed have resulted in excellent progress with respect to the starting points. Another reviewer stated that Al substitution is not new,

so they expected different analysis from the previous work. One final reviewer made comments on individual slides. Regarding Slide 4, the statement that NMC 442 is the optimum stoichiometric $LiMO_2$ is a bold statement that could use some more qualifications. Depending on the application and use, other versions hold benefits. Regarding Slide 9, good comparison of materials power capability, but more detail on each (e.g., particle size, loading, carbon additives, tap densities, etc.) would help judge the true power capability. The same information should be shared for Slide 12 to help understand whether power increase comes from the material itself or the test conditions. Regarding Slides 13 to 15, they show interesting and promising work on pyrophosphates.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer indicated the collaborations are effective and well-motivated with good coordination and integration, while the second respondent can see good collaboration from industry as well. The final reviewer said there was good collaboration with other program members and engagement with commercial entities through work with Primet. This reviewer added that LBNL Kostecki mentioned some existing work on pyrophosphates, which is also one of the topics of this program; if appropriate, discussions between these two groups would seem helpful. Additionally, collaboration with a high-voltage electrolyte group seems highly useful in achieving this program's goal of 200 Ah/kg.

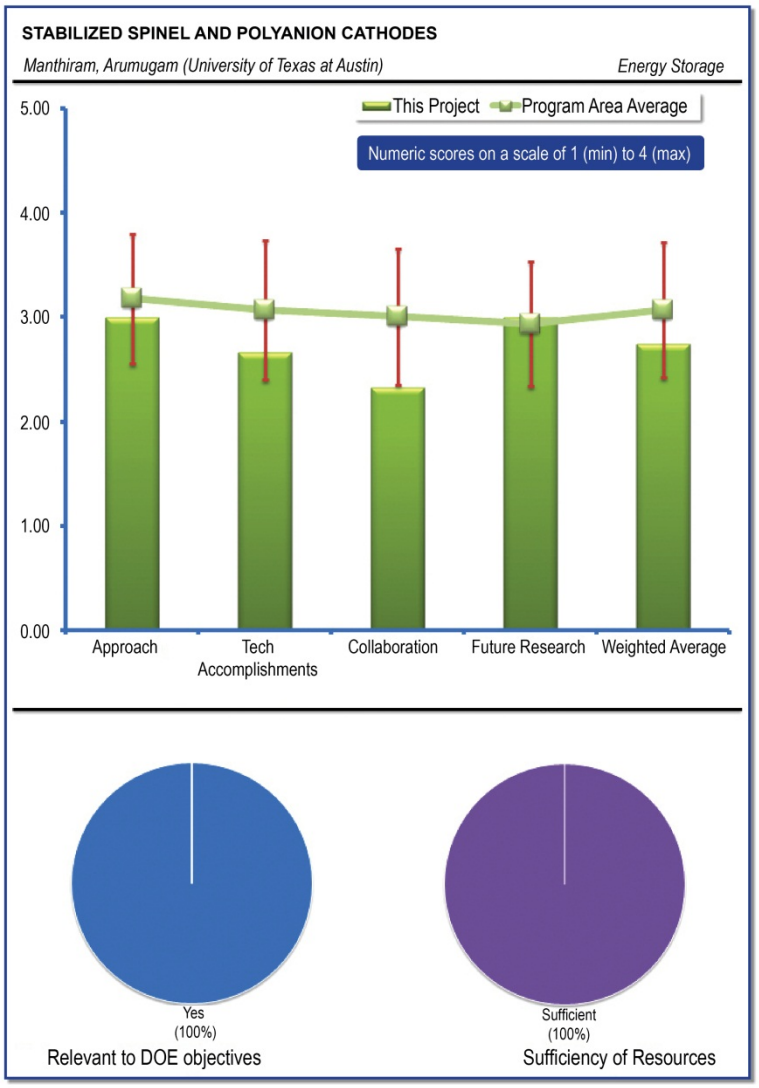
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer commented the remaining work is well-consistent with the already achieved results and are finalized to improve and finally reach the proposed objectives. Another reviewer noted the future work will look at non-lithiated cathodes, though no information was provided as to how lithiation will be addressed. Although many possibilities exist, this reviewer added, they all have issues and tradeoffs so it is important to understand the approach of this individual program. The final commenter remarked the proposed future research can focus more fundamental analysis for the materials.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers said the resources were sufficient. One person said the overall resources are considered adequate, while the other respondent in this section commented it seemed resources were sufficient.

STABILIZED SPINEL AND POLYANION CATHODES: Manthiram, Arumugam (University of Texas at Austin) – es051



REVIEWER SAMPLE SIZE

This project had a total of three reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

One reviewer commented the scientific and technological aspects investigated in the project are functional to the DOE objectives, while another noted cathode developments will enable further fleet electrification. One final reviewer indicated stabilized spinel is one of the big issues to use.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

The first respondent stated the project clearly identifies materials improvements of spinel cathodes by applying a variety of interesting solutions. This reviewer added the approach of combining structural and electrochemical characterization to analyze material changes is valuable and appropriate. A second reviewer noted a good balance of approaches to achieving improved cathodes. Another reviewer commented it is fine to use fluorinated cathode to stabilize as the PI tried for other materials.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One person felt the results are really interesting and well-supported and evaluated with good experimental evidence. This reviewer added the progress is good and can be further improved with more emphasis on stability: more focus on an acceptable number of cycles well above the values demonstrated. Another reviewer commented the fluorinated cathode was used previously by the PI, and this reviewer does not think this was used in the industry yet. This reviewer needs to know what the issue is that still remains. One final reviewer commented on a number of individual slides. Regarding Slide 7, Coulumbic efficiency was stated to be around 98%. Are the 2% of electrons going to electrolyte breakdown? If power/resistance is tested after cycling, is an impact of a growing SEI layer detected? Do the different substituted species perform differently? This reviewer added that, given the scale of the image, it is hard to tell any impact on coulombic efficiency (CE) from the different substitutions. Rate data without more information regarding the cell/electrode design (e.g., loadings, additives, thicknesses) and material properties (e.g., particle size, surface area, etc.) is difficult to judge. Regarding Slide 8, what is the particle size and penetration depth through the 10 seconds or so during which self-segregation is seen? Is the same seen with Ga and Cr? Regarding Slide 9, tap densities and the procedure to determine all of the morphologies should be shared to properly appreciate the microcubic's 2.0g/cc value. Regarding Slide 10, the commercial reference used to show the improved cycling of the microcubic is inappropriate. The researcher mentioned that the commercial example has a different valence distribution than his microcubic, which is why the cycling is poor. An apples-to-apples comparison reference should be shown in the

future to better show the impact of the microcubic morphology on cycling. Regarding Slide 13, the six formulations in the upper left corner have multiple data points for each. How was the range of non-stoichiometric non-oxygen/fluorine addition determined for each? The valence range tested for the Ti and Cr species seems smaller than that for the Fe or Al, for example.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented it seems that most of the work is done in their lab. Another respondent stated the collaboration framework is consistent with the needs of the project. One final reviewer noted a good amount of collaboration is summarized in Slide 18. However, this reviewer added, the electrolyte work with University of Rhode Island is never discussed in the presentation except in Slide 18. What work was carried out?

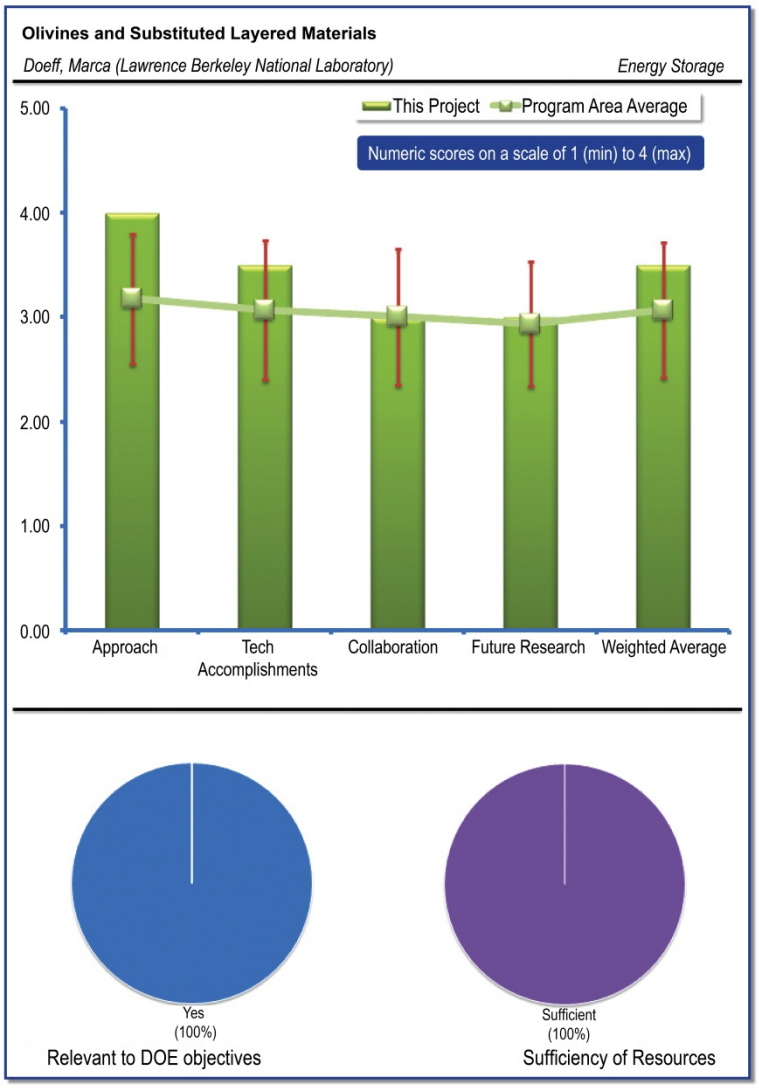
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person remarked the subsequent plan is reasonable even if after material selection and composition optimization more attention to the project objective is recommended with attention to higher capacity and longer cycle life (adequate stability work). Another person felt the future work is well-defined. The third reviewer commented the future work on silicates, vanadium, and high-voltage phosphates looks more likely to make progress towards the energy cost barriers and should be encouraged. This reviewer added that stabilization of the 4V spinel and an alternative for traditional $LiFePO_4$ are interesting, but the higher risk, higher reward work on the silicates, vandium, and high-voltage phosphates is more appealing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers said the resources were sufficient. One reviewer commented the project seems adequately supported, while the other respondent said there seemed to be sufficient resources.

Olivines and Substituted Layered Materials: Doeff, Marca (Lawrence Berkeley National Laboratory) – es052



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The lone respondent indicated the project addresses key aspects of Li-ion cells for better supporting DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented the structure of presentation is good, while the other indicated the project is very well organized and structured to give answers to the identified material problems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent stated the technical results show a significant progress with respect to the planned objectives, and added that the extension of structural investigation on a limited number of samples gives more proof about the feasibility of the preparation processes. The other reviewer commented that the performance of the original material is not good, so the group may need to review the synthesis method, but the analysis is detailed and good.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said some collaboration exists, while the other remarked the collaborations are all functional to the specific needs of the projects and are very complete with limited involvement from potential interested industries.

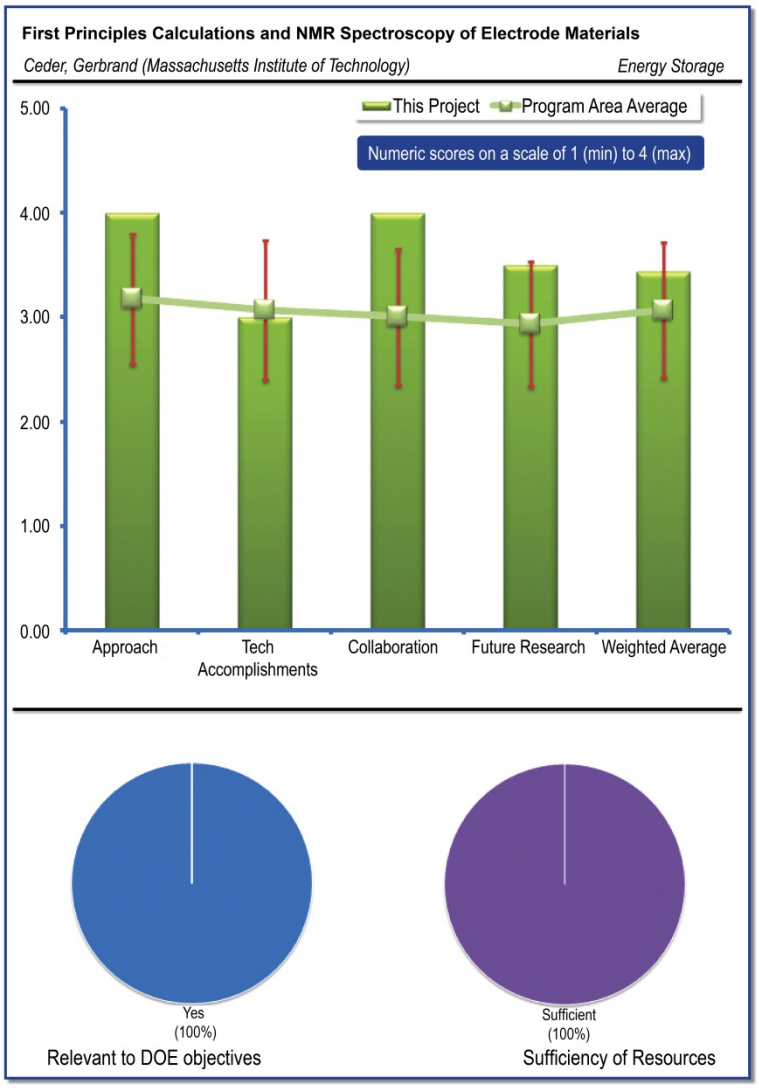
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer indicated the future work is well organized and prepared according to the results of the previous period, while the other stated the future plan is well-defined.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers said the resources were sufficient. One reviewer remarked they seem appropriate. The other respondent said it seems resources are sufficient.

First Principles Calculations and NMR Spectroscopy of Electrode Materials: Ceder, Gerbrand (Massachusetts Institute of Technology) – es054



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the project is well-aligned to support DOE objectives, while the other respondent said it is a good screening method for new cathode materials.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented the approach for work was well-defined, while the other person noted the technical barriers are well-addressed with consistent work that well integrates theoretical and experimental work with frontier research on novel materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent stated the results are highly promising, with outstanding progress opening the road to activities on new materials for the cathode and anode. The other person said it seems very effective to analyze using NMR, especially for alloy materials.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One person commented the experimental and simulation study was assigned well, while the other reviewer indicated there is a well-organized and efficient network of collaborations inside and outside the subprogram.

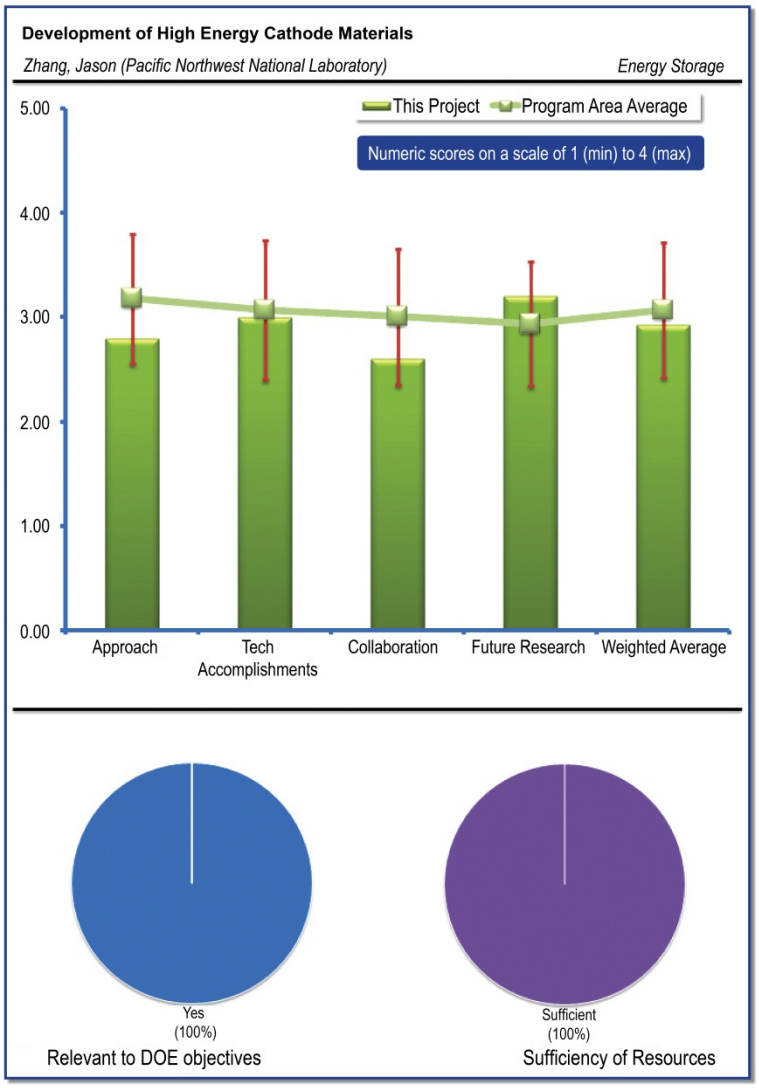
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person commented the future work is well organized, strongly based on previous results, and adequately integrated in the rest of the subprogram. The other respondent agreed, stating the future work is well-defined.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers said the resources were sufficient. One reviewer indicated there are no specific comments on the level of resources, while the other respondent commented that resources do not seem to be sufficient.

Development of High Energy Cathode Materials: Zhang, Jason (Pacific Northwest National Laboratory) – es056



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated the project adequately considers aspects related to DOE objectives, while another noted cathode developments will enable further fleet electrification. One final reviewer remarked high-energy cathode development is one of the critical barriers for the next generation of high-energy batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of suggestions in this section. This first commenter said the approach for the work is well-defined. Another person indicated the technical barriers are well identified and conveniently addressed with a project clearly focused on technological improvements of well-defined cathode materials. This reviewer added that the V-oxides are not new and, even if they are correctly analyzed, there should be more specific reference or diversification, in the approach description, with respect to the large research activity spent in the past on these intercalation compounds for Li metal cells. A third reviewer said good approach to look at higher energy materials such as $LiMnPO_4$ and $LiNi_{0.5}Mn_{1.5}O_4$. $LiMnPO_4$ thermal work is interesting, but improving the power/energy available is more important to the overall DOE goals. The $LiNi_{0.5}Mn_{1.5}O_4$ work should be more coordinated with other DOE work; the choice of one dopant (0.05 Cr) and one additive (0.25% LiBOB) seems more scattershot and less systematic than some other DOE work. The final reviewer commented the approach chosen for the preparation of the high voltage spinel material to make it easy to adopt by the industry is indeed practical. The PI might want to consider doping elements other than Cr; Cr is becoming more and more regulated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. The first respondent commented the achievements are interesting, with good progress on LNM cathodes and on nanostructuring V-cathodes. Another person noted the PI included a lot of data for the audience to understand, and added they want to see the issue more clearly, especially for the vanadium materials. A third reviewer commented good cycling performance is a must for the cathode to be used by the industry, and very good results are demonstrated. However, this reviewer added, high irreversible capacity on the first cycle, and thus reduced reversible capacity, cannot make this material high-energy material. The reviewer added that this material limitation is very serious in the full cell format. One final reviewer made a number of comments on individual slides. Regarding Slide 6, a loading level of 35mg/cm^2 is very heavy, especially for a power-challenged

material like $LiMnPO_4$. 22% KB is added to help get some capacity; could one trade down on the KB by reducing the loading level? Has any tradeoff of loading/KB/porosity been done to arrive at the current electrode? The 2009 goals were for 150mAh/g; that was dropped this year. Is 150mAh/g not achievable with $LiMnPO_4$? What sorts of anode and current collectors are used? If using copper, cycling to 2.0V vs. Lithium seems difficult. Regarding slides 13 and 14, comparing the two sets of cycling data, why does the charge/discharge capacity inverse? In Slide 13, $LNMO_4$, the charge capacity is lower than the discharge capacity. Is this a typo or is there decomposition occurring such that Coulombic efficiency is greater than 100%? In slides 14 to 16, what is the Coulombic efficiency over the long term? Does one see the LIBOB boost beyond the initial formation? Was the impact of other additives/levels considered or was this the only attempt? This reviewer added that 50% CE will be very difficult to use at lower temperatures. Regarding Slide 14, comparing the $LNMO_4$ and Cr-doped $LNMO_4$ is difficult without additional cell/electrode design information; are all parameters (loading, thickness, particle sizes, etc.) the same? Regarding Slide 17, what sort of carbon loadings/particle sizes are required to achieve the power depicted? Why is there so much emphasis on power at this early stage instead of energy improvement?

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated some collaboration exists, while another indicated the collaborations are considered sufficiently adequate even if more collaboration with other organizations working on the same subjects would be advisable. A third respondent acknowledged good collaborations with other groups; however, more integration into other $LiNi_{0.5}Mn_{1.5}O_4$ work seems useful, especially in the area of electrolytes. The final reviewer noted it might be beneficial to have a summary slide of the results provided by the partners and how it had influenced the PNNL research.

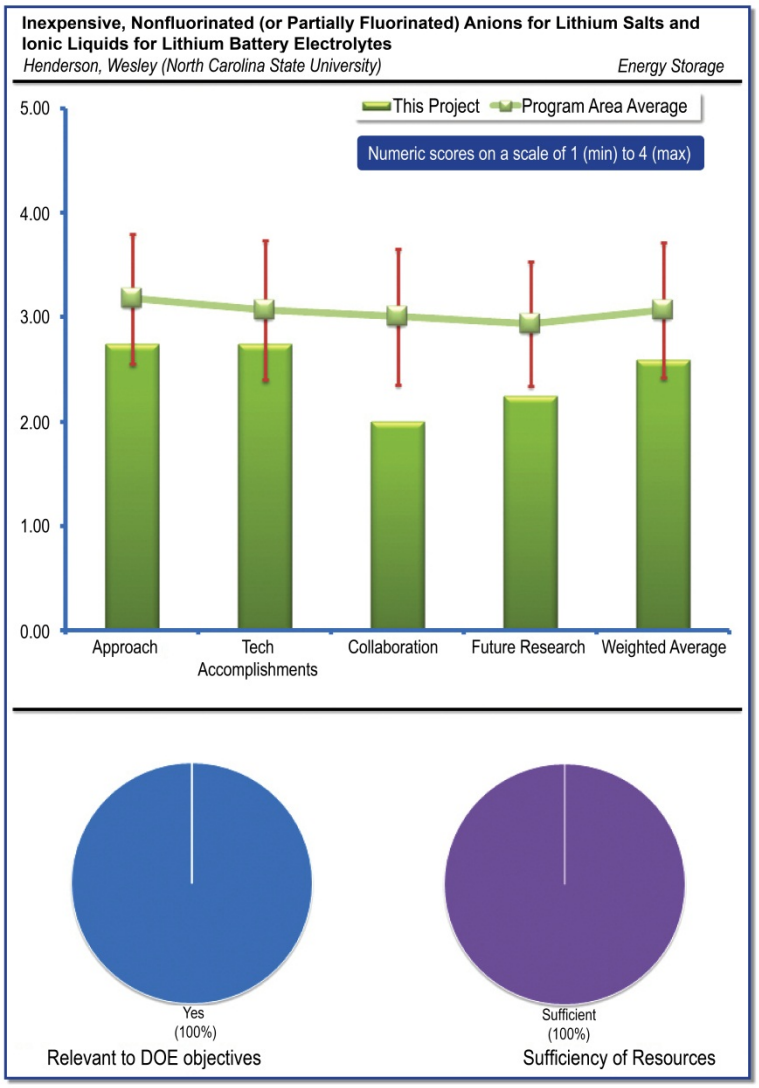
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt the future plan is reasonably correlated to the achieved results, adding that more work on the standard cell design based on the LBNL proposal is recommended. A second person commented that the future work on $LiNi_{0.5}Mn_{1.5}O_4$ seems reasonable, but added it was unclear what the future work on the vanadium compounds is. Another person noted a clear path forward to address the limitations of the high voltage spinel material and asked if there are any plans to continue work on vanadium cathodes. The final reviewer noted it seems there are no further research plans for the vanadium materials.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five respondents in this section said the resources were sufficient. One person stated the budget seemed adequate, while another agreed there seems to be sufficient resources.

Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes: Henderson, Wesley (North Carolina State University) – es057



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated the characterization and discovery of new electrolytes is important for getting DOE objectives, while another added that improvements in electrolytes will enable greater fleet electrification. The third reviewer commented that the electrolyte work should be done more in DOE projects.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of suggestions in this section. One commented that the project is well-organized and focused on technical barriers. The characterization of anions for Li battery electrolytes is an important means for selecting novel and optimized materials, even if it is not clear how the low-cost target is effectively addressed. A second reviewer commented on individual slides. Regarding Slide 3: it was unclear how the PI will address the last two objectives without any anode and cathode related work; collaboration with another group in this area is very strongly needed to leverage the work. Regarding Slide 5: the reviewer felt it was unclear how this approach will address the barriers of low temperature power. The materials considered that are borate-based are known to have lower Li+ dissociation than $LiPF_6$, so it is unclear how they have a chance of beating the incumbent. Another person suggested that a more narrow focus of work on a specifically targeted range of electrolyte constituents may be beneficial. One final respondent commented that it is fine to study the detailed structure of the old materials by Raman techniques, but the PI could try newer material as well.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked the characterization of the various electrolyte formulations is very complete and promising, with clear indication for the prosecution of the work. The progress is well in line with the projected objectives. Another person commented that the gassing is well-known issue for LiFOB and LiBOB, and added that the PI should extend the work to electrochemical study as well. The final reviewer made a number of comments, indicating the LiDFOB Phase Behavior seems reasonable on its own, but it is difficult to see how it will be applied. Central Glass and Army Research Laboratory (ARL) have previously synthesized this material and done some preliminary studies. It is difficult to see how the current work improves the likelihood that LiDFOB will be used. This reviewer noted that sulfones are used in the sulfur lithium literature, and asked if there has there been any attempt to examine that

usage for LiDFOB. Lastly, given how the high-voltage nitrile properties of material reported by the National Research Council (NRC) have been difficult for some to reproduce, this reviewer asked if the PI confirmed the voltage stability of his materials.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer commented the collaborations still remain at a very good level for the scientific aspects, but the required involvement of industry still remains unclear and open with no explanations yet. Another person indicated collaboration with a partner skilled in electrode/cell assembly is urgently needed. In Slide 35 the PI mentions a couple of partners he is considering; why not a national lab? This reviewer adds that other groups/companies have sent John Kerr electrolytes for his evaluation before, and asks if that has that been considered. The final reviewer stated the group can do more electrochemical study with some institutions.

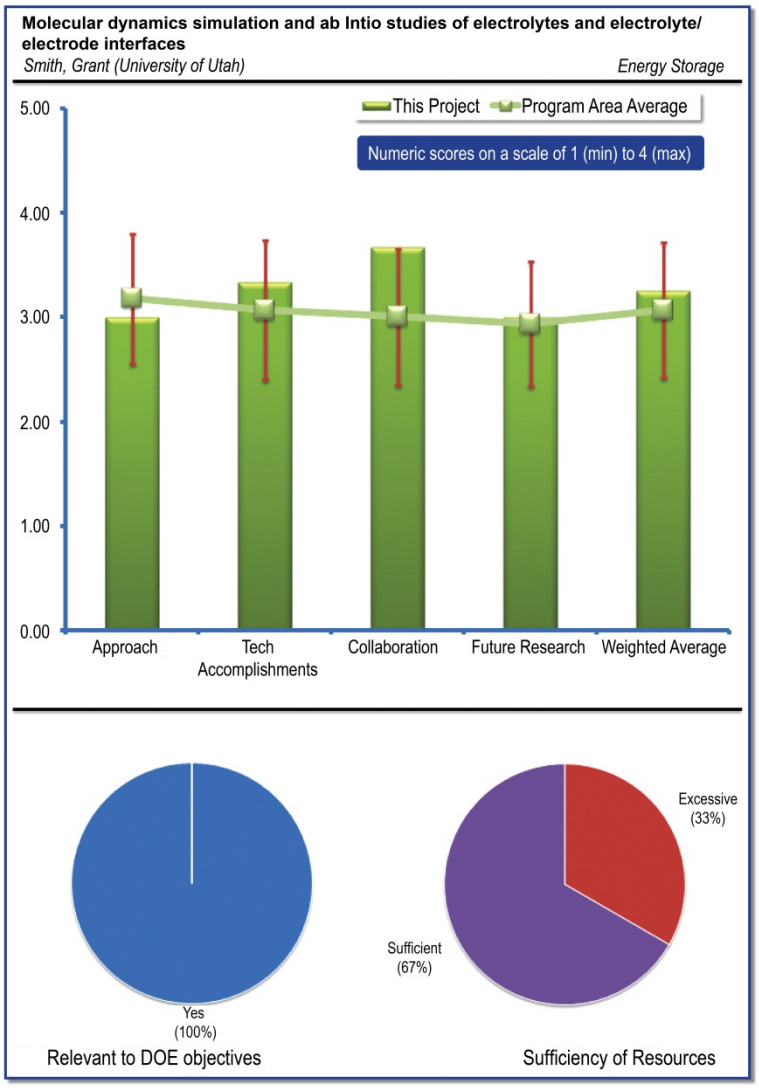
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewers offered a number of suggestions in this section. One reviewer commented the prosecution of activities is consistent with the previous results even if a better involvement of industry is not planned. Another reviewer felt a narrower focus may be beneficial. A third person suggested that high-voltage validation of electrolytes and some electrode/cell work should be added. The final respondent remarked that the PI should extend the work to electrochemical study as well.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four respondents said the resources were sufficient. One reviewer said there seems to be sufficient resources, while another had no specific comment.

Molecular dynamics simulation and ab intio studies of electrolytes and electrolyte/electrode interfaces: Smith, Grant (University of Utah) – es058



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One person stated the electrolyte and SEI characterizations are functional to meet DOE objectives. The other respondent commented that modeling would be a good method to understand the phenomena inside the cell.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated the approach based on simulations is complementary to the experimental one and is well-organized and feasible. This reviewer added the technical barriers are well addressed with simulations on two aspects: the electrolyte and the SEI. Another reviewer commented that the approach is good, but the apparent absence of any experimental confirmation activity to validate the modeling results, and/or the absence of an explanation regarding connection with any planned external model validation activity, seems to be a shortcoming. The final respondent indicated that, if the PI can find new materials based on the modeling results and extend the study, it would be good.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said it is quite significant progress for the last three months, while another said the results are interesting and show good progress with respect to the selected barriers.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted several collaborations exist with other institutions. The other commenting reviewer said that the PI has reached a central position as reference for simulation in the subprogram with a well-organized and integrated network of collaborations that are very effective in progressing in the specific field of electrolytes and SEI.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

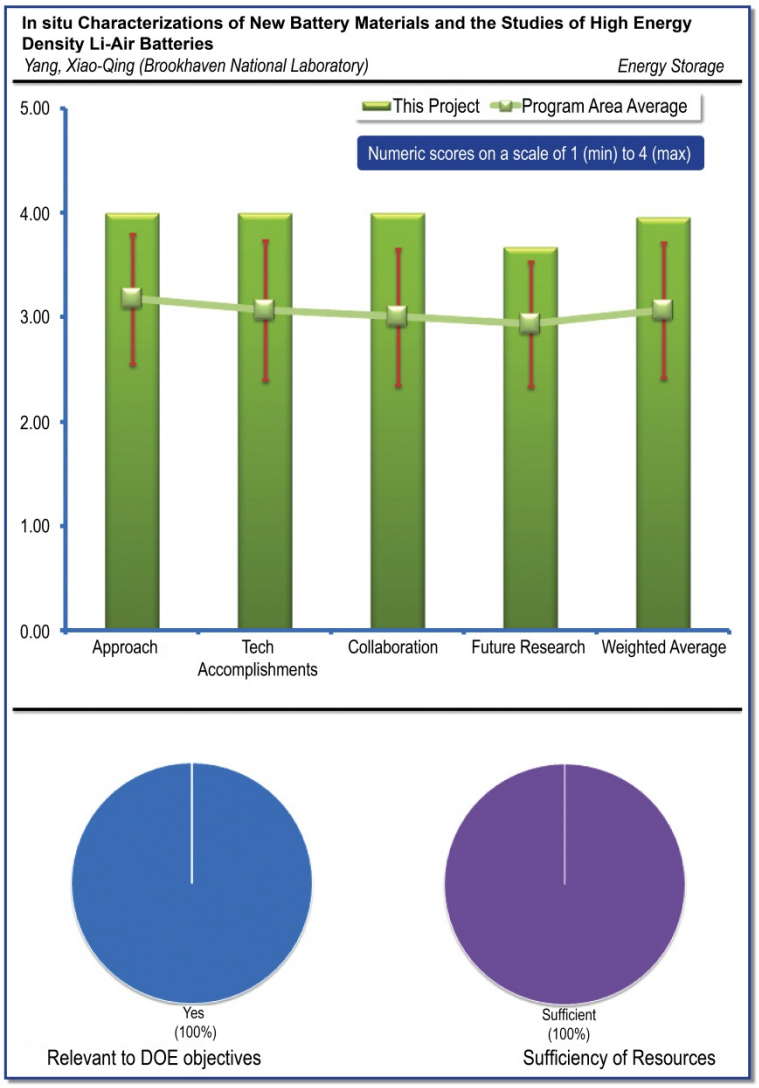
One reviewer indicated the planned work is well aligned with already achieved results and the requests from other institutions involved in the subprogram, adding that the main recommendation is to explicitly include model validation and conclusion in the

work. Another reviewer felt that work to validate the modeling results should be included, and/or reference to planned external validation work. The final respondent commented that, if the PI can do some electrochemical study to compare with the modeling, it would be good.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said the resources were sufficient, while one felt the resources are excessive. One reviewer said there seems to be sufficient resources, while another indicated no specific comment.

In situ Characterizations of New Battery Materials and the Studies of High Energy Density Li-Air Batteries: Yang, Xiao-Qing (Brookhaven National Laboratory) – es059



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent said the work done in this project is of general value and fundamental value in comparing and characterizing Li materials for DOE objectives. The other person commented that new material characterization is one of the proper roles of a national lab.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person commented that the approach for the work was well-defined and also focused on new systems such as Li-Air. The other respondent said the technical barriers identified are addressed in a complete manner with an innovative approach aimed at analyzing the behavior of components and materials during operations. This reviewer added the applied techniques and the focus on key aspects of various Li chemistries show a well-organized project with a very good vision of the investigation and problems to be solved.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that the data analysis is very detailed and understandable, while another felt that the development of new in-situ techniques (such as in-situ XRD during chemical delithiation) is excellent and should be furthered, and additional new alternate approaches should be explored. The final respondent indicated the progress is relevant, with important results on the possible chemical modifications of cathode materials to improve their usability in various Li cells. This reviewer added that some studies on aged cells would be beneficial in completing the analysis on the degradation mechanisms of positive electrode materials. The project is a powerful scientific and technological tool for assisting the entire BATT subprogram. The work on Li-air is giving interesting results.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted a well-structured and appropriate group of collaborations in and outside the BATT, with good coordination and rationale behind each individual collaboration. The other respondent commented that the group has a significant amount of collaboration with both other institutes and industry.

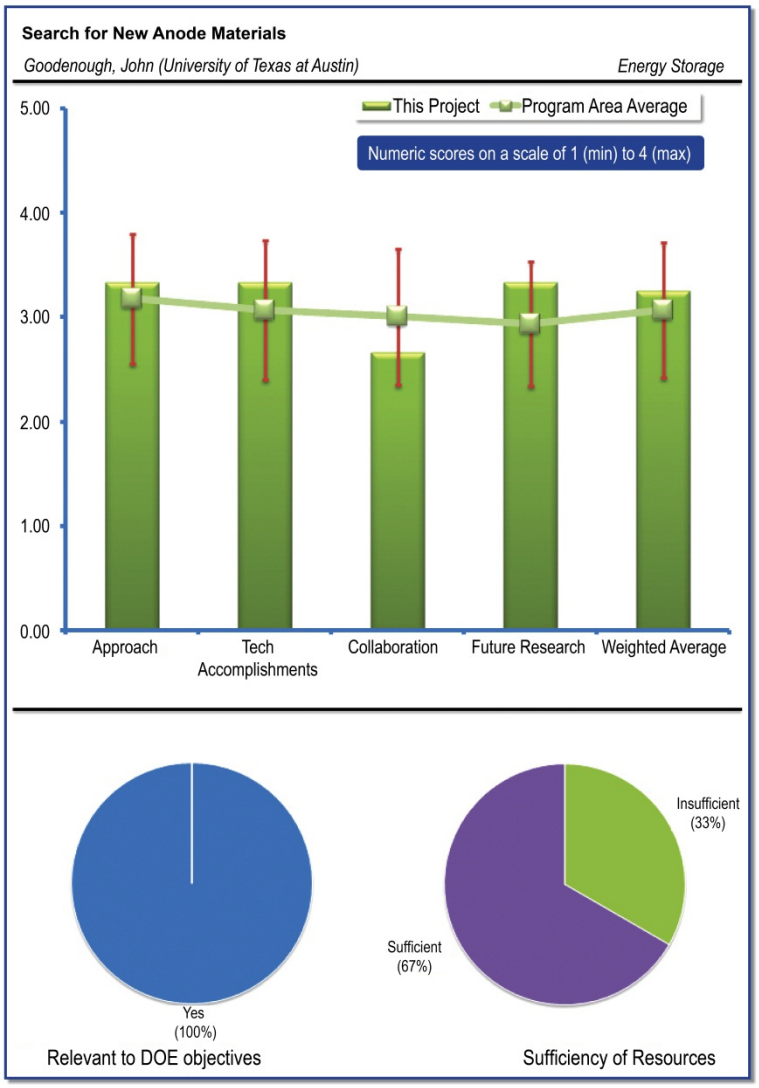
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first respondent commented that the future work is well-defined, while another said the work planned is consistent with the interesting results already achieved. This reviewer added that, due to the high level and quality of the expertise and equipment available, it is highly recommended that the group include a vis-à-vis comparison with other materials developed in other BATT projects to have a complete view of the potential need for further R&D on these materials. The final commenter said the proposed future work is generally excellent, but any focus on Li-Air (in the context of the potential for future automotive applications) should be very minimal (at most). In the place of Li-Air activity, additional focus and activity on Li-ion electrolytes would be of considerably greater value. This reviewer added the development of new in-situ techniques (such as in-situ XRD during chemical delithiation) should be furthered and additional new alternate in-situ approaches should be explored.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three respondents said the resources were sufficient. One reviewer said there seemed to be sufficient resources, while the other commented the extension of work to other materials and chemistries may require more efforts.

Search for New Anode Materials: Goodenough, John (University of Texas at Austin) – es060



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated the exploration of a new electrochemical storage system is functional in achieving DOE objectives, while the other respondent emphasized a need to look for new materials.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter said the project is well structured with the identification of clear technical barriers to be overcome. The basic concept and the cell design are developed and experimentally characterized. The other reviewer noted a good and reasonable explanation for choosing the materials for the flow battery.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated the results are promising and well in line with the planned objectives, while the other reviewer noted there are no electrochemical test conditions clearly indicated in the slides.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer remarked the collaborations are very limited and not even motivated; it is recommended the group analyze and propose contributions from other institutions. The other respondent also noted that there seems to be little collaboration, but added that the group may not need so much collaboration for this project.

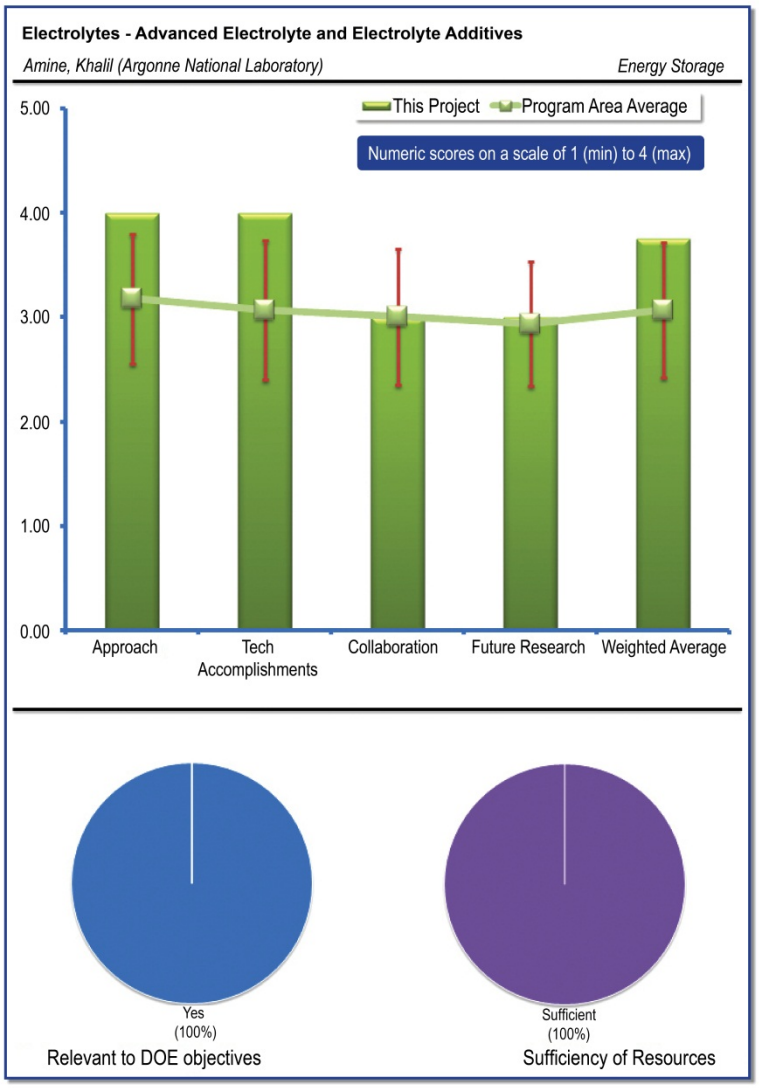
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person said the future work is reasonable, while the second respondent indicated the future work is well built on the achieved results.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers said the resources were sufficient, while one said they were insufficient. One person said the efforts are judged to be adequate, and another respondent said there seems to be sufficient resources.

Electrolytes - Advanced Electrolyte and Electrolyte Additives: Amine, Khalil (Argonne National Laboratory) – es066



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer said the work on electrolyte is useful for DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer commented that the project combines in an appropriate manner theoretical and experimental studies to select promising electrolyte materials and related additives able to meet the well-identified barriers of high stability during life and in severe conditions (abuse). The approach is reasonable starting from the survey of materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer indicated the achievements are very promising and complete, with an excellent integrated progress on the theoretical as well as the experimental part, with good indication in the selection of novel electrolytes and additives.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer said the network of collaborations is very good and appropriate even if a major involvement of other institutions of BATT, mostly focused in cell design, construction, and testing, may be useful experimental support in validating results.

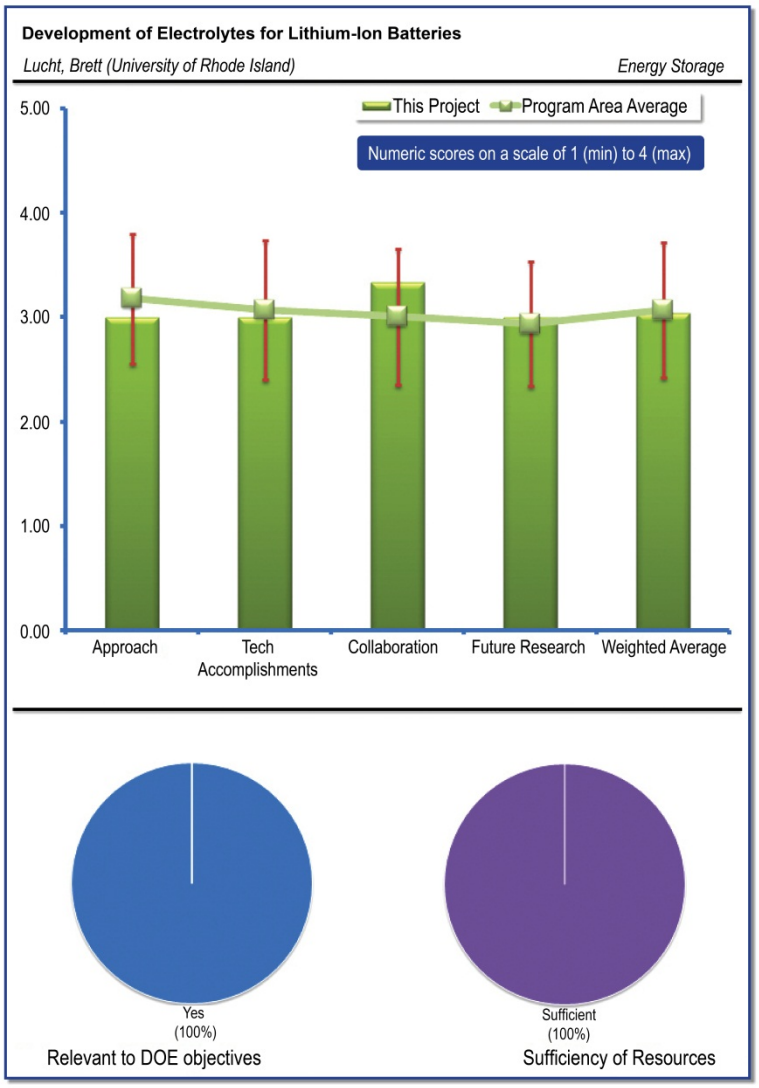
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The lone respondent said the proposed prosecution is consistent with the results already achieved. However, more collaboration with other institutions in BATT is recommended.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The lone reviewer said the resources were sufficient. The reviewer indicated the resources are considered adequate even in consideration of the possibility of having some feedback from other projects.

Development of Electrolytes for Lithium-ion Batteries: Lucht, Brett (University of Rhode Island) – es067



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted the electrolyte development is critical for reaching DOE objectives, while another stated improvements in electrolytes will enable greater fleet electrification. One final reviewer commented electrolyte work should be done more in DOE projects.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent felt the approach is reasonable and logical throughout, while another reviewer noted clear objectives are related to technical barriers. This reviewer added the project is well focused on improved electrolyte materials and additives able to be used in thin film formation. One final reviewer commented the PI just focuses on one material so he can extend the research more to other materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated the results are interesting and of general value, and added the progress is appreciable and well-positioned with respect to practical improvements of electrolyte behavior. A second respondent noted one of the famous issues for LiBOB is gas generation, and this reviewer wondered if this material could have the same issue. The final reviewer made a number of comments on individual slides. Regarding Slide 8, the PI mentioned that the current yield of 60% is significantly improved; what was the original yield? Regarding Slide 9, the PI should share details of several batches of various purity levels; otherwise it's hard to appreciate the scope of work done. The image on Slide 9 is hard to read just due to formatting. The increase of c-rate at the 4th cycle causes a dip in CE. Is the same seen in an identical setup (cell/electrode) of $LiPF_6$? Regarding slides 9 to 11, what are the solvents used? Regarding Slide 12, what is carboxymethyl starch (CMS) and is it supposed to be comparable to NG? Regarding Slide 14, what is the capacity of your LNMO electrode? The presenter mentioned C/20 charging, but what current does that translate to? A 5mV/s rate would take at max ~18 minutes to sweep from 0 to 5.3V, whereas a C/20 rate would take 20 hours to fully charge. These are rather different time rates, so it would be helpful to know the currents as well as to understand how comparable things are. Regarding Slide 15, the image on the right is hard to interpret with its peaks off-chart. How were the relative intensities evaluated? Was there any degradation in that peak intensity and/or other F peaks created outside of the 70 to -60ppm range? Regarding Slide 17, how were these additives determined? In opening, the approach states that computational methods will be used, but they are not mentioned anywhere else in the presentation.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said the network of collaborations is judged appropriate, with a claimed involvement of an industry partner for commercialization verification. The second reviewer noted a large degree of collaboration, which seems to be coordinated well. This reviewer added it is unclear what the role of S. China University Tech is since the computational activity was not discussed. One final reviewer commented that some collaboration exists.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers offered a number of suggestions in this section. The first respondent stated the proposed prosecution of work is consistent with the achievements and with the objectives of the project. It is recommended by this reviewer to complete the characterization of the developed materials including transfer number and other electrochemical measurements to fully characterize the materials with potential practical applications. A second respondent felt the future work seems reasonable, and added the silicon work should be emphasized to help benefit the other DOE groups working on this area. The final reviewer would like to see the mechanism for SEI and any gas formation.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers said the resources were sufficient. One reviewer said the resources are appropriate, while another commented there seems to be sufficient resources.

Bifunctional Electrolytes for Lithium-ion Batteries: Scherson, Daniel (Case Western Reserve University) – es068

REVIEWER SAMPLE SIZE

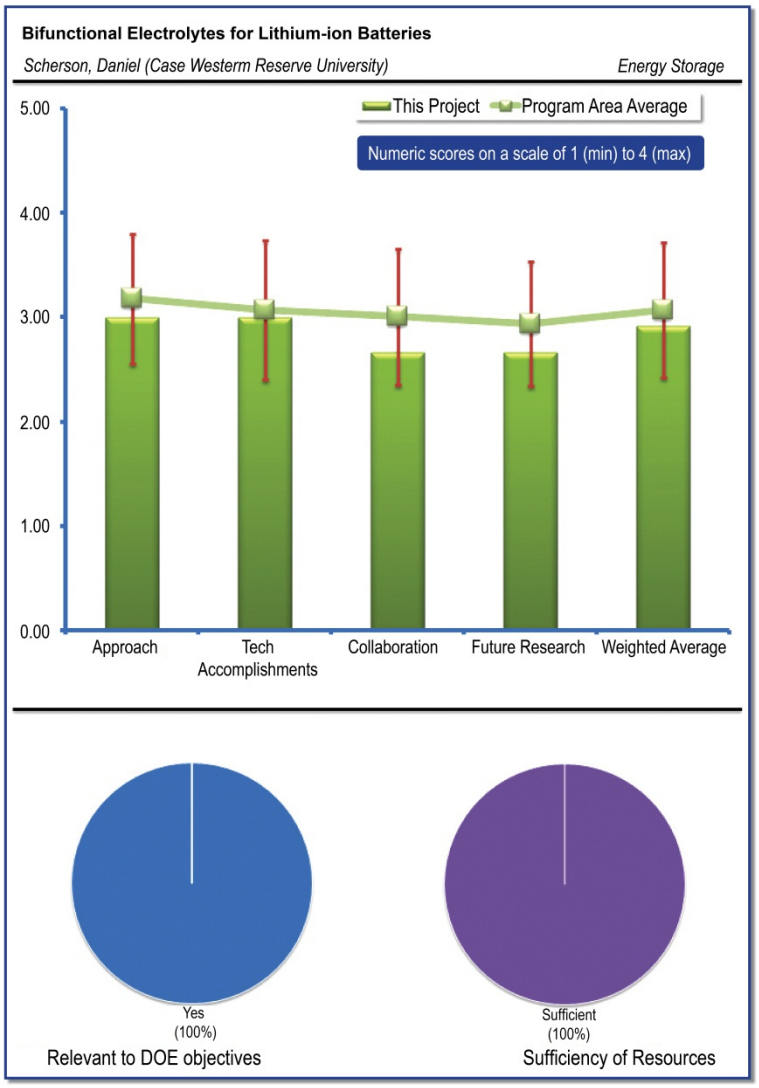
This project had a total of three reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

The first reviewer stated the development of improved electrolyte is an essential support to DOE objectives. Another commenter stated improvements in the electrolyte will enable greater fleet electrification. A third reviewer felt electrolyte work should be done more in DOE projects.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

Comments were generally positive in this section. One respondent said the project is well structured with an acceptable approach, while another commented the approach seems reasonable and logically thought out. One final reviewer stated the in-situ attenuated total reflectance - Fourier transform infrared spectroscopy (ATR-FTIR) seems to be an interesting method.



QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer noted the results are interesting with a good progress. A second reviewer felt there could be very high concentrations of oxygen in the cells at abnormal conditions; if the PI can show how the electrolyte reacts under different conditions, it would be good. The final reviewer commented on individual slides. Regarding Slide 7, the CASE salt is a modified LiBOB structure. How do the changes impact the delocalization of charge and the lithium dissociation capability of the new salt? Regarding Slide 8, does the CASE salt always form a dimer as depicted in here? Regarding Slide 11, why are only 2-3 cycles of the experimental shown, when the reference is run to at least 5? What happens on the first discharge of cell 3 of the experimental; the voltage curve seems rather erratic? Why is the voltage curve used if only taken to less than five cycles? This confounds the results further, unless the voltage curve is needed for some reason for the experimental? What is the CE of the experimental? Why was $LiCoO_2$ chosen as the cathode? No one intends to use $LiCoO_2$ moving forward, so a more BATT-relevant cathode seems appropriate. Regarding Slide 12, what is the advantage of using this method instead of the thermogravimetric analysis (TGA) method more common in the literature? Regarding Slide 13, is the middle row supposed to be the 2-MePh species? It is labeled with the generic Ar side groups. Regarding slides 4 and 16, the milestones list the completion of the in-situ ATR-FTIR cell on April 10, yet very little data was shared using this tool.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer noted some collaboration exists, while another person commented there are limited collaborations but they are well integrated. The final reviewer noted all of the collaborations are outside of the Vehicle Technologies (VT) program and based locally in Ohio. This reviewer added the researchers should consider if there are other partners that already exist in DOE and throughout the country that could assist their work.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One respondent indicated the future planning is consistent with previous work. Another reviewer said additional in-cell testing is recommended, while a third would like to see some results for the in-situ ATR-FTIR; it seems to be an interesting method.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers said the resources were sufficient. One reviewer stated the resources are adequate, while the other respondent in this section said there seems to be sufficient resources.

Studies on Oxide Cathode Crystals: Chen, Guoying (Lawrence Berkeley National Laboratory) – es069

Reviewer Sample Size

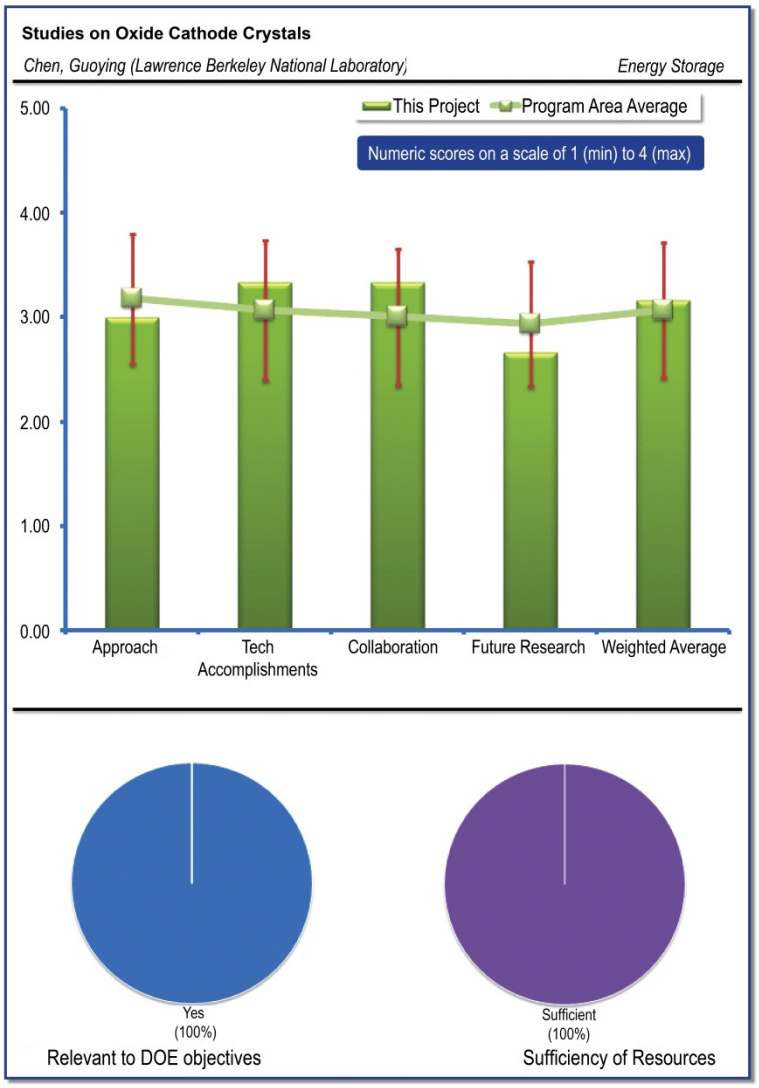
This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent said the project is functional to DOE objectives, while another stated improvements in cathodes will enable greater fleet electrification. The last respondent commented the relevance is fine but it can also be more specific.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person felt the approach for the objectives is well-defined. A second reviewer stated the selected technical barriers are reasonably approached with the material analysis even if limited to oxide cathodes. This reviewer added some improvements would be possible with more cell test work. The final reviewer commented the approach seems reasonable; however, the $LiMMnPO_4$ and thermal work alluded to in the milestones/objectives don't show up in the work presented.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated the results are valuable and well-directed towards the defined objectives with a clear identification of barriers. Another reviewer commented the analysis for the crystal was well done and the results were organized well. The final reviewer made a number of comments on individual slides. Regarding Slide 3, the last objective puts an emphasis on thermal stability for this project but no thermal data were shared. Regarding Slide 4, no work on $LiMMnPO_4$ was reported despite being an upcoming milestone. Regarding Slide 11, if this work is on single crystals, is that how the data on Slide 11 was created? What sort of experimental setup was created to test these materials for capacity and rate? Regarding Slide 12, this appears to be a comparison of one overlithiated sample (Seimi) versus two stoichiometric samples. To compare the size impact of the three, one should control for the other factors such as over-lithiation. The 1 um and 100nm crystals have LiOH and Li_2CO_3 labels in the SEM. Were the synthesis conditions the same for each and could that explain the capacity difference seen in the C/D data rather than size? What is the size domain of the Seimi samples? Regarding slides 10 and 16, SEM was used to look at high voltage LNMO and TEM was used to look at layered-layered morphology; were the converse studies done to examine morphology (i.e., SEM on layered-layered and TEM on high voltage LNMO crystals)? Regarding Slide 17, layered-layered work seems repetitive of Thackeray's previous work; one should clarify what is novel.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer stated the network of collaborations is outstanding and well integrated, while another said it seems to be appropriate collaboration with other institutions. The third reviewer indicated, regarding Slide 26, a large amount of collaborators were listed, and the work done by the authors should be clarified because most of the technical data reported appear to be of a type that was outsourced.

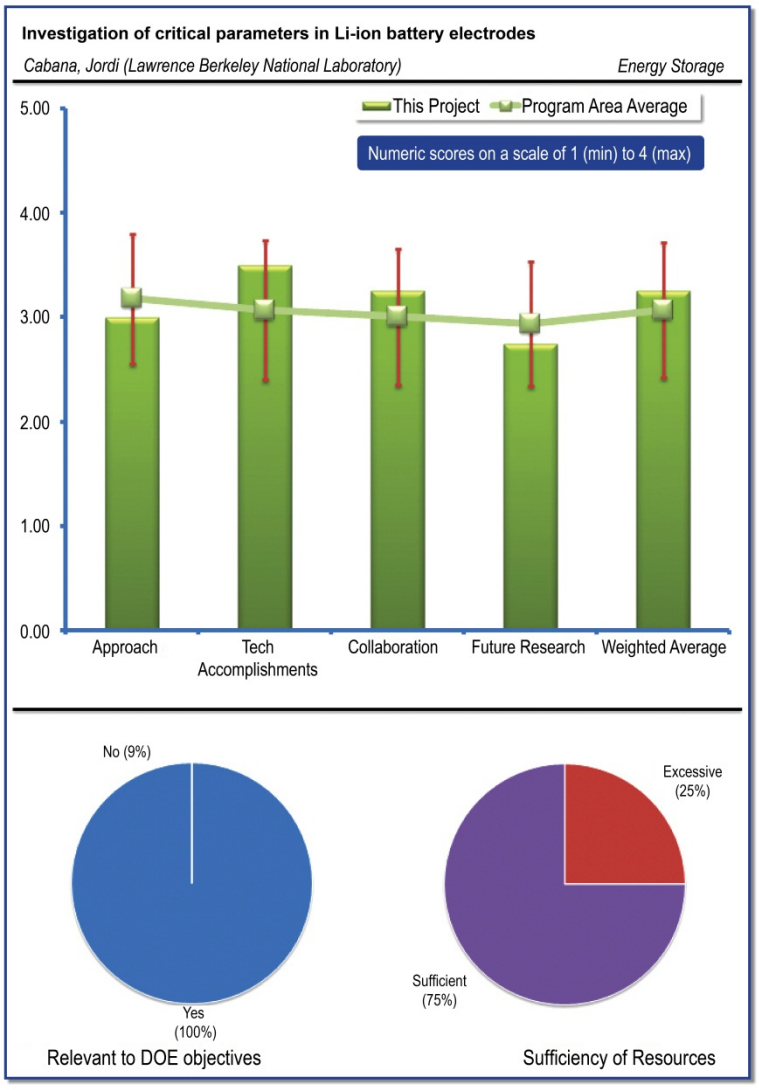
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer felt the future work is well-defined. A second respondent commented the plans for the future are adequately connected to the achieved results. One final reviewer noted larger integration and context to the work of the Ni/Mn spinel working group would be helpful.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers said sufficient. One person stated the resources seem appropriate, while another commented there seems to be sufficient resources.

Investigation of critical parameters in Li-ion battery electrodes: Cabana, Jordi (Lawrence Berkeley National Laboratory) – es070



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer said the project clearly addresses scientific and technological aspects functional to the achievement of DOE objectives. Another reviewer commented that improved cathodes and anodes will increase fleet electrification. One final reviewer felt that the relevance is fine, but the presentation title did not express the contents well.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of suggestions in this section. One reviewer said the approach is fine, adding that the title indicated the critical electrode parameter and yet this study focused on the materials. Another reviewer said the project has a focused approach on analyzing the behavior of defined classes of cathode materials with advanced techniques. The main improvement that may be suggested is to systematically analyze other cathode materials to try to give substantial inputs to improve cathode behavior. A third reviewer said better integration with other participants in the Ni/Mn spinel work is recommended, and added that little overall context/impact of this work to other activity is communicated. The final commenter stated that the first cycle inefficiency is common for all Ni-containing cathodes and, for the layered structures, is known to be reduced with the incorporation of cobalt. This reviewer added that NCA-type materials have been used in commercial applications and have demonstrated excellent cycling performance in the full cells. It might be helpful to take a broader view to assess the reasons for the irreversible capacity losses on the first cycle in the Ni-containing materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Remarks in this section are generally positive. One reviewer said the results are of relevant value with positive impact on material optimization, while another said very good progress towards the objectives, and selection of the techniques is commendable. A third person said the synthesized material was analyzed very well. One respondent posed a number of questions. Regarding Slide 5: how was the CE goal of 99.99% chosen? This efficiency will lead to 80% capacity after 2,231 cycles – what target does that meet? How was the ultimate goal rate set to C/2? Regarding Slide 12: what is the capacity performance of the material as a half cell, and what is the CE of the full cell? This reviewer also asked, more generally, what electrolyte was used and what was the voltage range swept for all of the group's work? Further, regarding Slide 17: how is the theoretical capacity of $LiCoO_2$ reported as less than 200 mAh/g? What

is the particle size/morphology of the NiO? One final reviewer asked, regarding Slide 15: is Li completely removed upon charge? If not, how does the investigator think it might affect the Coulombic efficiency?

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said there are appropriate collaborations and good coordination among them, while another commented that collaboration with other institutions seems appropriate. A third reviewer said it is good to state how the collaboration impacts the progress and helps with the design of experimental work. One final reviewer noted a lot of collaboration, but commented that the integration into other high voltage Ni/Mn spinel work is not made as clear as it could be.

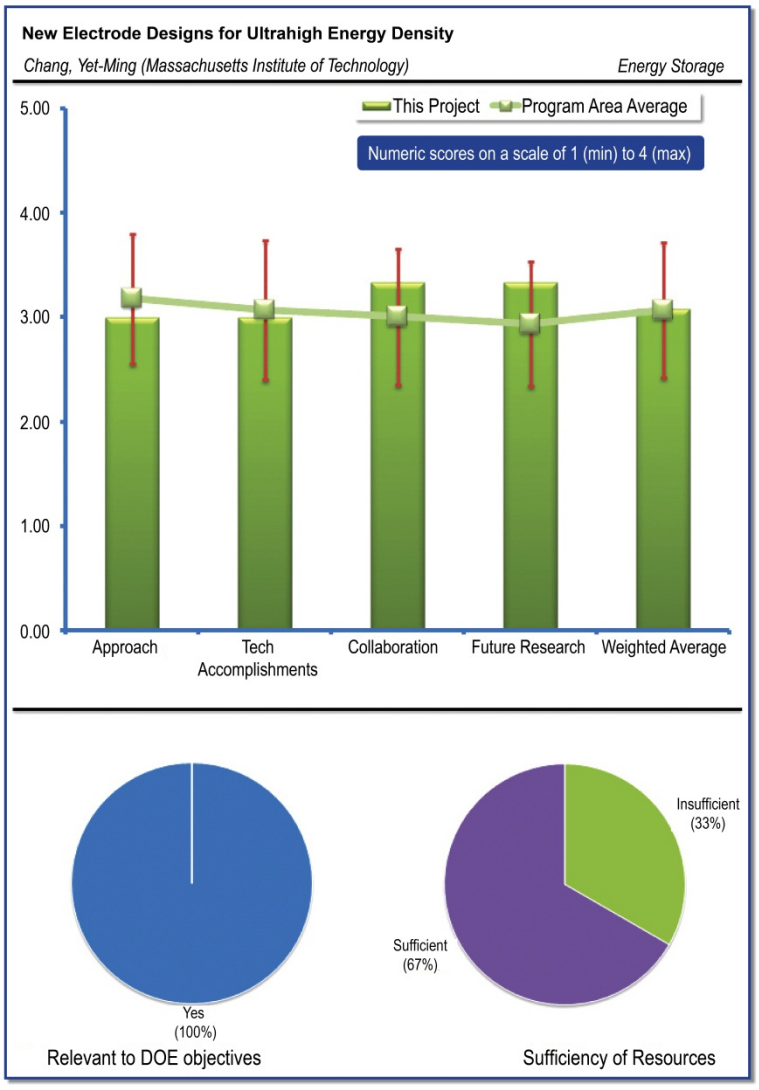
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Comments were generally positive in this section. One reviewer said the future work was well-defined, while another commented that the plan for future work is consistent with the achieved results. One person noted future work should clarify the connection to overall Ni/Mn spinel work. The final respondent indicated that the future work plan demonstrates an understanding of the material challenges and offers a good path forward. This reviewer added that it might be useful to look at the first cycle inefficiencies for the layered No-containing systems as well as the choice of the precursors. It is known, for example, that using lithium hydroxide for manufacturing of the Ni-based systems results in good-performing cathode materials.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Comments were mixed in this section. One reviewer said it seems to have sufficient resources, while another indicated there are no specific comments. The final respondent felt that the integration and contribution to other programs is unclear, particularly for a program that received twice the funding of many other programs in FY11.

New Electrode Designs for Ultrahigh Energy Density: Chiang, Yet-Ming (Massachusetts Institute of Technology) – es071



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the project looks at novel designs for improving Li batteries and better meeting DOE objectives. Another commented that electrode design is important for performance improvement and cost reduction of the battery. One final reviewer stated that electrode design is important but was not sure if this is suitable for university work.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer remarked that the project's objective of applying a novel cell design with an innovative preparation approach is very interesting, with a gradual approach starting from a conventional cathode material to arrive at a more innovative and applicable cathode material (such as Mn-based). Another person said very interesting approach, but added that the investigator might want to consider things other than water solvents to make sure Li/M stoichiometry is not affected during the procedure used to produce electrodes, which might result in a reduction of the delivered capacity. This reviewer added cathodes other than $LiCoO_2$ could be even more moisture sensitive. The final reviewer felt the pore design would be very important for thicker electrodes, but wondered if this non-uniform electrode can cause other issues.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally positive in this section. The first commenter stated the results are promising even in consideration of the large number of samples and the need to optimize the novel preparation approach. Another commented that there were excellent initial results for electrodes fabricated without any additives; very good understanding of the parameters controlling the electrode properties. This reviewer added good correlation of the results to the targeted applications. The final respondent would like to see how the non-uniform electrode affects the performance, and asked the investigator to please compare the result of energy density by volume also.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said the collaborations are adequate to the needs of the project, with good integration and coordination. The other respondent noted there are some collaborations.

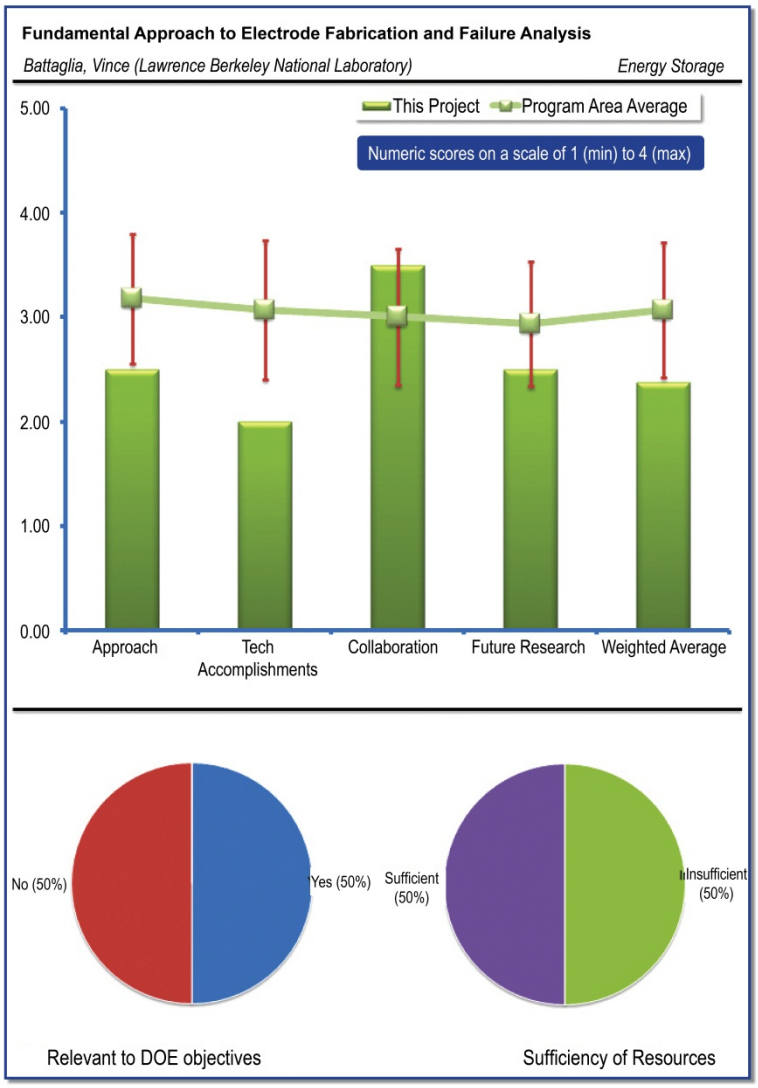
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said the future work is well-defined. The other respondent commented that the planned work for the next period is considered consistent with the results already achieved, and recommends accelerating the extension to other materials (not only one).

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said the resources were sufficient, while one said they were insufficient. One commenter said it seems more resources need to be added, and another reviewer asserted that the resources seem appropriate.

Fundamental Approach to Electrode Fabrication and Failure Analysis: Battaglia, Vince (Lawrence Berkeley National Laboratory) – es081



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the project is good towards DOE objectives. The other commenter said, as one reviewer mentioned last year, it is not national lab work.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated the project has clearly identified key barriers and created a feasible and well organized project with significant contributions to reach the proposed objectives. The other reviewer commented it is not clear if the PI wants to focus on the process or materials to improve the electrode. This reviewer does not see the fundamental approach as the title described.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person commented that the results are of high quality, with an additional must that is the creation of a common electrode preparation procedure: a way to standardize and make comparable the activities in other groups in BATT. However, the results on capacity fade and related material changes are valuable. The other respondent expressed a need for more fundamental electrode analysis.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated there is some collaboration with other institutions, while the other respondent commented there is an appropriate network of collaborations that may act as the skeleton of the overall exploratory research work in BATT.

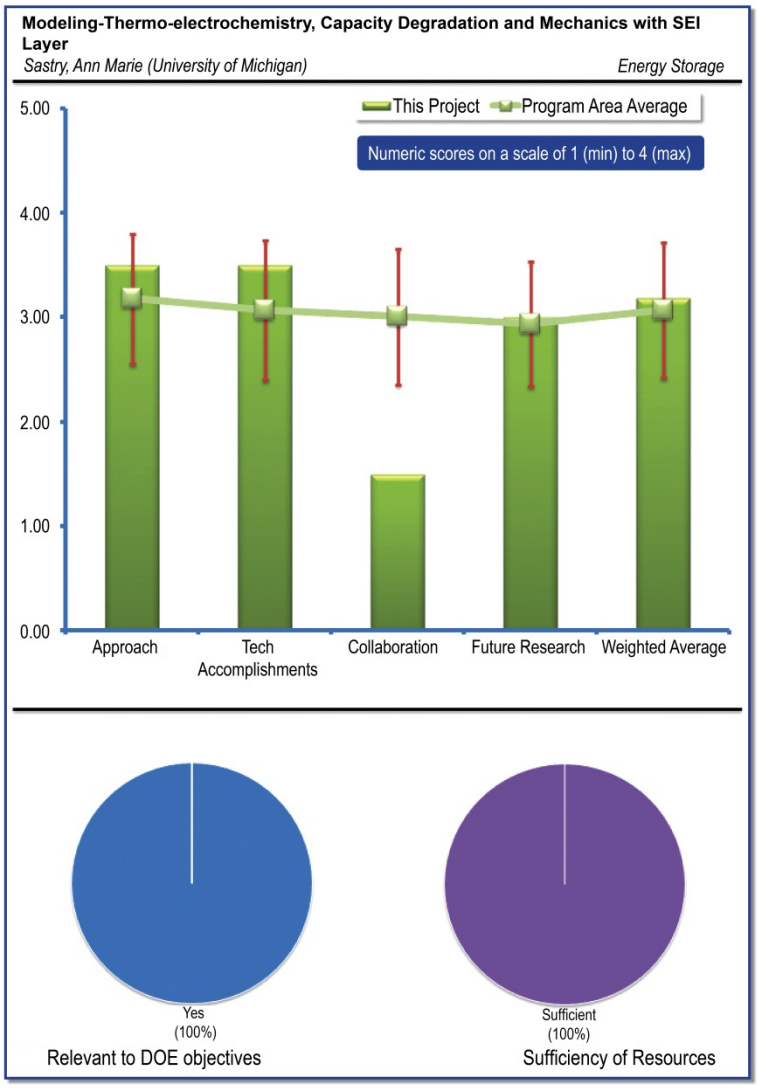
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person indicated that the planned future work is consistent with the already achieved results but apparently does not cover all the real needs of BATT in which a variety of other materials are developed and analyzed; a more structured coordination role of this project should be better planned and proposed. The other reviewer stated it is not clear why the PI focused on $LiNi_{0.5}Mn_{1.5}O_4$. This reviewer added that the PI could use more conventional materials to focus on the electrode failure mechanism.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said the resources were sufficient, while the other said they were insufficient. One reviewer stated that there seems to be insufficient resources. The second commenter felt that the resources are judged to be adequate even in the case of an increased role in harmonizing material selection in BATT.

Modeling-Thermo-electrochemistry, Capacity Degradation and Mechanics with SEI Layer: Sastry, Ann Marie (University of Michigan) – es082



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent said the project is addressing aspects functional to DOE objectives, while the other commented the modeling is one of the good methods to analyze the failure mechanism.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said the project is perfectly structured and organized with a clear focus on key technical aspects. The other respondent would like to see if the dissolution is actually the critical issue for the degradation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter said the results are relevant with an excellent progress towards the objectives. The other person noted SEI formation modeling is challenging, and would like to see the results.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer did not see so much collaboration, while the other commented that the lack of collaboration is not a positive aspect with limited involvement of other related projects.

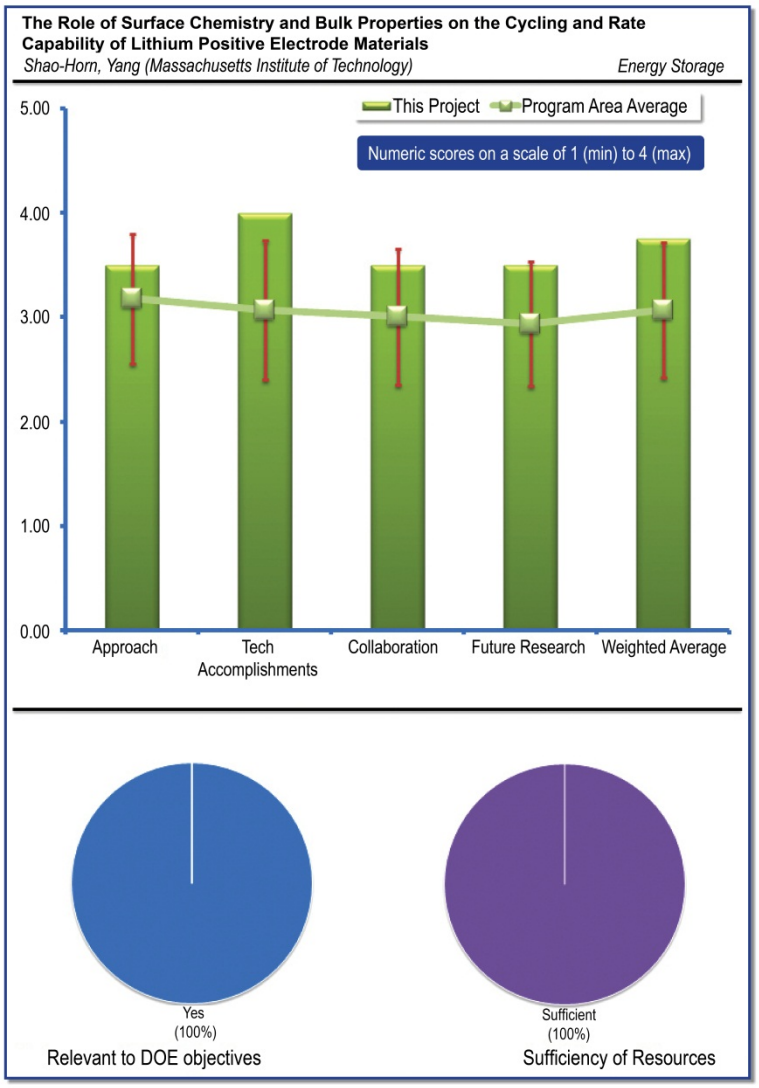
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person said the future work is well-defined. The other reviewer agreed, commenting the prosecution of the work is properly organized and based on previous results.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers said the resources were sufficient. One reviewer said the resources are appropriate, and the other said the project seemed to have sufficient resources.

The Role of Surface Chemistry and Bulk Properties on the Cycling and Rate Capability of Lithium Positive Electrode Materials: Shao-Horn, Yang (Massachusetts Institute of Technology) – es084



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the surface chemistry is very important and difficult to analyze, while the other reviewer commented there is evident feedback to DOE objectives even considering the basic research approach.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter said this kind of approach is common and reasonable. The other noted the project has a unique, systematic and feasible approach addressing surface analysis with cell behavior; in addition, the potentialities of Li-air cells are also clearly addressed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person commented that the results are very promising and excellent. This reviewer suggested the group increase the connection to practical behavior with extended life testing, and added that the activities on Li-air must be further developed. The other reviewer said it is an interesting finding about the cathode SEI. This person added that, if the group can support it with something other than XPS, it would be better.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said the collaborations are appropriate, while the other felt that some collaboration exists. This second reviewer believes it is enough based on the achievement.

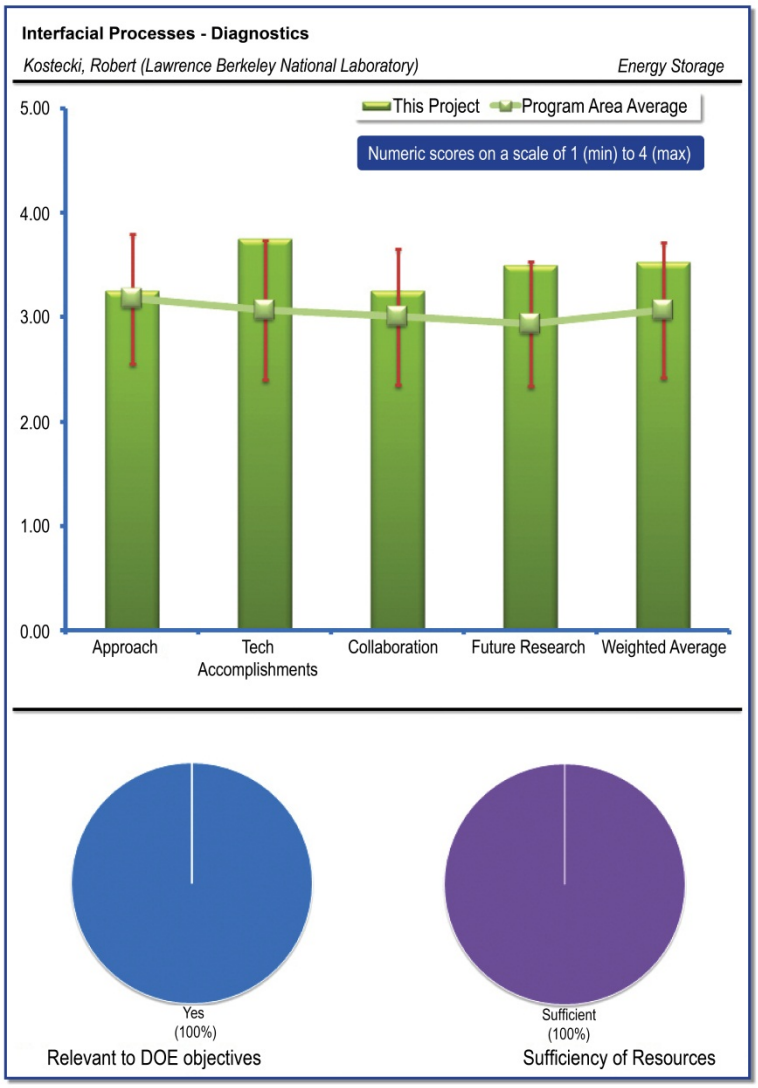
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person commented the future work is planned well, while the other respondent said the future work description is poorly described but seems reasonable.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both respondents said the resources were sufficient. One reviewer said the resources are adequate, while the other noted that there seems to be sufficient resources.

Interfacial Processes - Diagnostics: Kostecki, Robert (Lawrence Berkeley National Laboratory) – es085



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback was positive in this section. The first reviewer indicated that surface characterization is a fundamental tool in improving Li cell performances, and then get DOE objectives. A second reviewer remarked that interfacial behavior is critical to improve Li ion batteries further. Finally, a third reviewer noted that improved diagnostic and analysis techniques will help improve lithium ion battery materials, which will increase fleet electrification over the long term.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section. One reviewer commented that the project is well organized and integrated within BATT activities with the scope to support with a common surface characterization platform the development of novel materials. The next reviewer acknowledged good use of diagnostic and analysis techniques. A third reviewer noted that there are several good in-situ techniques used. The fourth reviewer remarked that while the approach is excellent, absence of any activity within this project related to carbon-based anode materials is unfortunate.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback was generally positive in this section. The first commenter stated that progress has been excellent and well described with experimental results. Additionally, the quality and excellence of the investigation techniques are a powerful tool for the fundamental and applied research. The second commenter remarked that $LiNi_{0.5}Ni_{1.5}O_4$ diagnostic results and conclusions are of great value and have excellent focus. A third commenter indicated that there are good in-situ and ex-situ data and that they were analyzed well. The fourth commenter offered comments and questions specific to presentation slides. This commenter specified that on Slide 6, the spectra band-assignments showed up well in the slides presented, but appeared differently in the slides shared with reviewers. The same commenter questioned whether a change was made to Slide 6 in this regard, and offered another query about whether the non-stable layer on the cathode is also seen with other cathodes with this voltage/electrolyte combination. Further, this commenter inquired whether there is something about the $LiMnPO_4$ that increases this decomposition, and if the same result would be seen if fluorinated solvents that were more stable were used. This fourth commenter also provided feedback on Slide 9, inquiring whether the electrolyte was studied after aging with something like inductively-coupled plasma (ICP). Further, this commenter noted that it would be

interesting to know if the Ni or Mn was solubilized into the electrolyte, and that it would be interesting to see the suspected surface enrichment if the particles could be sputtered to study the concentration as a function of depth. Finally, and in reference to the bottom of Slide 18, this same commenter offered that it would have been helpful to show the results of testing other electrolyte systems besides ethylene carbonate (EC)/ diethyl carbonate (DEC).

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The comments received in this section were generally positive. The first reviewer offered that there is a good amount of collaboration with other institutions, while the second reviewer stated that the collaborations are adequate. The third reviewer acknowledged Slide 2, stated that high power lithium (HPL) was acquired by DOW, and questioned how this has affected the relationship/collaboration over time. This same reviewer also referenced Slide 20 and stated that future collaboration with 3M's alloy systems should be particularly encouraged.

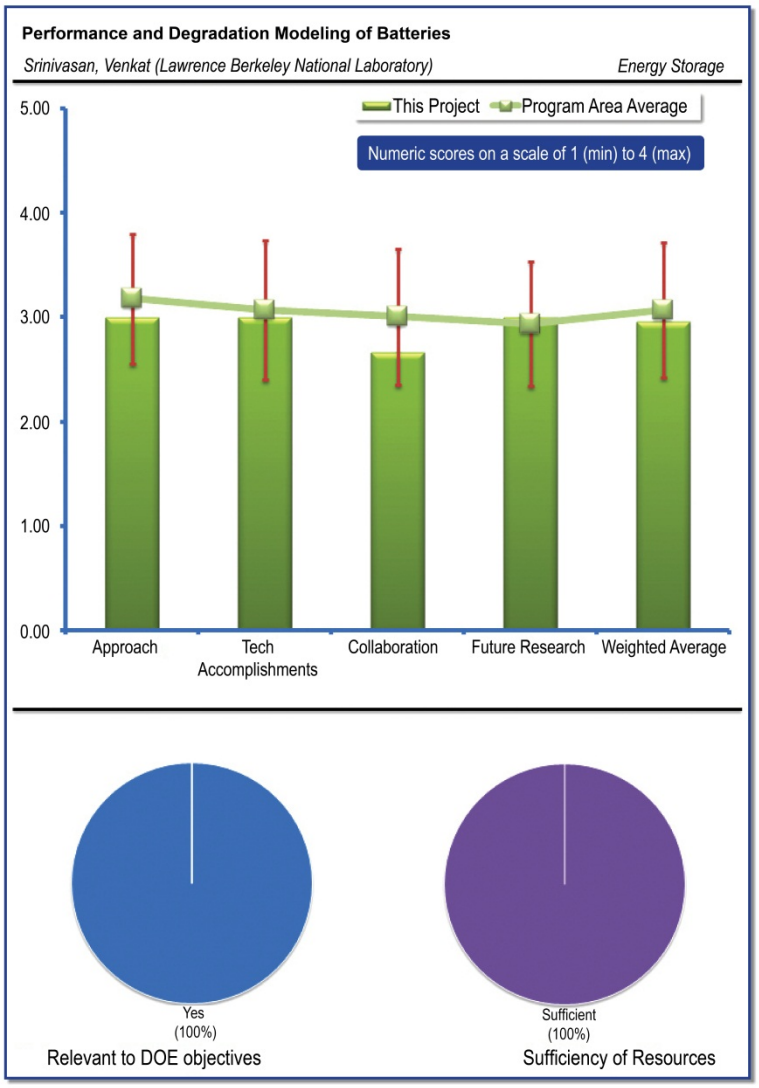
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Feedback from reviewers in this section was generally positive. One reviewer commented that the plan for future work is better than previous year on achieved results and BATT advanced investigation needs. A second reviewer indicated that proposed future work seems reasonable and logically thought out, and added that future alloy work with 3M should be particularly encouraged. The third reviewer noted that proposed future work is excellent, but absence of any planned activity related to carbon-based anode materials is again unfortunate. A fourth reviewer said to keep working on the in-situ method for other materials and analyze surface process.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The reviewers agreed that project resources were sufficient. A second reviewer added that the resources should be finally related to the number of materials to be investigated as a horizontal analytical tool for BATT.

Performance and Degradation Modeling of Batteries: Srinivasan, Venkat (Lawrence Berkeley National Laboratory) – es086



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. One reviewer offered that the modeling is a good method to analyze the phenomena in the cells, and a second reviewer stated that the modeling work is assisting the progress in Li batteries relevant to DOE objectives. The third commenter indicated that improved cathode and anode material modeling and understanding will help improve fleet electrification over the long term.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback from reviewers in this section was generally positive. The first reviewer remarked that the approach is well focused to the objectives with a good combination of models with experimental results. The second reviewer noted that while there is a good modeling approach, more reinforcement with experiments would strengthen the results. The third reviewer stated a desire to see more experimental data to support the modeling.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were generally positive. The first reviewer offered that progress is appreciable and well related to the identified barriers with modeling calculation and experimental validation. The second reviewer indicated that it was interesting to see the difference of SOC between the different particle size, as well as how fast Li can diffuse between the powder if there are good electron paths with carbon. This reviewer further inquired about the situation in the case of the layered materials or spinel materials. A third reviewer offered comments and questions specific to presentation slides. Specific to Slide 7, this reviewer noted that the right chart is labeled 5C rate, but each of the sizes has a different effective c-rate as their extent of superoxide dismutase (SOD) varies. This reviewer also stated that the 50nm c-rate has achieved 50% SOD after approximately 260 seconds, a rate of about 6.9C. This reviewer described that the examples of two particle sizes have a wide range of relative c-rates and it is a non-linear plot, so the c-rate changes during the experiment. Further, this reviewer noted that some commentary on what was kept equal beyond a c-rate label would be helpful. This third reviewer also acknowledged that the path dependence work discussed on Slide 10 is interesting, though correlation to more experimental data and commercial grade sample/size distributions would increase its relevance. This reviewer commented that Slides 14 and 15 point out that Silicon used in the manner depicted holds rather little Wh/L advantage over graphite, particularly at moderate rates, and questioned whether the loading trends' impact on power reverse themselves. Specific to Slide 14, this third

reviewer stated that higher loading (red) has slightly better power than the middle (blue) and lower loading (pink). However, this reviewer points out that, in Slide 15, the best power retention comes from the lowest loading (red). Finally, this third reviewer highlights Slide 18, which should clarify the vehicle system (e.g., EV, PHEV, HEV) on which the researcher is focused. This reviewer indicates that it was mentioned that 2C rate was high power and that is only appropriate for an EV application. This reviewer also explains that Slide 18 references PHEVs, which have FreedomCAR targets of 3 to 13C rates.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer feedback was somewhat positive in this section. The first commenter stated that the collaborations are part of the activities because the feedback from experimental groups is necessary to validate simulations and models. A second commenter acknowledged that some collaboration exists, while a third commenter noted more collaboration with experimental partners. This third commenter also added that the presentation does not make it clear what was collaborated on with those mentioned in Slide 2.

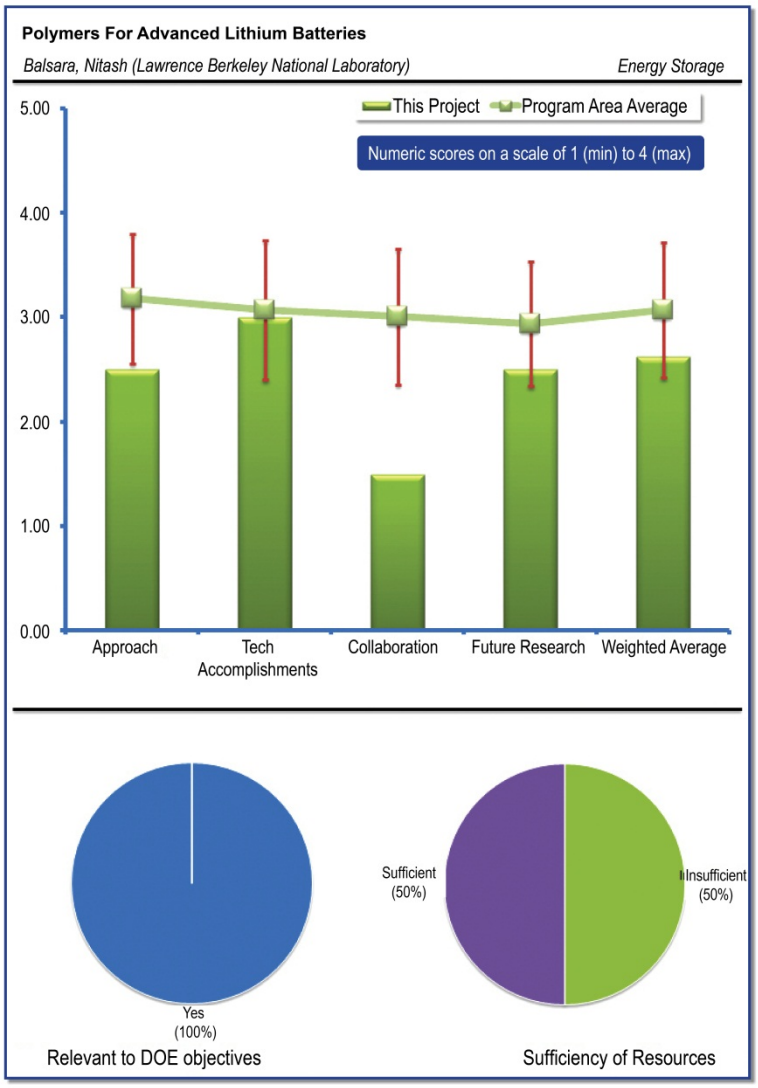
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The comments received in this section were generally positive. One reviewer noted that the future work is well-defined, and a second reviewer acknowledged good future direction. A third reviewer explained that planned work is consistent with the already achieved results, even if some other parameters or phenomena should be considered to further improve the simulation results and usability. Further, this commenter stated that the aging of cells should also be correlated somehow to the behavior of cathode and anode materials as it is recommended to consider the effect of temperature, which surely is a degradation factor.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewers agreed that project resources are sufficient. One reviewer noted that the resources seem adequate to the work, and a second reviewer commented that resources seem sufficient.

Polymers For Advanced Lithium Batteries: Balsara, Nitash (Lawrence Berkeley National Laboratory) – es088



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The comments received in this section were positive. One reviewer noted that the project aims well at DOE objectives, and a second states that the hybrid polymer is an interesting idea.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback from reviewers in this section was generally positive. The first reviewer offered that the approach is adequate with a good definition of technical barriers. A second reviewer explained that block copolymer would create uneven current distribution on the electrode and may cause some life issues.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments from reviewers were generally positive in this section. One reviewer commented that the results are promising, showing good progress. The second indicated that it would be good if the Principal Investigator can demonstrate the actual rate capability and identify the gap from the practical target performance.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer feedback in this section was generally negative. The first reviewer stated that there is no evidence of collaboration out of LBNL, and a second offered that collaboration with other institutions could not be seen.

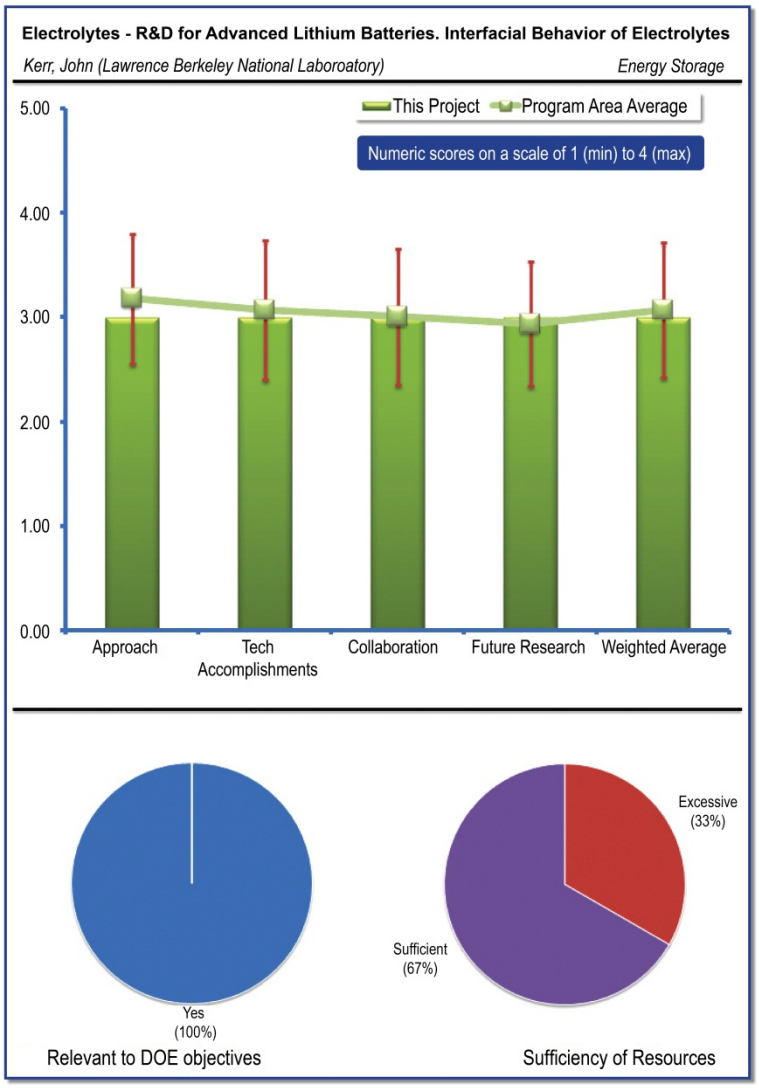
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were generally positive. One commenter described future plans as appropriate, while a second commenter stated there may need to be more work with industry to see the feasibility of the technology.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer feedback in this section was mixed. The first reviewer indicated that resources seem okay, while the second reviewer stated that it seems the resources are insufficient.

Electrolytes - R&D for Advanced Lithium Batteries. Interfacial Behavior of Electrolytes: Kerr, John (Lawrence Berkeley National Laboratory) – es089



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall feedback in this section was positive. The first commenter indicated that the project supports DOE objectives. A second respondent stated that the interfacial behavior is one of the biggest hurdles for the polymer electrolyte.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments were generally positive in this section. One reviewer remarked that the project has good organization with clear objectives to overcome selected barriers in the field of electrolyte materials. The second reviewer said good approach, and added that there are several polymer batteries in the market. Further, this reviewer offered that it would be good, as a benchmark, if the PI can investigate how interfacial issues are overcome. The third reviewer noted that activity with conductive additives in particular is excellent, solid work, but that work on Li-metal-based systems should be either eliminated or minimized.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were generally negative. The first reviewer explained that the results are interesting but not clearly presented, and added that the role of various solutions needs to be better described and analyzed. A second reviewer noted that the font for the graph is too small to see.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Feedback in this section was mixed. One commenter stated that there are several collaborations with other institutions. The second commenter acknowledged that while the collaborations are adequate and large, to some extent it is advisable to have more evident integration with other groups working on electrolyte materials.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewer comments were generally mixed in this section. One reviewer indicated that graphite anode should also be investigated. A second reviewer explained that the future plan is substantially related to the results already achieved even if there are concerns about the way ionic liquids and new materials have been proposed for the next period without effectively completing the work on the ongoing materials. The third reviewer offered that work on Li-metal-based systems should be either eliminated or minimized. Further, this reviewer added that activity with composite electrodes, specifically with conductive additives in particular, should be expanded accordingly.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer indicated that resources seem sufficient, while a second reviewer stated that the declared leverage with the DOE Fuel Cell Technologies (FC) subprogram does not clarify the effective use of resources.

Advanced Binder for Electrode Materials: Liu, Gao (Lawrence Berkeley National Laboratory) – es090

Reviewer Sample Size

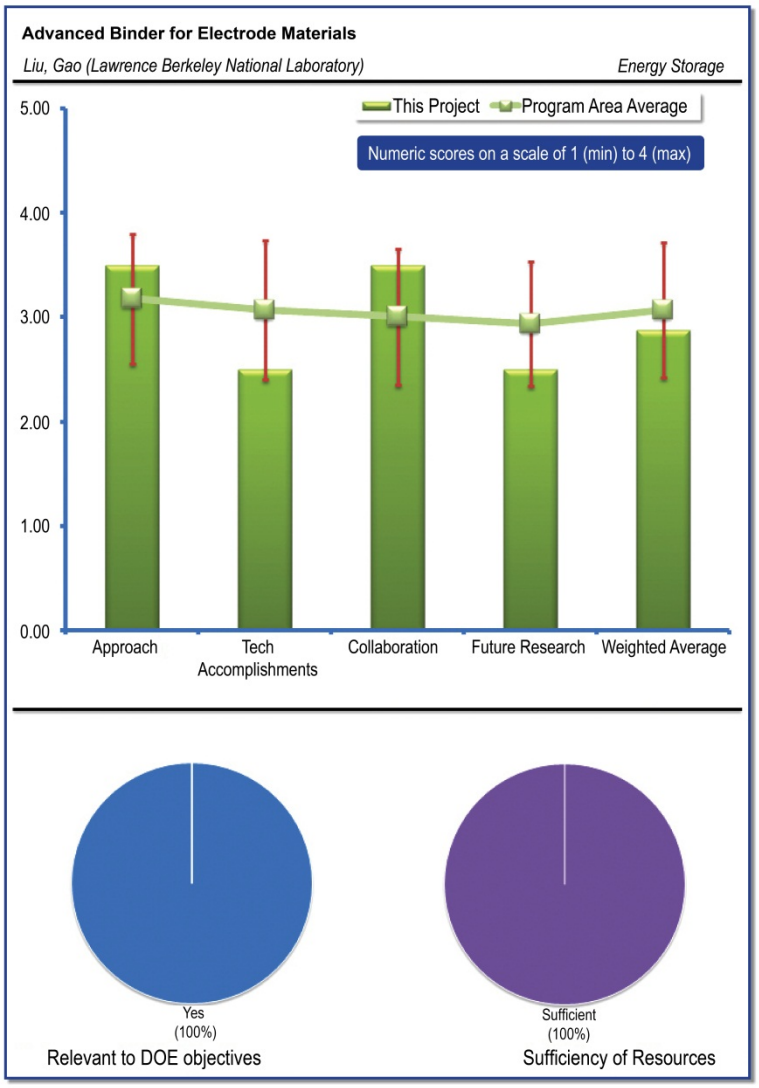
This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were positive in this section. One reviewer explained that the binder research is relevant in introducing new materials and new Li cells with improved performances relevant to DOE objectives. The second reviewer noted that a conductive polymer for the binder is an interesting idea.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer feedback in this section was positive. The first commenter offered that the project is clearly organized with feasible milestones and deliverables aimed at addressing specific technical barriers in using Si anode materials, as well as integrating other BATT projects. A second commenter noted that, according to another presentation, the conductivity between the particle could be the issue not only for Si, and added that the PI may be able to extend the scope to other materials such as graphite.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. The first reviewer acknowledged that progress is evident with very interesting results on new Si anode compositions using a polymer binder. This reviewer also said the variability of commercial Si has required additional work; it is not clear why improved Si, investigated in BATT, is not considered. This project could stay in the binder development. That SiO_2 is not good for SiOx was known in the industry ten years ago.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments in this section were positive. One reviewer stated that the network of collaborations is complete and appropriate with a balanced contribution of research and industry. A second reviewer indicated that there are several collaborations with material companies.

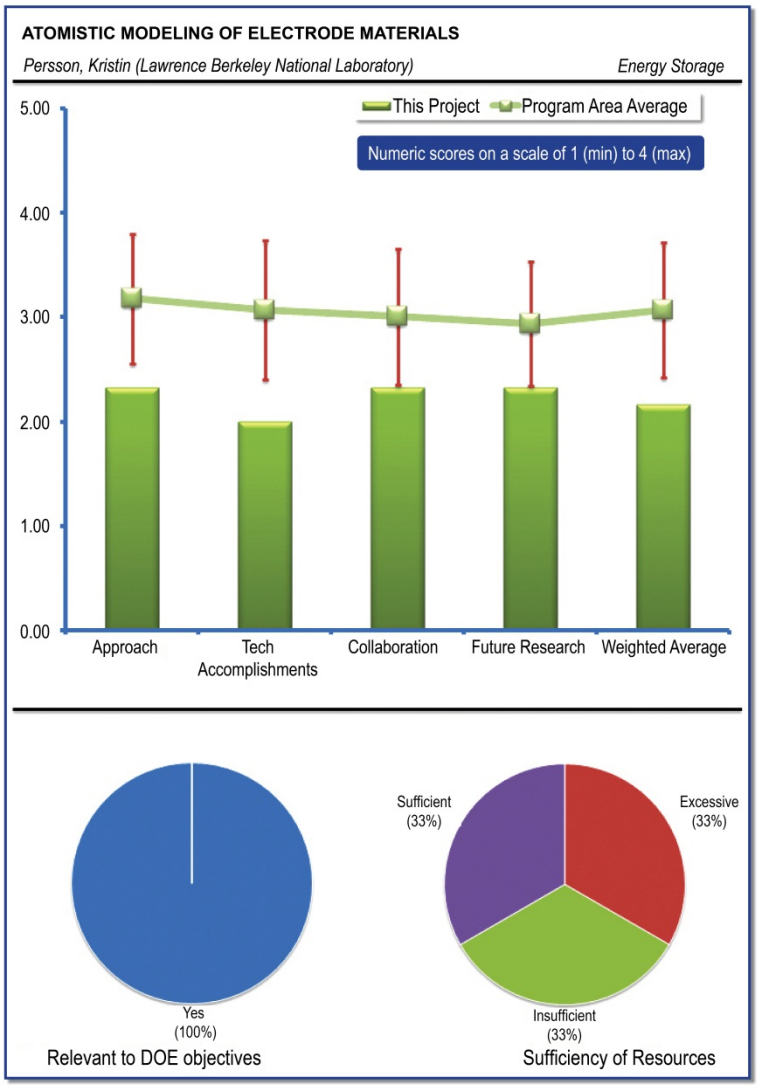
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Feedback was generally positive in this section. The first commenter remarked that the future work is well organized in relation to the previous results. The same reviewer also explained that it is not fully clear how the problem of commercial Si variability will be solved or faced, and that it may be recommended to use commercial and BATT Si powders to generalize the applicability of the proposed binder. The second commenter offered that closing the pore seems a critical issue for the current system and needs to be addressed. Furthermore, this respondent added that 70% porosity does not seem like a practical solution.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer stated that the resources were considered adequate, and a second reviewer noted that resources seem sufficient.

ATOMISTIC MODELING OF ELECTRODE MATERIALS: Persson, Kristin (Lawrence Berkeley National Laboratory) – es091



REVIEWER SAMPLE SIZE

This project had a total of three reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

Comments in this section were generally positive. The first respondent explained that the project is aimed at solving problems functional to DOE objectives. The second respondent offered that electrode materials modeling will help improve the understanding of lithium ion batteries and enable greater fleet electrification over time. The third respondent indicated that the modeling by itself is fine to understand the phenomena well.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

Feedback from reviewers in this section was mixed. While one reviewer stated that the approach is appropriate with the use of ab initio modeling to investigate key Li barriers, a second reviewer indicated uncertainty as to whether Li diffusion modeling in graphite is useful. The third reviewer remarked that the modeling approach seems reasonable, although no clear connection to experiment to confirm and to the overall context of the BATT program.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewer comments were mixed in this section. The first reviewer stated that the results are promising, adding that the focus on a few and well defined materials has been appropriate. This reviewer further noted that the progress is of value and must be completed with more experimental results. The second reviewer commented it seems obvious that Li intercalation would not happen from basal plane, and added that more experimental data to support modeling results would like to be seen. A third reviewer offered comments specific to presentation slides. Regarding Slide 2, this reviewer explained that the barriers of cost, cycle life, and rate are not addressed directly at all in this approach. Further, this reviewer commented that while there are indirect implications from material design, the connections are not made by the researcher. The third reviewer also noted, in reference to Slide 4, that no information on $LiCoO_2$ or $LiMnO_2$ was shared, and added that it would be interesting to understand why layered $LiMnO_2$ is to be studied. Regarding Slides 6 and 7, this reviewer opined that the information shown for lithium graphite bottleneck work is very limited. This reviewer further added that while there are references provided for the other work, very little of those articles made it into the review slides. This third reviewer expressed, in reference to the Slide 7 conclusion that the basal plan is more stable but does not allow for lithium absorption and that the edge plans would enable faster transport, does not add to the field. Regarding Slides 8 and 11, this same reviewer commented that more information was shared for the $LiFePO_4$ synthesis condition optimizing, but no original experimental

confirmation was provided to support the modeling. Finally, and in reference to Slide 12, this reviewer stated that no clear results for the Public Materials Database activity were shared.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The reviewer feedback in this section was generally positive. One reviewer said increased collaboration with experimentalists, and a second reviewer indicated that there is a little collaboration in LBNL. The third reviewer offered that the collaborations seemed appropriate but were not sufficiently emphasized and described in the presentation.

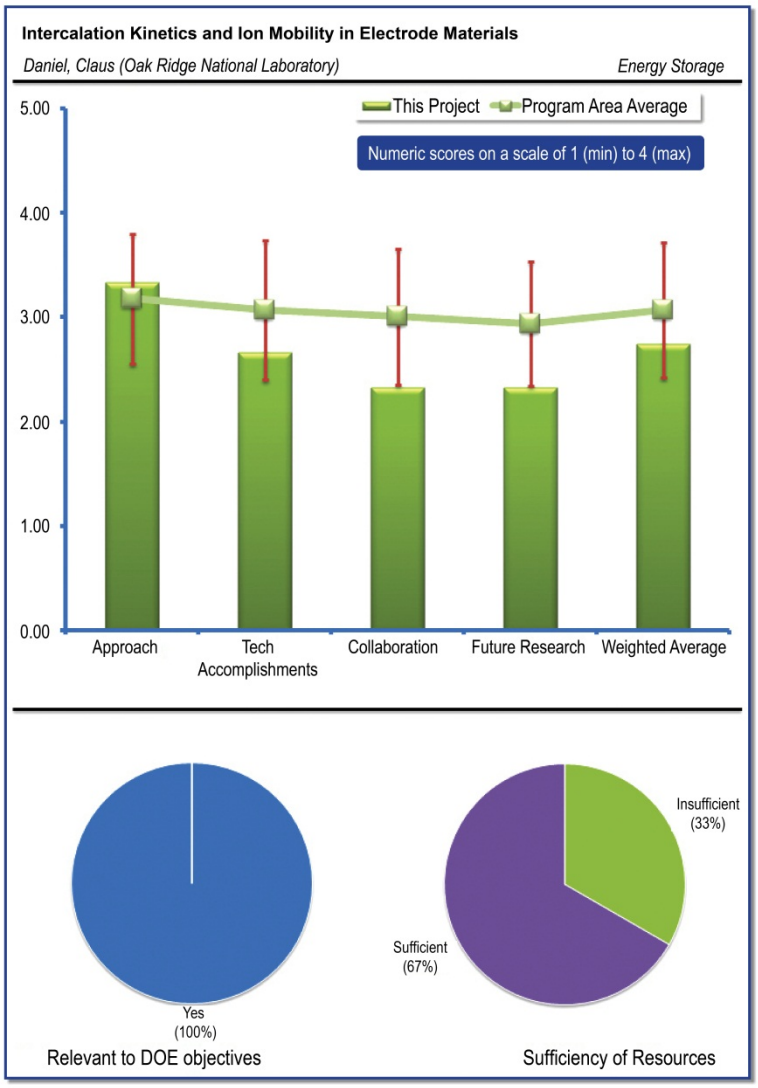
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Comments in this section were positive, in general. The first respondent stated that the work planned for next period is consistent with the results already achieved, and highly recommended an increased connection and validation with experimental results of the modeled materials and mechanisms. A second respondent asserted that more experimental data to support modeling results would like to be seen. The third respondent commented that future work should have a clearer connection to the overall BATT program goals and purpose. Additionally, this reviewer pointed out that work results should be presented at the AMR, rather than just included in referenced citations. This respondent further remarked that plans to work on layered $LiMnO_2$ or spinel $LiMn_2O_4$ should be clarified.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Comments in this section were mixed. While one reviewer indicated that resources do not seem sufficient, a second reviewer stated that the budget appears excessive given the increasing budget of this program and the limited results shared. The third commenter stated no specific suggestions.

Intercalation Kinetics and Ion Mobility in Electrode Materials: Daniel, Claus (Oak Ridge National Laboratory) – es093



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. One reviewer observed basic studies that are functional to DOE objectives. A second reviewer offered that improved analysis of material properties of lithium ion batteries will enable greater fleet electrification over the long term.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer feedback was generally positive in this section. The first commenter acknowledged a well-focused and combined approach with a clear plan and well defined objectives. The second commenter observed an interesting analysis approach to stress/strain behavior or materials. A third commenter remarked that in-situ methodology could be useful but the PI needs another methodology to support the results.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback in this section was mixed. One respondent stated that while the results are promising, more analysis and comparison with experimental results is needed. A second respondent explained that the grain boundary could be seen, but how it influences the electrochemical performance quantitatively could not be seen. The third responded provided feedback specific to presentation slides. This respondent, in reference to Slide 8, noted microindentation work seems very interesting, but inquired about the tip dimensions and indentation time, as well as whether or not that was the image shown on Slide 10. Further, regarding Slide 8, this reviewer questioned whether there is any expectation of what would happen to the mechanical behavior after cycling or heavy use. The third reviewer also queried, in reference to Slide 9, whether it is possible or practical to examine material for any cracking or other damage due to the indenting. Additionally, this respondent pointed out that Slide 10 images and scale bars were difficult to read, and that data should be more clearly communicated to support conclusions. Regarding Slide 11, this third respondent inquired as to what electrolyte was used. Finally, and in reference to Slide 12, the third reviewer suggested that more background on electrochmical strain microscopy (ESM) amplitude maps would help communicate the conclusions more clearly.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Mixed comments were received in this section. The first reviewer opined that a little collaboration exists, and a second reviewer encouraged collaborations with additional lithium ion battery material specialists. A third reviewer remarked that while the collaborations have been increased, they still seem inadequate and poorly integrated with the rest of the program.

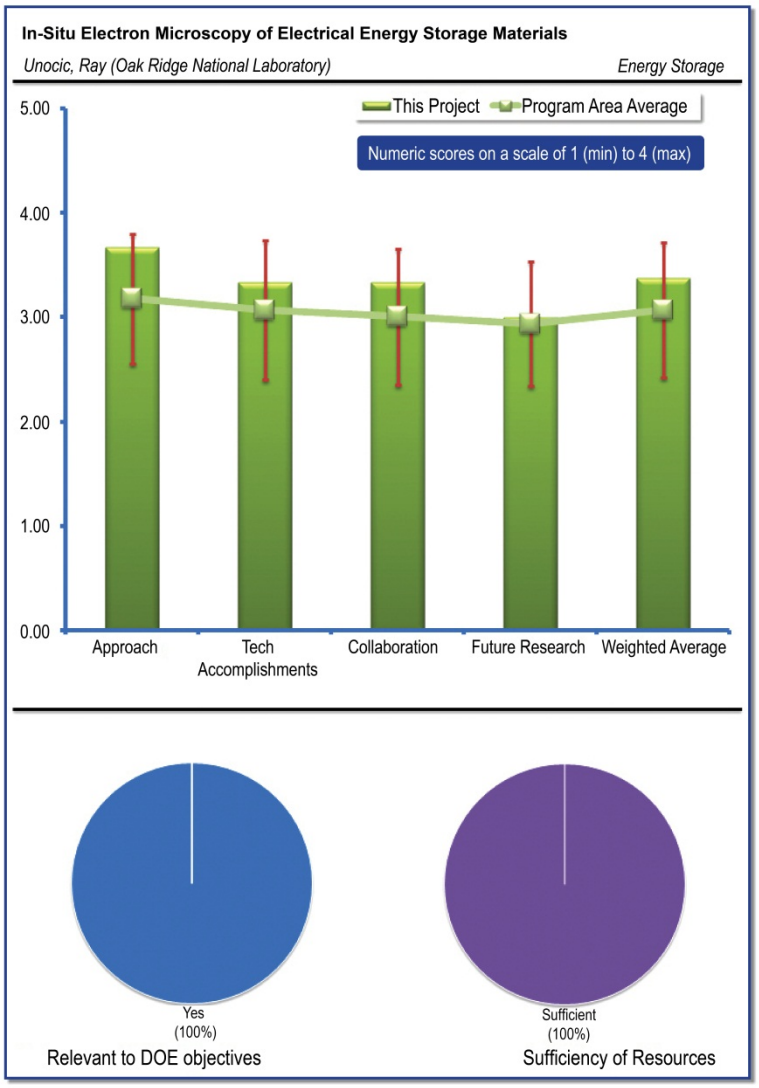
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Respondent feedback in this section was mixed. While one respondent noted that expansion of work to aged cathodes and/or various SOCs would be interesting, a second respondent requested that more electrochemical tests be conducted. Finally, a third respondent indicated that the future work is not clearly related to the technical barriers and the project objectives, and that a better description and major specifications are necessary to explain and justify the work.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Mixed comments were received in this section. Although one reviewer observed that resources seem insufficient, a second reviewer said judged okay.

In-Situ Electron Microscopy of Electrical Energy Storage Materials: Unocic, Ray (Oak Ridge National Laboratory) – es095



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback in this section was positive. One reviewer observed that diagnostic techniques are aimed at investigating basic mechanisms and improving materials selection for Li cell, which is functional to DOE objectives. A second reviewer commented that the direct observation is very interesting and useful with in-situ methodology.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, reviewer comments were positive in this section. The first respondent noted the excellent focus on developing and implementing a very valuable, new tool for the advancement of fundamental Li-ion electrochemistry understanding, and further remarked to keep going. The second respondent acknowledged that a lot of people have tried to do this and it is first time this respondent has seen the actual results. A third respondent explained that the idea to develop a brand new device for dynamically investigating the various processes is very challenging and stimulating. Additionally, this respondent commented that the barriers are well identified with some concern related to the description of the novel equipment, which is not clearly connected to the effective operation of the cells.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback in this section was generally positive. One commenter stated that results are very interesting, and a lot of things can be done with this new technique. While the second reviewer agreed that the results are interesting, this person added that there is substantial work to be done to reach a complete view of the investigated processes.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Positive comments were received in this section. The first reviewer observed a good network of collaborations, and the second reviewer pointed out good collaboration based on the results.

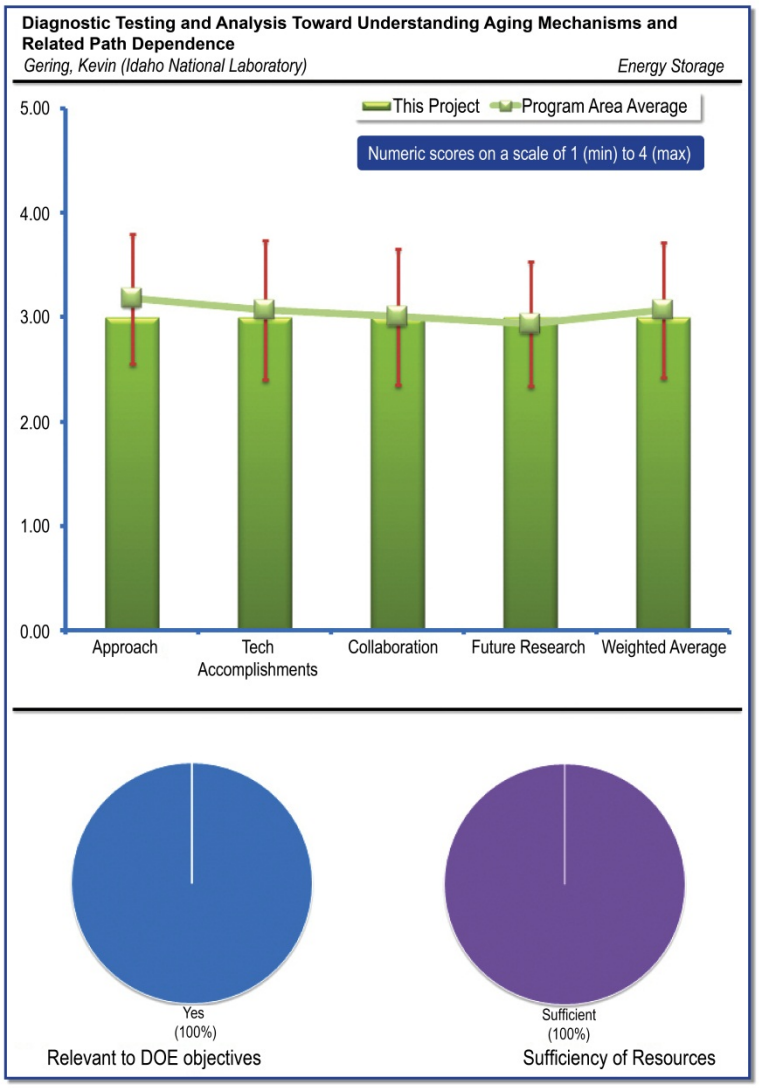
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was mixed. One respondent acknowledged very good initial results, and added that, hopefully, the PI could find out new things with this technique. A second respondent indicated that the future work is very generic and not well correlated to the technical barriers and project objectives.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Responses in this section are positive. The first commenter noted that resources seem adequate, while the second commenter stated that resources seem sufficient.

Diagnostic Testing and Analysis Toward Understanding Aging Mechanisms and Related Path Dependence: Gering, Kevin (Idaho National Laboratory) – es096



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback in this section was positive. A respondent indicated that this project is focused on understanding the aging process and path dependence in lithium-ion cells, and further added that safety and cycle life are important criteria for the ultimate success of lithium-ion technology for vehicles and to displace petroleum use. As a result, according to this respondent, the project is relevant.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments were generally positive in this section. One reviewer explained that this project aims to bridge the gap between laboratory evaluation of batteries and the real-world use conditions of lithium-ion batteries. Additionally, this reviewer observed that it focuses on understanding the nature and frequency of duty cycles and thermal cycles. Finally, this reviewer asserted that these are critical issues and need to be fully understood.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, positive feedback in this section was received. The reviewer described that path dependence studies have provided data that could help develop a better understanding of the aging processes, and that computational methods have been developed to facilitate the diagnosis. Further, this reviewer expressed that the development of interactive battery management system currently underway could become valuable.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Remarks in this section were generally positive. One commenter acknowledged that the project involves collaboration with Hawaii Natural Energy Institute, Argonne National Lab, and the University of California-Pomona, and that it provides a broad perspective involving universities and national labs. Additionally, this reviewer suggested that the PI should consider involving industries, particularly automotive companies, because the work is critical to the automotive industry and the investigators could get good, valuable feedback from the automotive industry.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer statements were positive, overall, in this section. The reviewer indicated that future work is aimed at a continuation of the current strategies, and that it also involves examining other path dependencies. This reviewer further offered that interaction with the automotive industry could help to define the future work more crisply.

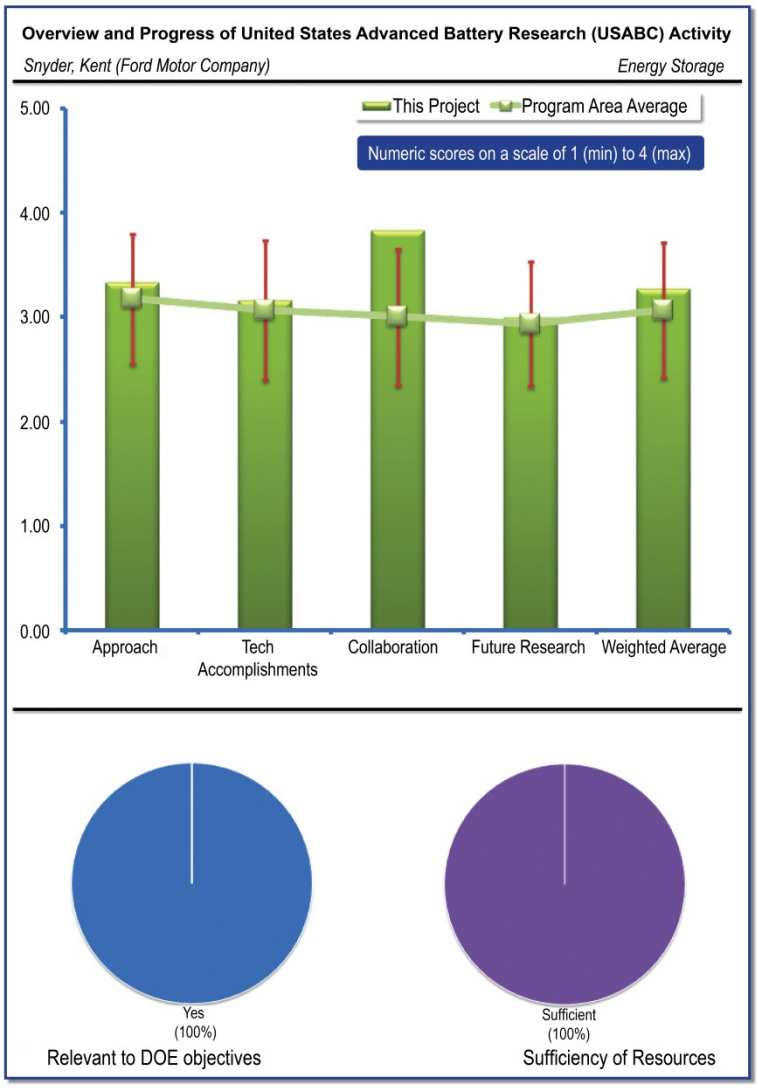
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Remarks in this section were generally negative, with one reviewer observing that funding is on the high side.

Overview and Progress of United States Advanced Battery Research (USABC) Activity: Snyder, Kent (Ford Motor Company) – es097

Reviewer Sample Size

This project had a total of six reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback in this section was very positive. One reviewer remarked that the USABC is absolutely essential toward bringing in the perspective of the OEMs, and added that this partnership should remain intact until batteries are commodities, and cost structure is reduced to acceptable market levels. Another reviewer stated that the project is a well-structured public-private initiative aimed at practically addressing DOE objectives, with selection of industry needs and requirements. The third reviewer expressed that the project is a direct co-operation of DOE activity with the auto companies to advance battery technology for use in propulsion of electric and hybrid vehicles. A fourth reviewer explained that battery technology and hardware are critical to development of the EV, HEV, and PHEV industry. This reviewer further mentioned that this program directly links battery developers with vehicle customers to guide R&D that directly meets vehicle manufacturer needs and benefits all parties involved. The fifth reviewer offered that this project is very relevant to the overall DOE goal of (partial) replacement of conventional vehicles with hybrid (HEV or PHEV) or electric vehicles, both to minimize GHG emissions as well as national dependence on petroleum resources. Additionally, this reviewer indicated that this USABC project is a collaborative effort between the leading U.S. auto manufacturers (i.e., Chrysler, Ford, and General Motors) and the National laboratories in conducting advanced battery research and development with joint funding from DOE and the contractors. Further, this person indicated that the objective of this consortium is to reduce the cost of batteries via increased energy density in high-energy (PHEV and EV) systems, and lower total energy content in HEV systems. Finally, this reviewer added that successful implementation of this project will result in widespread infusion of battery technologies in vehicular applications, which would in turn reduce petroleum consumption, and pave the way towards petroleum replacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments in this section were generally positive. The first respondent observed that the organizational and administrative approach is very well dimensioned to the significant level of efforts with clear approach for selecting priorities and key partners in developing results. A second respondent stated that the group combines the auto companies with the technology development activities in national laboratories, independent technology development partners with DOE resources, resulting in an efficient mechanism to further the development of electrified vehicle propulsion. The third respondent explained that the approach being adopted by USABC is sound, duly addressing the technical barriers with well-timed and appropriate milestones and deliverables that are consistent with developmental efforts elsewhere. This respondent further specified that several new projects are being initiated towards the following:

(i) newly developed alternate HEV goals of reduced cost via total energy content reduction, while maintaining significant HEV power capability; and (ii) higher-mile-range PHEV goals and historical EV goals. Additionally, this third respondent described that both the ongoing programs and the programs being initiated under USABC are well-directed towards meeting the objectives of reducing the cost for HEVs with high power and low energy systems, such as capacitors and high power batteries, and for the PHEVs with improved energy densities from the batteries. A fourth respondent pointed out that it is good that the focus of research is beginning to be reoriented towards PHEV and battery electric vehicle (BEV) applications, and also added that historic EV goals are long overdue for updating. The fifth respondent said generally focused on goals and good to see LEESS goals revised. This respondent added that EV battery goals are now 20 years old and need revision, and also pointed out that all goals are not consistent with each other for various applications. Furthermore, this fifth respondent suggested that it would be better to see more USABC reasoning and strategy shared in this forum. Finally, this respondent commented that the presentation was rather generic.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, feedback in this section was positive. The first commenter asserted that the achievements are very consistent with the level of effort, and indicate valuable progress. A second commenter offered that significant progress has been made through the cooperation and development of standards, new battery systems, testing capability to identify problem areas, and funding solutions to them. The third commenter expressed that good progress has been achieved in initiating several technology development programs relevant to the program objectives, and pointed out that notable progress has been made in developing hardware (i.e., suitable prototype cells and modules from SAFT, A123 and LG Chem), and the thermal management systems for the LG. Additionally, this commenter noted that some of these cells, packs, and battery systems have been delivered to the national laboratories for evaluation. Further, this commenter shared that good developmental work has been initiated on the advanced (shrink-resistant) separators, which are perceived as a key component in improving the safety of Li-ion batteries. Finally, this third commenter stated that, based on these accomplishments, it is clear that tangible products will emerge from this effort that can benefit HEVs and PHEVs. A fourth commenter explained that the USABC and DOE sponsorship have provided the ideal example of government-led efforts to reduce the country's dependence on foreign oil, and observed that the transportation segment is critical in this endeavor. The fifth commenter remarked that while some and/or most of the work is good or excellent, the presentation is so generic that the value of the recent projects to the USABC and Big 3 cannot be determined.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments received in this section were generally positive. One reviewer highlighted the project as an excellent example of how cooperation between the various parties can advance the technology. A second reviewer acknowledged very good collaboration with battery manufacturers, battery component suppliers, and national labs. A third reviewer indicated that the framework created with the public-private partnership has a complete network of collaborations involving research organizations and industry. The fourth reviewer pointed out that there is, by nature, prolific collaboration. The fifth reviewer explained that although there are useful collaborations with various national laboratories, particularly in the testing of prototype cells, packs, and battery modules, it is surprising that there has not been any collaboration in terms of getting advanced materials from these partnering laboratories. Further, this reviewer added that even though considerable materials development effort is ongoing at the national laboratories, it is not being fed into the USABC program. As a result, continued this reviewer, there is some disconnect, especially relative to material development. A sixth reviewer highlighted that working collaboratively with the major OEMs at the 50/50% level and utilizing/leveraging our national labs is a challenging accomplishment. This reviewer added that as market feasibility and product completion draw closer, this USABC effort should now be phased into greater contribution from the OEMs with the government assuming, perhaps, a minor 15-25% financial stake.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

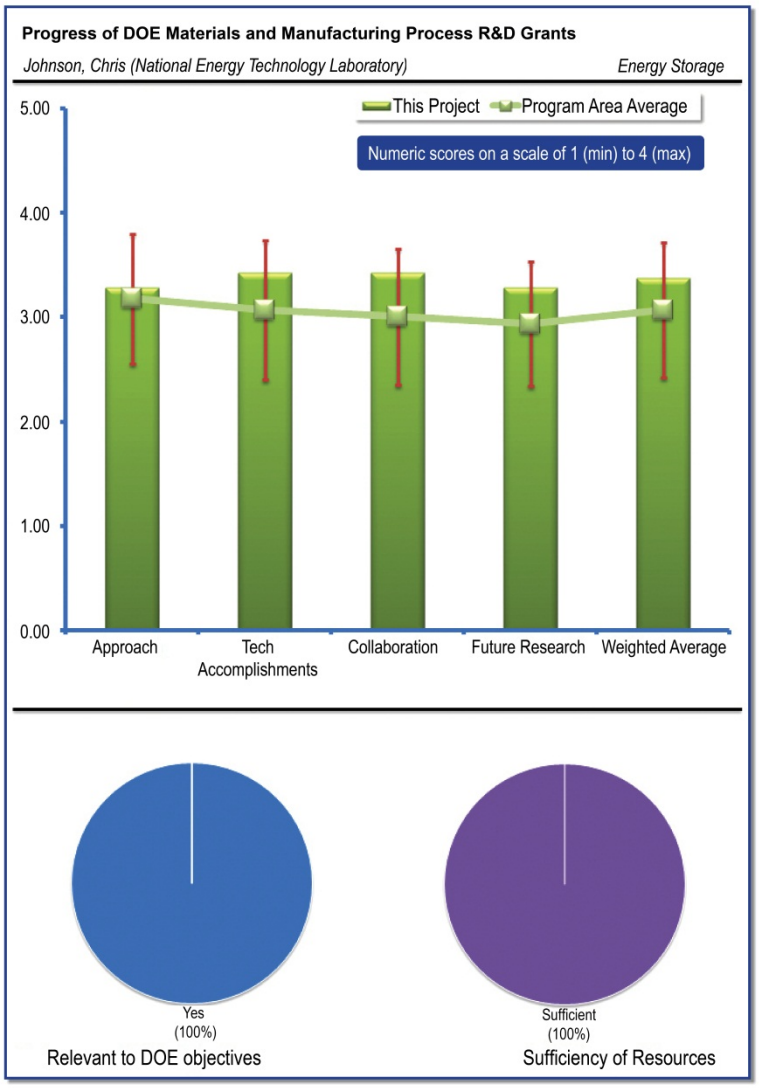
Reviewer feedback was mixed in this section. The first commenter stated that future needs have been identified and contracts are being placed. A second commenter observed that plans for future research are as follows: (i) initiate new programs for material

development (e.g., cathodes, anodes, electrolyte and separator) as well as for technology assessment; and (ii) demonstrate advancements in deliverable hardware in terms of high energy density and reduced cost (e.g., for high power systems). The third commenter indicated that the proposed future work is limitedly stressed even if USABC/FreedomCar has already established clear targets, but they are now in some cases outdated (not for PHEVs) and need to be revised in consideration of the present state of the art. The fourth reviewer expressed that there is no real roadmap other than a generic outline that says new projects will be evaluated and funded, and further requested that the vision, if any, be shared.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Overall, comments were positive in this section. The first respondent stated the funding is responsive to the needs, and the second respondent agreed that the resources are adequate for the planned effort. The third respondent explained that this is a huge funding effort with resources that are considered adequate in consideration of the other funding schemes made available by DOE. A fourth reviewer suggested that more insight be provided in this on-going project to show 1991-2011 spending with some projection on what might be needed for the next two to three years.

Progress of DOE Materials and Manufacturing Process R&D Grants: Johnson, Chris (National Energy Technology Laboratory) – es098



Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback was positive in this section. The first respondent stated that the program supports the needs of the energy storage program to develop new technologies for transportation. A second respondent agreed, indicating that the project is obviously based on DOE objectives with relevant commitment on material R&D and manufacturing. The third respondent observed that this project provides the money to the various areas that support the electrification of vehicle industry, and further noted that all aspects of the industry appear to benefit from the funds in sufficient amounts to make a difference. A fourth respondent acknowledged that this project is very relevant to the mission of the Vehicle Technologies Program, which is to develop more energy-efficient and environmentally friendly vehicular technologies that result in significantly less petroleum consumption and GHG emissions. Further, this respondent offered, this project supports these goals by providing grants for developing various materials and manufacturing processes, as well as ARRA funding for developing battery manufacturing facilities within the United States, with the objective of accelerating transition to the next generation of hybrid vehicle transportation. Finally, this fourth respondent asserted that successful implementation of this project will result in widespread infusion of battery technologies in vehicular applications, which would in turn reduce the petroleum consumption and pave the way towards petroleum replacement. The fifth respondent explained that battery manufacturing capacity and low-cost manufacturing processes are key to availability and affordability of batteries for EV, HEV, and PHEV applications for petroleum displacement. The sixth respondent described an excellent summary of projects that certainly brings everything together.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments received in this section were generally positive. The first evaluator indicated that the overall project is well designed and well integrated with materials developments under other DOE projects related to lithium batteries. Further, this evaluator added, the approach is sound, feasible, and addresses the technical barriers (e.g., manufacturability). Additionally, this evaluator described the two-fold approach being adopted by the National Energy Technology Laboratory (NETL): (i) institute several technology developmental projects, with approximately 50% cost share from the developers, on various components of Li-ion cells for the next generation lithium batteries; and (ii) assist in setting up manufacturing facilities within the United States for Li-ion batteries of various chemistries as well as capacitors, and the associated raw materials. The second evaluator observed a progressive approach taken in a broad area of important subject areas, particularly considering that much of the work was initiated three years ago. The third evaluator expressed that this project has proportioned the monies to the various companies that appear to be viable businesses in the industry

and willing to invest in the U.S. market. This approach, the third evaluator stated, increases the United States' ability to become less dependent on vehicle transportation energy sources outside of the United States, either petroleum or through support of vehicle electrification. A fourth evaluator reported that projects include the development of high energy batteries and related technologies as well as establishing battery manufacturing facilities to support the shift to electrified transportation to reduce dependence on foreign oil. The fifth evaluator pointed out that the approach is limitedly described, but substantially based on the selection of key research organizations and industry with breakthrough R&D proposals. A sixth evaluator mentioned that it was difficult to capture this in the overview presentation, but fast cycle manufacturing grants under ARRA was a direct approach to increasing battery manufacturing capacity. Furthermore, this evaluator suggested that the manufacturing process development is probably less effective.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer statements in this section were mixed. One commenter shared that presented results are excellent in terms of progress and substantial innovation in various sectors from material R&D up to manufacturing processes. The second commenter observed that assistance in the establishment of battery manufacturing facilities supports the development of new, high energy battery systems and production of new, high energy battery materials. A third commenter explained that the progress achieved in initiating several technology development programs based on cost-share related to the Materials and Manufacturing of Li-ion cells on different materials is encouraging. Additionally, this commenter remarked that reasonable progress has been accomplished in many of these individual programs. This third commenter goes on to state that two of the programs initiated (i.e., EnerDel and Tiax) stand out in terms of their inappropriate funding levels. Specifically, a funding of about $3.5M for redox shuttle development and about $2.4M for understanding the internal short are not as justifiable by their relevance and accomplishments. Further, this third commenter adds, the programs under the ARRA Battery Manufacturing grants have, appropriately, a broader portfolio covering different technologies beyond Li-ion batteries. Some of them have already demonstrated production capability and it looks quite promising that tangible products will emerge from this effort that can benefit HEVs and PHEVs. A fourth commenter said difficult to capture in the presentation, but acknowledged that the fast track RFP and review process getting $2B on contract very quickly and competently was very effective in getting on track for adequate battery manufacturing capacity. This commenter added that there may even be overcapacity, which will effectively reduce costs for vehicle manufacturing in the beginning. The fifth commenter described that this project had two portions. The first portion (i.e., Manufacturing Process R&D), as observed by this commenter, seemed to have some metrics included, but the progress against those metrics appeared to be modest even when the metrics were clear. This commenter went on to discuss the second portion (i.e., ARRA Manufacturing Grants) of this project, which appears to have progress, but performance indicators were not clear enough to rate the progress. Finally, this fifth commenter highlighted that most of the progress to which this commenter refers is based on industry knowledge and the GM Volt build progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Feedback from reviewers was mixed in this section. The first respondent described a large and consistent network of collaborations with transparent and timely selection process. This respondent expressed that it is very impressive how fast and accurately selections were made, and observed that $1.5B was granted in a short time and with valuable results. A second respondent observed that a wide range of technologies and industries with direct impact on reducing foreign oil are supported while establishing a production capability in U.S. territories. The third reviewer offered that there is not much collaboration across these individual programs and acknowledged that there is substantial cost-share from the developing organizations, which need to protect their intellectual property. A fourth respondent remarked that there is no clear coordination between partner(s), as well as a lack of clear NETL input to the institutions after the monies are allocated. This respondent added that reporting on the programs seems to be the only collaboration.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were mixed. One evaluator reported on future plans, which include supporting the R&D programs on materials and manufacturing processes as well as supporting the battery manufacturing facilities. This evaluator added that the focus on multiple technologies, as is being done here, will mitigate the risk considerably. The second evaluator described that the way is

well tracked on the work, which is clearly planned, accurately reviewed, and revised yearly. A third evaluator offered that work is related to lowering the cost of batteries while improving their performance. The fourth evaluator asserted that future plans were very unclear, and that given progress and desired goals, future plans could be assumed, but they need to be clearly spelled out.

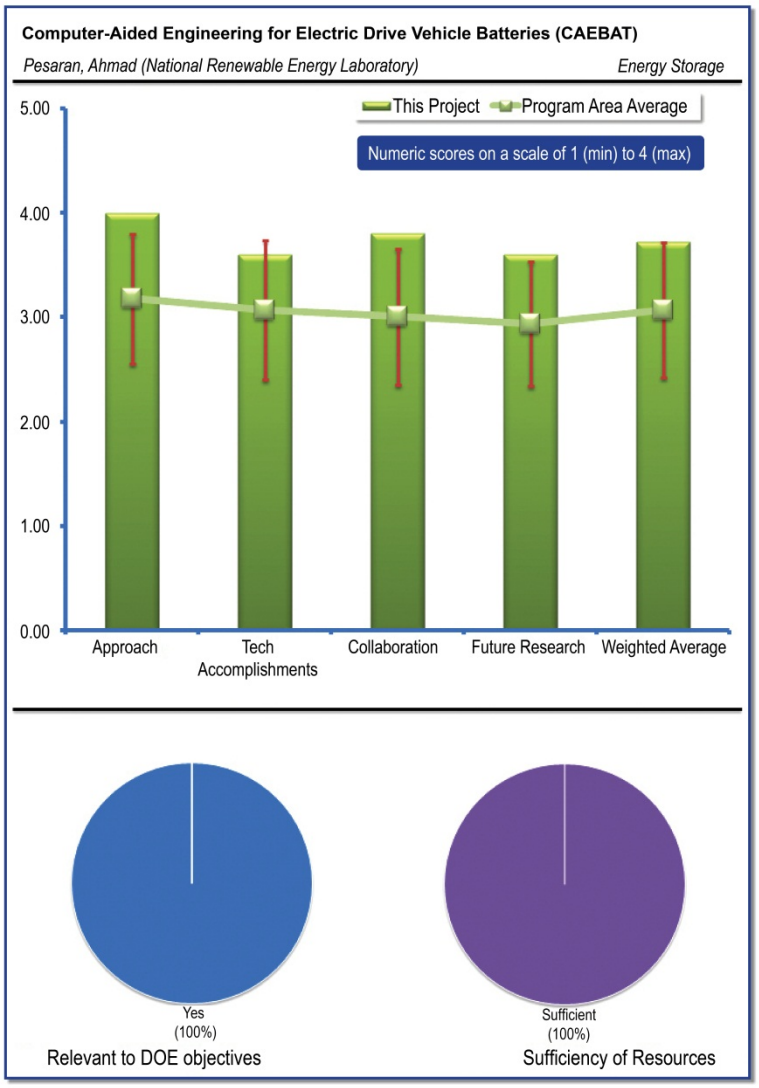
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Mixed reviews were received in this section. One commenter acknowledged that this is surely the hugest effort ever in the field. A second commenter indicated that funding is sufficient and will support the developments of new technologies in an orderly manner to avoid wasteful spending. Similarly, the third commenter expressed that the resources are adequate for the overall projects and most of individual projects, although two (i.e., EnrDel and Tiax) have resources that are not commensurate with their relevance and accomplishments. A fourth commenter cautioned on the possibility of overspending. This commenter also pointed out that one disturbing aspect is the very small number of jobs created per million dollars, which appears to be a common concern across all ARRA programs.

Computer-Aided Engineering for Electric Drive Vehicle Batteries (CAEBAT): Pesaran, Ahmad (National Renewable Energy Laboratory) – es099

Reviewer Sample Size

This project had a total of five reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback in this section was positive. One reviewer stated that the project is well directed towards DOE objectives. The second reviewer noted the need for a computerized tool to evaluate new chemistry, batteries, and systems for robustness for non-experts. This reviewer added that this will help with estimating life, cost, etc. The third reviewer explained that CAE tools can have extreme economic impact on battery performance and design as the CAE tools for vehicle structures have impacted the OEM design and economics of vehicles. A fourth reviewer remarked that commercially available and user-friendly computer modeling design tools for batteries will advance the sophistication and capability of battery manufacturers just as similar tools revolutionized the auto industry. Additionally, this reviewer mentioned that this will provide for better products optimized for lower cost. The fifth reviewer commented that computer aided design is an engineering tool that can reduce the time and effort to realize the best possible solution to a problem. This reviewer further added that this project is directly related to the reports of Smith and Kandler.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, remarks in this section were positive. The first evaluator indicated that this is a brand new, integrated approach to support engineering and analysis of Li batteries. This evaluator added that the project is ambitious and challenging, but well-structured and adequately ambitious because it is aimed at clear problem solving. The second evaluator described it as a very challenging but achievable project and noted a very ambitious approach to something that should well be worth it if successful. A third evaluator offered that the approach, when it results in a CAEBAT, will shorten the cycle of cell and system development. The fourth evaluator explained that a comprehensive program has been developed to speed the development of higher energy batteries for transportation. This reviewer added that this over-reaching program is designed to enhance NREL's existing electrochemical activities and speed the development of advanced reliable and safe battery systems. A fifth evaluator expressed that incorporating all of the modeling disciplines (e.g., CFD, thermal efficiency, lump mass, and structures) is a good way of starting. Further, this evaluator said that being able to model cell response to abuse is critical then progress this failure and cascade to propagation.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewer feedback was positive in this section. One commenter acknowledged a good start in setting up for real work to start this year. A second commenter offered that the results achieved so far are mostly preparatory, but very promising with good prospect for success. The third commenter explained that modeling and computer-aided engineering tools have been developed to understand and predict performance, and added that two other programs in the review by Kandler and Smith are the result of this over-reaching program.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Comments in this section were generally positive. The first reviewer noted that the network of collaborations is well organized and complete. A second reviewer observed that the results are being published and shared with other national laboratories and auto companies to assist in speeding the development of new, safe, high-performance battery systems. The third reviewer acknowledged a good start with national labs and many complicated relationships to management. This reviewer pointed out that IP and other issues may slow down and/or otherwise make successful execution difficult. Further, this reviewer highlighted a tracking need because collaboration is more necessary in this project than most.

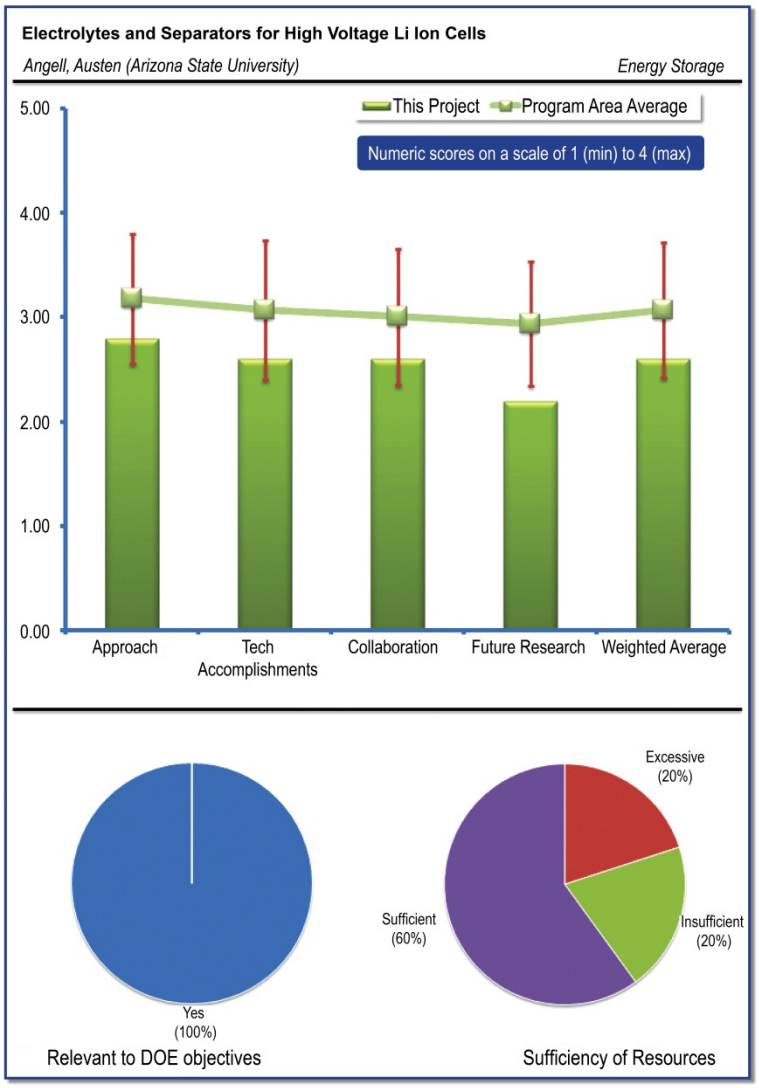
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Feedback in this section was positive. One respondent observed a good plan for an ambitious and challenging new project, while a second further described that future work addresses clear activities and an extension of collaborations. A third respondent said finalize the programs, transmit them to other laboratories, and share them with developers of battery systems. This respondent further noted that a key element has been the continued adequate funding of the program.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Comments received regarding this section were positive. The first evaluator offered that the effort is relevant and the resources necessary. The second evaluator stated that funding is adequate.

Electrolytes and Separators for High Voltage Li Ion Cells: Angell, Austen (Arizona State University) – es100



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback was generally positive in this section. One reviewer offered that there are clear targets aiming at DOE objectives. The second reviewer noted that improved electrolytes for lithium ion batteries will increase fleet electrification over time. A third reviewer indicated that high voltage electrolyte is the bottle neck for high voltage cathode. The fourth reviewer stated only if we believe that industry will go with high voltage cathodes and safety will not be compromised.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, comments in this section are generally positive. The first respondent stated that the work seems to be inspired by the work of others and is built on the best achievements in industry. The second respondent pointed out a need to set the target property for the compromised solution, such as the mixture with the conventional carbonate. A third respondent opined that the approach to sulfone-based solvents is interesting, and further offered that greater leveraging of BATT resources beyond the University of Utah would be constructive. The fourth respondent observed that while the approach is good, there is some confusion in the presentation that raises doubts about objectives and feasibility.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback from reviewers in this section was mixed overall. The first commenter observed good review of field work and improvements made, and a second commenter noted that the results are promising. The third commenter expressed that it is almost obvious that the mixture would increase the conductivity. As a result, this commenter adds, the PI needs to understand the negative impact of adding the conventional electrolyte. Furthermore, this third commenter asserted that fluorinated sulfone also needs to be investigated regarding the reduction side. A fourth commenter offered a combination of general statements in this area, as well as remarks specific to presentation slides. In general, this commenter discussed, overall results should be more clearly structured as data shared show select, mixed results but do not present an overall picture of the new work performed. Additionally, this person suggested that it would be useful to have more slides like Slide 8, but with more results. This commenter also observed that slides appear with low resolution, which makes reading difficult. Uncertainty was expressed by the fourth commenter as to whether the low resolution is the result of the conversion to a PDF or some other root cause, but requested that it be addressed for the future. The fourth reviewer

reported, in reference to Slide 3, that the "Relevance" tag states that only conductivity and high voltage are needed to improve energy density and power density, but many other components are needed as well. Specific to Slide 5, this commenter queried the significance of a visit by Toyota. Further referencing Slide 5, and noting the three different combinations of salt/solvent shown, this commenter questioned why there was no $LiPF_6$ paired with a sulfone or LiTFSI with EC/DMC to make it a more side by side comparison. Finally, for Slide 5, this person pointed out that the image shown is for methoxyethyl methyl sulfone (MEMS), but the chart data is for Trifluoroethylmethylsulfone (FEMS) and ethylmethylsulfone (EMS). Regarding Slide 6, the fourth commenter inquired about the trigger point for solvent decomposition to this group, and expressed that 0.1 mA/cm^2 seems rather large. Additionally, this commenter explained that it is difficult to judge whether it forms a good SEI or not without cycling data. Referencing Slide 12, the fourth commenter questioned the concentration of LiPF that is meant by saturated in methanesulfoneyl fluoride (MSF) and methanesulfoneyl chloride (MSCl). This commenter acknowledged the voltage stability shown for LiTFSI mixtures and conductivity for $LiPF_6$ on Slide 13, and expressed curiosity about what the converse of each looks like (i.e., voltage stability of $LiPF_6$ and conductivity of LiTFSI). Further, this commenter asked how the voltage stability of the EMS-MSF $LiPF_6$ mixture compares, and noted that it is shown on Slide 12, but at a different scale bar range that makes it difficult to do a side-by-side comparison. The fourth commenter, in reference to Slides 14 and 15, inquired about the C.E. of these CV, and observed that it is difficult to determine if lithium deposition and stripping are efficient. Finally, and in regard to Slide 16, the fourth commenter questioned whether the fluorination improved any experimentally measured property.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments in this section were mixed. While one respondent noted that the work of the collaborators is well referenced, the second respondent observed that the collaborations are limitedly described. A third respondent offered that work beyond the modeling at University of Utah should be encouraged, and that pairing with experimentalists should help get these electrolytes into cells sooner rather than later. Specific to Slide 2/17, this respondent pointed out that the work with Chen at LBNL is mentioned, but no detail given. This respondent added that Slide 2 also lists the University of Rhode Island and PNNL as partners, but their contributions are not described. The fourth respondent said the collaboration was not clear.

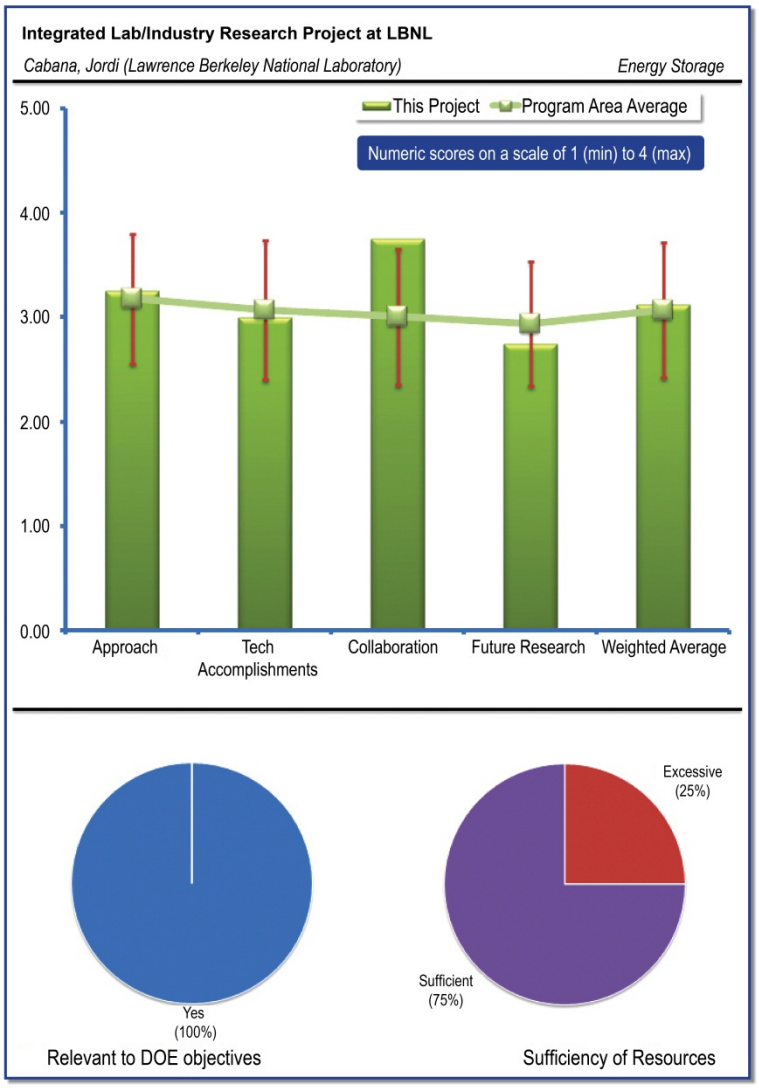
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Remarks in this section were generally negative. One reviewer stated that future work is not clearly described. The second reviewer discussed that content of future separator work, including intended materials or approach, does not seem to be defined. A third reviewer suggested that proposed future work should include cell based evaluations, and that separators are another large area of work. This reviewer also explained that it would be helpful to evaluate the performance of the sulfone in existing systems before advancing to a joint electrolyte/separator project. The fourth reviewer pointed out that more electrochemical study is needed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Feedback from the reviewers was mixed for this section. Although one reviewer indicated that funding for completed work seems appropriate, the sufficiency of resources is unknown because proposed future work content is unclear. The second reviewer opined that resources do not seem sufficient, and a third reviewer said no specific comments.

Integrated Lab/Industry Research Project at Lawrence Berkeley National Laboratory: Cabana, Jordi (Lawrence Berkeley National Laboratory) – es102



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer comments in this section were positive. One reviewer indicated that the project is relevant to DOE objectives. Another reviewer explained that use of Li metal is a big step to improve the energy, and the third reviewer offered that improvements in lithium metal anodes for lithium ion batteries can increase the level of fleet electrification over time.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback in this section was generally positive. The first respondent indicated excellent progress towards developing qualitative tools to observe Li anode upon cycling and understand the current options of the lithium anode stabilization. A second respondent observed a novel approach of leveraging a large group of researchers on one task, and added that it was interesting to compare the results of this group to the Ni/Mn spinel work group. The third respondent stated that although the project is very well integrated with contributions from ANL and LLBL, the industry part is not well specified. A fourth respondent remarked that the integrated lab work seems interesting, but the scope seems too wide.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer statements in this section were mixed. One reviewer commented that the results are interesting, but only preliminary due to the recent start of the project. This reviewer added that the results are mostly related to conventional dendrite formation and do not apparently cover the planned activities. A second reviewer noted good progress towards developing the necessary techniques to conduct future experimental work, but also identified a need to focus on the quantitative methods. The third reviewer observed that there is not a lot of data yet. A fourth reviewer offered comments specific to presentation slides. This reviewer expressed that setup, experiment, and results are poorly explained on Slide 7. Additionally, this reviewer remarked that the use of Kostecki's 4 electrode jig for lithium ceramic evaluation on Slide 8 looks promising. In reference to Slides 9 through 11, the fourth reviewer pointed out interesting work on the lithium glass, and suggested that more background on how and why these materials were chosen would be helpful.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Comments presented in this section were generally positive. One respondent noted an excellent selection of partners that should provide synergy in meeting the challenging objectives. The collaborations are adequate and well-coordinated, according to the second respondent, who also recommended that the participation of industry be enlarged due to the claimed lab/industry research approach. A third respondent observed that managing this large group and maintaining a sense of focus seems like it will be a challenge. This respondent also suggested to clearly mark out which group did what work in the future. The fourth respondent said this is supposed to be good.

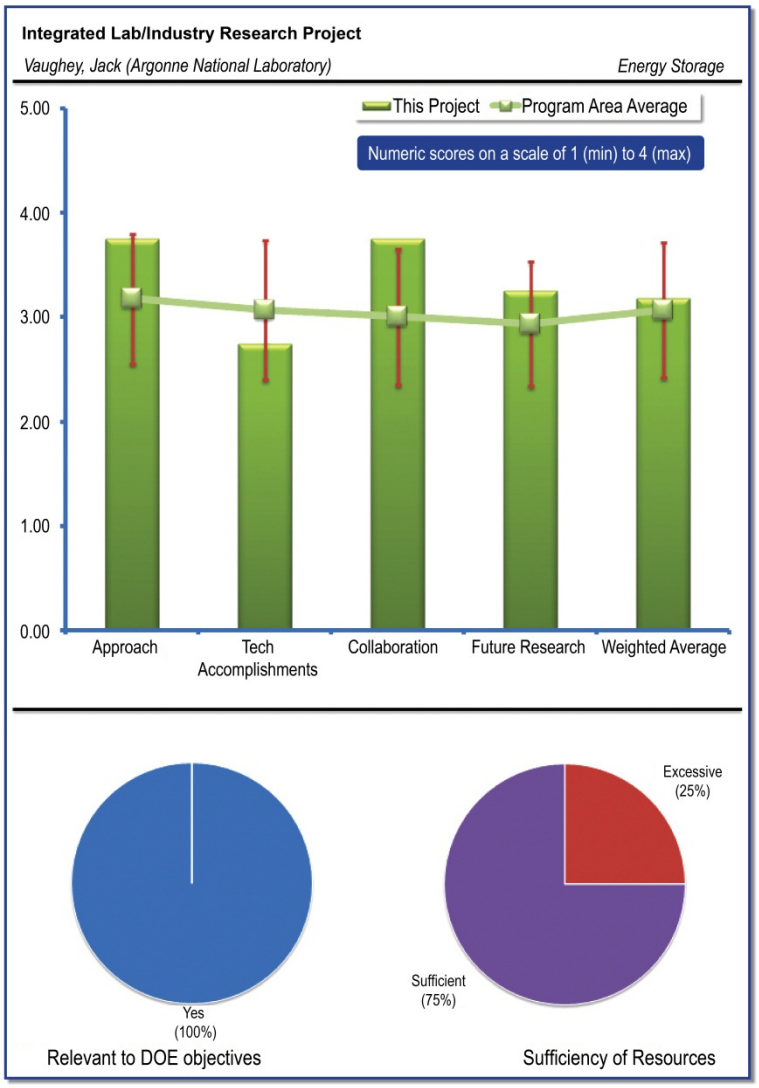
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Feedback was positive, overall, in this section. The first commenter remarked that future work looks thought-out and systematic. The second commenter acknowledged an excellent plan for periodic meetings between the partners and pointed out a great choice for the industry partner. According to the third commenter, the future work is well connected to the preliminary results even if it seems only partially connected to the overall project objectives. The fourth commenter explained that this is a long term project and suggested that the scope could probably be narrowed down more for each year.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewer comments in this section were mixed. Although one evaluator stated that the resources seem adequate, a second evaluator indicated that resources seem excessive.

Integrated Lab/Industry Research Project: Vaughey, Jack (Argonne National Laboratory) – es103



REVIEWER SAMPLE SIZE

This project had a total of four reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

Reviewer feedback in this section was positive. One reviewer asserted that the project is relevant. A second reviewer explained that many issues, including long-term historical limitations in cycle life capability of Li-metal systems, prohibit their potential for use in vehicle applications, and added that the program could be useful relative to the VTP program if it specifically serves to document the fundamental limitations. The third reviewer offered that use of Li metal is big step to improve the energy.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

Comments were generally positive in this section. The first respondent noted an excellent understanding of the challenges of the lithium metal anode rechargeability and thus, excellent selection of the techniques for the studies. The second respondent observed an adequate approach with excellent integration between ANL and LBNL expertise. A third respondent stated it is reasonable that the PI wants to improve the interfacial behavior on the Li for long life. The fourth respondent explained that the silane-based coating activity is of interest as it may apply to and enhance applications other than vehicle applications where lower cycle life capability may be acceptable.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Overall, reviewer statements were positive in this section. The first reviewer acknowledged that the project has demonstrated progress in the area of Li-metal coatings. According to the second reviewer, results are promising even if they are still preliminary because of the recent project start. The third reviewer agreed that initial results look very promising, and further offered that, in the area of coatings, attention should be given to cost of the coating reagents and coating procedures to make them scalable and thus acceptable by industry. A fourth reviewer pointed out that the silane coating is an interesting idea.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Comments in this section were positive. The first evaluator observed that the best in the field among companies/academia are working on this very challenging program. A second evaluator described the collaboration and coordination as high level with very good integration between ANL and LBNL. The third evaluator stated that this is supposed to be a good collaboration project.

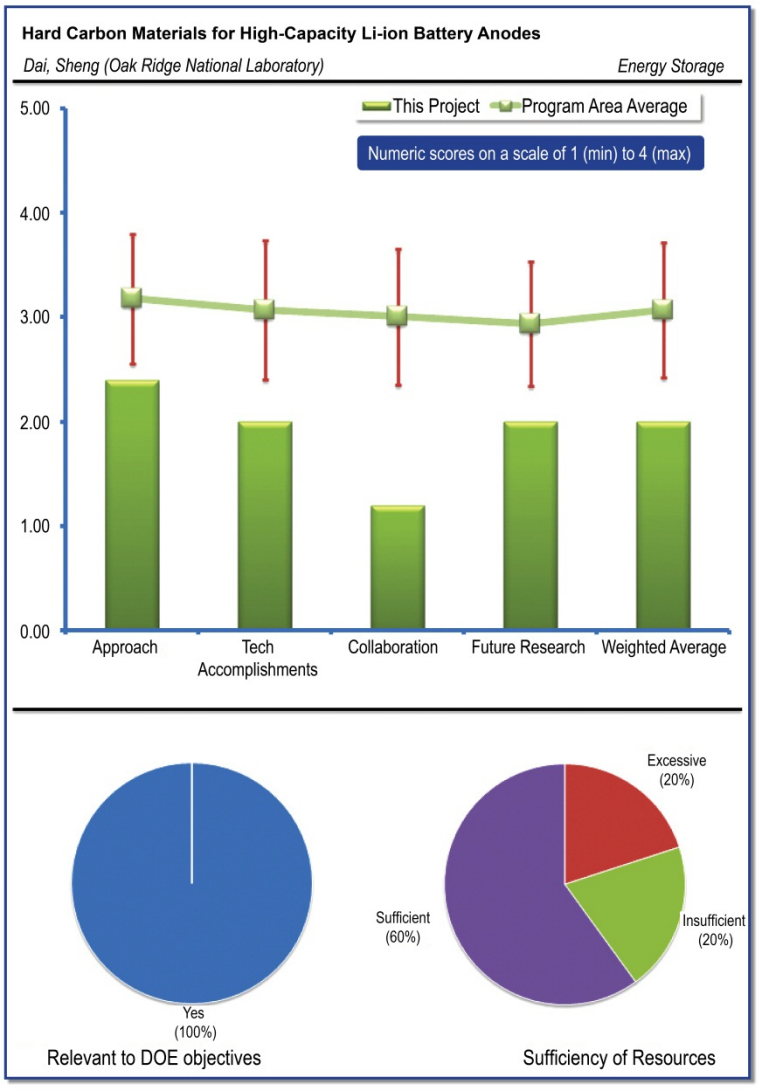
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Statements from reviewers were positive in this section. One respondent remarked that future work is defined well, and a second respondent observed that future work clearly shows the deep understanding of the challenges to be addressed. A third reviewer explained that further work with silane coatings and interfacial additives may be useful to better understand fundamental limitations. This respondent further noted that work to understand the fundamental beneficial mechanism(s) of silane coatings on Li may be useful, particularly as an alternative to further activity on ceramic lithium conductors. The fourth respondent stated it is appropriate.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer feedback in this section was generally positive. A reviewer indicated that resources seem sufficient, and a second reviewer offered no comments.

Hard Carbon Materials for High-Capacity Li-ion Battery Anodes: Dai, Sheng (Oak Ridge National Laboratory) – es104



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were generally positive. The first respondent indicated that the work on hard carbon is functional to meet DOE objectives of low cost and higher performances of Li batteries. A second reviewer offered that improvements in anodes for lithium ion batteries will improve fleet electrification over time. According to the third respondent, hard carbon is very old material but can be investigated again for a new market.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer feedback, overall, was mixed in this section. One reviewer acknowledged that the project addresses the technical barriers well with clear objectives, and that the solutions proposed are well described in terms of impact on the technical performances. However, this reviewer pointed out, it is unclear how the low cost target will be pursued. The second reviewer observed that approaches to improve cycling performance and volumetric capacities were good and provided good results. This reviewer further suggested that an approach to improve first cycle irreversible capacity should consider methods beyond the surface coating that cannot help with 40% loss. A third reviewer opined that an approach to optimizing one specific type of carbon without first surveying the existing is unlikely to lead to the barriers of cost, cycling, and energy being overcome. The fourth reviewer indicated that the PI should understand more about previous work for hard carbon because it is very old material commercialized by Sony in 1992, and it is well-known that the cycle life of hard carbon is good.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Statements in this section were generally mixed. One respondent stated that the results achieved so far are promising and well in line with the expected improvement to overcome technical barriers. This respondent observed that the cost issues are not considered and further recommended more vis-à-vis comparison with graphite. A second respondent acknowledged good results for cyclability and volumetric density improvement, and indicated that different approaches are required for the first cycle efficiency improvements. The third respondent remarked that the impact on potential energy density of significant irreversible capacity losses in the anode materials, if deployed in full cells, must be realistically considered and described. Further, this respondent added, investigation and description of power capability over a wide SOC range may illustrate additional advantages or disadvantages of the investigated materials compared to graphites. The fourth respondent mentioned that the irreversible capacity is too high, and that commercialized hard carbon has

considerably less irreversible capacity without any modifications the PI has tried in this project. The fifth respondent offered comments specific to presentation slides. Referring to Slide 4, this respondent noticed an unbalanced picture of the advantages and disadvantages of the hard carbon/graphite given. Regarding Slide 5, this respondent opined that projections of hydrocarbon (HC) suitability for vehicles based on the voltage steps are weak. Further, unless a flat profile cathode like $LiFePO_4$ is used, all cathode materials have sloped curves, as well, which must be dealt with regardless of anode voltage steps. This fifth respondent inquired about the source of the hysteresis seen in the absorption of mesoporous hard carbon (MC550) on Slide 6. Continuing to Slide 7, this respondent questioned why some tests are taken to 10C or 20C c-rates if the objective is EV batteries. In reference to Slide 10, this respondent queried how the initial carbon source was determined and optimized. Further on Slide 10, the fifth respondent noted that a great deal of the later work (e.g., Approach 1, 2 and 3) is based on this step and it seems odd to optimize so much downstream without first performing a wider survey. Additionally on Slide 10, this same respondent questioned what cathode will be used, what will be the resulting cell voltage, and how will increasing the voltage range increase C.E. if the anode will be run to 3.0V. Referring to Slide 11, the fifth respondent observed that the surface coating of ppy appears to reduce the rate capability of the standard and queried how cycle life was improved based on the chart shown. In regards to Slides 12 and 13, this respondent questioned whether the same boost in conductivity shown on Slide 12 can be derived from a cheaper alternative to CNT, such as carbon black, acetylene black, or vapor-grown carbon fiber (VGCF). Considering Slide 14, this respondent reported that the C.E. improved 3% through the coating, which seems within the margin of reproducibility of handmade cells, and inquired about the sort of reproducibility seen. This fifth respondent questioned how cycling was improved based on the chart shown on Slide 16 and further offered that it seems the untreated version had higher capacity values. Regarding Slide 18, this respondent inquired about the size and morphology of the commercial Cr_2O_3 and whether it matched the composite. Further on Slide 18, this respondent queried whether the loading of 57% Cr_2O_3 to the reminder carbon matched the composite in the electrode, and how much of the Cr_2O_3 is electrochemically active. This respondent noted that in Slide 16, the pure MC550 had a capacity of about 1,000 mAh/g, while the composite MC550-Cr2O3 on Slide 18 had a capacity of around 600 mAh/g with 43% MC550. Further, this fifth respondent suggested that a pure MC550 voltage curve next to the composite should be shown on Slide 18.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Overall, comments in this section were negative. One evaluator offered that interaction or collaboration with a significant international supplier of Li-ion anode materials and/or a significant international supplier of Li-ion battery cells would be extremely beneficial for this project. Further, this evaluator added that the current level of collaboration, if any, is unclear. A second evaluator remarked no evidence was presented for either academia or industry collaborations. The third evaluator asserted that no external collaboration was identified, and a fourth evaluator agreed that there were no collaborations indicated. This fourth evaluator further mentioned the involvement of other institutes working on anodes and the participation of selected industries would be beneficial in fully overcoming project objectives. A fifth evaluator stated that no collaborations were seen.

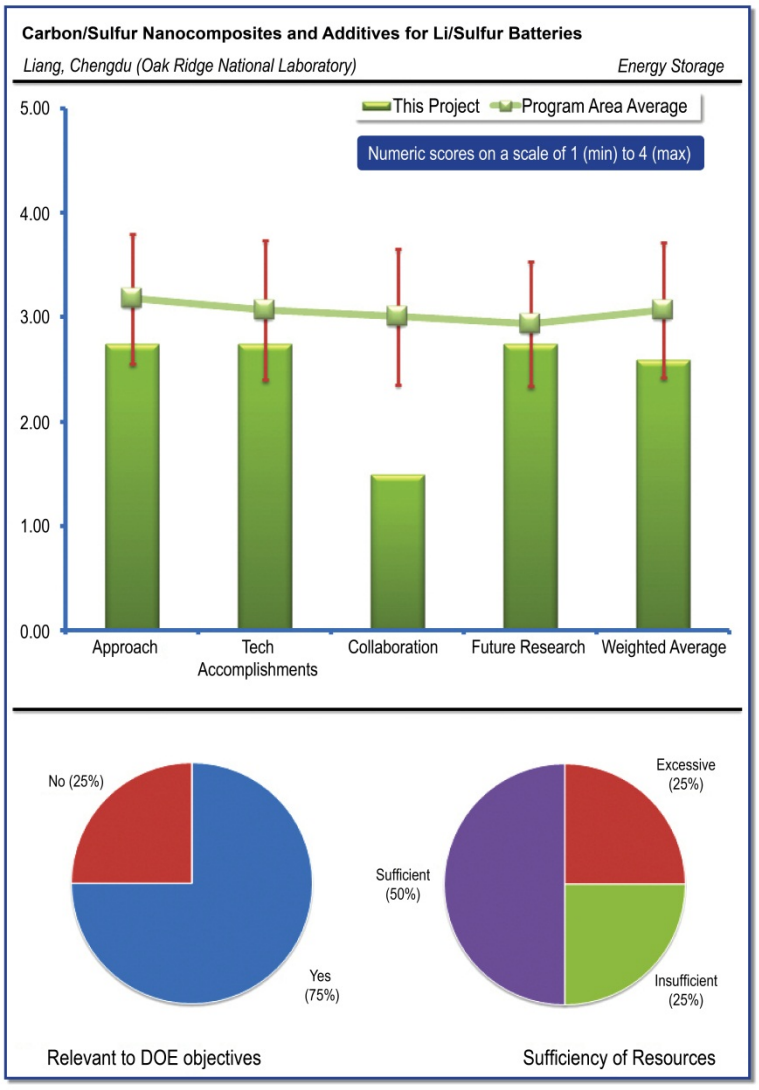
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Feedback was mixed in this section. The first respondent pointed out that further investigation into methods to reduce initial irreversible losses is planned and significant success in this area will be critical. The second respondent explained that the proposed prosecution of work is reasonable, but lacks some useful integration with well identified collaborations and inputs for introducing estimating cost aspects. Moreover, this respondent added, the proposed modification of carbon with CrO_2 seems limited and not sufficiently and clearly extended to alternative additives. A third respondent suggested that, before attempting to optimize one particular material, the researchers should survey the available materials to make sure an appropriate material to work on is selected. Further, this respondent added, existing commercial grade materials should be used as controls when comparing the results of their materials. The fourth respondent recommended that the PI should get the hard carbon that is commercially available for comparison. A fifth respondent said not clear and too general.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewer comments were mixed in this section. Although one reviewer indicated that resources are judged appropriate for an enlarged effort with other materials and analysis, a second reviewer observed that resources seem insufficient.

Carbon/Sulfur Nanocomposites and Additives for Li/Sulfur Batteries: Liang, Chengdu (Oak Ridge National Laboratory) – es105



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback in this section was generally mixed. One reviewer described exploratory work on Li-S towards DOE objectives, and a second reviewer opined that Li-S has the potential to increase energy density. A third reviewer observed no evidence that Li-S systems as a sub-class of Li-metal systems can ever achieve sufficient cycle life for automotive applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were mixed in this section. The first evaluator offered that the approach is holistic and targets all reactions in the Li/S cell, including corrosion issues of the cell parts. Although the second evaluator indicated that the project is properly addressing key technical barriers with reasonable objectives, this person pointed out that the integration with other efforts is limited to ORNL. The third evaluator said it was clear that the issue is S dissolution and Li_2S formation. A fourth evaluator identified that the primary focus of work appears to be on cathode side, when Li-metal anode issues may be the most fundamental problem.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The statements in this section were generally positive. The first respondent observed good results, specifically on the design of the sulfur electrodes and suggested catalytic process assisting with Li_2S reversibility. Results are promising and good in consideration of the start of the project, according to the second respondent. A third respondent explained that the cathode-side activity and accomplishments are valid and of value for non-automotive applications, after ignoring fundamental anode-side limitations and automotive applications. The fourth respondent remarked that it seems micro porous carbon could improve the S dissolution, but it is still far from the practical level. This respondent further noted that more significant breakthrough seems needed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Overall, feedback from reviewers in this section was negative. The first evaluator pointed out that the collaborations are limited to ORNL and no exploration has been done to identify other participants, particularly on the Li anode part, which seems to be a critical issue. No collaborations outside of ORNL were seen by the second evaluator. A third evaluator observed that there was not enough information on collaborative efforts.

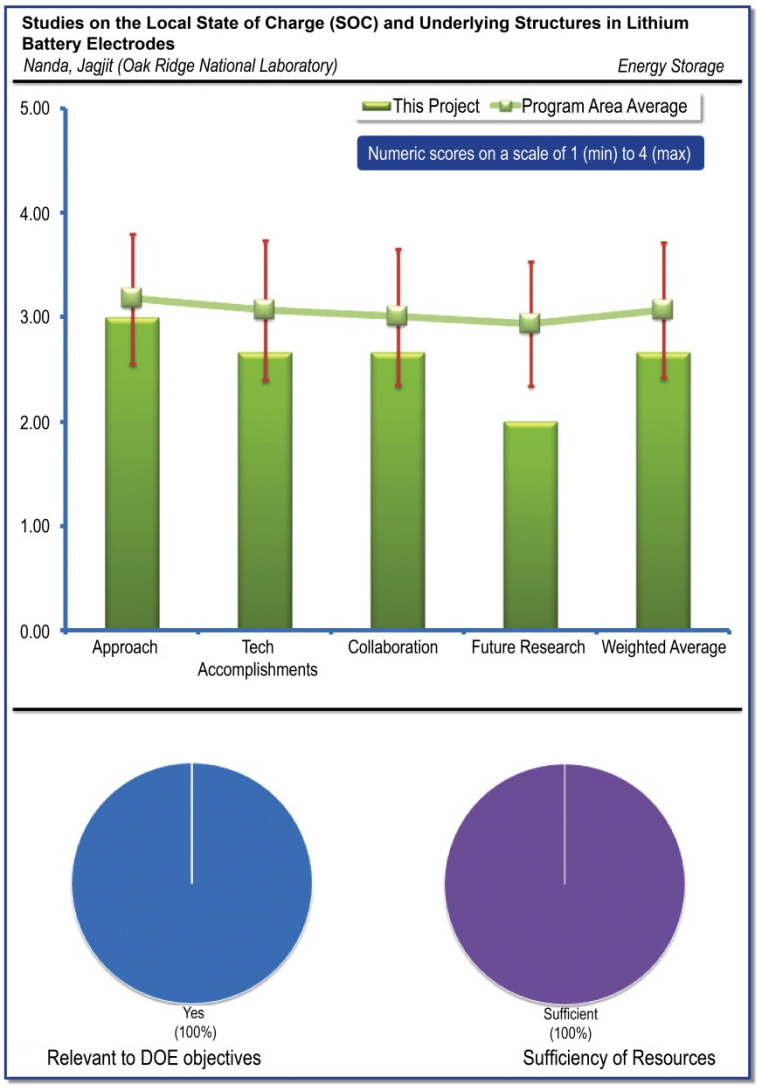
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Comments in this section were generally mixed. The first reviewer stated that the plan addresses the objectives well, and the second reviewer offered that the proposed plan is reasonably connected to the achieved results, even if more details are necessary to better understand the real work planned. This second reviewer further added that the focus on Li metal anode seems an open question that is not clearly addressed. A third reviewer remarked that significant breakthrough is needed.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Feedback from reviewers was mixed in this section. Although one respondent considered the resources adequate, the second respondent suggested that resources seem insufficient.

Studies on the Local State of Charge (SOC) and Underlying Structures in Lithium Battery Electrodes: Nanda, Jagjit (Oak Ridge National Laboratory) – es106



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall, statements from reviewers were positive in this section. The first reviewer remarked that analysis of aging mechanisms is useful in improving Li cells towards DOE objectives. A second reviewer offered that an in-situ technique is a good method to understand the phenomena in the cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer feedback in this section was generally positive. One respondent expressed that it is interesting to understand local SOC in the electrode. A second respondent explained that the approach is good addressing limited, but well defined barriers, with limited integration with other activities. The third respondent highlighted that although the project has milestones and well defined tasks, the approach is not well defined.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally negative in this section. The first commenter requested to see how local SOC differences can be relaxed by time and by the electrode structure. The data presentation requires more clarity and reference to the objectives, according to the second commenter. A third commenter agreed that the results were limited and not clearly presented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Feedback from reviewers was generally positive in this section. One reviewer indicated that some collaboration exists, while the second reviewer noted limited collaboration.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Comments in this section were generally negative. The first evaluator stated that future research is not explicitly present, and it probably implies to be a work in progress. A second evaluator opined that the proposed plan needs to be redefined and better specified. The third evaluator agreed, and highlighted the need for more definition of future work.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

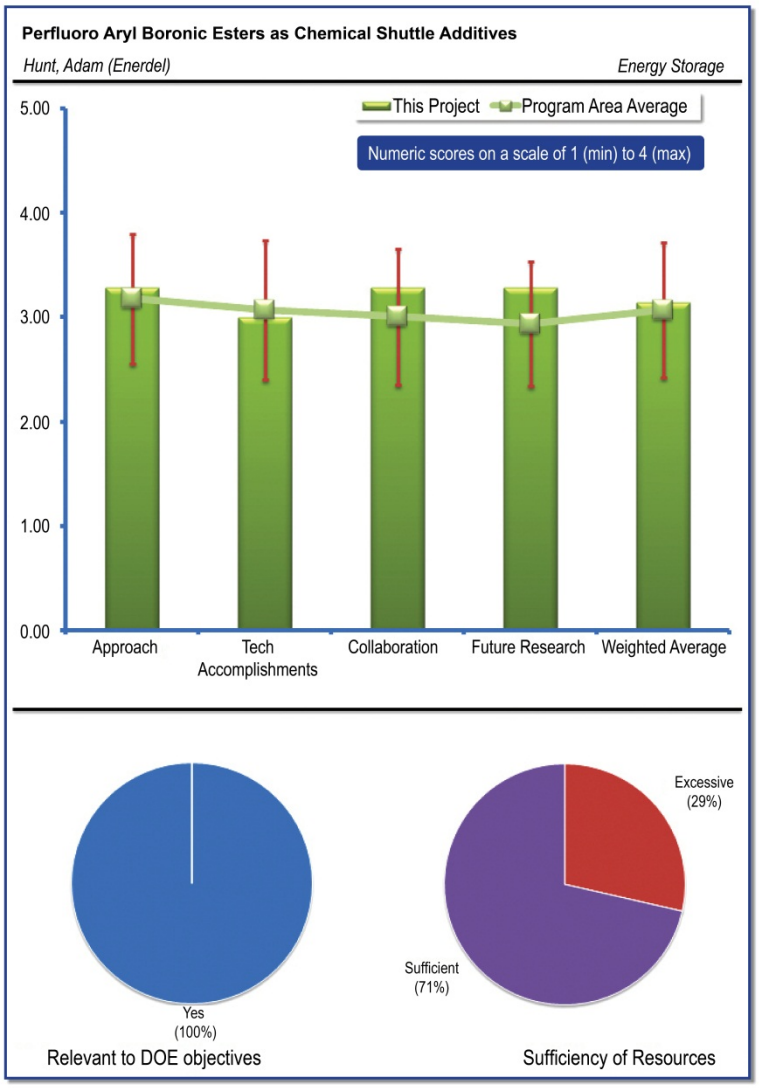
Overall, comments were generally positive in this section. One reviewer indicated that resources seem sufficient, while a second reviewer offered no specific comment.

Perfluoro Aryl Boronic Esters as Chemical Shuttle Additives: Hunt, Adam (Enerdel) – es107

Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?



Reviewer statements in this section were positive. One reviewer asserted that the project sufficiently supports DOE objectives. A second reviewer described that this project is aimed at developing redox shuttles for Li-ion cells to improve their safety and reliability, which is consistent with DOE goals of reducing petroleum consumption and GHG gas emission by replacing conventional automobiles with battery-powered hybrid and electric vehicles. Unlike aqueous rechargeable batteries, this reviewer adds, Li-ion chemistry is not tolerant to overcharge; poor cyclability and safety are an ultimate result of the cathodes, anodes, and electrolytes undergoing degradation. Currently, this second reviewer explained, a bulky and costly solution to avoid overcharging Li-ion cells is using smart electronics. Further, according to this reviewer, redox shuttles undergo oxidation at the cathode at the potentials corresponding to the overcharge potentials of the cathode, and reduction at the anode during overcharge. Finally, the objective here, as described by this second reviewer, is to develop a redox shuttle compound and employ it in a large format Li ion cell. A third reviewer offered that these shuttle additives are "outstanding" development toward safe implementation of batteries. Overcharge of a cell in a battery can lead to a catastrophic event and must be avoided, warned the third reviewer. This reviewer added that chemical shuttles could provide a means to prevent the explosion of a unit cell. A fourth reviewer indicated that the success of the chemical shuttle will help with the reduction of cell monitoring and balancing in a battery pack, which may help with the overcharge protection. Finally, a fifth reviewer said provides simpler mechanism for cell balancing, improving safety and robustness for lithium ion batteries for EV, hybrid electric vehicle (HEV), and PHEV applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback was generally positive in this section. One evaluator observed that results of molecular orbital modeling suggested that perfluoro Aryl Bodonic esters would be a good means to mitigate overcharge and control the cell voltage in a safe region. The second reviewer identified an interesting approach to improve Li cell safety. The third evaluator described that the approach is to test existing shuttles and not invent shuttles. Further, this evaluator noted, results could be available from the shuttle supplier. A good, general approach to test candidate redox couples for various requirements was acknowledged by the fourth evaluator. This evaluator pointed out that it seems cycle voltammetry or literature information can be quicker and more valuable than molecular orbital calculations. Furthermore, this fourth evaluator offered that in view of multiple requirements and narrow voltage range targeted, it may be necessary to screen test several dozen materials. This evaluator also suggested that there needs to be some additional thought into how to develop and acquire an ample selection of materials. A fifth evaluator reported that the approach in developing new redox

compounds functioning in the desired voltages range included identifying new shuttles through molecular orbital (MO) calculations, verifying their electrochemical potentials, reversibility, and compatibility, and maximizing conditions for rapid diffusion of the oxidized species to the anode. This evaluator added that a new class of redox shuttle agents based on fluorinated 1,3,2-benzodioxaborole (BDB) was developed by ANL for NMC cathodes and is being evaluated in this project. Combined with the performance assessment, this fifth evaluator stated, the effects of redox additives on the anode SEI are also being addressed to ensure that the cell performance is not adversely affected by the addition of redox compound to the electrolyte. The fifth evaluator continued that even though the redox shuttle approach looks elegant, there are serious and insurmountable issues of kinetics (e.g., reversibility, solubility, diffusion between the two electrodes) and finally, its longevity for a good cycle life, etc., to make this approach feasible. This same evaluator highlighted that similar efforts on this approach have been ongoing for years for different cathode systems with little success.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were mixed. The first respondent observed promising results. The second respondent reported that a model of tech process was developed to understand interactions with the cell components, especially the surface of the anode SEI layer. This respondent added that the choice of additives to form the SEI layer had an influence on performance, and that work is continuing to evaluate other shuttle molecules with improved performance. A third respondent described interesting work and interesting results. This respondent also noted that the three candidate materials reported were studied somewhat extensively and maybe too extensively. All were unsuitable for various reasons, as reported by this respondent, because of voltage, chemical incompatibility, and/or stability issues. Although these extensive studies provide interesting information to write a scholarly paper, this third respondent opined that they will not lead directly to a solution to the problem. This respondent also pointed out a need to recover from being behind schedule and specified that finding a way to get more candidate materials to test and testing them quickly is needed. Finally, this third respondent questioned if it is possible to find a redox couple such that the redox voltage can be tuned by chemical adjustment. The fourth respondent opined that technical accomplishments and progress achieved in this project are only modest. Specifically, this respondent noted, three redox shuttle molecules were evaluated without any success. The redox additive BDB showed incompatibility with the anode, thickened its SEI, and required further adjustments to the electrolyte (LiF addition), as explained by this respondent. Yet, this respondent added, its stability was not adequate, losing the redox function after one cycle. This fourth respondent opined that this work has become more academic with papers than being of any value in the near future, and explained that a couple of other redox shuttle were examined with different voltages and for different cathodes, without any success yet. Finally, this respondent emphasized that these modest accomplishments only underline the difficulty associated with the approach of adding redox shuttles to the electrolyte for built-in overcharge for Li-ion cells.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer statements were generally positive in this section. The first reviewer observed a good network of collaborations, and the second reviewer highlighted good collaboration with Purdue University and ANL. A third reviewer reported that Purdue University and ANL have collaborated in the work and contributed to the progress. The fourth reviewer explained that there is good, ongoing collaboration in the development of these redox additives with ANL and also with Purdue University in the assessment of and understanding the behavior of these redox compounds. The fifth reviewer suggested that 3M should be included in the list of collaborators because they have many years of experience with various chemical shuttles.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

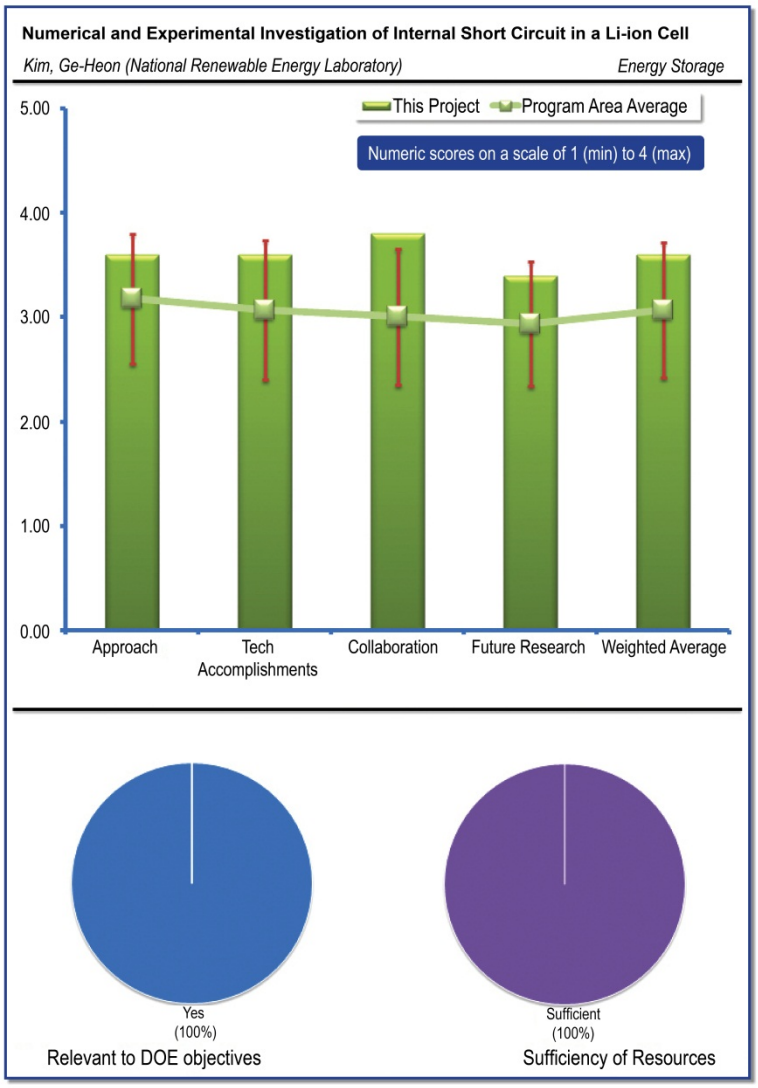
Comments in this section were generally mixed. The first evaluator stated that there is an adequate plan for future work. The second evaluator asserted that the proposed work is right-on what is needed, and further added that more experimental information is needed to arrive at the best redox shuttle molecule. A third evaluator explained that future plans are to continue the development of new redox shuttle molecules being developed at ANL for different cathodes (NMC, NCA or LFP), characterize them, and demonstrate their efficacy in large full cells. This evaluator subsequently remarked that future work appears logical, and suggested that it is better to

look at such redox additives being developed elsewhere in non-DOE laboratories. The fourth evaluator identified that the plan needs to be adjusted to recover from the missed FY2011 milestone.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Overall, feedback was mixed in this section. One commenter described the level of support as adequate, and a second commenter offered that resources are okay. The third commenter indicated that the program can be tailored to answer the fundamental questions of durability and effectiveness of the already known shuttles from 3M at a lower cost. A fourth reviewer expressed that resources are a little excessive for the project, which is still academic in nature.

Numerical and Experimental Investigation of Internal Short Circuit in a Li-ion Cell: Kim, Ge-Heon (National Renewable Energy Laboratory) – es109



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Positive remarks were received in this section. The first respondent asserted that the safety aspects are key to DOE objectives. A second reviewer explained that safety and reliability are key concerns regarding the introduction of high performance lithium ion batteries for HEV, EV, and PHEV applications, and have been a commercial barrier. Further, this reviewer highlighted that this work provides valuable insight on how to reduce serious safety risks for lithium ion batteries. According to the third reviewer, the internal short circuit is very difficult to sense and may have safety consequences. A fourth respondent emphasized that internal short circuits are the bane of Li-Ion batteries and every means must be used to identify the cause and prevent the internal shorting of a battery.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, reviewer feedback in this section was positive. One person indicated that the use of computer aided design speeds the solution to the problem and provides a fundamental base to identify and prevent internal shorting to occur. This person added that a means to induce an internal short has been developed and implemented in experimental cells to prove the calculations and provide a means to eliminate shorting in production cells. The second person reported that this addresses key barriers related to safety and reliability by modeling and quantifying the consequences of cell shorting. Additionally, the second person explained that it provides insight on how to design more safe cells and assess the shorting hazard based on cell design. Furthermore, according to the second person, both numerical modeling and experimental verification and testing are included in a creative and unique approach. A third reviewer observed a good project with a correct application of models. The reviewer said it may be helpful to model a scenario to simulate an internal short circuit which is seen in 18650 cells one out of multimillion times.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments in this section were generally positive. The first commenter stated that the results are very promising. A second commenter observed that unique insight has already been provided on how design affects shorting safety, and that this model can provide a tool to better develop specific batteries by manufacturers to evolve towards safer designs. This commenter acknowledged good, active collaboration with one or more battery companies, national labs, safety experts, and consulting. The third commenter explained that programs have been developed that are powerful in identifying the cause at an early stage such that individual problem cells can be

eliminated and/or bypassed in a vehicle battery. The combination of a test method and modeling may help to validate the model, suggested the fourth commenter.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Statements from reviewers in this section were positive. The first evaluator observed good, active collaboration with one or more battery companies, as well as collaboration with national labs, safety experts, and consulting. A second evaluator noted a proper and well organized group of collaborations. The third reviewer reported that the experimental cells have been made by Dow Kokam. Furthermore, this evaluator indicated that the National Aeronautics and Space Administration (NASA) has tested the shorting device and an expert consultant in battery testing and safety has been used in the program.

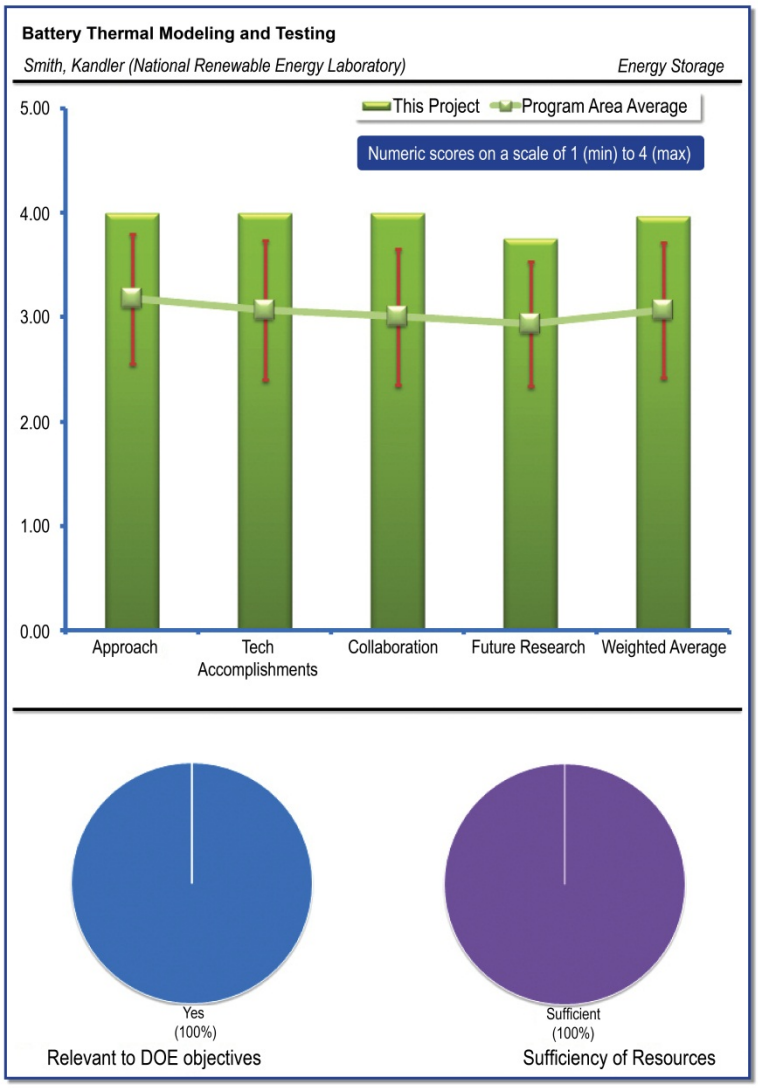
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Feedback was generally positive in this section. One reviewer acknowledged an appropriate and clear plan for future work that is correctly based on achieved results. The second reviewer asserted that this powerful methodology must be shared and adopted in DOE programs, especially those related to batteries for transportation and energy storage. A third reviewer suggested to compare the battery industry experience with the safety issues associated with the cell internal short to validate the model and simulation. Further, this reviewer continued, the results of this research should answer the frequency and intensity of internal shorts in the existing cell populations.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Comments in this section were generally positive. The first commenter asserted that money has been well spent, and the key has been the continued funding of the program to enable full project completion. A second commenter observed that resources are okay.

Battery Thermal Modeling and Testing: Smith, Kandler (National Renewable Energy Laboratory) – ess110



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback in this section was positive. One reviewer indicated that thermal testing is a necessary support to DOE objectives. A second reviewer explained that proper thermal management is required for battery systems for EV, HEV, and PHEV applications to enable safety, reliability, and life goals to be met. Further, this reviewer added, thermal modeling is an invaluable tool to the efficient development of effective thermal managements systems that enable battery pack system to still meet weight, packaging, and cost constraints. The third reviewer noted that thermal behavior of Li-Ion batteries in transportation is the key to safe operation and avoiding a catastrophic incident.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Statements in this section were positive. The first commenter offered that the ability to accurately characterize the thermal behavior battery system in order to avoid a catastrophic incident is essential to the success of electrification of energy storage and transportation. Additionally, this commenter pointed out, this project is one of the three programs that are essential to the overall, DOE electric vehicle program and go to the core of the technology. A second commenter observed a dual approach of world class thermal and calorimetric measurements capability coupled with numerical modeling, which is an excellent combination. The third commenter described a well-organized and focused project with a convincing approach combining various advanced tools to improve knowledge and extreme behavior of Li cells, modules, and batteries.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Positive feedback was received in this section. One evaluator noted an impressive and well-described amount of experimental and simulation results with a clear view and relevant progress. A second evaluator pointed out excellent work as has been historically true from this lab, and further acknowledged good, new measurements and modeling. This evaluator also remarked that the trade-off of studies with geographic effect is a practical problem that vehicle developers and manufacturers face. The third evaluator explained that accurate models of cells in a battery have been developed and should be used in all appropriate parts of the DOE program. Further, the evaluator said, this allows rapid characterization of thermal behavior as well as modeling of the overall performance of a battery system. Additionally, problems can be identified and removed before they occur in a particular cell and battery design. This

third evaluator also indicated that implementation across the board will speed development of safe battery systems by all parties in the game.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were positive. The first reviewer observed a well-organized network, and a second reviewer asserted that the three posters from NREL were a highlight of the conference. The second reviewer added that implementing this capability in all DOE battery programs is essential and will seed the introduction of safe, powerful batteries for EV, PHEV, and HEV applications.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, reviewer feedback was positive in this section. One respondent stated that this work provides a good example of the benefits of computer modeling, and suggested this approach should be applied in other, appropriate situations. The ability to finish the model was a key element in success. Often, this respondent continued, management stops this type of program just when it is in a position to deliver the fruits of the effort. The second respondent noted clear and acceptable planning.

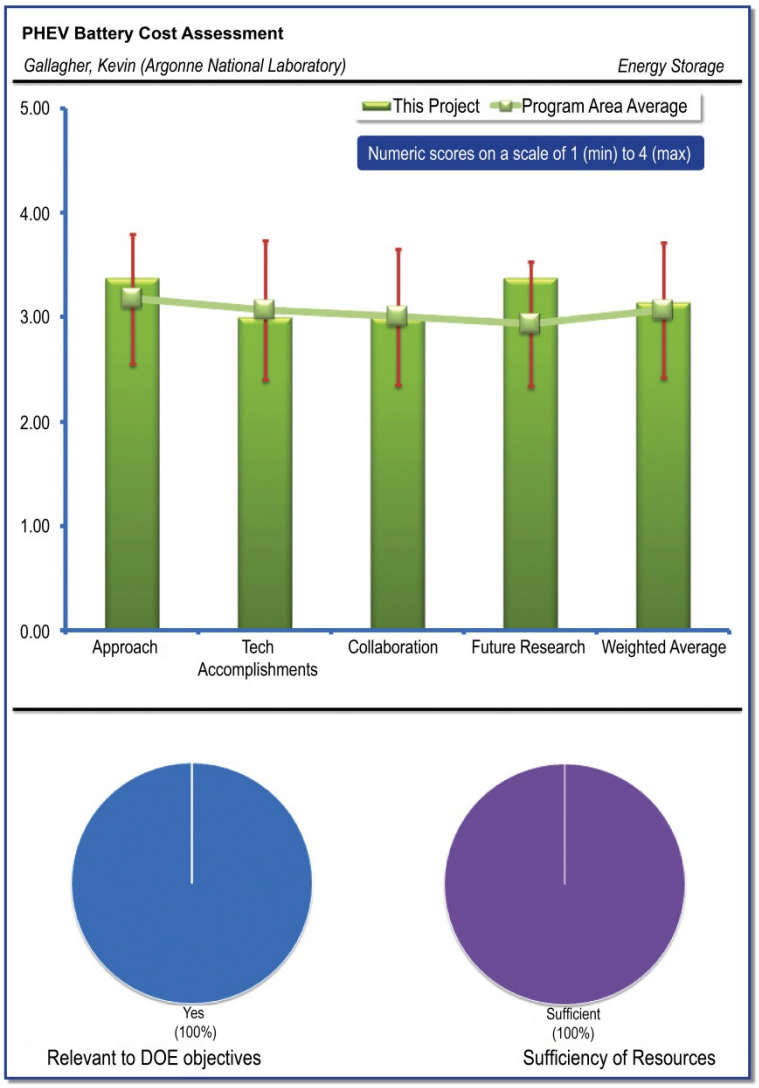
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Remarks in this section were generally positive. The first evaluator expressed that resources are adequate for the mission. A second evaluator explained that the resources are strongly dependent on the number of chemistry and designs analyzed.

PHEV Battery Cost Assessment: Gallagher, Kevin (Argonne National Laboratory) – es111

Reviewer Sample Size

This project had a total of eight reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. The first respondent offered that the project provides information that automotive OEMs can use to help determine the feasibility of using PHEV batteries and other hybrid battery approaches to help reach their 2020 fuel economy goals and reduce the use of petroleum, which is a DOE objective. A second respondent explained that this project is quite relevant to the overall DOE goal of partly replacing conventional vehicles with hybrid or electric vehicles to minimize national dependence on petroleum resources. Additionally, this respondent emphasized the high cost of batteries for PHEVs as a serious issue from the manufacturers' perspective that requires considerable attention. This respondent also remarked that the overall objective is to develop cost assessments, based on appropriate models, for predicting cost and performance characteristics for battery pack values from bench-scale results and for predicting methods and materials that enable the manufacturers to reach cost goals. Further, this second respondent stated, the objective is in support of an overall goal of developing a PHEV-40 with a price that is less than $3,400, a weight not exceeding 120 kg, and a volume within 80 liters. Finally, this respondent noted, these studies will assist in overcoming the cost barrier for Li-ion batteries for vehicular applications, if successful. A third respondent mentioned that the cost assessment is correctly prepared and relevant to DOE objectives. The fourth respondent stated that cost is always an issue, and a fifth respondent stressed that meeting cost goals are very critical to the success of electrification automotive vehicles. The sixth respondent agreed that cost is the biggest barrier to the introduction of hybrid vehicle technology capable of providing substantial reduction in vehicular petroleum consumption. This respondent further added that this work provides useful information on the impact of recent lithium-ion battery technology on cost, and specified that both the absolute and relative information are useful. Furthermore, this respondent opined that this work will provide software for cost estimation to the battery community at no cost so the industry can make use of tools developed here. A seventh respondent explained that cost projections are essential to battery evolution and market development of EVs. This respondent acknowledged that this project does follow a methodological approach for cell projections, but does need to include some control system and pack level cost projections to make it complete. This reviewer observed that it would also be interesting to do a detailed comparison between this model and Tiax.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, feedback in this section was generally positive. The first commenter reported that the approach adopted here was based on designing a battery and the required manufacturing facility in consideration of power area-specific impedance (ASI) and energy

requirements. Thus, said this commenter, reach cost goals by obtaining performance and cost calculations for advanced Li-ion electrochemical couples (lithium- and manganese-rich [LMR]-NMC, LNMO, Gr-Si composite), and predicting the required materials and processes. This commenter acknowledged that the approach is based on similar models developed at ANL in the past and utilizes the likely production costs for OEM manufactures in 2020. The first commenter explained that both the design and cost are coupled in the model, which quantifies the impact of underlying properties on the total battery pack cost such as cell chemistry, parallel cells, electrode thickness limits, power-to-energy ratio, etc. Finally, this commenter indicated that the project is well designed and integrated with other developments in materials and cell fabrication. A second commenter remarked that the use of a single spreadsheet is an excellent idea and will be very useful for battery developers to estimate the cost of their batteries. The third reviewer commented that developing an accurate model is a key to creating valuable information on process and product cost. A fourth commenter observed that the technical and economic barriers are well identified with a convincing approach based on modeling cell performances, and cost and manufacturing needs for cell optimization and applicability. Because references are minimally made to complete battery systems, this commenter did caution that some conclusions and comparisons with DOE targets may be misleading. The fifth commenter indicated that cost analysis is important and it is good to see multiple programs funded in this area. Although the approach seems comprehensive from first principles, this commenter pointed out that the presentation was not clear on the full plan in this new program. Further, this commenter noted, the objective to provide this tool free to battery developers increases the value of this program for the U.S. battery and vehicle industries. A sixth commenter asserted that the approach met the project goals in providing a model that can be used by a battery supplier and an automotive OEM in determining the cost of a plant and the viability of using a PHEV battery system for a particular application. However, this commenter remarked, the approach does have limitations in that it is not clear that the model is flexible enough to support different cell designs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback in this section was positive, overall. The first person stated that accomplishments this year met expectations. A second reviewer described that a spreadsheet has been developed to simulate a realistic production line, and it can be adapted to other chemistries and production situations. Further, this person added, a performance model has also been developed to provide input to the cost model. The third reviewer observed that the project met the stated goals and delivered desired results on time, but did note that a suggestion is to see validation of the model based on an existing cell and how well the model projected the cost and manufacturing details for that cell. This reviewer felt, however, that the project more than met the stated project goals and the model will be a valuable tool for automotive OEMs. A fourth person offered that the progress is significant in the direction to solve addressed barriers. Availability of a public model may be effective in improving the tool with feedback from various users, remarked this reviewer, though it is unclear how use of the publicly available tool may be managed by the PI to improve its usability. The fifth person acknowledged that reasonably good progress has been achieved in carrying out the cost analysis for PHEV application batteries, and the results are not unexpected. Specific accomplishments, as reported by this person, include the following: (i) development of a fully integrated Li-ion design and cost model into a single spreadsheet; (ii) demonstration of potential cost reduction from increased electrode thicknesses and large-format pouch cells; and (iii) calculated cost reduction from advanced Li-ion cathode materials, including the high capacity layered-layered composites and the performance requirements necessary to realize savings. This fifth reviewer identified one difficulty associated with this model, which is that it is heavily based on area-specific impedance data from ANL. The person further noted that DC impedance data is a strong function of the test parameters (current step, pulse duration and the test-vehicle), and that the model will instead be robust if it is based on the real-time performance data from the manufacturer's prototype cells. Finally, this fifth reviewer suggested that a more direct collaboration with the manufacturers of one or two representative chemistries, in terms of using their electrodes/cells data, will add credibility to these analyses and to the conclusions from this study. A sixth person criticized that results were not well organized and results were not profound at this early stage in the project. Furthermore, this person asserted that more is expected in the future.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Remarks were mixed in this section. The first reviewer reported that a wide range of groups, companies and people provided input to the model. The project involved all of the partners needed to deliver a meaningful product, according to a second reviewer, but the third reviewer observed limited collaborations with other institutions and organizations. This third reviewer suggested that some contributions of manufacturers and other component developers may be beneficial in refining the model and extending its applicability

to various cell designs and materials. A fourth reviewer remarked that there are no external collaborations here, and it is entirely an ANL in-house effort. This reviewer offered that a more direct collaboration with the battery manufacturers will be greatly beneficial. The fifth reviewer expressed that it was not clear how, in the future, this will evolve in relation with CAEBAT. A sixth reviewer said that it was good to hear about peer review and would like a follow-up on the recommendations of that next year.

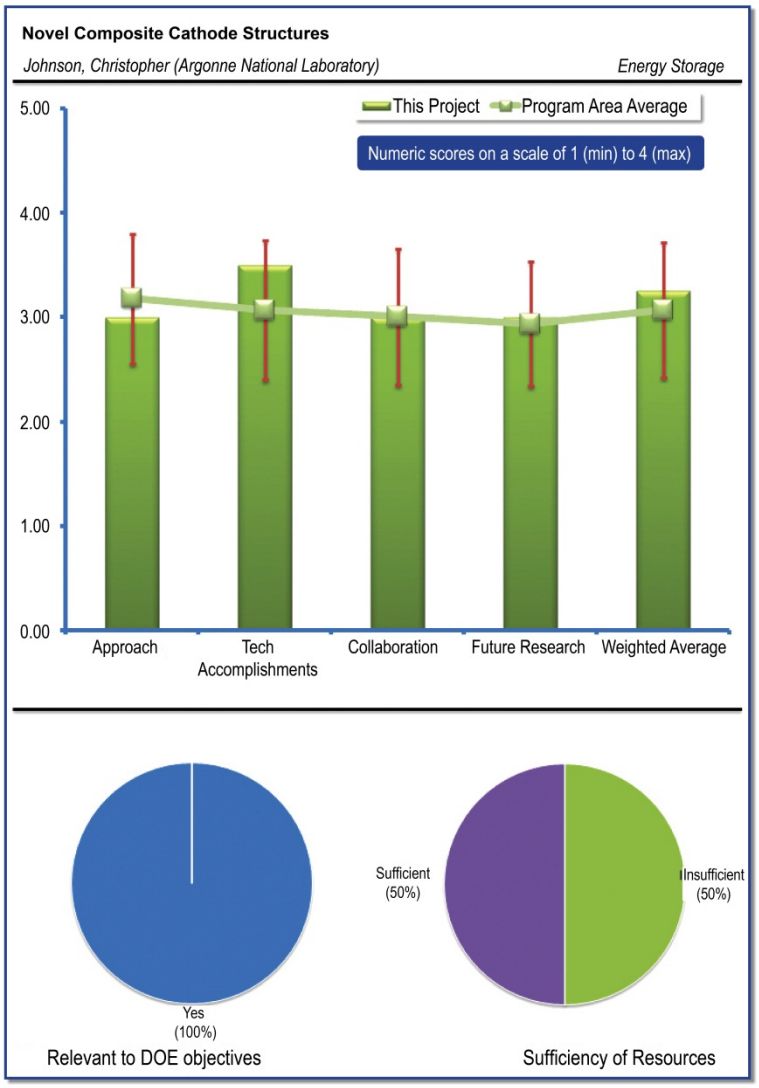
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was generally positive. One evaluator reported that the proposed future research includes the following: (i) advancing the thermal management portion of design and cost model; (ii) estimating cost reduction from advanced negative and positive electrode materials; (iii) further refining the model input parameters; and (iv) identifying battery pack integration component costs though collaboration. The second respondent observed that future project plans include adding a thermal management portion to model. This reviewer further suggested that different thermal management options be included in the model and that the model include self-contained cooling and heating systems. A third respondent indicated that planned activities for the coming year are appropriate and consistent with the work already done. However, this respondent opined that extension only to thermal management without considering the rest of electronics required (as the battery management system [BMS]) slows down completion of the model too much. The fourth respondent acknowledged that incorporating a thermal management model should be interesting, and the project at NREL can provide good input to this phase.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Overall, comments in this section were mixed. The first commenter stated that adequate resources are available, and the second commenter agreed that resources are adequate for the planned effort. The third commenter observed that the project involved multiple partners and accomplished the project goals at minimal cost. According to the description of the work and the proposed future work, the fourth commenter opined that the estimated budget is considered more than adequate.

Novel Composite Cathode Structures: Johnson, Christopher (Argonne National Laboratory) - es115



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Feedback was positive in this section. The first reviewer described that this project focuses on developing new cathode materials that can offer higher energy density, and noted that batteries are the prime candidates for HEVs and PHEVs, which are the viable, near-term solution to reducing petroleum consumption. The second reviewer indicated that cost and high thermal stability of cathode materials are central issues when trying to increase the battery range.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments in this section were generally positive. One commenter observed an interesting approach and that ion-exchange seems to be producing interesting powders. This commenter suggested that the authors later also focus on cost and possible steps to improve the synthesis of these materials. This first commenter also noted that the plausible mechanism of ion-exchange, where a shear of the crystal lattice seems to be taking place, was impressive. Further, according to this commenter, the TEM results shown in Slides 11 and 12 are very impressive and new. The results shown at different c rates are also impressive, asserted this first commenter. A second commenter reported that precursor materials based on sodium are ion exchanged with lithium. This commenter further added that they could become useful for sodium batteries even though the practical application of these materials is questionable because the ion exchange reactions for industrial production can increase the processing/manufacturing cost of the materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Remarks in this section were generally positive. The first evaluator pointed out that it is outstanding for a project that started only this year. A second evaluator offered that high capacities have been achieved with these materials and the cycle life is also good. However, this evaluator noted, they are not superior to some of the layered oxides already known to exhibit high capacity.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive in this section. One respondent observed that most of the collaboration is with ANL, which is natural, and identified some collaboration on TEM with Michigan Technology University (MTU). The second respondent recommended that the authors should try to collaborate with U.S. companies in the future. Acknowledging that it is not easy, this respondent suggested that the authors should try to find a way of doing that.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Feedback from reviewers in this section was generally positive. The first reviewer indicated that future work is focused on doping, thermal stability, and transport measurements, which is a natural extension. A second reviewer offered that tests on full cells should be strongly pursued, and that diagnostic analysis on full cells should be attempted.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Overall, comments in this section were somewhat mixed. Although one commenter observed a level of funding that is adequate for the efforts being pursued, the second commenter remarked that resources are insufficient if the authors pursue a strong collaboration with U.S. companies.

3. Power Electronics and Electrical Machines Technologies

Advanced technology vehicles such as hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell hybrid electric vehicles (FCHEVs), and electric vehicles (EVs), require power electronics and electrical machines (PEEM) to function. These devices allow the vehicle to use energy from the battery to assist in the propulsion of the vehicle, either on their own or in combination with an engine. Advanced electric drive vehicles can help meet important DOE goals, such as petroleum reduction. However, modern day PEEM technology is not sufficient to enable market-viable PHEVs, FCHEVs, and EVs. The Vehicle Technologies Program aims to develop these technologies by setting strategic goals for PEEM, and undertaking research projects that are carried out through collaboration among government, national laboratories, academia, and industry partners. Achieving the PEEM goals will require the development of new technologies. These new technologies must be compatible with high-volume manufacturing and must ensure high reliability, efficiency, and ruggedness. These technologies must also reduce cost, weight, and volume. Of all these challenges, cost is the greatest. PEEM project partners work together to ensure that technical attributes, vehicle-scale manufacturing, and cost sensitivities are addressed in a timely fashion and that the resulting technologies can be adopted by companies willing and able to supply products to automakers.

In August 2009, the Department announced the selection of ten projects totaling $495 million that will help accelerate the establishment of a globally competitive, domestic infrastructure for advanced electric drive vehicle manufacturing. ARRA-funded Power Electronics and Electrical Machines Technologies activities support programs to enable production and commercialization of advanced electric drive vehicles, which help to reduce petroleum consumption. Activities include developing low-cost electric propulsion systems; supporting an increase in production capacities for electric drive components, manufacturing plants, and parallel hybrid propulsion systems; and supporting development of electric drive semiconductors. Additionally, AARA-funded activities that support commercialization include accelerating the launch of HEVs/PHEVs through efforts including localizing the design and production of transaxle systems, and developing a lower-cost, higher-control standardized platform. These ARRA-funded projects were not evaluated during the 2011 AMR. The remainder of the Power Electronics and Electrical Machines Technologies activities that have been funded for FY 2011, however, were reviewed in the 2011 AMR.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Inverter Using Current Source Topology	Su, Gui-Jia (Oak Ridge National Laboratory)	3-3	3.40	3.20	3.20	3.40	3.28
A Segmented Drive Inverter Topology with a Small DC Bus Capacitor	Su, Gui-Jia (Oak Ridge National Laboratory)	3-5	3.00	3.17	2.67	2.83	3.02
Novel Flux Coupling Machine without Permanent Magnets	Hsu, John (Oak Ridge National Laboratory)	3-7	2.75	2.50	2.25	3.00	2.59
Benchmarking of Competitive Technologies	Burress, Tim (Oak Ridge National Laboratory)	3-9	3.50	3.67	3.00	3.17	3.48
Wide Bandgap Materials	Chinthavali, Madhu (Oak Ridge National Laboratory)	3-11	3.20	3.20	3.40	3.40	3.25
High Dialectric Constant Capacitors for Power Electronic Systems	Balachandran, Uthamalingam (Argonne National Laboratory)	3-14	3.00	3.25	3.50	3.25	3.22
High Temperature Polymer Capacitor Dielectric Films	Dirk, Shawn (Sandia National Laboratories)	3-16	3.50	3.25	3.25	3.50	3.34
Glass Ceramic Dielectrics for DC Bus Capacitors	*Lanagan, Michael (Pennsylvania State University)*	*3-18*	*3.00*	*3.00*	*3.00*	*3.00*	*3.00*

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Development, Test and Demonstration of a Cost-Effective, Compact, Light-Weight, and Scalable High Temperature Inverter for HEVs, PHEVs, and FCVs	Taylor, Ralph (Delphi Automotive Systems)	3-20	3.25	2.75	3.50	2.75	2.97
Scalable, Low-Cost, High Performance IPM Motor for Hybrid Vehicles	El-Refaie, Ayman (General Electric Global)	3-22	3.00	2.75	3.25	3.00	2.91
Advanced Integrated Electric Traction System	Smith, Greg (General Motors)	3-24	3.50	3.50	3.25	3.00	3.41
Permanent Magnet Development for Automotive Traction Motors	Anderson, Iver (Ames)	3-26	3.20	3.20	3.40	3.40	3.25
Air Cooling Technology for Power Electronic Thermal Control	Lustbader, Jason (National Renewable Energy Laboratory)	3-28	3.60	3.20	3.40	3.60	3.38
A New Class of Switched Reluctance Motors without Permanent Magnets	Burress, Tim (Oak Ridge National Laboratory)	3-30	3.17	3.17	2.50	2.83	3.04
Power Device Packaging	*Liang, Zhenxian (Oak Ridge National Laboratory)*	*3-32*	*3.25*	*3.25*	*3.00*	*3.25*	*3.22*
High Power Density Integrated Traction Machine Drive	Wang, Fei (Oak Ridge National Laboratory)	3-34	2.67	2.67	2.67	3.00	2.71
Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters	*Hefner, Allen (National Institute of Standards and Technology)*	*3-36*	*3.67*	*3.67*	*3.33*	*3.67*	*3.63*
Development of SiC Large Tapered Crystal Growth	Neudeck, Philip (National Aeronautics and Space Administration)	3-38	3.00	2.75	3.00	3.00	2.88
Thermal Performance and Reliability of Bonded Interfaces	Narumanchi, Sreekant (National Renewable Energy Laboratory)	3-40	3.40	3.00	3.20	3.20	3.15
Electric Motor Thermal Management	Bennion, Kevin (National Renewable Energy Laboratory)	3-42	3.20	2.60	3.00	2.80	2.83
Inverter Cost Analysis and Marketing Intelligence	Whaling, Christopher (Synthesis Partners)	3-44	2.67	2.40	3.20	2.20	2.54
Converter Topologies for Wired and Wireless Battery Chargers	Su, Gui-Jia (Oak Ridge National Laboratory)	3-46	3.00	3.20	3.20	3.20	3.15
Integration of Novel Flux Coupling Motor and Current Source Inverter	*Hsu, John (Oak Ridge National Laboratory)*	*3-48*	*2.33*	*2.33*	*2.33*	*2.67*	*2.38*
Motor Packaging with Consideration of Electromagnetic and Material Characteristics	*Miller, John (Oak Ridge National Laboratory)*	*3-50*	*3.00*	*2.50*	*2.75*	*3.00*	*2.72*
Physics of Failure of Electrical Interconnects	*DeVoto, Doug (National Renewable Energy Laboratory)*	*3-52*	*3.25*	*3.50*	*3.00*	*3.25*	*3.34*
Two-Phase Cooling Technology for Power Electronics with Novel Coolants	Moreno, Gilbert (National Renewable Energy Laboratory)	3-54	3.20	3.20	3.20	2.80	3.15
Integrated Vehicle Thermal Management â€“ Combining Fluid Loops in Electric Drive Vehicles	Rugh, John (National Renewable Energy Laboratory)	3-56	3.40	3.20	3.00	3.40	3.25
Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate	*Narumanchi, Sreekant (National Renewable Energy Laboratory)*	*3-58*	*3.00*	*3.40*	*3.00*	*3.00*	*3.20*
Overall Average			3.15	3.05	3.05	3.09	3.08

Note: Italics denote poster presentations.

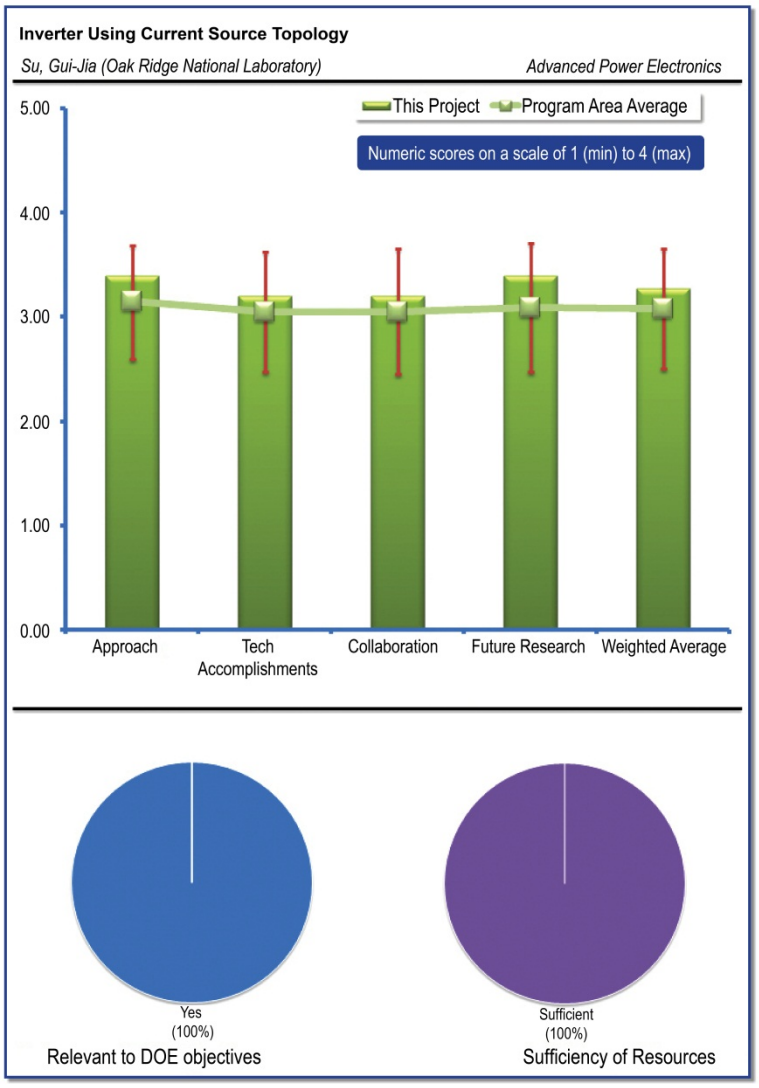
Inverter Using Current Source Topology: Su, Gui-Jia (Oak Ridge National Laboratory) – ape002

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most reviewers had a positive response to this question. One person expressed that electrification of vehicles is a vital part of improving energy efficiency in the transportation sector and this inverter has the potential to increase electric drive efficiency. Another reviewer acknowledged that this project will lead to smaller, lighter and lower cost inverters. This work will make it easier for OEMs to place the inverter into the engine compartment. One commenter stated that the potential significant advantages of the current source topology, coupled with Z source inverter paradigm, on dramatic reductions in ripple current and the associated filter passive volume and weight benefit will enhance efficiency, power density, and thus cost. The reviewer added that these benefits will improve the probability of rapid deployment of vehicles with dramatically reduced fuel requirements. The final reviewer remarked that the barriers were explained, but the presenter does not explicitly discuss petroleum displacement.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Responses to this question in general were positive. One person simply stated that the approach focuses on reducing the bulk capacitor size and on reducing the motor insulation requirement. Another reviewer applauded that the PI has put together an excellent team that includes Powerex for the reverse blocking (RB) IGBTs and MSU for topology work. The reviewer thought that the new topology for Trans qZCSI has good potential because it has improved boost ratio of 3:1. This reviewer added that this approach could also be used as an on-board charger. The reviewer concluded by stating that the big issues are the new reverse blocking insulated gate bipolar transistors (RBIGBT) which are not readily available and understanding the control on the new current source quasi Z Source topology. Another person commented that the presentation showed a well-balanced approach to the verification and validation of the Z-source current source inverter (ZCSI) for multi-functional application in HEV and PEV applications. They added that the project has an appropriate level of M&S effort to show the benefit to inverter performance and a good experimental validation plan. The reviewer added that they would have liked to have seen some detail on the packaging aspects of the proposed subsystem, including steady state and dynamic thermal analysis. Another commenter observed that combining inverter with boost technology is a sound approach and when combined with advances in the semiconductor arena should lead to an efficient unit with fewer components and thus lower cost. The final reviewer was critical, stating that the researchers show the size of the Camry silicon, but there is no mention of the equivalent RB-insulated-gate bipolar transistor (IGBT) silicon size. They added that the size of the silicon and the added feature

of reverse blocking come at some cost and asked whether this cost can be quantified. The reviewer concluded by acknowledging that otherwise the predicted results look very encouraging.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments to this question were generally positive, but with added suggestions of work to be included in the scope. One person remarked that the project appears to be on track with scheduled milestones completed. M&S results seem to bear out the potential for dramatic ripple current reductions. Another person expressed that the progress to date on the basic technology is very good, but added that they need to see more information on the reverse blocking IGBTs and their commercial viability. The reviewer concluded by stating that the potential for gallium nitride (GaN) is very good as this is a natural feature of the devices. One commenter noted that the simulated results are encouraging, but asked whether some quantification on the Si cost differences may be quantifiable, i.e., what is the difference in cost between a conventional power module rated at 600V / 400A vs. the Fuji 600V / 400A RB - power module. They felt that this quantification would help to validate some of the researchers' cost assumptions. The final reviewer affirmed that this project has demonstrated that all the DOE goals can be met. They noted that the researchers have made outstanding progress and that it will be even better if the inductor can be reduced. They added that the technology shows promise for even more reduction in mass and cost if GaN can be used to increase the switching frequency and shrink the inductor size. The reviewer thought that we may be trading a large capacitor for a large inductor since this is inductor fed. They concluded by that that the good part is the QZCSI which has only six switches and can buck boost.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responses to this question were generally positive. One person acknowledged that the team has MSU and Powerex involved, which are both excellent partners. One commenter stated that there is excellent collaboration with university and semiconductor manufacturer that uses the strengths of each to advance the design. Another reviewer noted that the researchers have assembled appropriate university and module manufacturer partners. This person pointed out that the project could benefit from closer involvement of vehicle manufacturers and component producers (passives, active and switching devices). The final reviewer asked whether Powerex will be making a power module with RB-IGBTs, and asked what their role in the project is if not.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments were generally positive, with several reviewers adding suggestions for additional efforts that should be included in the project to improve the project. One person thought that there is great potential for future work on this project to make more improvements, including faster switches using bandgap devices and reducing the inductors. Another reviewer noted that empirical validation of the theoretical and modeling predictions are necessary and sufficient to verify performance predictions. This person added that the researchers could have included a more detailed CSI inverter system test plan, which hopefully includes thermal and dynamic testing over the range of operation space, including re-generation and charging functions. One person applauded the very interesting approach that is focused on validating simulations. This person mentioned that they would like to see some information on the control strategy in the DSP included in the work plan. The final reviewer stated that they would like to see advanced plans based on test performance representative of an actual drive profile. They concluded by stating that the researchers need to show that the potential for increased efficiency with this architecture is possible without sacrificing transient performance.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

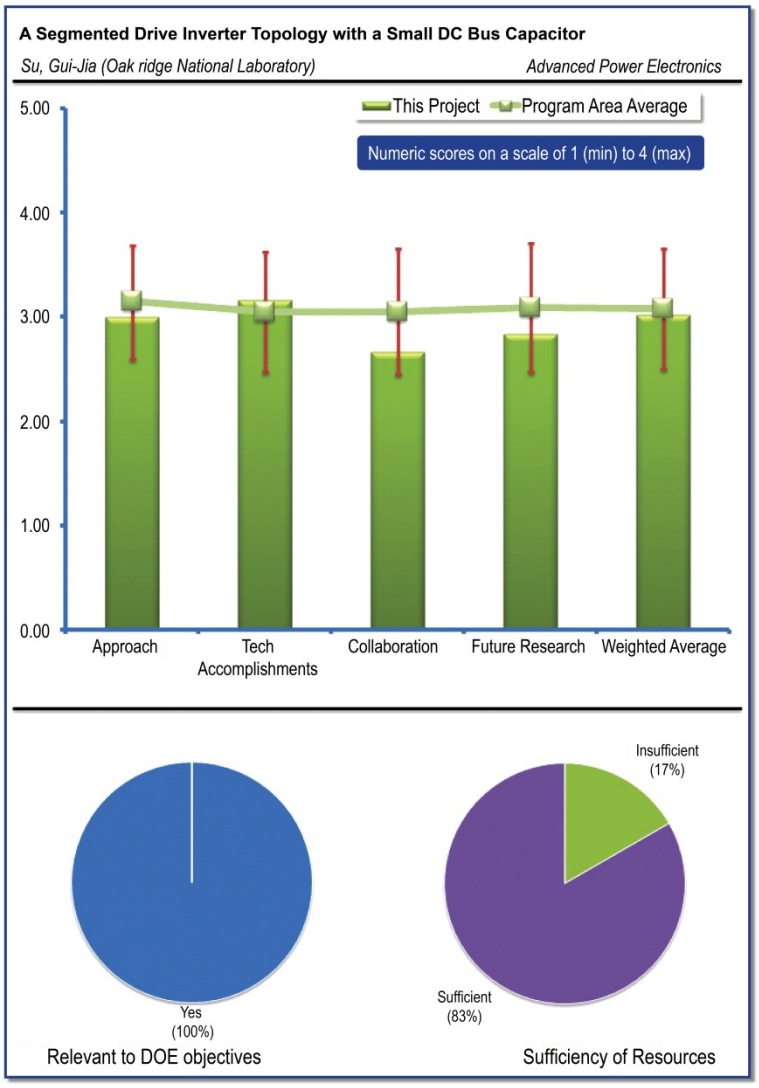
A Segmented Drive Inverter Topology with a Small DC Bus Capacitor: Su, Gui-Jia (Oak Ridge National Laboratory) – ape004

Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments to this question were generally positive. One person stated that the project supports goal of increasing power density and reducing cost of electric drive systems. Another person pointed out that traction drive inverters are fundamental to the realization of fossil fuel reduction through the deployment of hybrid and electric vehicle technologies. This reviewer added that this project has merit from a loss reduction standpoint and volumetric and mass power density improvements. One reviewer commented that improved inverter size and weight are important factors in making HEV and PHEV commercially attractive. They added that this project attacks one of the major contributors to both size and weight. Another person noted that inverter size and cost have significant impact on the adoption of electrified vehicles and that ripple current affects EMI and battery performance. The final reviewer commented that the project's support for DOE's petroleum displacement objective was implied but not explicitly stated.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Responses to this question were mixed, with several reviewers providing suggestions for improving the project work plan. One person commented that the technology is innovative and addresses key components (high impact) within the inverter. They suggested that quantifying the topology tradeoffs (identifying what is added, not just what is subtracted) would be useful for full disclosure. Another reviewer agreed that the project is highly innovative in its plan to integrate the TDI with the PM machine. The reviewer cautioned that this is however highly risky in terms of the thermal environment the inverter is likely to experience when integrated into the motor case. The packaging and thermal management will be key to successfully achieving this objective. This reviewer concluded by suggesting that establishing a closer partnership with motor manufacturers would be prudent. One person pointed out that since the material is under patent review it is not clear what the approach is, however, simulation results show a reduction in bulk capacitor size and cost. Another person had similar comments stating that the project review is hampered because the presenter did not explain what the approach actually is, so it was not possible for the reviewer to properly review the topology portion of the presentation. They did note that comments may be made regarding mounting the inverter on the motor. One person expressed that the integration of the electronics and the motor will present some challenges. Vibration, temperature, sealing, and EMC may add additional cost to the package. The reviewer asked whether this additional packaging cost will offset the cost of the eliminated motor cables. They concluded by suggesting that the researchers may want to consider the electronics as a separately packaged electronics package that

mounts to the motor. The final reviewer noted that the approach is reducing the current ripple value, but that an acceptable value was not specified. They added that at some point the cost of reducing the battery limit will exceed the benefit. The reviewer concluded by stating that torque ripple also needs to be specified over the speed range.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses to this question were mixed. One reviewer noted that the test results are promising (with the induction motor) and show that this technology has many advantages (battery, capacitor, and motor ripple). They added that the impact on the Toyota Prius motor will be useful, since it has been thoroughly tested and documented in past work. Another person asserted that the presentation of real-world data is an important milestone in showing technical accomplishments. One person commented that the progress appears to be tracking with the schedule and the accomplishment of relevant milestones. They pointed out that M&S is again leveraged appropriately with the empirical validation plan in place. This person concluded by suggesting that more detail should be place on the power module packaging and heat rejection considerations given the plan to integrate with the motor. One reviewer remarked that since the material is under patent review it is not clear what the approach is; it is difficult to evaluate progress. The final reviewer noted that the results show that the approach does limit current and torque ripples. They pointed out that the researchers need clear limits for these to determine when the project has met its goals. The reviewer also asked what the difference in the inductance of the Cap/Bus bar set up between the baseline and the segmented drives shown in the presentation is, asking whether this could this have an effect on the measured values.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reactions to this question were mixed. One person simply stated that the collaboration level is acceptable. Another person commented that the collaboration with industry has been proactive and useful to the project. Others felt that the researchers need to go further. One reviewer commented that a closer partnership with motor manufacturer(s) and module packaging expertise would have been prudent given the thermal concerns voiced in earlier question responses. The final reviewer commented that the researchers need to find a motor supplier to integrate the electronics being developed. They cautioned that this is a gap, but is a large part of the cost reduction claims on integrating the motor with the electronics.

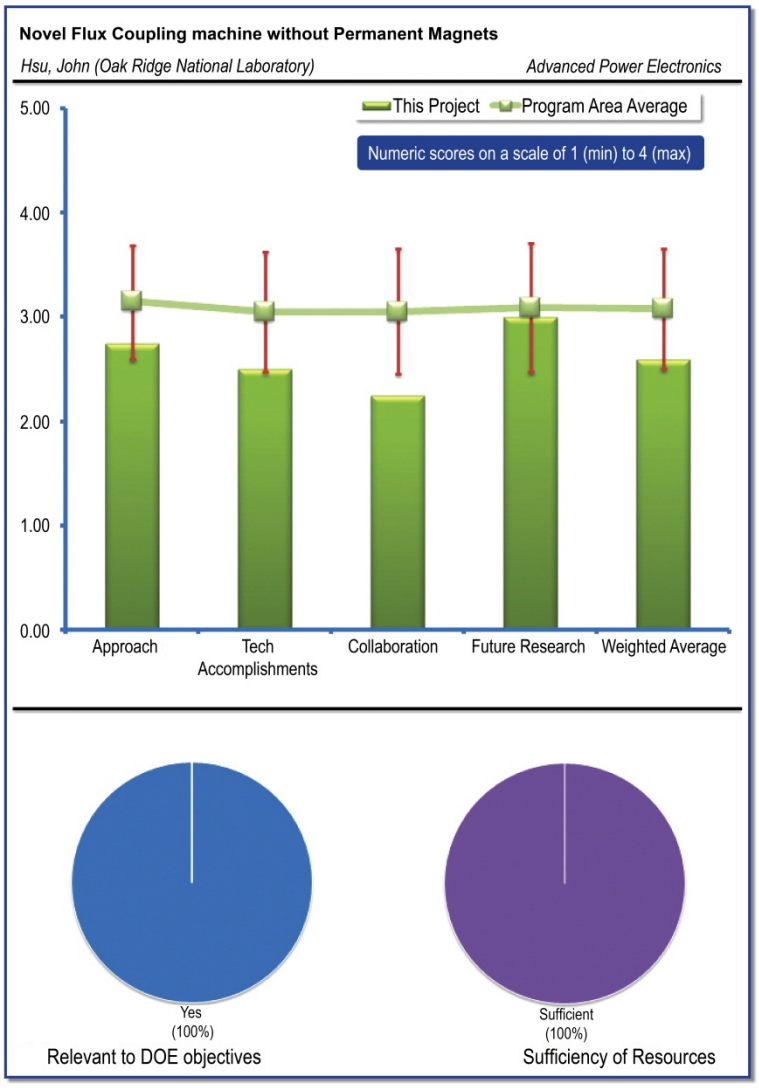
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers provided a range of suggestions for improving the scope of the future work. One person stated that the researchers need limits to be sharply focused, and that once they are established the project will be well on the way to success. One reviewer cautioned that adding the physical motor/inverter integration activity should not distract from the main goals of the program; this is a risk. Another reviewer emphasized that experimental validation is fundamental and a key aspect of the next two years effort. They added that the research plan appears to be adequate, provided thermal reliability considerations are prominent. Another person commented that mechanical vibration can be a major stumbling block. This reviewer suggested that consideration should be given to defining the expected environment and modeling the expected implementation to show that the devices will be reliable. Another commenter suggested that the researchers need to include a motor supplier to help with the packaging of the electronics. This reviewer noted that it appears the researchers understand the packaging issues, but still felt that a partner was needed. They concluded by remarking that as to the circuit design, more details of what you are doing need to be presented. The final person commented that quantifying the advantages and disadvantages should be thorough in the context of a separate inverter. This reviewer noted that it is important to measure and present the efficiency differences (motor and controller as a system), since the reduced motor ripple should increase efficiency with the new technology. They added that the researchers should also attempt to quantify the effect on the battery, since reduced DC ripple should increase the available energy in the battery. Between propulsion system efficiency and battery efficiency gains, they felt that this may be a real selling point for the topology.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

Novel Flux Coupling Machine without Permanent Magnets: Hsu, John (Oak Ridge National Laboratory) – ape005



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person simply stated that this project possibly eliminates rare-earth magnets in electric motors. Another reviewer commented that the presented motor technology is novel and addresses the current supply/cost issue with rare-earth magnets by eliminating them from this motor. The final reviewer had detailed comments, noting that rare-earth permanent magnets are a major cost factor in PM machines. The new machine design eliminates the magnet materials; therefore, this project has the potential of reducing the cost of electric machines and accelerating the implementation of electric powertrains in vehicles which supports the DOE objectives of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that the approach is generally good, although more FEA simulations should have been conducted prior or in parallel to the manufacturing of a prototype machine. This reviewer felt that it is unclear if 3D FEA simulations have been conducted in order to get accurate loss predictions. Moreover, the researchers provide little indication in how far the controls development has been completed especially regarding the control of the field winding. One person commented that it was a good decision that the novel winding technique was not included in the design and manufacturing of the prototype machines as this would have distracted the researchers from their main goal with this design, which is to eliminate permanent magnets. The other reviewer to comment cautioned that the construction of a novel motor like this is complex, so the reviewer would prefer to see the prototype as a two-step process where Step One would prove out the concept and Step Two would offer more optimization to address DOE targets.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Both commenting reviewers expressed concerns in this area. One reviewer commented that challenges with the prototype construction have prevented test data from being available this year. The reviewer fears that additional fabrication challenges may prevent prototype testing, and again, wishes that the proof-of-concept unit was less ambitious (as described in an earlier comment). The second reviewer felt that it is obvious that the main focus of the work since the last review was on the mechanical design and manufacturing of the prototype machine. The presented simulation results, geometry comparison and cost numbers are basically unchanged compared to the review from a year ago. This is somewhat understandable as the manufacturing of the novel machine

concept presents a major challenge. Nevertheless, the reviewer felt that it would have been good if additional simulation results would have been available, e.g., efficiency predictions. The reviewer pointed out that claims regarding cost reduction are still unproven as it seems that only material costs have been considered but not the manufacturing costs. The reviewer concluded by commenting the fact that the weight of the machine is significantly increased compared to a state-of-the-art interior permanent magnet (IPM) machine is a big disadvantage.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer observed that it seems as if there is no collaboration with outside partners besides some support in manufacturing the prototype machine. The reviewer thought that it would be beneficial if a supplier or OEM with manufacturing expertise support the project in order to ensure the manufacturability of the new machine concept in production and improve the cost estimation. The other reviewer noted that some collaboration activities have occurred (e.g., design reviews), but more collaboration with manufacturing would be useful, even at this stage of development.

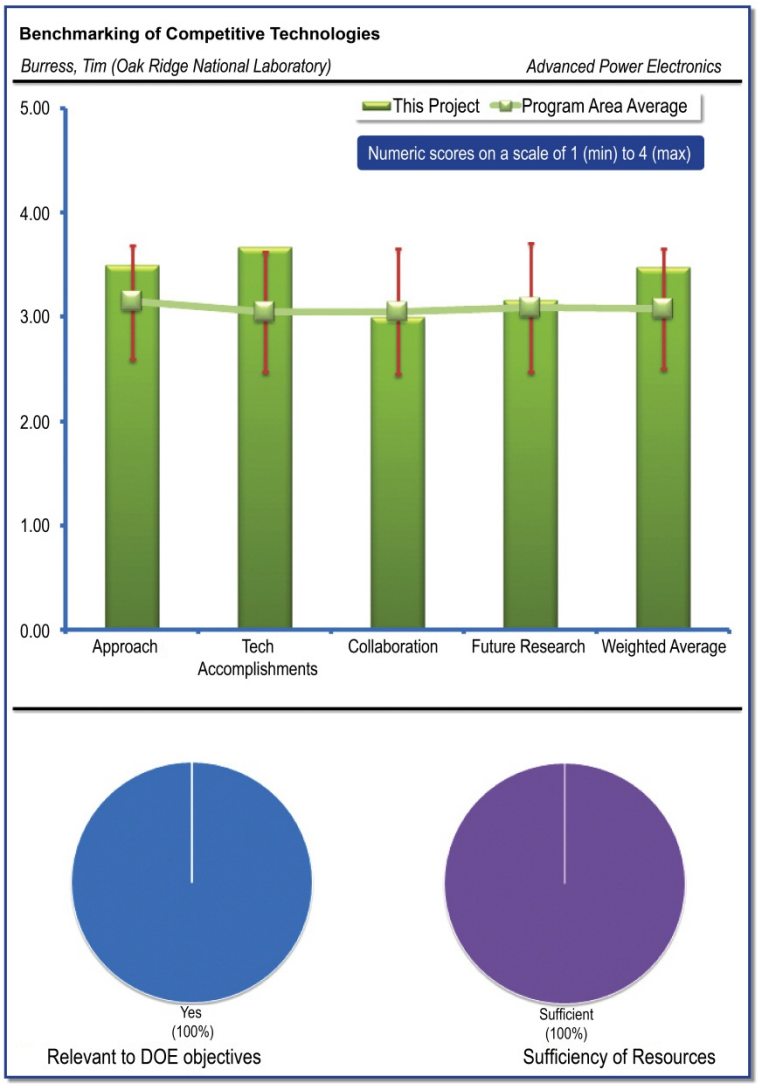
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first person said that, assuming that testing occurs in the near future, these will be useful data. If successful, this will be an interesting motor to study manufacturability issues. The other reviewer to comment remarked that the researchers claimed that the project is 80% complete although the prototype machine is not available yet. Therefore, the testing of the prototype machine has not started yet and a lot of tasks have to be completed within just a few months in order to prove the feasibility of the new machine concept.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

Benchmarking of Competitive Technologies: Burress, Tim (Oak Ridge National Laboratory) – ape006



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person simply stated that the project provides a good understanding of current state-of-the-art in vehicles. Another reviewer noted that this project defines a real-world baseline for current components. (If we are asking for improvement, we must know the starting point.) Another person commented that it is important to understand the best technologies available on the market. This effort will provide a realistic benchmark for the future DOE requirements and also is needed to provide direction for new technologies. Another reviewer commented that the benchmarking of electric powertrains in production vehicles is of very high interest for the domestic automotive industry. The thorough understanding of the design and performance of the technology of competitors helps the domestic automotive industry to improve and accelerate their own development process for electric powertrains which supports the objective of petroleum displacement. The final reviewer noted that the project reflects a key approach to aid in the accelerated deployment of fossil fuel displacing vehicular technology. A systems engineering approach to evaluation and comparison of leading electrical power system technologies is an outstanding approach to achieve this objective. The reviewer concluded by stating that the characterization of selected subsystems is thorough and sufficient to provide the desired performance characteristics of critical electrical and thermal equipment.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer simply commented that detailed teardown is the only way to understand what is going on in drivetrain technology. Another person applauded that the step-by-step approach in which the powertrain teardowns were conducted is outstanding. A lot of important information was gained with regard to the design and the performance of the electric powertrain subsystems motor and power electronics. The reviewer felt that the approach could be even further improved if an evaluation in the vehicle could be added in order to investigate the implemented control strategies. One person had detailed comments, stating that the project has focused the work plan and tasks on the critical subsystems that will most directly and significantly impacts DOE vehicular objectives. They described that traction drive inverters, motor, transaxle components, power electronics heat transfer equipment, and boost converter comparisons between relevant manufacturer models will provide tremendous benefit to the technology development effort of DOE in this area. The reviewer concluded by observing that experimental data collection and performance boundary conditions were well defined and laid-out, which are also well integrated with other DOE funded projects aimed at improving the cost, performance, and

reliability of critical subsystems. The final reviewer stated that the approach to evaluating motors could be improved by clearly stating test methods and control algorithms, ensuring repeatability between components.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All reviewer comments were positive. One person simply stated that the teardowns are well done with a plan. Another reviewer expressed that the comparison photos were impressive, adding that they hope that the more detailed report will be made available to the public. The reviewer believes that there is a lot more details than those presented. This reviewer concluded by congratulating the researchers on the good work determining the efficiency maps. One reviewer expressed that the summary of the findings about the Toyota and Lexus hybrid systems are very good. They added that it would be beneficial if the test conditions and control strategy are described in more detail because this would provide an even better understanding of the test results. The reviewer noted that work on the Hyundai system has been started this year and it will be very interesting to see the results of the complete teardown. The last reviewer noted that very good progress made in advancing the evaluation of newer model years' technology and comparing to benchmark standards of previous models. They pointed out that the efficiency mapping and the discovery of the PCU thermal pathway advances in the 2010 Prius should be very beneficial. They concluded by adding that it appears to be a very fruitful activity, which is accomplishing the goals and objectives of the project in an effective fashion.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive. One person felt that there was very good cooperation with other groups. Another person observed that there was an appropriate mix of technical expertise from National Laboratory centers of excellence in relevant areas. The final reviewer to comment acknowledged that the collaboration between a number of National Labs seems to work well. The reviewer felt that it would be beneficial if subject matter experts for every subcomponent would get more involved in order to achieve an even higher depth of understanding.

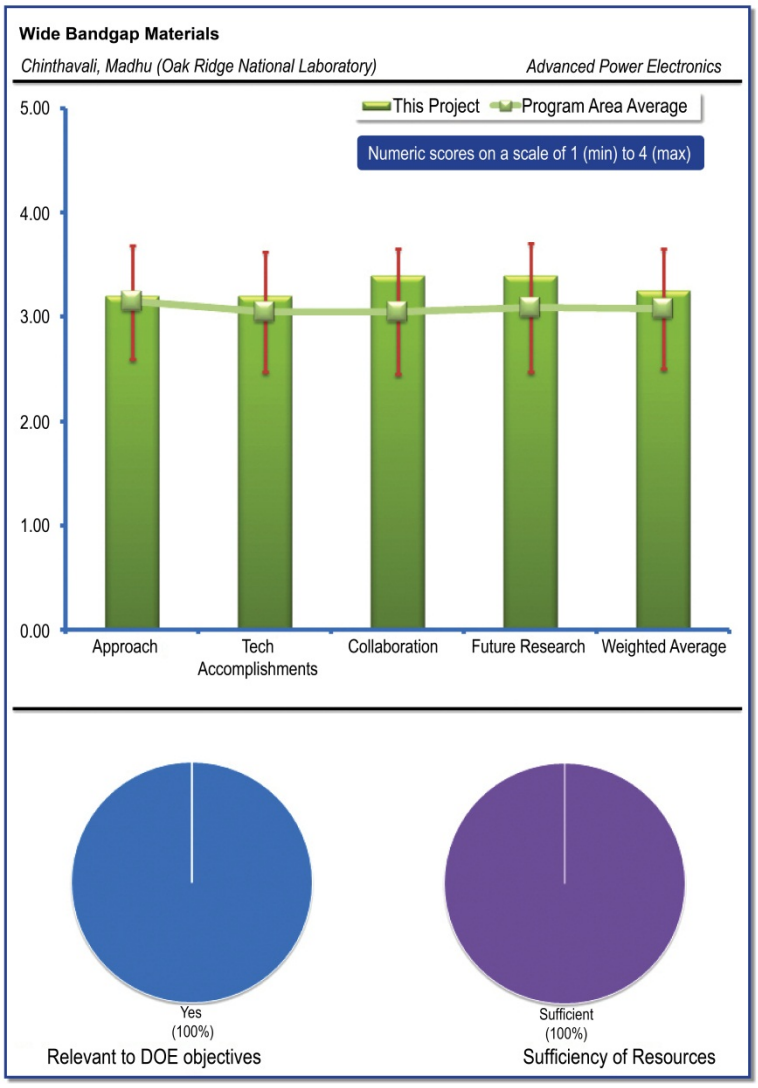
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that no future plans were presented. Others explained that the project effort is on-going. One person commented that this is an on-going program and properly proposes to continue looking at production items of interest. Another commenter also explained that the project is an ongoing effort and additional teardowns of electric powertrains will hopefully follow the current task which is focused on the Hyundai Sonata Hybrid. The reviewer felt that it would be outstanding if technology from foreign markets could be investigated too, e.g., the upcoming hybrid and electric systems of Renault and Peugeot (rear-axle hybrid). The final reviewer commented that the proposed completion of Hyundai benchmarking efforts during the coming year will provide an excellent complement to the vehicles already completed or ongoing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

Wide Bandgap Materials: Chinthavali, Madhu (Oak Ridge National Laboratory) – ape007



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer emphasized that improved inverters and converters are key factors in HEV and PHEV technology. Power electronic components are at the heart of those components; make those more efficient and fully understood, and the entire system benefits. Another person pointed out that wide bandgap semiconductors are an emerging advanced device technology that can lead to reduction of overall size and weight of inverter and enable higher temperature operation. Device benchmarking is important because many experimental devices are being introduced from multiple labs and vendors. Another reviewer stated that wide bandgap device would allow higher temperature operation to save the power electronics system cost. Another agreed, adding that wide bandgap devices offer the potential for significant increases in the efficiency of switching devices. To take advantage of this, a package will be required that allows the user to take full advantage of the device's characteristics and this project is exploring this area. The final reviewer had detailed comments, describing that the baseline characterization, SPICE model development, and performance qualification of the silicon carbide power switching and rectifying devices being conducted under this project are fundamental to the integration of these performance enhancing technologies into highly efficient drive and conversion components. The potential improvements to vehicle efficiency and reliability that these power device technologies will afford can further reduce fossil fuel consumption beyond the silicon-baseline hybrid and PEV vehicular entitlement. As these are newly emerging technologies, the quantitative characterization of real performance potential is crucial to understanding the overall system impact and cost benefit analysis required for deployment.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Responses to this question were generally positive. The first reviewer commented that the project has a number of test and modeling tasks that are important including static and dynamic testing, behavioral spice models, and loss model calculations. The reviewer explained that the test and modeling procedures are being performed for a wide range of wide bandgap device types: JBS, BJT, MOSFET, JFET (1,200 V / 100 A range). Another person observed that the project reflects an excellent objective analysis of competing and compatible power switch and rectifier technologies potentially suitable for significant performance and reliability improvements in vehicular applications. In addition, the effort highlights the subtle differences between silicon carbide (SiC) and Si power electronic devices, especially in terms of gate control. The reviewer felt that this aspect of the project is very useful for potential suppliers and vehicle manufacturers to understand prior to attempting to integrate the new technologies into products. One commenter felt that the project has an appropriate focus on sharing data that designers will need to implement next generation components.

Another reviewer commented that the use of a model for comparisons is very good as long as the model is realistic and provides reasonable results. The reviewer asked if the model has been checked to determine how realistic it is. They concluded by noting that focusing on the capabilities at ORNL should help as the expertise and equipment is readily available. The final reviewer suggested the researchers add the system level (inverter or DC-DC) testing data to demonstrate the benefit in additional to simulation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses to this question were mixed with some reviewers providing suggestions for improving the work plan. One person simply stated that the progress to date is very good as is access to the data. Another reviewer affirmed that measurable progress has been demonstrated and scheduled milestone objectives achieved. They felt that this appears to be a well-executed task which is generating highly useful and applicable data for vehicle component developers and manufacturers. The web-availability of data generated under this task is a highly attractive aspect of the subject project. They concluded by stating that this will certainly help accelerate the utilization of these performance enhancing technologies by enabling developers to conduct modeling and design trades using SOTA performance parameters. One reviewer remarked that the researchers need to speed up the system-level simulation. Another person acknowledged that leakage tests were done on a parallel combination of IGBT and diode together, but asked why these were not measured separately to evaluate technology. One person stated that the project could be improved by sharing not only component models, but models for inverter, motor, etc. The final reviewer commented that some of the modeling approaches and test procedures are not on par with the state-of-the-art in other labs, for example, the behavioral SPICE model for JFET switching results are shown for dynamic conditions and a time scale where the waveforms do not depend on the device models, only the circuit model. They noted that the turn-on current spike does depend on the devices' behavior but the time scale does not permit evaluation of the model performance. Also, gate voltage and current waveforms are needed to demonstrate accuracy of models.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responses to this question were all generally positive. One person pointed out that the project leverages all available device manufacturers and device types for analysis; this could only be accomplished with the intentional cooperation and collaboration of the manufacturers. Another person commented that the coordination to-date has largely involved obtaining samples to test from vendors and research programs. They added that very little collaboration with other test labs with state-of-the-art test and modeling approaches has been demonstrated. Another reviewer emphasized that the evolution to a common package configuration is an important step to improving collaboration. The final person stated that the collaboration is excellent so far. This reviewer added that future work may require involving additional suppliers of wide bandgap devices as well as analysis of package inductance and thermal performance, which the reviewer believes the capability to do this exists. The reviewer concluded by asking how much interaction has been accomplished with industry in general (industrial power module suppliers).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that if the project continues as scheduled, the contribution will continue to be significant. Another person noted that progress is based on current status. They cautioned that the ability of these devices to switch at very high rise times will lead to potential issues within the package and for the die due to the inductance of theinterconnects. Another concern is the thermal limitations of the interconnects and device bonding methods - current silicon device performance has been limited in the past due to the limitations of the solder used to attach the devices and the wire bonding process; these need to be addressed in the future plans. Another reviewer pointed out that the project leaders, in response to reviewers comments from AMR 2010, chose not to consider reliability-related metrics in the device assessment. The reviewer cautioned that this diminishes the value of the evaluations given that the characteristics measured by the project are closely tied to possible compromises in material quality and device design that impact reliability. For example, a 1,200 V SiC MOSFET can be made with substantially lower on-resistance with today's technology simply by designing the device to operate at a much higher gate oxide field; however, this substantially diminishes the device life expectancy especially at elevated temperatures. Also, much lower on-resistance devices can readily be made using bipolar type devices but the primary technology barrier for bipolar devices in SiC is the material quality based stacking fault induced forward bias degradation.

The reviewer recommends using a more holistic assessment of the technology readiness and performance rather than just measuring forward conduction and switching waveforms. The final commenter mentioned that some of the future tasks proposed are not relevant considering the current quality of measurement and modeling approach demonstrated by the project; for example, if models use constant inter electrode capacitances then there is no value in characterizing terminal inductances which will have much less impact on dynamic behavior than the nonlinear inter electrode capacitances.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

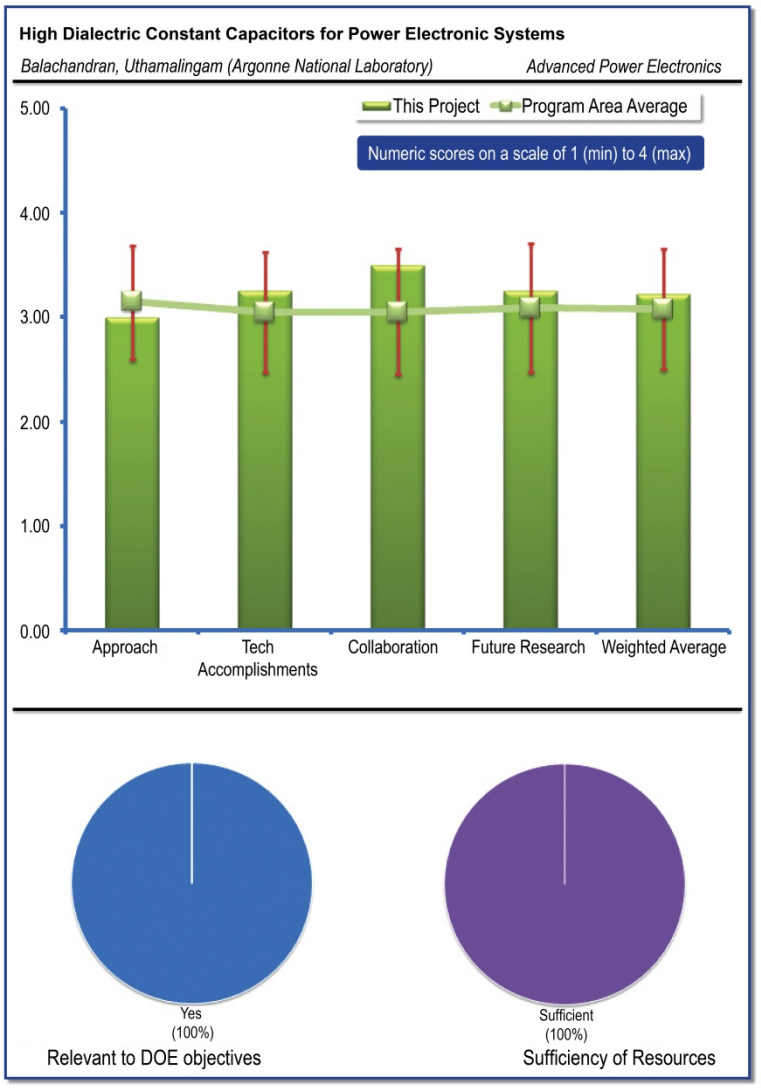
High Dialectric Constant Capacitors for Power Electronic Systems: Balachandran, Uthamalingam (Argonne National Laboratory) – ape008

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person pointed out that capacitors are one of the major cost drivers for traction inverter systems. Another reviewer commented that these advanced technology capacitors will be needed in greater quantities as their use in hybrid vehicles proliferates. Another reviewer emphasized that more effective inverters and converters are an important part of the PEV and HEV strategy. Capacitors are a major barrier to reducing cost and expanding operating environment. This project has the potential to address both of those concerns. The final person commented that capacitors that meet the needs of the power electronics world, such as high voltage ratings, and the ability to survive high temperatures while providing sufficient capacitance in a small package are very difficult to find. The approach in this project has the potential to solve this issue if the performance goals and costs are met.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer remarked that this project involves interesting work toward goal, but there is a lot of work to do with a lot of unknowns. The reviewer noted that modeling is difficult for newer materials, so this reviewer hopes the project gets to its objective. The other commenting reviewer stated that focusing on the technical barriers is good, but the researchers need to include robustness to environmental forces (such as moisture and vibration).They added that the researchers also need to be aware of the requirements of the manufacturing world on the packages selected for the devices.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that the project results show that impressive work has been done while exploring many unknowns. This reviewer would like to see more specific plan to achieve higher voltage capability. Another reviewer expressed that the progress to date shows excellent potential and results. They questioned where the target value of 1,000μF came from, because having a clear set of requirements will help keep the research team focused. The final reviewer commented that it would be more impressive to build a stacked capacitor that could be used with voltage, which they acknowledge is probably in the plan. The reviewer offered an aside, stating that comparative data should be shown using charts with the same axis scaling (e.g. Slide 9, capacitance vs. bias field).

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Comments to this question were all positive. One person simply stated that the research team appears to be working well together. The other commenter remarked that it appears the researchers are working with all the right folks. They also noted the good support from industry, academia, and national labs. The reviewer concluded by stating that if the researchers cannot get there, it is likely not practically feasible.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer commented that if successful, the researchers will have an excellent capacitor. Another reviewer observed that the research is headed in the right direction. The vision is simple, but technically conquering challenges is not simple. Another reviewer agreed that it is appropriate to focus on building stacked capacitors at 450V range since that is what industry needs now, but they encouraged the team to consider 600V as a working voltage. The final reviewer suggested the researchers consider building a 1,000 μF/450C capacitor in the future plan to evaluate the full performance.

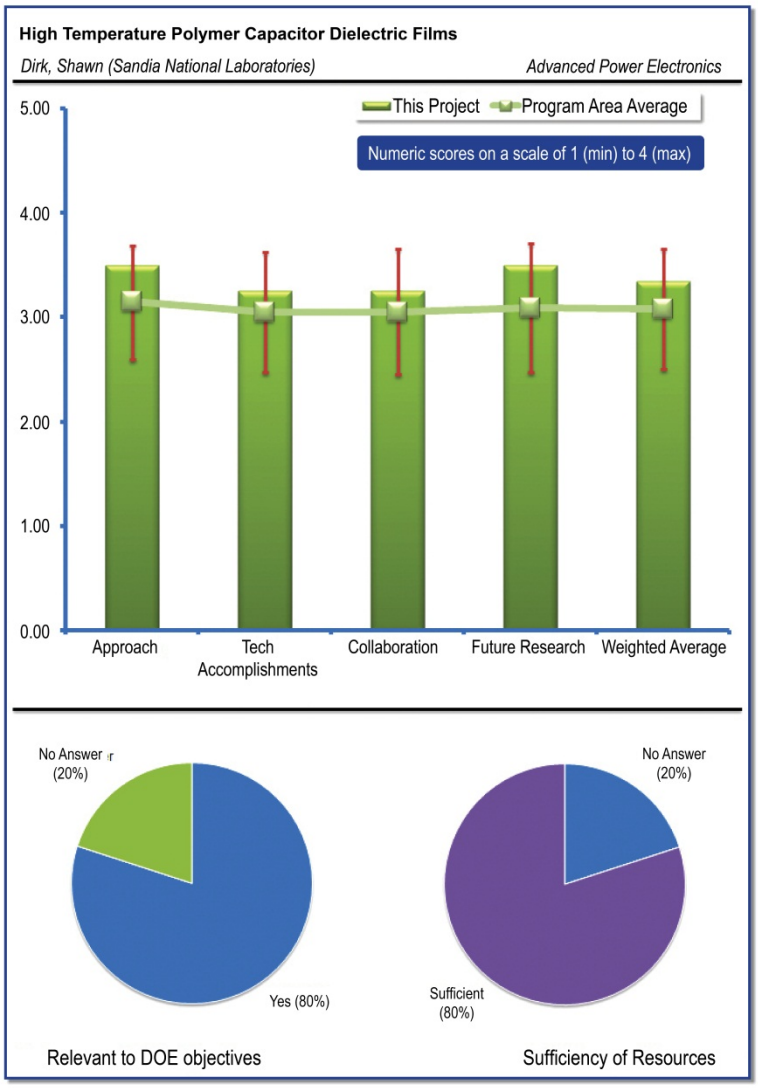
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

High Temperature Polymer Capacitor Dielectric Films: Dirk, Shawn (Sandia National Laboratories) – ape009

Reviewer Sample Size

This project had a total of 5 reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were all positive. One person noted that this was a good project as capacitors represent a significant cost and size impact to inverters. Another reviewer agreed, stating that capacitors are one of major contributor to the inverter in size, weight and cost, so this project's objectives to reduce these characteristics lines up with DOE goals. Another reviewer commented that these high-tech capacitors will be needed in much higher quantities in the future to support the proliferation of HEV vehicles. The final reviewer explained that more effective inverters and converters are an important part of the PEV and HEV strategy. This reviewer added that capacitors are a major barrier to reducing cost and size, and are a constraint regarding expanding operating environment, so this project has the potential to address these concerns.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Both responses were positive. The first reviewer commented that the approach is very solid. They point out that exacting and demanding work lay ahead, that the specific tasks and goals are clearly laid out as well as tactics and means to pursue them. This reviewer concludes by stating the strategy to solve problems looks very solid. The other reviewer to comment pointed out that the approach focuses on the issues with today's capacitors. They added that the materials chosen seem to be promising in terms of meeting technical goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were all positive. One person stated that the researchers were very strong here. They added that understanding the nanoparticle filler material use to extend BV is a strong accomplishment; doing so in a cost-effective manner is even better. Another reviewer commented that good work was shown on solving development hurdles (altering materials in a scientific manner rather than just trying stuff). The final reviewer observed that progress is good, but have they investigated the current method of extruding films to see if they can learn from it - especially in the area of lessons learned.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reactions to this question were generally positive. The first reviewer felt the project has good collaboration with what looks to be all the appropriate folks from industry, academia, and National Labs. The second reviewer commented that the collaboration appears acceptable, but reissued their earlier comment regarding involving industry contacts.

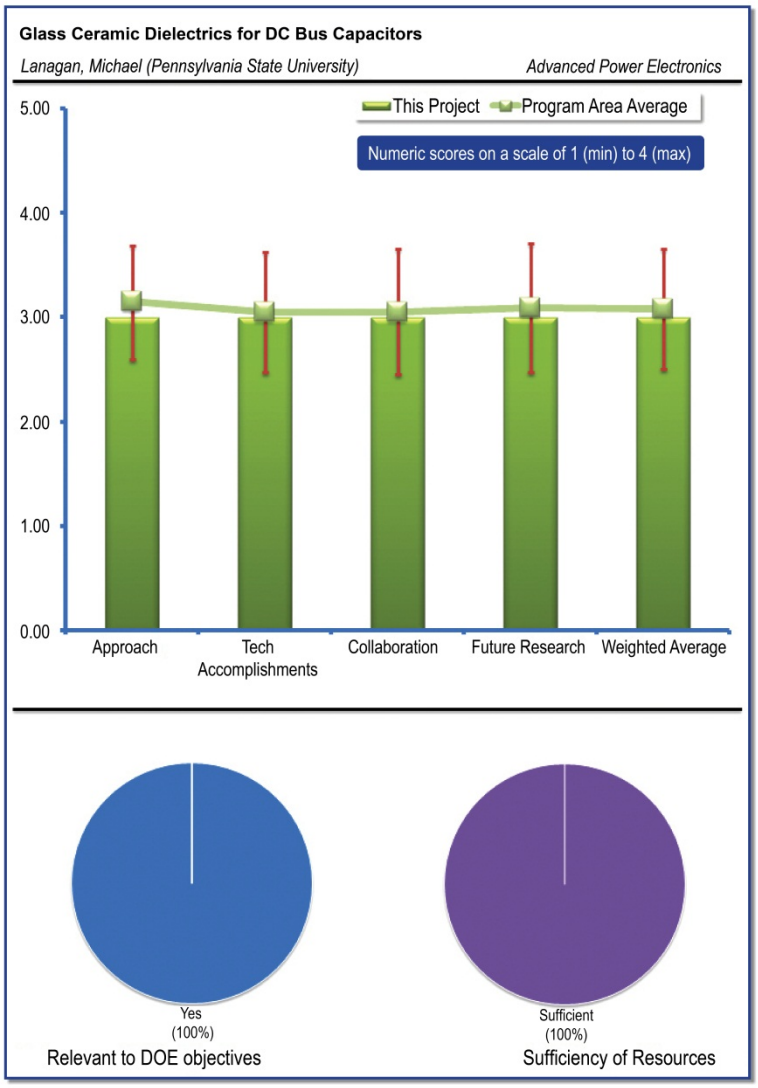
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer commented that the future research to advance the extension of BV is good. Another person commented that continuing to use cost-effective materials makes sense to a great degree. They added, however that working toward extrudable material seems very beneficial. Another reviewer stressed that it is important to actually fabricate a stacked capacitor that demonstrates meeting the requirements; this will show it is possible to bridge the gap between a lab demonstration of a small capacitor to a useful device. The final reviewer agreed the progress and plan are correct, but asked what is the ability to redirect the project scope if results indicate a change is required.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

Glass Ceramic Dielectrics for DC Bus Capacitors: Lanagan, Michael (Penn State University) – ape010



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer remarked that capacitors are a significant cost and size impact in inverter design. The other reviewer to comment asserted that more effective inverters and converters are an important part of the PEV and HEV strategy. Capacitors are a major barrier to reducing cost and size, and are a constraint regarding expanding operating environment, so this project has the potential to address these concerns.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The commenting reviewer remarked that the approach has potential but had concerns relative to how do these capacitors compare to existing film and ceramic caps. This reviewer also wondered what the limitations will be in terms of the environment.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said that the progress to date is good but that the researchers still have a ways to go to prove technology. The other reviewer expressed that the presentation would be enhanced by a description of the self-healing mechanism, but the reviewer understands that it is in the patent process.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The only respondent commented on the good collaboration in areas of the investigation, but suggested that the researchers may want to also involve film and ceramic capacitor experts.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said that the plan is great if the data supports the goals. The commenting reviewer suggested that the future work should include fabrication of a large C high V component.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

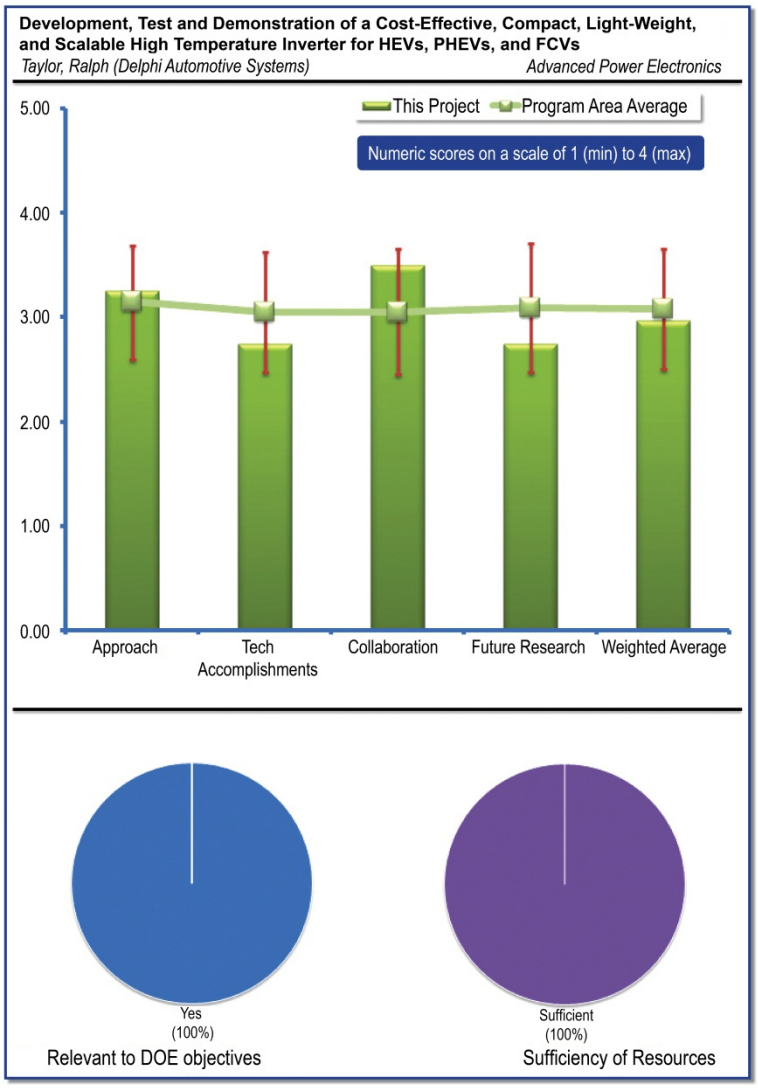
Development, Test and Demonstration of a Cost-Effective, Compact, Light-Weight, and Scalable High Temperature Inverter for HEVs, PHEVs, and FCVs: Taylor, Ralph (Delphi Automotive) – ape012

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were positive, with one person simply stating that this work is required to support electrification of the vehicle. Another reviewer explained that the project is addressing advanced inverter technologies and integration approaches. The project goals are to reduce size, weight, and cost while increasing performances in key areas such as high temperature operation. The last reviewer commented that a necessary prerequisite for successful deployment is the demonstration, and ultimately production, of reliable, highly efficient, lightweight inverters for vehicle traction drive applications. They added that this program correctly addresses these issues from an integration standpoint, but also includes appropriate subtasks to evaluate potential emerging technologies which may have significant impact on the ability to meet longer range goals and metrics.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the project utilizes a concurrent engineering approach for development and integration of multiple advanced inverter technologies. The approach includes development of individual component technologies with both high- and low-risk options as well as technology integration accounting for the interaction of multiple new and existing technologies. The reviewer felt that this is a major strength of this project. Another reviewer had detailed comments, observing a well-organized program structure with a focus on the performance metrics. The reviewer did not feel that the prime is functionally on-board with the longer term technologies, but rather included them for the purposes of saleability. This is an ingrained legacy auto industry mindset that needs to be eliminated in order for true innovation in the industry to occur. This can only begin by performing cost analysis at a systems level, which the reviewer did not see occurring. In addition, the reviewer added that the "innovative" technologies selected for the project subtasks do not reflect the best choices for power device or capacitor technologies. SiC/Si is a long shot technology at best, and the dielectrics considered do not reflect understanding of the very large investment required to scale-up and begin production of a film capacitor technology. GE and Purdue will never go down that path. The power device packaging appears innovative, but there is no analysis or consideration of reliability in a dual sided packaging from both a delta-T or voltage failure standpoint. The reviewer concluded by commenting that they expected more from a primary top tier auto industry supplier. One reviewer noted that the thermal path is being addressed as is thermal capacity of the capacitor. The power switch simulation is dependent upon the accuracy of the losses of the device and package, so the reviewer wondered if this has been done, cautioning that an error here can lead to better model based

performance than the real-world. This reviewer cautioned that the layout of inverter may lead to issues that are not related to technology, i.e., 3-phase leads passing through the middle of the unit may cause issues on the cards around it. The reviewer concluded by asking whether the cables are shielded.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that the multiple technologies being developed are at various readiness levels. Considering those technologies that are likely to be integrated during the term of the project, the project does substantially improve on the state-of-the-art and may meet the DOE goals if optimized. However, a few of the high payoff technologies being considered (such as the SiC-on-Si devices and possibly the Film-on-Foil capacitors) are too far from ready to impact the project under the current term. Another person expressed that the progress is hard to judge since the inverter has not been built and tested. This reviewer liked the approach of using two different caps representing medium- and high-risk. The reviewer was very concerned about the plan to receive parts, build unit, and expect it to work; new technology will require some care and feeding to get operational so presents a schedule risk. The final person criticized that they did not see measurable progress from the previous year, especially from Delphi's tasks. The reviewer asserted that the subtasks are highly unlikely to produce anything tangible during this project. The significantly reduced thermal impedance of the power device packaging will carry with it an associated susceptibility to dynamic thermal events (peak power demand, etc.). With a reduction in heat capacity and the plan to operate the IGBTs closer to their thermal limit a careful non-steady state thermal study is necessary. Similarly, dual-sided cooled power device packaging has historically had voltage breakdown/arcing type failure modes which Delphi has not addressed from a reliability standpoint.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responses to this question were all positive. One person noted that the project includes a well-balanced group of partners with a diverse range of expertise relevant to the subject program. Another reviewer agreed that there is good collaboration in terms of advanced devices and capacitors. The final reviewer commented that the coordination between multiple technology development and analysis tasks within the project and with other Vehicle Technology Program efforts is outstanding; this is a major strength of this project.

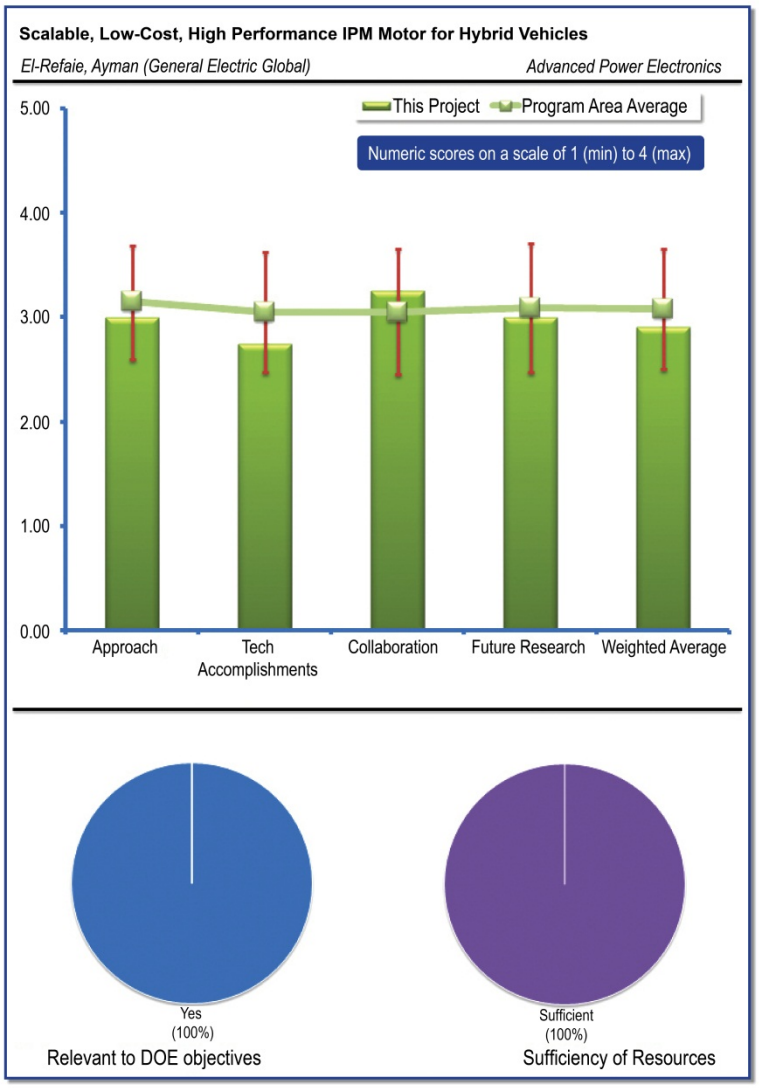
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer simply stated that the researcher has an acceptable plan in place to hopefully build and test a functional inverter. Another reviewer commented that the remainder of the project is well-planned and the technology integration approach is credible. However, the reviewer cautioned that there seems to be a compressed schedule for device and inverter testing for the few technologies that are not ready. They felt that the overall project may be more successful if there were more aggressive down-selection of technologies being considered for inverter integration; the project might consider continuing the research and development on the technologies that are not ready but focusing the inverter integration work on those technologies that will likely be ready to meet the inverter integration and testing schedule. The last reviewer thought that it is unrealistic to believe that the research team is going to get parts in-house, fabricate and inverter, assemble it, bench test it, and run it on a dynamometer in 6 weeks. They added that the unit probably will not have the correct cap either.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

Scalable, Low-Cost, High Performance IPM Motor for Hybrid Vehicles: El-Refaie, Ayman (General Electric Global) – ape013



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were positive. One person noted that the goal of the researchers is to develop an IPM machine with high-efficiency and low cost. Another reviewer expressed that this is very important work to improve the performance and mass of the electric motor. Another reviewer remarked that improved electric machines support vehicle electrification. The final reviewer emphasized that such electric machines are necessary for the broad implementation of electric drive systems in vehicles and thus support the DOE objective of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer commented that the technical barriers of a high-speed, high-efficiency motor seem to be identified by the researchers with suggested improvements in the rotor design. Unfortunately, some of the measures which have been applied in the new rotor design are not disclosed in detail so it is difficult to evaluate these. With their approach the researchers try to meet the very challenging high-speed efficiency requirements, but this might lead to higher manufacturing cost of the machine, e.g., due to higher PM material content. Another reviewer agreed, pointing out that GE has taken a broad approach to innovative motor design. The reviewer also added that it is difficult to judge the specifics since they were not presented, however the design approach is excellent. Another commenter stated that the embedded technology is not described in detail, but it appears that the approach focuses on incremental improvements (higher resistivity magnets) and not high impact technologies that would be typical of an advanced R&D program. The reviewer explained that the original innovations (e.g., high resistivity and soft magnetics) were eliminated from the program, perhaps with good reasons, but also in order to reduce the value of the program. The final person simply asked whether the new design benefits the manufacturing cost.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers provided a range of technical questions and insights. One reviewer warned that the segmented stator with concentrated winding might lead to higher harmonics causing losses in the rotor. This is addressed with the development of permanent magnets with higher resistivity and additional measures in the rotor. The reviewer suggested that it would be interesting to see a detailed cost tradeoff between the new magnet material with insulating layers and the conventional approach of segmenting the magnets axially. Another reviewer expressed concern that that the second proof of principle machine shows little improvement over the first machine

and it offers only modest progress. Parameters of the second machine should have resulted in more efficiency gains at high speed. They acknowledge that testing of the third machine may show improvement. Descriptions of early results were communicated to be better, but still fall short of targets. The reviewer, however, acknowledged that the DOE targets are aggressive and are difficult to achieve. Another reviewer noted that three generations of prototype machine have been built and the lessons learned from the previous prototypes have been applied to the design of the next prototype. The reviewer felt that the researchers have a clear path of addressing issues, always with the focus on meeting the challenging DOE requirements for a high-speed electric machine. The final reviewer described that the results to date show that an improved machine can be designed but the cost will be much higher due to unique processes and parts. The research team has made great progress in most of the important machine parameters as shown in the presentation, however there were some metrics that were not met, such as back EMF and cost. The reviewer wished that they could see more details of the motor design, but understands the proprietary nature of the work. The reviewer concluded by hoping that this work will lead to some new advancements in motor technology.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question were primarily positive. One commenter commented that the collaboration with universities and key component suppliers are appropriate. Another stated that GE has many good partners including internal divisions and outside consultants. The final reviewer to comment agreed that the collaboration between industry partners and universities is well coordinated. The reviewer felt that that the role of the supplier Electron Energy Corp. in the PM development should be described in more detail as it seems that this partner was not part of the project from the start.

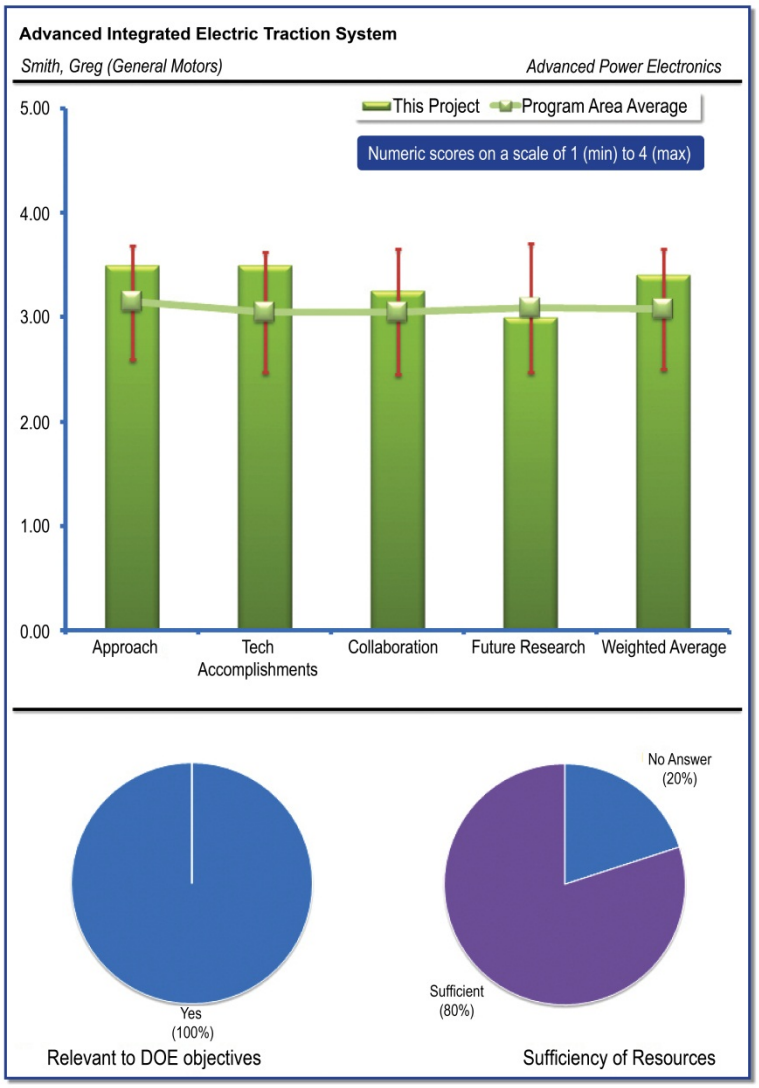
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person simply stated that the work is almost done so there is not much left for future work. Another commenter had a similar comment, pointing out that the researchers plan to complete the testing of the final 55 kW prototype machine soon; this is necessary to prove the claimed results. Another reviewer described that the third 55 kW prototype is based upon results of the first two prototypes. The 120 kW system is appropriate to address the increasing power demands of vehicle manufacturers and the reviewer hoped that the program budget and timing allows for the build of this higher power version. Another person stated that the future work is very interesting and will include the evaluation of the scaled prototype machine with 120 kW because this power level seems to be more appropriate for the vehicle applications into which the new high speed machine design would fit best (BEV, FCEV). The final reviewer thought that it would be interesting to see the results of a tradeoff for the cost between a higher speed/lower torque and a lower speed/higher torque machine design with the latter being a better fit for HEV applications in which the electric machines are integrated into the transmission.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

Advanced Integrated Electric Traction System: Smith, Greg (General Motors) – ape014



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers felt the project supports DOE's goals. One commenter simply stated that the project supports the goals. The other reviewer observed that the integrated systems development from an experience vehicle manufacturer supports vehicle electrification. Another reviewer had a related comment, but did not directly address whether the project supports the objectives, stating that this is a system level project by an OEM with the possibility of commercialization. The final reviewer commented that the project investigates advanced technologies, system integration and interfacing and manufacturing issues for Advanced Integrated Electric Traction Systems (ETS). The reviewer pointed out that the goals are to reduce cost, size, weight and increase efficiency, reliability, and manufacturability, and enable 105°C coolant, but did not mention whether these support DOE's petroleum reduction goal.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were positive to this question. One commenter explained that the project utilizes results of Phase 1 demonstration project and applies detailed design requirements and lessons learned from demonstration builds and testing to ensure compatibility with existing vehicles, ensure manufacturability, and meet advanced requirements for the ETS. Another reviewer observed that GM took a systems approach to the design and used practical manufacturing processes. The reviewer felt that the design that resulted is innovative but accessible. The final reviewer commented that the development approach was thorough and many tradeoffs were studied, including forward-looking manufacturing issues. They added that novel concepts were attempted as part of the plan.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person explained that the project is 97% complete and has completed hardware and witness testing and have met 2010 requirements and some of 2015 requirements. The reviewer added that the ETS works over full range of automotive conditions including extreme cold and hot etc., not just bench demonstration. The project has consideration of the impact of advanced technology on other system components such as interfaces, variability of prototype components, etc., and has identified and addressed key concerns in this area. Accomplishments and lessons learned include: 1) soldering to heavy Cu board, pin alignment, thick board aspect

ratio requires larger diameter vias, 2) identified gate drive grounding issues, and 3) identified poor louver contacting issues. Another reviewer commented that the lessons learned were shared, good and bad, which is useful to others and is not always released to the public. The reviewer added that many of the negatives regarding the 5-phase machine were shared (coil inductance and manufacturing challenges) and it will be useful to see the advantages relative to inverter kVA and bulk capacitance reduction. The reviewer hoped that if the conclusion is that 5-phase machines have more drawbacks than advantages, that this is noted in the report. Another commenter thought that the fact that the researchers were able to meet all the DOE requirements, except cost was excellent. Cost is always the most difficult parameter because it usually means reducing the amount of basic commodities such as steel, copper, etc. which is very difficult. The reviewer concluded by applauding that the performance of this system looks great and the packaging was executed well. Two reviewers had critical comments. One stated that gate drive highlighted as too many parts, and layout and traces encroach on heavy copper layers. The final reviewer questioned what the actual achievement on the cost target was.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responses to this question were positive. One person noted that suppliers and laboratories were engaged in the program. Another commenter remarked that the team for this project had many diverse companies and institutions. The final reviewer acknowledged that the project has numerous partners with Tier 1,2, and 3 suppliers in motor, inverter, and charger, as well as national labs. The reviewer thought that this coordination has provided benefit to the project and has provided input into other projects within Vehicle Technologies Program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the work is basically done except for the report. Another person had similar comments and stated that the program is being completed and that the report with its conclusions will be interesting and the lessons learned will be helpful. Another reviewer explained that vibe testing will be among last things done, to preserve the units rather than test to destruction. One commenter noted however that the project has identified priorities for future work and that power density and specific power have become less of an issue whereas efficiency is more important and cost is the priority. One reviewer pointed out that the power module, capacitor, and rare earth magnets are the priorities for cost concerns. The final reviewer suggested that in order to reduce cost, the ETS development needs to consider full system integration not just individual components.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

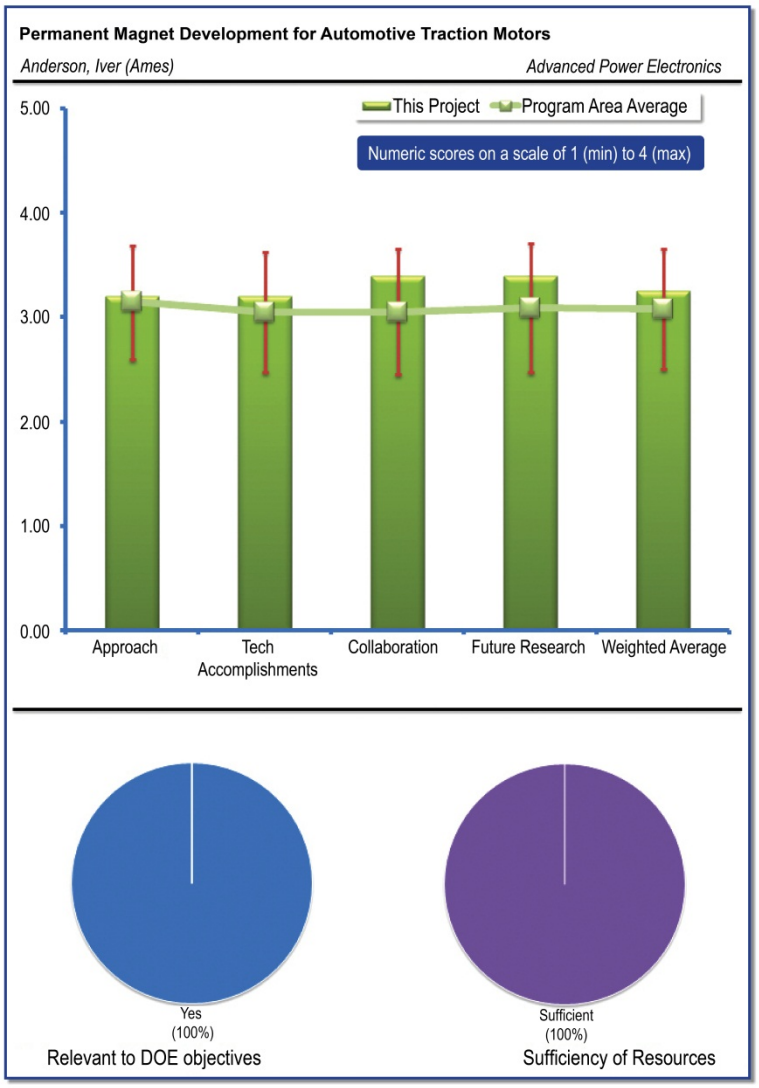
Permanent Magnet Development for Automotive Traction Motors: Anderson, Iver (Ames) – ape015

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewer comments to this question were positive. One commenter simply stated that replacement and minimization of rare-earth magnets is key for electrification success in automotive. A second reviewer noted that the project focuses on reducing or eliminating the rare earth permanent magnet materials content which can have a significant impact on reducing the cost. Another reviewer explained that permanent magnet machines dominate vehicle electrification, and work to improve the technology and reduce/eliminate dependency on China for these materials supports overall DOE objectives. The final commenter had detailed comments, stating that rare-earth permanent magnet materials are a main cost driver in electric machines. The researcher's goal is to develop new magnet materials with reduced heavy rare-earth content or to eliminate the rare-earth magnet material entirely by using different alloys. The reviewer agreed that both developments would reduce the cost of permanent magnets and would therefore accelerate the broad implementation of electric machines in vehicles.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Responses to this question were generally positive, but mixed with suggested scope additions to improve the project. One commenter expressed that the program addresses the issues directly: the elimination of dependence on materials that are difficult to obtain. The reviewer cautioned that a possible research approach deficiency is not integrating the magnet work with motor development and prototype work at an early stage of the work. Another person commented that the researchers have a good approach trying to address permanent magnets with reduced rare earth content as well as non-rare earth magnets. One reviewer noted that it seems that ferrite magnet materials have been excluded from the study up to now. The reviewer asked whether there are any plans to look into this topic at a later point in time. The final reviewer observed that the approach for reducing permanent magnet costs in this project follows two different paths. One path is the reduction or replacement of heavy rare-earth materials like Dysprosium while still maintaining high-coercivity which is needed for acceptable thermal performance of the permanent magnets. The second path is the development of rare-earth free permanent magnet materials with suitable performance. This part of the project looks in depth into the improvement of AlNiCo and the development of new alloys like Fe-Co-W.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments to this question were generally positive. One person remarked that the project shows good progress in terms of achieving a better understanding of permanent magnet metallurgy both for rare-earth and non-rare earth magnet materials. The work in the area of reduced Dysprosium content shows progress with promising results for $(BH)_{max}$ and high temperature performance. The reviewer asked when the achieved results will be transferred into an electric machine design in order to prove the applicability. Another person acknowledged that dysprosium-elimination and iron-cobalt magnet efforts are at their beginning stages, but early activities provide optimism that the work is getting a good start. Another reviewer agreed, stating that the Beyond-Rare-Earth part of the project is still in an early stage although it shows a few promising aspects. The reviewer added that if the significant improvement of the coercivity of AlNiCo would become reality, it would be a major breakthrough. The last reviewer agreed that good progress has been made, but felt that more understanding of how the proposed magnets compare to the state-of-the-art is needed.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Comments to this question were generally positive. One reviewer observed that the project has an impressive number of collaborators with different expertise. The reviewer felt that this will potentially accelerate the development of new magnet materials if the lead researchers are able to coordinate all the contributions in an effective manner. Another person also acknowledged that the collaborator list is long and diverse. The reviewer remarked that it will be important to manage the work (not spread the team too thin) by weighing the value of the feedback from this group of participants. The final reviewer cautioned that even though there is a very long list of collaborators, it is not clear what are their actual contributions, so this needs to be made clearer.

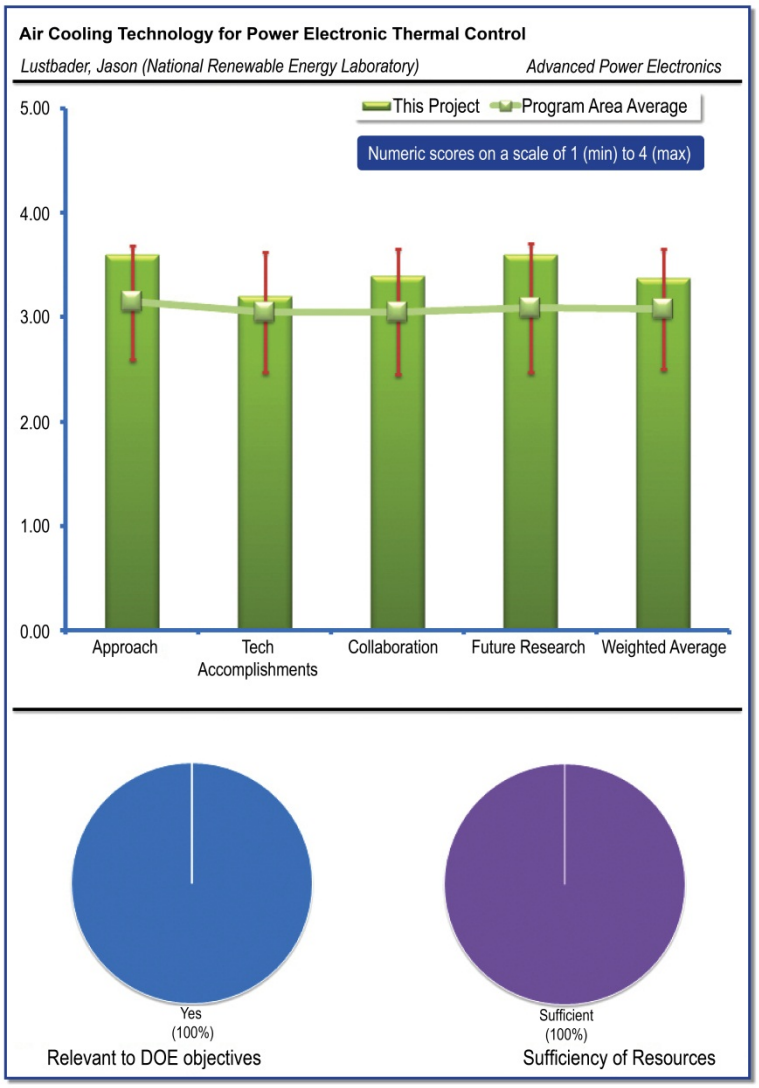
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One person commented that the future work to eliminate dysprosium and create higher coercivity nickel-cobalt magnet alloys is important and has high value. The reviewer felt that the ideas were presented that support both activities. Another reviewer observed that the researchers seem to have a clear plan on how to move forward with their current work. The final reviewer cautioned that before proceeding further with all the proposed areas, quantifying the impact of the theoretical properties of the proposed magnets on an actual motor performance would be highly desirable and recommended.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

Air Cooling Technology for Power Electronic Thermal Control: Lustbader, Jason (National Renewable Energy Laboratory) – ape019



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One person commented that thermal cooling is one of the most important aspects to meeting the DOE goals and it is a significant cost factor. The reviewer acknowledged that this project addresses novel cooling methods. Another reviewer noted that air-cooling has the potential to reduce the cost of the PE in the vehicle thus increasing affordability. Another person commented that the elimination of parasitic loads, such as dedicated liquid coolant loops for electronics cooling, provide both direct and indirect reduction of work required by the PCU, ICE, or generic bus energy conversion. Thus, additional fuel consumption savings is realized, which may also be augmented by volume and weight reductions. The magnitude of this impact will be borne out by the outcome of this and other similar trade studies of vehicle subsystems. The reviewer felt that the primary advantage of this project is the system level approach to subsystem optimization, which increases the relevance of the study outcome results. The final reviewer agreed that lower cost of power electronics helps to enable the market for power electronics; however, the reviewer cautioned that larger package volumes for power electronics modules may limit application opportunities.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments to this question were mixed, with some lauding the approach, while others were more critical and provided suggested guidance. One reviewer stated that the approach is a multi-dimensional study which is very comprehensive and balanced. It looks at a wide field of new technologies. The reviewer felt that the researchers appear to have all the control variables under consideration. Another reviewer remarked that the researchers presented one of the most well organized and intentional work plans observed during the review. The reviewer felt that each task was highly organized and cooperatively dovetailed with the other tasks in the project leading to an overall project structure which is highly likely to achieve a relevant outcome. The reviewer asked specifically, which components, if any, can be satisfactorily be managed using ambient air-cooling directly. The reviewer concluded by offering kudos to Mr. Lustbader, the PI. One commenter expressed that the approach focus on technical barriers is very good, but other issues related to side-effects of cooling method cannot be ignored. The side effects include audible noise and additional cost of cabling that different location may cause. One reviewer said that the researcher's approach is good, but it is not clear in an engineering sense what the researchers are designing to. Another reviewer simply stated that the researcher needs to pick an application for comparison. One person suggested that the researchers need to understand the heat flow capacity by air-cooling method for a 30 kW inverter system, the cost for the balance of the air-cooled system. They concluded by mentioning that the audible noise needs to be studied. The final

reviewer had detailed criticisms and suggestions to improve the approach. The reviewer remarked that from a systems approach please state the DOE targets for an air-cooled system and how your approach can meet those requirements. They suggested that the researchers refer to the previous FOA for a power electronics air-cooled inverter approach as an example; from that example provide your thermal design target, cooling design target, and package design target. Once that is done, discuss your proposed implementation to meet those targets.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that the results demonstrate a high degree of coherent focus on the proposed task plan and were obviously accomplished with a high degree of fidelity and confidence in these results. This reviewer felt that the project appears to be on schedule and well managed and executed. Another reviewer noted that so far the work is just starting to experiment with some new techniques such synthetic jets, but this is very promising. The reviewer remarked that the subject is so broad that in the future there will be more down selection of promising methods. Another reviewer stated that the progress on air-cooling is good and is using interesting ideas. They explained that air-cooling is currently being used in HEVs and BEVs with good success, but not without problems. The reviewer pointed out that concerns include investigating effects of time on the performance, i.e., how does fouling impact the air-cooling path (dust, etc.) as well as audible noise. The final reviewer agreed the researchers are off to a good start, but criticized that the engineering targets the investigators are trying to address are not clear.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments to this question were mixed. One person remarked that there was very good collaboration with other institutions and companies. However, another reviewer commented that it was not clear if there was any collaboration with vehicle manufacturers. The final reviewer offered that the only suggestion for improvement here might be to consult with vehicle and power electronics manufacturers for environmental boundary conditions and dynamic heating effects, respectively.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments to this question were generally positive, with two reviewers offering suggested improvements. The first reviewer stated that the work plan for future work encompasses all the needed systems, components, and technologies. Another reviewer commented that the proposed efforts for the balance of this year, and in the out-years, reflects the highly organized structure of this project. The reviewer also pointed out that leveraging prior results with a focus on the critical aspects of the study are obviously in place. Another reviewer commented that the approach is clear but need some specific design targets to address, so the researchers should state what these design targets are. The last reviewer to comment expressed that the plans looked good and they are focusing on the technical issues mentioned. Need to broaden the scope a little when some of the fundamental issues are solved.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No reviewer provided a comment to this question.

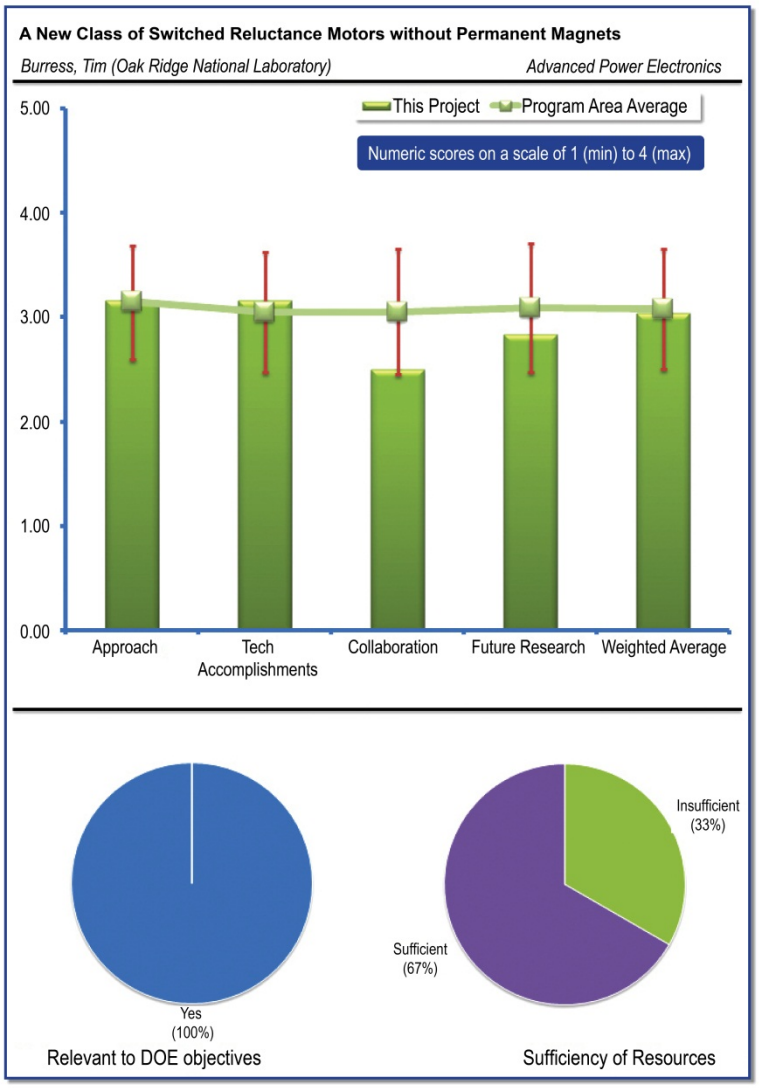
A New Class of Switched Reluctance Motors without Permanent Magnets: Burress, Tim (Oak Ridge National Laboratory) – ape020

Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments to this question were all positive, but only one person specifically mentioned the project supporting DOE goals. One reviewer simply noted that this project aims to produce a motor without rare earth magnets. Another reviewer had a similar reaction, commenting that the motor technology is novel and addresses the current supply/cost issue with rare-earth magnets by eliminating them from this motor. One reviewer remarked that switched reluctance machines do not need permanent magnets and have the potential of reducing the cost of electric drive systems, which supports the DOE objective. Another person described that the project proposes a new class of switched reluctance motors which potentially can have the same performance as rare-earth PM motors. The reviewer added that this potentially can cause a significant reduction in the motor's cost as well as eliminate the dependence on rare earth permanent magnets. The final reviewer to comment pointed out that the project will address fundamental torque ripple and acoustic noise issue which have prevented the use of switched reluctance machines.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments to this question were generally positive, with some questions being raised. One reviewer commented that the researchers' approach seems good in terms of doing analysis/simulation then moving towards building and testing a prototype. The reviewer noted that the accuracy and how detailed the analysis/simulations are need to be revisited. Another reviewer remarked that the program is well designed in terms of the design possibilities survey, modeling, and prototype fabrication/test activities. It appeared to this reviewer that this is an innovative version of a switched reluctance machine. Another reviewer commented that this is fresh approach to looking at switched reluctance motors; the initial results pointed to some new and innovative concepts which were not explored previously. The final reviewer had detailed comments, indicating that the project attempts to address the main issues of switched reluctance machines which are torque ripple and acoustic noise. The reviewer added that it was mentioned that several novel switched reluctance machine concepts have been investigated in detail before the most promising concept has been chosen for optimization and prototype build. Unfortunately, not many details about the investigated variants are provided. The reviewer concluded by noting that a prototype machine was built and tests are underway which is necessary to prove the claimed benefits.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reactions to this question were mixed. One reviewer expressed that good progress has been made in terms of building a prototype but there are several issues need to be resolved: (1) The fact that the measured torque is ~75% of predictions needs to be resolved, (2) More detailed loss/efficiency analysis is needed. Mechanical losses especially windage should be included, (3) It is not clear how torque ripple and noise will be verified by measurements, (4) The comparison to the DOE specs need to be on the basis of the required peak torque at the required speed, (5) What is the assumed coolant inlet temperature?, and (6) Has any detailed thermal performance been performed? Another reviewer described that testing has begun and issues are overcome as they occur. They added that test results at power and speed will occur shortly, given the progress made to date. One commenter said that the tests on the prototype machine look promising in respect to torque ripple and noise. The reviewer went on to say that the real test will be at higher torque levels where acoustic modalities occur. They concluded by mentioning that one thing that is promising is that torque ripple can be varied electronically so that higher power can be achieved at high speeds where ripple is not noticeable (but noise is). Another person stated that the researchers need to elaborate more on the unconventional design to reduce the torque ripple. One reviewer reported that the focus of the simulations seems to be on the main issues of switched reluctance machines which are torque ripple and vibrations, but this is not enough. The reviewer also noted that an additional part of the work has been the development of general machine design and controls optimization tools which is an impressive achievement. The final reviewer pointed out that the researchers state that extensive simulations have been conducted, but only very few results are presented. They added that no statements about loss and efficiency simulations and performance curves under consideration of thermal limits were presented.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer explained that most of the work has been conducted by the principal investigators. The reviewer felt that additional support from a motor supplier regarding manufacturability and cost of the novel machine design would have been helpful. Another person had similar observations, stating that it looks like mostly internal people working on the project. There should be more outside participation with switched reluctance experts or companies that make switched reluctance motors. One reviewer indicated that there was some level of collaboration with MotorSolver, but suggested that more collaboration with OEMs and people in industry with switched reluctance experience needs to increase to guide this effort in the right direction. The final person commented that the modeling and machine design partners are good, but that the lack of manufacturing and controls partners is a deficiency of this program.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One person commented that even without partners to help address future challenges, the work planned should quantify the performance of this new motor. Another person simply stated that they felt that future testing will show the direction for future research. One reviewer commented that it seems as if there is still a lot of work ahead of the researchers although there is not much time left until the project deadline. The reviewer offered that this may be a wrong impression due to the fact that not much detailed information is provided about the status and the plans to address potential issues. The reviewer added that the control of switched reluctance machines plays a major role in their performance and this is also not explained in enough detail so far. The final reviewer provided suggestions that full testing of the prototype is necessary as well as comparison to predictions and refining the design/analysis process based on measurements.

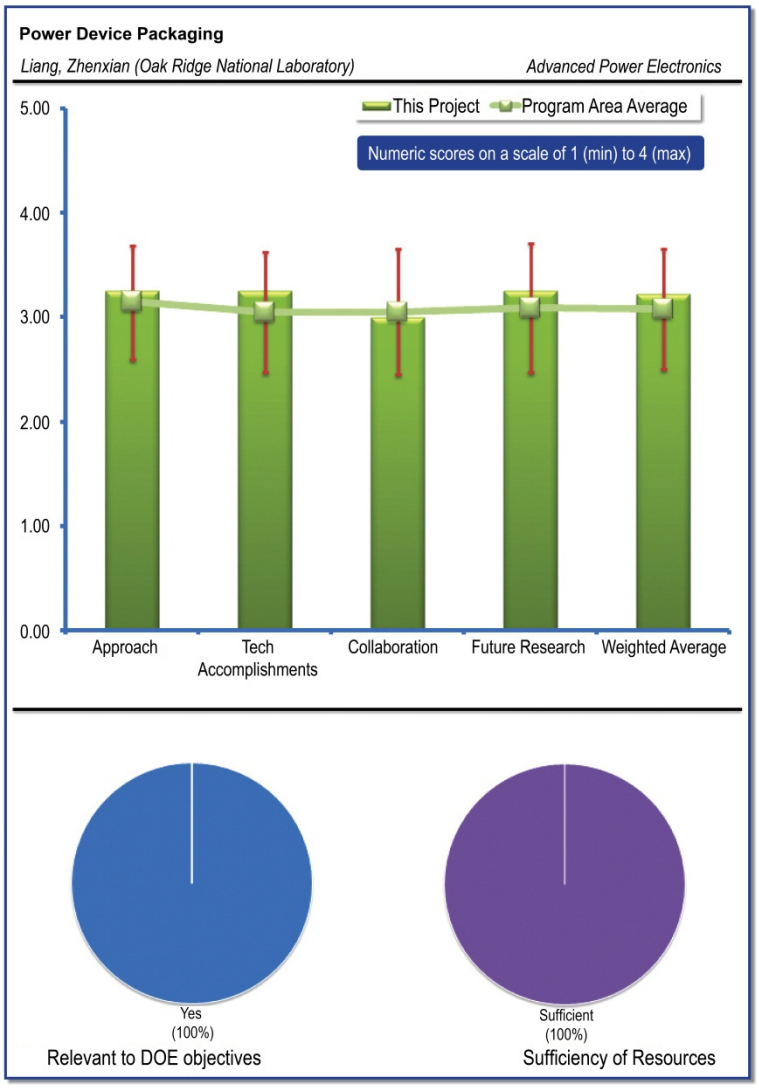
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer provided a comment to this question.

Power Device Packaging: Liang, Zhenxian (Oak Ridge National Laboratory) – ape023

Reviewer Sample Size

This project had a total of four reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented that the improvement of power device packaging in terms of cost and power density will enable the design of smaller inverters with lower costs; this supports the DOE objectives. Another reviewer agreed, stating that the power device package has a tremendous impact on the cost and performance of the power electronics and this project is addressing the package. The third reviewer felt that it was implied but not stated, that improving power density, manufacturability and cost of power modules helps to lower the cost of power electronics which helps to enable the market for HEVs, PHEVs, and FCVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer indicated that having the ability to design and build packages in house is a great advantage and will allow fast turnaround on potential solutions to problems discovered. Another reviewer agreed, saying that the development of power electronics packaging capabilities at a National Lab is a good approach as this permits the faster investigation of novel ideas without the immediate involvement of suppliers. The benchmarking of the state of the art technologies is very valuable. The third reviewer also agreed, stating that having a power module assembly process and access to failure analysis labs allows the capability to compare different power module configurations. The Automotive power module design/cost analysis tool is a good metric for comparing the different power modules currently used today. However, it was difficult to understand what they were doing with their new power module design since the work is under patent review. The reviewer felt that quantifying the goals by using the analysis tool to show what others have done versus what the project predicts the new design will achieve and felt that this approach to quantification of goals should be doable without having to reveal details of the design.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer indicated that the progress to date setting up the lab was great. Another reviewer indicated that the power module design analysis tool is an interesting approach to comparing different designs. The reviewer wanted to know if it was possible to present a chart - based on the tool - that shows the relative cost, reliability and power loss of the modules Oak Ridge National Laboratory (ORNL) has analyzed? The third reviewer felt that the accomplishments in terms of the benchmarking activity are very good both for the electrical and the mechanical analysis but that the progress of the new device packaging concept is difficult to evaluate as very few

details are provided. In addition, the reviewer felt that the claims of improvement are impressive but not proven at this point in time and that the support of other programs is of high value.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer noted that the collaboration is purely on a National Lab / university basis. Additional support and input from suppliers or Original Equipment Manufacturers (OEMs) would enhance the project results in terms of high volume production manufacturability. Another reviewer stated that it would be positive to see this project join with *Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters* (Allen Hefner of NIST) and *Physics of Failure of Electrical Interconnects* (Doug DeVoto of NREL) to take advantage of the failure modeling and performance modeling. This reviewer thought that joining with these two projects would create a closed loop path for package design as well as improve the modeling accuracy.

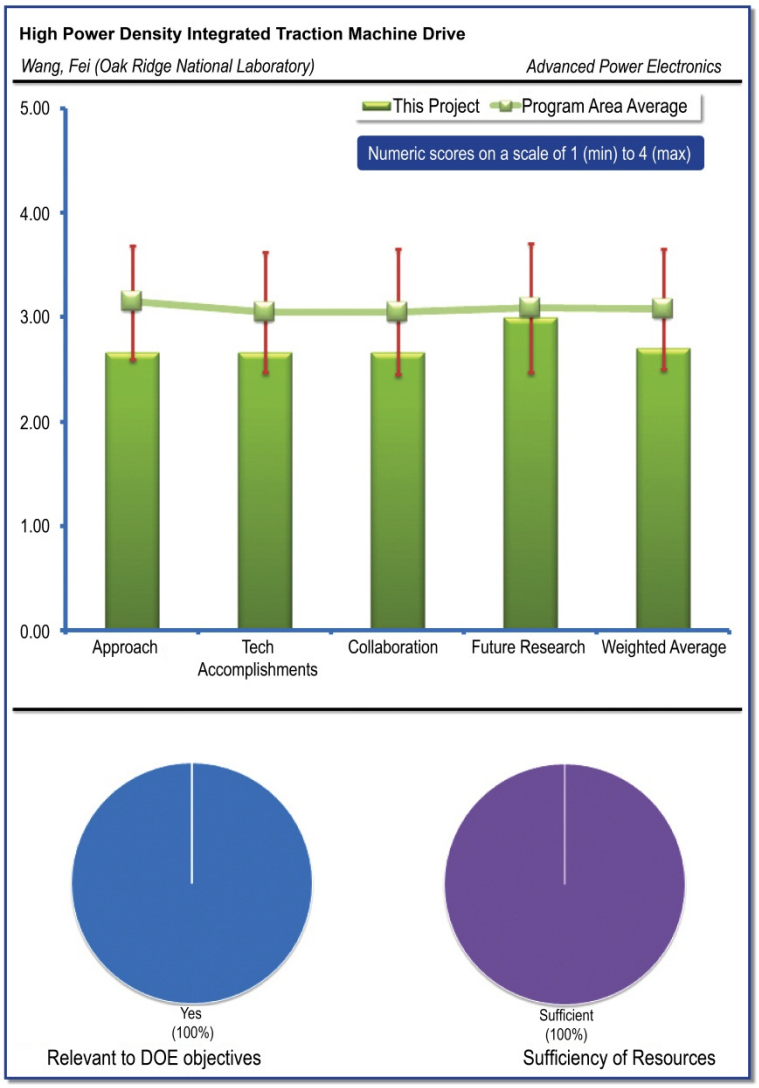
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer noted that the research had great potential if collaboration with other projects occurs. Another reviewer felt that the answer to this question was hard to determine since the details of the power module concept have not been presented but that the competitive assessment is always interesting. The third reviewer felt that the researchers have a reasonable plan for the future work. It is mentioned that in FY12 inverter-level packaging studies will be started. The reviewer noted that this seems to be outside of the original scope of the project and will hopefully not consume too many resources. It might be better to focus on the device packaging activities.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All four reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

High Power Density Integrated Traction Machine Drive: Wang, Fei (Oak Ridge National Laboratory) - ape024



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the goal of the project is to integrate the power electronics with the motor in a modular design which would result in a high power density. Moreover, the power electronics maximum operating temperature will be increased. Both measures could potentially accelerate the implementation of electric drive systems in vehicles and this supports the DOE objective. Another reviewer indicated that integrating the motor and inverter can have a significant impact on reducing the system cost.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer indicated that the researchers try to integrate a variety of innovations into one novel traction system. These are a multi-phase motor with modular design, a modular inverter with new packaging which is physically integrated with the motor, higher maximum junction temperature of the IGBT and a modular controller design which would provide better fault tolerance. The reviewer felt that it was an honorable approach, but that it might be better to separate the innovations on the subsystem level from the physical integration of motor and inverter because some of the innovations have a high value in itself (e.g. the increased junction temperature or the multi-phase motor). Moreover, the reviewer noted that the axial integration of the inverter and motor is not the preferred solution for transmission integrated hybrid drivetrains. A reviewer was not convinced that the 6-phase machine is the way to go. The reviewer noted that it adds significant complexity to the system and questioned whether the increase in number of devices was justified. Also, in order to achieve fault tolerance, the reviewer felt that the winding configuration needs to be modified to single-layer tooth winding. Additionally, the reviewer felt the key novelty is the packaging and integration part which could be shown first on a 3-phase machine before tackling the fault-tolerance issue. A reviewer noted concern about the location proposed to mount the inverter modules. Additionally, a reviewer noted concerns with scalability. This reviewer felt that, as the effort is currently targeting a 10 kW prototype, it has to be shown that there is no scale-up challenges in terms of packaging or any other aspect. One reviewer noted the need to understand the thermal and vibration impact on inverter mounting location.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt that good progress was made on the device and packaging side. In addition, the reviewer felt that the selection of the 6-phase motor was questionable and noted that no information was provided about the cooling mechanism and whether the motor is

designed to meet the 105°C requirement. Another reviewer noted that the accomplishments on the motor development side are difficult to evaluate because little detail is provided. The reviewer wanted to know what the simulated performance of the multi-phase machine was and how it compares to the DOE requirements. Additionally, the reviewer asked what the specific advantages of the modular design in terms of cost and performance were. The reviewer felt that the progress for the power electronics is described in more detail and first test results for the module are promising and that the device packaging seems to be on a good way, but the overall integration of motor and inverter seems to be in a very early stage, and that no further details were provided.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the collaboration with the University of Wisconsin was good. Another reviewer noted that there is collaboration with two universities but it seems as if no industry partner is involved. The reviewer felt that an industry partner might be necessary for better guidelines of which packaging concepts the industry is interested in. One reviewer left no comments.

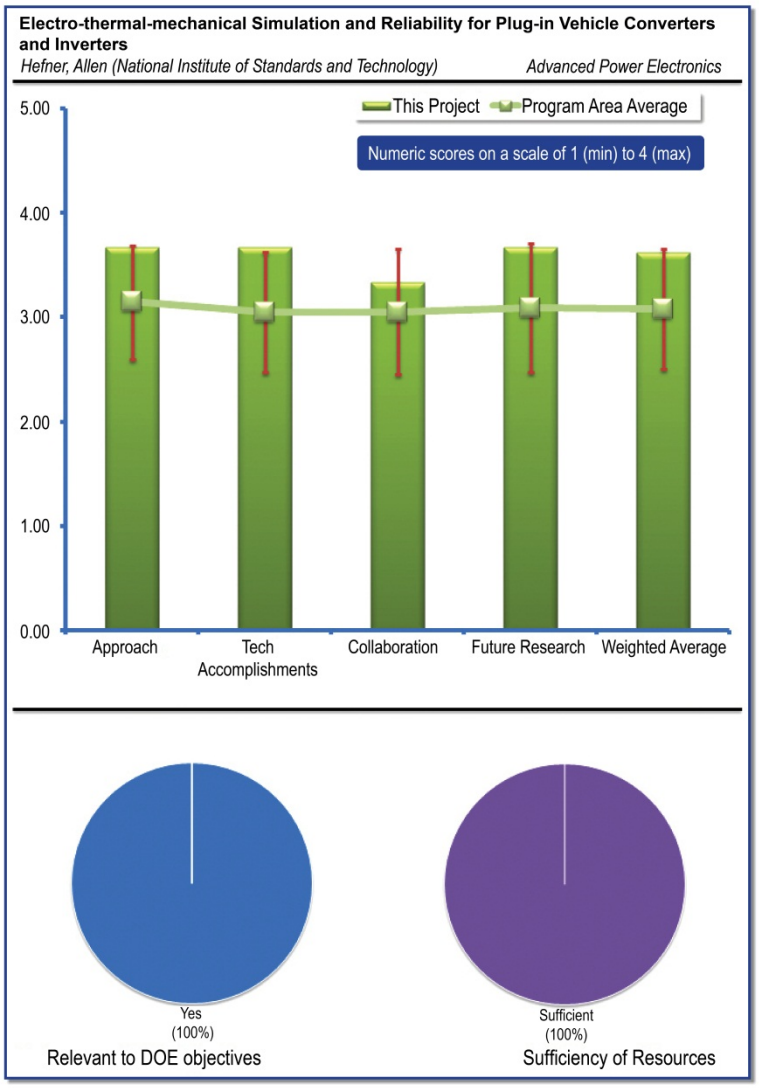
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that it is a good approach to first prove the feasibility of the new concepts through the planned test of the 10kW system. The reviewer stated that an estimation of the manufacturing cost of the integrated system is definitely needed for the next review because the cost impact of the new concept is unclear at this point in time. Another reviewer noted that the building and testing of the 10kW system is a critical deliverable in terms of highlighting any potential issues. The reviewer felt that it was not clear how the testing will be performed at 105 °C.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters: Hefner, Allen (National Institute of Standards and Technology) - ape026



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that it is important to understand the thermal electrical characteristics of power electronics. Another reviewer stated the following: one of the more subtle factors facing developers of optimized hybrid PEV technologies is the issue of understanding and managing the dynamic heat transfer and thermal management of power electronic subsystems. As volumetric and mass power density objectives become more aggressive, heat capacity and the margin for power device junction temperature management decrease. Thus, a critical understanding of dynamic, non-equilibrium thermal transients in these systems is crucial to the fielding of reliable electrical powered components. Both efficiency and catastrophic failure prevention necessitate this consideration. The subject project is outstanding in its inclusion of these considerations in power device and module design and analysis. Legacy steady state analysis of power components will not provide the performance or reliability required to successfully deploy these vehicular systems with this consideration. The subject project includes and leverages this critical consideration and thus provides the framework for key electrical component analysis and development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the investigator was building models of all the major thermal parts and interfaces found in power electronics. The investigator is creating these in Saber which, in the reviewer's opinion, is an excellent analytical tool. Another reviewer indicated that the electro-thermo-mechanical modeling project includes the requisite physics-based modeling required to enable critical consideration of technologies being developed for reliable vehicle applications. The reviewer felt that the use of modeling validation with power electronic component hardware characterization was excellent and that the goal of bond fatigue and failure predictions will be important to module and packaged power device development.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that the work so far looks to expand our understanding of the static and dynamic thermal characteristics of power electronics. The reviewer believes that this is a new approach and can lead to improved thermal and electrical design. Another reviewer felt that progress to date was on-target with APEEM goals, objectives, and schedules. An application of the physics-based

models to power packages and modules developed by other contractors reflects the relevance of this activity and the potential for it to measurably impact the evolving development of these key electronic components.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that the collaboration structure with the hardware from other projects being evaluated using the dynamic models was excellent. In addition, the goal to predict thermal fatigue of solders and wire bonds will provide valuable feedback to component developers involved. One reviewer noted that the Principal Investigator is working with many companies to develop the device models.

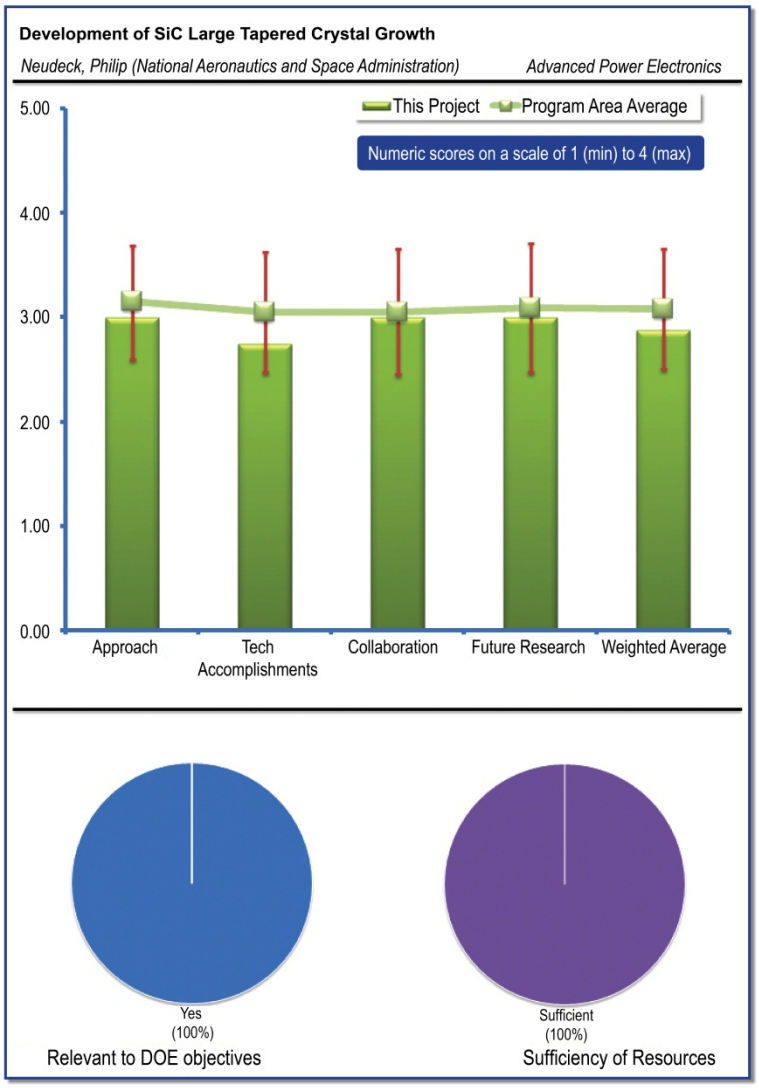
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer indicated that the prospect for valuable positive impact to the overall electrical component development portfolio is very high. The reviewer felt that successful validation of a developed thermo-mechanical prediction tool for reliability projections is a much needed capability if cost-effective vehicle subsystems are to be successfully developed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Development of SiC Large Tapered Crystal Growth: Neudeck, Philip (National Aeronautics and Space Administration) - ape027



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the potential impact to DOE objectives for this project are longer term, but prospectively significant. If the novel crystal growth technology being pursued is successfully demonstrated, a dramatic impact to Silicon Carbide (SiC) power device yield (meaning cost) and performance (i.e. efficiency which translates into greater fuel displacement) may be realized. Thus, while this project is a fundamental science type project – and thus higher risk – it can potentially have a significant impact on hybrid and PEV vehicle fuel consumption. Another reviewer noted that the project presumes that defects are inherent in existing SiC material growth approach and that a completely new approach is required to produce material that can enable devices that will meet VTP program goals. The project claims that the new approach will lead to an improved material which will lead to 100X improvement in material defects and 2X lower cost in SiC devices. Lower cost SiC devices may lead to propulsion inverters with lower cost, weight, and volume. A third reviewer stated that improving the efficiency of inverters and converts directly improves PEV and HEV. One area for improvement in those components is the electronic devices themselves. Using SiC electronics will help with that improvement; however, SiC is hampered by constraints that this project will help relax.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer noted that there was a very well organized research task structure, with requisite focus and emphasis on the critical technical barriers of fiber fabrication and floating solvent growth demonstration of high quality crystals. If demonstrated successfully, the project will provide tangible evidence for the potential utility of the investigated crystal growth approach. Another reviewer noted that this project takes a novel approach to creating crystals which not used in industry today; the reviewer feels it has the potential to change how things are done and is not just an evolutionary step. A third reviewer noted that the project claims that devices made with existing SiC materials do not meet fundamental limit expected for devices made with SiC. The reviewer indicated that this presumption is disputed by other experts. The reviewer also noted that the project strives to develop a new crystal growth method that will compete with existing boule growth methods. As there has been considerable investment over many years in the current approaches, this project represents a very high risk long term prospect that might meet and exceed the capabilities of existing SiC boule growth approaches.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer noted that real world demonstration of planned steps has happened as planned. Another reviewer felt that progress has been slow to this point, although reactor design, build, and initial experiment evaluation are very laborious and time consuming activities. The reviewer also indicated that, now that the initial source melt and seed crystal wetting experiments have been demonstrated, there should be rapid progress leading to grown crystal evaluations sufficient to determine process potential. A third reviewer noted that the approach proposed by the project requires two achievements; first the growth of a one-dimensional SiC crystal fiber, and second the two-dimensional radial crystal growth of SiC using the one-dimensional fiber as seed. The reviewer indicated that there are no crystal quality metrics for the program. The reviewer does feel that progress has been made since both linear and radial growth have been demonstrated: Laser heated float zone assisted fiber growth equipment complied, and ave grown SiC fiber from pseudo seed made from commercial wafer. Radial growth has been demonstrated using pseudo fiber. However, the reviewer feels that the quality of the material and the prospects of producing a boule or appreciable size are very uncertain.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer indicated that there are a number of collaborations with leaders in SiC crystal science within NASA and elsewhere. The competency of the project leader and his associates is the major strength of the project. Another reviewer indicated that there was good connection with the SUNY for critical crystal characterization feedback. The reviewer felt that it might have been advantageous to have included crystal growth expertise from Carnegie Mellon or another university program with a strong growth program history. A third reviewer indicated disappointment that collaboration seemed to be primarily with NASA.

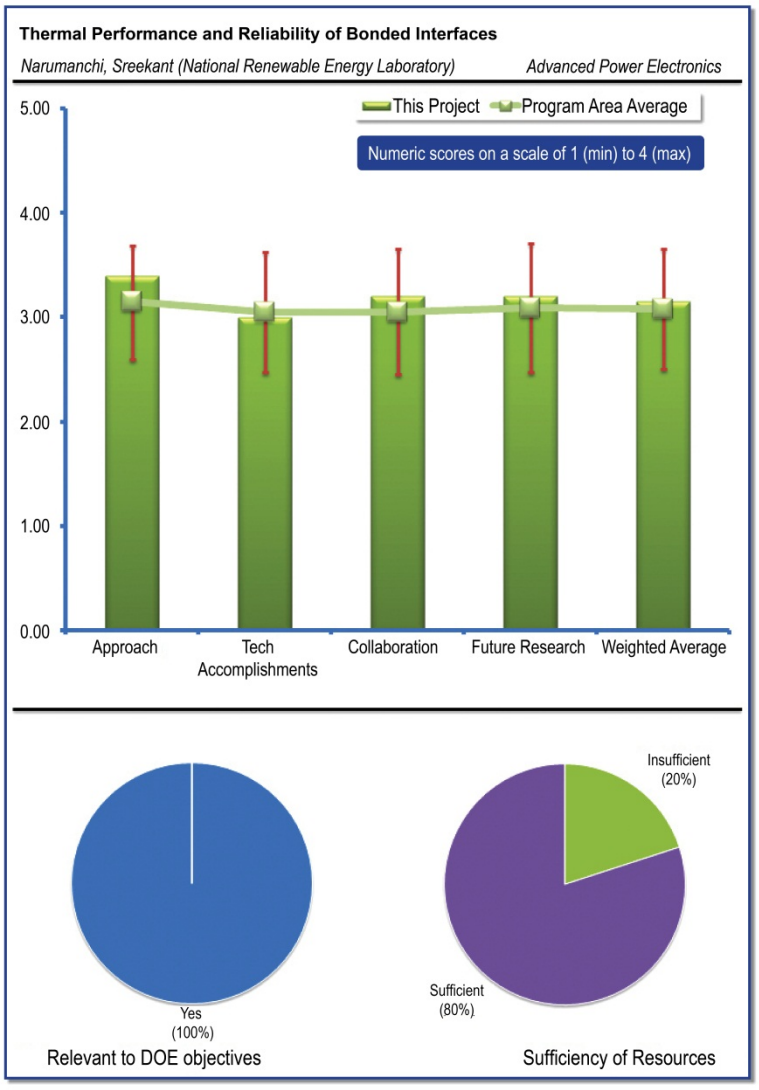
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer noted that the future planning was appropriate; the reviewer noted that after NASA has proven the fundamentals, it should initiate another project with more collaborators. Another reviewer indicated that NASA, if nothing else, has been highly focused on this approach to crystal growth for several years following their demonstration of single dislocation growth processes of in-plane SiC crystals. Thus, the project plan is highly aligned with their prior successes and they have an outstanding understanding of the technical barriers and practical obstacles which need to be overcome. A third reviewer indicated that the project plans to continue analysis of the material and to continue to improve growth rate and size of the crystal. Additionally, the reviewer noted that no metrics were given about crystal quality required at various stages of development to meet the stated goal of better material quality and lower cost than existing boule growth methods. The fourth reviewer remarked that the stated future plan for the project is if both fiber and radial growth processes demonstrated as viable in this project, initiate follow-on project (with more development partners and funding) to build and demonstrate “full-up” LTC boucle production prototype. This reviewer noted that there were no material metrics, timeline, or cost estimates of the research and development required to meet the stated goals of better material quality and lower cost than existing approaches.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All four reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Thermal Performance and Reliability of Bonded Interfaces: Narumanchi, Sreekant (National Renewable Energy Laboratory) - ape028



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer noted that this project has the possibility of improving the efficiency of the major heat generators inside inverters and converters. Another reviewer noted that this project addresses key joining issues that provides for thermal performance and reliability increases, and cost reduction. The third reviewer noted that improving thermal performance can reduce Si size, resulting in lower cost inverters. Reaching the target spec for thermal resistance of the bonded interface material (BIM) will also allow for more tolerance and robustness in the assembly process of the power stage.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer noted that the combination of modeling and comparing to real world parameters is important. The approach could be improved by considering failure/degradation modes that are unique to various BIMs. A reviewer indicated that the quality of these joints are dependent not only the materials being joined and type of joint, but the process that was used. The reviewer was concerned that not all these factors were being tracked and understood. A reviewer indicated that thermal shock testing may be an issue for materials that require a long dwell time between cycles. The reviewer was curious about how that testing can be accelerated for long dwell time, slow creep, materials. The reviewer also indicated that this approach can provide the initial design starting junction temperature of the power device which will be very useful.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that collecting thermal cycle data is a long process in terms of time but that the data are needed. Another reviewer agreed, indicating that it was good to see real world results.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer indicated that using a variety of outside sources helps to better define the problem and focus the results.

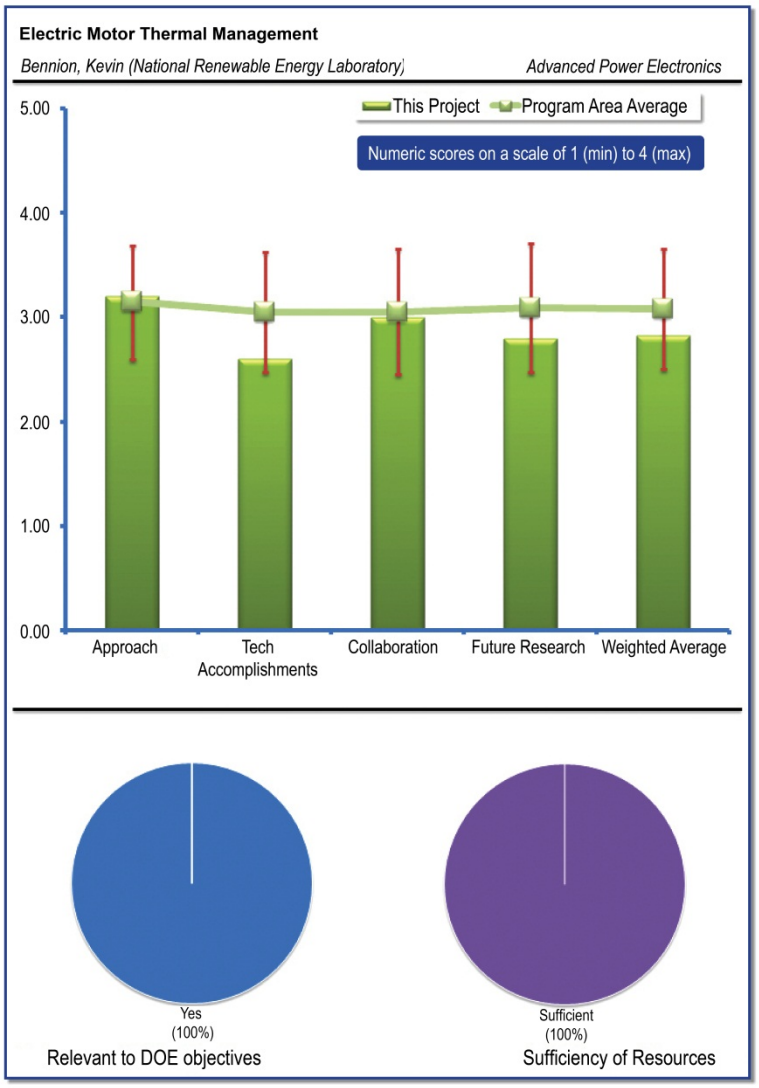
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer noted that the plan is a good one, and that it was important to stay on the plan. Another reviewer noted that the work is well defined and bounded.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Four of five reviewers felt that the resources for the project were sufficient to achieve the stated milestones in a timely fashion. One reviewer felt that the funds were insufficient.

Electric Motor Thermal Management: Bennion, Kevin (National Renewable Energy Laboratory) - ape030



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer stated that the better understanding and consequently improvement of the thermal limits of electric motors enables the design of motors with higher power density. The reviewer felt that this supports the DOE objective. Another reviewer noted that thermal management is a key enabler to meeting the traction motor performance targets. A third reviewer indicated that motor thermal management limits the output power, affects the size, and influences the cost of electric propulsion motors. A fourth reviewer stated that thermal management is important to achieving the DOE goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that the systematic approach with analysis of loss mechanisms in motors, packaging impact, cooling technologies and balance of the complete system is excellent. The reviewer also felt that the link into the Vehicle Technologies Program project "Combined Heating/Cooling Loops in Advanced Vehicles" is very valuable for the determination of overall system impacts. A reviewer stated that performing a literature review is a good starting point. The reviewer noted that the challenge is that this topic has been thoroughly investigated over the years and it may be challenging to identify what areas can be improved and how. The reviewer also indicated that a baseline case needs to be identified and thoroughly analyzed to be used in a comparing analysis for measurements. A reviewer indicated that the program is methodical; for example, the project is gathering data from industry to baseline the current state of motor cooling before moving to modeling and experiments. The investigator also recognizes that a one-size-fits-all approach is not realistic and is focusing on the most relevant, industry-adopted technology. A reviewer stated that the project is taking a broad multi-discipline approach to find the best thermal cooling methods. This will lead to better analytical tools and methods to understand all the key factors that influence cooling from the vehicle to mechanical design and environmental.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that this is a new project (year one) and a good understanding of current cooling technologies and possibilities has been achieved. The reviewer felt that the project is addressing feedback that is solicited and being received from industry. Another reviewer noted that the thermal load data of some example PM machines have been obtained and parametric FEA thermal models were developed. The person felt that the characterization of thermal interface properties for direct oil and water cooling jacket systems

is on a good path, and that the testing of thermal material properties (e.g. for laminations) is important. Overall, the reviewer indicated that the progress towards the project goals is very good. A third reviewer noted that progress to date is not as far along as the commenter expected. There were some system models built and some simulations. A fourth reviewer hoped that faster progress will be made later, and that perhaps the scope is too broad to investigate simultaneously. Another reviewer noted that there are some good areas of research identified but so far it might be early to judge the accomplishments. More quantitative analysis and test results are needed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that they have put together a good team of experts, with another reviewer noting that laboratories, universities and industry are all participating in this program. Another reviewer indicated that there seems to be good collaboration with the University of Wisconsin, Madison and ORNL on the project. A fourth reviewer indicated that the collaboration with the University of Wisconsin, Madison for the motor expertise is good, and that the inputs from other projects at ORNL like the benchmarking activity are beneficial for this project. The reviewer felt that the link into the Vehicle Technologies Program will ensure that overall system impacts are sufficiently considered.

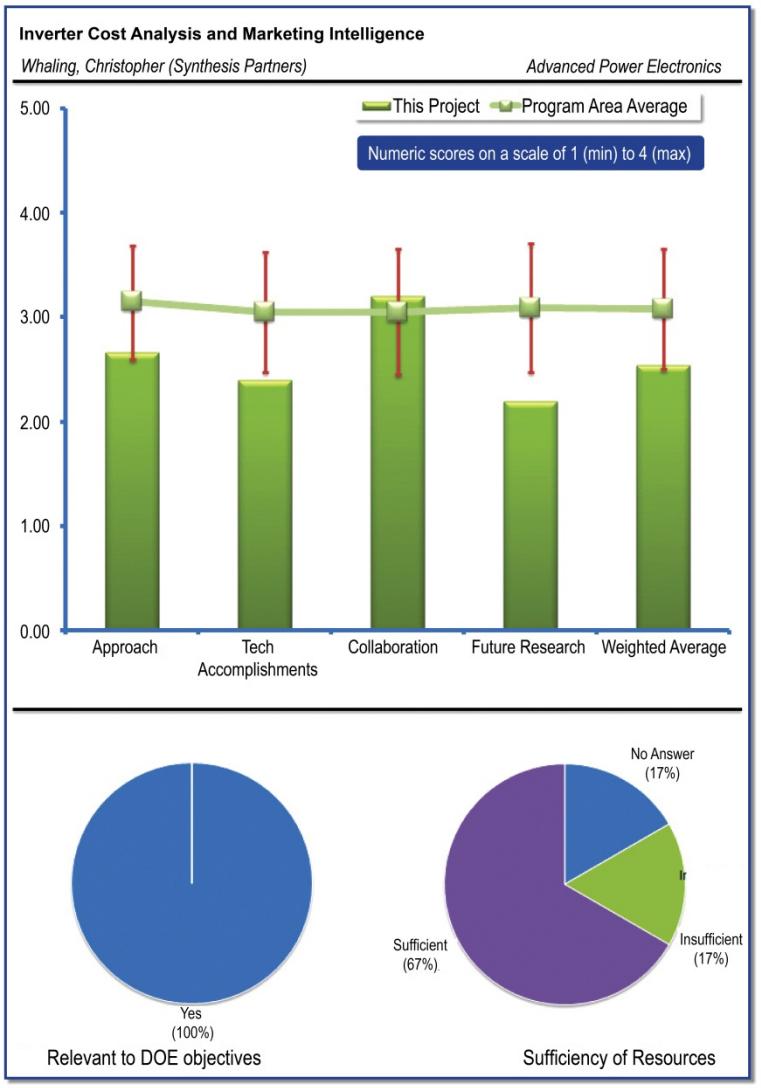
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the researchers have a clear plan for the next steps and a good understanding in which areas further work is necessary. The reviewer noted that it was mentioned in the presentation that the thermal performance improvement might lead to reduced heavy rare-earth magnet materials in PM machines, but the reviewer felt that induction machines should be investigated also as these would benefit significantly if thermal performance could be improved. Another reviewer noted that, while past work and progress is a good indicator that future work will be productive, specific plans and milestones were not clear. The reviewer encouraged more work to quantify the differences in available motor materials (e.g., difference between M19 and HF10 motor steel, comparison of stator varnish from a strength and heat rejection perspective, potting compounds to reject heat to the outer cooling jacket).The third reviewer felt that, instead of trying to look into a wide range of machine types, the commenter suggests focusing on the state of the art IPM motor and quantify what improvements can be made before moving on to other types. The fourth reviewer was not sure where the future will take this project. The reviewer felt that the project needs to be more clear about whether the goal is to look at cooling technologies or to develop thermal models.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Inverter Cost Analysis and Marketing Intelligence: Whaling, Christopher (Synthesis Partners) - ape032



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer felt that identifying cost drivers is a good means to develop a path to reduce the inverter cost. A second reviewer indicated that inverters are key components to vehicle electrification and cost/product information will help create better products. Another reviewer noted that the project discusses cost-effective approaches to vehicle electrification, and reduce vehicle reliance on fossil fuels. A fourth reviewer felt that it is worthwhile to understand the major cost drivers of power electronics to know what to attack. The reviewer indicated that the information from this project allows for a better understanding of what the issues in power electronics and electric machines are. One reviewer stated that the projection of cost and future drivers of component costs is a critical aspect of an emerging product market. The reviewer felt that without intentional and careful study to understand the limitations of rare earth element availability and cost, Li-ion battery market drivers, and TDI cost elements, it would be near impossible to successfully field profitable vehicular products in the future.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer noted that the collection of data from OEMs and Tier 1/2 Suppliers is the appropriate source of data. The reviewer felt that it will take some work to ensure that components are identified consistently to avoid confusion (e.g., one pie chart omitted thermal management and another omitted bus bars, even though both products likely included some amount of both). Another reviewer stated that projections are just that: projections. However, the reviewer felt that the subject effort is focused on the correct costs drivers for future vehicle manufacture and appear to be conducting a very thorough analysis of the critical parameters. One reviewer indicated that there seems to be two approaches depending on the study involved. One seems to be "go interview people". The other seems to be "scan a bunch of documents and look for references". The reviewer felt that neither approach seems to refine the direction of the search as information is acquired. A fourth reviewer suggests that the investigators establish more specific means to meet the goal.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer noted that, in spite of the very large volume of data to analyze and assess the project, it is making measurable progress and appears to be on schedule. The cost breakdown of the inverter is very interesting and valuable information. A reviewer stated that the cost distribution pie chart was helpful, but each represented one sample product. The reviewer noted that the presenter acknowledged that some slices will be variable. The reviewer felt that comments regarding the effect of volume were interesting, but the reason for

the knee of the curve at 50,000 [units] is not clear and may be the opinion of one OEM or supplier. Ultimately, the reviewer felt that too few specifics were provided for a project that will conclude in August 2011. A reviewer stated that the inverter survey compares current and future cost drivers; however, the definition of categories changes between the two charts (e.g. bus bars and thermal management). The reviewer felt that the work on automated search routines does not describe a mechanism to verify the automated search results. The reviewer was curious that if the scan-search method returns a set of information, would a human search of the same documents return more or less information? The reviewer also noted that there has been no progress on the Lithium-Ion work. A reviewer felt that the differences for cost drivers for now and future inverter are not clear. The reviewer wanted to know what changes occurred and how the project plans to meet the DOE goal. The reviewer also felt that the project needs more updates on the Li-ion battery and Beyond Rare Earth Magnets segments.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted that the OEM's, top tier suppliers, and all the relevant players are involved and providing input as required. The reviewer felt that anything less would not be acceptable. Another reviewer noted that the source of information includes Toyota and others, which is appropriate, but that the number of data points is unclear. The reviewer felt that it would be useful to study products that are new on the market like the Chevy Volt, the Nissan Leaf, and the Magna system for Ford. One reviewer expected the project to have more first-hand data from OEM/Supplier.

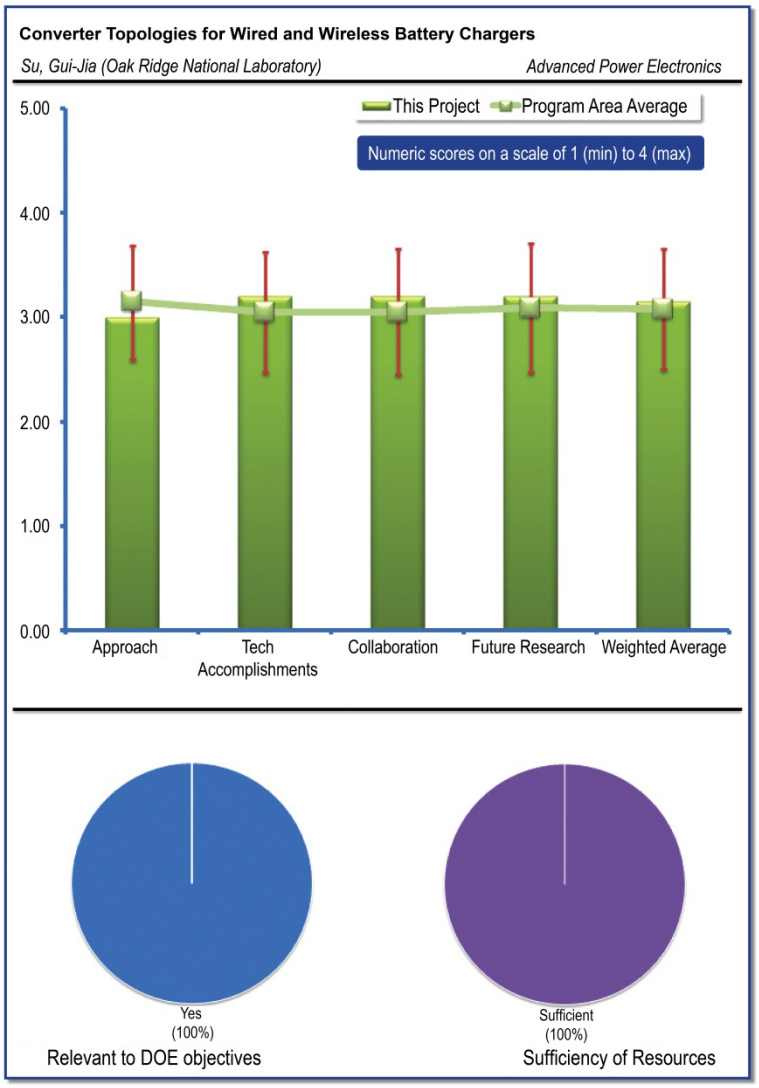
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that it was good that the final report will quantify costs rather than just the cost distribution. The reviewer felt that specific information about the underlying technologies would be useful to industry, but this reviewer understands that disclosing this would limit the input that would be received in the first place. The reviewer concluded that this limited industry input is why studying products on the market (Volt, Leaf) would be valuable, since the underlying technologies are public. The reviewer also felt that the presentation comments regarding the tendency to overdesign in the early stages of commercialization are accurate, and it will be useful to quantify this effect and offer possibilities and strategic thoughts for the future. Another reviewer noted that it was an aggressive plan to generate the cost metrics for batteries and rare earth magnets, in addition to completing the inverter analysis. The reviewer felt that all critical and necessary tasks still required completion. One reviewer noted that nothing was really specified regarding future work, and another stated that the future plan is not described in this presentation. Another reviewer remarked that discussions are ongoing.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four of five reviewers felt that the resources for the project were sufficient to achieve the stated milestones in a timely fashion. One reviewer felt that the funds were insufficient.

Converter Topologies for Wired and Wireless Battery Chargers: Su, Gui-Jia (Oak Ridge National Laboratory) - ape033



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer noted that chargers are a major cost factor for hybrid and electric vehicles. The reviewer felt that this project will explore new topologies for both wired and wireless chargers. Another reviewer noted that the project specifically addresses the need for battery charging, both wired and wireless. This reviewer felt that the technology will be needed to support HEV and EV technologies moving forward. A third reviewer noted that the project support for DOE objectives is implied but not stated. The reviewer felt that if the component cost decrease, and the overall inverter cost decreases, then this helps to enable inverters for HEV, PHEV and FCV's. A fourth reviewer noted that combining the on-board charger and other power electronics components like traction inverter is an effective way to the same system cost. Another reviewer indicated that an onboard charger adds $400 to vehicle cost and is unidirectional. The reviewer also noted that dual use propulsion inverter serving as charger and Vehicle-to-Grid (V2G) generator adds value at 90% less cost than separate charger/inverter equipment. The reviewer felt that there are important issues to address, which include previously demonstrated use of an onboard traction inverter for charging showed that it is difficult to provide galvanic isolation and cannot charge a dead battery and that a converter with high efficiency and power factor suitable for wireless charging is needed.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that the approach was very good. The reviewer felt that the discussion of efficiencies was well placed and supported and that the specific introduction of charging voltage and current was well done. The reviewer also noted that the method of addressing the alignment issue for wireless charging was well discussed as it represented real-world application issues that will arise. A reviewer felt that it was a good plan to perform literature study and simulations of new concepts followed by hardware demonstration. This reviewer suggested using simulation to investigate synchronous rectification and soft switching, new topologies to reduce switch count, ac-ac-dc approach (high frequency ac link), and resonant link to improves power factor. A reviewer noted that the project has shown two new topologies that could be effective based on simulations shown. The reviewer felt that one factor that needs to be considered is cost as it looks like the wireless method will be more expensive than the wired system and the wired system is expensive already. A reviewer noted that this project was a new start, and that the problems seem to be well understood, but the designs are not complete. A reviewer noted that there is a need to address system level issue like adding EMI filter into the AC line, how to synchronize the two MCU controller to achieve charger function, etc.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer noted that efficiencies were discussed and presented and that the simulation work of wireless charging results was shown. The reviewer chose to rate this section as a four because it seems to suggest that barriers will be overcome, and that wireless charging of this nature will proliferate. A reviewer indicated that this project has just started so accomplishments are modest at this time. The reviewer felt that the test set up showed good power transfer at 10 inches separation which the reviewer believed to be adequate. A reviewer indicated that only concepts and simulations were represented at this stage and that hardware experiments and concept verification were planned for the future. A reviewer reiterated that this project was a new start, and that the problems seem to be well understood, but the designs are not complete. A reviewer indicated that the power stage has been approved and working.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted that there was adequate collaboration with partners. Another reviewer added that the level of collaboration seems well defined and each group contribution is established and outlined. A reviewer commented that the partners chosen can help to define the vehicle environment. The reviewer felt that working with knowledge sources on antenna design and inductive power transfer were excellent choices for consulting on the design. A reviewer noted that the project leader stated that project is "looking to tech team for guidance". The reviewer felt that the project might benefit from more coordination and collaborations to establish V2G requirements.

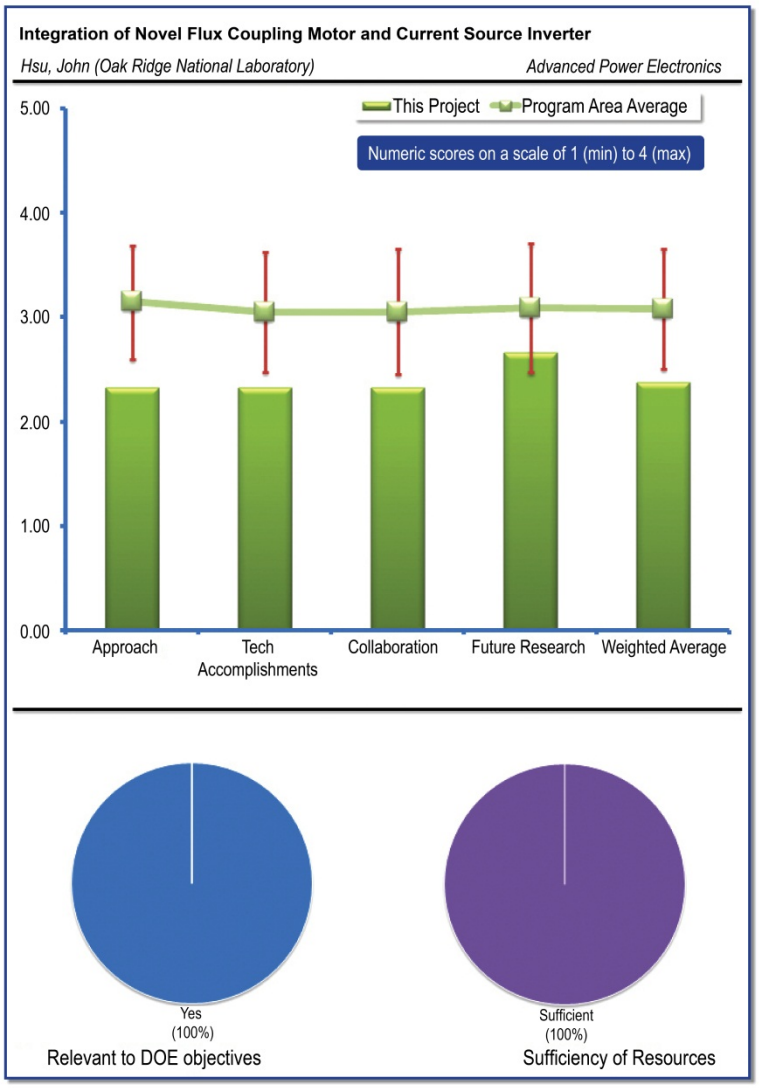
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer noted that the plan is clear to achieve the final objectives. Another reviewer commented that there was an excellent outline of the future goals. The reviewer did want to see some quantification, if possible, for cost, performance, and manufacturing goals and targets, etc. The third reviewer noted that design(s) is/are still being formulated, and it has not been shown how the barriers, like isolated integrated charger, will be addressed. The reviewer felt that the barriers appeared to be taken into account in the presentation. Another reviewer felt that this work is very important in that it could lead to another method of vehicle charging. However, at some point in the future this method will compete with direct charging via Society of Automotive Engineers (SAE) J1772 standards and the reviewer thinks that most OEMs will not want to have a dual charging system unless there is an advantage. The reviewer hopes that the researchers look at some of the practical implementation issues such as EMI and safety concerns. The fifth reviewer noted that a hardware demonstration of dual use propulsion inverter with galvanic isolation and dead battery charging would be valuable and that it was not clearly defined in the future work what V2G functions will be included in the study be simulating.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Integration of Novel Flux Coupling Motor and Current Source Inverter: Hsu, John (Oak Ridge National Laboratory) - ape034



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer stated that the project supports the goal of improving the traction system. Another reviewer noted that the program attempts to find synergies between a novel inverter and motor by using a single coil assembly to satisfy both the inverter inductor and motor excitation needs. The reviewer believes that a successful implementation would further vehicle electrification.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Another reviewer felt that the approach is an excellent and novel idea; however, it has very limited application. The reviewer noted that it combines the unique current source Quasi Z source inverter developed by Dr. Su at ORNL and the novel flux coupling motor by Dr. Hsu. The reviewer noted that both were very experimental at the time of the review. It was unclear to one reviewer that the inverter inductor and motor excitation needs may be satisfied with a single coil assembly. The reviewer felt that the requirements seem too different; more detail in the slides would have been helpful to show that the approach has merit and that it is difficult to evaluate the approach without these details.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer noted that, at the time of the review, the project is just getting started so there are just feasibility work results. Another reviewer noted that the program has only been going for about 6 months, but this is enough time to describe the parameters of the inductor/coil assembly and how it meets the needs of both the inverter and the motor. The reviewer remarked that it would be useful to describe how the AC blocking coil will be placed in the motor (without negating the inductance used for the inverter) and how the secondary coil will be integrated for additional flux production.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that no collaboration information was provided. Another reviewer noted that it was their belief that this work is mostly internal to ORNL.

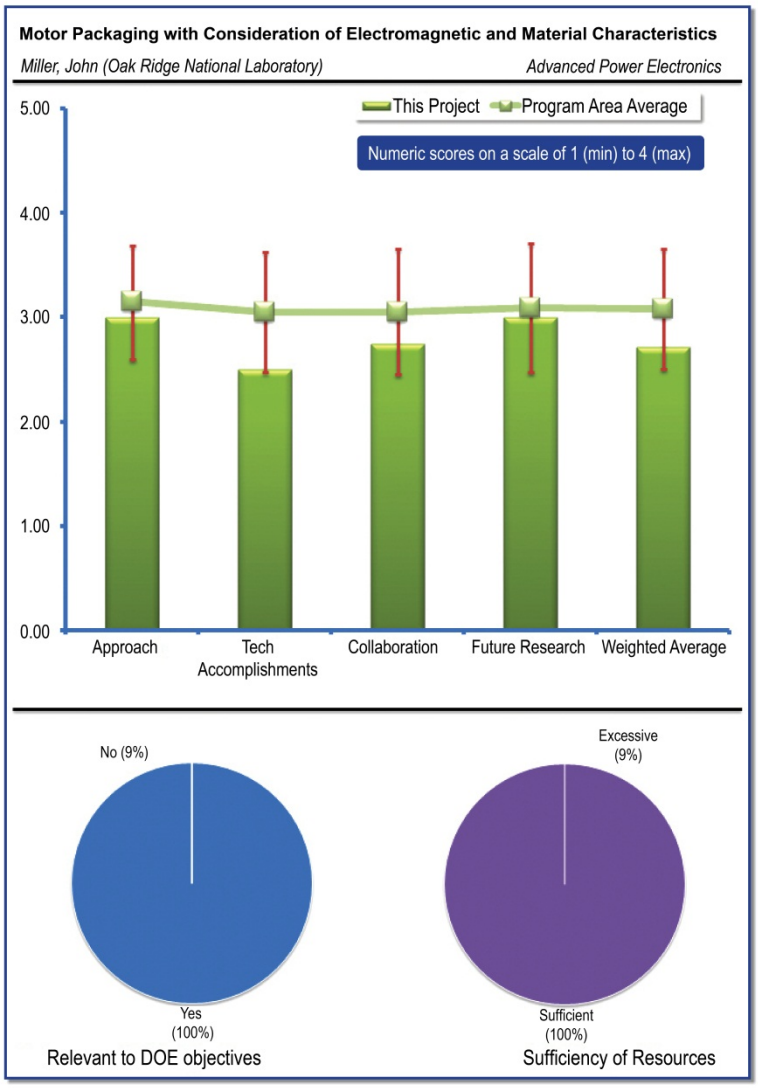
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer indicated that the goals for the remainder of FY11 are vague. A coil with sufficient leakage inductance for the CSI will likely be possible. The reviewer was unclear about how the AC flux blocking function is quantified. The reviewer was concerned that the program may be moved forward with an insufficient go/no-go standard and then struggle for the next year or two. The reviewer indicated that programs led by intelligent people may fail if too many novel features are stacked on top of one another, and this is what the program looks like. A reviewer noted that the future work looks good for the scope of the project. However, the scope of the system is extremely limited and not generally applicable.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Motor Packaging with Consideration of Electromagnetic and Material Characteristics: Miller, John (Oak Ridge National Laboratory) - ape035



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer stated that motors are a key component of any traction system and this work will help improve motor efficiency and cost. The reviewer felt that this was important to the growth of electric and hybrid vehicles. A reviewer noted that the project is targeting increasing the efficiency of traction motors as well as increasing the continuous power rating of these motors. The final reviewer indicated that improved propulsion motor efficiency and power support increased vehicle electrification.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer noted that trying to understand the various loss components as well as the various torque components is a good starting point. The reviewer remarked that the next step of evaluating the motor's performance using the proposed materials properties will help quantify the potential benefits. A reviewer indicated that the PI is looking at many key factors of motor design including winding methods, laminations, and rotor losses. This approach is analytical in the beginning and empirical in the end. In addition the PI is looking at novel lamination rolling methods to lower stator losses. Another reviewer indicated that much of the work that is proposed appears to be learning about issues that are already known in industry: motor windings, magnet leakage flux, air-gap flux shaping, lamination steel performance. The reviewer feels that it will be interesting to share these design methodology insights, and perhaps investigate alternatives, but thinks that this project an odd fit for a national laboratory. Since the work has just begun, the reviewer wondered whether or not the work will produce surprising results.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer indicated that the project just started in 2010 so there are not many results. Another reviewer noted that the project started in FY11. The reviewer stated that the work done so far is mainly finite element analysis simulations that are fairly straightforward and well known. The reviewer commented that more rigorous analysis and simulations based on expected materials properties should be performed as soon as possible. A reviewer noted that as a new program, little progress has been made and it remains to be seen where it leads. The reviewer feels that better high frequency and heat transfer materials are needed, so this work (bullet #3 of the FY11 Future Work) should be a focus item. The reviewer also noted that it is important to increase the efficiency in the light-load, mid-to-

high-speed region of operation and not so important to increase the high torque efficiency. In addition, the reviewer indicated that efficiency increases are more important than continuous power increases in automotive applications.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer remarked that there is an excellent team assembled for this project. Another reviewer noted that collaboration with NREL and ORNL's Material Science division are appropriate. The reviewer stated that they have wondered for some time why the ORNL Material Science team was not engaged in these programs. The reviewer also encouraged industry involvement. The third reviewer stated that the work done so far is mainly within the machines group within ORNL. The reviewer observed that it remains to be seen how the collaboration with the materials group within ORNL will evolve as well as the collaboration with NREL.

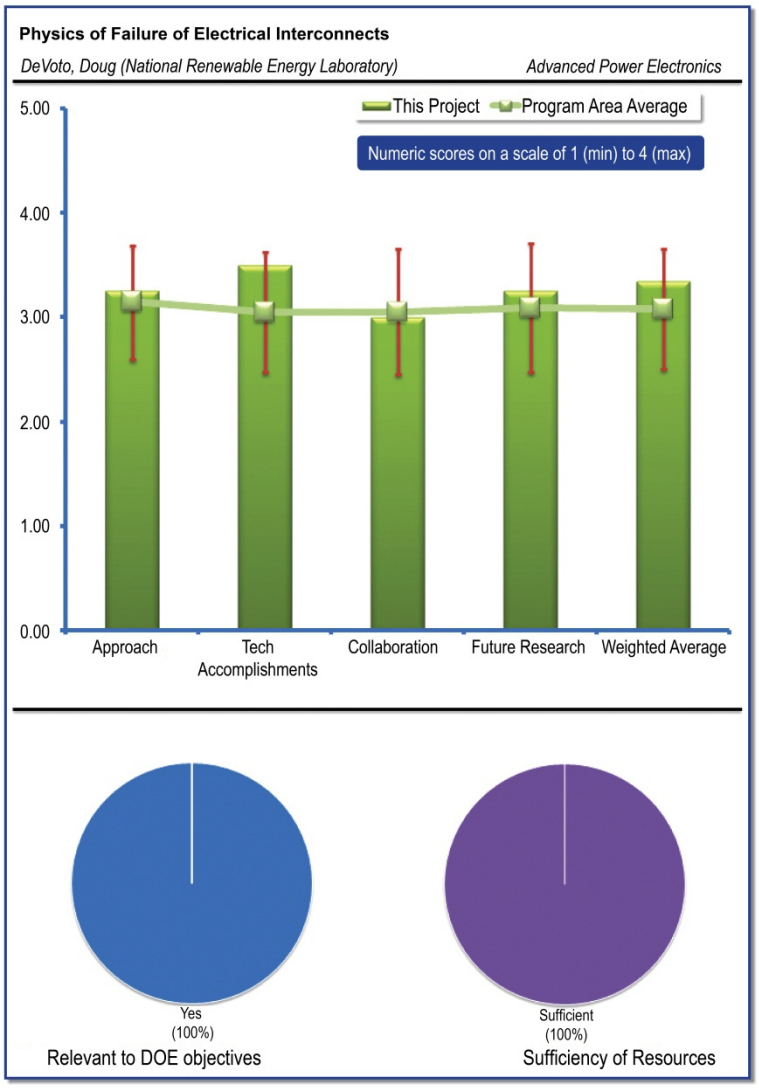
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer expressed that this project is on the right track and the proposed work is meaningful and practical. The second reviewer noted that future work with a focus on light-load efficiency improvement is encouraged. The reviewer felt that this may lead to innovative ideas, or toward ideas that are already known in industry and felt that it would be interesting to look at this work next year at the merit review. Another reviewer stated that if the analysis and simulations based on expected materials properties shows promising results in terms of motor's performance, then the proposed future work of developing these materials and eventually using them to build and test a motor makes sense. If the analysis does not show promising results then it is not recommended to proceed with the materials development.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Physics of Failure of Electrical Interconnects: DeVoto, Doug (National Renewable Energy Laboratory) – ape036



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that the ribbon bonding process has the potential of increasing the reliability and current capabilities of electrical interconnects. With this, the design of advanced power electronics would be enabled which supports the DOE objectives. Another reviewer indicated that this project is a key element of understanding what is necessary to have a reliable and cost effective power module. The third reviewer stated that for electric drive vehicles to be successful in the market, they must be as reliable (if not more reliable) than a conventional vehicle. The reviewer felt that the project addresses one of the weak points of today's electronics.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer felt that the approach is logical and straightforward. Another reviewer stated that, in contrast to many other projects, this project aims to investigate a very specific topic. The reviewer remarked that the approach is good because it will ensure that the focus is not lost in a multitude of goals. The reviewer also noted that different geometries and materials for ribbon bonds will be developed and tested. Moreover, simulation models for electrical interconnects will be developed or improved. A third reviewer indicated that the principal investigator will need to keep this well-coordinated with the physics of failure activity on power modules/inverters.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated that the accomplishments to date are fine. Another reviewer noted that the project is still in an early phase but the plan which has been set in place is good. The reviewer felt that the selection of industry partners is important and will add value to the project and the reliability testing is initiated and will lead to a better understanding of the new bonding technique.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer indicated that the choice of collaboration partners is good, especially the fact that the input from industry is actively pursued which is often not the case in research projects. Another reviewer wanted to know how the data are getting to industry. The reviewer felt that unless the data are used to solve problems they are useless.

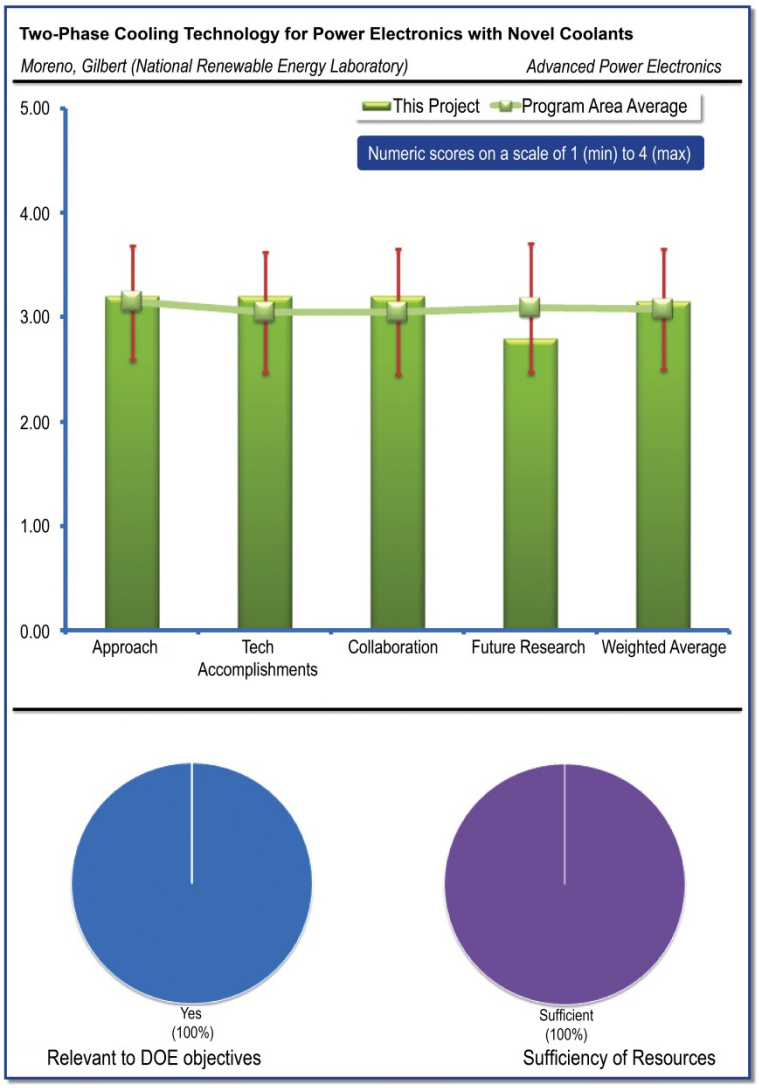
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that the researchers have set up a clear and detailed plan how to proceed with the testing. The reviewer commented that it would be interesting if more details about the modeling activity will be provided in the future. Another reviewer felt that collaboration with other DOE projects will provide a very powerful tool to solve this issue.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All four reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Two-Phase Cooling Technology for Power Electronics with Novel Coolants: Moreno, Gilbert (National Renewable Energy Laboratory) - ape037



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer stated that a two phase cooling concept has the potential to increase the power density of power electronics and thus does support the DOE objectives. Another reviewer agreed, stating that the ability to remove heat from the unit is fundamental to creating a cost effective and reliable unit. A third reviewer noted that better thermal performance helps to reduce the cost of power electronics helping to enable the market for power electronic devices. One reviewer remarked that this project doesn't address the fundamental cost issue, but that the project may support DOE objectives in the long term.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that in this project the higher heat transfer capabilities of two-phase cooling systems will be investigated including surface enhancements and other measures. The reviewer felt that the approach to performing this work is good and that collaboration with industry partners regarding the refrigerant and surface treatment chemistry aspects is valuable. One reviewer indicated that the project needs to demonstrate how this approach will lead to meeting [FY/CY]2015 DOE APEEM cost [estimates/requirements]. Another reviewer noted that the barriers to effective two-phase cooling are being addressed in terms of cooling medium and various approaches. The reviewer felt that the strengths and weaknesses of these materials need to be investigated from how they would be used and/or implemented in a vehicle. As an example from the reviewer, a submerged cooling approach with a fluid that boils requires a space above the level of the fluid for the vapor to rise and condense. Further, this reviewer continued, if this space is not properly sized then under some operating conditions the hardware may become exposed and fail. Additionally, the method by which signal interfaces are supported also needs to be addressed. The reviewer felt that none of these issues were insurmountable but would need to be addressed to get support from a manufacturer. A reviewer noted that this project is a new start. The reviewer was interested to know how the principal investigator planned to convince the commercial industry that the system that uses this approach is reliable. The reviewer wanted to know if it would be possible to provide a straw man list of tests and their required results to convince industry this could be a reliable system. The reviewer felt that industry would be able to add to the list of tests and results needed to determine reliability. Another reviewer wanted to compare what would happen if the 3M micro porous coating was applied to the Lexus part and applied it thru TIM to a cold rail to what would happen without the 3M coating.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer noted that the progress that was shown indicates that the performance of these mediums is excellent. Another reviewer stated that the project is in an early stage but the researchers started immediately with tests of immersion boiling. The reviewer noted that it was proven that immersion boiling with enhanced surfaces decreases the thermal resistance significantly which is a somewhat expected result. The reviewer felt that what is missing so far is the evaluation of the overall system impact of these kinds of cooling technologies. It has to be evaluated early on what the effects are on sealing, contamination issues and especially costs of the system. The reviewer noted that it was mentioned in the presentation that this research is planned for FY 13, but the reviewer felt that this was too late for this activity to occur in the project timeline. A third reviewer noted that this project is a new start; the reviewer felt that the project had a very good thermal performance possible but that there is a need to address system issues as well as legacy issues. The reviewer wanted to know what went wrong with Continental's red box in the GM application and what would GM need to convince themselves this could be a viable approach.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted that the project has the right partners, but they need to help by providing input on how to define the requirements for the system. Another reviewer stated that the collaboration with the industry in terms of material science is very good. The reviewer felt that additional input and support is needed from power electronics suppliers for the evaluation of the overall system impacts. A third reviewer felt that potential suppliers of power electronics need to be added to the team fairly soon to assist in answering some of the implementation issues that may require a change in the approach.

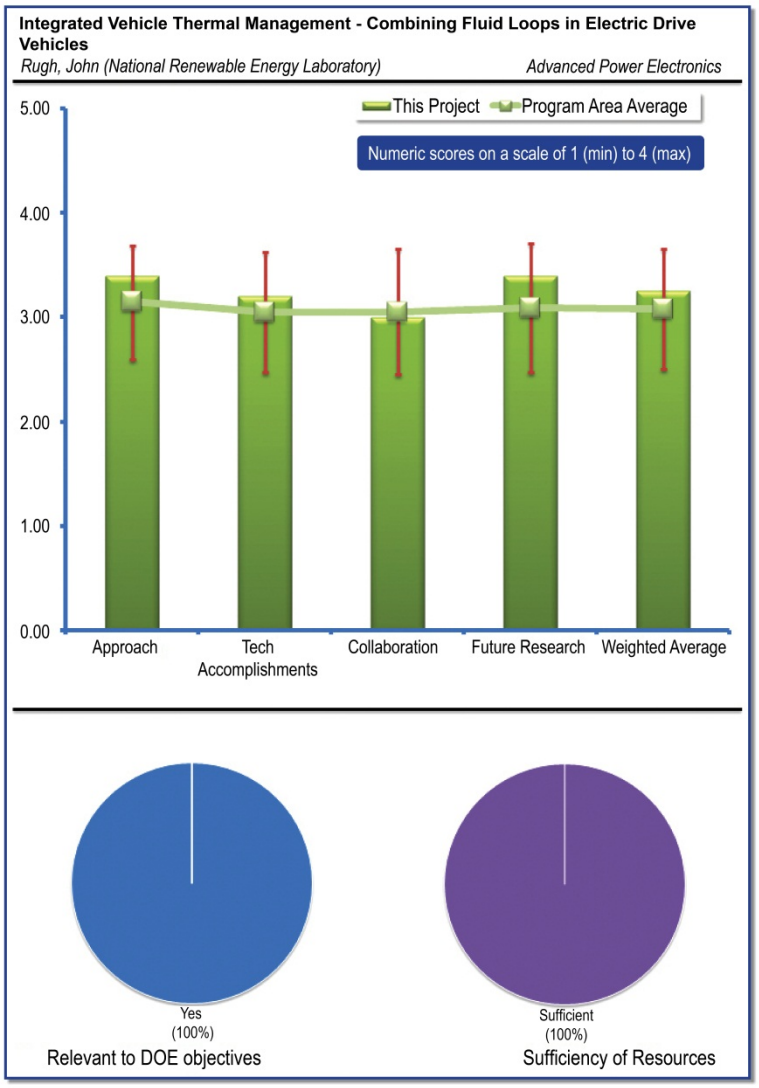
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that plans were reasonable and addressed the issues that had been seen to date. Another reviewer stated that the future work plan regarding the investigation of the two-phase cooling concept itself is good. The reviewer felt that what has to be added as soon as possible to the planned work is an investigation of the applicability of the novel cooling technique in real-world power electronics. The third reviewer noted that the scope may be increasing as the definition of the system requirements develop. A fourth reviewer indicated extreme concern about the direction of this project and its ability to provide something useful, but believed the technical work was good.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

Integrated Vehicle Thermal Management – Combining Fluid Loops in Electric Drive Vehicles: Rugh, John (National Renewable Energy Laboratory) - ape038



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the combination of cooling systems for different subsystems in an electric vehicle might lead to cost reductions and system simplification with increased reliability. The reviewer felt that this supports the DOE objectives. A second reviewer felt that this project could be very helpful in improving cost and reliability by simplifying thermal system on the vehicle. Another reviewer indicated that the project's ability to support DOE objectives was not directly stated but that utilizing existing cooling systems within the vehicle can lower the cost of automotive power electronics and help to enable the market. A fourth reviewer noted that the project has the potential to reduce the cost of the vehicle.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that an extensive effort is planned to model the thermal characteristics of all subsystems in an electric vehicle. The reviewer noted that it has to be ensured that all subsystems are modeled accurately so that the benefits of combining cooling loops can be evaluated. The reviewer felt that the involvement of industry experts is crucial for this part of the project. Another reviewer noted that this project is a new start. The reviewer felt that reuse of existing cooling system models is a good approach as it helps to minimize time and allows the project to concentrate on the system modifications required of a combined cooling approach. A third reviewer agreed that the number of thermal systems in some vehicles is excessive. The reviewer felt that the desire to reduce them is noble but the reviewer was not sure that this project can address all of the causes as some are based on the internal structure of the OEM. The reviewer stated that sometimes cross-functional teams don't play well together. The reviewer felt that if this project can show that it is possible to address the cooling needs of the various systems with common cooling loops then that will be a significant aid in getting the teams to cooperate. One reviewer felt that there was a need for more specifics in the objectives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that the approach is good. Another reviewer stated that the progress is very good considering that the project was started in FY2011. The reviewer noted that a process for the thermal modeling of cooling loops was set up and models for several subsystems were implemented. The reviewer felt that the assumptions for the modeling of the subsystems should be explained in more detail. The reviewer noted that, generally, OEMs have reasons for choosing different cooling loop temperatures for different

subsystems in electric vehicles because this leads to optimal designs for the subsystems. The reviewer felt that this has to be accurately reflected in the models, so that the outcome of the overall system model also accurate. A third reviewer indicated that progress on the technical piece is very good. The reviewer wanted to know if the FAST tool had been verified and wanted to know if it predicted reasonable values.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer stated that the collaboration with Visteon is probably not sufficient for the accurate modeling of all subsystems, especially for the electric drive system components. The reviewer remarked that additional OEM and suppliers have to get involved. The reviewer also felt that the collaboration between the VTP members is important. Another reviewer felt that the idea of getting strong support from a single OEM is good, but may be difficult. The reviewer noted that the combined cooling approach encroaches on many subsystems that today may not have a common goal. The reviewer expressed hope that the project can pull them together. A third reviewer noted that the project probably needs more cooperation from OEMs especially the different teams within an OEM but that this might also cause a delay in the project. The fourth reviewer suggested that the project work with only one OEM.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer felt that the approach was well defined. Another reviewer indicated that the project plans were great but that it was unclear how the project results will get implemented in the OEMs. A third reviewer felt that building a prototype system after the extensive modeling effort is the right approach; however, the reviewer thought that it was unclear how building a prototype system will be accomplished with the allocated budget since the reviewer felt that it would be an expensive prototype system. The reviewer suggested that additional comments on the prototype system, particularly the costs, could be included in the next review. The reviewer also felt that, besides the costs of building a prototype, the system cost impact in a production has to be evaluated (i.e. how are the subsystem costs influenced by the combination of cooling loops).

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All five reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

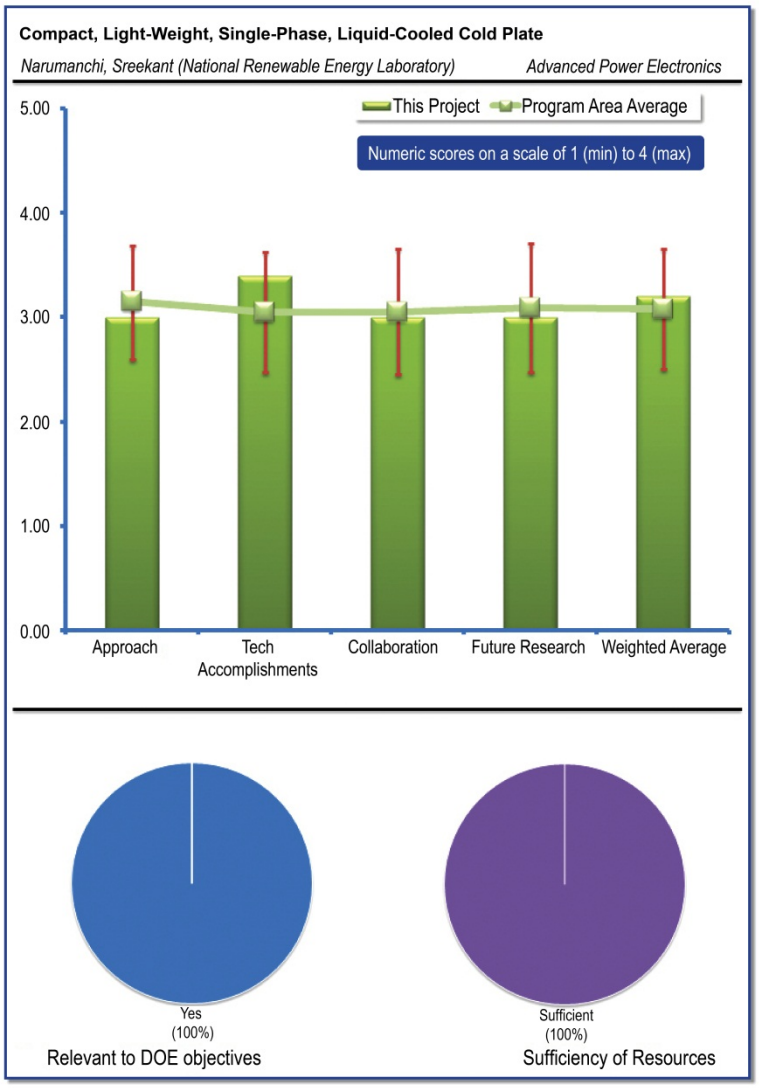
Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate: Narumanchi, Sreekant (National Renewable Energy Laboratory) - ape039

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that the effective management of waste heat in emerging vehicle technology is fundamental to the successful deployment of cost competitive products with power density, volume, total weight, and efficiency metrics that yield measurable fuel displacement. The subject project is focused on addressing the key heat transfer paradigm for the traction drive inverter cooling heat exchanger. In order to achieve the required PCU efficiency, and thus energy savings, high heat transfer coefficient cooling is absolutely necessary. This project focuses on an evaluation of a potentially game-changing cooling technology which could enable the attainment of PCU power density metrics and improve electronic device reliability by reducing junction temperatures. Another reviewer noted that improving heat rejection from electronic components can extend the operating efficiency and range of inverters and converters. This reviewer further observed that advanced cooling is compatible with existing cooling systems used for power electronics on vehicles.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer felt that the potential heat transfer coefficient attainable using the single phase impingement jet heat exchanger is very attractive. The reviewer noted that much work has historically been accomplished on spray type cooling, surface modification, and heat transfer and that the problems have always been one of reliability, complexity, and fluidic contamination and clogging. These critical issues required focused attention to either mitigate or eliminate prior to reliable operation in vehicular platforms. In addition, the reviewer felt that it is common to conduct heat transfer research using only steady state/equilibrium analysis, i.e. First Law energy balance, but that it is increasingly important to consider the dynamic Second Law effects as power density is increased, which necessarily reduces heat capacity leaving components susceptible to large temperature excursions. A reviewer noted that the project describes a plastic heat exchanger, but the implementation is somewhat different. Although there seems to be a plastic manifold, the heat exchange actually takes place on an aluminum surface that is conditioned. The reviewer felt that that does not detract from the importance of the work but that the project is not described correctly.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that the accomplishments were a good start for this stage of the project. Another reviewer indicated that the project appears to be progressing on schedule with impressive heat transfer coefficients demonstrated with the impingement jets. If carefully

considered, this type of technology can have significant impact on vehicle electronics reliability through controlled junction temperature excursions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that the collaborations with HEV and PEV drive manufacturers and electronics cooling expertise was very good. The reviewer's only recommendation was to collect power module manufacturer input on device response and impacts to module performance as a result of the cooling technology changes to base plate boundary conditions.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the plan to complete the subject study was very good and well organized. The reviewer made a point to refer the project partners back to prior comments recommending non-equilibrium thermodynamic analysis here. Another reviewer felt that it is good to consider the long term effects of the jet on base-plate finish. The project would be enhanced by defining pass/fail criteria for the effects. The third reviewer indicated that the project could be further enhanced by evaluating the advisability of multiple jets per surface. The reviewer suggested that the project explicitly determine if multiple jets help and how much separation should exist between multiple jets.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All five reviewers felt that the funding resources were sufficient to achieve the stated milestones in a timely fashion.

4. Advanced Combustion Engine Technologies

The Advanced Combustion Engine subprogram of the U.S. Department of Energy's Vehicle Technologies Program (VTP) is improving the fuel economy of passenger vehicles (cars and light trucks) and commercial vehicles (medium-duty and commercial trucks) by increasing the efficiency of the engines that power them. Work is done in collaboration with industry, national laboratories, and universities, as well as in conjunction with the U.S. DRIVE Partnership for passenger vehicle applications and the 21st Century Truck Partnership for commercial vehicle applications. Research and development (R&D) efforts focus on improving engine efficiency while meeting future federal and state emissions regulations through a combination of: combustion technologies that minimize in-cylinder formation of emissions; aftertreatment technologies that further reduce exhaust emissions; and understanding fuel property impacts on combustion and emissions. Technologies that improve the overall engine performance are also pursued.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling	Musculus, Mark (Sandia National Laboratories)	4-5	3.89	3.78	4.00	3.67	3.82
Low-Temperature Automotive Diesel Combustion	Miles, Paul (Sandia National Laboratories)	4-8	3.30	3.40	3.70	3.10	3.38
HCCI and Stratified-Charge CI Engine Combustion Research	Dec, John (Sandia National Laboratories)	4-11	3.44	3.56	3.67	3.22	3.50
Low-Temperature Diesel Combustion Cross-Cut Research	Pickett, Lyle (Sandia National Laboratories)	4-14	3.40	3.40	3.90	3.20	3.44
Automotive HCCI Engine Research	Steeper, Richard (Sandia National Laboratories)	4-17	3.27	3.27	3.64	3.09	3.30
Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research	Oefelein, Joe (Sandia National Laboratories)	4-20	3.63	3.13	3.63	3.25	3.33
Free-Piston Engine	Van Blarigan, Peter (Sandia National Laboratories)	4-22	2.36	1.82	2.36	2.36	2.09
Optimization of Direct-Injection H2 Combustion Engine Performance, Efficiency, and Emissions	Wallner, Tom (Argonne National Laboratory)	4-25	3.29	3.71	3.14	2.86	3.43
Fuel Injection and Spray Research Using X-Ray Diagnostics	Powell, Christopher (Argonne National Laboratory)	4-27	3.42	3.17	3.00	3.08	3.20
Use of Low Cetane Fuel to Enable Low Temperature Combustion	Ciatti, Steve (Argonne National Laboratory)	4-31	3.23	3.15	3.08	3.23	3.17
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines	Aceves, Salvador (Lawrence Livermore National Laboratory)	4-35	3.40	3.60	3.40	3.20	3.48
Chemical Kinetic Research on HCCI & Diesel Fuels	Pitz, Bill (Lawrence Livermore National Laboratory)	4-37	3.91	3.64	3.64	3.36	3.67
2011 DOE Vehicle Technologies KIVA-Development	Carrington, David (Los Alamos National Laboratory)	4-40	3.00	3.22	3.33	3.00	3.15
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Daw, Stuart (Oak Ridge National Laboratory)	4-43	3.33	3.00	3.22	3.11	3.13

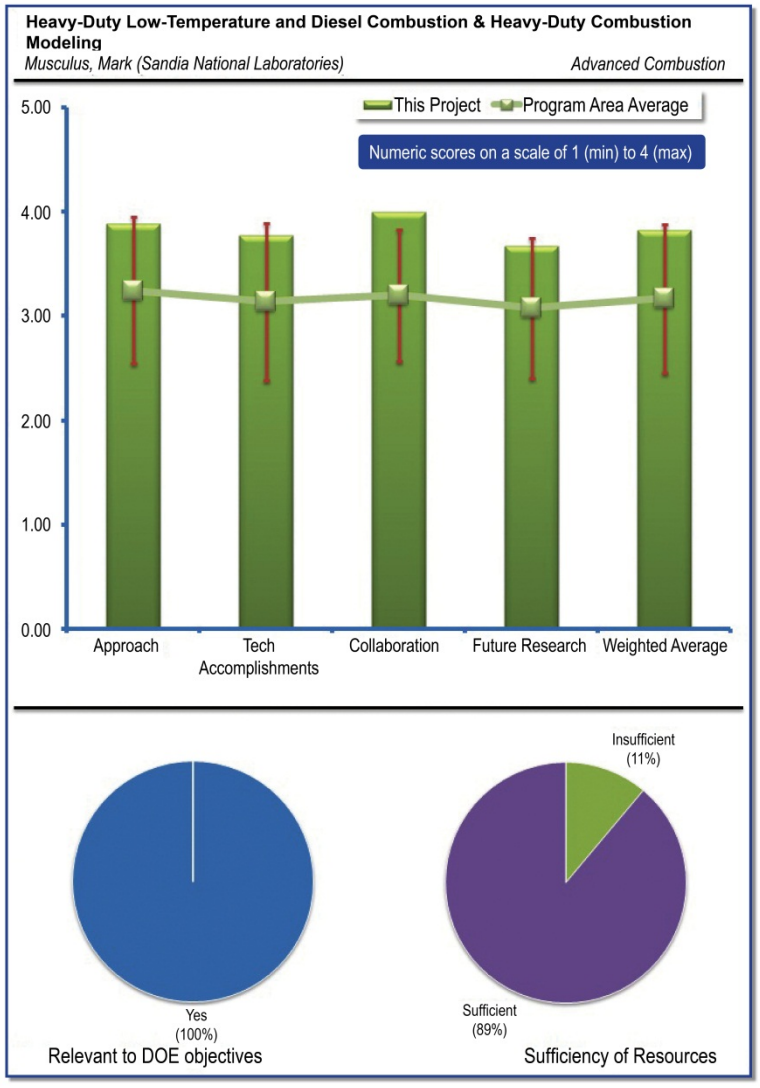
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Curran, Scott (Oak Ridge National Laboratory)	4-46	3.38	3.50	3.25	3.00	3.38
High Efficiency Engine Systems Development and Evaluation	Briggs, Tom (Oak Ridge National Laboratory)	4-48	3.50	3.33	3.42	3.17	3.36
A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines	Assanis, Dennis (University of Michigan)	4-51	3.27	3.18	3.73	3.10	3.26
Optimization of Advanced Diesel Engine Combustion Strategies	Reitz, Rolf (University of Wisconsin)	4-54	3.83	3.75	3.67	3.50	3.73
Flex Fuel Optimized SI and HCCI Engine	Zhu, Gouming (Michigan State University)	4-56	3.00	2.64	2.55	2.91	2.75
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR	Daw, Stuart (Oak Ridge National Laboratory)	4-59	4.00	3.67	4.00	3.33	3.75
CLEERS Aftertreatment Modeling and Analysis	Lee, Jong (Pacific Northwest National Laboratory)	4-61	3.33	2.67	3.67	3.33	3.04
Development of Advanced Diesel Particulate Filtration (DPF) Systems	Lee, Kyeong (Argonne National Laboratory)	4-63	2.00	2.00	1.67	1.67	1.92
Combination and Integration of DPF-SCR Aftertreatment Technologies	Rappe, Ken (Pacific Northwest National Laboratory)	4-65	2.33	2.33	2.67	2.33	2.38
Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials	Peden, Chuck (Pacific Northwest National Laboratory)	4-67	3.33	3.33	3.00	3.00	3.25
Degradation Mechanisms of Urea Selective Catalytic Reduction Technology	Peden, Chuck (Pacific Northwest National Laboratory)	4-69	4.00	3.50	4.00	3.50	3.69
Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels	Johnson, John (Michigan Technological University)	4-71	3.67	3.67	3.33	3.00	3.54
Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems	Harold, Michael (University of Houston)	4-73	3.50	3.00	4.00	3.00	3.25
Three-Dimensional Composite Nanostructures for Lean NOx Emission Control	Gao, Puxian (University of Connecticut)	4-75	2.00	3.00	1.50	2.00	2.44
Efficient Emissions Control for Multi-Mode Lean DI Engines	Parks, Jim (Oak Ridge National Laboratory)	4-77	3.00	3.00	3.00	3.33	3.04
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Partridge, Bill (Oak Ridge National Laboratory)	4-80	3.50	3.00	3.50	3.00	3.19
Emissions Control for Lean Gasoline Engines	Toops, Todd (Oak Ridge National Laboratory)	4-82	3.67	3.00	3.67	2.67	3.21
Development of Chemical Kinetic Models for Lean NOx Traps	Larson, Richard (Sandia National Laboratories)	4-84	3.00	3.50	2.50	3.00	3.19
Advanced Boost System Development for Diesel HCCI/LTC Application	Sun, Harold (Ford Motor Company)	4-86	3.33	3.33	3.33	3.33	3.33
Advanced Collaborative Emissions Study (ACES)	Greenbaum, Dan (Health Effects Institute)	4-88	4.00	3.00	3.50	3.00	3.31

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Measurement and Characterization of Unregulated Emissions from Advanced Technologies	Storey, John (Oak Ridge National Laboratory)	4-90	3.67	3.00	3.00	3.00	3.17
Collaborative Lubricating Oil Study on Emissions (CLOSE Project)	Lawson, Doug (National Renewable Energy Laboratory)	4-92	3.33	3.67	3.67	3.00	3.50
Thermoelectric HVAC for Light-Duty Vehicle Applications	Maranville, Clay (Ford Motor Company)	4-94	3.67	3.33	3.67	3.67	3.50
Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling	Meisner, Greg (General Motors)	4-96	3.00	3.00	3.33	3.33	3.08
Thermoelectric Conversion of Waste Heat to Electricity in an IC Engine Powered Vehicle	Schock, Harold (Michigan State University)	4-98	3.67	4.00	3.33	3.67	3.79
Develop Thermoelectric Technology for Automotive Waste Heat Recovery	Meisner, Greg (General Motors)	4-100	3.00	3.00	3.33	3.00	3.04
Automotive Waste Heat Conversion to Power Program	LaGrandeur, John (BSST LLC)	4-102	3.50	3.75	3.50	3.50	3.63
Neutron Imaging of Advanced Engine Technologies	Toops, Todd (Oak Ridge National Laboratory)	4-104	3.43	3.14	3.14	2.86	3.18
Expanding Robust HCCI Operation (Delphi CRADA)	Szybist, James (Oak Ridge National Laboratory)	4-106	2.78	2.78	2.56	2.78	2.75
Rapid Compression Machine - A Key Experimental Device to Effectively Collaborate with Basic Energy Sciences	Gupta, Sreenath (Argonne National Laboratory)	4-108	2.80	2.40	3.10	2.70	2.63
Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials	Peden, Chuck (Pacific Northwest National Laboratory)	4-110	2.67	2.67	3.33	3.00	2.79
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Stewart, Mark (Pacific Northwest National Laboratory)	4-112	3.50	3.00	3.50	3.50	3.25
Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	Stanton, Donald (Cummins)	4-114	3.33	3.33	3.00	3.33	3.29
Supertruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research	Sisken, Kevin (Detroit Diesel)	4-116	3.00	3.00	3.00	2.67	2.96
Supertruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Jadin, Dennis (Navistar International Corp.)	4-118	2.67	3.33	3.67	3.33	3.21
High Fuel Economy Heavy-Duty Truck Engine	Tai, Chun (Volvo)	4-120	3.20	3.20	3.20	3.40	3.23
ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine	Ruth, Michael (Cummins)	4-122	3.40	3.20	3.20	3.60	3.30
A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency	Reese, Ron (Chrysler LLC)	4-124	2.50	2.75	2.50	2.75	2.66
Lean Gasoline System Development for Fuel Efficient Small Car	Smith, Stuart (General Motors)	4-127	3.00	2.60	2.20	3.20	2.73

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Gasoline Ultra Fuel Efficient Vehicle	Confer, Keith (Delphi Automotive Systems)	4-130	3.00	3.00	3.33	3.00	3.04
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Rinkevich, Dan (Ford Motor Company)	4-132	3.67	3.33	2.67	3.67	3.38
Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles	Yilmaz, Hakan (Robert Bosch)	4-134	3.00	3.00	4.00	3.00	3.13
Integration of Advanced Materials and Interfaces for Durable Thermoelectric Automobile Exhaust Waste Heat Harvesting Devices	*Ju, Yongho (University of California at Los Angeles)*	*4-135*	*3.50*	*3.50*	*3.00*	*3.00*	*3.38*
Thermoelectrics Partnership: High Performance Thermoelectric Waste Heat Recovery System Based on Zintl Phase Materials with Embedded Nanoparticles	*Shakouri, Ali (University of California at Santa Cruz)*	*4-137*	*3.50*	*3.00*	*3.50*	*3.00*	*3.19*
NSF/DOE Thermoelectric Partnership: Inorganic-Organic Hybrid Thermoelectrics	*Vaddiraju, Sreeram (Texas A&M University)*	*4-139*	*3.00*	*3.00*	*1.00*	*2.50*	*2.69*
An integrated approach towards efficient, scalable, and low cost thermoelectric waste heat recovery devices for vehicles	*Huxtable, Scott (VPI & SU)*	*4-141*	*3.00*	*2.50*	*2.50*	*3.00*	*2.69*
NSF/DOE Thermoelectric Partnership: High-Performance Thermoelectric Devices Based on Abundant Silicide Materials for Vehicle Waste Heat Recovery	*Shi, Li (University of Texas, Austin)*	*4-143*	*3.00*	*3.00*	*3.00*	*3.00*	*3.00*
Thermoelectrics for Automotive Waste Heat Recovery	*Xu, Xianfan (Purdue University)*	*4-145*	*3.00*	*3.00*	*3.50*	*3.50*	*3.13*
Overall Average			3.25	3.14	3.20	3.08	3.17

Note: Italics denote poster presentations.

Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling: Musculus, Mark (Sandia National Laboratories) – ace001



Reviewer Sample Size

This project had a total of nine reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally felt the project was relevant since it strongly supports advanced combustion modes that may lead to higher efficiency and lower emissions. It was pointed out that low-temperature combustion (LTC), and specifically reactivity controlled compression ignition combustion (RCCI), shows good potential for significant improvements in fuel efficiency. One person noted that this supports efforts of dual fueled LTC combustion which the University of Wisconsin has demonstrated to be capable of higher efficiency at steady state operating points in their lab. That affirmed a comment by another reviewer that felt understanding of in-cylinder processes relating to RCCI combustion is still limited, so given the demonstrated efficiency of RCCI combustion by the University of Wisconsin and others, optical work in this area is very important and needed. Another reviewer stated that this provides in-cylinder understanding of high efficiency LTC concepts like RCCI for heavy duty applications. It was also noted by a reviewer that investigating behavior of sprays is key to high efficiency combustion modes. Another mentioned that this research is applicable to improving indicated specific fuel consumption (ISFC) of internal combustion (IC) engines through enabling non-standard combustion mode strategies that can simultaneously deliver very low engine out NOx and particulate matter (PM). A reviewer felt that this were revolutionary discoveries aimed at advancing combustion and emissions. A final reviewer asked if this research had light duty applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said it had a good and pragmatic approach that includes modifying the tasks as new technologies (like RCCI) emerge. Two other reviewers felt it was a well-focused approach, with one going on to say that this was innovative and an example of what a national lab should be doing. A fourth commented that this world-leading research is well thought out to create genuine understanding in a way that is accessible to product designers. The fifth person remarked that this project is delivering fundamental knowledge to the community concerning the physics associated with flame propagation versus distributed ignition. This reviewer went on to state that it is a very outstanding effort focused on addressing the key physics associated with RCCI. Their only suggestion was to include metal engine work to address the impact of the various combustion mode strategies on ISFC. A sixth reviewer listed the key aspects of the project that included providing fundamental knowledge of flame behavior, probing effects of injection timing and various mixing approaches, providing data for evaluating models of combustion process, specifically providing an understanding of unburned hydrocarbons (UHC) and soot emissions, and using laser spark to improve understanding of flame propagation versus auto

ignition. This reviewer stated that although the optical engine conditions are not exactly the same as the University of Wisconsin, the approach will still provide insight into the RCCI process. A seventh reviewer was not sure the investigator could explain the post injection activities very well. In their opinion, it had more to do with switching to a lower cone angle spray which messed up the combustion. The last reviewer wanted to know what would be changed for light duty applications.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer felt very good progress in understanding these very complex systems. Another reviewer agreed, stating that excellent progress was made on a wide range of fronts with diagnostics, measurements and modeling described. A reviewer observed that the initial work has been promised toward building understanding on how to properly model RCCI, though it is obvious much work is still ahead of the PI. This person believes the only possible area of improvement could be in addressing the impact of RCCI control strategies on ISFC in a metal engine. Another person listed examples to demonstrate the good progress that has been made. This included; 1) post-injection lowers soot, 2) wide-angles reduced soot only in the squish region, but left soot unoxidized in bowl region, 3) narrow-angle injector investigated provided same soot reduction, although higher soot resulted because of impingement on bowl walls, 4) added gasoline direct injection (GDI) side-injector to engine for early-injection premixed charge, 5) investigated three diesel injection timings and looked at heat release rate differences, 6) RCCI combustion is mostly auto ignition; with some flame propagation, and 7) heat release is affected by reactivity gradients. High load soot vs. injector angle was the noted progress by another reviewer who also commented that some work towards understanding ISFC of various strategies would be useful, even on optical engine. This reviewer also pointed out that very insightful results were shown through the given first look at RCCI. Another reviewer also mentioned the first in-cylinder chemi-luminescence video of RCCI.

The final commenter provided specific feedback on slides from the presentation that are also applicable to other evaluation categories. For Slide 11, the GDI location and orientation in the combustion chamber influence the generated phenomena and thus the observed results. Putting it in place of the side-window may provide global misleading results, or directionally wrong findings. However, reported results under the stated objectives in Slide 7 are plausible, especially in the context of understanding BASIC combustion aspects which are not affected by temporal fuel-air mixing. On Slide 17, adding the plasma spark via a focused laser beam is a nice experimental tool. On Slide 19, the location of the GDI injector is a handicap to the experiment setup and will not give results that readily correlate to real-life. In reference to Slide 24, the investigator should continue close-coupled modeling and experimental work, with both feed-forward and feedback iterative process. The reviewer concluded by stating that it seems that the team is on the threshold of revolutionary discoveries, with promising real-life applications.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Overall, reviewers were please by the collaboration on this project, with one noting the investigator's work with the University of Wisconsin at Madison and industry. A second reviewer affirmed that this is a model for how to integrate government sponsored work, National Labs, academia, and industry. This person went on to say that there is a long history of excellent collaboration and this work is continuing that. A third person felt the researchers had no issues working with ideas and concepts generated elsewhere, since they currently host a graduate student from University of Wisconsin and work with Memorandum of Understanding (MOU) partners. Another reviewer stated that it looks like great information for the MOU and University of Wisconsin on RCCI that can be used to improve the modeling results. The fifth reviewer pointed out that this project has strong collaboration; it is coordinated with the Advanced Engine Combustion Working Group that is collection of various key industrial partners. Another agreed that there was a wide spectrum of collaborating institutions, although it was heavily slanted towards the University of Wisconsin for RCCI studies. Criticism from the seventh reviewer was that too many publications (and travel) distract from better value-added efforts. The last reviewer was glad to see this moving into new area (RCCI), and recognizes the significance of this new approach.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The proposed list of future work was fine according to the first commenter. One reviewer noted a solid approach to the issue, but would like to see more work to address off cycle conditions such as cold starting. Another remarked that the proposed research plan is fundamentally sound. However, this reviewer did have the suggestion to keep an eye on the impact of ISFC as a function of the various combustion strategies, even though it is difficult to understand this in an optical engine. Suggestions from another reviewer included in-cylinder mixing, multi injection, LTC, and polycyclic aromatic hydrocarbon (PAH). One person observed that the split between optical and metal engine experiments should be better delineated. This reviewer felt the shortcomings of measuring fuel consumption for the calculation of thermal efficiency should be resolved. The final reviewer proposed an approach for future research that included 2 parts. Part 1 establishes a corresponding metal research engine, preferably at University of Wisconsin at Madison to capitalize on their solid core competency, and introduce its test results into the effort. This makes the iterative research cycle described above a 3-segment loop. Part 2 establishes a corresponding multi-cylinder research engine, preferably at ORNL to capitalize on their solid core competency, and introduce its test results into the effort. This makes the iterative research cycle described above a 4-segment loop. This reviewer suggested that a robust multi-year program be developed along these lines with goals focused on short cycle-time and fairly robust development. The objectives could be defined so that progressively lower hanging fruits are harvested for the U.S. vehicle industry.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The one reviewer who felt resources were insufficient noted that no amount of funding is sufficient enough for such an excellent work. Eight reviewers stated that the resources were sufficient. Expanding on this one reviewer said there was a good balance between budget and tasks completed, although was curious to know if the time available on the optical engine and similar experimental apparatus was the limiting factor in the progress achieved per unit time. Another reviewer was not clear what additional funding would enable. Comments from two other reviewers asserted that the resources seem to be about right and that the funding level appears commensurate with this effort.

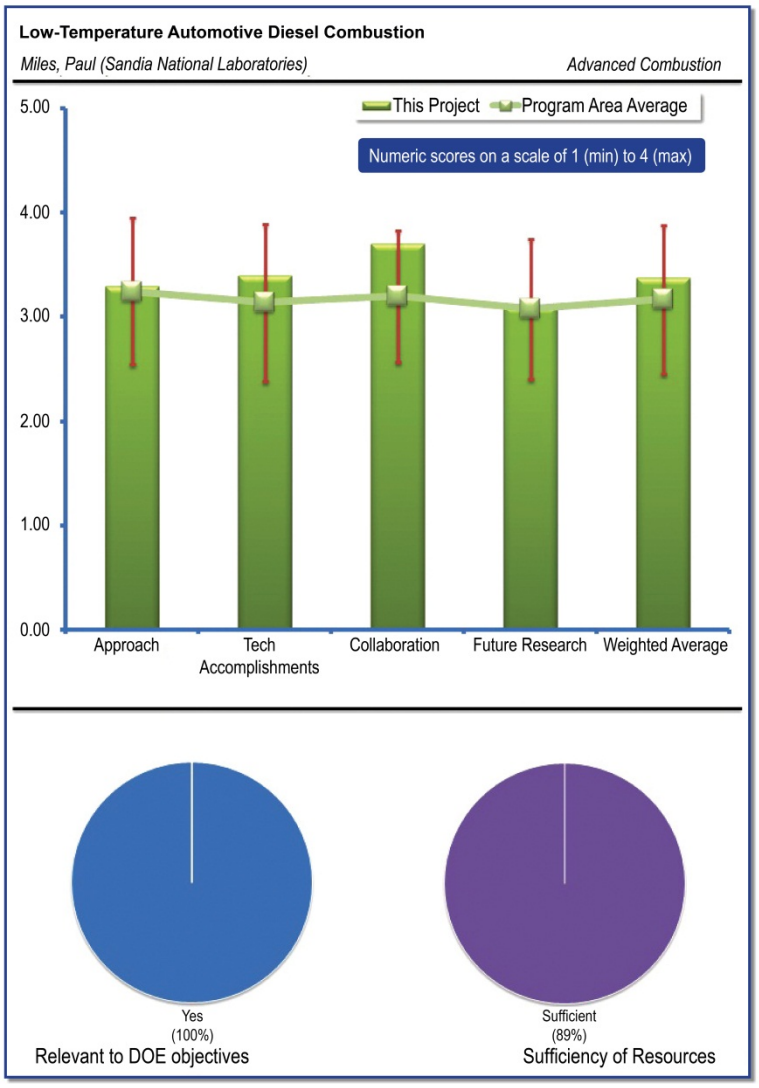
Low-Temperature Automotive Diesel Combustion: Miles, Paul (Sandia National Laboratories) – ace002

Reviewer Sample Size

This project had a total of ten reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt this research was directly linked to efficiency and emissions targets, while another commented that it improves understanding of LTC to yield higher efficiency and reduce emissions. A third reviewer said that LTC might be a way to improve gasoline engine efficiency. The fourth reviewer acknowledged that the project's focus is on emissions of diesel combustion in automobiles which is more efficient than typical gasoline combustion in automobiles. Another pointed out that this is the light-duty compliment to Musculus (PI for ace001). A sixth reviewer mentioned that it provides fundamental understanding of light-duty diesel LTC combustion. Another person observed that a good portfolio of engine investigative studies which should lead to light-duty next generation engine fuel efficiency improvements. The last reviewer stated that it indirectly addresses DOE goals by studying the impact of ignition quality, evaporation, and turbulence on advanced combustion modes in compression ignition (CI) engines.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer expressed that the project has a good comprehensive approach to experimental investigations, modeling and visualization for light-duty (LD) engine studies. Another felt that this was top quality research with great tools and careful design of the experiments. A third reviewer remarked that close collaboration with the University of Wisconsin, Oak Ridge National Laboratory and General Motors, in addition to providing optical engine data to this group, results in a good approach. Overall, another commenter stated that it was a good approach, although much time was spent studying flow structures and showing that turbulence modeling in IC engines needs improvement especially during post injection mixing processes. This reviewer felt more time could have been spent investigating fuel property effects on RCCI/advanced combustion modes on ISFC, though this person did acknowledge that mixing is important. That reviewer also pointed out that this project should be closely collaborating with ACE001. The fifth reviewer noted that Slide 5 is a really good example of connecting fundamental research to industrial R&D; however, no reports or correlations were presented or alluded to. This person stated that the project improved in that some designed experiments (orthogonal fuel matrix) were used, but there seems to be too much emphasis on experimental testing vs. simulation. The last person inquired as to whether this approach parallels the proposed PRESICE model development and if there is a way to quantify the sensitivity of the various combustion system design parameters.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer pointed out a wide range of accomplishments, including good progress on UHC/carbon monoxide (CO) emissions in LTC, and modeling. Progress listed by another person included turbulence model assessment and in-cylinder flow characterization with particle image velocimetry (PIV). A third reviewer noted that the measurement of the in cylinder flow field is impressive and this shows the weakness of using a segment model for computational fluid dynamics (CFD) for this type of combustion work which is important to know. Another reviewer commented that last year's experimental (Sandia National Laboratories [SNL]) work plan (Slide 18 of the 2010 presentation) was only partially addressed, while the University of Wisconsin plan (Slide 19) seems to have been more thoroughly executed. This reviewer advised the investigator not to automatically assume that simulation has the error, when discrepancies arise between measured and simulated results. This forces-fit the experimental results into a new model formulation (e.g., Turbulence model shortcomings…). The new model with "variable constant" could very well fit the wrong experimental data. This reviewer also noted that Slide 11 may drive this point home since it shows about 50% variability across a wide range of experimental mean tangential velocity measurements vs. radius from the center of swirl structure. The reviewer concluded by stating that sometimes experimental data can be significantly more unreliable than simulation. A fifth reviewer acknowledged that good progress was made in understanding biodiesel wall impingement during PM regeneration, assessing the impact of ignition quality and evaporation on advanced combustion modes, and modeling post injection mixing. However, this person also said that it was not clear what the multi-cylinder engine (MCE) metal engine results were concerning the impact of advanced combustion modes on ISFC - possibly there was lack of time, but this is the main nugget for this project and should be closely collaborated with the key fundamental aspects of this project. Comments from a sixth reviewer pointed out that previously, discrepancies with model predictions of UHC and CO were observed. This person noted that it has been determined that fuel cetane number and ignition quality were quite influential, while fuel volatility was less effective. The reviewer went on to state that significant shortcomings in the renormalization group (RNG) models to predict turbulence levels have been observed. In addition, swirl center tilt and precession has been observed. This person concluded by remarking that work has shown that biofuel tends to wet the wall more at late injection timings. The last reviewer affirmed that the processes are becoming clearer thanks to work like this, but there remain many issues to worry about.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

A wide range of collaborators was noted by the reviewers. One reviewer mentioned the strong collaboration with the University of Wisconsin at Madison which was affirmed by another who felt the investigator did an excellent job of working with this university. Another commented that this is a model for collaboration between DOE, National Labs, academia, and industry. One reviewer acknowledged the close contact with members of MOU, collaboration with General Motors funded work at the University of Wisconsin, and the post doc at Sandia provided by General Motors. The good collaboration was pointed out by another reviewer who gave examples of Reitz doing simulations, Foster doing metal engine, leveraging funding by General Motors at the University of Wisconsin, as well as with the Diesel Engine Research Consortium (DERC). The remaining reviewer affirmed that there is close collaboration between the investigator, General Motors, and the University of Wisconsin. However, this person noted that Oak Ridge National Laboratory was named as a funded partner though no results were shown from the MCE.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

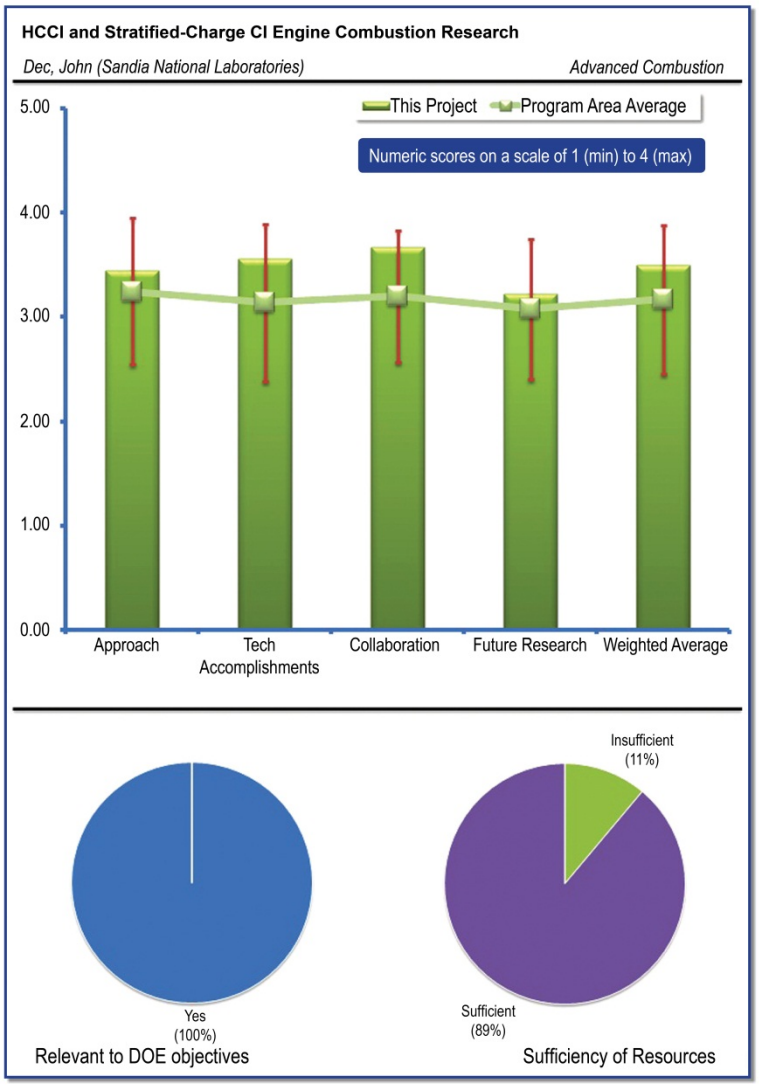
One researcher felt that the future plans listed were fine and anther suggested more of the same, but several others offered additional suggestions. One reviewer expressed interest in increasing the simulation effort by extrapolating the operational range and boundary conditions in the virtual lab. This person felt the researchers should share discoveries and results of this effort with the Advanced Engine Combustion MOU partners, ahead of trying to devise an experimental setup at SDL to validate it. Another researcher mentioned that for light-duty vehicles, cold start emissions are critical and some work is needed to ask how LTC can co-exist with light-duty cold start test requirements. This person went on to question whether LTC is worth the trip if you have to buy catalysts to meet cold emissions. One of the reviewers suggested trying to further improve predictive capability of models because it was not clear

what the approach is and still seems to rely heavily on empiricism. The final commenter suggested less of a focus on flow structures and more of a focus on the link between RCCI/advanced combustion mode fundamentals and the impact on ISFC.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All nine reviewers responded that the resources were sufficient for this project. Additional comments from the reviewers stated that results per unit budget seem on track, resources seem about the right level, and that it is great to see solid support from industry. One reviewer remarked that this is a WELL funded project and that it would be nice to see ORNL's contribution to this project given their portion was roughly 15% of the budget. A reviewer mentioned that resources are perhaps more-than-sufficient for SNL and is insufficient for UW. This person pointed out that the PI responded to a comment by a reviewer last year: “Too many publications can be a distraction” by providing rationale and justifying it to “transferring the knowledge gained.” This reviewer wants to again reiterate that criticism by expressing that too many publications distract from better value-added efforts, and consumes much time and budget. This also goes for travel to attend and presentations at too many conferences. The reviewer believes that transfer of knowledge gained is accomplished through the MOU membership, and in fact should be limited to it. This person feels the investigator should report an itemized list of the percent of the budget that is spent on publications and travel, which includes preparation time, write-up, response to reviews, etc. This reviewer concluded by questioning if the investigator would spend the same amount of time and resources if the funding source is a SNL-Laboratory Directed Research and Development (LDRD) project?

HCCI and Stratified-Charge CI Engine Combustion Research: Dec, John (Sandia National Laboratories) – ace004



Reviewer Sample Size

This project had a total of nine reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

This project was described by reviewers as providing fundamental understanding of controlling homogeneous charge compression ignition (HCCI) at higher loads, while another summarized it as the emission and efficiency impacts of light-duty HCCI. One reviewer felt the combination of premixed and injection controlled combustion offers a potentially large capacity for improvement in engine fuel efficiency. Additional comments from reviewers stated that this supports high efficiency HCCI combustion, is well aligned with HCCI/LTC interest, and is focused on key items noted of interest by DOE. One researcher observed that extending load range of HCCI directly addresses key barrier to implementation. The final reviewer remarked that this project provides insight into high efficiency LTC gasoline combustion like HCCI and partially stratified charge LTC combustion.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Summarizing the approach, one reviewer mentioned that the investigator uses an optical engine for in-cylinder understanding, extending high load operating range of gasoline HCCI; which extends efficiency of HCCI and improves understanding. Another pointed out that this was a good combination of experimental methods and technologies aimed specifically at technical barriers. The third reviewer noted the fundamental understanding towards development of HCCI engine by industry through this project. One reviewer liked the ability to run optical and metal engine in the same lab, by the same PI. A fifth commented that as usual, the researcher carefully thought out experiments and used world class tools to improve understanding of the HCCI processes. Another reviewer felt that the strategy displayed in Slide 4 would be substantially improved if there are feed-forward and feedback continuous loops among the 4 outlined elements. The seventh observed that ringing metric may not be appropriate metric for combustion noise/vibration/harshness (NVH).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt the researcher produced fascinating results, pointing out that the in-cylinder diagnostics combined with modeling make a very compelling case and help clarify these very complex situations. A second mentioned the excellent work on

gaining understanding of the effects of charge and temperature stratification, and remarked that the investigator is showing good progress on increasing the load range. A third reviewer also acknowledged that good progress has been made. This person went on to point out that in regards to thermal stratification, autoignition proceeded from hottest to coldest pockets and that thermal stratification of bulk gas is most critical for controlling high load HCCI. This reviewer questioned whether the researcher was investigating how cold gas from boundary layer mixes into bulk gas. In addition, this third reviewer had comments on the efficiency of boosted HCCI that included: partial fuel stratification increases high-load limit of boosted HCCI, autoignition proceeds from richer mixture to leaner mixture, and when boosted, mixture becomes much higher in phi sensitivity. This person concluded by stating that ethanol influences thermal stratification more and is also effective. The fourth commenter noted that the investigator had very interesting results, but felt that it will be difficult to take from lab controlled conditions into vehicle application. Another reviewer also acknowledged this by saying that it was a nice fundamental study, but this person would like to see the barriers identified (and addressed) that will allow this work to ultimately impact commercial product, because it was unclear how this will be done with respect to thermal stratification. The fifth reviewer recommended focusing on much reduced NVH limits (<3 bar/deg) for light duty. The sixth person was also concerned that this approach will be dominated by noise factors present in real world engines and expressed an interest in this being addressed. A seventh reviewer mentioned that the results shown starting on Slide 13 would be significantly enhanced if the testing was done via a statistically designed test matrix, instead of carrying out "systematic sweeps". This person felt the conclusions may be impacted by this. The last person expressed that there was very good progress in covering the spectrum of direct injection (DI) versus PM combustion regimes. However, this reviewer wanted to know how much further improvements can be expected in thermal efficiency as a result of the optimization of these two technologies and questioned whether engineering intuition would be able to tell us that the optimum solution lies somewhere in the middle of the range of fuel injected quantity that results in PM versus DI combustion.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that there was good dissemination of results and collaboration with other institutions, while another specifically mentioned SNL Advanced Engine Combustion and Sjoberg. A third reviewer felt that the investigator established excellent, close working relationships and that the active support and involvement of industry is great. Another person commented on the researcher providing data directly to General Motors for in-house development of their codes to account for thermal stratification. The fifth reviewer acknowledged that the investigator provides data for modeling at Sandia (LES, Oefelein), provides understanding for work at General Motors, and complements work at the University of Wisconsin, while at the same time collaboration within the MOU and with several other collaborators exists.

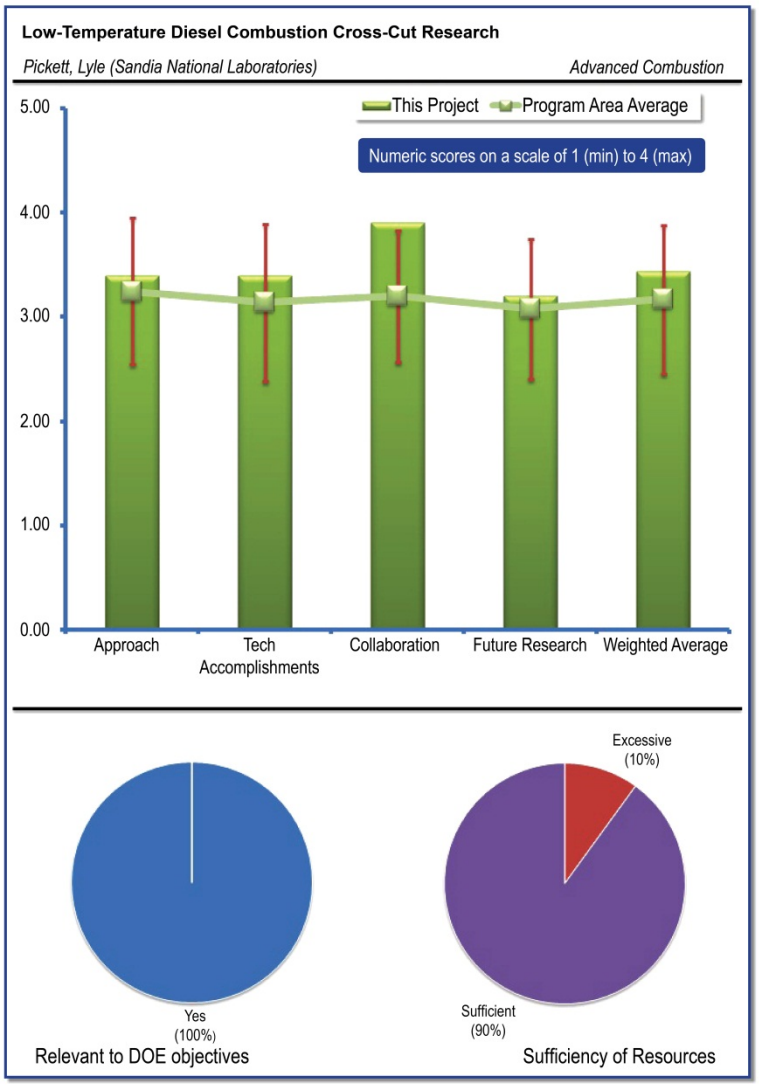
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

While one reviewer felt that the proposed work is relevant, the others included recommendations for improvement. One reviewer mentioned that more specific future tasks and plans would be more useful. This person stated that there are a number of issues in this area that demand attention, so perhaps a more systematic approach for covering the experimental domain required. Another commenter wanted the investigator to consider moving to either light or heavy duty architecture, because it was unclear how direct the findings translate to both. This person observed that 44% indicated thermal efficiency (ITE) at 14 bar indicated mean effective pressure (IMEP) with high rise rates and HCCI control issues, is not very high. This reviewer questioned that if real benefit is low NOx, are the data available? Another reviewer commented that the researcher had very good plans for further development; however, the light-duty/medium-duty systems have major cold start emission concerns and none of the HCCI research seems to address cold starting. This person pointed out that light-duty vehicles typically make 90% of total cycle emissions in the first 30 seconds or so. Feedback from the final reviewer was that the researcher may consider solving the global heat transfer equation of the combustion chamber. This reviewer went on to state that the boundary conditions (thermal properties, etc.) of the firedeck, piston top and bore/liner should be readily available, while General Motors or University of Michigan (UM) can do analyses in one-dimensional (1D), two-dimensional (2D), and/or full three-dimensional (3D), accurately and easily. A recommendation from this person was to superimpose the measured T-maps (e.g., slides 9 -12 in 2011 presentation) and explore further.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The one reviewer who asserted that the resources were insufficient recommended switching to a relevant light duty platform with rapid hardware commissioning in 2011. Eight reviewers decided that the resources for the project were sufficient. One of these gave an additional comment stating that the budget seems well-spent, while another remarked that it seems appropriate and that it is good to see industry's active support. One person responded that the resources were sufficient and generous.

Low-Temperature Diesel Combustion Cross-Cut Research: Pickett, Lyle (Sandia National Laboratories) –ace005



Reviewer Sample Size

This project had a total of ten reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer affirmed that this project supports DOE objectives by providing fundamental spray formation knowledge including evaporation and mixing effects on ignition and flame propagation. This person went on to explain that though this project does not directly support address the fuel consumption improvement goals of DOE it does provide a basis that can be used by others investigating RCCI and other combustion modes that do impact ISFC. A second reviewer pointed out that strong experimental and visualization techniques are required for the development of future high efficiency engines. Another stated that this project provides an understanding of fuel spray impact on combustion that should lead to better control and improved efficiency. The fourth commenter remarked that diesel, gasoline, and mixed fuel systems use DI and they depend critically on air-fuel mixing, so improved data and models are needed. Noted by another reviewer was that good models of sprays and mixing are keys to being able to model engines that use LTC concepts. A sixth reviewer commented that this work is improving the predictability of models, which should lead to an improved understanding of sprays and is important because in-cylinder injection is becoming more relevant for both diesel and gas. The final reviewer stated that the investigator focuses on understanding spray behavior relevant to LTC.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer summarized the approach stating that the project provides fundamental understanding of fuel sprays; all high efficiency engines use direct injection, multiple injection, two-phase mixing, etc. This person went on to mention that the researcher provides data for modeling via the Engine Combustion Network (ECN), included gasoline sprays this year, uses laser ignition to differentiate autoignition and flame propagation, and that Schlieren and Mie scattering is conducted simultaneously. This reviewer concluded by noting the strong coupling between experiments and CFD modeling that has been established. Debating the addition of gasoline sprays, a second reviewer commented that the approach seems suitable, but there is a wide range of topics covered with both diesel and gasoline sprays. This person questioned the extent to which this is investigator-driven, rather than prescribed by the DOE. However, a third commenter felt that adding gasoline sprays to the portfolio of research is appropriate. A fourth reviewer remarked that the combustion network approach is outstanding toward ensuring that various partners are conducting experiments and analysis similar enough to collectively improve the fundamental understanding of spray formation processes - evaporation, mixing, and spray thermal stratification. Another person acknowledged that the investigator had produced good test data results for improving modeling capabilities. The sixth reviewer liked Slide 5, but asserted that the investigator should take it a few more steps down the research

development & demonstration (RD&D) path with others, especially the industrial partners. Explaining further this person suggested integrating with the work of others at SNL and beyond to make sense of all of these closely fitting pieces of a complex puzzle, which should include the applied research and advanced development domains. The seventh commenter felt that the modeling and observations in the project lead to questions that need to be explored more fully and that the investigator should compare results to conventional diesel type combustion to understand differences and reasons. The final reviewer acknowledged that this was solid work on detailing injection. However, this person also noted that autoignition and flame propagation seem to be somewhat different regime from HCCI/ premixed charge compression ignition (PCCI)/RCCI engines, so the investigator should be sure conditions are meaningful.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Good progress on a year-to-year basis was expressed by one reviewer. This was affirmed by a second person who identified specific areas of progress that included models of mixing have been validated with mixture fraction measurements, global penetration rate has been related to mixture distribution, and ignition of gasoline sprays in the constant-volume chamber has started. In addition, this reviewer noted that a 2-hole injector of an 8-hole injector is being studied, the investigator is using laser ignition to set baseline flame propagation behavior, and when ambient temp is raised, autoignition occurs 20-mm downstream which is followed by what looks like an autoignition flame. A third reviewer encouraged the investigator to stay with "Transition Combustion", even if tangible progress seems slow. Another person acknowledged the nice work, observing that ECN seems useful and good for reaching others. The fifth reviewer stated that this work was interesting, specifically noting that finding flame propagation after self-ignition is opposite of s/a HCCI. The last commenter remarked that to date, very good measurements of vapor concentrations and penetration have been produced from this effort. However, this person felt that it would have been helpful to see more results alluded to in Slide 14 such that the reviewer could have a better feel concerning progress made this past year. Although, the reviewer acknowledged that there is a limited time slot for the presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A number of positive remarks about the Engine Combustion Network were given by the reviewers which included ECN is a nice initiative, excellent work with the ECN, ECN good example of collaboration, ECN and its web site deserve "4", ECN provides a great forum to collect information from a variety of researchers and make it available to the general community, and ECN is a powerful approach to collaborative. However, a few additional comments on the ECN from reviewers mentioned that the ECN is perhaps duplicative and that too much collaboration with outside organizations, especially on the global domain, for the sake of harmony and professional courtesy can be a deterrent. One reviewer suggested that perhaps the ECN scope should be expanded to gasoline injectors, while another requested that in future reviews, it would be nice to see how the ECN has positively advanced the state of the art in spray simulation by including a few specific examples. One reviewer remarked that the collaboration with the ECN and MOU partners is very good. Another affirmed this by stating that the project has excellent collaboration between many industry partners through the combustion network and Advanced Engine Combustion MOU. This person pointed out that the idea of using similar or exact hardware is a great approach that is only possible with real collaboration.

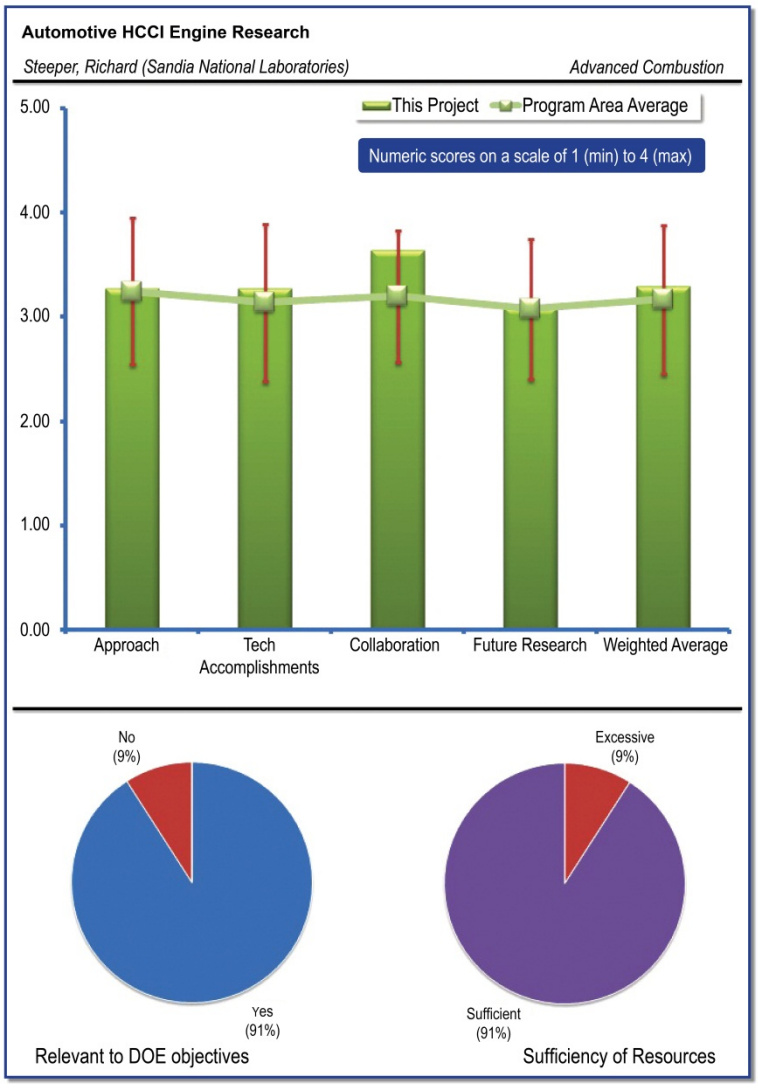
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer remarked that it was nice to see that gasoline sprays are now planned for evaluation. Another concurred, saying the gasoline work planned makes the balance between diesel and gasoline work better than in the past. A reviewer felt the PI has a very comprehensive parametric spray study planned for next year which will be of great value to the spray combustion community, although it might be too aggressive. However, another asserted that future progress is possible on a wide front, but needs to be well thought out, or will simply become reactive and scattered. The other reviewers stressed the importance of collaborating with other research areas stating that the investigator should compare results to work done on conventional and HCCI diesel and be clear on how this integrates into engine concepts like RCCI. Another reviewer reiterated this interest to see sprays (both in hardware, supply pressure, and flow rates) more indicative of RCCI combustion currently being studied by other researchers.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Nine of the ten reviewers responded that the resources for the project were sufficient. One of these commented that progress seems to match budget and vice versa. Another mentioned that it seems to be sufficient, but may perhaps be a bit high versus other efforts. The last reviewer asserted that the resources for the project were excessive, and went on further to state that there does not appear to be any funded partners, which leads to the question why this project has such a high funding level compared to other SNL projects. This person thought that the reason for this was that possibly part of the funding is/was invested in hardware.

Automotive HCCI Engine Research: Steeper, Richard (Sandia National Laboratories) – ace006



Reviewer Sample Size

This project had a total of 11 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Summarizing the research, one reviewer noted that this project is focused sharply on enabling advanced combustion models in gasoline engines that are necessary for efficient part load operation. In particular, this person explained that it explores the use of negative valve overlap (NVO) injection strategies for controlled phasing of the main heat release event. Directly addressing this question, one reviewer stated that the project supports the goal of achieving 25% fuel efficiency improvement through extending the HCCI operating range and that in combination with other technologies, this approach may enable that goal. Another pointed out that extending operation of HCCI to the light-duty automotive market application will likely result in fuel consumption reductions in that market. Disagreeing with these other reviewers one person was not too sure about the efficiency improvements of this method. Five other reviewers remarked on certain aspects of the research while not necessarily specifying the relationship to petroleum displacement. Their comments included: high Efficiency and low NOx operation of HCCI, work on NVO fueling can yield control of HCCI combustion, good study of issues of interest to HCCI combustion, understanding NVO fueling and its reactions with requests from industry, and addresses barriers for LTC combustion like gasoline HCCI while providing fundamental knowledge. The final reviewer said that the investigator uses the right words and terminology and that it seems that "the industrial partners" endorse it, so it has to be relevant.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers approved of the approach being used, but had mixed reactions related to the relevance and value to this research. One person noted that the optical engine is a good tool to visualize mixing and combustion during NVO operation and pointed out that relevant hardware and operating conditions are investigated, due to good interaction with OEM collaborators. This person also affirmed that state-of-the-art visualization techniques are applied and collaboration with modeling community is good. A second reviewer remarked that combustion control is a key barrier to HCCI combustion and that this work can lead to realistic ways to accomplish this, however with some loss of power density and efficiency. Two other reviewers stated that this is a well-defined problem being studied carefully and that it is an excellent combination of experimental, diagnostic and modeling. The fifth commenter mentioned the laser modulation for CO diagnostics and CFD modeling. A sixth reviewer felt that this project has a very good approach using optical engine, modeling, and zero-dimensional engine modeling to assess NVO injection strategies. This person's only suggestion is to explore heat transfer as a potential important phenomenon that could impact the main heat release event. This reviewer pointed out that the CFD analysis did show that heat transfer modeling was an issue during the power stroke which leads to

the possibility that the heat transfer during NVO and the compression stroke could be issues, too. The seventh person affirmed that the approach is outstanding, and the tools being developed (e.g., tunable diode laser [TDL]) are very useful for understanding the fundamentals. However, this commenter also remarked that the narrow focus on NVO to extend the useful range of HCCI may not offer significant incremental benefit over other engine technologies, yet introduces some additional aftertreatment and engine control complexity. The eighth reviewer said that it is not abundantly clear why NVO offers higher fuel efficiency possibilities than any other regime of operation of HCCI performance and that there needs to be better motivation other than being of relevance to a specific OEM. The last person questioned whether "riding the NVO horse" is a good investment of funding, talent and resources, or, if this research is too narrow of a focus in the bigger scheme of HCCI. This reviewer expressed that the reported experimental work is OK; however, it could be of little added value to the entire state-of-the-art knowledge database of HCCI combustion. This person pointed out that advancements in simulation, along with other programs' results from SNL and elsewhere, call for a revision or revamp of this program's activities and directions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt a good range of achievements were made on a wide front, including both the experimental and diagnostic tool development. The second person agreed that there was good progress, complimenting the nice combination of experiment and modeling, while another commented on the impressive correlation between experiment and simulation. The fourth reviewer acknowledged that the CO absorption diagnostic work was progressing well and remarked on the CFD validation of results. Another person pointed out that the investigator has made significant progress this past year trying to understand NVO injection timing impacts on the main heat release event through the development and use of CO measurement techniques, optical engine experiments, and chemistry modeling. Good progress was also noted by the sixth reviewer who listed the following accomplishments by the researcher: probed reasons for early heat release during late NVO injection, seeded with candidate species to determine the role of intermediate species on affecting heat release, developed Tunable Diode Laser for in cylinder measurement of CO, and updated GT-POWER model. This person also noted that acetylene provides similar early heat release, acetylene (C2H2) is known as an ignition enhancer, and that the good agreement between KIVA model predictions and NVO heat release measurements is very encouraging. The seventh reviewer questioned the accomplishment noting that the fundamental understanding of the C2H2 mechanism is important to expanding the range of HCCI operation, but questioned specifically to what degree. This person pointed out that it appears, even if fully successful, this would offer only incremental efficiency gains relative to other technologies, particularly when the goal is to push the HCCI range to higher load where less marginal gain is offered. The last commenter stated they were hard pressed to find real original findings and discoveries, criticizing that slides 6-10 do not present new findings that could not be obtained via a competent simulation exercise and/or from literature. This person said that the methodology in slides 11-19, started in prior year, is "nice", but the researcher should assess its forward value to continue investing in its development.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers were pleased with the collaborations on this project. One said it was a very good and comprehensive set of collaborators, while another remarked on the tight coordination with potential implementers. The third reviewer remarked that the collaboration with industry and the integration of the experiment with modeling is commendable. This person went on to point out that this will increase body of institutional knowledge in this area, and improve future in-cylinder combustion and cycle simulation modeling capabilities. Another commenter felt it was appropriate to have universities and OEMs as collaborators. This was affirmed by another reviewer who commented on the good collaboration that exists with Lawrence Livermore National laboratory (LLNL), University of Wisconsin, General Motors and Ford, and all the members of the MOU. The sixth person noted the good collaboration with General Motors and that Ford is starting to now get involved as well. The seventh reviewer remarked on the excellent collaboration among the PI, the University of Wisconsin, and LLNL utilizing the strengths of each organization in addition to technical input from General Motors and Ford. Another person acknowledged that the collaborators are well known and acclaimed, but felt that their respective roles do not match their capabilities, abilities, or reputation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Expressing their approval, one reviewer stated that the future plans as listed are fine, while another just said to keep going. A third person remarked that the combination of experiments, diagnostic developments and modeling is a powerful suite of tools, and wanted to know what overlap there is in the modeling area to other similar projects. Another commenter stated that overall, it was an outstanding plan, but suggested to consider running some hot motoring experiments to better understand heat transfer characteristics of the optical engine as referenced in the above approach section. The fifth reviewer observed that now with better understanding the influence of NVO injection on combustion, the effort should explore how robust of a combustion control parameter it is over a wider range of charge and coolant temperatures. This person noted that moving from isooctane to real gas is good and that General Motors sending new heads is a sign of active support. Another commenter mentioned that the quality of the work is outstanding, and the switch to a new test platform will only improve the relevance. This person believes that broadening the scope of the study to include other mixed-mode combustion regimes would be useful. It was also stated by this reviewer that the work presumes that extending HCCI is the best option, but perhaps other options should be considered that would be more consistent with the overall efficiency/emissions goals. The seventh reviewer also expressed that it was not clear if HCCI is relevant part load combustion mode is based on control and NVO status. The last person questioned whether upgrading the facility and engine hardware, even duplicating a setup that exists somewhere else at SNL, is a good stewardship for project budget. This reviewer also asked where this project would fall, if "industry partners" were forced to priority-rank all the funded programs at SNL.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Ten of the eleven reviewers responded that the resources for the project were sufficient. One person expanded to state that the budget and tasks show good agreement. Another felt that the cumulative benefits of this project to the overall program are perhaps broader than the scope suggests, and for that reason the level of funding is justified. One of these reviewers stated that the funding seems reasonable, though compared with other SNL combustion projects, it appears to be a little underfunded on an output versus funding ratio perspective. The eleventh reviewer asserted that the resources for the project were excessive. This person questioned whether this project would survive if the DOE funding to SNL is cut by X% next year, where "X" is 10, 20, or another percentage. This comment applies to this and all projects, not only at SNL, but also at all other national labs.

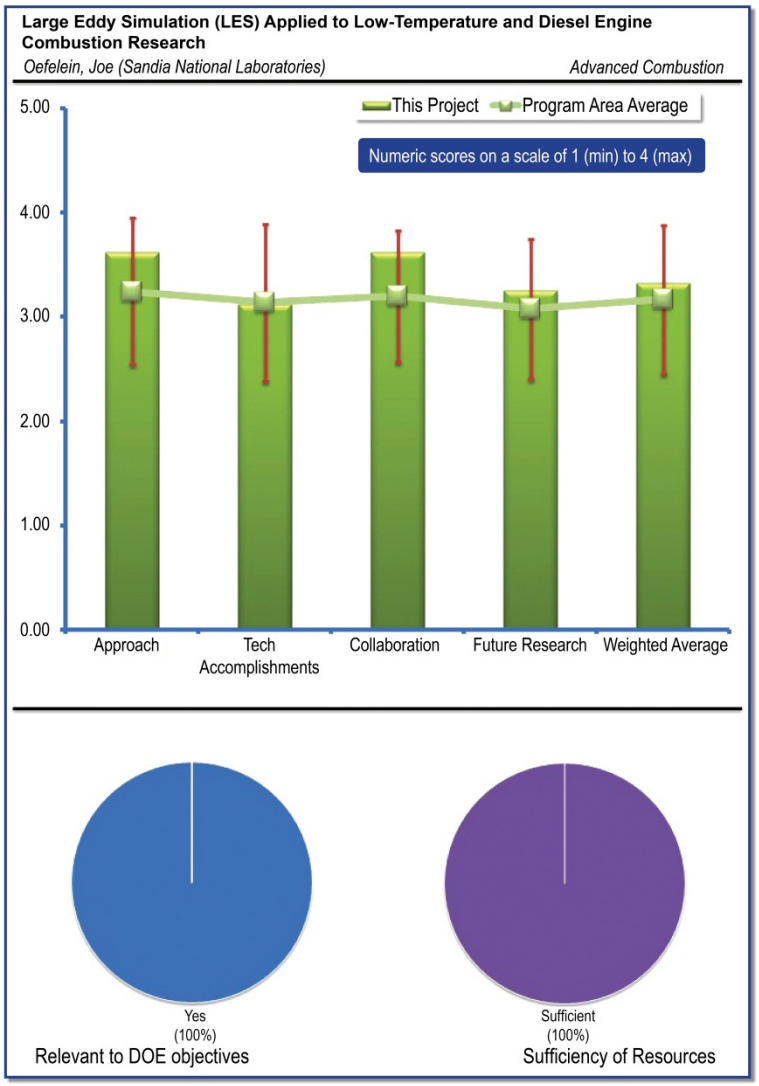
Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research: Oefelein, Joe (Sandia National Laboratories) – ace007

Reviewer Sample Size

This project had a total of eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

This aspect was summarized by one reviewer, who stated advanced simulation is a critical complementing element of future test programs aimed at reducing fuel consumption. Most other reviewers affirmed this, with one reviewer noting that high fidelity modeling provides insight into highly efficient engine designs. A third person commented that the long term value for fundamental computations is good and that this will ultimately link well with other engine combustion work. Another concurred, mentioning that high performance computing is another important tool in engine development. The fifth commenter said that this leads to improvements in computer models to improve future engine designs. The last reviewer pointed out that this research is focused on understanding LTC combustion which is a barrier and is also on efficient and routine use of exascale computing.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that this approach sets the ideal standard for CFD, to which other more available, affordable, and engineering-oriented approaches can be compared to. This person detailed components of the approach mentioning the access to advanced massively paralleled and newest DOE computers, as well as the Office of Sciences Supercomputers. Also pointed out was the solving of fully coupled equations (direct numerical simulation [DNS]), detailed thermodynamics, no tuned constants, eliminating constraints of computer capabilities on computational model performance, and connections to Jaguar. This commenter concluded by stating this work bridges basic and applied research. Another reviewer also acknowledged the strong link between basic and applied research and that the project was a good explanation of Jaguar computational resource. The third reviewer wanted to know how this work ties into the pending PRESICE modeling. Another person asserted that this project pushes forward the frontier of computations in a significant way and felt the use of DOE computational capabilities to approach the engine problem is unique. The fifth commenter thought the validation test cases where the efforts are being applied, though extremely challenging, are appropriate for future work. The reviewer pointed out that including additional work in kinetics of spark ignition and flame-front propagation in stratified charge engines, perhaps including mixed-mode combustion, would also be a useful validation case going forward. The last reviewer remarked that the approach is good, but noted that this project runs the risk of seeming to be a solution looking for a problem. This person pointed out that there are enough areas of interest to keep computational facilities busy indefinitely, and questioned how the topic areas are chosen.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that nice progress towards basic understanding of complex phenomena. Another person listed accomplishments that included completing large eddy simulation of transient jets and conducting computations of work at SNL with Pickett, Musculus and Dec. The third commenter stated that leveraging the available computational capability to further the understanding of fundamental, ongoing experimental programs will ultimately provide invaluable insight toward overcoming barriers. This person mentioned, for example, continuing to add critical features such as the state model in the spray simulation demonstrates continued good progress in the right direction. Other reviewers were more critical of the accomplishments with one saying that there was good continuing progress, but the direction of the calculations seems obscure. Another person concurred stating that the investigator showed some good things, but future is not all that clear on this project. The last reviewer was not clear on timeline and tasks for subset to full engine validation, because it was not explained what the success look like.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers, such as the first reviewer, felt that there was good, wide-ranging collaborations with a range of institutions and investigators. Another commented that collaboration with key experimental investigators to provide data for the model evaluation is good. Two other reviewers pointed out that the work was directly coupled with BES and Office of Vehicle Technologies (OVT), and that there was nice linkage to BES, other researchers, and industry. Another commenter stated that the partnerships included are appropriate for the success of the project, although perhaps future collaboration on fundamental next-generation direct injection spark ignited (DISI) systems would be useful.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer remarked that computation is a powerful tool, but the direction needs to be more pro-active and not reactive. This person mentioned that we have been told for years that high-power computing will lead to better engine design, but we have yet to see any engine design outputs from studies like this. This reviewer concluded by explaining that steady combustion in an aerospace application is trivial compared to fully transient, unsteady combustion in a piston engine. The second commenter noted that validation with current homogeneous engine may be helpful and that building confidence of tool key to acceptance should be included in future studies. The third reviewer felt that the scope of the efforts is appropriate for this time. This person suggested that given the importance of advanced boosted DISI engine technology, especially stratified charge modes, in the next decade or so, perhaps some effort could be directed in this area. Another commenter acknowledged that we need to keep going on these fundamentals, because they will change the game somewhere in the future. A fifth person was not real sure where this is heading in the future and another reviewer commented that the specific future research was rather vague. The final reviewer stated that this was interesting and needed research, but for this approach to impact product, the time (and cost) of the approach needs to be significantly reduced.

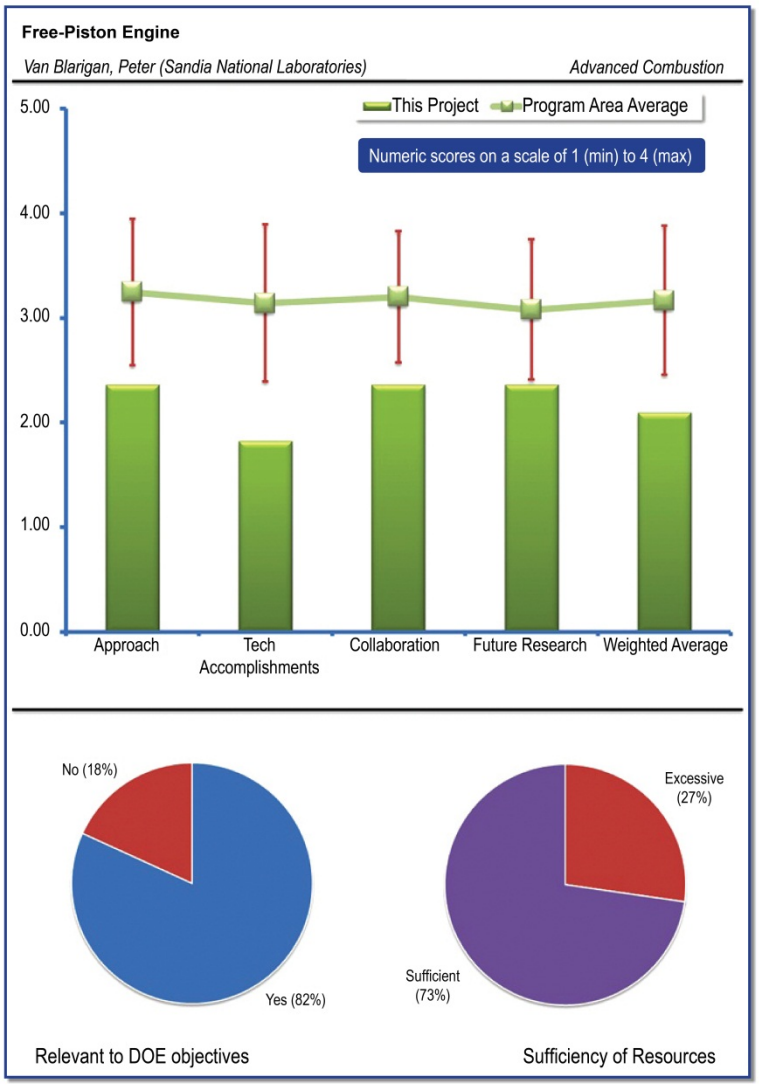
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All eight reviewers responded that the resources for the project were sufficient. One of these reviewers was not clear how additional funding would accelerate progress, one explained that the funding seems about right, and another felt that the budget seems appropriate. One reviewer mentioned that the expectations are high with this level of funding, so expanding the work in outside of just LTC/HCCI may provide a greater payback.

Free-Piston Engine: Van Blarigan, Peter (Sandia National Laboratories) - ace008

Reviewer Sample Size

This project had a total of eleven reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewers provided mixed opinions on this work, with most acknowledging that the work is highly speculative in nature. One reviewer felt that it does have relevance for fuel efficiency improvements in automotive and stationary generation applications. Another said that it was interesting work with great potential but it has many issues to overcome. A third reviewer described this as a unique project with high potential and high risk that is looking for very high efficiency conversion from fuel to electrical energy. Expressed by another commenter, this project is a very long range concept but is estimated to have potential for high efficiency. However, other reviewers were not convinced of the benefits with one stating that it barely supports the DOE objectives because the concept is very high risk, but possibly has only medium reward for mobile applications. Another reviewer questioned if there was a practical use for this device. One person has been tracking this project for the last few years and feels that it does not really fit with the DOE objectives. Another commenter acknowledged that the project is relevant, but only if there is progress. One person pointed out that there was much interest to identify peak thermal efficiency results. The final reviewer asserted that to the extent that the Free-Piston Engine program can contribute to long-range understanding of the potential of novel technologies to reduce fuel consumption, it is a valuable program.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked that the investigator used a nice systematic approach to the design and attempted to address design issues up front, although long term issues like lube and cooling are still pretty fuzzy. The second person noted that the researcher did a good job of trying to address the technical hurdles. A third reviewer mentioned that this provides a good research tool and prototype by studying free piston linear alternator and using high compression ratios of 20-40 with HCCI combustion. The approach is systematic, but progress is very slow was noted by a fourth person. Another commenter pointed out that the compression ratio tradeoff of efficiency with heat losses requires further work, and that single cycle experiments are interesting, but boundary conditions, such as temperatures, representative of sustained engine operation are needed. The sixth reviewer pointed out that it would have been better to use a mechanical coupling to focus on the combustion and indicated efficiency rather than mechanism and electrical coupling design. Another person felt that more effort should have been spent realistically assessing this concept's capability to meet ISFC targets before building hardware including air system, friction, linear motors, etc. While the eighth commenter thought this was a very interesting project, the design of the test apparatus adopts an inherently high risk approach to evaluating many complex elements simultaneously, rather than in a controlled, isolated manner. This person observed that beyond just the complexities of the linear engine/alternator

mechanism, it appears that many critical uncertainties remain in the air exchange, in the combustion process (highly dilute port fuel injected [PFI] CI at extreme compression ration [CR]), and in the heat transfer. Thus, this reviewer concluded that it may be difficult to interpret the results that may one day be obtained. The ninth commenter felt that the real question is whether this can move beyond academic interest to practical device. The final reviewer pointed out that the opposed piston, 2-stroke engine has been over-researched and over-developed for the last 70 years, after the German Junker engine of World War II and this research cycle tends to repeat every 10-20 years. This person remarked that hundreds of millions of dollars are spent, with claims of approaching a solution to its Achilles' heel, but that DOE is better off investing their funds in a better mouse trap. This reviewer acknowledges that a few private and venture-capital companies have sprung out, are making big noise recently on the merit of the opposed piston engine, and even one known truck-engine company announced partnership with one of them. However, this implies that this cycle is approaching its peak and this person expressed that if investors are ready to put their money into it, let them do so and use taxpayers money for something else pertinent to the national agenda.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Almost all reviewers mentioned that there has been very slow progress on this project. One person acknowledged that developing a new engine concept is a very time and budget consuming enterprise, but the progress on this project seems to be glacially slow. Another commenter noted that the funding of this project has been worthwhile; representing a long-term vision of "what could be", but the execution has not been on par with the vision. This person stated that fuel needs to be burned to advance the concept, and ultimately to decide whether to push forward with more work in this area (ideally) or to stop altogether. A reviewer pointed out that this project has been moving slowly for a few years, but consented that a significant amount of effort has been spent on hardware development. This person does not think the investigator was clear in explaining how the depth of the analysis has been, which makes it hard to truly assess the merits of this engine concept. This reviewer believes that this project has serious real world engine design challenges that will be difficult to overcome including cooling, tribological, scavenging, and charge preparation issues. Another commenter also expressed that progress has been very slow and gave an example of the project hiring a new person last December even though the original plan was to hire a person early in 2010. This person listed a few accomplishments including running the motor at operating compression ratio, with a bounce chamber, having a Helium starting system, and that the Data acquisition system is now functioning. One reviewer pointed out that the milestones of this complex project were shown, but the investigator did not show how those relate to past plans or what the future roadmap looks like. Being more critical, one reviewer stated that there was nothing of value to report as an accomplishment and that it is like a senior project hardware activity. Another reviewer stated that there has been quite some time invested without yet having a single fired stroke. This person expressed interest in seeing if the device is controllable under combustion, while another commenter agreed that is will be exciting to see if it runs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that the collaboration with General Motors and University of Michigan for model validation, while needed, does not provide the kind of collaboration needed to address the hardware design, build, and test issues on this project. Another person also remarked that the General Motors and the University of Michigan collaboration seems token, and a bit out of date. Questioning whether this project is a part of the MOU's group projects, or sanctioned by it, the third commenter observed that General Motors and others are playing a supporting role and are not contributing to real R&D. Another reviewer also noted that the investigator is working with the University of Michigan on modeling this engine, though the contributions with General Motors are not obvious. This person was hopeful that the University of Michigan will aid in truly assessing the potential of this engine concept for delivering the claimed ISFC levels at the targeted very high compression ratios. The fifth commenter inquired as to whether the project was fully leveraging progress in power electronics world. One reviewer stated that it was good to see academic and industrial partners, while another mentioned that the collaboration on this project has been improved in the past couple of years, and is appropriate for this stage of development. This last reviewer felt that once data can be generated from the test article, further collaboration can be expected.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt the list of future work as listed is fine; however, the traditional problem with this project is the extremely slow rate of progress. This person expects to see that the hiring of the new person last year will approximately double the rate of progress. Another commenter noted that much of the proposed work is not really value-added, but is only overcoming the challenges of getting the test apparatus functional. This person mentioned that once the engine is operational, it would be useful to see more specifics laid out describing what aspects of the proposed "combustion experiments" will be focused on. This reviewer also wanted to know how the instrumentation will be applied to evaluate all critical aspects of the engine performance, so that the most useful aspects of the results may be sorted out. A third person concurred that a lot depends on the results of the experiments. Another reviewer was glad to see progress toward combustion, but was concerned that there are still many detail issues to work out. The fifth reviewer asserted that is was critical to see it running in sustained operation, at any speed or load. Another reiterated this by expressing that the future research is okay provided it is executed and that it is important to see combustion data in 2012. The seventh person stated that we need to see data as soon as possible under realistic boundary conditions. Another reviewer felt that the proposed future research is good assuming fired results are available at the 2012 Annual Merit Review, but that if this did not happen, then it will be difficult to recommend further funding. The ninth commenter pointed out that progress is steady but very slow and that it seems as though more and more barriers to the operation of the prototype engine crop up. This person remarked that the engine has been on the verge of running for several years now, or so it seems. Another reviewer wanted to know if there is a calendar timeline that leads to expected results milestones and decision points, although this person felt that there was no need to continue this activity. The last commenter asserted that there are too many failure modes to count with this thing.

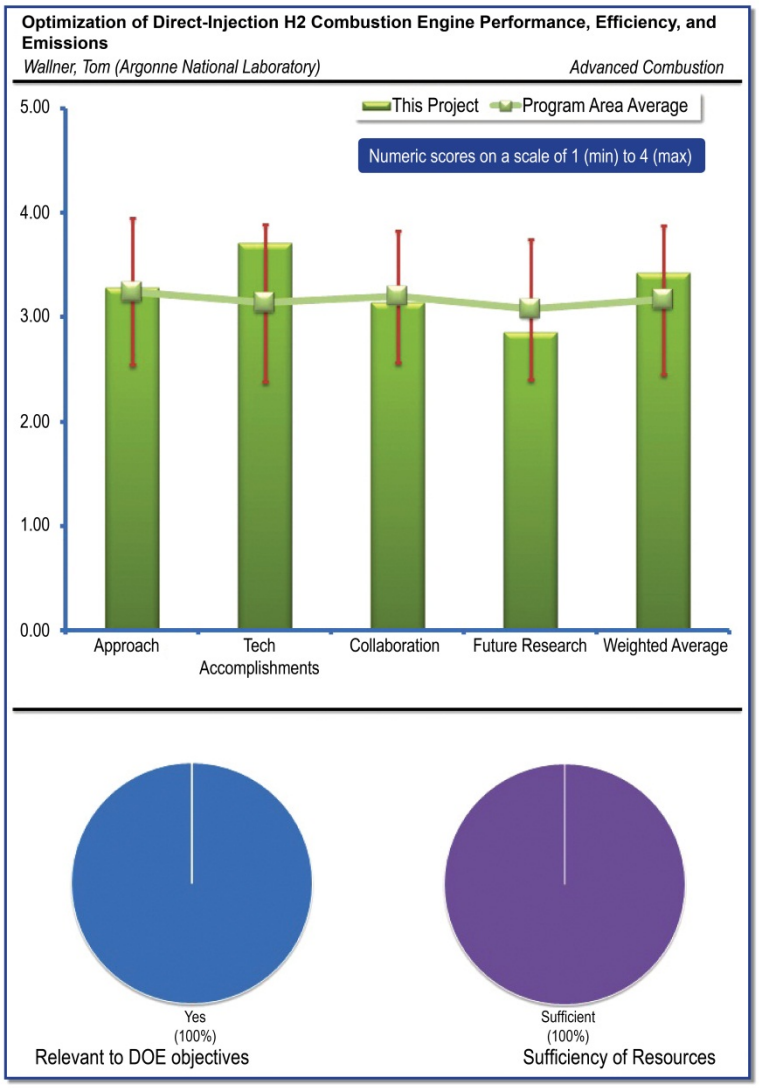
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Eight of the reviewers responded that the resources for the project were sufficient. One of these went on to state that the level of funding for such a long-term project is appropriate, but expressed hope that this next year will show a stronger return on the many years invested. Another reviewer acknowledged that this project is a real long shot and would have suggested to not fund it so highly, except hardware tests do need funding. The last of these eight reviewers to provide additional comments stated that the funding is adequate for this project and pointed out that it appears to be spent more on hardware development which has allowed the progression of this project. The other three reviewers felt that the resources for the project were excessive. One of these reviewers suggested that future funding should be tied to milestones vs. realistic targets. Another commenter remarked that the resources were excessive given the progress. The last person questioned whether this project would survive if the DOE funding to SNL is cut by X% next year, where "X" is 10, 20, or ??%. This comment applies to this and all projects, not only at SNL, but also at all other national labs.

Optimization of Direct-Injection H2 Combustion Engine Performance, Efficiency, and Emissions: Wallner, Tom (Argonne National Laboratory) – ace009

Reviewer Sample Size

This project had a total of seven reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer mentioned that hydrogen use could displace petroleum usage at the cost of electric power (presumably) for hydrogen production. A second person noted that hydrogen could be a replacement for some petroleum pointed out. Another reviewer concurred with that statement and also remarked that understanding efficiency potential of a hydrogen internal combustion engines (ICE) is a useful for comparison to a fuel cell. The fourth commenter observed that this project is targeted at fundamentals and delivering on 45% with hydrogen. Another person said that this was nice work for potential hydrogen applications, but also expressed that major hydrogen use is unlikely, but it is appropriate to be prepared. The final reviewer remarked that this project investigates hydrogen as a fuel to displace petroleum, but noted that the key issue for this project is Hydrogen fueling infrastructure, which is outside the control of this project. However, this person acknowledged that this project will provide data to a hydrogen IC engine if the infrastructure issues ever get resolved.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the investigator had a very good approach that was systematic and wide in scope, while another mentioned that the work was well focused and very practical. The third commenter stated that this was solid work on a technology that might be useful if hydrogen fuel infrastructure should ever come about. Another person affirmed that the project provides early data to make decisions of pursuing Hydrogen as an IC engine fuel and that it explores the tradeoff between efficiency and NOx emissions. The last reviewer pointed out that the project is concluding, so this review will have less future impact than for continuing projects. This person pointed out that the words "optimization" and "optimized" are used liberally and that "Optimized engine" is a misnomer, even within the limited scope and activities of the project. It was asserted that the injection system is "upgraded" within Westport's capability, but hardly optimized by Bosch/Delphi/Denso standards. This reviewer observed that a few experimental efforts could have been avoided by having a highly competent combustion system expert group carry out these tests in the simulation lab.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that the investigator produced an excellent set of results using a very comprehensive study with very worthwhile conclusions showing the efficiency benefits of gaseous hydrogen usage. A second commenter noted that all key objectives were met, while another complemented the excellent work on the drive cycle analysis. The fourth person remarked that the good solid results that provide a base of quality data for future analyses and that the technology has been developed enough to form an opinion of capability. Another reviewer felt there was good progress and affirmed that goals for both efficiency and NOx were achieved. After 6+ years of work, the fifth commenter asserted that the project has extended the hydrogen internal combustion engine to DI system and that indirectly, it has established that the hydrogen ICE engine time has not arrived yet. Nevertheless, this person pointed out that the investigator showed the hydrogen ICE is more viable than the hydrogen fuel cell, so this may be a significant accomplishment in this context. The sixth commenter listed the accomplishments by the investigator, which included completed the development of an efficiency-optimized hydrogen combustion system; found that a longer stroke was more efficient; assessed three injector nozzle designs to show that the 5-hole and 13-hole sprays collapsed and injected down along the cylinder axis; completed a full mapping of the engine; reached DOE goals (45%) at peak efficiency and world wide mapping point (WWMP) with very low NOx emissions; and evaluated drive cycle fuel economy and emissions with the Autonomie tool kit.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer expressed that the close collaboration with industrial partners is one reason for the robustness of the results in this project. Another felt there were good collaborations with Ford and others. The third commenter questioned how much of the financial budget weight and the technical input have the international team partners contributed, aside from the nice collegial exchanges. The last reviewer mentioned that the single cylinder metal and optical engines at ANL and SNL, multi-cylinder experiments at the OEM, and support from modeling provide for a sound approach.

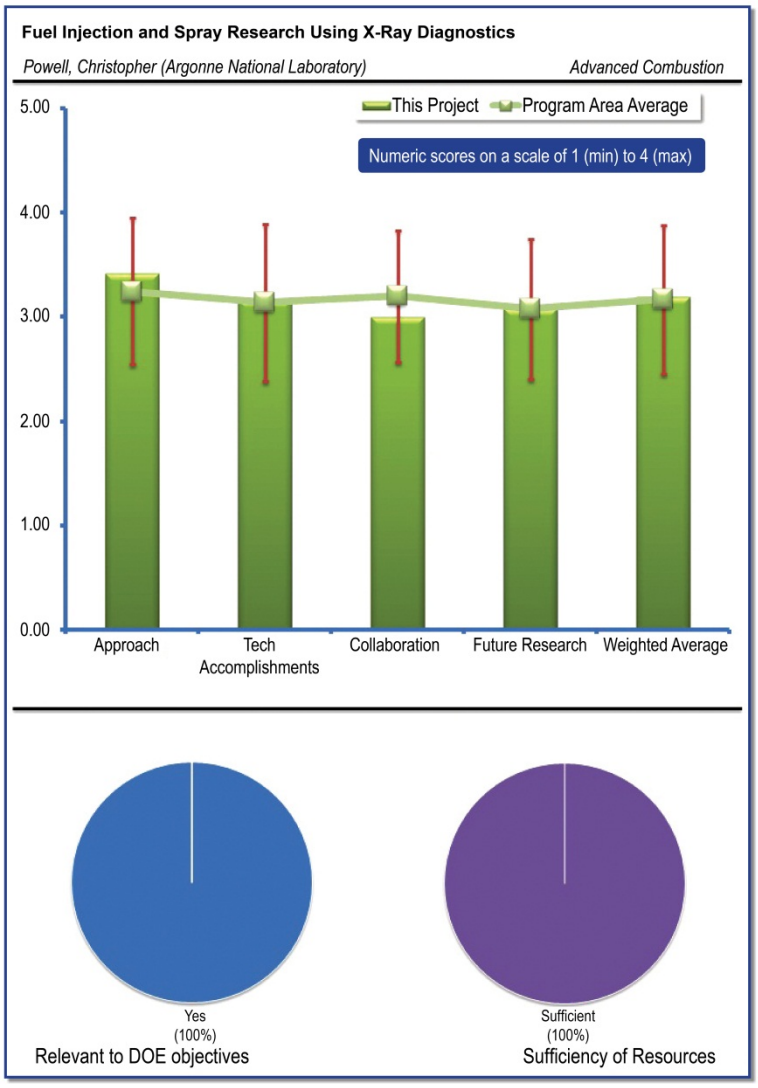
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer acknowledged that this was a good project, but felt it was appropriate to see the project wrapping up given that goals were achieved. A second person concurred that it was an appropriate plan to wrap up this investigation. Another commenter mentioned that one more iteration with an alternate nozzle design is planned as a wrap up of this project, but recommended that the project should be wrapped up following that and not allowed to languish on indefinitely. The fourth reviewer felt that the program could achieve more, possibly commercialization, if pursued. The last commenter suggested spending more time on the documentation and the final report, instead of going on to carry more "optimization." This person recommended that the investigator avoid presenting the findings as globally applicable to DI, hydrogen ICE engines and instead, make it clear that the findings apply only within a limited set of hardware and experimental schemes. A final comment by this reviewer was to include TNO's and other work, which is referenced in the investigator's response to other reviewers of prior years, in the final report.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All seven reviewers responded that the resources for the project were sufficient. One reviewer stated that it was good enough to conclude the final year of the program, while another said that it seems sufficient to bring the project to an end.

Fuel Injection and Spray Research Using X-Ray Diagnostics: Powell, Christopher (Argonne National Laboratory) – ace010



Reviewer Sample Size

This project had a total of 12 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project indirectly supports the overall DOE objectives of petroleum displacement by providing a tool to assess spray formation processes, including break-up and mixing phenomena for exploring engine spray formation processes in high efficiency, and DI engines using advanced combustion strategies. Another reviewer came to a similar conclusion, assuming that more fundamental knowledge of fuel spray characteristics will lead to more efficient combustion which would reduce fuel consumption and thus reduce dependence on combustion. The third commenter affirmed that fuel injection is a critical process in any engine system, and a better understanding or ability to simulate fuel injection and spray formation can support improved and advanced combustion. Two other reviewers concurred with this mentioning that this project provides insight in fuel injection behavior and that injection is critical to diesel, gasoline DI, HCCI, RCCI. A sixth person asserted that this was good work in understanding fuel injection with better resolution, while another commenter remarked that this investigation has the potential to provide fundamental understanding of fuel sprays. The final reviewer commented that detailed in-situ studies of injector operation and spray behavior are an important new diagnostic tool.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the approach is systematic and well thought out. Another stated that X-ray absorption sounds like a good approach to study multiple injection events which is difficult for other approaches. Two other reviewers concurred, mentioning that this is a unique tool for close in analysis and that the technique shows good promise. The fourth commenter noted that the investigator makes use of unique diagnostic capability with X-rays and that it would be interesting to see several types of injector designs (solenoid, indirect Piezo, direct Piezo) to quantify injection near opening and closing events. Another reviewer pointed out that the high energy X-ray system at ANL is a useful tool, but past work on this subject required a very high level of dopant, making some of the physical characteristics of the fuel somewhat unrealistic. Nonetheless, this person acknowledged that this program at ANL has provided some valuable information on the behavior of injectors. The sixth commenter remarked that with X-ray diagnostics of fuel sprays, the X-rays scatter far less than visible light with some being absorbed, but the investigator should get a good quantitative idea of where the fuel is located in the spray. This person believes the approach should aim to provide specific information of interest to modelers of sprays and that in this next year, by providing spray and needle motion data to the Engine Combustion Network, this goal should be realized. However, this reviewer asserted that a closer tie should be established with the spray and engine modeling work at the University of Wisconsin. The seventh commenter stated that having a dedicated X-ray beam lab allows more focused studying of

fuel property effects on sprays, and another person recognized that this project has unique capabilities unavailable elsewhere. The last reviewer observed that the years of DOE investing are starting to pay-off with this project and yield interesting information concerning near field spray formation processes. This person noted that the investigator has upgraded the chamber for 100°C operating temperature; however, this is still too low for many diesel-like operating conditions and possibly more focus should be on gasoline DI where combustion chamber mean temperature during injection is much lower than diesel engines.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt the investigator was making good, steady progress in an interesting field. Another commenter noted that being able to study pure fuels and multiple spray events are major accomplishments. A third reviewer pointed out the nice alignment of x-ray diagnostic with low cetane test plan. The fourth reviewer said that the researcher presented some interesting and useful results, but that it would be useful to extend the view to evaluate greater distance from nozzle. Another person remarked on the nice data so far, but questioned how it connects in detail to the modelers. The sixth commenter said that the X-ray movies of injector pintle are interesting; however, the investigator needs to show correlation to a combustion metric to make it more valuable. A seventh person expressed that it was nice to see dedicated lab and expected to see more volume of results in coming years with more collaborations. The eighth reviewer also mentioned that now the VT beamline has dedicated lab space which will expand experimental capacity and the resolution and need for dopants has been eliminated, which are major enhancements to this approach that eliminate weaknesses and concerns raised in past reviews. This reviewer also commented on the expanded consideration of spray phenomena to include multiple injections, as well as supporting other DOE projects at ANL, through extensive studies of low cetane fuel combustion, and at SNL-L, through the Engine Combustion Network. Still, this reviewer pointed out that the investigator cannot perform evaporating studies on conventional fuels and is limited to 100C. The ninth reviewer stated that given the limitations on the spray chamber boundary conditions, the generated data have been informative for near injector hole break-up studies at very low temperatures. However, this person pointed out that much work still lies ahead of the researcher to truly investigate real world sprays, though as noted above, the most applicable application is gasoline DI where bulk cylinder temperatures are moderate in comparison to diesel engines. A tenth commenter felt there was slow progress, since many spray phenomena and characteristics could be studied, but were not. It was acknowledged that perhaps the limited beam-time has been the issue as it was in the past. Now with dedicated lab between Basic Sciences and VT, this person was hoping to see more time for experiments, which should spawn more collaborations. This commenter also remarked that the upgraded optics for finer resolution was sorely needed which will hopefully provide more near-injector data for spray atomization models, and that the higher x-ray flux should permit study of pure fuels without additive. This tenth reviewer observed that multiple injection events were imaged, but there was no effect on penetration of second spray or spray angle of second spray. It was questioned whether this could be because the downstream distance investigated was terminated at 12-mm. This person pointed out that typical distances in engine combustion chambers is larger than this distance and that larger downstream distance should be investigated. This researcher concluded by commenting on the contributing to ECN of needle motion. The eleventh reviewer recommended ensuring the validity of the measurements and, more importantly, its reduction to quantitative values which needs to be through independent means or measurements. This person acknowledged that this may be a challenging task, as new discoveries may have to be pursued; however, fuel injection equipment (FIE) companies, especially Bosch (Germany and Austria) have the know-how to help out. It was pointed out that because this would be exposing their "treasure chest", ANL must ensure strict confidentiality and security of information gained, so that the FIE company may open up. This commenter also stated that the "Excellent reproducibility" is good, but wanted to know what exactly the investigator was measuring, and if it is qualitative distribution or indeed quantitative measurement (Example: What EXACTLY are the "parcels?"). Additional thoughts from this person included use a statistically valid experiment, instead of running arbitrary sweeps and individual test points; do not use injector current as an indication of actual fuel injection event reference (quantity and timing). Hopefully, your Bosch and /or Delphi collaborators should be able to explain this to you, and provide further information regarding for example hydraulic and inertia lags, electric and physical damping, etc. Errors can be quite significant and has led to costly mistakes in the R&D arena! Continued this reviewer, two "identical" injectors, fed by the same injector current, will yield two different fuel injection events into the combustion space. The variability may not be too significant for commercial use, and is in fact dealt with through calibration techniques and injection system controls. On the other hand, such variability could be significant for the ANL R&D efforts, and could mask the discovery of important findings when you are using such sophisticated methodologies. This reviewer also referenced Slide 12: the 3-hole injector will not

give similar results as a 7-hole injector, unless other parameters are rationally adjusted. The simple change in the exit flow area (restriction) changes the nature of fluid flow, under both static and dynamic conditions. Perhaps a starting point is to use dimensionless numbers of fluid and heat transfer flow (Reynolds, Prandtl, Nusselt, etc.) as an initial boundary condition, then change quickly to turbulent and cavitating flow assimilation? This will give results that are directionally more representative of the General Motors 1.9L engine and other experimental lab systems.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that the good OEM interaction should lead to important results for fundamental injector design. The second commenter mentioned the links to General Motors through engines, the Sandia Engine Combustion Network and other researchers at ANL, while another also pointed out the support of the ECN. The fourth reviewer remarked that the primary collaboration seems to be via the Engine Combustion Network where members use similar injectors and common injection conditions, and with colleagues at ANL. This person noted that it sounded like collaborations with industry are to be initiated. The fifth commenter affirmed the excellent payback on collaboration with the SNL team and pointed out that ANL and SNL should chart up a more cohesive, 2-part team, with full/complete feedback loops. This person also suggested adding the Combustion MOU group of SNL as a formal partner and not over-spending or getting over involved in the ECN activities. Another reviewer stated that this project has outstanding collaboration with the investigator participating as an SNL engine combustion network partner while working with three fuel injector suppliers. The seventh commenter acknowledged the solid interaction with several suppliers, but others did not seem to be represented, perhaps because they were not as obvious. The last reviewer felt that collaborations could be significantly improved. This person asserted that the recent connections with the ECN and the University of Wisconsin are a step in the right direction and that these connections should be exercised diligently.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

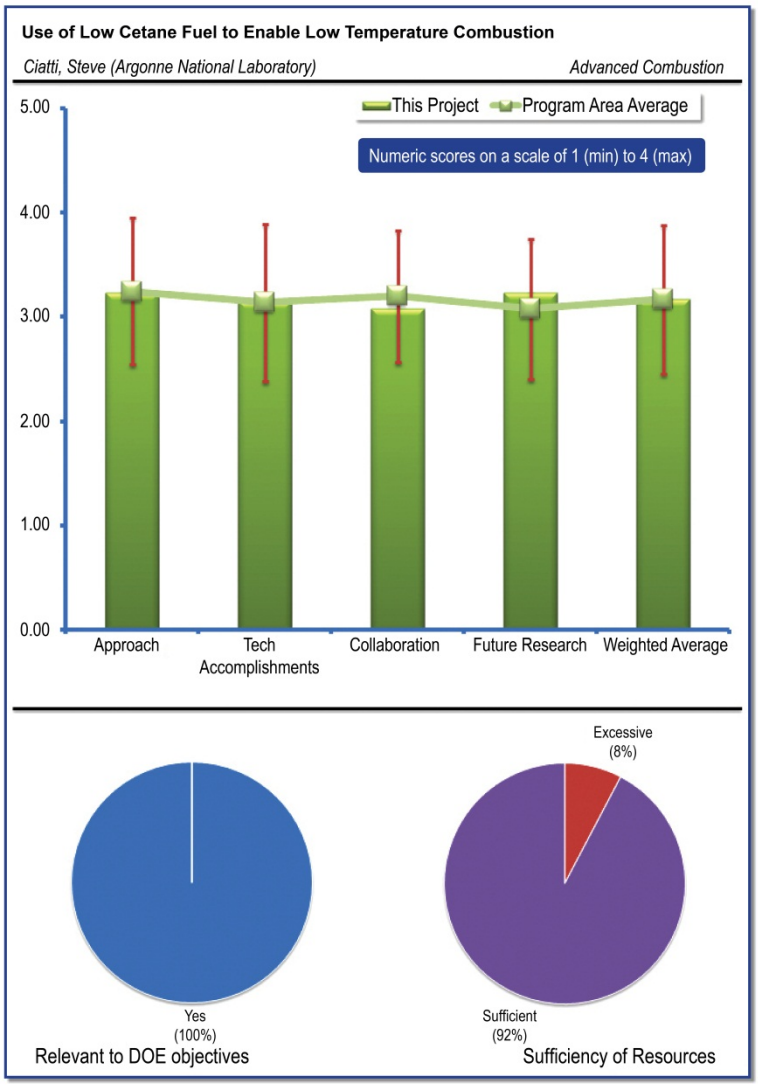
The first reviewer remarked that the valuable work should continue and another mentioned that the proposed plan seems reasonable. The third commenter said that it was a nice broad plan for work on 1.9L, Delphi, Westport, etc., while another reviewer commented that the cavitation study should prove very interesting. The fifth reviewer pointed out that improved beam characteristics should only improve the results of the spray and mechanical operation of the injectors and that there should be greater interaction with spray modelers now that the experimental results have reached this level of sophistication. Another person noted that spray penetration, wall wetting, and piston wetting are very important for gasoline DI smoke/PM mitigation when combustion chamber temperatures are cold (perhaps during the first 200-300 seconds of the FTP cycle on a light-duty vehicle), and that it would be good to consider research in this area. The seventh commenter felt the investigator should not just duplicate what have been done before with Bosch on the Delphi HW and should instead explore new issues and new frontiers. This person's advice was to discourage "general users" applications, at least for few years down the road, so that the high value tasks relevant to the OVT charter can be addressed, which include diesel and gasoline-related injection and combustion issues. Another reviewer stated that in looking to continue the General Motors engine measurements, the researcher should consider cavitation phenomena and develop collaborations with Delphi, Chrysler, and Westport. This person felt that it would be very helpful to expand the cell capabilities to study evaporating sprays with practical fuels. The ninth commenter asserted that it would be good to see more gasoline work in the future. A different reviewer concurred with this, recommending that the investigator focus more on gasoline or gaseous fuels due the chamber temperature limitation of 100ºC, since this type of limit makes it very difficult to properly simulate realistic diesel bulk temperatures during the injection event. The final reviewer said the future steps as outlined in this report are all good and that hopefully a large portion of them can be completed at the next report period.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All twelve reviewers responded that the resources for the project are sufficient. Additional comments from reviewers stated that the budget seems sufficient or that there was no evidence that it is not sufficient. Another person remarked that the resources were at least sufficient, noting that the dollar value seems large but is perhaps justified by work volume. Not sure about funding, a fourth reviewer expressed that the funding level is quite high in comparison to other projects though only six weeks out of year are spent performing

experiments. This person mentioned that possibly renting space at (Advanced Photon Source) APS is expensive, which was also asserted by a different commenter that assumed access constraints to APS remain. The sixth reviewer observed that the funding has been stable, which has permitted significant improvements of the facility and thereby the approach. The last commenter suggested establishing a "productivity measure" that would be a (robust) metric on the use of the new dedicated facility, including both time-on and output in terms of data analysis and conclusions. This person asserted that the investigator should not add new technical staff and manpower, and instead do more with the current expert staff and support personnel. This reviewer questioned whether the new DOE APS upgrade (ca. 2015) will put the facility out of commission, and if so, how long would the estimated time off be. This person concluded by pointing out that if this time off will be few weeks or months, it might be better or wiser to hold off on this "upgrade" until some useful utilization and more harvesting of results from the latest upgrade and the current beamline is garnered?

Use of Low Cetane Fuel to Enable Low Temperature Combustion: Ciatti, Steve (Argonne National Laboratory) – ace011



Reviewer Sample Size

This project had a total of 13 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that the project's goal of improving engine efficiency via advanced combustion, if successful, would improve fuel economy and reduce fuel consumption, reducing amount of petroleum needed. Another person stated that the project represents a potentially attractive commercial pathway for achieving reduction in fuel consumption. The third commenter pointed out that avoiding soot and NOx emissions through the control of fuel stratification to enable high efficiency combustion can reduce the efficiency burden from very low engine emissions, thereby providing a path to clean combustion technology with a lower fuel economy penalty. Another reviewer remarked that the use of gasoline (as opposed to diesel) in high efficiency engine operations will reduce overall petroleum usage. The fifth reviewer affirmed that this is a very good experimental project studying the possibility of operating a high efficiency, compression ignition engine on gasoline. This person noted that much work is still ahead of the PI, but acknowledged that the initial results are promising. Another commenter felt that this is very useful work to extract higher efficiency using alternatives to gasoline. The seventh commenter said that the investigator aims to further improve thermal efficiency with diesel architectures using gasoline-like fuels, while another person mentioned that this project is the evaluation of gasoline-based LTC strategies. The last reviewer observed that the researcher is investigating advanced high efficiency LTC combustion by using gasoline in a diesel engine.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that this was a good systematic approach to a worthwhile project. Another concurred that the approach seems reasonable and is similar to others using gasoline-type fuels in CI engines. The third commenter felt that studying the impact of low cetane fuel properties to enhance and extend LTC is a well-focused research project. A different person affirmed that the investigator was doing excellent work with sound results and that it is very useful to see DOE's approach to testing. The fifth reviewer commented that the approach is very well structured for achieving the targets laid out; however, it is somewhat unclear what the emissions goals are for this project. This person observed that the engine-out emissions seem to float around non-specific targets and that perhaps this can be better defined. This reviewer would also like to see PM measurements included as part of this study. A different commenter remarked that the approach was reasonable, but more thought is needed for low load and cold start conditions. The seventh reviewer pointed out that the researcher was combining in-cylinder visualization with advanced combustion studies in a sophisticated production engine system (a light duty diesel engine operating on gasoline). This person noted that the investigator was combining

modeling with partners, as well as performing spray imaging at ANL-APS and engine studies to understand the phenomena occurring with different fuels and injection strategies. It was also observed that the project is using a low cetane/high volatility fuel (low cetane gasoline with lubricity additive), and using injection parameters to study combustion phasing. The eighth commenter suggested to avoid soot and NOx by early injection, before start of combustion. A different reviewer felt that the project slightly improved over prior reporting period and used statistical design of experiments in part of the testing. The researchers involved in this work are urged by this person to compare their approach to that of ACE019's (Assanis, et al.) as an example. This is not to see if there is a duplication of efforts, but to devise a similar systematic R&D approach in order to uncover the underlying phenomena and apply them to real life. This reviewer pointed out that there are other programs that are presented at the Annual Merit Review, which include total, multi-cylinder engine hardware, and this program will benefit from studying the pros and cons of these. The tenth commenter urged the investigator to consider plotting experimental results in a traditional "response plot" fashion versus the control factors to clearly show the effects. This person mentioned that the inability to run low loads is problematic and that it is unlikely that gasoline below 91 research octane number (RON) is going to be readily available. Another reviewer remarked that the general approach has been good as an initial investigation, though it would have been highly beneficial to have taken PM exhaust measurements. The modeling work and eventual experimental work at the University of Wisconsin should be very insightful during the next years. Lastly, this person felt that the investigator's approach of further studying EGR rate and injection timing changes on the chosen load points will be very helpful. The final commenter stated that low Cetane fuels (like gasoline) provide longer ignition delay, which promotes more mixing and lower soot and injection ends before combustion. The investigator should maintain partial stratification of fuel air and EGR. This person observed that the project has migrated from a controls focused project to one that seeks to develop base combustion strategies. In Slide 5, the statement saying this project is different from other LTC projects because it uses little to no EGR does not make sense. This reviewer pointed out that in most of the data presented in this report, the gasoline LTC cases use more EGR than the base conventional diesel case, therefore, it was questioned as to what significance is the fact that no EGR is used for the 2 bar case.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Many reviewers noted that the investigator was making good progress and included remarks such as: good progress with useful results, good work as far as it goes, and very good progress on an interesting approach to using gasoline fuels rather than conventional diesel fuels. Another commenter agreed that it seems like good progress and good results at intermediate to high speeds and low, but pointed out that the challenge is at low speed, low load. A different reviewer said that there was good progress, but it was not clear from the presentation what the potential efficiency improvements are. One reviewer expressed that it was a nice presentation of alternative injection strategies. Another reviewer pointed out that the initial experimental portion of this project has been very insightful in assessing the capability of operating a high compression ratio engine on gasoline. This commenter mentioned that the investigator showed good work developing injection strategies that enable pretty good initial operation on gasoline, although there is much work is ahead for the researcher. A different reviewer affirmed that the accomplishments are good from a fuel consumption standpoint, but the emissions targets need to be more of a constraining factor. This person felt that adding the collaboration with modeling groups at the University of Wisconsin is very positive, as is broader collaboration with other groups at ANL and SNL. One commenter listed the project’s technical achievements, which included demonstrating low NOx and output as high as 16 bar brake mean effective pressure (BMEP) and >30% brake thermal efficiency (BTE), able to vary injection timing, boost and EGR levels with current setup, demonstrated significant capability to operate under the gasoline LTC operation and working toward maintaining diesel brake specific fuel consumption (BSFC) but low engine out NOx, while keeping CO and HC penalty as low as possible.

Another reviewer asked about the logic behind the selected values of injection strategies of Slide 10, since it is very hard to establish phenomenological conclusions from this work. This person also questioned what the fundamentals are (physics, thermodynamics, combustion, kinetics, etc.) that guide the approach, design of the tests, parameters and their values, etc. It was remarked that it is not enough to simply state "by fluid mechanics", because no state-of-the-art fluid mechanics knowledge or tools are sufficient enough to simply guide in the set-up of the prescribed tests. This reviewer pointed out that a much simpler approach might have been adopted, and in such case the fidelity with real-life system may not exist. It was acknowledged that using a statistically designed experiment is encouraging; however, further quantitative trends and conclusions from post-processing the data shown in Slide 28 are absent. This person concluded by asking if the analysis was aborted prematurely, or if it was just not reported at the Annual Merit Review. The final commenter suggested that key parameters like BSFC should be presented in tabular format so that precise differences between

baselines and gasoline LTC combustion can be properly made. It seems from Slide 8 that there has been an increase in BSFC going from conventional diesel to gasoline LTC. This person stated that if this increase in equal to or greater that the fuel penalty for NOx aftertreatment in a conventional diesel, then there would be no profit in gasoline LTC. Smoke and/or particulates are a critical variable in any combustion mode and should be measured on this project in order to get a complete picture of the value of gasoline LTC. It was observed that at the 1,500 revolutions per minute (RPM) 2 bar point there is a significant increase in HC and CO emissions for gasoline LTC, and the reviewer wanted to know what the plan is to investigate other strategies to lower HC emissions at this point. A measure of knock or ringing index should be included in all the experimental work so that these constraints are not being violated. This person also criticized that on the summary Slide 8, a vague statement is made that greater than 30% BTE is achieved at most operating points, but in the body of the report not a single plot or table of BTE is presented to substantiate this claim. This reviewer concluded by stating that either BSFC or BTE should be used consistently and in light of others reporting BTE's in the high 30%'s, it was questions as to what this project is investigating to achieve higher BTE's.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that there was good interaction with industrial partners and cross-industry groups. Another listed the close collaboration with General Motors and with the University of Wisconsin, while British Petroleum is supplying fuels. This reviewer mentioned that the University of Wisconsin Engine Research Center is simulating some of the experimental studies from this program and the comparisons looks quite good. A third commenter acknowledged the excellent collaboration between the investigator, General Motors, and the University of Wisconsin Engine Research Center. This person observed that General Motors is actively engaged in this project and the University of Wisconsin is and will be providing additional analytical and experimental support of this effort. A different reviewer noted the increased dialog with Sandia. The fifth reviewer stated that the industry coordination is appropriate for a project of this nature, although perhaps the input of a heavy duty engine manufacturer would be useful. This person went on to point out that linking this work with modeling and more fundamental combustion studies is important to the success. Other reviewers were less supportive of the collaborations, with one remarking that the partners are somewhat limited to one OEM and one energy company plus the University Wisconsin. This was reiterated by another that asserted there was good collaboration, but with a somewhat limited range of partners. The eighth commenter gave the suggestion to improve the core competency and the quality of contributions of the collaborators. The last reviewer felt that this project seems to be conducted in somewhat of a vacuum and that a more specific tie should be sought with the modeling work at University of Wisconsin. This person expressed that the investigation should try and relate this work to John Dec's work on partial fuel stratification, which also uses gasoline, but uses alternate methods to achieve ignition of low-cetane fuels.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

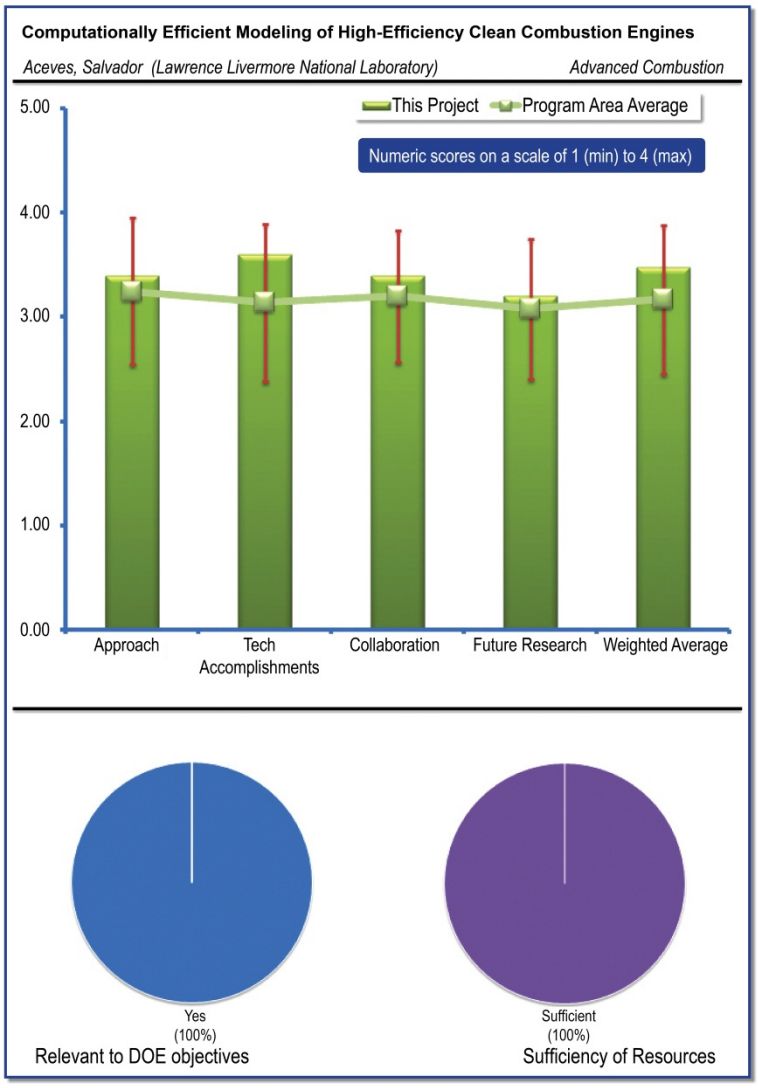
One reviewer stated that the plans seem reasonable and build on results to date. Another reviewer felt there was good use of experimental design and a systematic approach to an interesting area of research. A different commenter said the plans look good, but advised the investigator to consider higher injection pressure as well. The only suggestion by the fourth reviewer is to add PM/smoke as an additional measurement. Another reviewer remarked that the test plan is mapped out well; however, the ultimate success of this depends also on how the challenges of achieving idle, low load and transient operation are addressed. This person also asserted that some attention must be given to cold starting with this approach. The sixth commenter reiterated the investigator's proposed work, which includes: expanding the database of experiments, operate with fuels for advanced combustion engines, perform in-cylinder measurements, and continue APS x-ray imaging of spray. This person suggested that the researcher should emphasize PM and particle sizing measurements to see what amount and type of particles may be emitted by this combustion process, and also speciate the HC emissions to see what type of HC's are being emitted. Another reviewer felt that the investigator should focus on meeting remainder of experimental metric (CR, Injectors, Strategies, EGR etc.), and also mentioned that smoke/soot measurements would be valuable. The eighth commenter questioned why the researcher was going back to a parametric sweep, after having tried the statistical DOE approach. A different person commented that much more effort is needed to understand how the investigator addresses the full range of operation. This person pointed out that light loads have to be run, and questioned how that would be done. It was also asked whether a dual fuel RCCI approach needed. This reviewer mentioned that most emission comes from cold start for LD vehicles, so the

investigator wanted to know how the project will do the start and runs. The last reviewer also picked up on this point, asking how the investigator planned to address idle and cold start, given the ignition / combustion difficulties at light loads. This person said that if there is no clear plan for this, then the project would be more relevant if even lower cetane fuel was used (i.e. 91 RON) and an electrical ignition source was added.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Twelve of the thirteen reviewers for this project responded that the resources for this project were sufficient. One explained that stable funding is keeping progress on this program quite robust and that future funding should be kept at this level to maintain progress. Another commented that the resources are sufficient to achieve the future milestones. A different reviewer stated that there was no evidence that resources are not sufficient. A reviewer also asserted that the project appears adequately funded to support the investigator and the University of Wisconsin. One of these reviewers remarked that the resources might be excessive unless solutions are proposed for light load and cold starting. This person mentioned that otherwise, the researcher may have perhaps not proven that this concept will work in real systems. The one differing opinion regarding the level of resources for the project came from the thirteenth reviewer, who stated the funding was excessive.

Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines: Aceves, Salvador (Lawrence Livermore National Laboratory) –ace012



Reviewer Sample Size

This project had a total of ten reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer pointed out that high efficiency clean combustion engines can be enabled by predictive simulation, and therefore this work is directly responsive to the objective of lowering fuel use and displacing petroleum. This person also mentioned that this work is directly responsive to the grand challenge from the Basic Research Needs Workshop on 21st century transportation fuels. Another commenter remarked that the development of tractable combustion models should enable optimization and/or design of engines with higher fuel efficiency, which should reduce fuel/petroleum requirements. The third reviewer asserted that simulation of high efficiency engine combustion is a potentially important tool for the engine design community. A different person concurred with this statement by also noting the improved simulation tools for high efficiency engines. The fifth commenter mentioned that this directly supports future simulation capabilities and leverages a U.S. competitive advantage in supercomputing. Another person said that bringing simulation tools to a usable state within industry is quite relevant and needed. The last reviewer summarized that the project addresses mixing and combustion processes for various advanced LTC and high efficiency clean combustion concepts.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Some reviewers were positive about the approach, stating that the project well defined and that there was great basic scientific contribution. Others, however, disagreed with one reviewer remarking that the approach remains piecemeal and not necessarily well-motivated, while another mentioned that it was unclear what the path to implementation for industry was for all this. This reviewer did acknowledge that there was some mention of work with convergent Science, which is good. One reviewer pointed out that the investigator should consider high fidelity combustion kinetics and fluid dynamics to achieve predictive capability. This person pointed out that this requires reduction of the computational expensive of simulating complex combustion phenomena involved in high efficiency clean combustion regimes. The last reviewer commented on the project, noting that it models chemical kinetics and fluid mechanics of combustion processes in engines with a focus on being computationally effective. This reviewer also stated that the investigator is applying the numerical tools to high efficiency clean combustion and reducing computational expense to make them accessible to engineering workstations.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer felt there was amazing progress and that it is encouraging to see these improvements rapidly moving toward customer usability. The second commenter mentioned four major areas of advances by the investigator which included numerics, computing architecture, improving sub-models in KIVA platform for large-scale CFD, and detailed comparison with experiments. This person observed that the researcher was looking for 1000-fold speed improvements by numerics and the use of graphic processing units for simplified and faster parallel computations by tailoring the algorithms to use these fast and inexpensive processors. Another reviewer also commented on those accomplishments by listing the improved the numerical stability and improved computation architectures that can now get 1000X speedup. A different reviewer concurred that progress on reducing computing time seems very good. The fifth commenter remarked that the 11x improvement sounds good and pointed out that the investigator mentioned it is possible to do better, but did not explain how. Another expressed that it was an important approach, but that the accomplishments are not necessarily well-linked to the stated program goals. The seventh person suggested that it would be beneficial for the reviewers if the investigator showed a few simple case studies, along with any improvement over time with validation. The last commenter criticized that the researcher was not clear how results will be disseminated.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer felt that there was good coordination with industry and other academic institutions, which was reiterated by another person who observed that there was extensive collaboration with industry, labs and universities. A third commenter also mentioned that the collaboration is quite extensive with several National labs and universities. A different person remarked that is was good to see linkage to private industry, as way to quickly deploy the results to industry. The sixth reviewer criticized the coordination with industry, noting that collaborations mostly seem to be with national labs and universities. This person pointed out that the primary industry collaboration listed was through the Advanced Engine Combustion MOU, and it was not clear if sufficient "collaboration" comes through the 2 presentations per year at this forum. The seventh commenter asserted that the investigator should converge licensing and interactions. The last reviewer expressed that many groups are depending on this work.

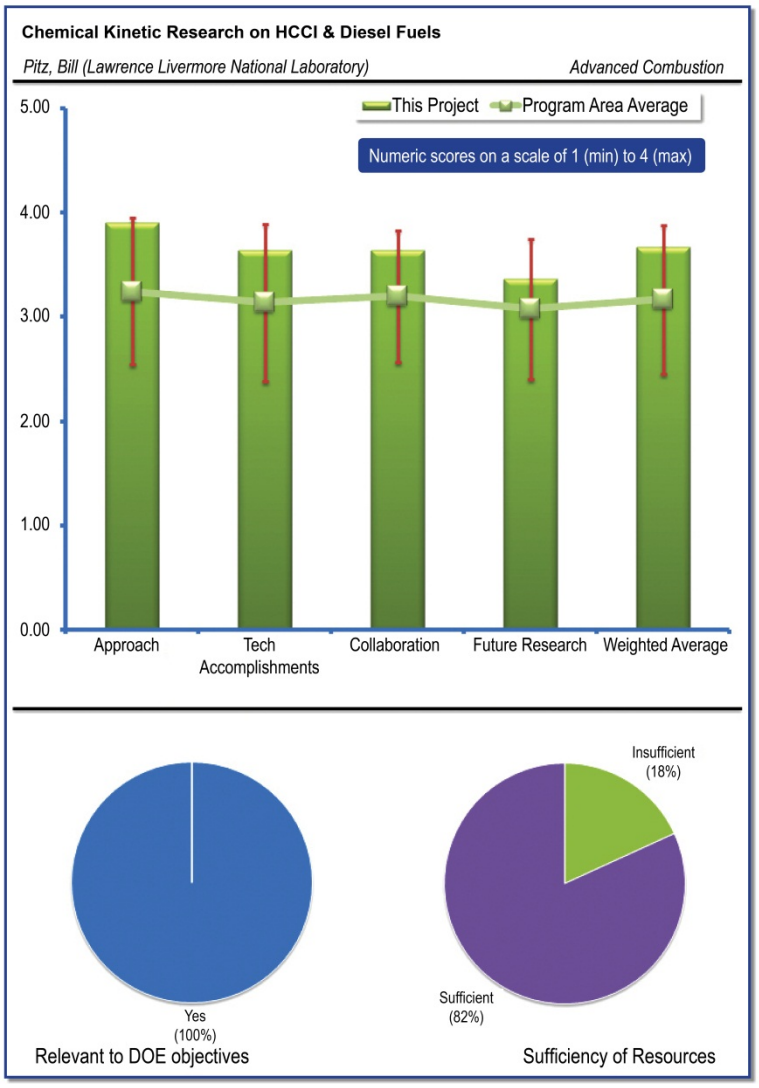
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer stated that there was a good outlook for this project if it can truly deliver on its stated goals of bringing engine simulation to the desktop environment. Another person also mentioned the project's intent to achieve large scale parallel computation on a desktop computing platform and felt that this is a laudable goal which may enable broader implementation of computational design of advanced engines. The third commenter acknowledged that the continued narrow focus on numerics and computation speed efforts are appropriate. A different reviewer noted that the proposed plans seem reasonable, while another said to keep up the good work. The last person remarked that it was unclear what the future plan of these codes for graphic processing units is. It was not clear to this reviewer whether they work on future computer hardware, or if any of the software people are planning to pick this up and produce codes for industry.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All ten reviewers responded that the resources for this project are sufficient. One went on to mention that the effort seems to be suitable. Another commenter pointed out that this project's stable funding is key to maintaining progress over the long term and suggested to maintain this funding level to ensure continued progress.

Chemical Kinetic Research on HCCI & Diesel Fuels: Pitz, Bill (Lawrence Livermore National Laboratory) – ace013



Reviewer Sample Size

This project had a total of 11 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One person summarized the general consensus of the reviewers by stating that this project indirectly supports the overall DOE objectives of petroleum displacement. This person explained that this is a very fundamental fuel chemistry project that is critical toward the continual development and refinement of kinetics models that are important for the simulation and assessment of advanced combustion modes in compression ignition engine. An additional comment from another commenter was that the reduced mechanism chemistries and reaction kinetics parameters are an important requirement for the fundamental modeling of high efficiency engines. A different reviewer stated that understanding the chemical kinetics of combustion is even more important in advanced combustion and for unconventional fuels to achieve truly predictive simulation capabilities. The fourth person asserted that the development of fundamental kinetic models should help improve engine optimization and design and thus fuel efficiency. Another commenter mentioned that this project provides an understanding of chemical kinetics in the combustion processes, which are key to understanding advanced LTC and highly dilute combustion concepts. A different reviewer pointed out that kinetic combustion models are needed to fully model combustion, while appropriate models are also needed to simulate complex fuels. The seventh commenter remarked that this was solid work leading the world in fuel chemistry and is fundamentally needed for many modeling purposes. Another person affirmed that this is important work for chemical reaction models, while others reiterated that chemical kinetic models for combustion and emissions are very important and required.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the approach of mechanism development has proven to be very effective to support simulation, because the kinetic models are continually being updated and validated. This person pointed out that the network of connections to the fundamental and applied combustion communities provides a technically rigorous and rapidly responding basis for mechanism development. Another commenter felt that this was an excellent approach to modeling, reducing models, and comparison to experimental results, and a third concurred that this was great work. The fourth person remarked that the approach has been logical throughout the years, explaining that the investigator has developed the basic building blocks for continually refining ignition chemistry in CI engines through careful additional of chosen specie classes that are deemed important in the various ignition stage processes. A different reviewer asserted that the focus on filling gaps in kinetic data/models that exist from key components in real fuels, such as methylalkanes and larger (C8) aromatics, is very relevant as well as validation against existing experimental data.

Another complimented the investigator on using several different types of machines to get the data needed to confirm the chemical kinetics models. The seventh reviewer mentioned that the approach is systematic and well-thought out, although the choice of iso-alkanes as the "next" functional group to study is not well explained. Another person was also critical on the investigator's priorities of fuels and requested more detail of reasons behind path chosen for research. This person questioned whether there were voids in the fuels database and suggested that the investigator determine which ones matter and why. The last reviewer summarized the approach mentioning that the investigator develops models of chemical kinetics of gasoline, diesel and advanced HCCI fuels, determines reduced models for efficient combustive flow simulation (CFS) models, uses the models to simulate advanced combustion concepts, and develops surrogates for gasoline.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted that there were several significant accomplishments, particularly in modeling chemical reactions, that have been made this year and that the extent of progress is commendable. Another person concurred that the progress seems good. The third commenter mentioned that significant results were reported with substantial improvement in model efficiency. Another reviewer felt that there was good progress in reducing the computational burden of first-principles combustion modeling. A reviewer asserted that the investigator has made really good progress toward more realistic fuel models. The sixth commenter acknowledged that the developments of this project are very valuable for achieving the goal of predictive simulation of engine combustion for current and future fuels. Specifically, this person pointed out that the investigator added mechanisms for methyl alkanes and substituted aromatics, and developed a new methodology for matching gasoline surrogate properties to real fuels through the negative temperature coefficient (NTC) behavior. The researcher also developed a new method for mechanism reduction based on functional groups in the molecules being simulated. This person concluded that the experimental comparisons of the new mechanisms look good for ignition behavior and for flame speeds in most cases. The seventh reviewer remarked that the posting of mechanisms on website useful and recognized the accomplishment of validating 2-methyl alkane mechanism. The last commenter said that each year this project continues to develop mechanisms that allow experimentalists to evaluate against their appropriate experiments and help the community decide which mechanisms are best. This person added that this is an evolving project and can really use additional experimental support for test/evaluation/validation of proposed new mechanisms.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw strong collaboration. The first reviewer acknowledged that the investigator has established a wide range of collaborations resulting in a good leveraging of effort to obtain new and extended results. Another person pointed out the collaboration with many groups through application of the models to prediction of experimental results and for validation and improvement of the kinetic mechanisms. This person also noted that the investigator participates in the DOE and industry supported working groups. The third commenter remarked that the experimental efforts with the University of California at San Diego and others are beneficial. A different reviewer asserted that there seems to be good collaboration and exchange of information with Sandia and some universities. This person observed that direct collaboration with industry seems to mainly consist of participation in some Coordinating Research Council activities such as Advanced Vehicle/Fuel/Lubricants Committee (AVFL-18) and any input obtained during presentations at semi-annual Advanced Engine Combustion MOU HCCI meetings. The fifth commenter felt that there is strong collaboration with SNL, Universities, and the combustion network in reducing and experimentally evaluating portions of the various developed kinetic mechanisms. Another person listed the researcher's coordination efforts that included MOU group of collaborators, John Dec at Sandia, various university collaborations, and the Fuels for Advanced Combustion Engines Group. The last reviewer noted that this work is used by most serious researchers in the field.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

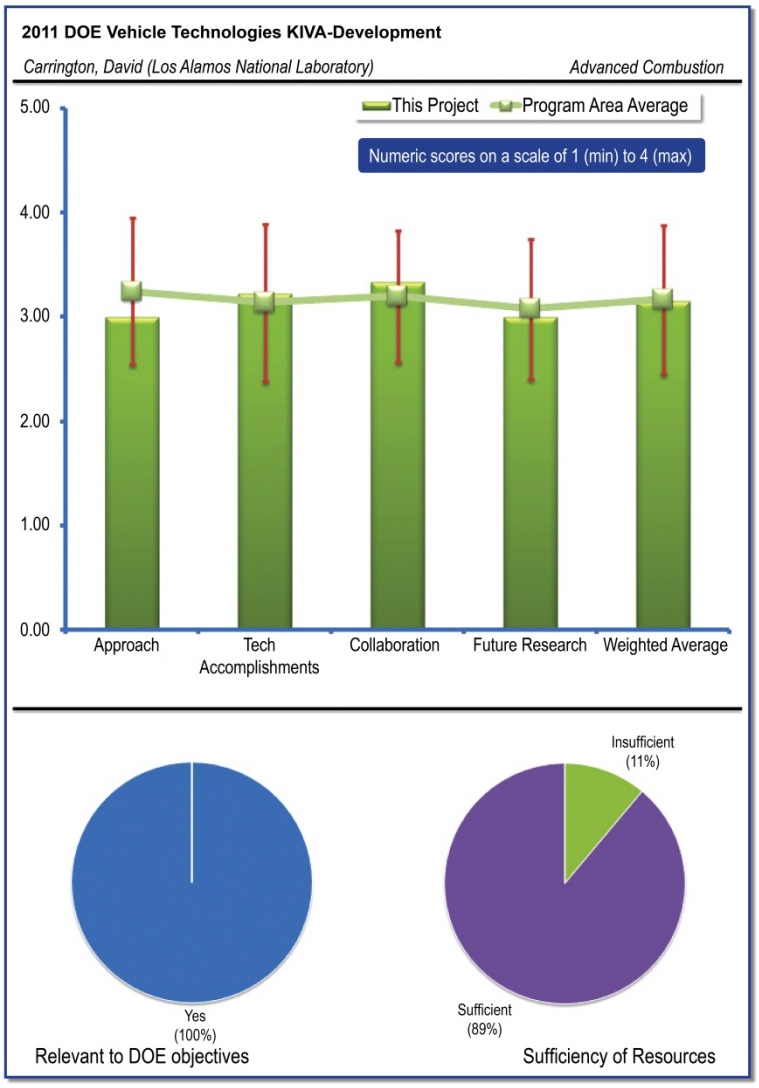
Listing the researcher's proposed work to perform validations on additional alkane structures, improve gasoline surrogates, and continue the functional group - mechanism reduction effort, the first reviewer felt that these efforts will continue to advance the ability to achieve predictive simulation of engine combustion. Another commenter concurred that the plans to validate mechanisms for the 2-

and 3-methyl alkanes and development of an improved gasoline surrogate are very worthwhile and build on accomplishments already made. A third person encouraged the investigator to continue the good progress. A recommendation from a different reviewer is to find partners to increase the current experimental efforts that further refine the proposed mechanisms. This person acknowledged that this is a challenge, but notes that it is a critical building block for engine developers. The fifth commenter would like a clearer picture of what is all in diesel fuel and gasoline relative to the fuels the investigator is doing reactions for and requested to know whether the project is 50% done, 10% done, etc. The last reviewer criticized that the motivation for next functional group to study is lacking.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers responded that the resources for the project were insufficient. One of these reviewers remarked that this work seems to yield a lot of knowledge for the small amount spent on it suggested to spend more to learn more faster. The other reviewer stated that this project needs additional experimental support to accelerate refinement of the proposed mechanisms such that engine developers will see a bigger benefit sooner versus later. Nine reviewers felt that the resources for the project were sufficient. One reviewer added that the funding seems to be about right. Another person requested to know from the investigator how more funding would be used, while at the same time asked what could be cut with less funding. A different commenter acknowledged that this was great work and questioned whether the scope or rate of progress be significantly increased if the budget were increased. Another reviewer pointed out that funding has been stable and increased slightly in 2011. This person felt that this is very good news given how important this work is to the entire engine/combustion community and also asserted that this program is a good candidate for additional funds because the impact is so great.

2011 DOE Vehicle Technologies KIVA-Development: Carrington, David (Los Alamos National Laboratory) – ace014



Reviewer Sample Size

This project had a total of nine reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that KIVA is a powerful tool for simulation of diesel combustion and contributes to diesel engine development. Responding directly to this question, which others only alluded to in their answers, this reviewer pointed out that higher efficiency engines can lead to petroleum displacement and that this tool can also shorten the design cycle. Another concurred, mentioning that KIVA is a powerful tool for engine simulation with upgrades and validation being helpful for improved predictive capability. A different commenter affirmed that KIVA is a needed tool and should be supported. This reviewer said that although it may not be widely used at the OEM level, KIVA is "required" at the university level as a way to empower students and professors to push the state of the art and improve the code. The fourth reviewer noted that the investigator seeks to improve understanding of combustion processes by modeling the spray, fuel-air mixing, fluid mechanics and chemical processes in the combustion process. This person went on to assert that the KIVA code is fairly widely used in the combustion community and applied to present and future combustion concepts. Another commenter expressed that KIVA has become the de-facto engine simulation code for CFD and chemical kinetics but it still requires significant effort to produce useful results for engine design. The sixth person pointed out that improved, faster, and easier to use combustion CFD methods are important to create better engine designs. The last reviewer appeared to reiterate the general opinion of the group by stating that KIVA is THE tool for engine simulations.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the approach seemed to be a bit ad-hoc or scattershot, although perhaps it is just not well-motivated. Another mentioned that it was difficult to assess/see the results and impact, so this person suggested that the investigator provide more examples. A different commenter stated that the researcher needs to incorporate engine related validation of model accuracy. Another reviewer recommended researching new numerical and grid methods and new algorithms for flexibility, adaptability, and stability. The last commenter noted that the investigator is building from the current KIVA platform by improving algorithms, adding capacity to simulate cylinder heat transfer, and improving grid generation. It was pointed out that the researcher used several improvement methodologies, the understanding of which is beyond the ability of this reviewer. This reviewer summarized that the efforts focus on improving accuracy and robustness of the algorithms, which are backed up by validation and verification. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first person affirmed that the investigator made good progress, but the direct application to engine simulation should be better enunciated. This commenter explained that the driven cavity flow, or flow over a backward facing step, is interesting from a computational fluid dynamics point of view, but not for engine designers and simulators. The second reviewer pointed out the addition of conjugate heat transfer proper step in making model more predictive, even though results are similar to baseline condition. This person also observed that the researcher effectively removed some of the tuning parameters and replaced them with physical inputs. Another commenter acknowledged that the investigator developed an hp-adaptive (higher-order polynomial approximation) process which provides more accurate and robust turbulent reactive flow modeling. This reviewer observed the following: a new algorithm characteristic-based split (CBS)-FEM method to replace the KIVA-4 advective approach was developed, which is very diffusive; concluded that some finite-element methods are better for fluid mechanics formulations compared to finite volume methods; and improved wall heat transfer under PCCI conditions with wall impingement. The fourth reviewer noted the improved algorithms in KIVA and continuing efforts on validation, as well as added conjugate heat transfer feature to improve consideration of wall film efforts to better simulate partially premixed combustion and improved adaptive meshing, which will shorten computation times and improve accuracy. This person suggested that for future Annual Merit Review presentations the presenter should include less of the fine detail and jargon in the main body of the talk, and leave much of that for the technical backup. Instead, it would be more effective to boil down the motivation and the approaches to levels that the non-numerical analysis members of the audience can better appreciate the motivation, approach and accomplishments. This point was reiterated by another reviewer who stated that it was very difficult to follow the presentation if not fully steeped in the detailed computational methods, so it would be better to include more practical impacts and results. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer observed a good array of collaborators, which shows that this is considered to be an important research area. Another commenter pointed out that this project included many collaborators, particularly at the University level, which more Vehicle Technology program projects should include. This person felt that this project is a model for broad university collaboration and an example of a program with more than just the University of Wisconsin and University of Michigan as university collaborators. Suggested to maintain working group, host workshops and support the code for thousands of users. A different reviewer specifically pointed out the Iowa State collaboration. The fourth commenter remarked that there seems to be good connection between this group developing the model framework and the community of KIVA users. Another reviewer acknowledged the collaborations with principal investigators at four universities, and a vast KIVA user community (thousands of users) that exists. This person suggested that a running tally of KIVA licenses and users should be presented every year so it is possible to get an idea of how widely the code is being used. The sixth commenter questioned why the University of Wisconsin was not a collaborator given their wide use of KIVA. This person also inquired as to whether any industrial users would be willing to become a collaborator. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the choice of emphasis of future work is not well motivated. This person pointed out that much work needs to be done, and then questioned where the time and effort should be spent and why. Another commenter asserted that a focus on reducing empiricism is a must and that it would be useful to see a list of all the assumed inputs and what is planned to replace them with physical quantities. A different reviewer commented on improving methodology for simulating moving boundaries to improve consideration of valve motion. This person mentioned that efforts will continue to increase robustness, permit simulations with higher resolution, and apply overset parts/grids. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer that felt the resources for the project are insufficient. This person pointed out that it was only partial funding in 2011, which is an impediment to successful collaboration and progress with this important tool. It was recommended that this project receive more funding if at all possible. The remaining eight reviewers responded that the resources for this project are sufficient. One of these reviewers said that the funding seems sufficient, but acknowledged that they are not an expert in this area. A different commenter wanted to know how many others are involved in the day to day KIVA development other than PI. Another reviewer questioned how this competes with commercial codes and how is it advancing the science over what is commercially available.

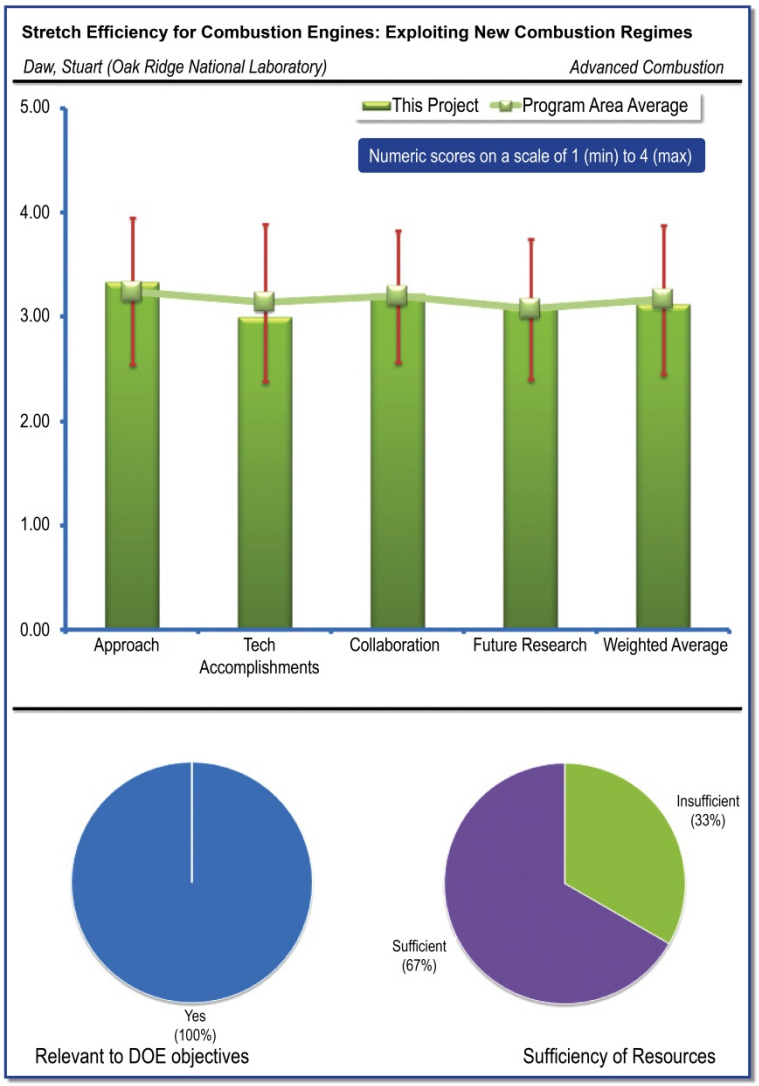
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Daw, Stuart (ORNL) – ace015

Reviewer Sample Size

This project had a total of nine reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project provides one of the strongest bases for data-driven decision-making that will guide future work on efficiency improvements. Another person affirmed that this project directly addresses DOE efficiency goals for ICE technology. It was pointed out by a different commenter that though to date this is a theoretical study, it is valuable in exploring the thermodynamic limits of what is possible concerning maximum possible engine efficiency. The fourth reviewer mentioned that this project probes potential for achieving maximum theoretical efficiencies in engines, and another said this effort is key to stretch efficiency objectives. A fifth commenter noted that it is always useful to determine what are feasible targets for long range efficiency objectives, because this can set limits on objectives. A different person felt this was an interesting analysis of possible future directions. The last reviewer was pleased to see that this work was performed by the national labs, where a very advanced conceptual study of this kind should be conducted.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer mentioned that the approach is fundamental and from a first-principles point of view, which is appropriate in this context. A second commenter remarked that the researcher has been methodically investigating the thermodynamic limit of peak engine efficiency through conducting workshops, seeking the counsel of various university experts, and investigating practical issues with theoretically pushing engine efficiency limits to 60% or higher. This person's only suggestion is to also include lean burn in future analysis in addition to stoichiometric. A different reviewer stated that this is an invaluable exercise in "blue sky" thinking and that this will eventually lead to more practical approaches to achieving next-level ICE efficiency gains. The fourth person affirmed that this is clearly out of the box thinking. However, this person felt that the investigator needs to consider the engine out emissions and also the energy available for operating emission control devices such as lean NOx traps and 3-way catalysts. Another reviewer also applauded the out-of-the box thinking. This person acknowledged that the thermodynamic analysis is thorough; however pumping and friction should be included in the analysis. Stating that maximum fuel efficiencies of 50-60% can be achieved, a sixth commenter remarked that this study focuses on why today's engines do not meet these theoretical efficiencies and pointed at ways in which to increase the efficiency of today's engines. This person commented that the approach is sound and involves consulting with experts, conducting colloquia, conducting analysis and modeling (I and II Law analysis), and considers heat and mass transfer along with chemical kinetics. A different reviewer said that the investigator used an excellent survey of experts in the field to further look at

new methods to approach maximum efficiency. An eighth person concurred that there was a nice combination of expert consultation and analysis. The last commenter felt that more description into brainstorming process would be helpful.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter felt there was good progress, but commented that areas of emphasis should be better motivated and explained. Another reviewer stated that the engine platforms and cycles considered are appropriate for the initial phase of study; however elements of this may be more appropriate for heavy duty engines. This person also mentioned that perhaps boost systems should be included to address potential power density loss in some advanced cycles. A different commenter remarked that is was good to see real thought on stretch goals but asserted that the researcher still has to put this in context of power density and packaging for mobile equipment. Solid progress was expressed by the fourth person. The fifth reviewer pointed out that this project has been a high output versus funding type of project that is exploring the limits on engine efficiency. This person suggested that it would be very helpful to include lean burn in any analysis and experimental efforts. The last commenter highlighted the investigator's progress on studying Thermochemical recuperation to capture waste exhaust heat to reform HC fuel into a syngas mixture which can be added back into the chamber to modify the combustion process and make it more efficient. It was also noted that gains in efficiency that could be made have been quantified. This reviewer pointed out that one finding that the investigator should capture is molar expansion pressure rise, since energy has to be captured in pressure form for it to be useable, and ultimately that is what moves the piston. This person also acknowledged that several publications have resulted from this work, chemical looping has been studied and the regenerative air preheating and thermochemical recuperation (RAPTR) and variable valve actuation (VVA) experiments continued.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted that the investigator has included the input from many engineers in universities, Industry, and the government, while at the same time chairing workshops that included the aforementioned partners. Another commenter also affirmed that collaboration exists with several universities and industries, involved in analytical and experimental aspects of the study. One reviewer stated that the collaboration on the project is outstanding for a forward-looking project such as this. A different reviewer acknowledged the investigator's good use of external experts, but felt that the range of these could be expanded. The last commenter observed that the collaboration is probably as much as the researcher can get out of other groups.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer suggested that future research should include alternative combustion cycles and not be limited to traditional piston motion. This person pointed out that if the intent is to see how far engine efficiency can be pushed, the investigator should not impose artificial limitations just because that is the way that engines have always been designed. Along these same lines, another commenter said that it would probably be useful to reconvene another expert seminar to look at new concepts. The third reviewer was unclear how relevant RAPTR is, and mentioned that the investigator should have more examples with correlations. A different commenter stated that the proposed research for the time and funding proposed is reasonable. This person noted that the focus of the work is almost exclusively on thermodynamic efficiency, and then questioned whether there is sufficient means in the testing proposed to differentiate the thermodynamic from the mechanical efficiency to fully evaluate the potential benefits. A fifth reviewer expressed that the investigator needs to account for mechanical efficiency and power density in the analysis. This person also pointed out that it would also be helpful to differentiate between light duty and heavy duty. The researcher commented that marine engines are in the 50%+ BTE range, which is true, but those are very low speed with big bore, and are more representative of heavy duty rather than light duty. This person advised the investigator to avoid the misconception that 60% BTE is likely or practical for a light duty application. The sixth commenter said that the proposed experimental work with more real world engine process analysis is a logical approach to further explore more practical efficiency limits of engines. This person suggested including lean burn in future work. Another reviewer asserted that the VVA experiments should be the main focus, since that could be a practical pathway to embody Thermochemical recuperation. The last reviewer commented that this is interesting work and worth doing.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Six of the reviewers responded that the resources for the project were sufficient. One added that the investigator should potentially collaborate with engine development activity. Another affirmed that the funding seems appropriate assuming it includes adequate proportions for experimental work with the VVA engine and the RAPTR device. Three other commenting reviewers felt that the resources were insufficient. One of these reviewers expressed that the level of funding is not adequate to support a significant amount of experimental effort. This reviewer pointed out that the return may be longer-term, but additional funding would be worthwhile. The second of these reviewers felt this would be worth more effort, while the last stated that it is a pretty small effort but perhaps appropriate for a low level program.

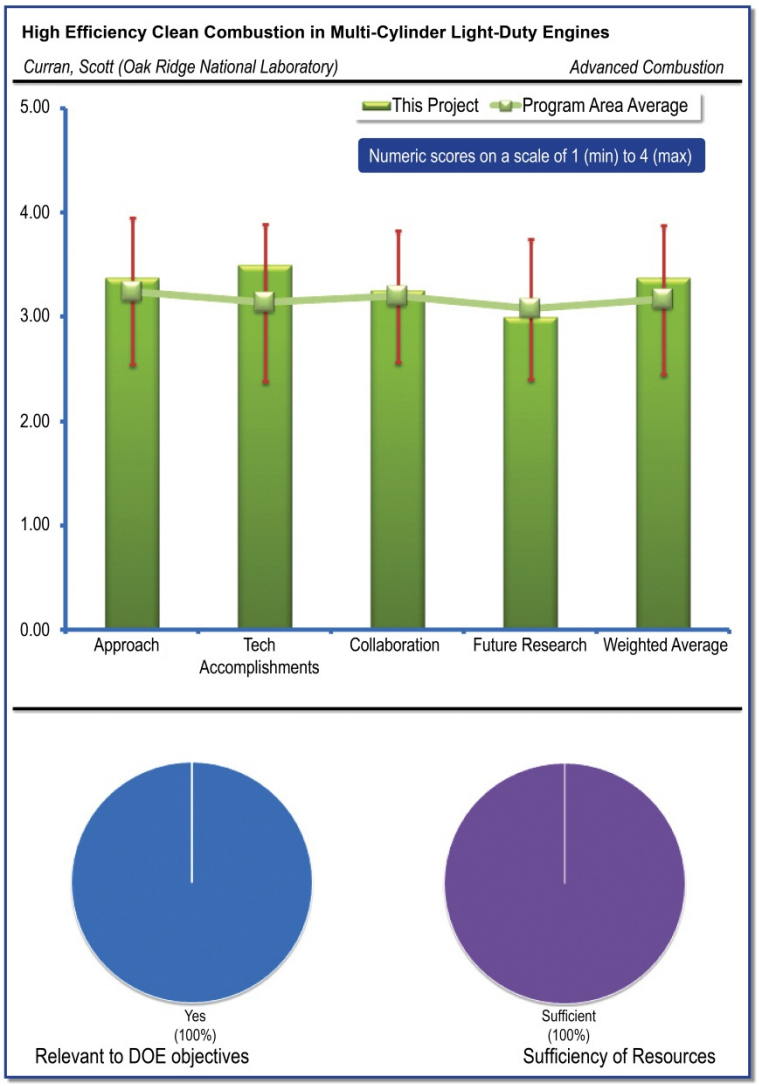
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Curran, Scott (Oak Ridge National Laboratory) – ace016

Reviewer Sample Size

This project had a total of eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One commenter asserted that achieving clean combustion with diesel equivalent efficiencies is consistent with DOE objectives. Another person stated that improving engine efficiency is a key requirement for the future. A reviewer noted that RCCI related high efficiency research is very relevant, while a different reviewer reiterated this same point by expressing that there is a definitely a need for RCCI evaluation on multi-cylinder complete engine. Another commenter acknowledged that this is a very good approach for achieving low fuel consumption, but pointed out that a combustion system of this nature is probably lower priority for light duty. The last person observed that this project seeks to demonstrate the potential of advanced high efficiency diesel and gasoline combustion concepts in a multi-cylinder setting.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt the approach is well thought out and comprehensive. Another stated that the comparison of RCCI to conventional Diesel is useful, while a third reviewer noted that fuel neutrality is an important piece. The fourth commenter remarked that the investigator had a good approach of combining modeling and "real" engine experiments to test feasibility of implementing advanced combustion on production-like engine hardware. A different reviewer concurred that it was great to have full engine RCCI data and that it will be interesting to see how this can be optimized. The sixth reviewer observed that this project was a good complement to RCCI research happening elsewhere. This person also affirmed that the production-like approach is important for understanding new roadblocks preventing mass implementation. A different commenter acknowledged that the approach taken to achieve low fuel consumption with appropriate emissions targets is very strong. However, this person pointed that the bar for light duty is set very high for achieving this with reasonable cost, reliability, NVH, and ease of refueling, in addition to other critical factors. Contrary to the other reviewers that felt the project was utilizing a “real” world model, this seventh person commented that if the goal is to make something commercially attractive for light duty, the project must in some way deal with issues such as eliminating the need for direct cylinder pressure sensing, mitigating the consumption of the secondary fuel and moderating the rate of heat release in the cylinder. The last reviewer highlighted aspects of the project’s approach that aimed to evaluate proposed advanced combustion concepts in multi-cylinder production-type engines to expose practical issues and evaluate the state of technology

readiness. Noting that experimentation is the focus of this project, this person said that combustion modeling, dynamic modeling, engine-system modeling, and vehicle system modeling are used to understand the results.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One commenter expressed that the experimental work is doing an excellent job of staying in front of the modeling work and expanding the useful range of RCCI combustion. This person also pointed out that exploring the emissions profile will be an important step to addressing the aftertreatment requirements that, by first indications, may potentially be quite unique. Another reviewer affirmed that the investigator was producing good progress and interesting results on testing of RCCI concept. A different person also acknowledged the project's robust results, but noted that the proper context of these forms of combustion should be described. This person explained that the correct new view of the gasoline-diesel spark ignition (SI)-LTC domain is more likely 2- or 3- dimensional, with fuel type, ignition type, and level of mixing as being the proper axes. One commenter stated that the overlay of PFI stoic Atkinson at 2000 RPM, 6 bar BMEP would be useful, and that this could potentially match Diesel BSFC. Another reviewer asserted that there were excellent results, but would like to see a direct comparison to indicated single cylinder efficiency at similar operating points with breakdown of differences. The last reviewer listed the investigator's progress, which included installing a diesel engine for the diesel work and a gasoline 2.0-liter LNF engine for the gasoline work. This reviewer noted that the multi-cylinder experiment is running points that the University of Wisconsin has run and modeled on the single cylinder. Also, FTP simulation points have been run by the investigator and RCCI operation has been demonstrated. This commenter observed the addition of ethanol permits operation with no EGR at higher loads. At the 2,000 rpm and 6 bar BMEP point, RCCI experiments were conducted to see if the University of Wisconsin's predicted BTE improvements of about 10% can be achieved. This person noted that no improvement in BTE is seen, but said that the researcher offered reasons for this that included the lack of multiple injection (fuel system goes unstable when attempting to inject small quantities of fuel) and high combustion instability for RCCI.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers provided a range of responses about collaborations. A commenter felt there was good collaboration with OEMs, suppliers and universities. Another person concurred that there was excellent collaboration exists with the University of Wisconsin, Bosch, Borg Warner, and the University of Michigan. A different reviewer questioned the level of collaboration provided by these partners. This person remarked that it was not clear if these were true collaborations, and hoped that it was not just a case of obtaining equipment from the OEM's and modeling data from the universities. The last commenter acknowledged that the level of collaboration is good, but pointed out that the project could really benefit from more collaboration with industry, particularly on the fuel injection strategies for extending RCCI.

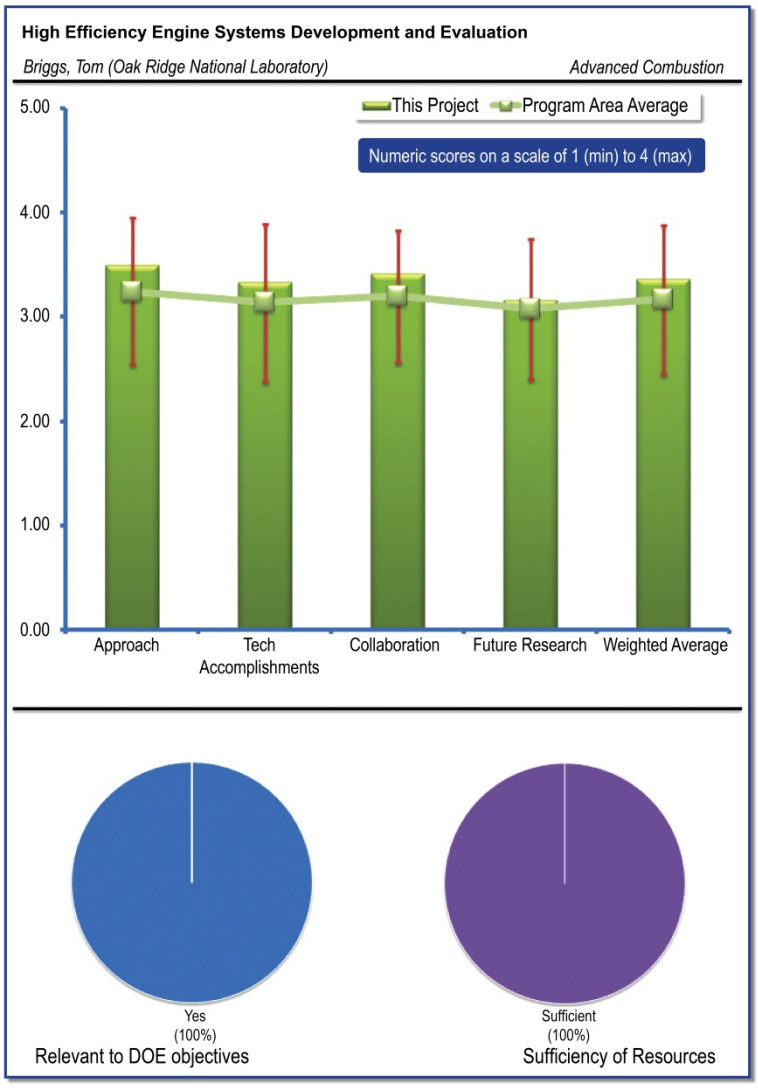
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the elements addressed are appropriate for achieving RCCI in a light-duty engine, but critical areas for commercialization in the light duty fleet must be identified and addressed. This person felt that input from OEMs would be very valuable. The fifth person commented that the plans seem reasonable. The third commenter strongly encouraged more research into the combustion stability issues for feedback control systems, while a fourth said that it would be useful to add transient development. A different reviewer criticized the research direction by questioning if it is driven by the hardware available rather than the other way around. The final reviewer pointed out that the investigators plans are to continue to demonstrate RCCI and high-dilution stoichiometric gasoline combustion by addressing the new barriers (fuel-system limitations, high coefficient of variation [COV], etc.) that have been unearthed. This person also reiterated the researcher's plan for FTP steady-state point emissions evaluation and fuel effects on RCCI combustion.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All seven reviewers responded that the resources for the project are sufficient. One reviewer commented that the level of funding is sufficient for the project goals at this time.

High Efficiency Engine Systems Development and Evaluation: Briggs, Tom (Oak Ridge National Laboratory) – ace017



Reviewer Sample Size

This project had a total of 12 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer said the project is an excellent example of a sound application of fundamental principles to guide technology selection in order to meet stretch efficiency targets. A second commenter noted direct demonstration of higher fuel economy, while another said the project directly supports DOE's goal of demonstrating 45% BTE by 2010. Similarly, another respondent said this project directly addresses the DOE goal by demonstrating key engine technologies in a more realistic, multicylinder setting. This reviewer added it directly supports efficiency goals, performance milestones, and Advanced Combustion and Emissions Control (ACEC) goal setting. Another reviewer commented that this is directly addressing DOE objectives through optimization of a metal engine for both part- and full-load thermal efficiency while meeting Tier 2 bin 5 emission standards and forecasting vehicle-level fuel economy performance through vehicle modeling efforts. One commenter said investigating the maximum potential of the efficiency of an engine-vehicle system is an important step in determining the petroleum reduction that can be achieved and at what cost of system complexity. Another said success in improving engine efficiency would result in improved fuel efficiency/economy and thus reduce fuel and petroleum requirements per vehicle. One person noted peak efficiency demonstration on diesel architecture, while another said hardware demonstration of DOE efficiency goals. One final reviewer said waste heat recovery offers potential for fuel savings.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section. One reviewer said the good selection of a wide-range map is useful to demonstrate trends versus single points. Another said excellent use of thermodynamic analysis to guide the selection of technology and to help create a stationary target, and a basis for comparing benefits. A third respondent said good approach of using modeling and experiments to determine and improve efficiencies at road-load conditions relevant to actual engine platforms. Another reviewer said very well planned project approach, including engine experiments for developing portions of the engine map, engine system modeling for assessing first- and second-law energy distribution and losses, vehicle modeling for assessing near real world behavior of the high efficiency clean combustion (HECC) engine, and bottoming cycle modeling for assessing potential engine efficiency gains. This approach allows for a high output-to-funding ratio from an engine and vehicle system perspective. One reviewer said the investigations and demonstrations are conducted on a multicylinder basis with practical intake and exhaust systems, fuel systems (including turbo charging), etc. This person added that experiments are supported by GT-POWER modeling and second-law analysis

is also conducted. Another commenter said nice lab demonstration of theoretical possibilities. This reviewer would also like to see more consideration of powertrain matching issues: downsize/down-speed opportunities to get closer to the actual peak efficiency. Another reviewer likes the analytical approach of looking at availability and finding all the sources where one can get energy. However, this reviewer adds, the organic Rankine cycle (ORC) system is not very practical at the low loads. One person said good work, but this looks like a very expensive system for the road load output. Another respondent said the second-law analysis is appropriate. It is difficult to interpret the energy breakdown to see the remaining opportunity. The ORC approach may lend itself to heavy-duty (HD) applications. The LD cycle will have limited opportunity. One final reviewer said one of the fundamental problems of waste heat recovery (WHR) as implemented here is that the ORC system has its highest energy recovery (and hence contributes most to the overall system efficiency) when the engine load is highest. However, this leads to significantly lower recovery at low road loads, where the engine efficiency needs to be boosted most. This reviewer added that this is not addressed in this project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. One reviewer noted that the group had achieved the milestone of 45% BTE, while another commented good results and added that the project should focus design and analysis on road load cycle. A third commenter said nice work in the lab and models. Another person said good results with what the researcher has done. The presentation showed all the faults along with all the benefits: a good, balanced story. One respondent noted that the DOE and ACEC goal of 45% peak brake thermal efficiency was met. This was obtained by adding an Organic Rankine Cycle for converting exhaust energy into electric energy through a turbine/generator. This reviewer added that several models of alternate configurations have been completed, and noted simulated UDDS and US06 cycle performance. Another person said that this is a great project that explores what might be possible for HECC light-duty diesels for increasing engine thermal efficiency and vehicle fuel economy while meeting Tier 2 bin 5. In particular, it points towards the limit of WHR toward improving engine efficiency and vehicle fuel economy, and also the limit of turbo-compounding on improving light-duty engine thermal efficiency. One reviewer asked if there is a means to assess the impact on aftertreatment temperatures. Another commented: 45% BTE demonstrated at 2250 RPM, 18 bar BMEP. This person added that it may be useful to compare to other production diesels (advertised), as well as lower CR to minimize friction; a graphic to emphasize the very small net yield status from ORC would be useful. One respondent said the demonstration of the WHR is impressive, yet does not include a few key elements; the global warming potential (GWP) of the ORC working fluid (R245fa) is very high, and an alternative would be needed to satisfy GHG emissions targets. Energy storage would also need to be addressed to determine the true incremental benefit. Another commented that the system is oversized – we know how ORC systems work, and that they do work, but sizing is critical. This was not performed here. One final reviewer likes this project, in that it is the only one which has provided multi-cylinder data demonstrating the 45% BTE goal; however, the rate of progress this year seems to have slowed significantly, and does not reflect the funding level.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive in this section. One reviewer said that the collaboration for a project at this stage of development is outstanding, and is promising for the future success. Another said good collaboration and consulting relationships exist with key suppliers like Barber-Nichols, Borg Warner, GT-POWER, and Cummins. A third reviewer commented that this project has included partnering with a turbo manufacturer and an engine OEM interested in the bottoming cycle of this effort and another OEM provided engine set-up support. One person noted that there seems to be collaboration with ACEC Technology team plus interactions (but not necessarily complete collaboration) with several companies on specific components. Another reviewer suggested that it would be nice to have closer industrial support at the system level.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments were mixed in this section. The first reviewer said this seems to be appropriate and build on previous work. Another commented that the proposed future research focus includes air system options that enable RCCI and highly premixed combustion, the exploration of RCCI and highly premixed combustion in light duty diesels, and second-law analysis. Based on other presentations and

other work sponsored by DOE, this is a sound plan that can further peel back the possibility of using these advanced combustion modes for improving real world type light duty diesel engine efficiency versus single cylinder engines. A third reviewer indicated that logical evaluations of RCCI and PCCI advanced combustion concepts are planned, adding that this will provide valuable, and more real-world, demonstrations of these advanced concepts on a multicylinder platform. Planned second-law analysis will help ACEC in its engine-efficiency goal-setting objectives. One respondent said the area of concentration is of critical importance to the development of efficient, turbocharged/downsized engine platforms. This person asked, to what extent can low heat rejection concepts and variable exhaust valve timing be combined with the test engine to improve the performance of future prototype exhaust energy recovery systems? Another respondent said good work planned, but suggested the researcher please consider downsize/downspeed opportunities while considering transient drive requirements. One person felt that it was not clear if the series sequential boost system will help peak efficiency region with typical match; what are the plans to size components to optimize the system in this area? One commenter queried whether we need yet another demonstration of WHR through ORC. This person added we know that it works, but sizing and duty-cycle-specific implementation is the most important unknown (unless the project goal is to develop new hardware for LD applications, which it does not seem to be). Another person said it is not clear that working with LTC makes sense, adding that this will only lower exhaust temperature. It is better to focus on optimizing for conventional diesel. One respondent said that the future plans lack detail, while one final commenter indicated a lot of nice words, but not a lot of substance.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All twelve respondents said sufficient. One reviewer said about right, while another said funding in the last two years seems commensurate with this effort and appears to have tracked the experimental portions of this effort. A third respondent said this project needs to be re-evaluated to determine whether we need yet another demonstration of what we already know; namely, that there is a large amount of waste heat in the exhaust, EGR, and coolant of any engine, but it is extremely difficult to recover under partial-load conditions. Another reviewer said the funding is sufficient for the present stage of the project, but clearly more resources could be justified for future work. One final respondent said hopefully the progress picks up to match the funding.

A University Consortium on Efficient and High-Pressure, Lean Burn (HPLB) Engines: Assanis, Dennis (University of Michigan) – ace019

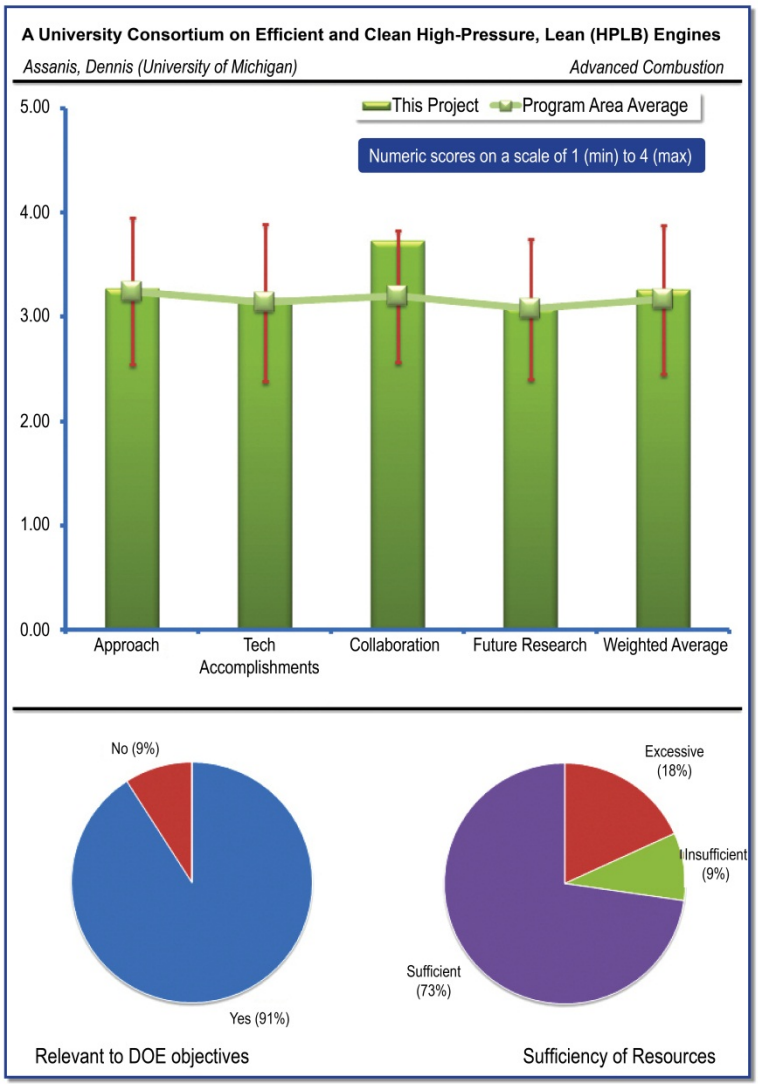
Reviewer Sample Size

This project had a total of 11 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer said high-efficiency LD engines will facilitate petroleum reduction once implemented, while another said advanced high-efficiency clean combustion can directly lead to the displacement of petroleum. A third respondent agreed, stating that success in improving engine efficiency would reduce fuel and thus petroleum consumption. One person said the project investigates advanced light-duty gasoline combustion concepts with an aim to improve understanding. Another reviewer indicated significant study to pull many aspects of combustion together. One final reviewer was less favorable, stating the work seems redundant to other work and without a clearly defined path to a specific goal.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?



Comments tended to be positive in this section, though a few reviewers did express some suggestions and reservations. One person said nice modeling plus experimental approach, while another reviewer noted a good combination of engine experiments, simulation, and modeling. A third respondent indicated a great use of many tools and capabilities available within different facilities. Another reviewer stated the group is targeting improvements in light duty gasoline engines to achieve 45% peak engine efficiency. This reviewer added that, to achieve this, they are exploring lean burn, high pressure, multi-mode combustion, enabled by sophisticated engine configuration and control. They are linking simulation and experimental studies at various scales (rapid compression machine [RCM] and engine). One reviewer observed an impressive array of research, but added it was unclear how it ties together or complements each other. One person emphasized the systematic and integrated approach, adding solid competency is exhibited in the approach, and in the results. Multi-faceted approach, covering the bases, and capitalizing on individual entities' core strength. This is perhaps one of the most proficient and well-rounded combustion and engine programs under the OVT umbrella, which should advance the state-of-the-art of the technology and bear good fruits! Another respondent remarked the approach seems to be a wide range of sub-tasks that are loosely linked to the project goal – we understand that spark-assisted compression ignition has the potential to improve fuel efficiency through extending the lean limit, but why the development of the microwave ignition device? What about laser-based ignition, or more conventional approaches? The reviewer added this project seems to be a catch-all project funding interesting sub-tasks that the PIs were interested in pursuing anyway. One reviewer commented the approach seems to include everything but the kitchen sink. There are various combustion strategies from HCCI, spark assisted compression ignition (SACI), and high-dilution stoichiometric SI, at various physical locations like UM, Massachusetts Institute of Technology (MIT), University of

California-Berkeley, and various labs within UM, such as the optical engine, diesel engine, fully flexible valve actuation (FFVA) camless engine, and the rapid compression facility (RCF) are being engaged in what seems like a shot-gun approach. There does not seem evident a master integration of all the work going on. This reviewer added the concern is that at the end of the day we have elements and subsets of various combustion issues that do not integrate well to meet the objectives of demonstrating a high-efficiency gasoline engine that meets the objectives. The final respondent felt the basic analysis to support the project is flawed because of the erroneous assumptions of combustion phasing and burn rate being constant. Task 1, though the basic combustion tenet of the project, completely ignores the realities of combustion; it is completely unreasonable to assume a CA50 of 10 degrees can be achieved at 12:1 CR, phi=1, and 3 bar inlet pressure.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. One reviewer indicated the program seems on track, while another commented numerous accomplishments within the individual facilities, labs, and institutions have been accomplished. A third reviewer said the program advanced the understanding of the HPLB technology on many fronts, and also advanced experimental and simulation techniques, acquired new findings, and identified logical next steps. This reviewer also noted the excellent managerial skills of the PI, as he navigates multi-institutions and complex work tasks, then weave them into a cohesive fabric. Clear presentation and well laid out graphs. Another respondent noted thermodynamic analyses have been completed that confirm the benefits of high pressure and lean burn, setting potential targets to achieve experimentally. The program incorporated GT-POWER analyses in vehicle cycle calculations to show overall potential gains of 50% with dilution, boosting, and downsizing. There has been continued progress on the use of stratification and SACI (multi-mode) combustion. Also, the program is investigating novel spark strategies to extend the lean limit. One reviewer asked how SACI compares to HCCI and lean-SI for NVH and ISFC. Another reviewer commented the technical accomplishments seem scattered and diffuse. Will they be brought together in the final half of the project? Another person agreed, stating many good results, but that it was difficult to see how it will tie together. One respondent commented that the project could benefit from some clear goals. One final reviewer indicated stratified HCCI seems like a poor choice of words. How does this compare or compliment other similar efforts in this area? For the RCM work, what octane and how do its results compare to other published work? Regarding the NOx standard… which one? Please specify next time. This reviewer felt it was not clear how SACI combustion was achieved. What was the charge air temperature, and is it reasonable? This reviewer added that it was not clear what the new and novel contribution was regarding the flame speed correlate.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive in this section. One person noted it was great to see such wide collaboration, while another said excellent collaboration. A third reviewer said there is strong industry and national lab involvement and support for the program, noting the consortium with MIT and University of California-Berkeley to broaden experimental facilities capabilities. An impressive overall team. Another respondent remarked the consortium enables collaborations of the three universities with each other and with several energy companies and automakers. One reviewer said good collaboration, although to date each institution seems to be following its own path. Presumably these disparate results will be brought together at the end. Another person simply said see prior comments. One final reviewer noted the collaboration is extensive; however, the integration of knowledge gained is a concern.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers offered a number of comments and suggestions in this section. One person commented the planned work will advance all the program goals, adding that, for each task, the future work is well thought out and should continue to advance the knowledge base. Another reviewer stated the plans seem appropriate. One respondent emphasized the need for a strong focus on task 1 to create the design for utilizing results and various mechanisms. Another stated that, in order for each facility and lab to better contribute, a common pathway to achieving the objectives should be clearly communicated. A fifth reviewer indicated expanding the range of test fuels will be critical work. Another person indicated the program should (1) keep the overall system demonstration in focus, and develop a clear pathway and its associated validation plan, and (2) develop a combined (simulation plus testing) process of elimination

to narrow down the variables and parameters, in order to converge on item (1). One reviewer remarked that it needs to be described how all of these disparate sub-tasks will be drawn together to reach the final goals. One final reviewer asked how the program will choose and organize tasks towards the 45% BTE goal. This reviewer said it was not clear. This person added that HCCI and SACI ~ 6 bar net mean effective pressure (NMEP is far below the identified 12-18 bar BMEP region shown for peak BTE.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Eight reviewers said sufficient, two said excessive, and one said insufficient. The first reviewer said good investment! The other respondent said the funding is only partial in the current fiscal year. This makes progress on programs very difficult and is incompatible with graduate student-focused research. This reviewer added DOE should not do this to university programs.

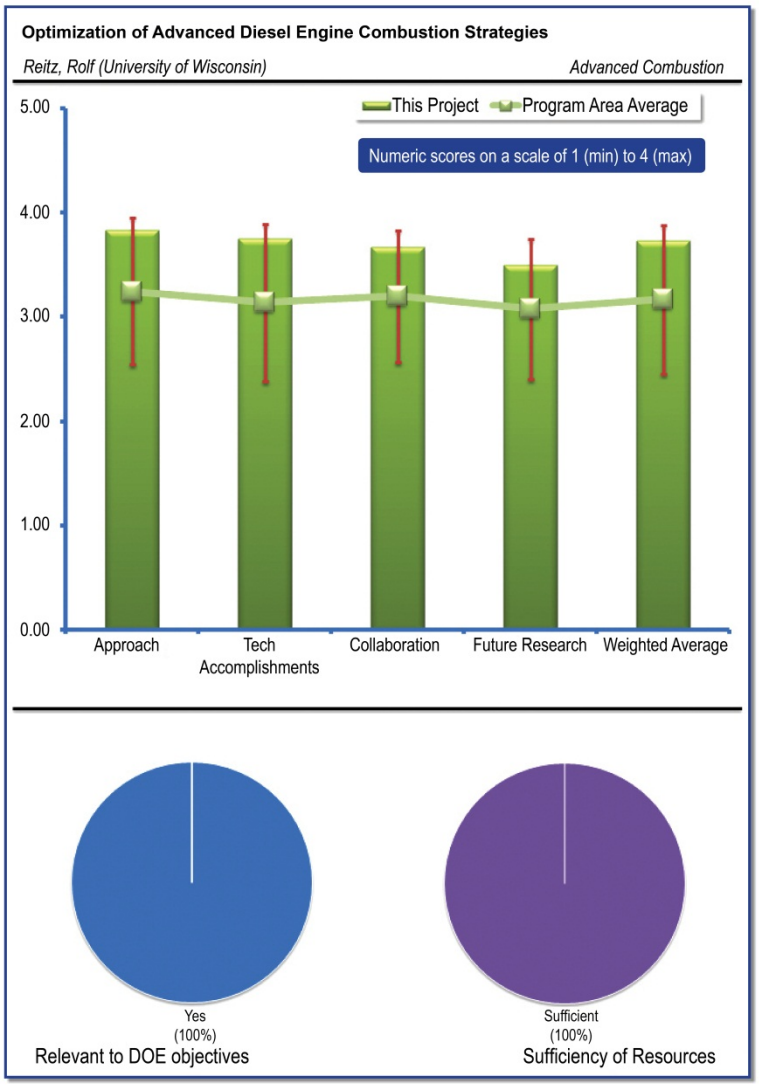
Optimization of Advanced Diesel Engine Combustion Strategies: Reitz, Rolf (University of Wisconsin) – ace020

Reviewer Sample Size

This project had a total of 12 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer indicated improved fuel efficiency is a requirement for the future, and added that this project has the potential for significant reductions in fuel usage. Another reviewer indicated top quality work directly demonstrating high efficiency in IC engines. A third respondent said achieving practical 55% BTE HD engines will lead to significant fuel savings and the potential to displace petroleum. Another reviewer agreed, saying the focus is on improving engine and fuel efficiency where success would translate into lower fuel and thus petroleum consumption. Another person remarked leading work in RCCI combustion is very useful to explore potential efficiency benefits. The final reviewer indicated the program addresses the challenges of increasing diesel engine efficiency via LTC while minimizing emissions.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments tended to be positive in this section. One reviewer commented the approach is comprehensive but seems to be well-arranged and justified. Another person said excellent approach of investigating engine design, fuel properties, and operation strategies and using analytical, modeling, and experimental tools. A third reviewer said pioneering work on high-efficiency engines, adding that a broad range of tools and methods is used effectively. One person, similarly, noted an excellent mix of simulation models and experimental results leading to model improvements and good test results. Another reviewer very much applauds the mixed simulation and experimental approach. One respondent noted the program is combining simulating and experimental studies in advanced combustion, considering PCCI and dual fuel combustion operation, and includes combustion and in-cylinder visualization, coupled to predictive modeling. Another person remarked use high-fidelity computing and engine experiments to design a new engine combustion system based on PCCI and RCCI combustion concepts. One reviewer felt there needs to be more focus on achieving brake efficiency, and **added that the focus on gross indicated efficiency obscures the problems with gas management at high** EGR rates. The final reviewer noted the comprehensive suite of research, but added that it was unclear how it ties together to deliver DOE objectives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally positive in this section. One reviewer said very good progress in a number of different areas, while another stated very good results demonstrated. Another simply wrote great work. A fourth reviewer noted a wide range of achievements, where the most important is the improvement of brake thermal efficiency through the judicious use of dual fuel reactivity controlled combustion. Another respondent said very good progress, too numerous to comment on here, has been made towards objectives. One person felt the work with RCCI dual fuels is of great interest to industry. One reviewer noted the work includes hardware studies, fundamental experimental and numerical methods development, and a broad scale of studies. This program has already demonstrated significant accomplishments, with the results from the "RCCI" combustion having created worldwide interest in this process and its potential. Rarely does an engine and fuels research project stimulate such interest. This reviewer added this is a credit to the innovative and comprehensive approach of the investigators. Another respondent said excellent work on striving to meet emissions regulations engine out with novel approaches, and added that it is difficult to get a final picture of what is all needed on a final multicylinder engine to achieve all this. One final reviewer noted the interesting explanation as to the rationale behind the two diesel injections on the RCCI engine (first injection in the squish region, second one in the piston bowl).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive in this section. One reviewer noted the wide range of collaborations, including OEMs, suppliers, and national labs. This reviewer also indicated very good technology transfer activities. A second reviewer commented strong industrial involvement and support, while a third remarked a good example of how to do it. Another respondent said good collaboration exists with Sandia, GM, and the 24-member DERC consortium. One final reviewer indicated the primary, most frequent collaboration appears to be with Sandia and GM, adding that collaboration with members of the UW DERC were also mentioned, although at least the formal interactions are much less frequent.

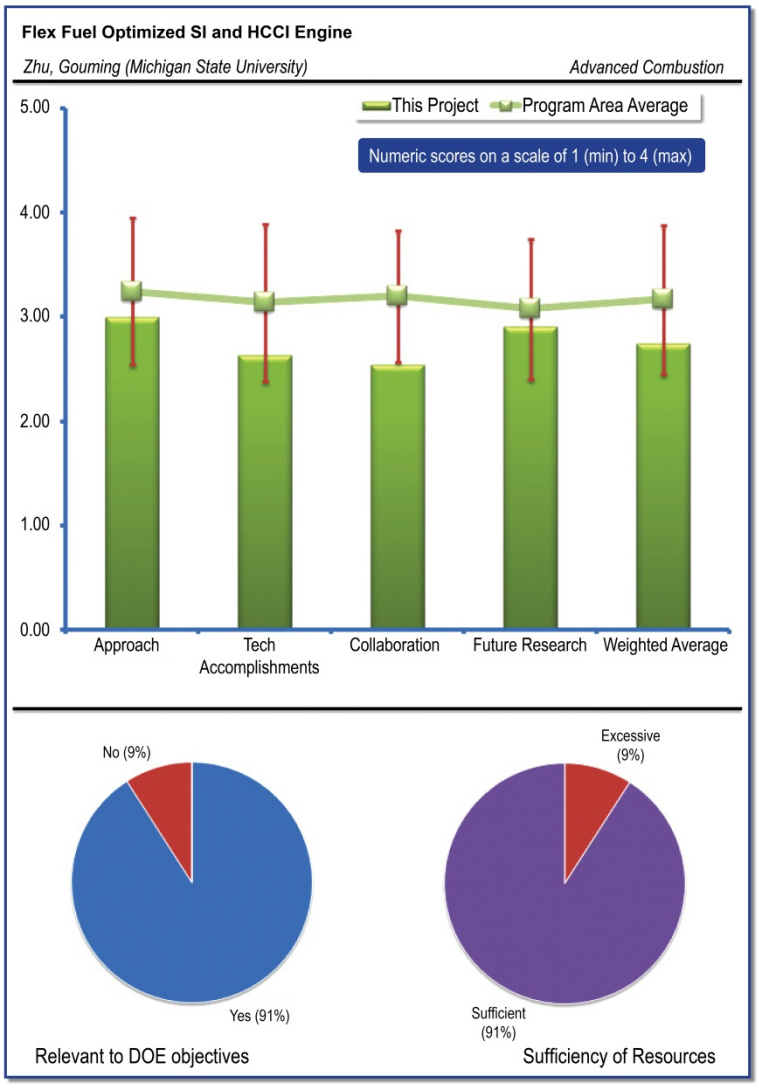
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments and suggestions were generally positive in this section. One reviewer said plans look good, while another commented the plans proposed for each task build on past progress and remain focused on meeting objectives. A third reviewer noted an ambitious set of goals, although a large amount has already been achieved. This reviewer added the control of RCCI under transient operation will be a substantial task. A fourth respondent indicated future research will expand the range of operation of these advanced combustion modes and continue kinetic mechanism and simulation capabilities. This reviewer added that significant observations should arise from the planned work on all the tasks. One reviewer indicated that many results are presented on a gross peak efficiency basis. Changes in efficiency are shown for variables that impact mechanical efficiency (such as fuel pressure and real boosting systems), but with no accounting for the parasitic load. This reviewer added it would be nice to include in the analysis, and provide an estimated BTE with the list of assumptions. Another reviewer noted the focus on transient is important. Also, the future research needs more focus on complete engine development and evaluation. One final reviewer would like to see some thought toward total vehicle operation including cold starts. How will you meet emissions in LD cycles where cold start makes most of the emissions? How do you run engine idle and other very light mode conditions?

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All twelve reviewers said sufficient. One reviewer indicated solid funding for a major project, while the other respondent in this section said the funding is stable and sufficient to support a strong program.

Flex Fuel Optimized SI and HCCI Engine: Zhu, Gouming (Michigan State University) – ace021



Reviewer Sample Size

This project had a total of eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were slightly mixed in this section, but generally positive. The first person indicated the objective to enable advanced SI and HCCI combustion can provide increased efficiency and use of E85 can displace petroleum directly. Another reviewer said the program is developing a method to transition from SI to HCCI, which is a more efficient mode of operation. A third person commented the controls for LTC are important for transitioning LTC from research to production environment. Another reviewer said the group looks at some practical aspects of mixed mode systems. One person remarked the research addresses barriers for HCCI by developing model-based controls for controlling mode transitions between SI and HCCI combustion modes, while another said control strategies are needed for transient operation between SI and HCCI modes to allow effective operation. One reviewer said exact relevance of this project is obscure. Another commented not specifically mentioned, and added that presumably the answer is yes if one realized outcome of successful development of their transition control schemes between SI and HCCI is fuel economy improvement and/or enables use of higher concentration ethanol blends. The final reviewer did not know, and added that this project is focusing on transitioning between SI and HCCI combustion. This reviewer felt there was no discussion on target efficiency or vehicle fuel economy gains, and asked if this is the big picture or if the use of E85 in SI engines is.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were mixed in this section. One person said the combination of modeling and optical and metal engine tests seems appropriate, while another indicated good work with practical hardware. A third reviewer commented demonstrating a dual mode SI and HCCI combustion operations scheme for a blend of gasoline and E85 is a sharply focused research area that is needed for flex-fuel vehicles (FFVs). Another commenter said good combination of modeling and experimental, and added that the group needs to be sure the results are not engine specific and can be applied generically. One respondent stated the group is using simulation and engine/valve control to achieve robust control of a SI-HCCI combustion engine, including operation on E85, and includes metal and single-cylinder engine approaches, including optical access engine. Another reviewer stated very large-scale project. How to scale back in hardware commissioning is difficult? One person said solid approach. Perhaps it was done but not presented how you came to select the combination of hardware and strategy – is it optimal? Another reviewer felt the goals are worthy but the approach is diffuse, and asked why a new controller (hardware) needed to be developed when off-the-shelf items are available. One reviewer remarked this project does not seem to have a pathway to first of all design and fabricate an HCCI engine. This reviewer added that the real-time control system and hybrid combustion model to study SI to HCCI combustion mode transitions seems to have progressed ahead of the

base HCCI engine. The final reviewer noted the PI appears to have put a lot of faith in the ability of GT-POWER to model combustion well under SI and HCCI conditions. This reviewer's experience has been that such zero-dimensional models are highly empirical and yield accurate or inaccurate results based on the engine and various boundary conditions. This reviewer is not confident in this approach until the PI generates real world data. Otherwise, the general approach seems reasonable from a controls perspective.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers expressed a number of reservations in this section. One commenter stated solid accomplishment to get this much working, but added there is still some way to go. The second reviewer thinks the control strategy is the useful part of this. Another reviewer was wondering if there was research into prior art of doing these transitions, and asked if some engines are doing this today. A fourth reviewer commented the simulation task is developing a combustion model and validating against GT-POWER, and the model will be used in hardware in the loop (HIL) for model-based control development. The model validation was successful. The group completed optical engine development, and completed an injector spray bench. They are continuing to work on engine system development, but completed development of the electrical cam phasing system and made progress on the engine controller interface. The group also performed simulations on transitions from SI to HCCI mode operations to determine control response requirements. Another reviewer commented the bulk of the technical accomplishments are in the future, and added that the PI still has to commission a new engine that can handle such mode transition combustion excursions. It appears much effort was spent just studying control laws and simulating what might be possible from a transition control perspective. One person felt the progress is very slow and a lot of effort has been expended on engine hardware that has taken too much time to develop and perfect. Another commenter said good results from modeling but very little experimental. It seems a challenge to complete this essential work within budget and timeline. This reviewer added that it is not clear that emissions during the transition phase can be ignored. One final reviewer indicated a 2-step valve and electrical cam-phasing has been installed on the Chrysler engine, and an optical engine has been fabricated. This reviewer's concern is meeting deadlines for experimental objectives, i.e., demonstrating model evaluation on the Chrysler engine and the single cylinder optical engine operation, etc. It seems like the base engine for HCCI operation has to be developed from scratch for both gasoline and E85 operation. This reviewer added that it seems like at the moment there is no HCCI engine to calibrate and validate all the model and control system development work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were similar in this section, focusing on the partnership with Chrysler. One reviewer noted the significant involvement of Chrysler, with hardware support, while another commented on the close partnership with one OEM. A third reviewer said this project is strongly partnered with a light duty vehicle OEM. Are there any other partners that could aid the PI in better understanding how combustion transitions from SI to HCCI? One person commented small group of collaborators, while another noted there appears to be the single collaborator of Chrysler (i.e., collaborations, especially with industry, are somewhat less than other programs). One final reviewer remarked the only partner is Chrysler, who is supplying engine hardware for a basic homogenous-charge engine. It seems like work has to start fresh to convert this engine to operate properly in the HCCI mode over a typical operating range. So far, no work has been reported on this front, but the control system has progressed well along. It seems like the cart is before the horse.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

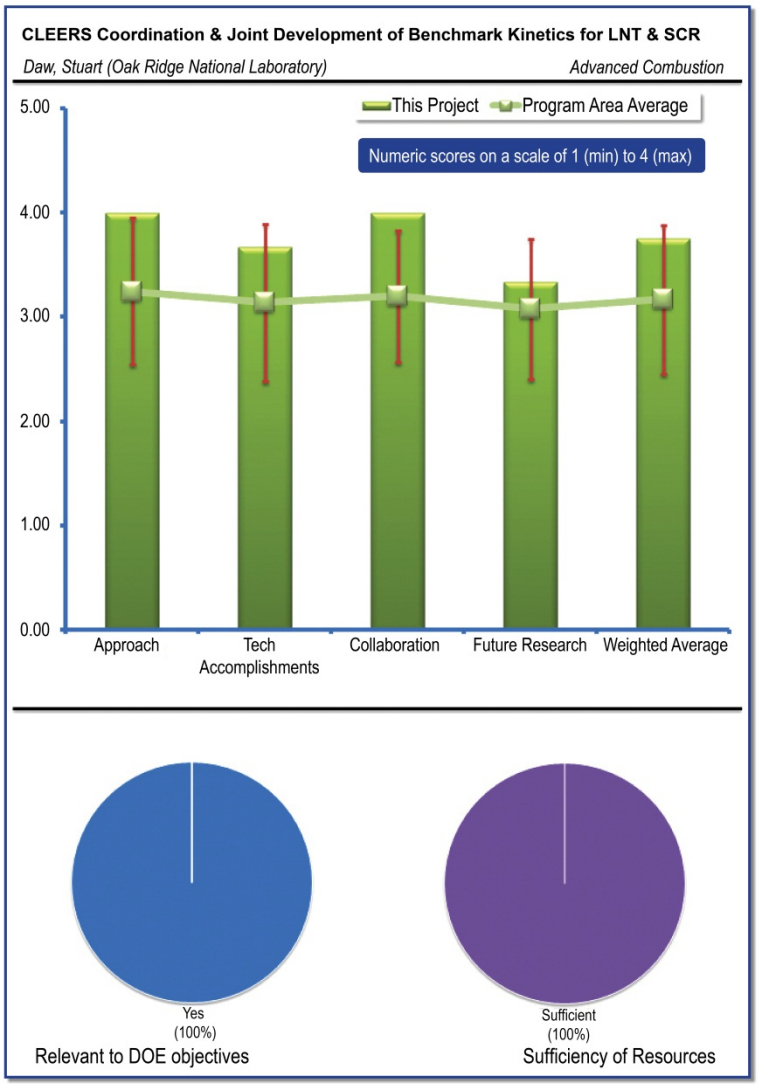
Reviewers offered a number of suggestions in this section. One reviewer said good plan, but a lot to do yet. Another commented that much work needs to be done to make this expenditure worthwhile. A third reviewer said to complete engine control integration and validate the engine control strategy in the single-cylinder engine and then in the multi-cylinder engine. Another person indicated it seems to be useful work planned. However, for LD systems this reviewer thinks the group needs to address cold start issues and overall emission control needs. How much HCCI will you be able to run? If practical constraints and cold start force aftertreatment and conventional combustion, do you gain enough to be worthwhile? A fifth reviewer said definitely need to get some data from the engine to validate models. One person commented, overall, a good approach, and added that this next year might call for some possible multi-dimensional combustion mode transition modeling to aid the PI in understanding the physics of how to most optimally

transition from SI to HCCI combustion modes. One final reviewer suggested partnerships with institutions that have the know-how to design and fabricate a state-of-the-art HCCI engine should be pursued to speed up the project instead of reinventing the wheel.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Ten reviewers said sufficient, while one said excessive. Comments were mixed in this section. One reviewer noted a large budget compared to the results achieved to date, while a second said the resources seem appropriate. The final reviewer remarked the funding level is sufficient, but the large dip in FY11 is problematic. This reviewer added that this creates significant difficulties with graduate student-based research, and DOE should insulate its university programs from these funding fluctuations.

CLEERS Coordination & Joint Development of Benchmark Kinetics for Lean NOx Trap (LNT) & SCR: Daw, Stuart (Oak Ridge National Laboratory) – ace022



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer commented aftertreatment technology is a key enabler for many combustion strategies that offer the potential for enhanced fuel economy, adding that fundamentals associated with their application are key to the development of improved performance and durability, as well as laying the groundwork for their cost reduction. A second reviewer said developing reactor protocols for the LNT and SCR catalysts is a major contribution to the industry. This is clearly pre-competitive and allows the industrial participants to be able to concur on the correct measurement conditions that are necessary to use to develop reaction kinetics for these production catalysts. One final reviewer stated that particularly the SCR aftertreatment system can allow the engine to run with better fuel economy, where it makes more NOx. The activity of an excellent SCR catalyst is needed to make this possible, so this research is very relevant for NOx. This final reviewer added that the unique distribution of results via the cross-cut lean exhaust emission reduction simulation (CLEERS) conference and the web seminars is an excellent way to let many know what is going on in new areas and then make use of them.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section. One person remarked the CLEERS program serves as an excellent forum for drawing specialists in the aftertreatment area together to share knowledge related to catalyst mechanisms for reaction and deactivation. This knowledge, in turn, provides the basis for the development of robust kinetic models. Key to the development of these models is the availability of suitable kinetic data covering the relevant chemical processes. Each of these activities is addressed well in this program. Additionally, the CLEERS group itself queries its stakeholders on a regular basis to help ensure that the approaches and directions are consistent with industry needs. A second reviewer stated the workshops and focus group calls provide an outstanding method for the competitive companies to discuss pre-competitive issues. This reviewer added that developing reactor protocols is an activity that would not be undertaken by the industrial partners. These protocols have been used by industry to evaluate catalysts of interest to them. These protocols are in use to develop kinetics for aftertreatment emissions predictions. This reviewer commented that it is hard to believe that this crucial work would be done under any other forum. One final respondent agreed, noting that the range of techniques used is extensive and difficult to improve upon. One method that is not too common, but useful, is SSITKA, or Steady

State Isotopic Transient Kinetic Analysis. It can provide information on how the coverage of an adsorbed reactant changes in steady-state conditions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One respondent observed the accomplishments and progress appear to be in line with the project plans, while a second person stated that the technical results on how ammonia and nitrous oxide (N_2O) are involved in the reaction are very interesting and new. They are representative of the interesting results. One final respondent noted the LNT reactor data made available from ORNL has been used by more than two groups to develop catalyst kinetics. This reviewer added that an SCR protocol is in the development phase. PNNL has begun to develop kinetics from this protocol and has presented a first-pass kinetic mechanism for NOx reduction. It is not clear if this protocol is sufficient, however, since modeling is going on in parallel with the protocol development. It seems clear that a refined protocol will be developed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive in this section. One person commented the actual interactions in the programs are excellent, and the distribution of information via CLEERS is really important and valued by those who use these materials forums. A second person noted the university and academic lab participation is excellent. The focus of many of the current DOE aftertreatment CRADAs suggests that industrial partners are finding value in the CLEERS work and developing their own related programs as a result. One final reviewer noted that a typical focus group conference call with have more than 40 participants. This reviewer highlighted the fact that so many industrial professionals take time out of a typically busy day to participate in a technical phone discussion, adding that is a high indication of strong collaboration. This reviewer lastly noted the coordination with a number of other institutions to promote the modeling.

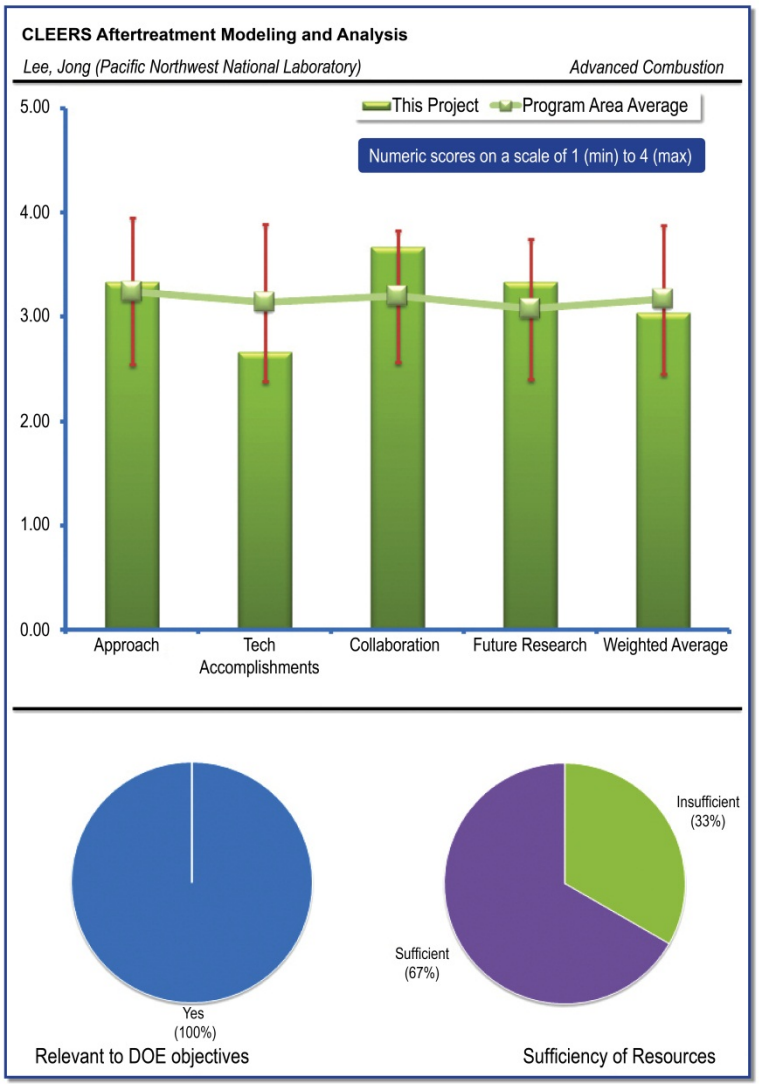
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments were somewhat mixed in this section. One reviewer commented that future work with the inclusion of aging and sulfur effects seems very appropriate. A second respondent, in contrast, noted very unclear discussion on what is being planned for the SCR fouling. Actually, this reviewer added, there was no clear definition of what fouling was viewed to be, and no procedure was identified to do either the aging or the fouling. This reviewer does, however, believe evaluating the kinetics of properly aged SCR catalysts is an important step in the modeling of these components. One final reviewer made a number of comments. This person said there is a perception that many DOE-funded programs are developing models of their own. Are they reinventing the wheel or building off existing work? If the former, are their ways we can transition to the latter? If the latter, perhaps we need to document this better to ensure that the value of funding this area is not underestimated. This reviewer also noted that an additional area where CLEERS might coordinate relates to broader utilization of the models for research guidance. Would there be value in brainstorming amongst the group on how different models might be "interrogated" to provide research guidance, either for formulation or application development? Lastly, this reviewer requested, with regard to experiments on hydrothermally aged SCR samples, please make sure that the aging requirements of the industrial stakeholders is adequately surveyed to ensure that the chosen aging is broadly accepted.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All three respondents said sufficient. The lone respondent here stated the funding allows quite a range of useful projects. There are certainly projects that could be added; however, this reviewer does not believe that ORNL has the staff to take on more projects. This reviewer added that future funding cuts could put in jeopardy this very useful program.

CLEERS Aftertreatment Modeling and Analysis: Lee, Jong (Pacific Northwest National Laboratory) – ace023



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer remarked the project covers lean-burn aftertreatment technologies (DOC, LNT, SCR, filters), while another noted that the SCR portion of catalyst deactivation is a current need for industry. One final respondent commented the modeling serves as a basis for quickly optimizing and controlling systems for peak performance and minimum fuel penalty. Improved deNOx performance translates into lower fuel consumption with engine calibrations. This reviewer added that analytical work provides the tools for evaluating materials and developing fundamental understanding.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were mixed in this section. One respondent noted that the work is reaching a conclusion and is addressing the proposed goals. A second reviewer commented the group is using a state-of-the-art analytical and experimental technique to understand the base performance of several catalysts, and is evolving from current, base materials as well as new, experimental types (k-$MgAl_2O_4$). This reviewer is a little concerned about the universality of a detailed model developed on one catalyst or catalyst family. Can these models be applied to other catalysts? How can the models be made more flexible and universal? This reviewer added obtaining the catalysts ought not to be a barrier. They are available as replacement parts or might be obtained from the OEM. Fe-zinc (Z) are not the same. The final respondent said recognizing that it is often difficult for a national lab to keep up with proprietary developments in industry, it is good to see that PNNL is open to receiving new technology from an OEM (i.e., the state-of-the-art Cu/zeolite catalyst Cu/chabazite [CHA]). Use collaborations to stay relevant. This reviewer added that it is not clear who is leveraging CLEERS models. There are a lot of models out there. This reviewer thought there were more CLEERS activities than the PNNL CRADAs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were generally positive in this section. One person remarked the experimental and analytical results are quite impressive and will serve as a strong basis for developing models. This person likes the use of a wide variety of catalysts as a way of understanding the fundamentals. The competitive adsorption results on zeolite are very impressive and show the potential for the approach. The metrics of interest are a good indicator of utility. A second reviewer commented nice, careful work on most key issues. The LNT work was repeated later in a CRADA presentation and no modeling was included here. This second reviewer would

like to see more on diesel particulate filters (DPF) and DOC. One final reviewer commented this is mostly a characterization study and further observed that work is needed, though it will not address creating better SCR technologies.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments were generally positive in this section. One reviewer commented excellent collaborations with multiple industry partners and other national labs, while a second said PNNL is working well with GM from what this reviewer can see. The final respondent said fantastic assortment of fundamental, integrator, and industry partners. No gaps. There is not much information given on the sharing of data and level of collaboration, but there was some mention of conference papers for getting the data out to industry.

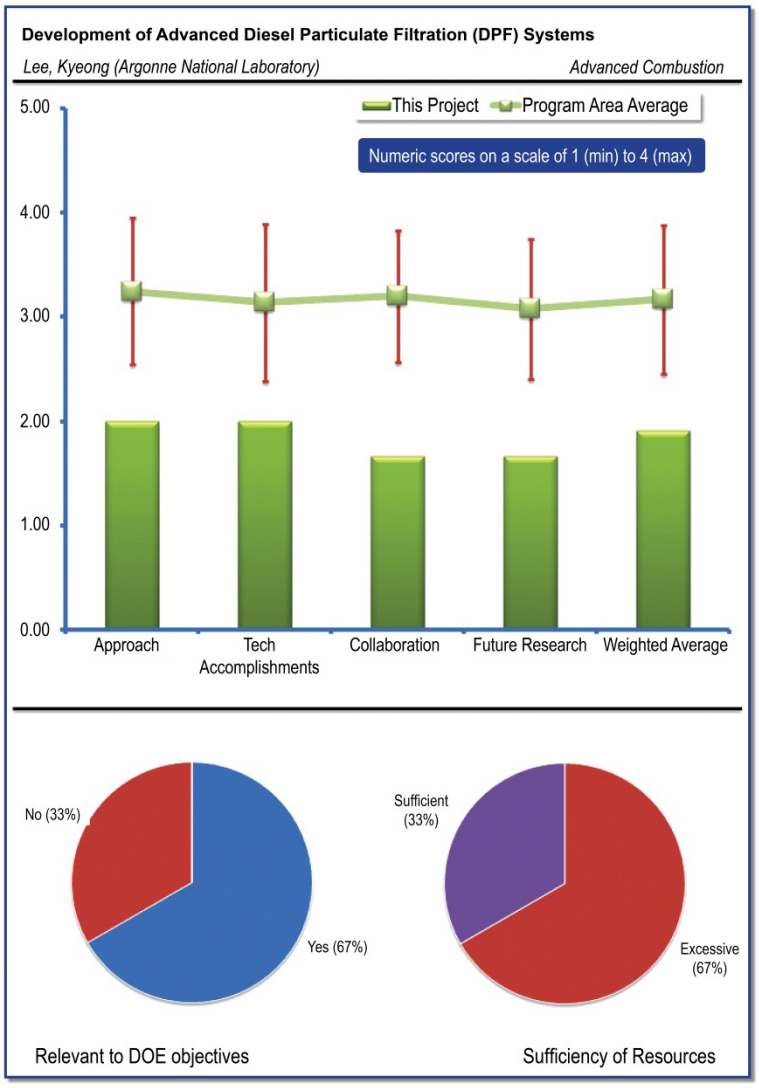
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said the systems approach is being followed and clearly defined roles are set. A second commenter stated the modeling work on SCR is very important to meet the high-performance demands of SCR to deliver fuel-consumption gains. This work should be accelerated. High-temperature (HT)LNT work is important for lean-gasoline applications that are coming later in the decade. This is important. This reviewer suggested de-emphasizing the DPF work, adding that the calibrations are going to low PM and high NOx. DPF performance with soot (regeneration, etc.) will become less important for fuel-consumption benefits. The final reviewer made a number of comments. This respondent said modeling Fe/zeolite is not interesting to U.S. OEMs, as mentioned by reviewers last year. Keep the prime work focused on Cu/CHA. Also of interest are materials that do not adsorb ammonia, i.e., modified zirconias (Rhodia, Umicore). This reviewer felt the fundamental work proposed on K LNTs will be very beneficial to understand the migration into substrates. The group needs to include substrate study in the next steps. This person added that a DPF model based on pore structure would be very beneficial to predict full-size filter behavior on materials/structures that do not exist yet and to determine how to integrate catalytic coatings. This final reviewer also asked about DOCs.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers said sufficient, while one said insufficient. The lone respondent here commented the funding seems about right, but it may be a little light given the core nature of the project and the scope. However, this reviewer added, the results are impressive. Would more money give faster results?

Development of Advanced Diesel Particulate Filtration (DPF) Systems: Lee, Kyeong (Argonne National Laboratories) – ace024



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said lowering the backpressure of soot filters and enhancing their regeneration strategies will reduce the energy consumption associated with vehicle operation. A second respondent commented understanding and reducing back pressure in DPFs as a function of soot loading would be important for petroleum displacement in diesel engines using diesel and biodiesel fuels. The final reviewer believed that cordierite filtration is in general sufficient, but does not see this work providing any improvement in diesel filtration technology.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of comments and suggestions in this section. The first person felt the oxidation activation energy work was not particularly useful, adding there is really very little helpful information in the variation in the activation energies. This reviewer added the continuing work on the segmentally blocked channel approach still gives physically unreasonable results; there must be an experimental issue that is causing this. A second reviewer commented the general approach is appropriate, but has not yet covered some key systems. This reviewer added it is important to know the actual soot loading on the DPF, and that is not being measured. This is a key measurement needed to make sense of the "improved DPF" whose back pressure levels off for high times of soot loading. The final reviewer remarked that it is not clear how a number of activities will contribute significantly to meeting the objectives of this program, and went on to offer a number of specific comments. (1) Regarding the characterization of pore size with catalyst coating, the effect of washcoat loading on flow restriction is well known, and state-of-the-art coatings are minimized to lower their impact on flow restriction. This reviewer asks how this characterization contributes to a control strategy. (2) The PI has apparently resolved some of the variance in activation energy values obtained under helium (He) vs. nitrogen (N_2) or Argonne (Ar). It is not clear, however, how resolution of this disparity contributes significantly to addressing real world regeneration control problems. (3) Explanations associated with the observed advantages of the modified filter plugging strategy are inadequate. Pressure drop results are counter-intuitive. It appears that the filter model was developed without making soot loading measurements, which is problematic. How this design will contribute to enhanced regeneration control and filter survivability is unclear. If advantages in pressure drop are only observed at high filter loadings and the soot loading on the reduced filtration surface is actually increased (for example, a thicker soot cake in the downstream section relative to a conventional filter), then exothermic generation and associated filter melting would actually appear to be more likely. (4) Lastly, this reviewer asked how another TEM image analysis of soot contributes to the development of the enhanced control strategy targeted in this program.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments were somewhat negative in this section. One reviewer sees nothing particularly new accomplished in this project. A second respondent stated it is not clear how all of the completed activities contribute to the development of an enhanced control strategy. What is the approach for accomplishing this? What will differentiate this control strategy from others? One final reviewer commented the actual results show a leveling off of back pressure as the time of soot exposure increases, which presumably means more soot is present. So these results were not explained, even though the results are counterintuitive, since if soot is being collected, it would make sense that the DPF will plug at some point.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Respondents generally expressed uncertainty in this section. One reviewer said it is not apparent how the activities in this program are coordinated with the work carried out by others. Measurements appear to be repeated (soot characterization and activation energy measurement) rather than built upon. A second person commented it is not clear what in this project interests Corning. Corning's interest was not made particularly clear during the talk. One wonders if they were most interested in the pore size measurements. One final reviewer added that collaborators were not emphasized, so this is hard to evaluate. This reviewer added it does not appear that there has been much interaction with a company that would have provided guidance on how to proceed.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Comments were generally negative in this section. One person noted, again, it is not clear how this work contributes to enhanced filter operations. A second reviewer commented that continuing in the direction shown by the past two years of reviews does not seem to have any value. One final person pointed out that, before proceeding with regeneration studies and some of the other work for the future, the grams/liter of soot in the brick needs to be determined. This reviewer added that only then can a better understanding of a near leveling off in back pressure be explained.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said excessive, while one said sufficient. Comments were generally negative in this section. One reviewer remarked that there is no apparent payback for the money spent on this project. Another commented this program seems to have received a great deal of funding with little potential for capturing significant value and addressing the outlined barriers. This final reviewer assumed the resources are sufficient, unless there is no way to measure the soot loading available in the lab.

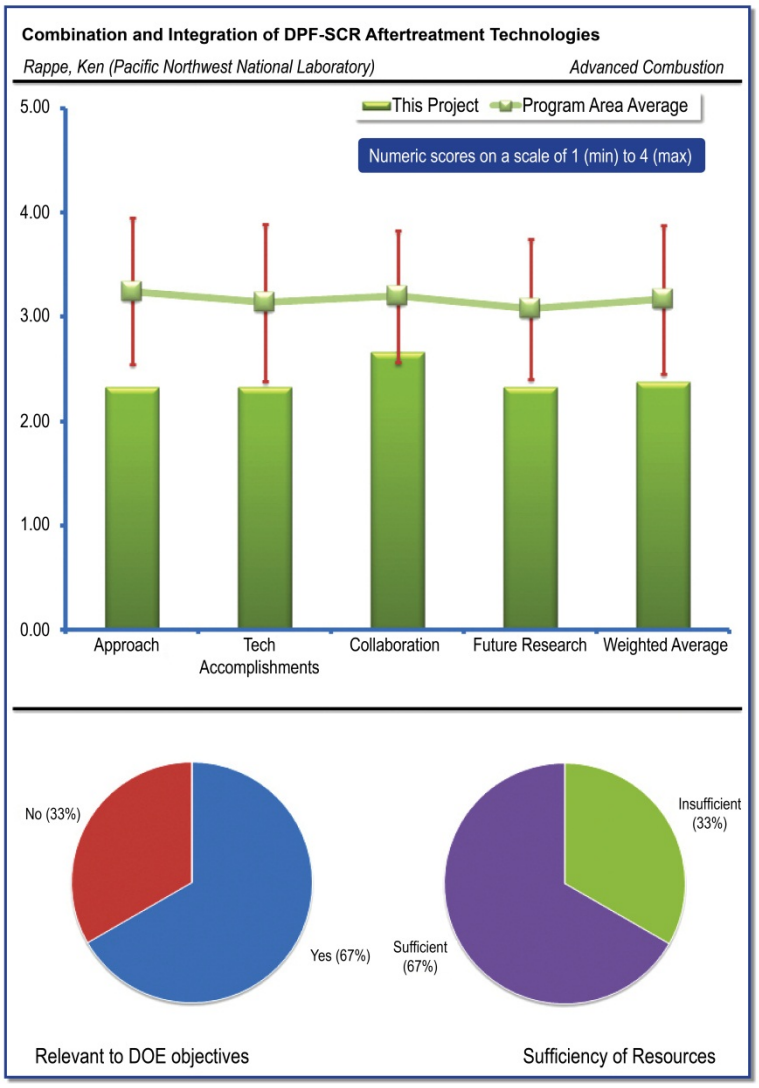
Combination and Integration of DPF-SCR Aftertreatment Technologies: Rappe, Ken (Pacific Northwest National Laboratory) – ace025

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were mixed in this section. One reviewer stated the topic is of relevance for potential cost savings in diesel aftertreatment. Another respondent said integrated DPF+SCR systems allow more SCR catalyst to be utilized on a vehicle within the same space. This results in higher deNOx performance and, the reviewer emphasized, thus lower fuel consumption through a higher NOx engine calibration. The final reviewer remarked that integrating SCR and filter functions will not necessarily result in less fuel usage. SCR filters have higher backpressure than conventional filters, with a lower safe soot limit resulting in more frequent regenerations. This reviewer added that, to meet the NOx target, another SCR brick is often required. The only possible way it could save fuel is if the original filter was located far downstream and by combining the SCR and filter, the location may be moved upstream, closer to the engine for less heat loss. This person added that this is usually not the case for heavy-duty systems.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of comments and suggestions in this section. One person said the evaluation of samples is behind schedule due to scaled-up catalyst creation. A second reviewer commented that, in essence, it appears the vendor simply provided DPFs with three or four levels of SCR catalyst and the investigators are testing various features. This person added that fundamental properties need to be linked to coating quality to help direct what type of coating quality is desired. The investigators are beginning to investigate fundamental properties, and this can add to the understanding of what a good coating is. The final respondent indicated the approach is centered on good SCR and should include good filtration function: testing full-size filters for maximum soot loading and regeneration behavior, as well as performance on certification cycles. This reviewer added that only then can the system be determined – is another SCR catalyst still needed, is a slip catalyst for ammonia (NH_3), CO and HC needed, etc. Finally, an assessment of the calibration impacts is needed – different regeneration frequency, temperature limitations, regeneration emission penalty, etc. This reviewer noted this was alluded to in the presentation, but no well-defined test plan was indicated. The regeneration frequency, temperature and duration will also determine the aging of the entire catalyst system.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewers indicated some reservations in this section. One person noted the work is at a stop while the next set of samples to evaluate is being developed; not clear if this situation will be resolved. A second reviewer commented the results so far address critical aspects such as backpressure and coating limitations; they do not address regeneration behavior, duration, frequency, and aging. The final respondent remarked there does not appear to be anything profound here compared to what is now coming in the literature. This project is 60% complete, so the next 40% needs to focus on gaps and value (see future direction). A valuable contribution would be to tie performance to coating quality. This reviewer added that, fundamentally, there are gaps on the soot/catalyst interaction (NO_2 behavior, NH_3 behavior, the effect on NO recycling in passive regeneration, ash behavior, etc.).

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One person commented the right partners are here (research, catalyzer, OEM), but added it appears that the coating vendor is not doing much. It would be very useful to get different types of coating to tie performance to coating quality. A second reviewer commented that PACCAR seems to be still involved with the project, adding that a washcoater came on board, but there's been limited progress. The final reviewer commented that supplier involvement is essential and the interaction here seems good because it is resulting in valid samples to test. The interaction with the University of Utrecht appears to be rather informal and the objectives they have are probably not essential to the project; however, the speaker noted that they are not receiving any direct funding from DOE, so the loose relationship is understandable. That said, their work could be leveraged better to have more impact on the program objectives.

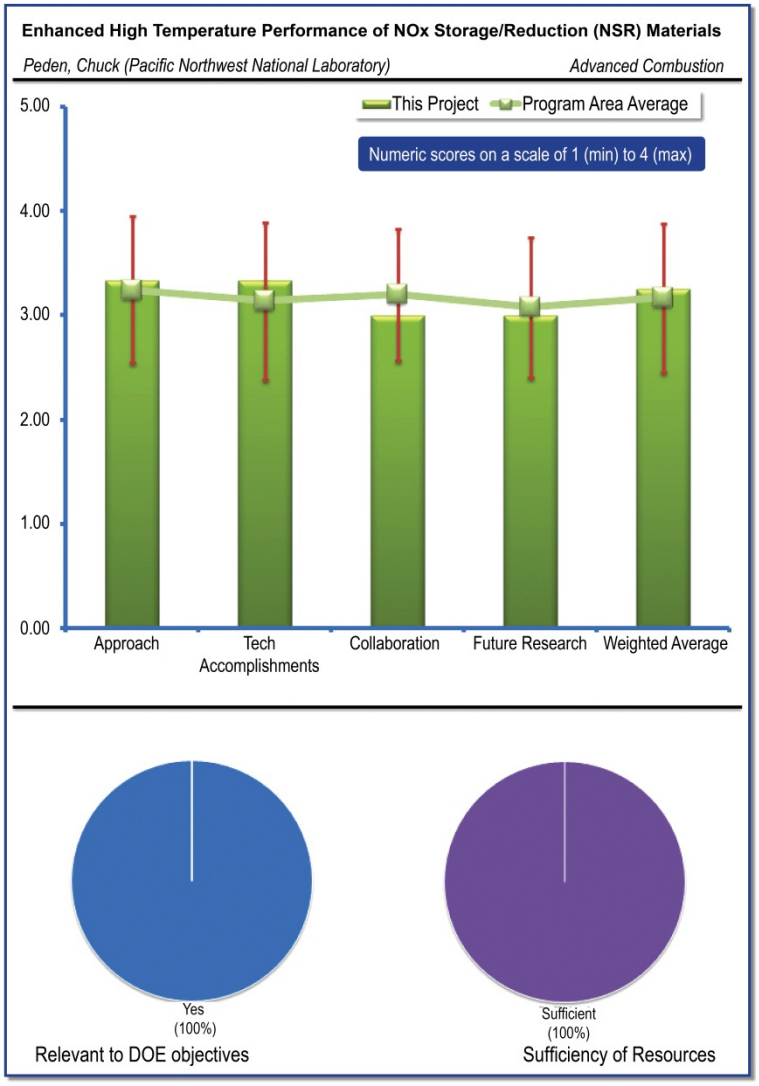
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One respondent stated that continuing with last year's proposed work is the next step. A second reviewer would like to see more on regeneration behavior of the integrated SCR filter and how the SCR filter fits into an emission control system. The final respondent indicated, looking at the nature of the experiments and work, it is critical to develop a usable and consistent coating method. This reviewer added the team needs to get this sorted as soon as possible to begin delivering valuable, usable fundamental information. Perhaps the team ought to determine the best type of coating: lining the pores versus the membrane. It seems best to this reviewer to promote the membrane approach rather than coating the pores, but then back pressure through the membrane will be very high. This will need to be resolved, and might be a very valuable contribution.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said sufficient, while one said insufficient. The first respondent said sufficient, but the team needs to work more efficiently going forward to provide meaningful data (see previous comment). The other person to comment here indicated the funding level seems low for being able to really prove if the SCR filter is going to be viable in a diesel exhaust system.

Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials: Peden, Chuck (Pacific Northwest National Laboratory) – ace026



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One person stated better high-temperature performance for an LNT will be especially helpful, especially for lean gasoline applications. This work helps move along the high-temperature functionality of the LNT for practical applications. The other respondent said that, although SCR has become the aftertreatment solution of choice for HD diesel, advantages in low-temperature performance of NOx storage catalysts have resulted in their selection for many Euro 5/6 passenger car applications. They are of interest for lean DISI as well. This reviewer added that both of these represent opportunities for reduction in petroleum use in the transportation sector.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of observations in this section. One person indicated the methods and their application seem well designed. A second reviewer said that effectively PNNL is leveraging a long history of evaluating catalytic materials, adding that this work becomes outstanding because the work is able to compare work that is done under other projects. As long as the research group continues to be effective, it justifies very good ratings. In addition, this reviewer noted the utilization of high-temperature LNT catalysts is an important addition to the aftertreatment tool box. The extensive capabilities of this laboratory allow PNNL to synthesize similar catalysts to what is believed the suppliers have provided and can use that information to usefully evaluate the properties of potassium storage materials. The final reviewer said broadening the operating window to include higher temperatures is an important objective. It is well known that potassium (K)-based storage materials can accomplish this. Unfortunately, this reviewer added, desulfation and K-migration issues are also well known with these materials. PNNL has all the right tools to study catalysts; however, is an investigation of sulfation/desulfation the best approach? Do we need to step back a little further and investigate more closely how the storage components interact with the support oxide and the related interaction of the storage component with NOx to yield high temperature storage? Could this understanding lead us to new materials? This reviewer went on to ask if enhancing the thermal stability to accommodate higher temperature deSOx is really desirable. Doesn't this mean that more energy would be expended to accomplish the desulfation? Doesn't higher temperature translate into more precious-group metals (PGM) sintering, which drives the use of higher PGM loadings, or sacrifices low temperature performance?

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments were generally positive in this section. One reviewer stated the study of the John Marvin Inc. (JMI) and PNNL materials showed interesting effects on performance from the analyses done. We look forward to the data on desulfation at different temperatures on the PNNL materials to see if it matches the behavior in the JMI material. A second respondent said this is a nice evaluation of a supplier-provided high-temperature LNT. It is very helpful to see a relevant set of experiments on this catalyst. Generally the work attacks the relevant issues. The comparison to the potassium MgAl2O3 support is interesting. However, this reviewer added, the effect of oxygen storage is not evaluated and that is an important facet. The final reviewer remarked that some different materials have been prepared and relative NOx performances and thermal durabilities have been studied. The direction of upcoming surface characterizations is key. In related presentations this reviewer believes to have seen images suggesting that K might be present in different arrangements after different conditioning treatments. These are observations which should be extended upon.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One commenter acknowledged this research group is well connected to researchers who have characterized existing LNT formulations, studied the mechanisms of their deactivation, and are developing kinetic models consistent with these observations. It appears to this reviewer, however, that their existing catalyst supplier is providing very limited access and understanding of details related to their "advanced" formulation, and quite probably limited direction in the material discovery process that is central to meeting the objectives of this program. The other respondent commented that most of the work was done at PNNL, adding there seems to be little input from the partners; however, the work is good and the suppliers are providing prototype catalysts and allowing presentation of some of the results. This person added that the government supplier relationship is always a difficult balancing act between proprietary issues and the need for enhanced evaluation of new formulations. The fact that Johnson Matthey has shared this formulation is a good measure of their trust for the PNNL staff and their valuation of the PNNL work.

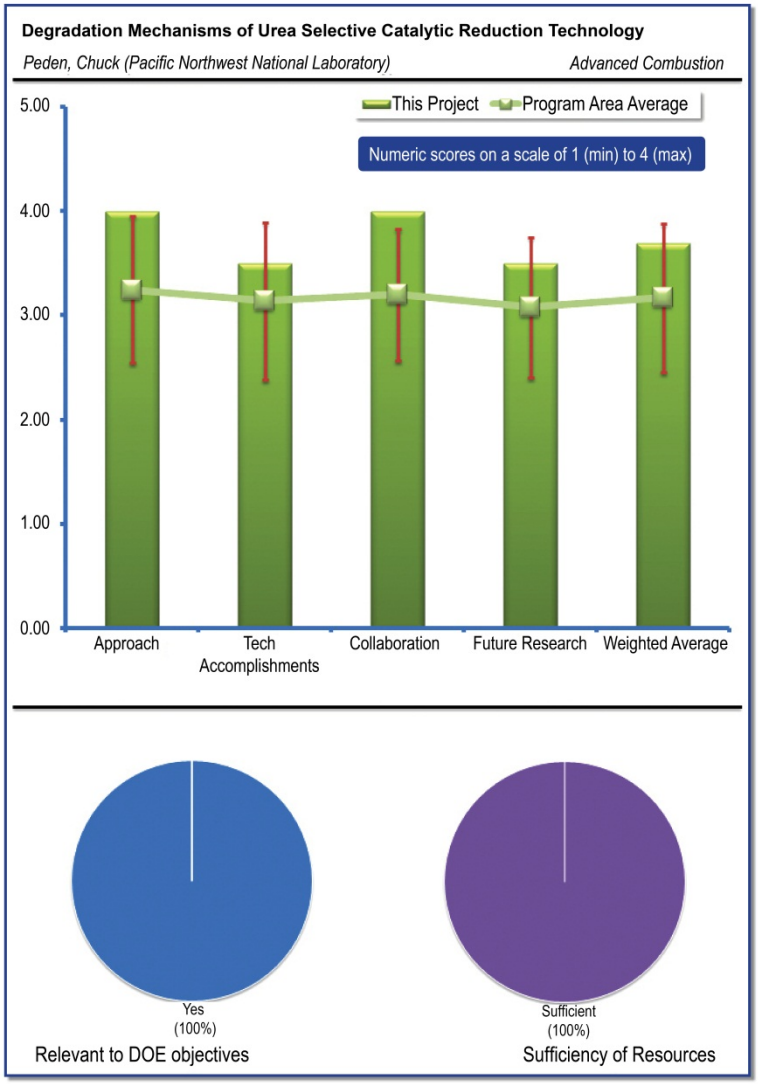
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One person noted that, under the section on characterization of the Johnson Matthey (JM)-supplied NSR, seeing the statement "determination of optimum conditions" causes it to sound like developmental work, not pre-competitive. This reviewer asks if this is appropriate for DOE funding. The other respondent wishes there were a mixed potassium/barium system in the future plans. This reviewer suspected that will be the NSR of the future, especially for gasoline applications. So far there is little information on the effect of the interaction between the two storage compounds. In addition, this reviewer added, the lack of oxygen storage is worrisome, but not a no-go issue.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers said sufficient. The lone respondent commented the instrumental leverage of the national lab is extremely crucial to being able to successfully accomplish this project.

Degradation Mechanisms of Urea Selective Catalytic Reduction Technology: Peden, Chuck (Pacific Northwest National Laboratory) – ace027



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One person indicated SCR is a lean emission control technology that enables higher fuel economy than other lean NOx options, adding that understanding the DOC is important for overall system function. The other respondent emphasized the need to have durable catalysts to provide acceptable performance for the full useful life of the vehicle. Air quality is the priority. If there is degradation, this reviewer added, the system will need to be run in a less efficient manner. This project quantifies degradation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent thinks the approaches are spot-on: analyze road samples and run fundamental studies on lab samples, and then correlate results. The other reviewer said the approach seems sound, and would like to see details of the vehicle aging in the future.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person commented they have found critical thermal aging mechanisms of DOC and SCR catalysts that should lead to lab agings that represent these mechanisms to the level of a vehicle-aged sample (to be determined). The other respondent noted the project is 80% complete. The DOC aging study results shown are so-so. The carbon impact is important understanding. What is the effect? Is it blocking or chemical? The PGM aging is less so. Quantification is good, but this reviewer is not sure this adds much to the understanding. What else besides thermal impacts can impact PGM growth and reaction? Sulfur aided? Maybe much can be gained by a quantification of chemistry to grain size, and this person encouraged trying to add insight into the relationship. This reviewer thinks the SCR XRD results are exciting and valuable, adding that correlation of the XRD parameters to performance could yield valuable test protocols.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted the government-industry cooperation seems impressive, highlighted the guidance, samples, etc. from industry and the quantification and analyses from the government. This reviewer added: good. The other respondent commented this is a 1:1 CRADA and the meeting frequency seems about right (audio every 2 months). This person also noted that there are no other institutions involved.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer commented the plans seem reasonable, adding that the real value is on developing a protocol that can be fast and effective. The group seems to have some of the essentials here for that: XRD vs. performance, for example, on both DOC and SCR. The group has little time left and should make sure it spends it on tying everything together into a valuable package. Tests should be focused on filling in gaps, not on new testing, samples, etc. How do poisons tie into XRD results, for example? This reviewer warned about being careful not to get too diluted. The other respondent emphasized the need to understand chemical poisoning effects, if any, from the analysis of the vehicle-aged catalyst. This reviewer added that then these impacts may be incorporated in the lab-aging proposal.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said sufficient. One reviewer said the funding level appears to be sufficient to meet goals, while the other respondent similarly commented there seems to be enough resources to complete the study. This second reviewer emphasized the focus needs to be on wrapping this up and making sure loose ends are tied, as is not sure there is enough left to enter new testing.

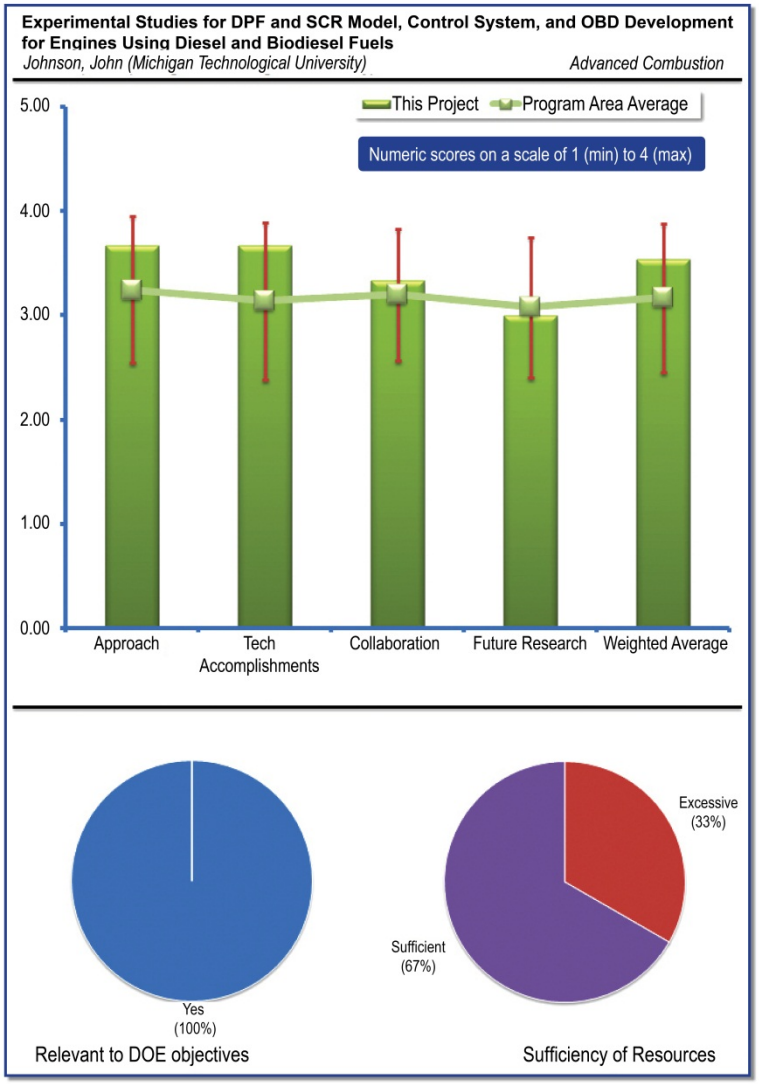
Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels: Johnson, John (Michigan Technological University) – ace028

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said optimization of aftertreatment system controls and OBD are important to the HD industry and directly impact combustion and fuel economy. The second person noted the OBD focus as part of the project is important to have long-term durability of the aftertreatment. Modeling could optimize the injection of fuels and enhance fuel economy. The final respondent indicated coupling the modeling with control strategy development is difficult and important to the ultimate application of one of these SCR-DPF combination devices. This reviewer added that one might wonder if this work should be done at the engine manufacturers. However, they do seem to be intimately involved in the project. Consequently, this might be viewed as the most cost-efficient way to develop a control strategy for this device for the industry.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments were generally positive in this section, with a few suggestions. One reviewer commented that estimators are dependent on getting lots of data now at a lot of places, and coordination is key to this approach. The second respondent said this industry-integrated project seems to be a very effective way in which to accomplish the integrated system. This reviewer emphasized the integration of the aftertreatment modeling with the control strategy/sensor development and the full experimental application. This has all the pieces, and it should be very effective. This is one of the few projects that includes an approach to sensor inclusion and evaluation, and, as such, it deserves high marks.

The final respondent remarked that the approach appears generally sound; however, it seems like leaving maldistribution effects for NH_3 storage and soot loading to the end of the program could be a problem. If this reviewer understands correctly, 1D models are being used to fit the real-world data and drive development of the estimator. On the other hand, if there are maldistributions, are not parameters being adjusted to compensate, which will then have to be corrected once maldistribution effects are characterized?

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked this project is moving along well, adding that it is interesting that several of the elements of the project are moving along in parallel. The evidence seems to be that all the pieces are coming together. Other than the sensor work, this reviewer added, much of this is similar to the work being done in the rest of the technical community. The major accomplishment to this point is all the elements seem to progressing successfully and appear to be integrating. Individual accomplishments seem to be evolutionary. The other respondent in this section noted the results on the contribution of back-diffusion to passive filter regeneration are interesting; however, the fact that the highest relative contributing effects are being observed at the highest temperatures and exhaust flow rates may suggest that there is another mechanism that has been overlooked. This reviewer added that the progress on active filter regeneration appears to be behind schedule. During this short review, little was shared on the strategies and success/failure of associated PM sensors. Because this general area is of high interest to upcoming OBD requirements, this reviewer hopes this is only a reflection of the limited time for presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One respondent noted the large team of folks from many places, while another stated this project is so integrated and cannot imagine that the integration could be much better in today's proprietary environment. The final respondent noted that 1-D models are being developed as a first step in the development of the estimator. This reviewer asked how these models relate to those developed previously by other DOE-funded programs. Are we reinventing the wheel?

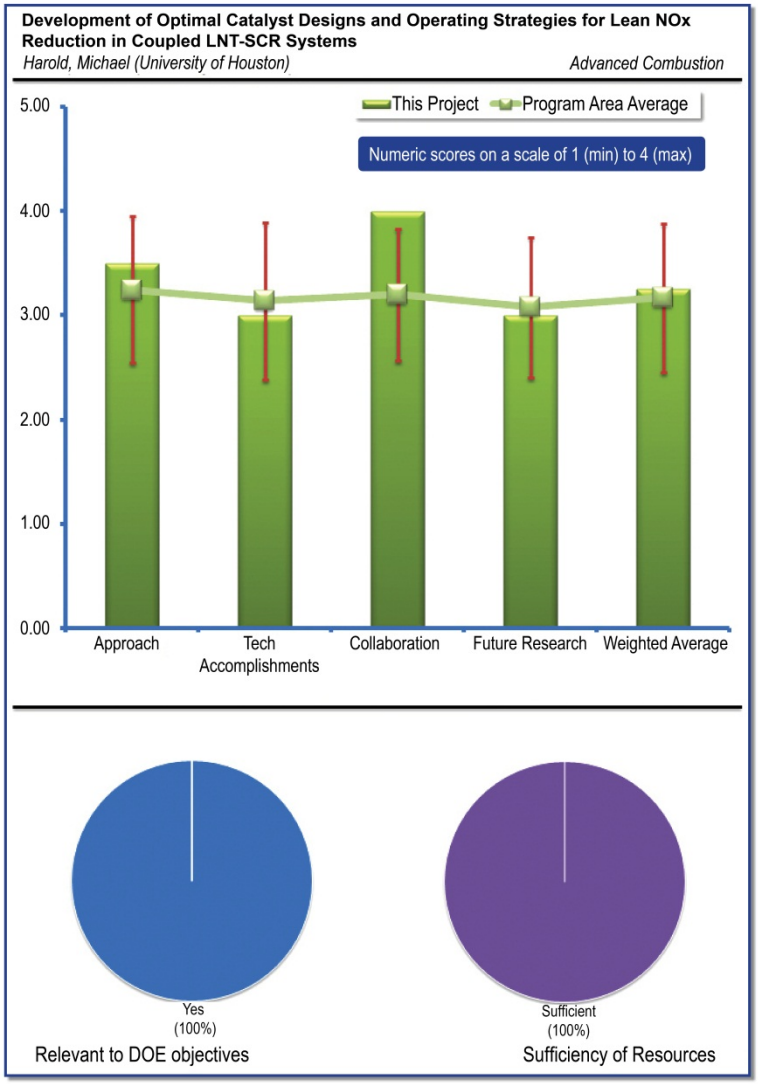
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers expressed some reservations in this section. One commented the project seems to be coming together on time, but added that if something does not fit it could have problems. That will be the major challenge for the research team. The reviewers were not given backup plans if one or more of the tasks is not successful or falls significantly behind. This reviewer suspects that there is some backup plans in consideration, but it could be a big enough problem that it should have been included in the review. A second reviewer indicated there is still a great deal to accomplish. Is it possible to do it all? If not, which objectives will be given highest priority? The final respondents felt that the inclusion of so many estimators and getting them to come to fruition together seems challenging; independent estimators would at least not depend on all the others working.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers said sufficient, while one said excessive. One reviewer commented the resources seem to be sufficient and everything seems to be getting done. The other respondent remarked that, with the widespread commercialization of filter + SCR systems in 2010, future projects need to strive to address precompetitive technical challenges. This reviewer added that it seems like this program provides an excellent learning experience for students, but may not contribute as much to technology advancement as the equivalent money spent elsewhere could.

Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems: Harold, Michael (University of Houston) – ace029



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented that the project concerns lean NOx control for higher fuel efficiency at lower cost. The other respondent said lean burn, dilute (EGR) gasoline engines are emerging as the most efficient. OEMs are projecting application by decade's end. Engine-out NOx emissions are nominally Tier 2 Bin 5 (0.3 g/kWh). Nominally 70-80% deNOx is needed to meet State of California Low-Emission Vehicle III (LEVIII) requirements. This work could provide an attractive deNOx option for these engines, allowing them to focus on even higher fuel economy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One person said the design is very well thought-out. There is a fundamental understanding of each unit operation and modeling, and then using that understanding to determine the best configuration. Hypotheses, results, explanation, confirmation, retest: classic. The other respondent said the approach includes link of rxr tests/modeling to vehicle testing. However, this reviewer added, it was not clear what vehicle would be tested.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer was glad to see someone finally study in detail the sandwich and layered LNT SCR approaches. The other person commented that the results more than half-way through are quite interesting. There are new findings (impact of HCs on deNOx in SCR), and NH_3 drivers in LNT. This reviewer added that the base understanding is being developed to begin optimizing the system.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent noted good collaboration with multiple research groups, leveraging their strengths. The second commented that, by all indications, this is a well-managed project. Coordinated and meaningful contributions are coming from all partners. Strengths of each are being utilized. It is well done, this reviewer concluded.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer noted the SpaciMS work on layered or zone coated samples might be very interesting. It might be interesting to look at LNT-SCR mixtures, understanding problems with PGM migration. The other respondent was unconvinced that Fe/zeolite is appropriate for this system, and added that Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) studies should help elucidate the non-NH_3 mechanism.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said sufficient. The lone respondent said the project is large and well managed, adding that resources are large, but adequate.

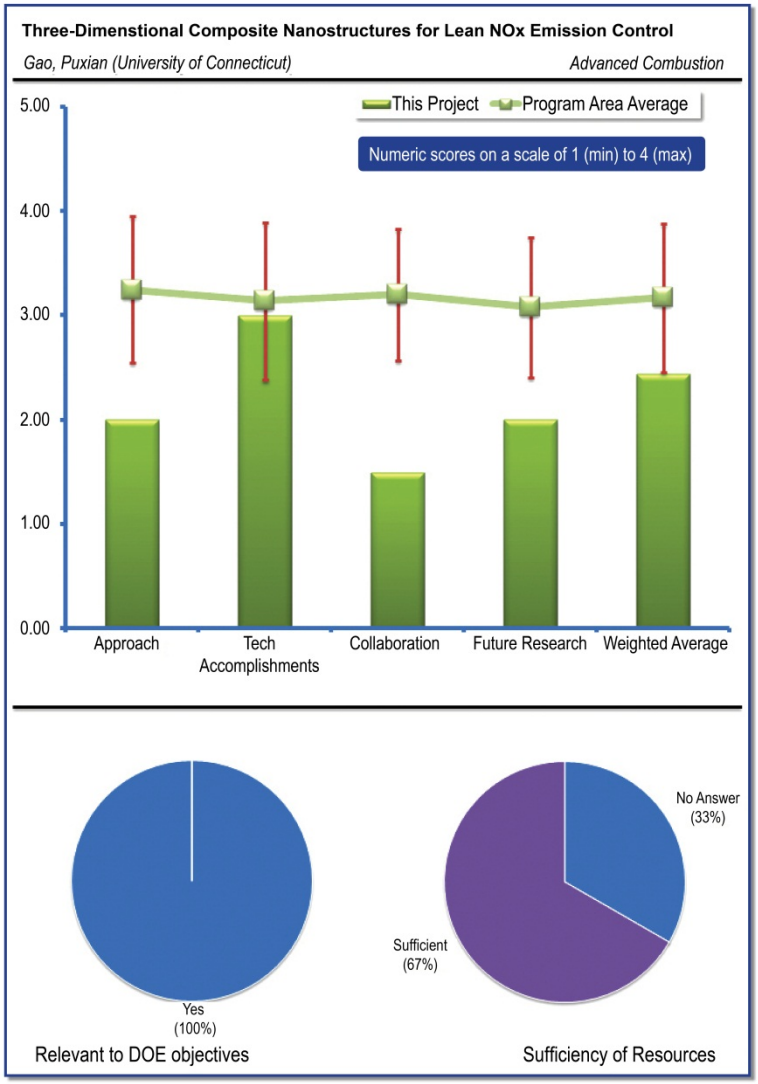
Three-Dimensional Composite Nanostructures for Lean NOx Emission Control: Gao, Puxian (University of Connecticut) – ace030

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said that this is extremely advanced catalyst/material science being directed toward an area where breakthrough technology is required. It needs to be recognized that it is high risk. The other person commented that reducing the PGM content of aftertreatment catalysts is an enabler for future high fuel economy engines. So far these materials seem to be using the same amount of PGM loadings that are commonly used in production. This is a highly speculative project, and as such it still has potential to make a significant breakthrough. However, this second reviewer cannot find much evidence in the presentation that any NOx reduction measurements have been accomplished. This work cheerfully discusses a range of microsynthesis, but there is still very little evidence that this microsynthesis has any impact whatsoever.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said novel material and structure for an emission catalyst. Alternative support oxides may be required to enhance thermal durability and sulfur tolerance. It is critical to assess whether the type of surface area associated with this type of catalyst architecture adds value. Simple reactor experiments demonstrating activity of base concepts should be pushed forward quickly. Hydrothermal stability is more important than simple thermal stability. Also, it is not clear to this reviewer if the atomistic modeling will add value. This reviewer may become a believer if initial catalytic results are encouraging and these models are proven to point in the direction of improved materials. The second commenter noted that the synthesis work appears to be outstanding; however, the definition of the NOx reactions to be treated is not discussed and seems to be very poorly understood. Even though emission testing is listed as an accomplishment, as best as this reviewer can determine the work has only shown simple CO oxidation, and no NOx testing has yet been attempted. This should not be considered as an accomplishment at this point. Additionally, many of the perovskite materials that are considered in this project are very sulfur sensitive. However, there has been no sulfur poisoning testing. The rationale given for sulfur resistance could be correct; however, there was no evidence given that the "sacrificial" theory of the nanowires was not justified with any additional evidence. This reviewer is extremely uncomfortable with density functional theory (DFT) as the justification of catalytic activity. This is insufficient because it is based on an idealized structure, which is probably not realistic. Also, the DFT calculations are based on an assumption of a particular reaction mechanism/pathway. The reviewer adds that that is just not sufficient.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewers expressed some concern in this section. The first said that a range of materials has been generated, and added that activity tests are desperately needed to help establish project credibility. A second respondent commented the synthesis work appears to be quite creative; however, the funding and goal for this project is NOx reduction or oxidation (the PI is not at all clear about this focus). Consequently, this reviewer thinks the progress must be viewed as very weak. The final reviewer said the project team has prepared and tested as materials the titanium dioxide (TiO2)-coated material and some with metal. They have Brunauer-Emmett-Teller (BET) numbers, but have not demonstrated why this would be any better than other options.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One person said Honda seems to be the major consumer contact, and some materials have been provided by Honda; however, there is very minimal evidence that Honda is an active participant in this project. A second respondent stated this appears to be a fairly isolated research program. Although there is some industrial sponsorship, the PI is encouraged to seek support and direction from an emissions catalyst company. The final reviewer said it is not clear how much interaction and guidance is being received from the OEM and other suppliers to help focus what measurements to make.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer commented that reaction tests need to be given highest priority. The other respondent noted that there was no clear indication of the specific catalytic process that each of the coatings was made to enhance, adding that no sulfur testing seems to be in the plan. Emission testing seems to at least be in progress, but did not seem to be an aggressive part of the program. This reviewer added that there seems to be an excessive focus on thermal stability at the detriment of a number of other gateway barriers.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said resources appear to be sufficient to establish and achieve the current objectives, while another reviewer was not sure. The final respondent said this is a high risk project. This reviewer does not believe that this project can be accomplished with less funding, but cannot justify additional funds at this point with the relatively low promise so far demonstrated. This person added that the focus should be adjusted to provide better evidence that this approach has promise. If better promise is not shown in the next year, this reviewer would recommend termination of the project.

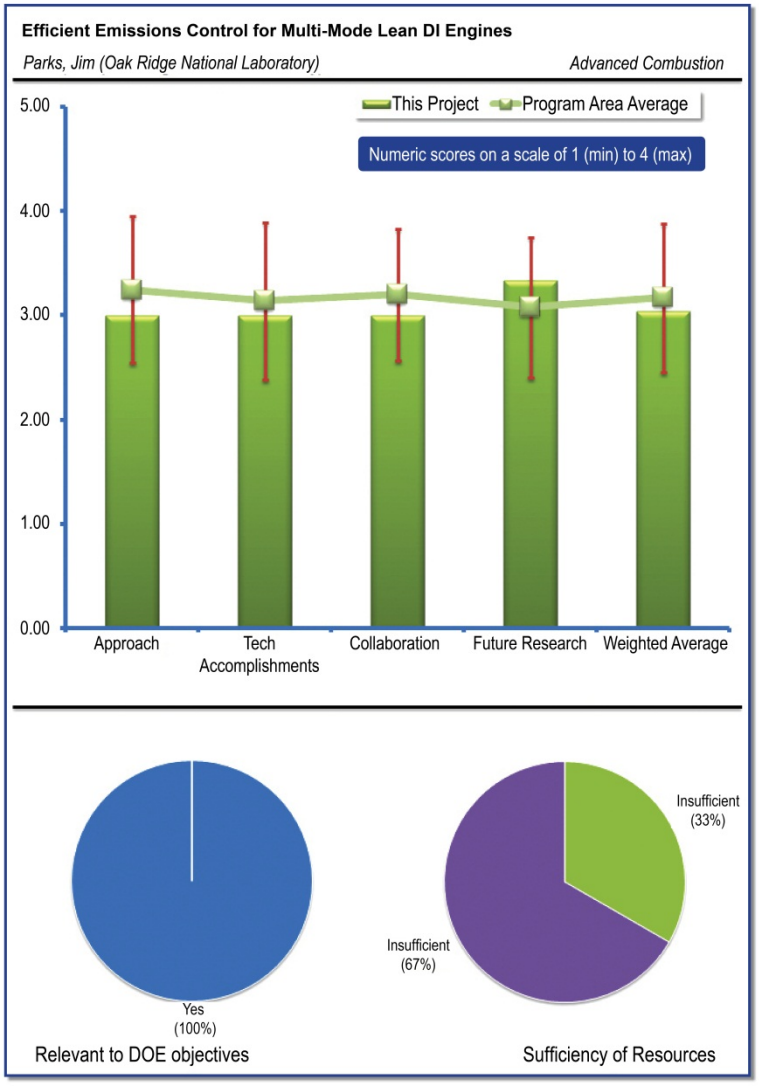
Efficient Emissions Control for Multi-Mode Lean DI Engines: Parks, Jim (Oak Ridge National Laboratory) – ace031

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments were generally positive in this section. One reviewer commented on the engine combustion modes to enable higher efficiency and lean aftertreatment, thus saving fuel. A second reviewer remarked that advanced combustion modes can deliver higher combustion efficiency and unique emissions issues, adding that this kind of fundamental and practical understanding will advance these kinds of engines, leading to lower cost of high-efficiency platforms. This reviewer added it is very important to take the fundamental work to the next step to begin showing practical application and solving unknown fundamental problems; excellent! The final respondent similarly commented this project supports the necessary emission offsets that may be required for implementation of RCCI and PCCI technologies, which are purported to significantly improve thermal efficiency and fuel economy of diesel- and dual-fueled applications.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers offered a number of comments in this section. The first respondent noted the excellent example of taking fundamental work (RCCI) into a practical application, coupled with advancing further, pointed fundamental understanding. This reviewer added that the engine is a good choice. The combustion modes seem well understood (very important to get a good representation), and this reviewer noted the very solid base understanding of these issues by the investigators. A second reviewer felt it was good to include DOC and SCR technologies in the study on new combustion modes, and would like to see DPF included and system interactions – but perhaps this requires more funding. The final reviewer said technical barriers are addressed well for the scope of this project, which is focused on exhaust aftertreatment. As a standalone project, this reviewer added, it could be rated at least 3-4; however, the basic work that is being done on PCCI and RCCI technology is not yet producing significant gains in thermal efficiency or fuel economy, so the work being done here to take care of the increases in HC to achieve the reductions in NOx may not be the final direction that is needed. (RCCI: 10x engine out (EO) HC increase, 10x EO NOx decrease; PCCI: 2x HC increase, with 1/4 NOx of baseline).

This final reviewer also added that it was not made clear that, once the RCCI and PCCI activities were successful at producing significant improvements in BSFC or Thermal Efficiency (today's data: RCCI with 1.5% improvement in BTE and 10x degraded HC performance, and PCCI with "comparable Brake Thermal Efficiency to conventional diesel with reduced NOx emissions" and 2x

increase in EO HC), the emissions to be corrected would in fact be what is being used to evaluate aftertreatment technologies. This reviewer said demonstrated, and asked if the 10x HC increases will be the real problem to be solved.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments were generally positive in this section. The first reviewer said excellent characterization of PM/particulate number (PN) from the three engines, and added it might be interesting to see composition work to better quantify particulates (ash differences?). This reviewer added good start on Nanostellar catalyst work. It looks like the group is on the right path. It would be good to have some fundamental characterization to gain understanding and improve performance. This reviewer also noted the very impressive and important new results on HC adsorption on zeolites. Speciation, distribution, and oxidation behavior on zeolite are all valuable fundamental findings. A second reviewer commented that, considering the base work to improve fuel economy is not fully complete and the premise "RCCI is fuel-efficient with emissions that can largely be controlled with DOC alone, thus reducing the fuel penalty and cost of the after treatment system" was not demonstrated, significant progress has been demonstrated in aftertreatment development for the RCCI case. The final respondent noted the project is serving an important purpose in bridging the gap between engine and reactor. It is nice to see a relevant SCR catalyst being utilized. This final reviewer suggested more on filters and system interactions/approaches.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers were generally positive in this section, while offering some suggestions. The first person said the collaboration with ORNL and University of Wisconsin (well known for leadership in RCCI work) is a great asset. Catalyst suppliers are being leveraged. This reviewer added that CLEERS is a strong resource for crosscut activities and can provide additional confirmation that the assumptions for the PCCI and RCCI base engines and fuel savings assumptions/results are on track. A second respondent indicated the GM collaboration is important to make sure the engine modes are representative and adding credibility; this seems accomplished. ORNL has enough experience on what the practical issues are, but GM also seems to feed into this. Perhaps lacking might be some feedback into the more fundamental investigations from the national labs or universities. However, this does not seem to be a major issue. The final reviewer expressed a need for a better DOC benchmark than the model DOC. This reviewer suggested a current production catalyst on medium-duty trucks, and that the group solicit Manufacturers of Emissions Control Association (MECA) and U.S. OEMs for samples. This reviewer noted good collaboration with other groups to leverage their knowledge and maximize the use of the funding.

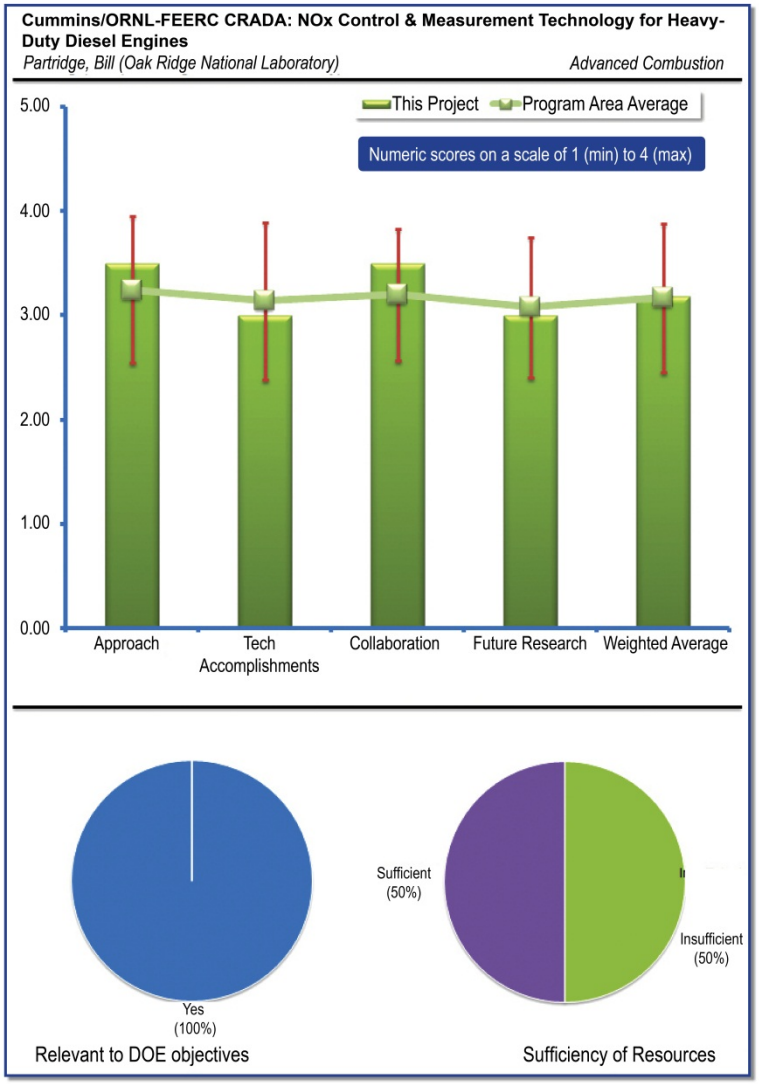
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers offered a number of comments in this section. The first person remarked HC speciation and coking behavior on zeolite SCR catalysts is extremely important; consider zeolite in DOC as well. Another respondent said that, although controls work is being done on the "combustion side" of this project, it is clear that there will be a need for future controls-level and modeling work for the aftertreatment side for NH_3 generation. The final respondent said further evaluation of DOC under different modes is important. It might be interesting to couple this with a more fundamental understanding/confirmation of the mechanisms, and perhaps more speciation/performance coupling should be considered (what about heavy HCs; higher-CO modes?). This reviewer noted it is critical to look at the HC adsorption on zeolites and the effect of the exotherm on durability. This reviewer's guess: CuZ will show very different effects. This is at the heart of HC adsorption issues on zeolites. Regarding the DPF directions: the group is spot-on on DPF implications from advanced-combustion modes. Low-temperature (LT) PM needs active regeneration, and this is no longer needed here. DPF implications are significant. Also important: ash. This is an emerging issue, and one needs to be ahead of the health authorities on it. This final reviewer asked if there are differences in ash emissions and composition with different combustion modes. What about some insights into ash distribution on DPF? Impacts of low soot on filtration efficiency?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said sufficient, while one said insufficient. One reviewer said the funding is appropriate for the aftertreatment technology studies. The other respondent asked: $200K per year on such critical work? This reviewer noted the group is delivering incredible value and has to ask: what could be done by doubling the funding? Excellent track record, key results, good understanding of weeding out the next level of problem solving. This reviewer concluded: go for it!

Cummins/ORNL- Fuels, Engines, and Emissions Research Center (FEERC) CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines: Partridge, Bill (Oak Ridge National Laboratory) – ace032



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer said correlating the catalyst performance with the engine variations is very necessary to assist the OEM electronic control unit (ECU) developers in producing the optimal engine control strategy. The other respondent commented that the diagnosis of emission control systems is in its infancy with new challenges still arising (NO_2, PM, etc.). Inefficiencies in combustion control and aftertreatment system diagnosis drive the utilization of larger and more complicated systems, which in turn drives up the cost of emission compliance. This ultimately limits diesel penetration into the North American marketplace.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said this program illustrates excellent utilization of DOE money and national lab expertise: let industry identify difficult technical problems that appear to require special tools to better understand the fundamentals, then let the national lab develop/provide the tools, techniques, and analysis to address the problem. The other reviewer commented that overall the SCR catalyst evaluation studies are great. The hallmark of this work over the years has been the instrumental development and measurements. This report has continued that consistent series of successes. The reviewer adds that perhaps his or her only discomfort is that the work is such a mélange of technologies that a focused approach is difficult to identify. However, the success of this group in getting these approaches into common use in the technical community allows them a significant measure of leeway.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent commented that the tool/technique for estimating intake EGR-mixing is envisioned, design validated, and readied for real world assessment. Bravo! The other reviewer indicated that there is such a mixture of projects presented here that a clear definition of accomplishments is hard. (1) SCR work: there are very good indications of spatial information on the ammonia storage; however, with no accompanying modeling information, it is difficult to see where it fits with the work of the Trinconi group or the Koltsakis group. This reviewer had a mixed response here. (2) CO_2 fast measurement: this could be a game changer for determining the response of CO_2 to changes in engine operating conditions. Very good response here. (3) LNT measurement: there is not enough

information to make a judgment. This is continuing work, but it is not obvious where it fits with the CLEERS LNT measurements. Is it part of them?

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The lone respondent said the collaborations are outstanding. It is very clear that the work is recognized as enabling, and multiple partners are willing to work on these measurements. This reviewer wishes they would get more reports on the partners' work to see how much of an impact it has. This reviewer especially likes the number of visitors that the group brings in, adding that this makes the collaborations work especially well.

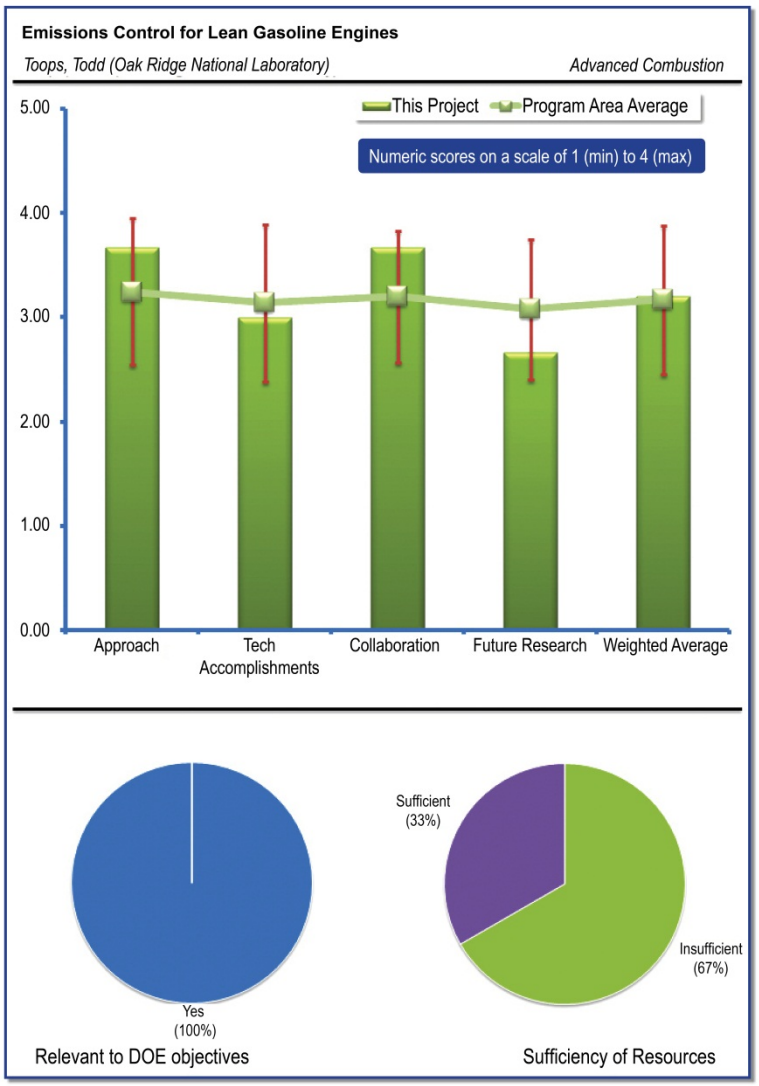
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first commenter mentioned that "Self-Diagnosing" SmartCatalyst is a big challenge, which will take time. It has a much higher risk for failure. The approach appears sound. Many people seem confused by name. This reviewer added that sharing more on the approach and plans for the development of fiber sensors would be useful. The second reviewer said, based on past history, most of these future plans will work out; HOWEVER, they are awfully vague and make it hard to judge. For the control work, how is this going to be implemented? Is there an active partner to use the control work? Is it Cummins? With the communication limits on the CRADAs, it is difficult to tell. When is the Fuel-in-oil work going to be declared a success and fully transferred? Is there a clear way to share the combustion variation information with the technical community? Very weak on the mid-infrared (IR) laser and the fiber based ammonia plans. Very hard to judge.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said sufficient, while the other said insufficient. The lone respondent said their resource ranking is not a funding comment. This reviewer wishes that there was more engine modeling attached to this project to evaluate the measurements. It is not clear that the resource is being effectively developed.

Emissions Control for Lean Gasoline Engines: Toops, Todd (Oak Ridge National Laboratory) – ace033



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer commented aftertreatment that enables lean burn gasoline. A second person said successful Lean NOx Trap technology (efficient, low fuel consumption regeneration, cost effective, and durable) may enable 5-15% fuel economy savings on gasoline engines. Three way catalysts have the limitation that they are not able to operate efficiently in lean exhaust stream. Optimization of LNT technology through improved technology, modeling to minimize regeneration fueling, and product durability are needed.

A third reviewer said Toyota, Nissan, Ford, and Mercedes have all publicly put lean GDI on their long-term technology roadmaps. Toyota showed 48% BTE at an operating point, while emitting only 0.3 g/kWh NOx (Bin 5 levels). This reviewer added that 70-80% deNOx will be needed to capture these very impressive results in a practical application. Dilute (EGR) and lean gasoline will be the future ICE in the U.S. to a large degree in the 2016 to 2025 timeframe.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said the project is taking fundamental understanding to the next step (engine), with inputs from a catalyzer and OEM, with loop-back into the fundamental understanding; generous public disclosure of results: beautiful. This reviewer added good engine choice, and commented it would be nice to bring the engine to a lean limit with and without EGR to better represent future direction, but the project has a good base engine. Another commenter stated best approach slide of any emission control project presented so far. Great way to see the link from fundamental catalysis to on-engine studies. It would be nice if a U.S. OEM engine were used. This reviewer went on to suggest that perhaps there could be a link to a U.S. industry project currently developing lean burn engines, adding that these engines will not be available for a while, though. The final reviewer noted the study and modeling of 3-way catalyst and LNT exhaust to optimize performance, as well as the evaluation of industry-supplied catalysts to improve performance.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One person felt that the characterization of engine operation and performance is good. It improves community understanding of base lean-burn engines today. The result on rich gas composition from a TWC is interesting. Good investigation. Bench work on NOx storage characteristics is very well designed and analyzed. Good correlations and descriptions/analyses. Nice, new understanding, at

least regarding public domain. Valuable to get out and communicate. This reviewer added that Ceria impacts are well-known, but perhaps not well documented elsewhere. Marginal benefit to community understanding. However, calcium impacts are new, interesting, and important. This reviewer wants more! A second reviewer said particulates should be measured; this was alluded to but not presented. The final commenter said modeling of single case LNT TWC configuration has been achieved and shared. Literature-based numbers have been quoted for fuel economy; however, no significant benefits for fuel economy were made or claimed for this study currently or in the future plans. As an enabling technology for lean combustion, some clear path to demonstrate actual fuel-economy impact is recommended.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said the research has got it all, and everyone seems to be involved: ORNL facilities and practical-fundamental ties; GM on the engine results and pertinence (hats off to them in choosing a competitor's engine); Umicore involvement is obvious and significant, important; fundamental loopback is also there. This reviewer did not see too many results, but the impact is there; project seems quite well managed. Another reviewer noted the coordination with CLEERS, Umicore, and loosely with GM, and added that communication about details of direct benefits from CLEERS participation is recommended. One final reviewer encouraged more interaction with catalyst suppliers.

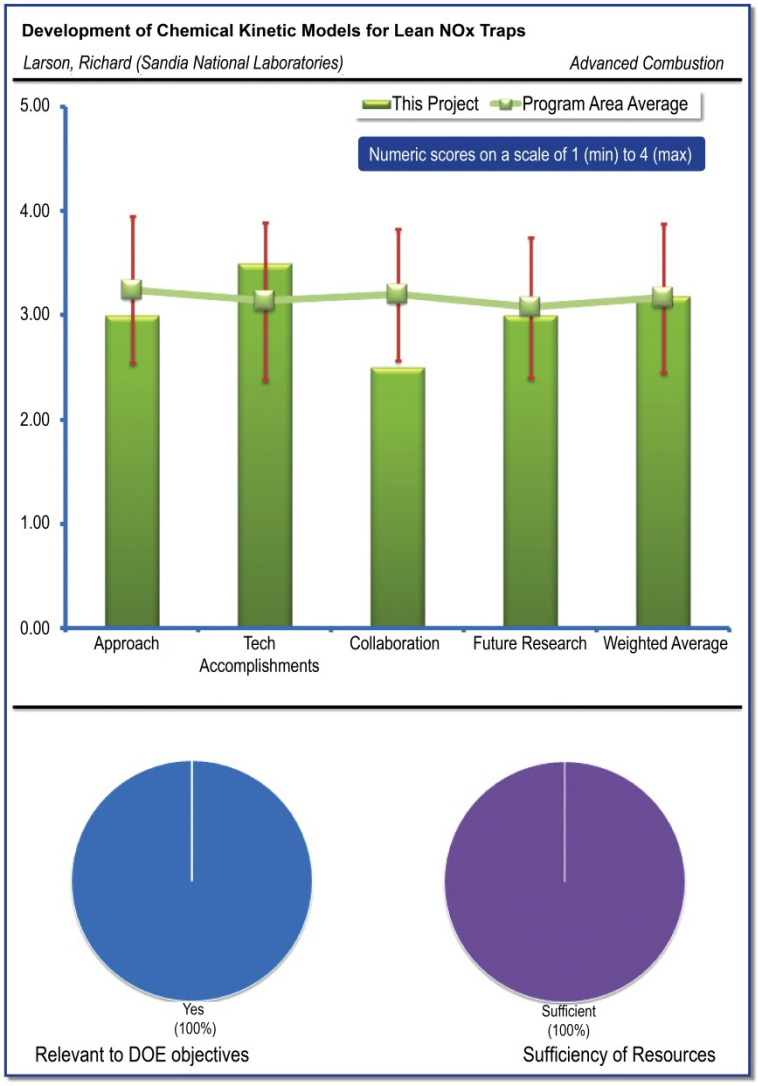
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the plan for future work is building on past work. Specific goals showing the fuel economy improvement that is planned for this project and the approach to get there are possible improvements. This reviewer added that systematically evaluating, modeling, and sharing data through CLEERS on aftertreatment material technologies is an excellent approach that can multiply outputs of research. A second respondent suggested the investigator consider moving into extra lean (lambda 1.6, maybe? find lean limit, even go with a strong spark). Add EGR to maybe 10-25%. These are the future engines. Maybe this is next proposal/program. Regarding the sulfur and calcium work: craving fundamental understanding on calcium effects. Regarding the Ceria work: the researcher may want to pull back on this. Oxygen effects and others are well-understood. This is the base LNT. The reviewer suggested the investigator broaden out into other oxygen-storage materials, if he still wants to go down this path. The heated microscope is interesting and a good example of using new, fundamental tools. The final reviewer commented on the need to leverage industry projects on lean burn gasoline and get a new engine aimed at U.S. emission standards. Continue to share engine data back to CLEERS. Also, try urea SCR approach. Medium-duty diesel trucks are already using it, and its applicability to lean gasoline has been shown by other groups. This reviewer added that urea SCR would allow for even greater fuel savings.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers said insufficient, while one said sufficient. The first reviewer said $200K is delivering quite a bit here. This seems so small given the scope and parties involved. Engine work alone will eat this up. What happens if you add more? This is a very critical and important area – lean gasoline – and is clearly underwhelmed here. One reviewer commented that the resources are sufficient for the size and scope of this project, while another said the project appears to be making good use of the funding available, adding that more funding would allow for more technical progress.

Development of Chemical Kinetic Models for Lean NOx Traps: Larson, Richard (Sandia National Laboratories) – ace035



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first person commented that making the connection between the microkinetic model (of which this work is a good example) and the global reaction kinetics that are a commonly used approach in industry is important. This work provides a basis for validating and evaluating the global models. The other respondent said LNTs are being applied widely in Europe to meet Euro 6 LD emission requirements. Lean DISI engines represent a potential next step in furthering the efficiency of gasoline engines; however, without advancements in LNT technology that increase their efficiency and lower their cost, this may not occur.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that the development of the model appears to be progressing well, with new attributes being incorporated to enhance applicability. This person added that the coordination with CLEERS data acquisition is good. The other reviewer commented there is rarely a comparison of this work to a global mechanism; consequently, there is no way at present to evaluate the short comings of the typical global reaction mechanism. This persona added that a comparison of this work to the predictions of Kocii (Catalysis Today (2009)) would be most informative and would be a more extensive justification of the funds invested in this project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer is extremely impressed with the agreement between the experiments and the sulfur poisoning models, noting that this comparison has been viewed as a significant barrier. However, the extension to a global sulfur poisoning mechanism is not obvious. The other commented noted steady progress in key areas that do not seem to be addressed in other LNT simulations (i.e. sulfation/desulfation).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted close collaboration with ORNL to obtain critical test data. The other respondent commented that, at this point, there is no clear connection to GM and the modeling, adding that more detail on that would have been helpful. The connection with

ORNL is good; however, it appears from this presentation to be almost one way (i.e., from ORNL to SNL). This reviewer noted it would have been very helpful to have SNL indicate how they have modified any experimental approach used by ORNL.

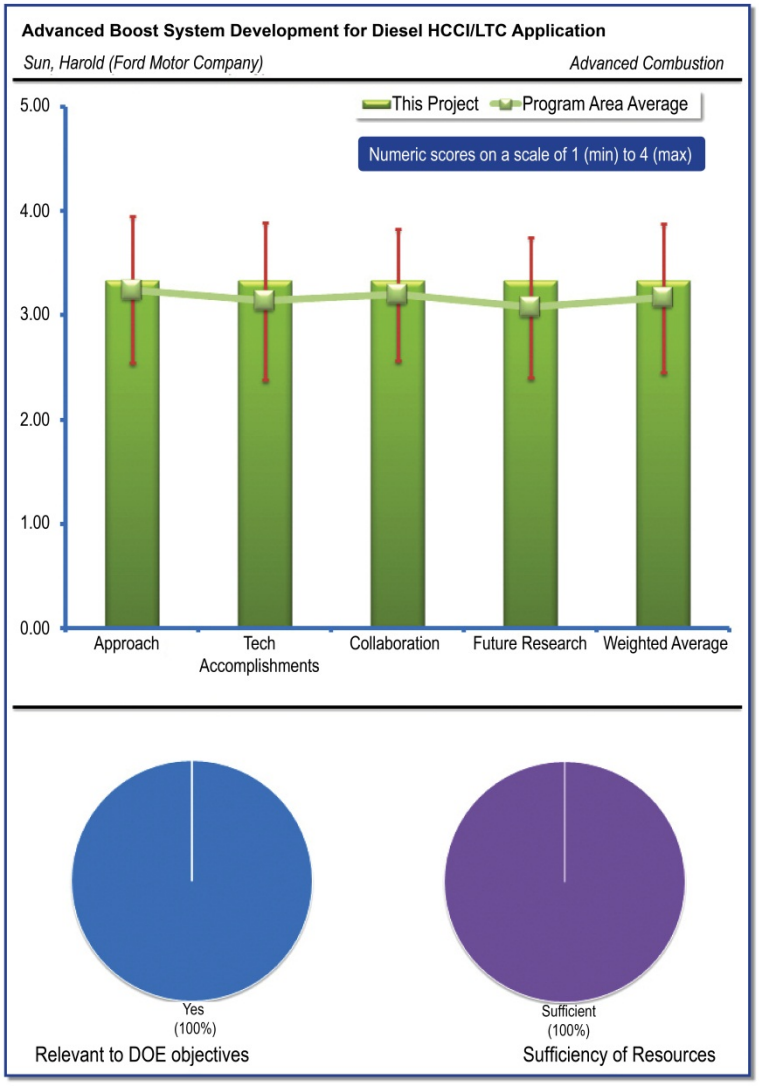
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The first reviewer said it appears that the model has advanced sufficiently so that it should begin to be used as a tool for providing research guidance for catalyst development. Brainstorming with stakeholders to address the potential (and direction) of this path is recommended. The other commenter felt the whole issue between isothermal and adiabatic is like the 800-pound gorilla hanging around on the outside of the presentation. It would seem to be that a few evaluations with adiabatic conditions and isothermal conditions would indicate how big a deal the effect is. This reviewer is guessing that nothing in the trapping and release mechanism has a major effect on the thermodynamics. However, the CO energy release does have a major effect on the temperature of the catalyst wall and at this point we have no inkling at all as to how big an effect that is. A low level sensitivity analysis would be extremely helpful.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said sufficient. The lone respondent said the resources seem to be sufficient, especially since the work is so leveraged with the experimental work from ORNL.

Advanced Boost System Development for Diesel HCCI/LTC Application: Sun, Harold (Ford Motor Company) –ace037



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said this contributes to a higher efficiency engine, while another said good explanation provided to describe the need for turbocharger redesign due to the effects of heavy EGR. One final commenter said improved boost systems are critical enablers for high efficiency combustion operation. Objectives are right on target. Air handling will make or break the implementation of many of these combustion modes. With that said, this reviewer is not sure Ford is the appropriate place for this development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said good work on a fundamental component. A second stated optimize compressor, diffuser, and mixed flow turbine; well-defined approach and milestones; the approach progression seems logical; and significant modeling is well done. This reviewer added that this is the best approach for cost effective development of turbomachinery. Hardware often behaves much differently than turbomachinery simulations when exposed to multi-cylinder engine variations. Modeling gives excellent guidance though. One final reviewer said the translation of technology from "large" turbo development to "small" turbo development does present some risks that this team may not be able to overcome in the timeframe/budget remaining. This was acknowledged in the presentation that innovations were needed to be successful.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Comments were mixed in this section. One person noted surprisingly large improvements have been shown on engines. A second reviewer commented on something that was not in the presentation: bearing change - journal to ball provided 2-3% improvement. This person added that thrust bearing problems were highlighted, but noted that it was unclear how the bearing design change and the failure to the thrust surface were related, if at all. Other accomplishments seem to be reasonable for the size of the program. One final reviewer commented that the project is one year behind schedule at the moment. This reviewer does not believe that this impacts the requested funding from DOE. This reviewer also noted the following: bench and engine evaluations of turbomachinery; nice progress toward project targets; dynamometer results actually exceeded targets. Characterization on dynamometer is very important and supported simulation and bench findings with more applicable data. Engine tests did result in bearing failure on turbomachinery. Will the technology findings from this study be transferable to other engine platforms?

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said the project seems to have suppliers closely integrated. Another person said appropriate team with sufficient detail on partner contributions to evaluate, and added thanks and also a good plan for technology transfer beyond Ford. The final respondent noted Concepts NREC, Wayne State University, and turbo suppliers (unnamed??). This reviewer could not really tell who was doing what, other than Slide 17. This may be better than a "fair," but this reviewer could not conclude that from the presentation.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer said the extension to LD is important, while another commented good plan to finish up the program and demonstrate program goals on an LTC engine by September 2011. A final reviewer said future work looks reasonable, adding that transient calibration on engine dynamometer will be very important. Any plans for vehicle testing? Plans to demonstrate expansion of advanced combustion? More specifically, will you demonstrate expanded, dilute operation as a result of improved turbomachinery technology?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three respondents said sufficient. One commenter said the resources seem appropriate, while the other respondent said the project is finishing in September 2011 and the budget appears somewhat under spent. This may be because over half the total project funding came in FY11, so the final six months should have a lot of activity to complete the demonstration.

Advanced Collaborative Emissions Study (ACES): Greenbaum, Dan (Health Effects Institute) – ace044

Reviewer Sample Size

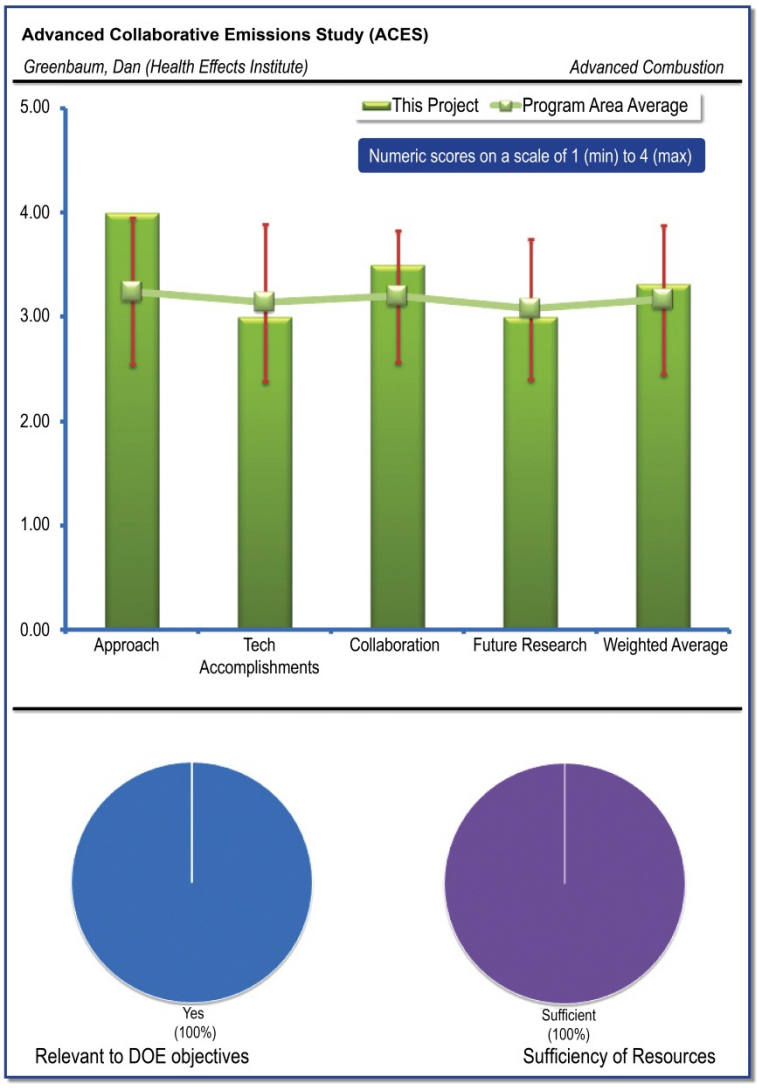
This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers felt that careful characterization of the health effects of particulate matter is crucial to the suitable selection of particulate emission standards for both diesel and DI gasoline engines. They stated that this most recent study seems to indicate that the most recent standards are sufficient for health safety.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer deemed this a reasonable way in which to directly evaluate the effect of diesel effluent on mammals. It was agreed that by directly running the emission into the atmosphere that the test animals breathe seems to be the most appropriate method.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers agreed that the accomplishments appear quite sufficient. However, since the authors have not yet gotten closure on the results, a better rating for technical accomplishment is not yet appropriate. The emphasis in the presentation on getting the entire dataset peer reviewed before finalization is comforting. It was felt that the accomplishments will be very effectively propagated given the partners involved with this work. The final reviewer stated that the phase three health effects study has been slow starting, but it appears to be on track and progressing on schedule now.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the list of advisors is quite impressive and it was assumed that range of advisors are effective in disseminating the results of this study to the rest of the professional community.

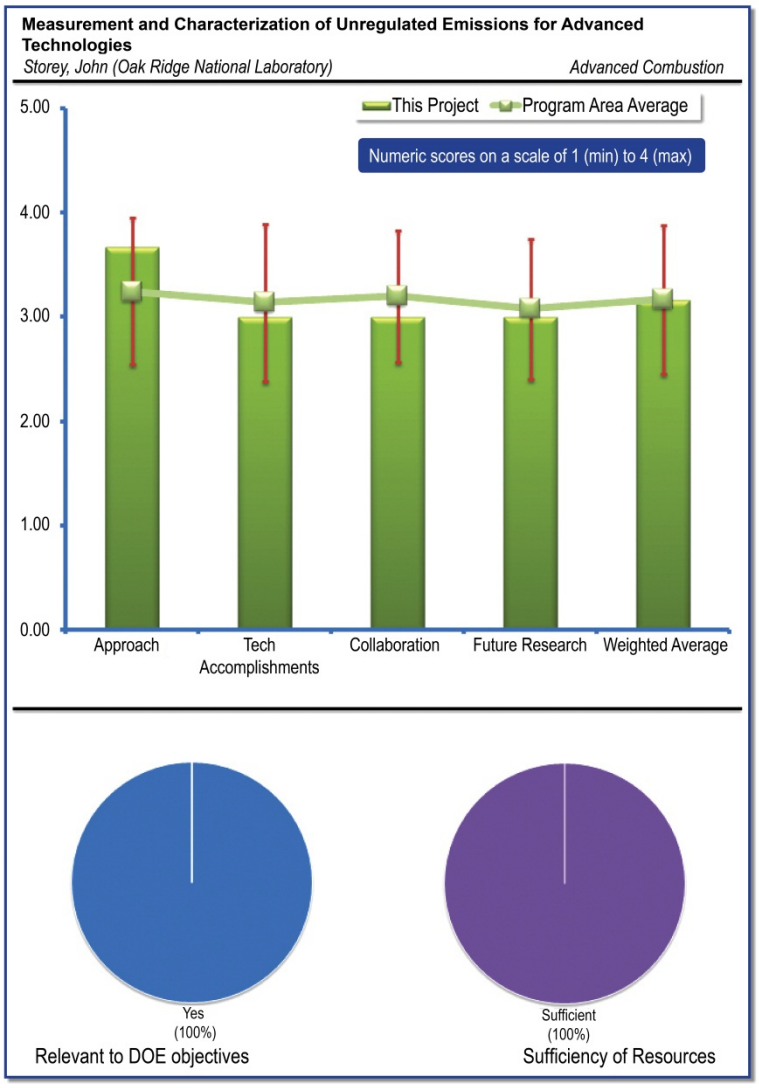
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The reviewers were unable to tell from the presentation what specifically is in the future for this project. It was questioned if it is simply final data analysis or if there is another step planned for this project.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer felt that nothing has been skipped in this project due to funding limitations.

Measurement and Characterization of Unregulated Emissions from Advanced Technologies: Storey, John (Oak Ridge National Laboratory) – ace045



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer acknowledged that particulate emissions from lean gasoline engines need to be characterized and evaluated to determine if aftertreatment will be necessary for their control. This work provides a basis for that determination. Another reviewer pointed out that the results from this appear to be quite similar to the results of Mark Stewart of PNNL. The final reviewer said that moving into ethanol is a major strategic public policy direction to displace petroleum. We need to know the characteristics of the emissions with the most toxicity (PM, PN).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Overall, it was felt that this project is a very nice monotonic comparison of the gasoline, E10 and E20 is helpful in giving us an indication of how those effects will scale with additional blended alcohol. Reviewers stated that the strong focus on the driving cycles is great and that the effect of transients on particulate formation in diesels is well known and expanding that knowledge to gasoline engines is absolutely necessary. The final reviewer pointed out that the project is focused on fundamental characterization of particulate emissions on ethanol and GDI which is right in line with the future directions in gasoline.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer believed that using production engines for this study is a great benefit. Since they are production vehicles, a clear indication of the future issues can be determined. Unfortunately, they are basically all European cycle engines and there are US DISI engines in production! Another reviewer was very impressed with the work covering the range of issues and felt that it was properly analyzed, compared, and spot on regarding objectives. The third reviewer stated that the work adds substantially to the knowledge database and will serve as the basis for further work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer was extremely uncomfortable that there was no interaction on this work with the similar work at PNNL. It was thought that some of the results are very similar and it would have been a good approach to have clearly separated out the areas that each would study. The final reviewer stated that although the work is heavily focused on ORNL, it meets the collaborative promises of the proposal. It was assumed there was little guidance from GM and Coordinating Research Council (CRC).

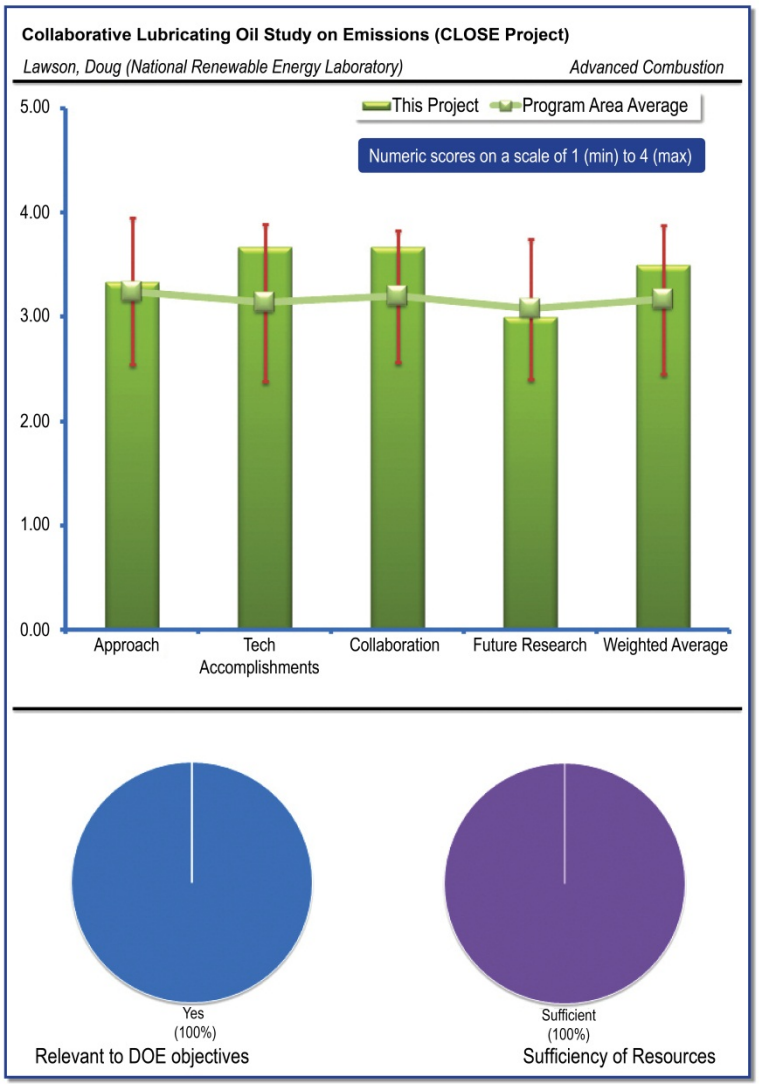
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer believed that evaluating stop-start is a very good task since this technology is getting into common use in the lean and dilute engine production arena. The reviewer stated that definitive knowledge of the effect of stop-start on particulate emissions is needed. The second reviewer felt that the work with urea by-products is excellent. This reviewer noted that Storey has a strong background here and will make good contributions. This reviewer also added that more work is needed on RCCI and that there needs to be analytical work on PM and PN composition. All particles are not the same in terms of toxicity. The final reviewer felt that the morphology work seems to add little to the base understanding.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer struggled with the question of whether there is too much of an overlap in facilities between ORNL and PNNL in this area. This reviewer believed that PNNL can do all the measurements that ORNL would like to do with the new engine exhaust particle sizer and questions the need for duplicate capabilities. The final reviewer thought the resources appropriate and stated that the authors have accomplished much with the resources. No more or less is needed.

Collaborative Lubricating Oil Study on Emissions (CLOSE Project): Lawson, Doug (National Renewable Energy Laboratory) – ace046



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that tracing the effect of engine oil on pollutant fractions shows that the oil contribution is indeed significant. However, it was not clear exactly how that effect can be controlled but showing the level of the effect is the first step and this does show that the engine oil components have an effect on the character of the organic emissions. Another felt that as we move to alternative-fueled vehicles, we need to understand the impact on toxic emissions that might not be addressed with current or contemplated aftertreatment. PM from gasoline and compressed natural gas (CNG) vehicles is an example. The final reviewer believed that this study lays out a valid experimental approach that can how serve as the basis for more thorough evaluation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer acknowledged that using the inherent tracers in the oil and then comparing those with added deuterated high organic compound is rational and appropriate. However, the reviewer was disappointed that more, high emitter vehicles could not have been included in this study. Another maintained that the experimental approach is a good one, including select representative vehicles and measure them in laboratory conditions, use tracers to discern between fuel and oil PM, and valid PN measurement methods. This reviewer applauded the choice of the CNG buses, as this is a contemporary issue. The third reviewer was a little puzzled by the treatment of calcium. This reviewer assumed the authors know the material balance on ash components with DPFs show more than half is missing. Clarifying that less than half the amount of ash estimated by lube oil consumption is retained on the DPF. It is now known that the DPF traps almost all of the ash that goes into the exhaust. The final reviewer also expressed a desire to have preferred to see at least one DPF vehicle and one with much EGR (2002-2006).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers thought that showing that the oil contribution is 20% or less is important. The reviewer also acknowledged that the observation that the oil contribution increased dramatically just after an oil change is important to future particulate evaluations. The PM and lube oil emissions rates are logical and well documented. Data-spread is expected and handled very well. It was felt that the study is a benchmark for further work. One reviewer did mention that it would have been nice to see some analyses of the various size fractions. Such as an explanation of the metal oxide component in the PM, which is emerging as a major health issue of interest.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer felt that the partner list seems to be quite good but mentioned that it would have been helpful to get some indication of how well the results were being incorporated into the consideration of those regulatory groups. Another expressed that it is excellent to see the regulators involved! This reviewer also pointed out that the transit authorities and companies can benefit from the work, as well as the inverse.

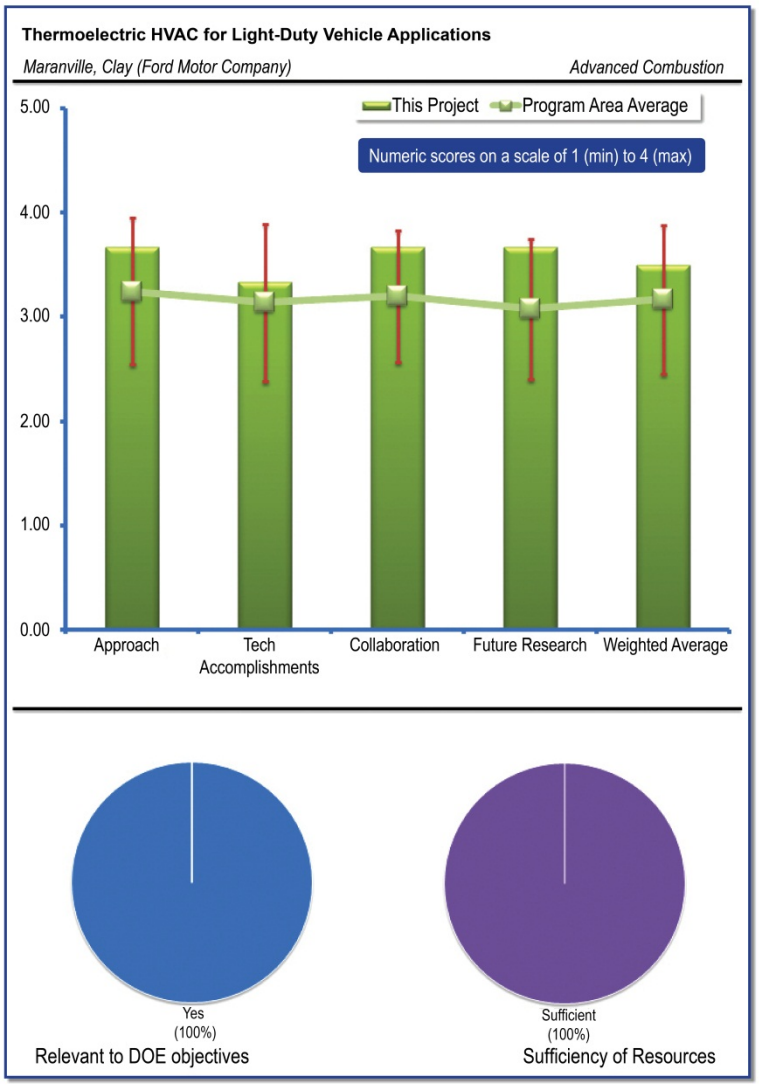
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that working with a greater number of vehicles would have added to the credibility of the program which is apparently complete. The reviewer also mentioned that if DOE does not extend it, there seems to be no indication that the other interested parties are going to take up the funding mantle which is disappointing. Another reviewer noted that no comments were made here; however, this reviewer expected the lead investigators to propose follow-up study on GDI, LD NG, new light-duty diesel (LDD), etc.; and to look as metal oxide emissions and possibly toxicity.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers saw that obviously there were sufficient resources because the project is complete so by definition the funding was sufficient.

Thermoelectric HVAC for Light-Duty Vehicle Applications: Maranville, Clay (Ford Motor Company) – ace047



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers commented that the project supports DOE objectives. The first reviewer pointed out that this project is a systems integration effort for a thermoelectric system into light duty vehicles. This reviewer felt that such an effort is, of course, very important and Ford is well positioned to succeed in this activity. Another reviewer stated that the Ford Motor Company is developing an alternative cooling technology for use on automobiles. This work supports petroleum displacement by reducing mechanical loads on the engine, thereby requiring less fossil-based fuels. Instead, the cooling system is purely electronic. The final reviewer felt that the project fully supports the overall DOE objectives of petroleum displacement

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer acknowledged that the overall effort concerns developing test protocols for automotive HVAC systems, bring to bear a combination of computer aided engineering (CAE), thermal comfort models, and subject testing to determine optimal heating and cooling node locations, develop advanced thermoelectric materials and device designs that enable high-efficiency systems, and design, integrate, and validate performance of the concept architecture and device hardware in a demonstration vehicle. Another reviewer stated that regarding thermoelectrics (TE) materials, bismuth (III) telluride (Bi2Te3) systems have been selected for the modules that would be integrated into a commercial product. This reviewer felt that if there are concerns with meeting supply of TE in particular (e.g., if TE systems were integrated into all new vehicles in the U.S. - some 10M or so per year), a backup plan might be worthwhile to consider for an alternative material system. The third reviewer pointed out that this work is dramatically new, so much analysis work is needed before leveraging the system to production automotive platforms. In the present work, they are developing test, evaluation, engineering and testing metrics upon which the new technologies can follow the path to production. The final reviewer felt that the approach to meet the project objectives is clearly defined and presented and that the project was well designed with good approach to overcome the barriers that could be encountered

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Overall, reviewers felt that the progress has been demonstrated well toward DOE goals. The first reviewer maintained that Phase I, completed this past year, included modeling to demonstrate that a zonal architecture for a TE system in a light duty vehicle was

viable. Some detailed results were presented to show cooling energy consumption, thermal sensation/comfort analysis options, evaluation of distributed outlet configurations to identify climate zonal system architectures, and modeling to perform initial sizing calculations (among other aspects). Also, a calorimeter test apparatus was designed and built to validate device performance. The model developed was shown to predict performance and allow for sizing models. Another expressed that it would be beneficial to have more specific data to judge, but the reviewer understands the nature of the proprietary data and protection of work for internal use (e.g., the modeling work done by the Visteon subcontractor reported no quantitative results in this presentation, only qualitative, which is understandable but makes review somewhat of a challenge.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers felt that the collaboration effort is excellent. One pointed out that the partnerships with Visteon, BSST, NREL, ZT::Plus, Ohio State University, and Amerigon are very effective and add significantly to the project. Another expressed that Ford has selected the best academic (e.g., Ohio State) and sub-contractor partners. They have done an excellent job or reducing risk. Ford should encourage collaborators to reduce risk further by investigating new materials whose earth-abundance is more advantageous (chalcogenide-free alternatives).

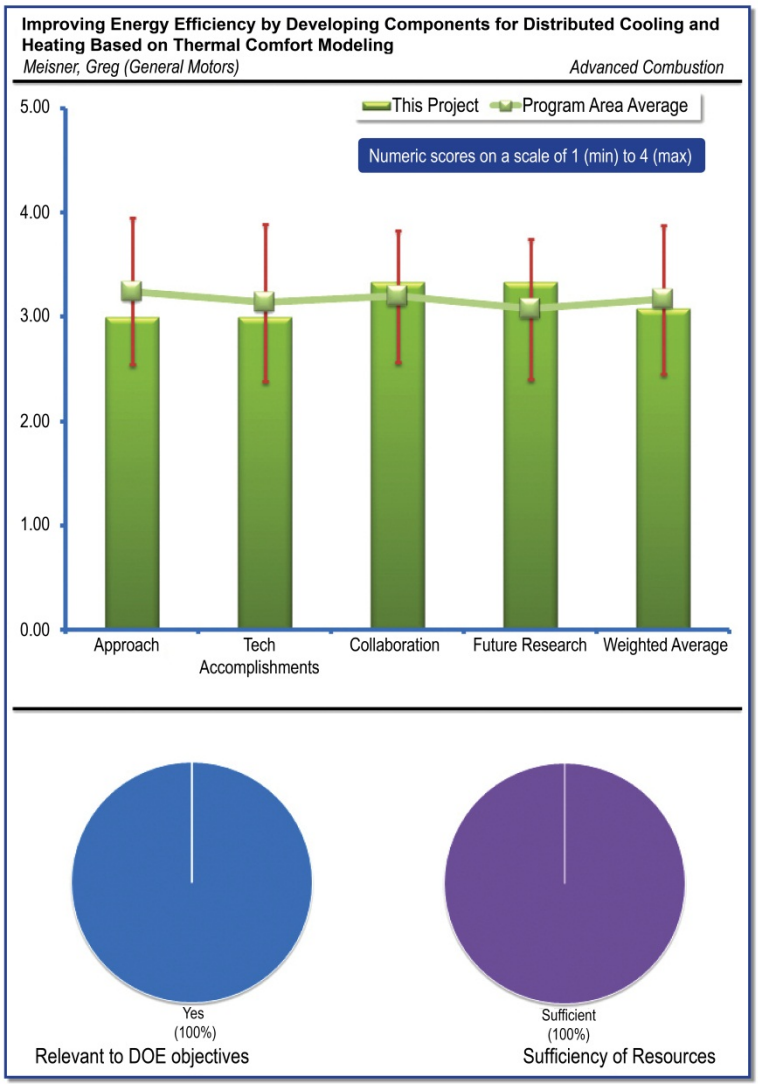
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the proposed phase III (FY 2012) will involve developing prototyping controls, system cost analysis, hardware fabrication and bench testing—all logical extensions of the modeling effort carried out this past year. Another stated that some elements of the project overlap with GM and that it would be useful, and ultimately (perhaps) facility deployment, if there could be some element of cooperation. This would certainly be advantageous for DOE's investment and ultimately it might reduce the timeline for system integration into a commercial product. Other reviewers felt that Ford has a good plan for continuing to push this new technology closer to production and that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer pointed out that DOE is investing a lot in this project, with over $1M this past year alone. Hopefully, the overall timeline for Ford to integrate a zonal TE system into a product line will be facilitated by the efforts being pursued. Another manufacturer, BMW, is also pursuing TE systems. Perhaps, Ford might consider benchmarking their efforts in a broad-based sense against them to learn what BMW is doing to facilitate integration of TE waste heat recovery into some of its product line. Doing so will enhance DOE's return on investment and improve Ford's product line. Another reviewer recommended increasing funding to the Ford performer to investigate new materials that would be more production worthy. The reviewer also encouraged Ford to describe their thermal management strategy for the hot side of their cooling system (where the heat is "dumped"). The reviewer questioned if that is an area that deserves attention, and if so, whether additional performance be obtained by thermal management of the cooling system.

Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling: Meisner, Greg (General Motors) – ace048



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall, reviewers agreed that the project fully supports the overall DOE objectives of petroleum displacement. The first reviewer felt that the successful development of a thermal comfort modeling effort has good potential to impact (reduce) our use of gasoline. Another stated that this GM program does support the overall objective of reduced fuel usage. The goal is to eliminate heavy air conditioning units that add unnecessary mechanical loads to IC engines.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer pointed out that the overall objective is to use TE HVAC for distributed cooling/heating as well as to improve efficiency of TE generators. Phase I efforts included developing thermal comfort models, identifying locations for distributed HVAC components, and carrying out environmental tests to identify locations for distributed heating & cooling. The reviewer also stated that the research also includes lattice thermal conductivity modeling to identify the role of phonon scattering, including nano-cluster doping effects and phonon density of states to examine the role of low frequency phonon modes for lead (II) telluride (PbTe) materials. The material selected appears to be PbTe, so issues of long term availability should be considered and alternative materials considered. Various skutterudite materials (CoSb3) are being included. The modeling is interesting; however it is unclear how results from the TE materials simulations will translate to fabrication and integration. Another reviewer stated that their approach is primarily to study practical system implementation, not to develop new component level technologies. The reviewer felt that is a weakness considering the potential lack of availability of some materials needed. The reviewer also stated that there appears to be very little value added from the University of Nevada Las Vegas (UNLV) collaborator for this work; the focus of the UNLV effort is on high-temperature power-generation materials which are completely irrelevant to this work. The final reviewer maintained that the approach to meet the project objectives was clearly defined and presented.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer asserted that a range of accomplishments were achieved over the past year, including identification of initial set of components for distributed heating and cooling development, building a vehicle with simulated TE devices, developing testing protocols to evaluate performance, and wind tunnel tests to build a "mule" vehicle with simulated TE devices for predicting a thermal

comfort evaluation strategy. The reviewer also noted that GM and Delphi jointly selected the Cadillac SRX for the demonstration project. Vehicle occupants were modeled and test and simulation procedures established. A fully instrumented “thermal mannequin” was developed by the university partner, University of California-Berkeley. Regarding materials, this reviewer noted that extensive modeling of the PbTe nanocluster systems was performed. According to another reviewer, the GM team has made reasonable progress towards testing and understanding the cooling potential for a viable thermoelectric cooling system on vehicles. They have designed and tested the system using the Berkeley mannequin. They have obtained data that adds value to the DOE application. Two unaddressed issues arise from the effect of humidity on the system: First, cooling humid air requires much more heat pumping than dry air (must add latent heat), and humidity adds an additional level of "discomfort" to the passengers that the mannequin may not detect. The final reviewer believed that the progress has been demonstrated well toward DOE goals.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers felt that the collaboration effort on the part of the project team was excellent. The first reviewer specified that the collaborations with University of California, Delphi Thermal Systems, and University of Nevada-Las Vegas: thermoelectric materials computational research, and GM Vehicle Engineering: vehicle requirements are effective. Another reviewer felt that the GM team has partnered with capable team members, but some appear to have irrelevant focus. The UNLV task seemed to be misguided at best. For the power-generation program, GM teamed with Marlow, so that relationship should be leveraged to the advantage of GM's cooling program.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that the proposed continuing work will involve CFD and vehicle Design of Experiments (DoE) analysis, developing a design of experiments analysis and developing control strategies. However, it was unclear precisely how the materials modeling effort would be translating into integration and synthesis of the materials being modeled. The third reviewer felt that since some elements of the project overlap with Ford, it would be useful, and ultimately (perhaps) facilitate deployment, if there could be some element of cooperation. This would certainly be advantageous for DOE's investment and ultimately it might reduce the timeline for system integration into a commercial product. The third reviewer mentioned that their future plans are reasonable; however, very little specific technology was described. The reviewer had questions such as what does the cooling systems look like, where does the TE module deposit the heat, to the chassis, or flowing air. The reviewer also questioned what alternative materials are under consideration, especially considering that the availability of key materials (tellurium) may be a significant technical issue.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

A reviewer noted that the DOE investment is extensive and, as remarked above, it might be prudent to find a way to facilitate information exchange with Ford (and vice versa). Doing so will allow for leveraging the DOE (and GM) investment and ultimately assist integration of a zonal climate system and waste heat recovery. Other reviewers felt that GM appears to have adequate resources to complete the tasks, and address the issues.

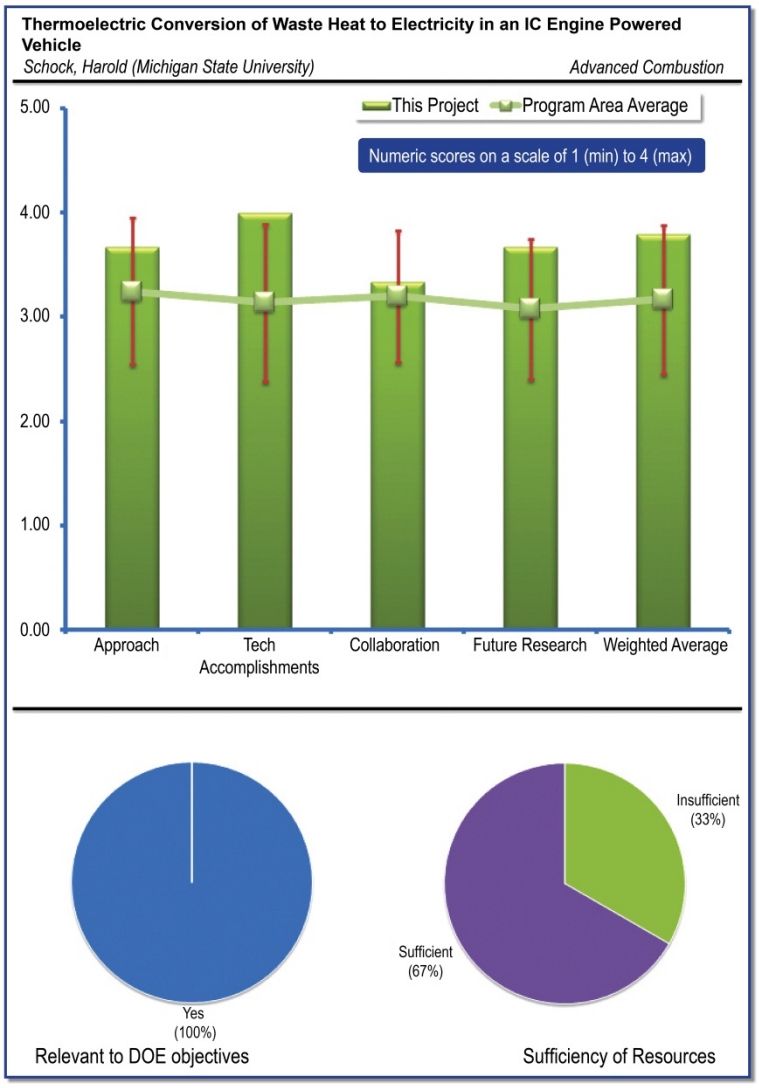
Thermoelectric Conversion of Waste Heat to Electricity in an IC Engine Powered Vehicle: Schock, Harold (Michigan State University) – ace049

Reviewer Sample Size P.6

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall, the reviewers felt that the project fully supports the overall DOE objectives of petroleum displacement. The first reviewer stated that this project is a successful development of a TE device for waste heat recovery and is certainly a relevant effort to DOE's objectives. The goal is to show that TE materials can provide a cost-effective approach to waste heat conversion to electricity. The effort on materials development and the issues involved are well developed. Another reviewer agreed by stating that the work performed by the Michigan State University team is highly relevant to the overall objective of reducing petroleum usage. Their strategy is to implement thermoelectric power generators to produce electrical power from the waste-heat from vehicles. Petroleum usage is reduced because the mechanical load to the engine is lowered (alternator) and fuel economy is improved.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally approved of the approach taken in this project. The first stated that this project has involved a lot of collaborations and interactions to pursue a broad range of tasks including thermoelectric generator (TEG) design and construction, TEG simulation, CFD analysis and systems utilization. The PI team is similarly extensive. The second reviewer was very impressed with the approach used and stated that the Michigan State University (MSU) team rapidly identified difficult technical issues and has developed viable and clever solutions. One issue is differential thermal expansion which causes the fracture of the main components of the converter. They developed at least two innovations to help solve that problem: a compliant hot-side electrical contact that provides mechanical strain-relief, and an electrical means of "by-passing" failed elements. Although the issue remains unsolved, there is little doubt that their innovation and creativity would produce a viable long-term solution. They have made impressive progress and produced working prototypes that were integrated with test-beds. They have generated valuable experimental data and new innovations. The final reviewer felt that the approach to meet the project objectives was clearly defined and presented and that the project was well designed with good approach to overcome the barriers that could be encountered.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer pointed out that the PI developed "coupled bypass technology" which is novel; a range of 1 to 200W generators were developed and highly insulated modules using aerogel wool insulation were demonstrated in the Phase 2/3 efforts. Effective integration between numerical and experimental studies were essential to developing significant progress. The reviewer also asserted that the identification of skutterudites (non-heritage materials) is prudent and well thought out. The team developed a fabrication method for the skutterudie materials and the TEGs themselves. This would seem to be a significant accomplishment and allow for adopting these materials in production. The reviewer also acknowledged that the PI developed a system for "laboratory scale" TE module fabrication method, so the PIs have a lot of expertise in this area. A fully instrumented TEG system was developed for testing that allows for attachment to cylindrical shapes (important for exhaust system attachment). The TEGs were integrated into a circuit board to allow for monitoring and data evaluation. Extensive tests were carried out and detailed modeling was pursued to predict TEG output and the results agreed well with measurement. The reviewer found the identification of failure modes of the insulation is interesting and was impressed that the efforts also included development of methods for laboratory scale mass production of skutterudite, This seems to be a significant result. Another reviewer noted that the technical issues for this project are severe, and despite that, Prof. Shock has made remarkable progress and shown creative, innovative solutions. A realistic implementation has been demonstrated and important lessons have been learned. The third reviewer felt that the technical accomplishments are great and the progress has been demonstrated well toward DOE goals.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

All reviewers felt that the collaboration effort is excellent for this project. One reviewer pointed out that the collaboration with Purdue, NASA-Jet Propulsion Laboratory (JPL), Northwestern and Tellurex, Office of Naval Research, DOE Oak Ridge High Temperature Materials Laboratory, and the Air Force Research Laboratory, Wright-Patterson Air Force Base (WPAFB) is excellent and brought a lot to this effort. Another maintained that the MSU team has an extended family of partners, all of whom seem to closely collaborate. There appears to be some redundancy, which helps reduce overall risk.

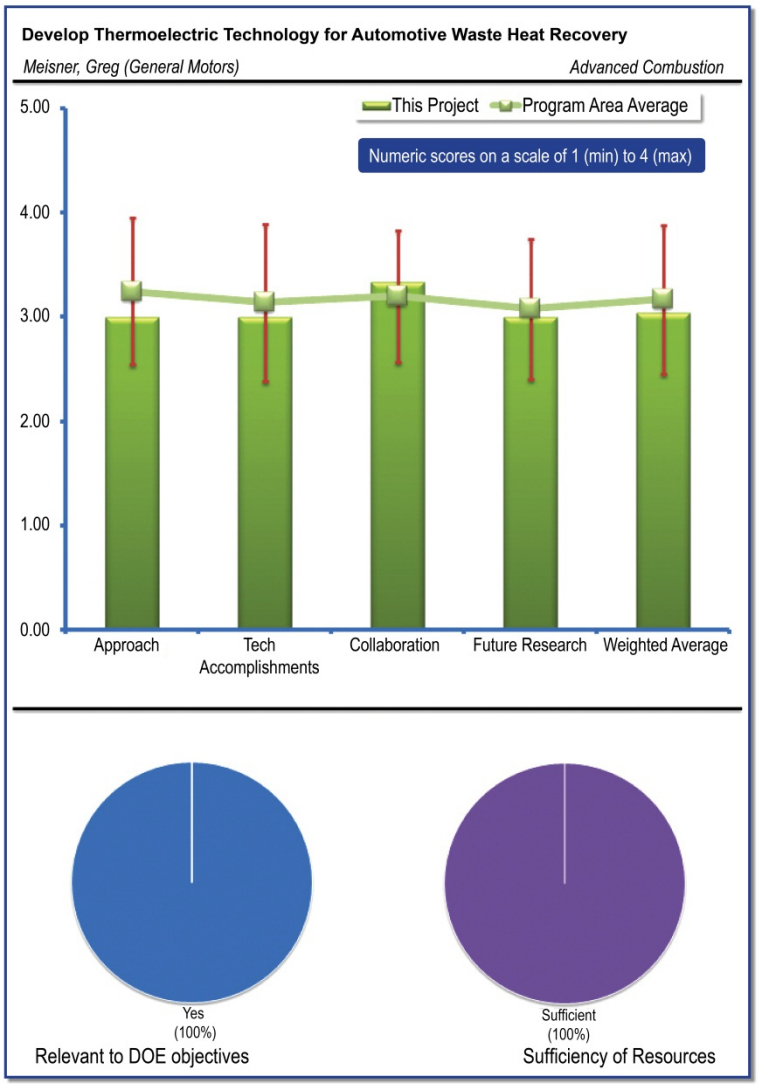
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers observed that according to the PI the project has apparently ended and future work appears to involve development of follow-on proposals. A reviewer did note that although it appears this project has ended, the future plans appear to be well considered and addressed appropriately. This reviewer admitted liking this work, and although there are significant issues, it appears that the PI have a good understanding of them, an excellent track record of innovative solutions, and a reasonable path to be successful. The final reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that the team assembled for this effort is extensive (many PIs and tasks). The funding level seems to be adequate for the number of PIs involved and the extensive array of tasks performed. However, one reviewer noted that this project was reported to have ended early.

Develop Thermoelectric Technology for Automotive Waste Heat Recovery: Meisner, Greg (General Motors) – ace 050



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers perceived that the project supports DOE objectives. The first reviewer felt that a successful demonstration of TE technology for automotive waste heat recovery would certainly be a significant accomplishment and, in this regard, the project is highly relevant. Another reviewer asserted that the GM work supports the overall goal of reduced fuel usage. Their long-term goal is to use skutterudite materials as the active device material in thermoelectric energy converters, although, for the present work, they are using an alternate, better known material to prove their system. The final reviewer maintained that this project fully supports the overall DOE objectives of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer pointed out that the approach involved fabrication and prototype assembly, outfitting a demonstrate vehicle, evaluating performance in the vehicle, and developing a material synthesis protocol for skutterudites. The materials used were BiTe for TEG#1 and TEG#2. Skutterudites materials were integrated into a TEG#3 module. This reviewer went on to explain that the tasks have included attempting to improve ZT by triple filling n-type materials, evaluation material mechanical properties, and exploring new TE modules. The second reviewer noted that their approach is reasonable, but not very aggressive. This reviewer thought that there is large risk that the lessons learned from the industry standard materials will not translate to their long-term strategy for skutterudite modules. There is significant risk when transitioning to new modules, such as the need for high-temperature stability of the hot-side electrical contact, for managing differential thermal expansion, for mitigating sublimation/oxidation of the active materials. Overall, they are focused on important technical barriers and are making excellent progress towards overcoming them. The final reviewer acknowledged that the project was well designed with good approach to achieve the objectives and at the same time overcome the barriers that could be encountered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer expressed that the bench scale tests was carried out to evaluate performance of various TEG modules. Prototypes TEG #1 and #2 were fabricated and tested and open circuit voltages measured. An extensive test arrangement was designed for evaluating performance and monitoring output from each TE module in the overall integrated system. Also, materials synthesis efforts were pursued. Another reviewer thought that the GM team has made reasonable progress towards a viable integration path for

thermoelectric power generation on vehicles. They have designed and built a modular, reconfigurable test-bed that can dramatically increase the speed of identifying technical issues. However, they really need to produce active prototypes where lessons learned from the test-bed are implemented, shown, proved and validated. The final reviewer felt that good technical accomplishments and progress toward the DOE goals had be realized.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers felt that the collaboration is very good. Marlow is developing the TE module; ORNL is assisting with material and thermal property characterization; Future Tech is involved with TEG system development; and UNLV is pursuing efforts with computational materials development. It would be useful to provide a better linkage between the materials simulation and synthesis efforts to show greater value to the material simulations. The second reviewer noted that the GM team has partnered with the flagship thermoelectric module producer in the United States, which is fantastic, and should dramatically simplify eventual plans for production. Marlow has a long track record of excellent performance, and have proceeded up many learning curves.

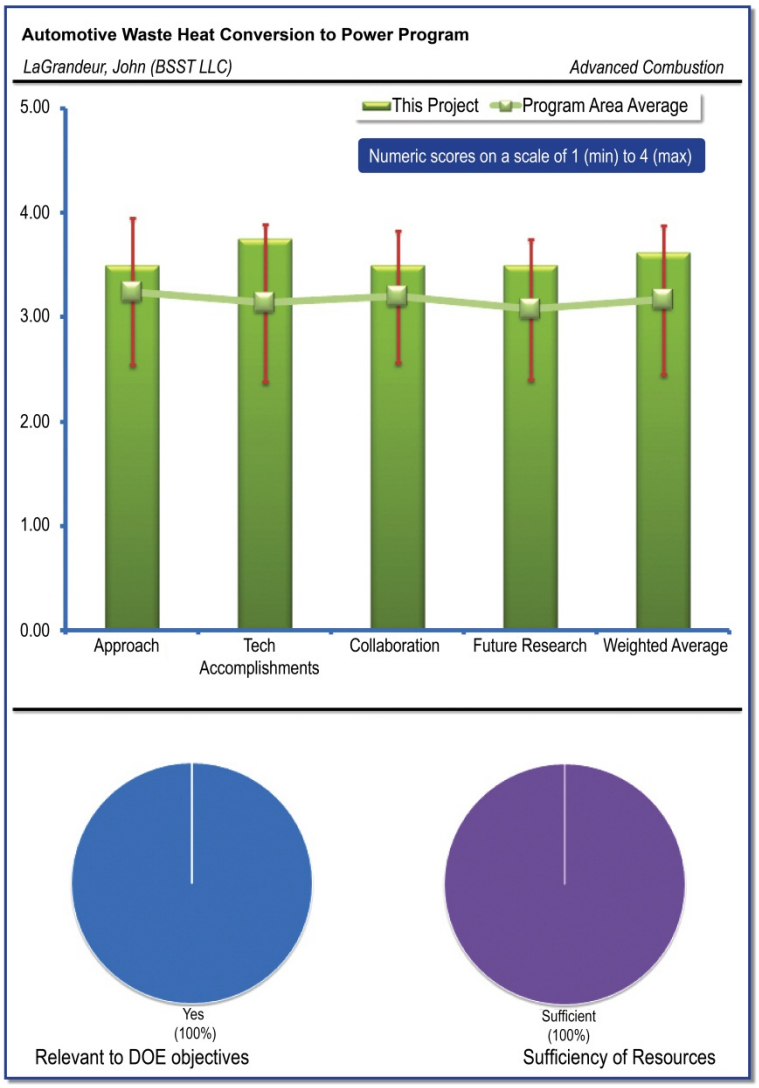
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer observed that since the project has apparently ended, the future work is based on proposals pending. The proposed tasks are reasonable for follow-on work, as they would include further work with skutterudites, assembly of new modules, and dynamometer tests. The PI should endeavor to work out a timeline for full integration of a TE system into a product line. Another reviewer felt that their future plans are excellent, in that their next plan of action is to transition from the legacy bismuth telluride technology into the more relevant skutterudite devices. It cannot be encouraged more highly to increase the rate of progress on the work. There appear to be significant challenges that will be encountered and progress needs to be faster. The final reviewer noted that the proposed future work is good and clearly demonstrates that the work plan can mitigate risk.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer noticed that from the budget figures given, it seems that DOE has invested more than GM. The reviewer felt that this may not be the optimal situation, as presumably GM will derive profit and develop a competitive edge if successful, and that GM management should see the wisdom of thermoelectric and contribute a greater share. The second reviewer asserted that GM appears to have adequate resources to complete the tasks, and address the issues. If one area deserves a plus-up of funding it is to the Marlow partner, because the main issues that will be encountered are those at the Marlow level. The main stumbling blocks going forward are device-related, so it would seem prudent to allocate more of the present funding towards Marlow.

Automotive Waste Heat Conversion to Power Program: LaGrandeur, John (BSST LLC) – ace051



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall, the reviewers agreed that the project fully supports the overall DOE objectives of petroleum displacement. The first reviewer felt that this is a very relevant project by its development of a circular TEG module for waste heat recovery. The material selected is skutterudites, and the PI has developed a range of testing and fabrication activities. The reviewer also noted that the TEG module is very novel. Another felt that waste heat recovery is clearly needed to meet fuel economy targets set by DOE. The third reviewer asserted that the BSST project for reclaiming waste-heat strongly supports the DOE objective for reducing fuel usage on vehicles. This reviewer stated that their strategy is to produce electricity for on-board use from the waste-heat, thereby eliminating the need for an alternator which adds unnecessary mechanical load to the engine.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer pointed out the broad-based approach is to improve the manufacturability of TEG systems for TE engines. A novel circular TEG was developed and fabricated which facilitates attachment to a cylindrical surface. Apparently, close tolerances are needed to reduce contact resistances between the TEG elements and the cylindrical surface and maintaining contact pressure is crucial to retard degrading performance. This reviewer also acknowledged that much of the effort over the past year involved fully characterizing the cylindrical TEG, no doubt a crucial effort for its long term reliability. Another reviewer asserted that this is an innovative design and practical implementation strategy. Although there have been setbacks due to manufacturing issues, many technical barriers which require invention have been managed well. The third reviewer believed that the BSST approach builds on their numerous significant innovations. The project team employs their "Y" device design for improved thermal and stress management. The reviewer pointed out that one design they may want to reconsider is the cooling pipes (bellows) between neighboring devices, which would seem to add significant complexity and perhaps reduced production-ready technology. One of their principal issues is interfacial contact resistance and they have a well-considered path to understand and address that. The final reviewer emphasized that the project has a good approach to achieve the objectives and at the same time overcome the barriers that could be encountered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer noted that a thorough set of tests were carried out to understand the role of interfaces on TEG performance. It was shown that the electrical interface resistance has a strong effect of power output. Much of the effort seemed to have been devoted to

diagnostics to probe the role of heat transfer between the ring and TE engines. It was found that tighter tolerances are needed to reduce contact resistance. The method of assessing contact resistances was unclear. Some of the results are self-evident (e.g., effect of power output on thermal grease thickness), the documentation of which is nonetheless very important. This reviewer also pointed out that the (understanding) reliance on tight tolerances raises the question of product costs, as tighter tolerances will presumably increase fabrication costs. A number of design changes were identified to improve performance. The hot and cold side heat transfer exceeded expectations, while the role of interfaces is currently a work in progress. A reviewer noted that the potential target for production is 2018 with projected volumes of 100K/yr. Another reviewer expressed that significant progress has been made to produce a viable thermal electric subsystem for an under floor exhaust system. The novel design is packageable, and although there have been assumptions and manufacturing issues which have reduced projected performance from 1kW, the progress is still outstanding. Samples are being packaged for vehicle testing at OEMs with a power range of 300-500+ Watts. The reviewer pointed out out that the vehicle TEG system on-cost is targeted to be 500 Euro with 30% material cost, including 100 Euro Valve, 50 Euro Can, 50 Euro Power electronics, and 50 Euro Other. The fourth reviewer maintained that BSST has done an excellent job of integrating their novel device structures into a working prototype (test-bed). They have shown reasonable power generation, and have proposed excellent "countermeasures" for mitigating future risk. It was felt that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers acknowledged that the partnerships include Ford and BMW, JPL, Caltech and NREL, and that the collaboration effort is excellent. The second reviewer specifically pointed out the excellent use of OEM involvement and material suppliers to solve some technical issues. Ford and BMW modeling contributions were also noted. The final reviewer emphasized that BSST has assembled an excellent team who seem to have good collaboration. And although there is some redundancy, that helps reduce risk. One issue is that they are planning to transition to skutterudite materials, which seem to offer mammoth technical challenges, including differential thermal expansion, sublimation, oxidation, and issues with the stability of the hot-side contact.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, the reviewers felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The first reviewer stated that the future work will involve dynamometer testing, and installation and testing in a BMWx6 and Ford Fusion. Additional work is recognized to improve TE materials scale up. It might be prudent to consider a cost analysis of the TEG system being developed and some form of accelerated reliability testing. Also, thermal interfaces are as important as electrical interfaces. Some means to characterize the thermal contact resistance would be prudent to evaluate performance and thereby suggest design changes if needed. The second reviewer felt that the project had very good plans for additional materials research, vehicle development and commercialization. The reviewer also pointed out that if the results continue to be this impressive, private investment funding should soon overtake the DOE funding to commercially implement this technology. Another reviewer asserted that BSST has proposed future work that adds value to the DOE program, and offers a path towards production viability. However, the technical barriers along that path are severe. The track record of significant innovations from BSST would seem to be well-suited to produce important solutions to these barriers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer noted that the costs are reasonable for product development, with DOE contributing about 60% and BSST about 40%. Another reviewer labeled the resources currently sufficient and necessary; however, based on current track record of success, additional funding is not expected to be required in the near future. The third reviewer stated that BSST appears to have adequate resources to complete the tasks, but increased funding may be warranted because of the significant future technical barriers.

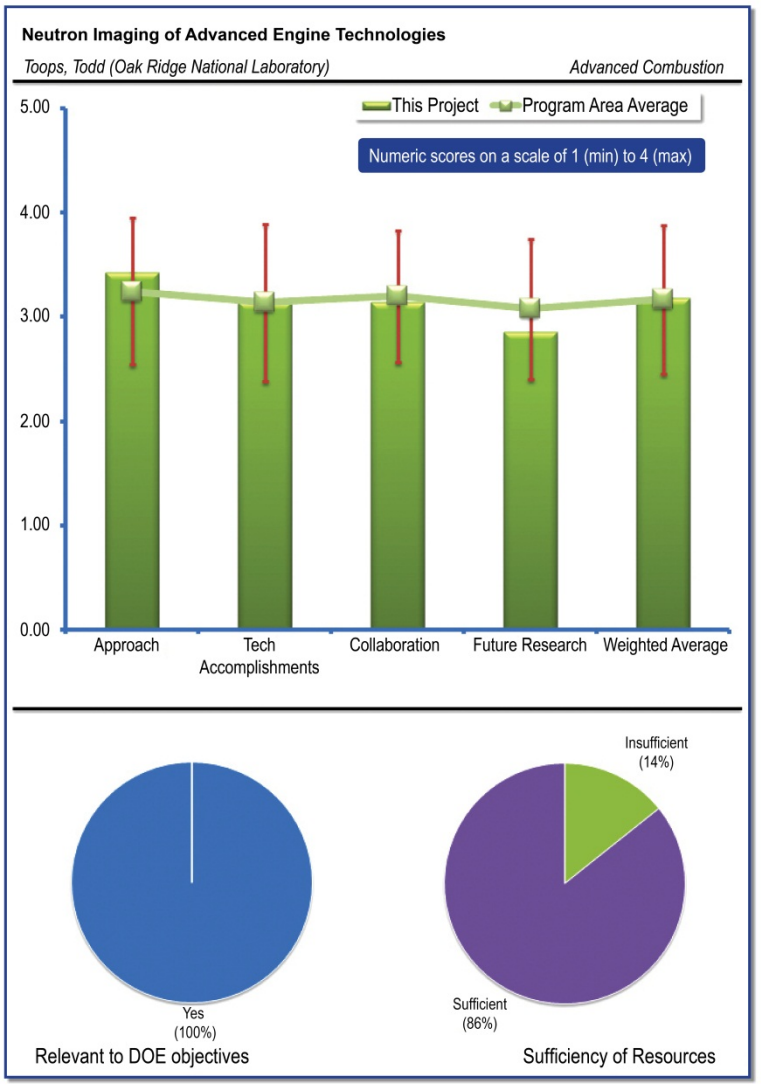
Neutron Imaging of Advanced Engine Technologies: Toops, Todd (Oak Ridge National Laboratory) – ace0052

Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that managing DPF regeneration and efficient EGR cooling are significant contributors to fuel saving. Another said that this project was an application of a unique DOE capability to a problem of interest. The third reviewer noted that this project is focused on developing and demonstrating a tool for improving PM filter design and regeneration; though this may have a minimal to small impact on vehicle fuel economy it is important project for engine suppliers and their suppliers for improving future engine system designs and also exploring combustion modes that lead to higher thermal efficiency while possibly producing more PM which must be filtered/regenerated in a PM filter. The final reviewer acknowledged that the project addresses barriers to improve regeneration of DPF's to enable diesel engine combustion to decrease fuel economy penalty.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that the testing was somewhat scattered, but that it seems appropriate for such an exploration of possibilities. Another reviewer stated that this unique capability unavailable elsewhere. The reviewer also questioned if the results could be quantified rather than evaluating quality of image. The third reviewer felt that the project's strength is the development of an advanced diagnostic tool for PM filters, EGR coolers, and possibly fuel injectors. There is still much to learn about PM filter reliability, performance, and regeneration using this new tool. The final reviewer explained that this uses a nondestructive neutron imaging technique to study the inside morphology of particulate filters and that a tomographic technique is employed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers felt that it was early in the project to evaluate any real accomplishments. However, the second reviewer would like to see better connection to needs of experimental combustion development work. Another felt that these were good initial results, but had yet to see something really new that compels use of this method. The fourth reviewer acknowledged excellent progress for new project. However, the reviewer thought the project needs to continue to scope out applications of this technique. Another asserted that the initial results generated from this tool are very promising toward studying PM filter soot loading and regeneration on a near real

time basis. The real value of this tool will be realized in the future. The final reviewer pointed out that the potential to visualize soot layers with increased resolution has been demonstrated. Model as standards have been imaged. Determined that Ca-based ash is difficult to image. These imaging techniques are also being applied to EGR coolers.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer mentioned that the DPF and EGR cooler manufacturer involvement could be increased. Another pointed out that there were interactions with multiple industrial partners. The third reviewer expressed that the PI has collaborated with other parts of his organization, a catalyst supplier, and engine suppliers during the development of this new tool to initially assess its visualization capability. The final reviewer asserted that appropriate partners like neutron scientists, beamline access, and the Technical University of Munich, which has right expertise, exists.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer emphasized the need to identify reasons why this must be used and verify that what is seen here is not different from conditions in-situ (the method is not portable!). The second reviewer expressed the need to make sure this does not become redundant with the ANL APS. Another reviewer felt that based on funding support, the PI may want to focus on one or two applications versus three for this new tool. Possibly focusing more on PM filters and EGR coolers would be most appropriate versus fuel injectors. The final reviewer pointed out that the PI will look at pressure drop characteristics with regeneration, will apply the technique to fuel spray imaging; the potential exist to visualize fluid flowing in passages. The reviewer also noted that it looks like ultimately this technique can be used to study the interaction between fuel injection and air flow within a metal engine cylinder, which will supplement data from optical engines.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated that the resources were acceptable for the exploratory phase, and a second reviewer suggested expanding to fuel injection, EGR coolers, etc. A third reviewer pointed out that this appears to be an adequately funded project as long as partners continue to supply the PI with test pieces.

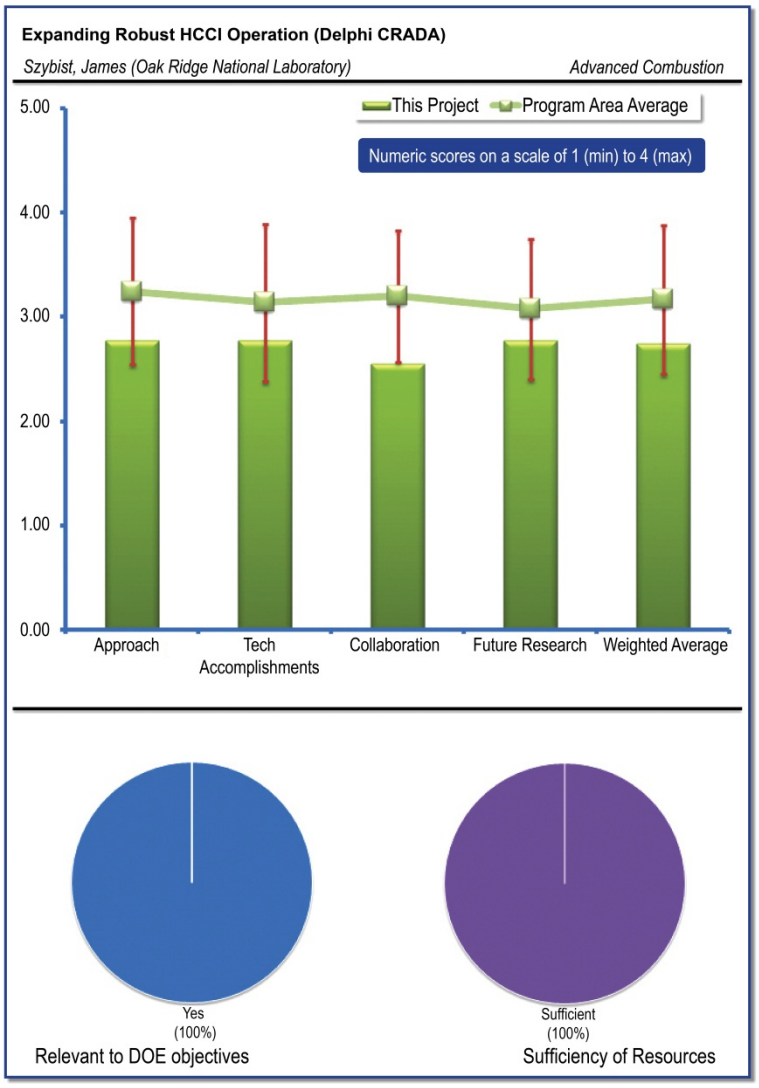
Expanding Robust HCCI Operation (Delphi CRADA): Szybist, James (Oak Ridge National Laboratory) – ace053

Reviewer Sample Size

This project had a total of nine reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer acknowledged that engine modeling and control are important adjuncts in the development of high fuel efficiency engines, which will in turn result in a reduction in petroleum usage. The second reviewer felt that the low NOx, high efficiency combustion mode is relevant. Another reviewer stated that this is one possible approach for achieving objectives of reducing fuel consumption. The third reviewer asserted that expanding range of successful HCCI operation would improve fuel economy and thus reduce petroleum requirements. Another reviewer added that controlling and extending HCCI operation is necessary to move toward production. The final reviewers noted that this project addresses application of HCCI technology closer to production concepts with a major supplier and that this project addresses the controls challenges of HCCI combustion concepts.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought the approach seemed well-thought out and systematic. However, this reviewer pointed that the use of GT-POWER for fully transient engine control is questionable – it was never designed for that purpose. The second reviewer noted that this project may represent an important step toward eventual implementation of HCCI combustion in light-duty engines. The only concern is that elements of the project have the appearance of a calibration exercise, with little emphasis on instrumentation for advanced understanding. Working to integrate this project with other modeling and fundamental combustion activities is important to the success. Another felt that the approach of coupling experimental data and modeling makes sense. The fourth reviewer pointed out that this was an overall good approach, but it is strange to start this work without cooled EGR and multiple injection capability. These should be fundamental considerations for HCCI work. The fifth reviewer believed that the objectives were limited, but were deemed appropriate for the CRADA purpose. Another reviewer warned not to discount the importance of NOx values since they directly impact the frequency of the NOx aftertreatment regeneration and therefore the overall cycle efficiency. The final reviewer felt that this project does not seem to be starting with a well-developed HCCI base engine. The minimum net indicated fuel consumption reported is very poor, about 250 g/kWhr, which is well above typical HCCI levels. The combustion constraints of ringing index below 7 Mw/m2 and COV of IMEP below 5% are too liberal and do not represent a practical engine. The reviewer also questioned the point of developing a control system that seeks to expand the robust HCCI operating range of a substandard base HCCI engine. By the time the

base HCCI engine is developed and improved, time would have run out and not much time will be left to develop a meaningful control system.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that there has been fair progress to date considering the project has only recently been initiated. The second reviewer stated that more comparison to current SI combustion would better frame efficiency opportunity. ISFC's seem higher than expected for HCCI. Another maintained that the progress to date using the flexible HVA system has yielded a good baseline understanding of the capability of the hardware. However, better definition/alignment of the ISFC and IS emissions goal is needed. For example, the 8-9-10 g/min fueling rate does not seem to correlate with the WWMP targets of other programs. The fourth reviewer acknowledged that the results are interesting, but not clear from results to date whether these approaches (vs. other approaches) will lead to significant changes in HCCI operating range. Other reviewers felt that the results were good within the limits of hardware and that they were presumably useful for the CRADA partner. The seventh reviewer needs to understand what success looks like. Stated goals are HCCI in production like environment. The evaluator questioned if this will include an assessment of environmental and customer noise factors. The final reviewer stated that as mentioned earlier, the HCCI engine being used for study is substandard. The net ISFC numbers reported are poor. The response to start of injection (SOI) timing for NVO injection has already been reported in the literature and is not new information.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers mentioned that the only collaboration mentioned is a CRADA with Delphi. The first reviewer believed that collaboration with Delphi offers assurance that any ideas or technology developed under this project should at least be considered for production. However, another reviewer felt that the collaboration with Delphi is valuable, but collaboration with other more fundamental HCCI programs is recommended. The third reviewer stated that it seems like Delphi should have been involved to provide more capable fuel injection system. Another felt that the project was outstanding with one partner, but only with one. Another reviewer pointed out that it seems to be related to Steeper's work at SNL and that the two projects would benefit by working more closely together. The final reviewer expressed that Delphi is not an expert in base HCCI engine technology and without a properly designed HCCI combustion engine, or without knowing what results to expect from and HCCI engine, this project may not meet its goals.

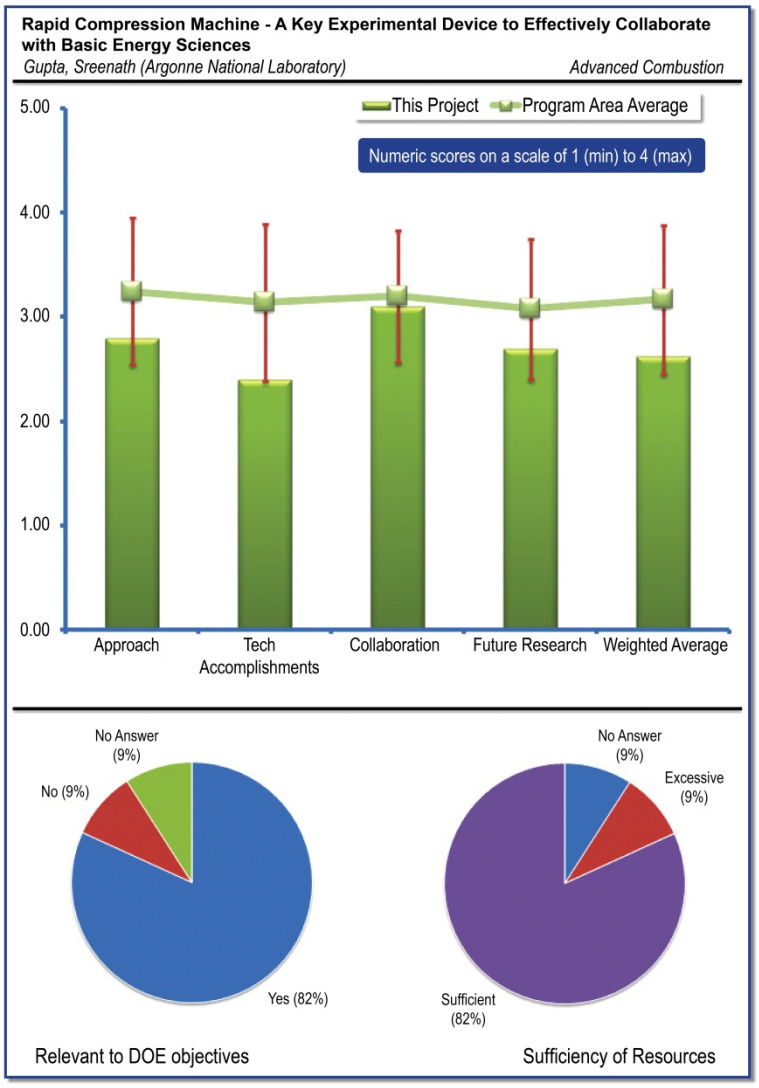
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer asserted that the future plans to expand the limits of HCCI are good, but the engine operation is highly constrained by emissions levels, required engine efficiency, knock limits, etc. Also the use of GT-POWER for transient, multi-cylinder engine operation is questionable. The second reviewer agreed by stating that the future research proposed is certainly reasonable, but may benefit from some stretch goals being laid out for the program for ISFC and emissions. Another pointed out that the CRADAs limited objectives will be served by the plan. The fourth reviewer would like to see more explicit goals shown with load range expansion. The final reviewer felt that so far, this project does not seem to have the in-house expertise to develop a typical HCCI engine, let alone expand its robust operation. The future plans simply mimic what has already been demonstrated. The project should focus on first being able to execute what has already been demonstrated in the open literature.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Respondents agreed that the level of funding is appropriate to continue the collaborative work of this nature with industry.

Rapid Compression Machine – A Key Experimental Device to Effectively Collaborate with Basic Energy Sciences: Gupta, Sreenath (Argonne National Laboratory) – ace054



Reviewer Sample Size

This project had a total of 11 reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer agreed that fundamental studies of fuel combustion kinetics are important for the development of fuel efficient engines. The second reviewer pointed out that understanding the fundamental combustion chemistry of conventional, unconventional, surrogate and model fuels under conventional and advanced combustion conditions (elements of the grand challenge from the Basic Research Needs [BRN] Workshop on 21st Century Transportation Fuels) requires detailed combustion data. This project will add to the capacity to generate such information, and thereby will contribute to the data needed to generate a predictive capability to design the engines of the future. With that capability, higher efficiency engines can be developed more efficiently. Another felt that there is certainly new information to learn via Rapid Compression Machines, but it is not well explained exactly the void in past research this work is focused on. The fourth reviewer asserted that improved fundamental understanding of combustion kinetics should enable improvements in engine design/operation with improved fuel economy. The fifth reviewer stated that this project has no added value, as it duplicates (many) other setups that have existed for a long time. See for example presentation # ace019 for a variety of RCM's that have been used for years prior. The evaluator added that even if this "new" mouse trap brings additional features, it can hardly qualify for OVT funding. The evaluator continued by stating that it indirectly support DOE objectives by providing others with ignition data on various fuels of interest that could be candidates for advanced combustion modes in efficient CI or SI engines. The final reviewer noted that this project enhances the predictive capability of in cylinder combustion performance and emissions of advanced combustion concepts.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that development and use of a rapid compression machine will provide useful chemical and combustion kinetic information for the development of high efficiency engines operating on a range of fuels. Another reviewer confirmed that using an RCM is a practical choice since throughput of fuels and rate of generation of data, as well as ease of simulation, is good. The reviewer also noted that it provides an additional level of experimental data between shock tubes, flow reactors, and engines. It will have two methods for getting fuel into the RCM, heating for low boiling point fuels and a nebulizer for high boiling point fuels. The key feature is having high pressure capacity in the RCM and enabling delivery of higher boiling fuels. The third reviewer acknowledged that the approach of using RCM is good, but appears to be tremendous overlap with efforts at other organizations, such as the RCM efforts at University of Michigan (very similar/identical fuel components to those already studied or in progress) and

chemical mechanism validation at LLNL. Another reviewer noted that it should be made clear why another RCM is needed and what will be done that others cannot or do not do while the fifth reviewer questioned if the device unique to the national labs and/or universities. Another reviewer mentioned that the PI has spent a fair amount of time considering fuel ranges and operating conditions that the RCM must handle in the future. This approach lead to design modifications of the RCM which will pay-off in the future due to the relevant boundary conditions the RCM will address for various fuels. The final reviewer pointed out that this RCM facility seems like a duplicate of other existing RCM facilities. The claim is the high pressure capability is unique. However, at least for automotive applications, pressures up to 365 bar are not necessary. The ability to get a uniform fuel-air mixture with the nebulizer approach seems uncertain. The ability to get valid samples with the piezo fast-sampling approach seems uncertain.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers were of the opinion that the technical accomplishments are good although overall progress is slow. The second reviewer noted that the PI is working on a redesign of an existing RCM and has mostly completed auxiliary systems to get fuels into the RCM and rapid sampling and imaging. The reviewer also stated that they will perform tests on both low boiling point (BP) fuels and some high BP fuels in this calendar year. However, one reviewer did note that there were no data yet but another noted that they are busy with hardware design and experimental setup, only with barely any accomplishments. The fourth reviewer pointed out that although much effort has been spent designing and developing the RCM hardware, the major accomplishments for this project lie in the future. It was also indicated that there has been some delay due to equipment damage, however, work has continued on other hardware such as the fuel air aerosol generator and the fast sampling system.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer pointed out that participation in the RCM group is a good development to allow sharing of information on the machine hardware design and operation. The second reviewer noted that strong university involvement is a valuable component to include for such work. The reviewer also added that it may be valuable to include collaboration with NREL or a U.S. Department of Agriculture (USDA) lab to provide more interaction with those who are developing emerging biofuels. However, another reviewer indicated that the project is focused on developing an experimental capability at a selected location and thus does not include much collaboration beyond support from those at other institutions who helped the PI develop RCM hardware. The final reviewer agreed by adding that appropriate advice and know-how has been obtained from other labs and institutions.

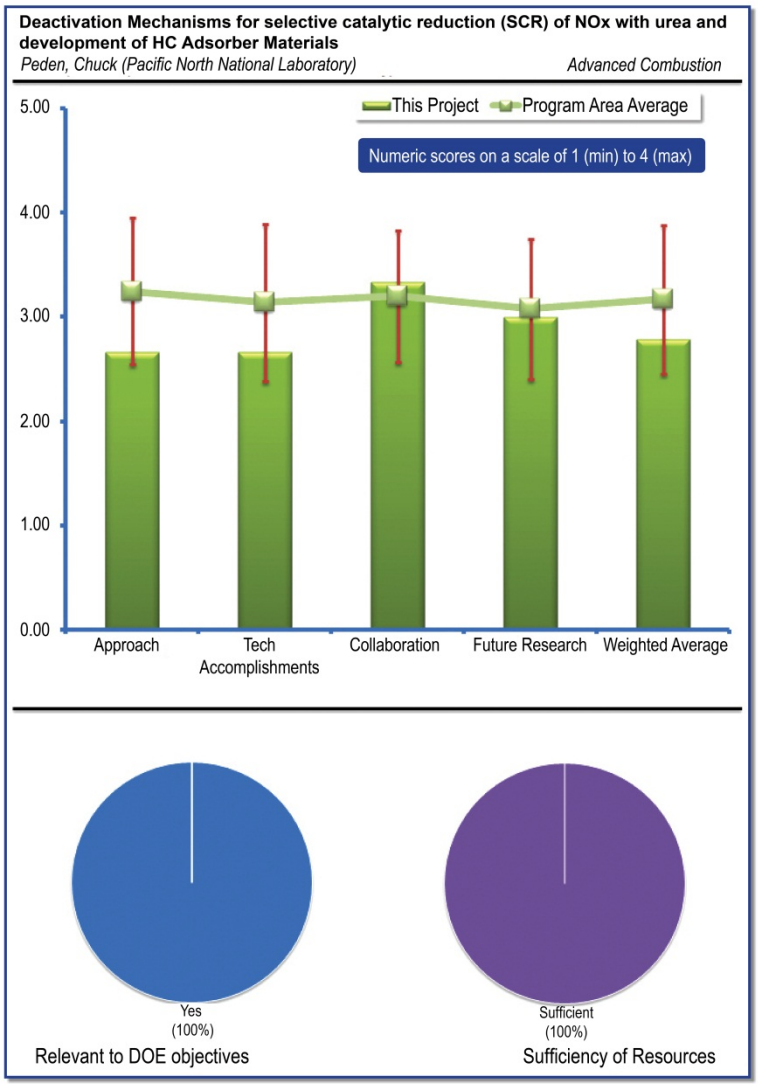
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers asserted that extensions to alternative fuels including biodiesel should provide useful information in engine design and emissions studies. Another noted that plans to study various surrogate fuels to complement other basic studies in shock tube apparatus will generate data to supply to LLNL kinetic model development activity. The third respondent's only suggestion was to include gasoline and diesel fuel (DF-2) as fuel candidates in future RCM studies and that the latter is a good baseline case given the reasonable amount of ignition literature on DF-2. The final reviewer acknowledged that the limitations in the RCM approach to generating chemical kinetic data seem to be recognized well and methods to overcome them have been planned.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Some reviewers thought that it was a healthy funding profile, and support from BES as well and overall seems appropriate. Another reviewer stated that this has been a well-supported effort to bring new capability to the PI's institution that hopefully will pay off in the future. The final reviewer indicated that the budget is quite generous compared to the progress to date.

Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials: Peden, Chuck (Pacific Northwest National Laboratory) – ace055



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that this project supports petroleum displacement, though somewhat indirectly. Identification of SCR catalyst degradation mechanisms and laboratory aging protocols will help speed testing of emissions-compliant high-efficiency diesel engines. The second reviewer confirmed that extended performance of SCR systems are needed so in-use vehicles keep operating with high-NOx high-efficiency calibrations as they approach full useful life. We need to learn more about the fundamentals of these degradation mechanisms. Another noted that HC absorbers are emerging as a critical cold start technology for meeting LEVIII regulations. Much engine measures are used to overcome cold start HC emissions. These resources might be better spent on fuel efficiency which these studies facilitate. The third reviewer included that SCR catalysts and HC traps are currently necessary to enable use of Diesel powertrains in the USA due to stringent NOx regulations. It is unlikely that this project will have significant direct impact on DOE goals for petroleum displacement because 1) SCR injection systems are still needed and too expensive for passenger cars so durability improvements will not significantly increase diesel use and 2) alternative NOx reduction techniques requiring dual fuels or low temperature combustion have not been demonstrated to improve realizable thermal efficiency require invention and may point to a need for other types of research beyond HC absorbers.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer, after noting that this project is outside of this reviewer's area of expertise and that comments should be considered accordingly, stated that it seems that in the absence of complete understanding of the chemical, mechanical, and possibly other aging mechanisms involved, there is a risk of getting misleading results when comparing catalysts that are aged for hundreds of hours in an engine aftertreatment system with catalysts that are subjected to an accelerated aging process for a few hours in a lab. Unless the investigators know all of the relevant parameters to consider, the lab-aged catalysts may mimic some aspects of the degradation in engine-aged catalysts but produce different behavior in other aspects. The second reviewer approved of the approach of taking OEM inputs and previous work and then elaborating and fundamentally explaining observations and then getting into public domain and said this method is excellent. The reviewer also added that the fundamental approaches are noteworthy, such as hypotheses and tests to support or refute and simplify and focus on mechanisms, which were very nicely done. Another reviewer indicated that with the basic

premise defined to identify and characterize deactivation mechanisms of SCR catalysts, and to evaluate HC absorber technologies, the activities are implemented reasonably well and promising formulations and deactivation (failure) mechanisms are being evaluated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer began by noting that the project started Februrary 2007 and is scheduled to end FY12, so it is largely complete (HC Trap work just started last October). This reviewer went on to comment on the presenter's statement that "there is a critical need to develop realistic laboratory aging protocols that effectively simulate engine aging induced catalyst deactivation. For this, a fundamental understanding of the deactivation mechanisms is essential." The reviewer indicated that this sounds like a reasonable premise, however the reviewer indicated that it does not seem like they have gained a full understanding yet. As best as this reviewer could tell, they have identified some effects of catalyst aging but are only beginning to understand the underlying causes. The second reviewer expressed that sulfur dioxide (SO2) versus sulfite (SO3) impacts on CuZ needed a little more fundamental understanding. This reviewer also questioned how this helps compositional development. Another reviewer thought that hydrothermal aging of SCR was "classic work!" The reviewer added that they could run some experiments to quantify, develop a hypothesis, and test to confirm. The reviewer also noted very nice fundamental insight that may deliver new approaches. The reviewer also felt that the HC absorber was very interesting and valuable building of fundamental understanding which included pointed results that address needs. Another reviewer commented that there was no significant breakthrough and only moderate progress. This reviewer summarized the testing results as 1) strong interaction between Cu and Aluminum (Al) in the aged catalysts that show good high-temperature NH3-SCR performance and 2) lower silicon (Si)/Al ratio zeolites appear more effective for HC adsorption and desorption.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

With respect to PNNL and Ford only, the first reviewer deemed the collaboration probably adequate, but might be more effective with more people involved. This reviewer also noted that later it was revealed that PNNL is pursuing other SCR studies with GM. IP concerns necessitated keeping the projects separate. The second reviewer indicated that the project team is hooked up with the OEM leader on zeolites and SCR-Ford. This reviewer added that they are obviously quite involved and helping to guide the programs and needs and that this is a model program of OEM collaboration and the NLs delivering fundamental understanding. The reviewer also noted that the GM program has a similar objective but a very different approach and results. This is helping to build knowledge on perhaps different formulations. This will further the fundamental understanding for societal benefit. The final reviewer noted that the Ford CRADA shows support and credibility.

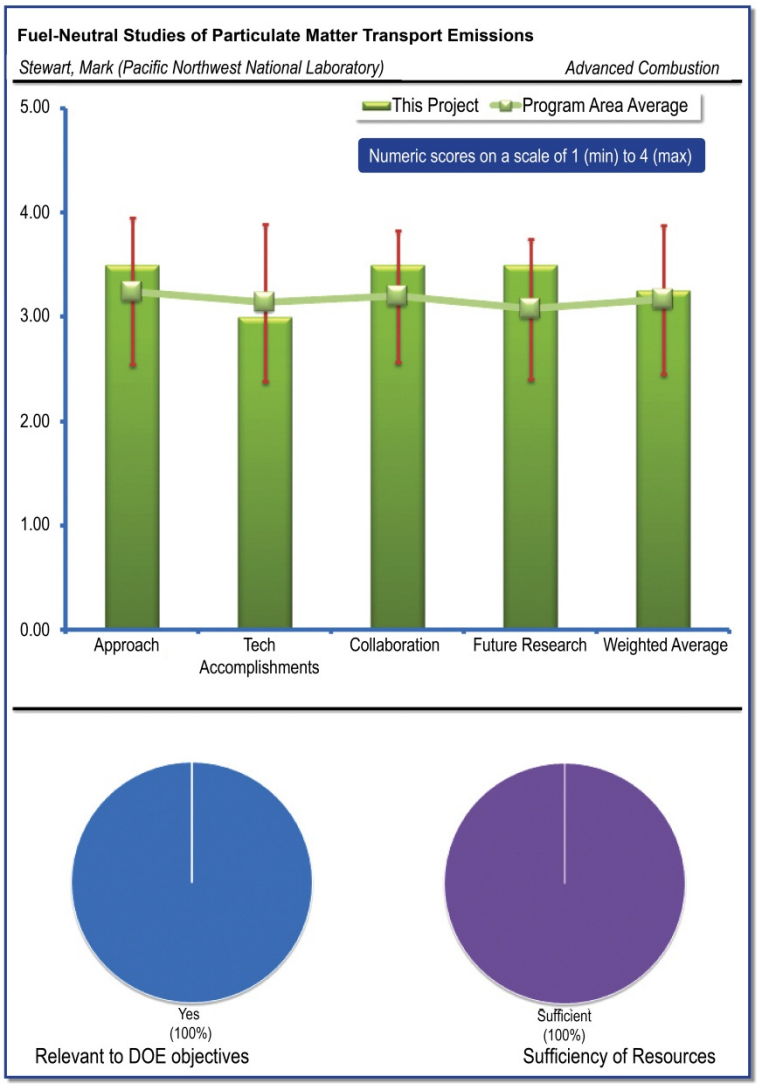
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewers felt that the proposed future research appears appropriate, useful, and achievable. The second reviewer stated that they should keep it going, adding that the team knows what is needed and how to get it. Another reviewer asserted that the fact that the "future work" is now morphing into SCR behind LNT shows flexibility for the project to react to engine technology evolution and trends, but points to only early understanding of the true need for this work.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer pronounced that the project team seems to have made notable progress with relatively modest resources. Other reviewers agreed that the team is very efficient in delivering the fundamental understanding. Adding that the levels of funding, along with that of the GM program seems adequate to add value.

Fuel-Neutral Studies of Particulate Matter Transport Emissions: Stewart, Mark (Pacific Northwest National Laboratory) – ace056



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer confirmed that advanced DISI engines are expected to become a key higher efficiency, low cost powertrain in North America. Health effects associated with DISI particulate is important as fuel and engine hardware evolve. The second reviewer noted that it is still expected that gasoline engines will be the primary engine for the foreseeable future. Lean gasoline has the potential for significant fuel economy benefits. This work gives us a significant step into identifying needs for particulate filters in the DI gasoline engine arena.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent felt that the project had excellent equipment for the job and that it builds on demonstrated experience to expand understanding in an important new area. Another reviewer noted that as always the work is quite good and state of the art. However, at present this reviewer saw no connection with modeling and questioned how it was going to be solved.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers noted that work is moving forward well and that it covers a very good range of conditions. However, one reviewer did not see a distinction between soot cake and no soot cake filtration in this study.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer liked the collaboration with GM and ORNL. Another noted that the collaboration is quite good, adding that incorporating the input from an OEM is very important and the group selected from the OEM is quite knowledgeable. However, as noted above, this reviewer thought there seems to be no modeling collaboration.

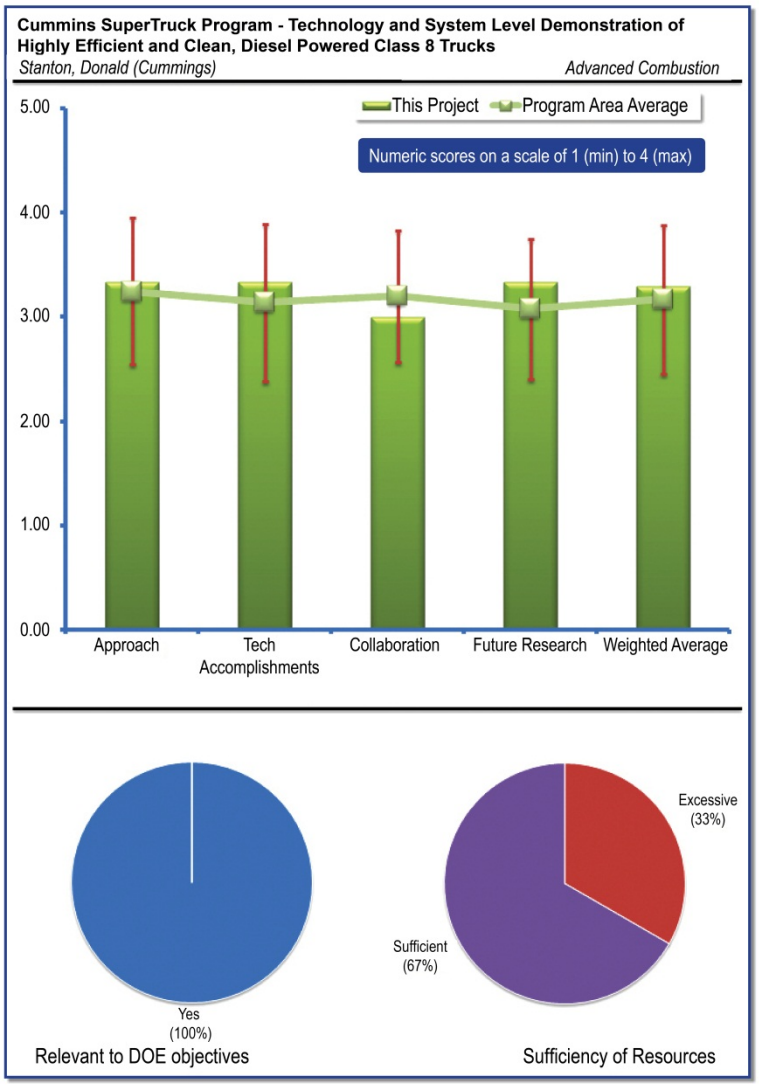
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer confirmed that the future work broadens our understanding of particulate from a NA engine with a range of fuels to complement previous studies with European and earlier generation DISI engines. The second reviewer agreed that work on the soot oxidation kinetics is needed. Especially since the data seems to indicate that the character of the soot particles is different than what is observed from diesel engines. However, this reviewer noted that some aspects of this work overlap with the project of John Storey at ORNL and the reviewer would like to see more coordination so that work is not duplicated.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer pointed out that the high level of collaboration is clearly leveraging the resources very effectively. This reviewer also noted that it is sort of a catch-22; the more effective the leveraging, the more likely it is that the resources are deemed adequate. However, this reviewer did think that some resources have to be allocated to the soot production modeling.

Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: Stanton, Donald (Cummins) – ace057



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that the overall objectives of this project are to improve the efficiency of a HD engine to > 50%, and that of the total tractor trailer by 50% over the current efficiency. Such an improvement while being overly optimistic does provide a stretch goal for fuel efficiency. With a significant portion of fuel being consumed by Heavy-Duty trucks, such increased fuel efficiencies can translate to significant fuel savings. The second reviewer indicated that the project is directly relevant to major DOE fuel efficiency (FE) targets and Recovery Act targets. The final reviewer thought that the program aims at the DOE Supertruck goals, as well as the ARRA goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer confirmed that the PI acknowledges a multi-pronged approach in achieving the > 50% engine efficiency and a 50% improvement for the total vehicle. However, the improvement in one aspect could negatively impact another: For example, use of WHR could improve engine efficiency but adds to the overall weight. With only projections provided so far (as opposed to test results) it was difficult to judge the net efficacy in able to meet the objectives. The second reviewer thought that the projections of FE improvement are amazing and provide a solid plan for vehicle integration and commercialization of many advanced technologies. Another reviewer felt that the comprehensive approach is projected to exceed the target goals for efficiency improvement. The approach seems to be heavily dependent on significant improvements in SCR aftertreatment efficiency to handle increased engine-out NOx emissions. This may be achievable for demonstration purposes, but may have cost roadblocks for commercialization. This reviewer added that a few of the elements are novel and will be interesting to see next year's progress, particularly the use of VVA to allow over expanded / Miller cycles / 6*8 stroke aftertreatment regen. This reviewer also thought that the details of the third generation fuel system would be interesting to reveal next year too.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

With the information shared so far (which is very little), the first reviewer felt that the technical progress appears to be on track. The PI does acknowledge three specific issues that were realized early – under hood cooling, weight gain by WHR, etc.–and provides assurance that they have been addressed. Projections are also provided for performance improvement of the tractor-trailer through

weight reduction, reduction of rolling resistance etc. Another reviewer asserted that 51% BTE by year end will be most impressive. The third reviewer noted that just completing the first year of a 4-year program, progress has been made in going from 42% BTE to 47.5% now. Reaching 50% by end of year seems achievable based on the material presented. The reviewer also added that the program will need a lot of success in SCR efficiency improvement.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer indicated that the collaborations with parts suppliers are very relevant and stand to leverage their respective expertise. However, the roles of ORNL and Purdue University are somewhat hazy; other than including them for team building, there is very little involvement. The second reviewer confirmed that the project had a solid team of manufacturers and suppliers. The final reviewer agreed that there was a good mixture of industry, academia, suppliers, and national lab. The reviewer also pointed out the heavily dependent on internal Cummins groups, which was deemed to be okay.

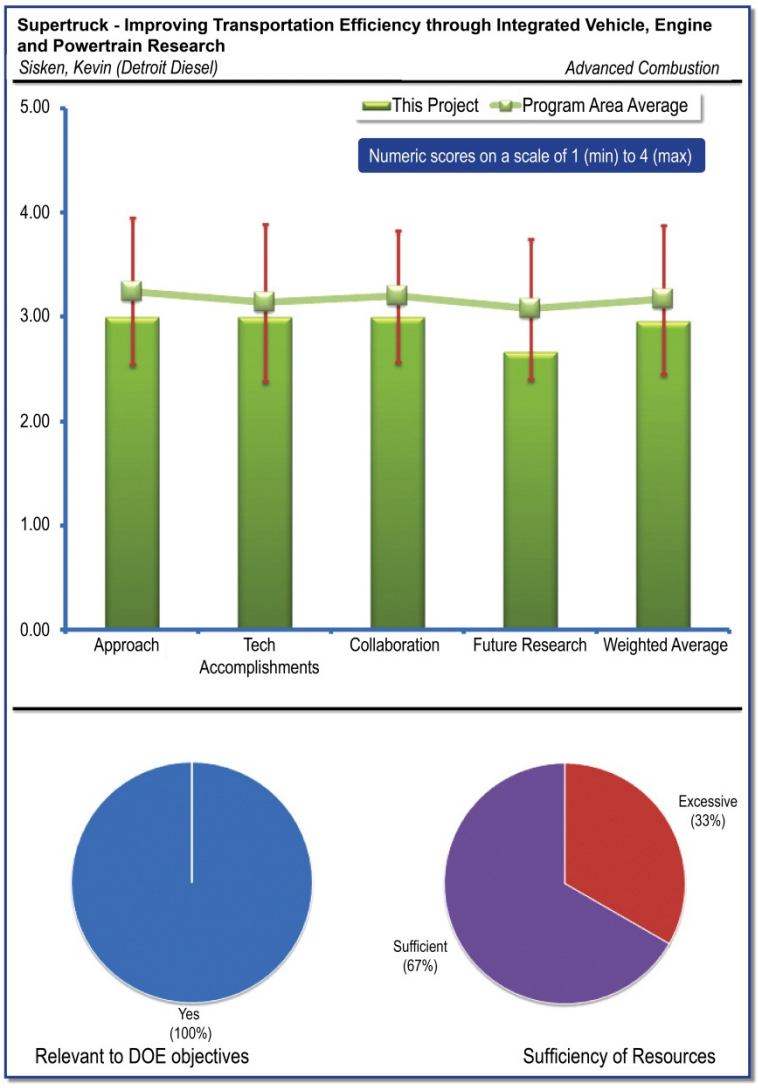
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

From the presentation, the first reviewer noted a path for project progress appears to have been identified. This being the very first year they have shown sufficient progress to be on track with the initially proposed schedule. The second agreed that a solid plan should meet objectives. The third reviewer requested more specific detail next year on the SCR and fuel system technologies that are being incorporated.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer indicated that $39M for the proposed effort is excessive. WHR and other technologies have been developed by Cummins as a part of previous efforts. While 50% performance improvement for the tractor trailer is a stretch goal, it might be worth providing a more achievable goal while keeping the funding at a commensurate level. The second reviewer saw the big program properly funded. The final reviewer was impressed with the leverage of DOE funds with >50% cost share.

Supertruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research: Sisken, Kevin (Detroit Diesel) – ace058



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that since the main objective of the program being to achieve 50% improvement in freight efficiency of tractor-trailers, it supports the overall DOE objectives of petroleum displacement. Other reviewers indicated that this has direct relevance to fuel use and the Supertruck and ARRA goals are being addressed.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer noted that a pathway for project execution has been identified, and areas for efficiency improvement – engine combustion modifications, friction reduction, WHR, reduction of pumping losses, intelligent controls and better aftertreatment – have been identified. The reviewer added that while most of them appear to lead to an improved product, additional weight due to WHR system could be an issue. For marginal improvement in efficiency, the additional cost of the WHR system may not be justifiable. Similar identification of issues and pathways for overall improvement of tractor-trailer performance is necessary. Especially, pathways for reduction in fuel consumption during idling/ or being at a rest stop are necessary. The second reviewer thought that the project had a solid approach, although noting some uncertainty on how well things are really going to work. The final reviewer felt that Downsizing/Downrating is a major element in the strategy which is good for improved BSFC, but doubted its abilities to regulated emissions. Relaying in improvements to SCR to control the higher NOx, which will take back some of the fuel efficiency gains. Controls and predictive driving route is an interesting concept, but the reviewer wonders how much is there to gain from this.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer expressed that this being the first year of the project, Detroit Diesel Corporation (DDC) has identified a number of areas for improvement and is working towards them. They have already shown improvement through friction reduction, reduced parasitic losses, and combustion chamber modifications. Another felt that it is a good demonstration so far. Others went on to point out that it is year one of a 5 year program completed and a 3% efficiency improvement will be demonstrated by end of the year. This reviewer also noted that a waste heat recovery - Rankin cycle resulting in a gain of 5% is expected. This reviewer indicated that it was difficult to understand the contributions of the other technologies being proposed, Slide 5 kind of does that, but it wasn't very clear.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first respondent pointed out that DDC is partnering with various organizations to leverage their respective areas of expertise. Especially, their partnership with MIT to identify ways to reduce friction is commendable. On the same token, their partnership with ORNL to develop a viable WHR system is questionable. Instead, a working with an industrial supplier like ORMAT (or others) is recommended. Another deemed the project mainly in house, but well supported. It was observed that it is a small team, but looks OK. No major suppliers were considered to be significant players (i.e., aftertreatment).

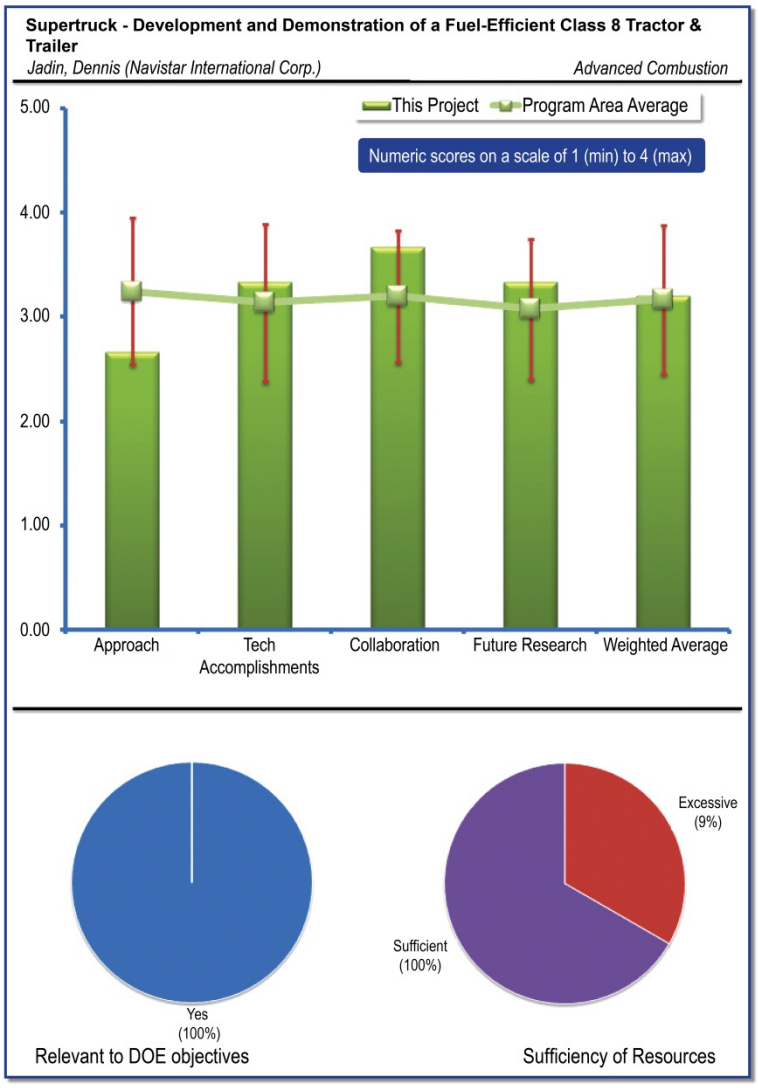
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer pointed out that not many details are provided regarding the future work to provide a fair assessment and a "fair" ranking has been issued based on past performance assuming a similar trajectory into the future. The second reviewer felt that solid plans for major improvements were established. The final respondent noted that future work was okay but the presentation was a little vague.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer thought it was a well-funded program making good progress. The second reviewer noted that it was difficult to tell much in the first year but should be able to better evaluate next year. The final reviewer stated that the allocated funds, to the amount of $40M, are excessive considering the nature and scope of work. They may have been justified in having to address the stretch goals of 50% improvement in tractor-trailer performance. More reasonable goals with commensurately matched (reduced) funding levels are recommended.

Supertruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: Jadin, Dennis (Navistar International Corp.) – ace059



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer indicated that this project aims to improve the fleet efficiency of tractor-trailers by 50% over the current levels. As on-highway trucks account for a major portion of our fuel consumption, this project supports overall DOE objectives to reduce petroleum consumption. Another reviewer noted direct relevance to DOE goals. The final reviewer noted that this project addresses technologies for 50% improvement in overall freight efficiency from tractor-trailer combination.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

From the presented material the first reviewer noted that it appears that Navistar has adequately identified the barriers and potential pathways to address them but on a second look, their approach appears ambiguous. For example, they appear to pursue PCCI and in a parallel path reactivity controlled combustion. In a similar manner, they appear to pursue both Organic Rankine Cycle as well as turbo-compounding. Instead of turning every stone, following an approach guided by sound engineering sense would be prudent. However, continued this reviewer, their efforts to improve efficiency through combustion improvement, friction reduction and parasitic loss reduction are commendable. This reviewer added that not many details are provided in improving the overall vehicle (tractor-trailer) as opposed to just improving the performance of the engine. The second reviewer indicated some uncertainty in the WHR plan and engine out NOx level. Another noted the detailed technology roadmap but was unsure of the reasoning for the optional paths and parallel paths. It seemed paths are distinctly different rather than complementary. For example, PCCI may require NOx aftertreatment whereas dual-fuel may not. The reviewer questioned whether the project team intends to down-select soon or continue on multiple paths and options and when are the decision points? The reviewer also questioned if the team expects significant recoverable energy in EGR loop when running dual-fuel mode. Exhaust temperature is normally lower for dual-fuel. This reviewer asked if turbo-machinery efficiency improvements still be there when high dilution is run with dual-fuel.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that Navistar's efforts towards efficiency improvement through combustion system development have shown progress at medium and high speeds. However, the system has shown moderate progress at low speeds. However, they have shown significant improvements in air system development, parasitic loss reduction and friction reduction. While they seem to be on track

with developing turbo compounding, their progress towards Organic Rankine cycle appears to lag behind. The efficiency gain stack up that they provide is a combination of test results and simulations. Furthermore the net system performance is also dependent on coupling of engine performance with aftertreatment system. The second reviewer deemed the project to be somewhat behind the others, but many good technologies are on the way. The final reviewer indicated nice progress and parametric study on BTE. This reviewer questioned the 4% increase in turbocharger efficiency with dual-fuel. However, the reviewer stated that the consideration of engine systems was nice and appears to be a very thorough study. The reviewer questioned if the team will include WHR if they take the dual-fuel path in the end. The reviewer thought that 55% BTE with dual-fuel is very aggressive goal and reported that dual-fuel peak BTE on a similar size engine is approximately 59% gross ITE. Bridging that will be a challenge, but not thought to be impossible.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer indicated that Navistar is partnering with various organizations in this effort to leverage their respective areas of expertise. Though they are working with Wisconsin ERC, who has the current expertise with RCCI, they are not readily acknowledged. Another reviewer thought the project seems well integrated with suppliers and partners. It was also stated that the team is great for this project and has many of the best partners in the technology areas.

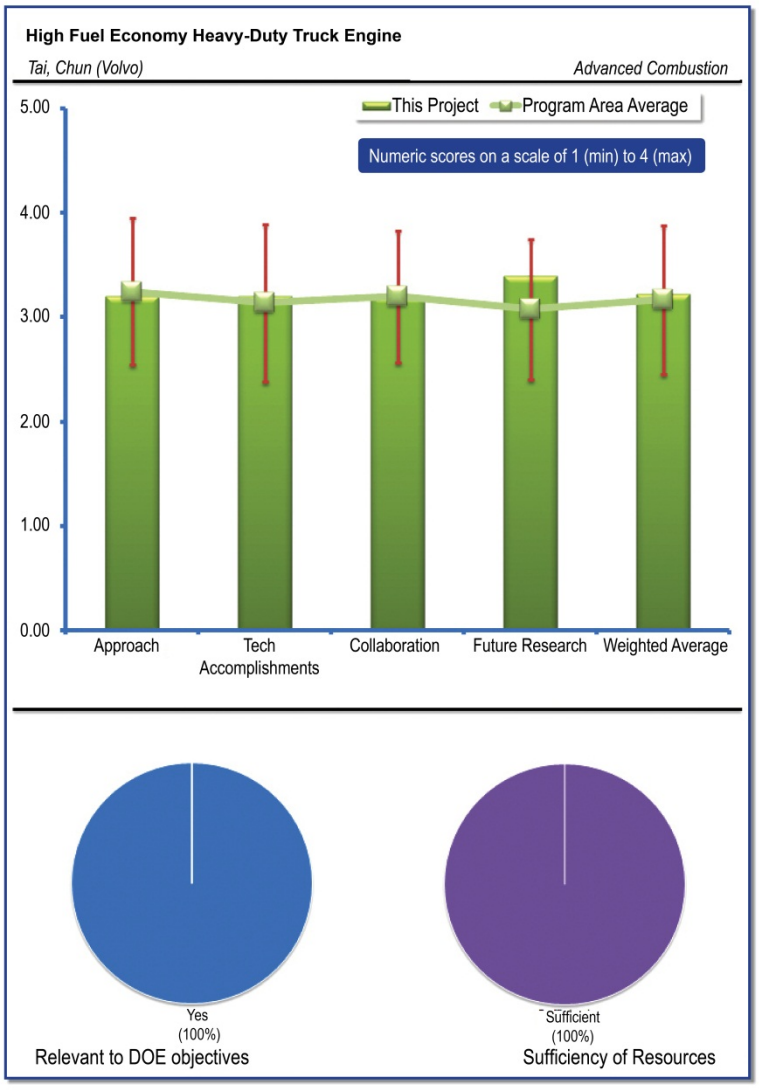
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that details are provided only for the proposed work in the rest of FY 2011 and not many details are provided for work proposed thereafter. The second reviewer expressed interest in dual fuel work. Although the reviewer was not so sure it is the answer, this reviewer was glad to see it getting attention. The final reviewer felt the plans forward were great and is looking forward to seeing a report out next year.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer felt that the $37M allocation for a stretch goal of 50% improvement over current (tractor-trailer) performance is commensurate. Another reviewer felt that the work was well funded.

High Fuel Economy Heavy-Duty Truck Engine: Tai, Chun (Volvo) – ace060



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer indicated that with an objective to improve the fuel conversion efficiency by more than 10% for long Haul (Heavy Duty) trucks, and particularly promote use of renewable fuels like biodiesels, the current project supports the DOE's overall objective of petroleum displacement. Other respondents noted that the project results in vehicle efficiency improvement and cost effectiveness. Another reviewer questioned if a biodiesel demonstration was part of this solicitation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that while the approaches for combustion system optimization, turbo-compounding, and Organic rankine Cycle follow that of other truck manufacturers, novelty of this approach is in investigating (i) mild hybridization and (ii) evaluation of biodiesels for promotion of renewables. Considering the fact that HD trucks spend very little time in transient operation, hybridization is likely to offer very little improvement. Evaluation of biodiesels appears somewhat misplaced as compared to the main objective of efficiency improvement for this project. Another reviewer felt that a good approach for the scope of the program had been used and a nice balance of simulation and test had been employed. The third respondent asserted that the project had well defined milestones and status. The reviewer also noted that the approach was nice that included optimized air/dilution handling, mild hybridization, idle reduction, and thermal energy recovery. The reviewer also commented on the experiment and simulation which goals exceeded with 14.5% improvement in in-use efficiency. The project included non-hybrid and hybrid demonstrators, bio-fuel research (which was deemed very important with increased penetration of bio-fuels), high dilution combustion for reduced NOx. This was noted even if lean NOx aftertreatment is required in the future; the reduction in PGM due to reduced engine-out levels will be cost effective. Another reviewer indicated that the project fully funded. It is finished!

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that adequate progress is being reported for the pathways identified for efficiency improvement and GHG reduction including: *Combustion/Eats Optimization* - offers 5-6% point efficiency improvements; t*urbo-compounding* - fully mechanical system with fixed speed ratio offers promise; *WHR through ORC* - through simulations optimal configuration and ideal hardware identified; m*ild Hybridization* - simulations showed hybridization to offer very little improvement for HD trucks; and b*io-*

Diesels - sufficient data generated to estimate short term impacts. Another reviewer noted that after looking in the rearview mirror, this industrial partner did "OK". The third reviewer noted that the project had beaten the expectations. The fourth respondent expressed good integration with hybrid vehicle but was unsure if there were any specific milestones this program was supposed to achieve. Another reviewer noted that the project is very near completion with goals met and there is a no-cost extension to clean up a few details. The Rankine system will continue to be developed and eventually on-vehicle. The reviewer added that the accomplishments appear consistent with plan and results to-date show original goals were exceeded by Volvo. The reviewer was interested that the mechanical turbine coupling was most efficient and questioned what the barrier losses for electromechanical were. This reviewer also noted a nice Rankine simulation and design and questioned if the piston expander has an advantage over scroll expander, noting that both can handle a small amount of liquid water.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers agreed that the team is comprised of entities with unique and needed expertise. Another reviewer noted that the PI used Ricardo, internal organizations, and academia to help out. The fourth reviewer noted that the Rankine system was developed with Ricardo, University of California, Los Angeles (UCLA) and biodiesel work was collaborated with Penn State University.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer indicated that the contractor promises to complete the remaining activities to wrap up this effort by end of FY2011. This reviewer pointed out that in the overview slide (pg.2) the project is projected to end by Oct. 2011, but on pg. 18, it is stated that the promising technologies will be integrated into demo vehicles in 2012. Based on this, the reviewer concluded that the total efficiency gains are just projections based on prototype system tests and model predictions. Another reviewer noted that the program is ending, but it seems internal work will continue. The final reviewer questioned if the Rankine system be part of the final package for this project. This reviewer also inquired if the bio-fuel impact WHR heat exchanger efficiency is different from conventional diesel fuel, and concluded by noting that the goals are met and the no-cost extension is to clean up the details.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Overall, reviewers felt that the resources are sufficient and the program was sized about right. It was also pointed out that there was good leveraging of DOE funds at a 2:1 ratio.

ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine: Ruth, Michael (Cummins) – ace061

Reviewer Sample Size

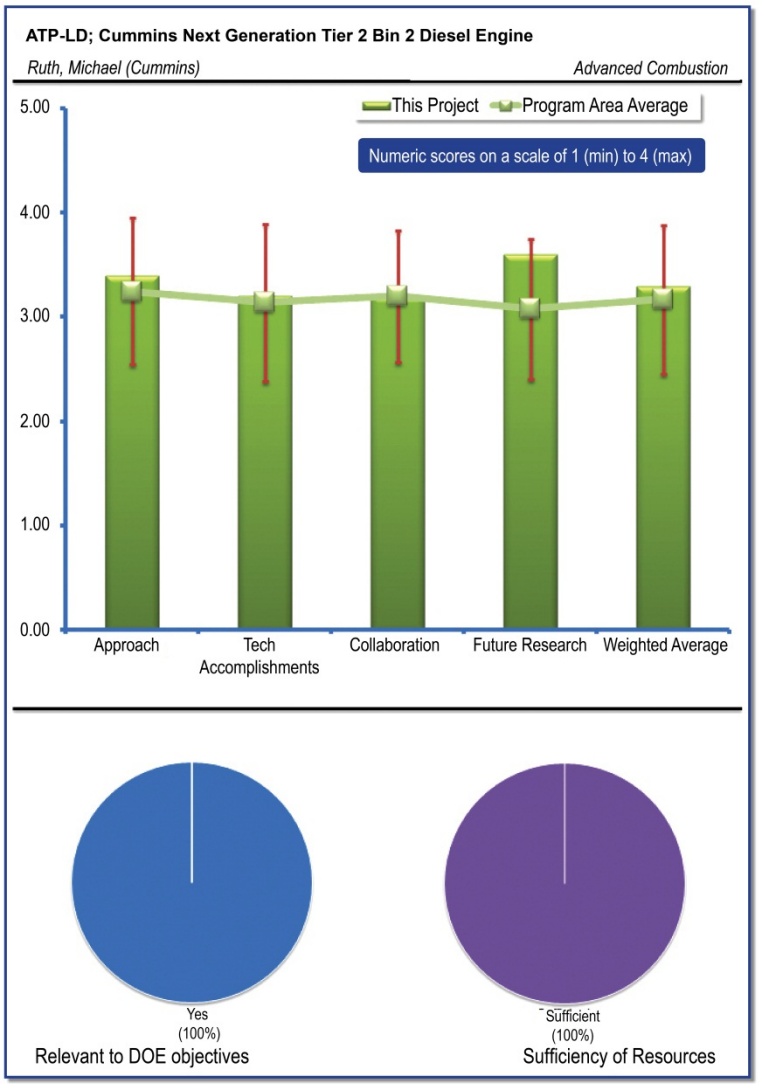
This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall, reviewers confirmed that this project aims to improve the fuel economy of a 1/2 ton pick truck by 40% and that such reductions will lead to less petroleum consumption and is in accord with overall DOE objectives. Reviewers also noted that this work is at the core of DOE/OVT mission.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer, considering the fact that this project was awarded in 10/2010, expressed that it appears that the team is still in the initial stages of developing a strategy. Current strategy includes a combination of down sized engine, extension of PCCI, reduction of fuel penalty due to aftertreatment besides others. In addition to these traditional approaches (low-hanging fruit) this reviewer highly recommended that the team look into dual-fuel strategies, reactivity controlled compression ignition (Wisconsin ERC), and use of low-quality gasoline in a diesel engine (ANL), that are showing promise. The second reviewer thought that the project was systematic and sound and reflects high competency. This reviewer asserted that the polynuclear aromatics (PNA) approach is innovative, and is worth pursuing. This reviewer felt that the LP-HP EGR combo is expensive and challenging for a MD truck application, even though some after-marketers are touting it. The third reviewer wondered if a 4 cylinder with the same torque as a diesel will be marketable and noted that the project is depending on customers being very interested in FE. Another felt that the overall approach appears to be comprehensive and should lead to a successful program. Using low pressure EGR to reduce the pumping work is good but weight reduction goals are pretty aggressive, with some risk there. This reviewer inquired if the piston goals realistic (same as gasoline engine piston weight goal) what the risk of not achieving these is. The reviewer also pointed out that downsizing is helping with the quality of exhaust for better aftertreatment performance. The final reviewer felt that the approach outlined in 2011 milestones is consistent with goals and that the inclusion of mule vehicle operation in first year is big plus. The reviewer also felt that the longer term, 2012-2014, milestones also seem reasonable in combination with more detail from later slides. This reviewer added that it was great to make use of knowledge discovery from previous studies. The use of low pressure EGR to reduce EGR pumping work makes sense to reduce penalty. This reviewer was glad to see that the project team was not abandoning EGR in pursuit of only aftertreatment (AT). The combined approach will lead to lower precious metals requirements and cost. The down-sized approach helps with power density and FE. The PNA is a good approach to more efficient AT. However, the reviewer did not know the details but understand the reasons. Overall, the approach appears to be integration of technologies well understood by Cummins.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that the progress shown is commensurate with the late start of this project. The team has identified downsizing of the engine to be their main strategy which, in addition to Low-pr loop EGR, and reduction of fuel penalty due to aftertreatment, are their chief strategies. This reviewer added that they appear to be making progress in that direction. The second reviewer felt that the PI laid out a sound plan and executed well in the first few months of it by getting up and running with the many facets of the program. Another indicated that this was a good start from a high baseline of technology. The fourth added that the program is only six months old and it will be better able to evaluate next year. The final reviewer would have liked more information on accomplishments but did realize that the time does not allow for more, and added that having the mule engine built and simulated early on will go a long way for the success of this program and that progress there looks great.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer confirmed that this was a good team to address technology challenges and did not see any missing partners who would make this stronger. The second reviewer asserted that while the overall team appears to bring the necessary expertise, the inclusion of NexGen and Oak Ridge National Lab is nebulous. Their role is not clear in the overall project. The third reviewer noted that the project is carrying out multi-suppliers' collaboration, such as Bosch and JM and that it may be enhanced by including high-power expert entities, such as the University of Wisconsin-Madison and ORNL, in engine combustion, controls, experimentation, etc. The fourth reviewer maintained that the university collaborations are a little weak and NexGen was mentioned, but now are out. Johnson-Matthey for aftertreatment looks good.

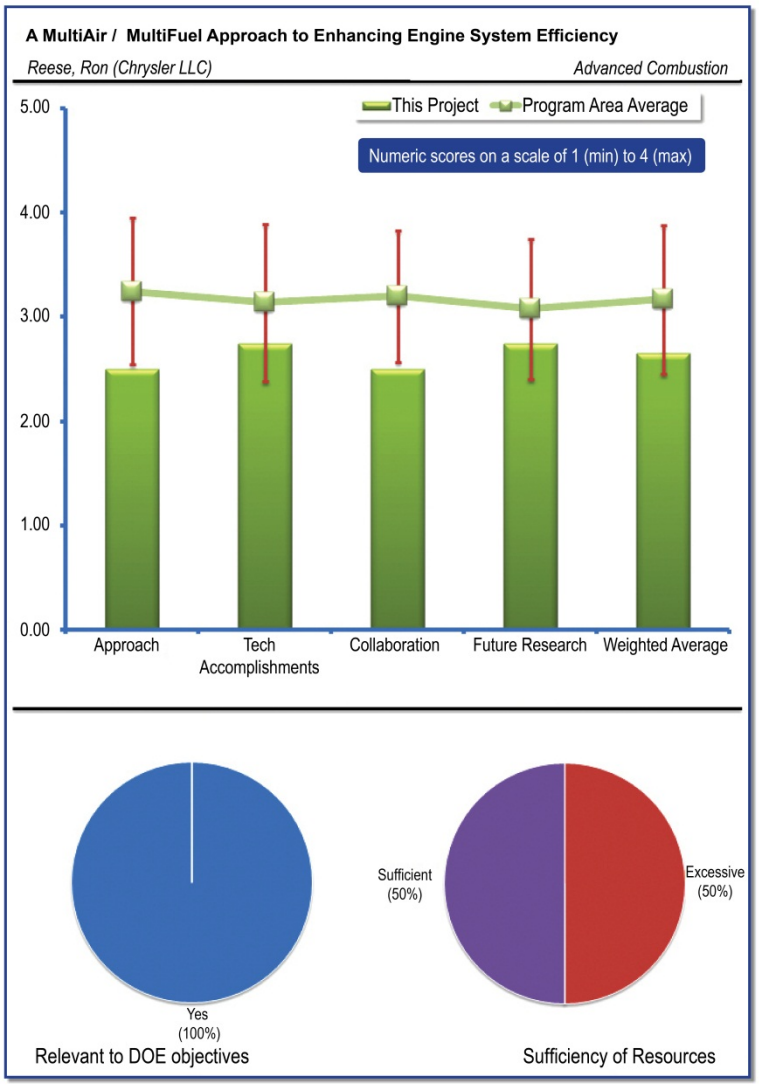
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer recommended evaluating dual-fuel (or RCCI concept) that shows high efficiency gains with concommittant reduced emissions. The second reviewer felt that this was a good plan should result in successful design. Another pointed out that this seems reasonable, but since this just started six months ago, there are not results yet to guide any revisions to the proposed future work. The final reviewer agreed by stating that it is early in program but it is on track. The future (approach for upcoming years) makes sense to meet objectives.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The final respondent noted that only 3-4% of the budget has been spent in the first 6 months. This was assumed to be just the inertia of getting the program started, and will track closer in the following years.

A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency: Reese, Ron (Chrysler, LLC)- ace062



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers noted that the project aims at increasing fuel economy, reducing greenhouse emissions, provides FE improvement for large volume LD vehicles and that achieving 25% reduction in FE is clearly supporting petroleum displacement. The final reviewer felt that this was well matched with DOE objectives for LD fuel economy improvement. Selection of Chrysler minivan makes sense due to high volume.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the approach reflects the assembly of few recycled technologies and that the team has included "the kitchen sink" in a collection that is not really practical for ARPA or for serious product development. However, it has been known for over a decade now that downsized and boosted, if applied properly, will be valuable. The second reviewer confirmed that the high EGR, boosted, stoichiometric system seems unique in the DOE projects, and that given excellent results published by the Southwest Research Institute (SwRI) High Efficiency Dilute Gasoline Engine (HEDGE) consortium this seems like a good idea and very interesting work. Another reviewer thought that the use of two engines makes sense. Starting with the near-term platform to learn and provide knowledge for design of improved long-term platform. The multi-cylinder engine approach makes sense due to timeline. However, this reviewer inquired if there is value in also having simultaneous single-cylinder engine experiments. This reviewer also questioned if three spark plugs per cylinder be realistic for production, if there is modeling to support potential of three ignition sources, and if there are other ignition hardware possibilities. This reviewer noted that the compression ratio seems rather low for efficiency and if diesel used as ignition source and questions if the PI has modeled this scenario. This reviewer asserted that the project had great focus on better matching of most efficient speed/load with vehicle demands over LD drive-cycle. Taking this approach across relevant speed/load range is critical to overall FE improvement. The final reviewer indicated that for the level of funding and timing, the approach presented was at best poorly communicated, and at worst inefficient and ineffectual. The direction of the engineering, tools, partners, and all aspects of the project are not well supported. The approach had no concise strategies presented, no substantiated methodologies considered, no goals for fuel economy reduction based on technologies. The only significant approach which was clearly communicated was the hiring of additional employees by the awardee.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer felt that this was a good start and interesting result so far. The second reviewer noted that 1D simulation best approach to understanding technologies on a systems level. This reviewer added that there was nice design activity. The reviewer noted that there are a lot of head penetrations and questioned if it makes it difficult to design for higher in-cylinder pressures. Very clever design of crankshaft mounted absorber to allow for more efficient system. Great to evaluate potential of multiple CFD codes to determine best fit. This reviewer inquired if the PI is making use of the expertise of organizations such as UW (Reitz) or UM (Assanis) or other known experts to support the dual-fuel modeling. The third reviewer felt that the Alpha engine is not practical, in its totality or as subsystems! This reviewer added that it will NEVER go into production, in any form. Packaging of this collection of elements (including the kitchen sink) under the hood is extremely challenging, if at all feasible. Two-stage turbocharging, especially for gasoline engine, is likely to cause trouble for product developments beyond the preliminary "Alpha" stage. Production release of a 2-stage system in a gasoline (2.4L), 4-cylinder engine is an extremely high risk proposal, from both technical and business perspectives. The added cost of a 2-turbo system + 2 EGR systems + EGR cooler + associated components, sensors and controls should pose significant doubt on the value equation. Perhaps the developments of this skunk-work testbed is not intended for product development, but rather for building Chrysler's core technical competency. The reviewer also pointed out that adding a diesel fuel injector substantially complicated the cylinder head design. Adding a diesel C.R. fuel injection system adds complications to the engine design, controls and system reliability. Introducing diesel fuel into the combustion of a GDI, spark-ignition process is a novel RESEARCH (See ace001) that is in its early stages. It is way too early to incorporate here. Asymmetric, side GDI injector is not optimum arrangement and creates a real challenge in developing a robust combustion system for all real-life operating conditions. Two fuels onboard a passenger vehicle is not a good idea for the next several years, market research would support this claim. This reviewer also commented on Slide 10 that the idea of incorporating crankshaft pendulum absorber is to be applauded. Engine height, block redesign, and many other factors prohibited using this technology in the past. Many internal R&D programs pursued it for decades, and a few public papers addressed it. See for example published Ford's work: 1991: Society of Automotive Engineers (SAE) paper # 911876, 2003: SAE paper # 2003-01-1484 (available at http://www.egr.msu.edu/dvrl/pubs/Nester-etal_MI03.pdf). Argonne National Lab has substantial core competencies and capabilities, but 3D CFD combustion is definitely not one of them. This is why ANL contracts the University of Wisconsin-Madison and others to carry out these simulations for their R&D programs. The arrangement described in this slide benefits neither Chrysler nor ANL. This reviewer questioned if Alpha 2 is for code validation only. This effort may be viewed as a training exercise for ANL, otherwise it is better handled by having a university team (UWM or UM) and SNL involved and findings and conclusions are primitive. The fourth reviewer stated that little progress was communicated outside of eliminating the multi air product from consideration on the engine (opting for a more conventional approach due to packaging of twin turbo design. Potential directions for the technical path were identified with statements like "if one spark plug is good, and two are better, it would be great to see how three would work". Pet technologies which have not been demonstrated to work effectively were presented and will be apparently developed with public funds.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The final reviewer asserted great collaborations and thanked the team for describing team contributions where relevant throughout the presentation and noted that this was helpful. The reviewer expected different teaming for simulation and combustion studies, perhaps with a university such as University of Wisconsin or University of Michigan. The reviewer thought that Argonne is a great match for spray imaging and fundamentals and that Delphi is great match for sensing and control. This reviewer commented that Ohio State University (OSU)has wide range of expertise in hybrid controls and liked how the team is making use of that expertise for more "conventional" approach. The second reviewer indicated that this is primarily internal but some useful interactions and is appropriate for the project. Another pointed out that partners have been identified but it was not clear how this was working. The final reviewer noted that the four additional partners are well recognized names. However, their roles reflect a misfit, because they are not used in their respective core competency. Collectively, real engineering coordination and integration are not apparent. The reviewer also noted that someone at the meeting mentioned that Fiat Research in Italy has substantial know how and core competency in the subject research and development area. This is also apparent from a survey of Fiat's product fuel economy data. The reviewer questioned why Chrysler is not capitalizing on this.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers agreed that they are looking forward to the team's results. One reviewer noted that the plan going forward is reasonable but not well defined or communicated and pointed out that the project can clearly rate a three with better communication of strategy, resources, and results. The final reviewer felt that the overall plans were good going forward and were consistent with a successful plan. However, this reviewer advised considering involving the University of Wisconsin or similar in modeling.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first respondent felt that this effort was well funded. The second reviewer felt that the merits do not seem to warrant the investment. Another reviewer added that based on the proposed plan the funding is excessive and unless plans are improved the resource level is too high.

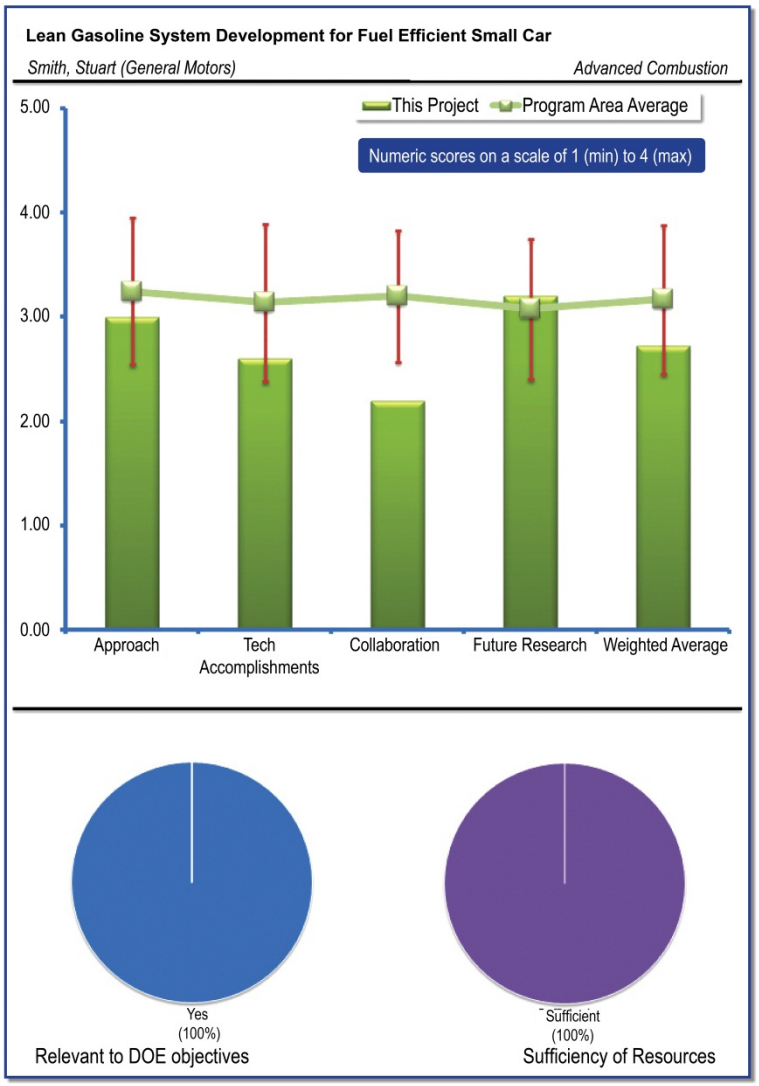
Lean Gasoline System Development for Fuel Efficient Small Car: Smith, Stuart (General Motors) – ace063

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer pointed out that lean burn, DI gasoline engine technology is a valid path to improved vehicle fuel economy. The second reviewer added that there is large FE improvement in high volume vehicles. Another indicated that fuel economy improvement demonstration using lean gasoline combustion to reduce petroleum consumption and that 25% improvement in FE is the goal. The third reviewer confirmed that the integrated vehicle systems approach presented has potential for real world corporate average fuel economy (CAFE) fuel economy improvements with building block technologies. A down sized and powered up approach (higher power density) is the general trend for solutions, but there is some risk that without fuel price increases, the technology may be overpriced. The final reviewer noted that objectives consistent with DOE objectives of petroleum displacement.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent felt that the approach to assess architectures through modeling and experience arrived at a general configuration of 4 cylinder, GDI, high EGR, lean combustion, novel approach to after treatment and a good experimental program are all excellent. Experimental program includes modeling, single cylinder dyno, hardware design of critical engine and exhaust components, multi cylinder dyno, and vehicle work. The reviewer also pointed out that there was some indication that there is fundamental knowledge to be learned at injector combustion level. The second reviewer indicated that the approach is very well defined from process to resources to demonstration. The reviewer appreciated the summary of approach on Slide 4. The reviewer inquired into the plan for operation of lean versus stoichiometric across the speed-load range and how this is addressed. The third reviewer noted that lean combustion aftertreatment development will be needed to achieve the Tier 2 Bin 2 emissions standards (T2B2) emissions levels. The approach of using the TWC to generate NH3 for the SCR is novel and will be interesting to follow. This reviewer also pointed out that the project is using a 12V start/stop system to reduce idling. The spray imaging work looks good and should help provide some insight into the disparity in performance between injector manufacturers. The final respondent pointed out that great reliance is being placed on a complex and difficult to control aftertreatment system. This reviewer was skeptical that it will do what is needed, and there is not a solid alternate plan.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer noted that GM can achieve significantly improved outcome if they capitalize on readily available relevant technologies, along with systematic development steps. The lean combustion spray "fundamental investigation" via Schlieren and magnetic-electro imaging (MEI) images does not reveal new findings. Lean gasoline combustion has been investigated by many renowned researchers in the USA and abroad, way beyond the reported findings in the presentation. This reviewer is under the impression that investigations have been within GM's own R&D extended domain in recent past. Perhaps this effort may be considered a training exercise for GM's new core of R&D staff, and thus creating job. This reviewer felt that timing sweeps and dwell time between the two injections will significantly influence the results. Other influential parameters are many such as the rail pressure. This reviewer questioned what else besides smoke was measured, how the two injectors were ranked, were the experiments repeatable, will the behavior duplicate with different set of injectors from the same respective suppliers, and did the team use a statistical DOE test matrix to prescribe the tests, or was it a non-statistical parametric testing. This reviewer noted that hopefully, GM researchers are capitalizing on the vast database and know-how that are readily available within the aftertreatment R&D community and PNNL is an example to guide such work. This reviewer questioned why GM is reinventing the wheel. The second reviewer noted that hardware and designs are in place for start of testing systems. However, this reviewer commented that CFD combustion simulations do not seem to match data very well based on the slideshow and questioned if the decisions are based on such poor simulation. The mention of risk mitigation plans can be viewed as concern over meeting the objectives or as prudent engineering. Another reviewer felt that the project was simply on target for 1st year. The fourth reviewer noted that the project was self-reported "on track" with lean performance, however, no data shown for emissions, fuel economy, coefficient of variation of the indicated mean effective pressure (COVIMEP) (combustion quality). The words say that the project is on target for highway fuel economy (HWFE) of 13% by June 2011. It seems that there would be some preliminary data if vehicle level work will show 13% by June. This reviewer noted that this is the only supporting qualitative data provided. This reviewer also felt that this project optimized BSFC over the widest operating range and confirmed the combustion system on single cylinder and multi-cylinder engines. It meets production combustion stability targets, and lean engine out NOx targets. The reviewer added that the engine was designed with production feasible and cost-effective hardware. The evaluator requested average BSFC improvement or BSFC map, average EO NOx compared to baseline, specific power change relative to baseline, and COVIMEP measurements best and worst compared to baseline. The final reviewer indicated nice experimental spray work in support of CFD modeling. Agree completely that this is a very necessary step. The commenter also stated that it was excellent to see comparison of single phase (SP) vs. dual phase with injectors from different suppliers. Results were surprising (at least to this reviewer) but very important to know. The reviewer added that the passive ammonia SCR system (PASS) approach makes sense and there was good progress addressing the correct challenges. The evaluator questioned what is PGM loading of TWC to generate sufficient ammonia and how that compares to LNT. The reviewer was guessing much lower, but is not an expert in this area.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers provided a range of comments in response to GM's level of collaboration. The first reviewer noted that this was mostly internal, but that is appropriate for this project. The second reviewer noted that the above sections contain detailed explanation of why this category scores "poor." This reviewer finds it unfathomable that the GM team would be doing this work without external team memberships. Undoubtedly, much in-kind contributions are pouring in from the many organizations that the GM team is interacting with and supporting! If this is indeed true, it is suggested that the next year's report makes these collaborations clear, even if these entities are not included in the formal DOE-GM contract (financials). The GM team will gain substantial know-how and insight by studying the current commercially available DI gasoline engines, benchmark it, and reverse-engineer it! This can be undertaken within GM, or via an external expert house. Another reviewer indicated that there was no collaboration. The reviewer noted that it was typical GM and questioned if suppliers would be more helpful if they were "partners". The fourth respondent noted stated that GM is not acknowledging any significant collaboration. It is unlikely that some work is not being done by suppliers and other operations outside GM. Acknowledging collaborators is more credible and allows some lessons learned from this work to be leveraged across the industry. The final reviewer pointed out no collaboration outside of GM so was not sure how to rate this. This does require significant collaboration within GM.

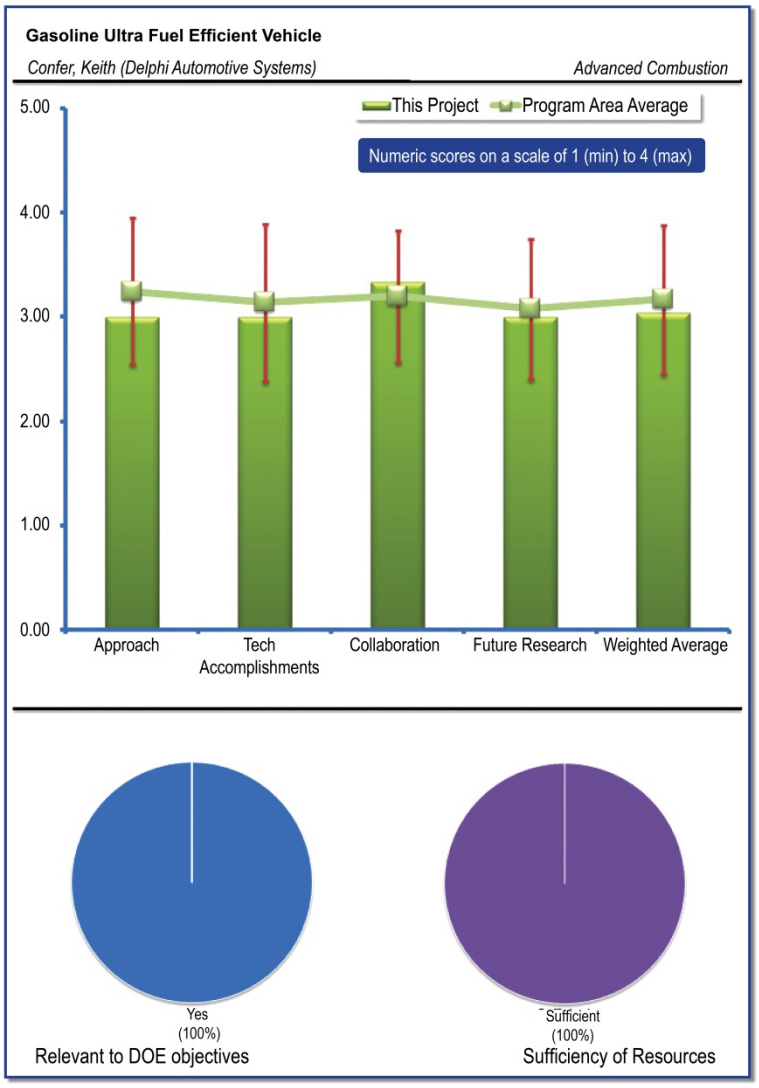
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer maintained that future plans are on target and make sense in support of approach. Another reviewer asserted that the plan appears to be addressing major issues, including PM. The fuel injector performance differences need to be understood. The reviewer would like to see more effort put into this, rather than writing it off as a disinterested supplier. The third reviewer stated that it could be improved based on the above comments and added that the program would be significantly handicapped and inferior, if the team is not investigating turbocharged configuration. The slides did not show a turbocharger. This reviewer would rate the future plans, the entire program, as "Poor" if it is restricted to NA lean burn gasoline. The fourth reviewer felt that the combustion part seems weak considering the objectives and thinks the aftertreatment will be very difficult in this concept. The final reviewer noted the novel cost effective SCR is a great one if it becomes practical. Other technologies such as supercharging/turbocharging are good architecture choices. Considerations for noise, vibration, and other issues relating to downsizing which have prevented use in the past may be worthy of future discussion.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that the project was well funded and perhaps generously sufficient. The final respondent noted that to undertake this kind of research for real world implementations takes significant investment. The resources are more than sufficient, and this level of funding requires demonstrated metrics and some care to insure that the dollars are clearly focused on the goals of this project.

Gasoline Ultra Fuel Efficient Vehicle: Confer, Keith (Delphi Automotive Systems) – ace064



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that the project is staged to give solid incremental improvements in efficiency in the early phase, and larger improvements later on. It is well-balanced from a risk standpoint. Another reviewer noted big efficiency improvement on high volume vehicles. The final reviewer pointed out that this project is aimed at improving LD engine efficiency for reduced oil consumption.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer noted that the Phase I accomplishments offer very practical improvements in efficiency. The Phase II is somewhat higher risk, from an emissions and power density standpoint, not to mention consumer acceptance. The reviewer added that more work needs to be done to extend the load-speed range of operation, and to characterize the engine-out emissions profile. The second reviewer indicated that this was an interesting concept, but the team has no data to support the full range operation in gasoline direct injection compression ignition (GDCI) which is critical to overall results. The final reviewer pointed out that GDCI is a novel approach to solving the high efficiency barrier. It was noted that this was "Not an aftertreatment project." That may be premature to say if PM regulations end up in light duty gasoline engines. The evaluator added that the single cylinder engine used for initial tests was a good approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer acknowledged that the Phase I and Phase II progress to date is good, but seems to be covering some old ground. However, the GDCI injector may be the most significant development to arise from the Phase II work, as it may have importance to others working in the area of LTC. Another felt that the results were good results so far, but data were needed for full speed/load range. Another reviewer noted that this is the first half of first year, so accomplishments are just starting. The start stop rig is functional, as well as the friction rig. Work on optimization of fuel injection strategy has made good progress.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that the collaboration on this project alone is sufficient and appropriate, but perhaps more work with other LTC programs on the GDCI fuel injection system would be recommended. Another noted that the project seems well integrated with

an OEM. The final reviewer added that Hyundai, Wayne State, WERC (although not indicated, assumed the KIVA modeling was done there) resulted in a good mix of industry and academia.

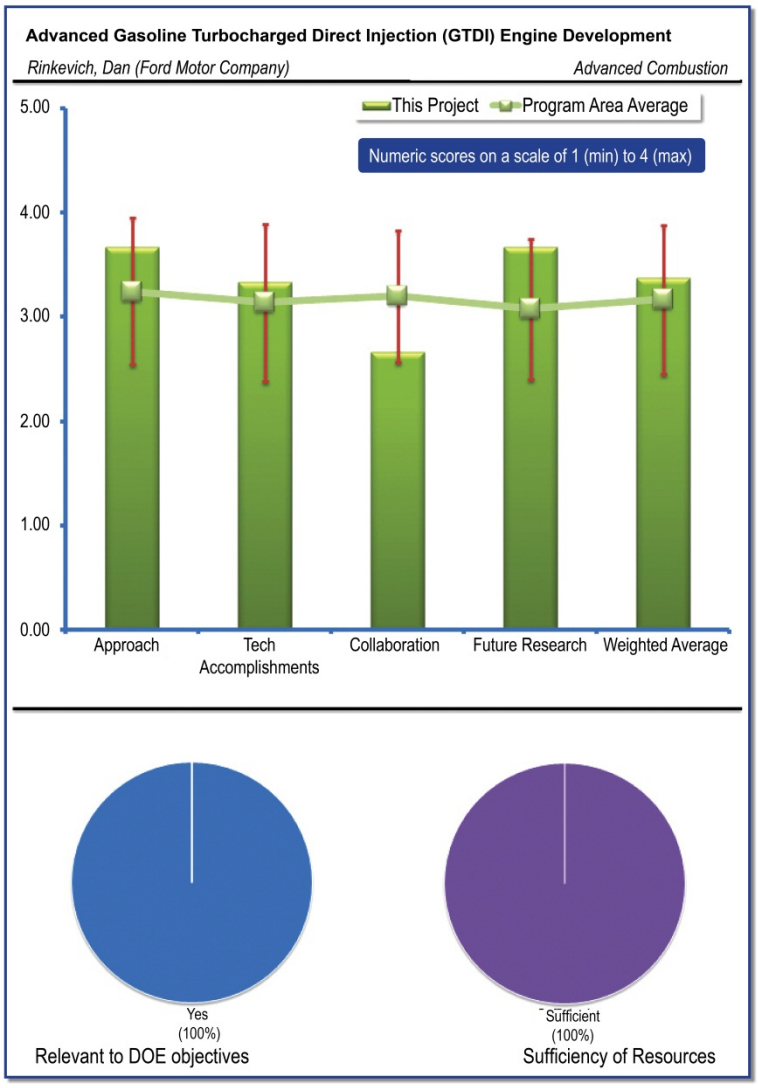
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer indicated that the key to the Phase II work will be the successful implementation of the GDCI injection strategy. The reviewer added that more work in the area of emissions characterization and exhaust heat availability would be useful to evaluate the potential of the technology. The second reviewer pointed out that the project teem needs to look off cycle, not design a cycle beater. The final reviewer felt that there was a good mixture of simulation and testing. The evaluator also noted that there is continued single cylinder testing planned and they will also build a demonstration vehicle.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer indicated that the project funding is appropriate for this level of development. Other reviewers felt that the project was well funded but it was difficult to evaluate this early in the program.

Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Rinkevich, Dan (Ford Motor Company) – ace065



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that in general, this project explores possibly the single most important technology for light duty engines in the next 15 years. Other reviewers pointed out that there are big efficiency improvements on high volume products and the Advanced Technology Powertrains for Light-Duty Vehicles (ATP-LD) program goals are being sought after.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent noted that the strategy is very good and that each element of the plan works to integrate both well-known and novel technologies to yield significant overall improvement. The focus on advanced lean burn is also appropriate, but perhaps as a lower priority until other breakthroughs that would allow a broader power band of lean operation. Transitioning between lean and stoich would otherwise come with an unacceptable emissions penalty relative to other approaches. The second reviewer confirmed that this project builds on a solid technical base with good analytics and projections. The reviewer would like to see more analysis on lean versus very high EGR. The reviewer questioned if the team really gets an advantage worth the aftertreatment issues. The final reviewer indicated that the program has a heavy dependence on the engine downsizing to obtain 18% of the 25% fuel economy goal. This evaluator did not know whether this is realistic from a commercialization standpoint (i.e., engine durability & reliability). Aftertreatment development will also be a key player in the success of this approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that while the project is still in early stages, it is set on the right path for the follow-on efforts. Another reviewer felt there is solid progress. The final reviewer pointed out that it is very early in the program, so it is difficult to evaluate the accomplishments. The work on the aftertreatment that was presented looks good, as well as the single cylinder work and design of the engine components.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer deemed the collaboration appropriate for this OEM-led project. The second reviewer believed that the collaboration at this point is relatively limited and that more collaboration with the national labs on the lean burn strategy would benefit the

program. The final reviewer pointed out that there is only one partner, MTU. The reviewer questioned if there is any chance of getting a supplier involved, like with the aftertreatment.

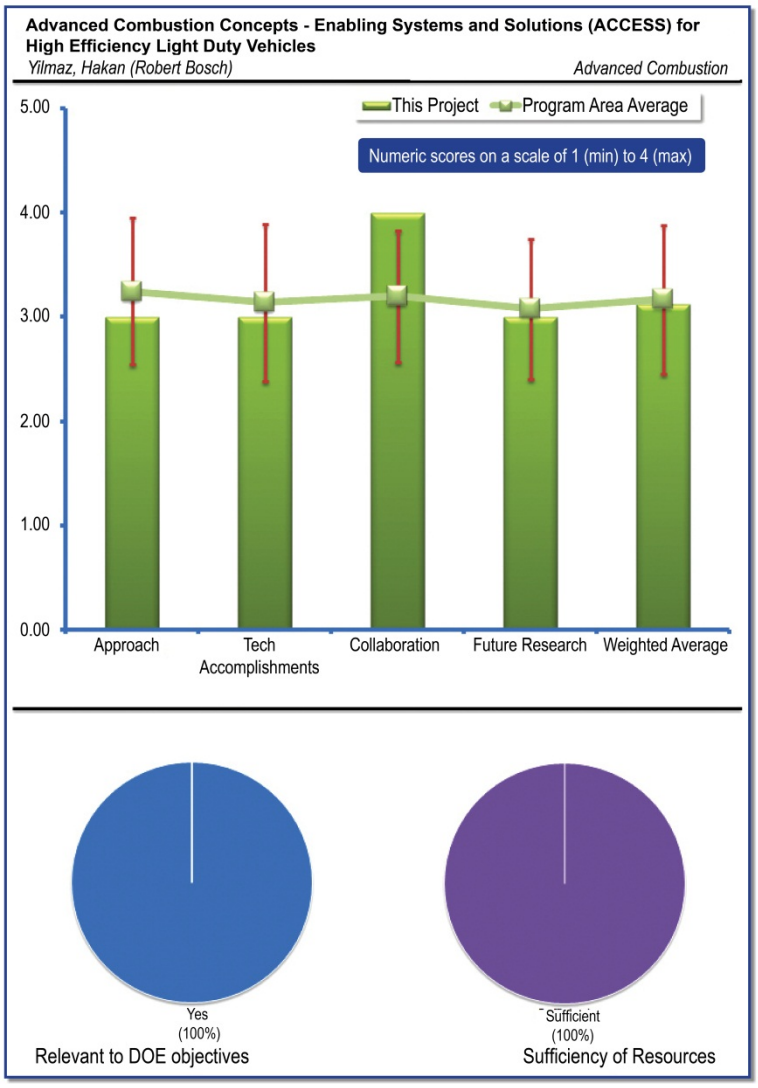
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that the success in furthering turbo/downsized engine technology is critical for achieving fuel economy goals in light duty, and the research proposed addresses the most significant elements. The second reviewer thought that this was an overall good approach and plan of attack. The final reviewer noted that it looks okay but it is still mostly the original plan since it is so early in the program.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer indicated that if the efforts are expanded to include fundamental combustion studies at the labs, then further resources could be justified. Other reviewers thought that it was difficult to evaluate after only six months but it looks okay and well-funded.

Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles: Yilmaz, Hakan (Robert Bosch) – ace066



Reviewer Sample Size

This project had a total of one reviewer.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer noted 30% fuel efficiency improvement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The reviewer felt that a very extensive organizational plan was presented. While this is impressive, it will be interesting to see the next year's presentation on how well it is working. The rerviewer also noted that heavy dependence on engine downsizing will be a key to the success of this program. Multi-mode combustion will also contribute heavily to achieving the goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The reviewer pointed out that the project has been comprised of mostly planning since this just started in October. However, some significant achievements have been noted include spray targeting completed, cylinder head design, PFI/GDI design complete, modeling at Michigan, first engine June 15th, 3 total one each at Michigan, AVL, Bosch, and rans, and LES simulations at Stanford.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewer noted a good mix of partners across a broad spectrum with an extensive organization plan.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, the reviewer pronounced that all proposed future work looks good.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The reviewer indicated that this is a rather large budget, but the number of concurrent activities seems in line with the funding level.

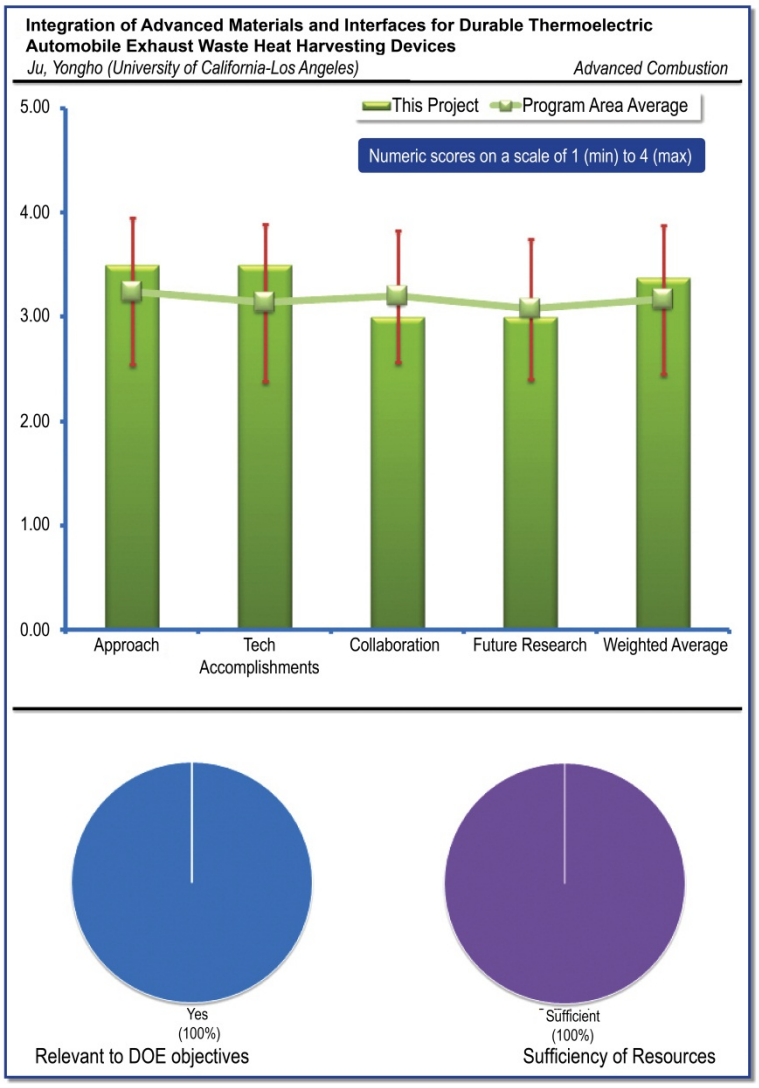
Integration of Advanced Materials and Interfaces for Durable Thermoelectric Automobile Exhaust Waste Heat Harvesting Devices: Ju, Yongho (University of California-Los Angeles) – ace069

Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that this project is addressing and developing solutions for thermal interfaces that can be implemented between various critical components in waste heat recovery systems in automotive applications. This solutions could be applied between heat exchangers and active energy conversion devices, thermal interfaces within advanced heating, ventilating, and air conditioning systems (HVAC), and at any surface where there is a strong requirement to transfer high heat fluxes in advanced automotive energy systems. This project is evaluating the thermo-mechanical reliability of their thermal interface solutions, developing bonding techniques, and developing flexible thermal interface solutions that could be quite important and relevant to automotive exhaust energy recovery and advanced automotive HVAC systems. The final reviewer felt that the project fully supports the overall DOE objectives of petroleum displacement



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer expressed that this project is well-designed and has a sound technical approach for tuning coefficient of thermal expansion (CTE) properties in metal-matrix Nano-composites through the use of silver (Ag) and ZrW2O8 Nano-powders and developing liquid-based flexible interfaces. These advanced materials could have an important impact in enhancing thermal interface design in various thermoelectric, organic Rankine cycle, and other energy systems applicable to automotive exhaust energy recovery and advanced HVAC systems. This team is dealing directly with thermal stability testing of these materials/interfaces as part of their project plan, which is an important characteristic in the intended automotive applications. This team appears well integrated with others in the technical community who are grappling directly with thermal interface design issues in these systems. The second reviewer indicated that the project was well designed with good approach to overcome the barriers that could be encountered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer asserted that this project team has some good CTE results at this early stage using Ag Nano-powders that create thermally and electrically conducting materials that could be used at critical active electrical interfaces within thermoelectric devices. Ag is expensive, but the project team has plans to transition other less expensive materials into their metal-matrix composite

compositions. Good thermal stability results so far in their project. This team appears well on their way to fabricating and charactering a complete series of metal-matrix nanocomposites that cover the expected range of CTE values for thermoelectric (TE) materials being developed by other technical teams. The project team has just initiated work on liquid-based flexible thermal interfaces, so no concrete results are available as yet. However, the project team has a good understanding of the technical challenges (i.e., evaporation loss, oxidation), a reasonable design concept, and they have identified promising materials (Bi, Sn) as filler materials in their design. The second reviewer felt that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer maintained that this team has some good collaborative support from NASA-JPL. They are also already pursuing collaborative opportunities for technology transfer with potential industrial partners. It remains to be seen how successful they will be in technology development and transfer. Another felt that the collaboration effort is excellent.

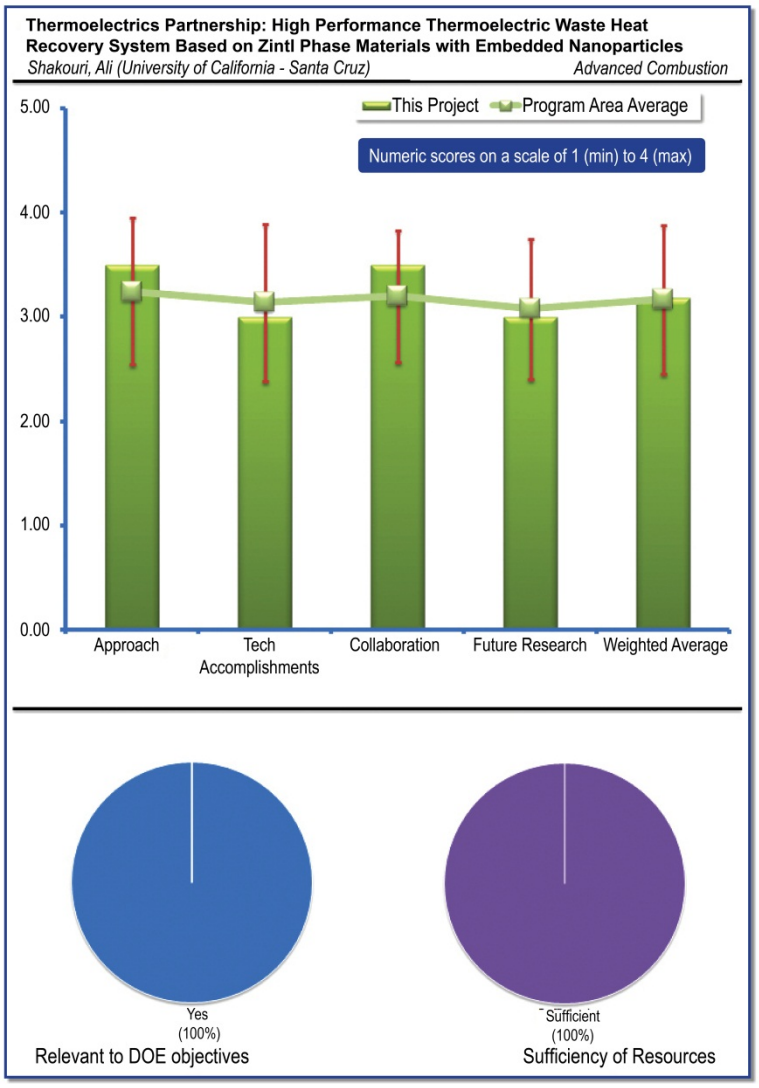
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer indicated that the proposed future work is good and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that their project plans appear technically sound and well thought out. However, this team could benefit more with better definition of thermal interface performance criteria and requirements to serve as technical targets.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were made.

Thermoelectrics Partnership: High Performance Thermoelectric Waste Heat Recovery System Based on Zintl Phase Materials with Embedded Nanoparticles: Shakouri, Ali (University of California - Santa Cruz) - ace070



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer maintained that the project fully supports the DOE objective of petroleum displacement. The second reviewer pointed out that this project is developing environmentally benign nanosttuctured "bulk" materials with enhanced thermoelectric performance (ZT>1.3-1.8) in the 500-800° Kelvin (K) temperature range for automotive waste heat recovery. Materials being investigated are in the proper temperature ranges for automotive WHR and therefore could potentially contribute to enhance performance WHR systems that could improve vehicle on-board energy management and efficiency. The ZT goals are ambitious, but definitely at the performance level needed to make vehicle WHR using thermoelectric systems a successful technology.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that this project has a good balance between analytic transport modeling and experimental work to validate analytic results and use both sets of results to achieve the project goals. Their approach of embedding nanoparticles into the material crystal structure appears feasible, but the devil is always in the details. The evaluator instructed the team to make no mistake; the ZT goals are ambitious and quite challenging. They also presented discussion on their material synthesis approaches and future plans, which was good. However, this project does not really address the structural properties of their proposed materials, which is a major deficiency of this project because these properties are critical to transitioning these materials into operating devices. There also are no discussions on the effect of thermal cycling on these materials, which is another critical characteristic required to transition these materials to operating TE devices. The last reviewer felt that the project was well designed with good approach to overcome the barriers that could be encountered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer felt that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals. A second reviewer noted that the ZT values they have reported so far with Bi-doped Mg2Si and 5% Si nanocomposite filling are quite modest (ZT ~ 0.7 at 800°K). However, the project team appears to have well thought-out plans for improving and optimizing the materials to

achieve higher performance. It is going to be quite challenging to embed the proper size nanoparticles (2-20 nm) into the Mg2Si and Mg2SiSn crystal structures and get them to stay there during all the envisioned operating environments these materials will be subjected to.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers thought that the project team has established good collaboration between two University of California campuses and NASA-JPL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer indicated that this project does not really address the structural properties of their proposed materials, which is a major deficiency of this project because these properties are critical to transitioning these materials into operating devices. The project team also does not discuss the effect of thermal cycling on these materials, which is another critical characteristic required to transition these materials to operating TE devices. There does not appear to be any plans to address these deficiencies in their current planned activities. Consequently, it is difficult to assess how successful this project team will be transitioning these materials to operating devices even if they are successful at achieving their project goals.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were made on the resources.

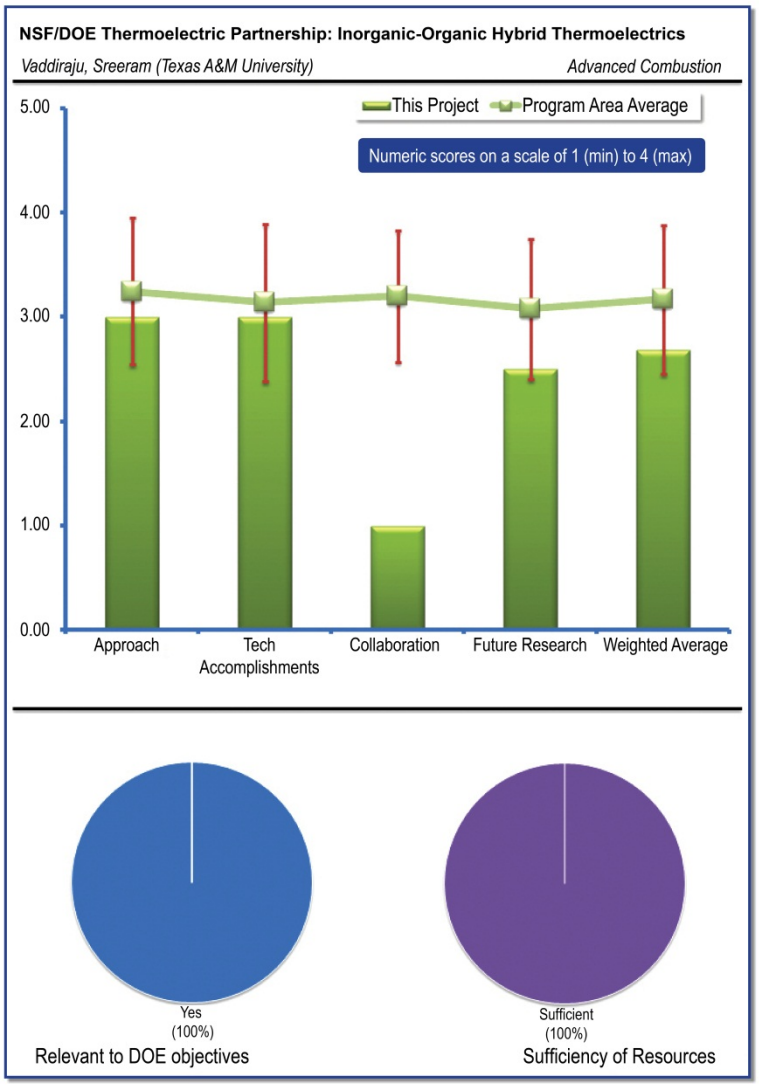
National Science Foundation (NSF) /DOE Thermoelectric Partnership: Inorganic-Organic Hybrid Thermoelectrics: Vaddiraju, Sreeram (Texas A&M University) – ace071

Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that the project fully supports the overall DOE objectives of petroleum displacement. The second reviewer expressed that the project supports the stated DOE objective of petroleum displacement by potentially offering a new, innovative technique for developing advanced, high-temperature TE materials based on bulk synthesis of inorganic quantum wire TE materials which could have a high ZT (Figure of Merit x Temperature) factor. The authors seek to develop versions of Zn3P2, InN and CoSb3 nanowires using self-catalysis for vehicular waste heat recovery systems, thereby increasing the engine and vehicle efficiency. The authors seek advanced versions of these materials that could operate at temperatures up to 800 C.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The last reviewer thought that the project was well designed with good technical approach to achieve the objectives and at the same time overcome the barriers that could be encountered. The second reviewer stated that the author has a basic misunderstanding about what absolute temperatures or temperature differentials are available in automotive engine and exhaust systems. Temperatures of 800C or temperature differentials of 800C will generally not be available in actual operating waste heat recovery systems as stated by the author in Slide 5. It is not clear how these Zn3P2, InN and CoSb3 nanowire materials would be integrated or formed into an operating TE couple even if the author(s) are successful at developing them. There are pretty conceptual pictures, but no coherent plan is presented on how the concepts would be transformed into an operating TE couple. There is no discussion about how to electrically connect these nanowire materials into an operating TE couple. There are also no partners on the project that could help in transitioning these nanowire TE materials to an operating TE couple. The reviewer added that the milestones are insufficiently described and the time sequencing of activities and deliverables is not clearly described.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The second reviewer asserted that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals. The second reviewer pointed out that the progress to date appears modest at best. This work has demonstrated self-catalytic synthesis of Zn3P2, InN and CoSb3 nanowires and the author(s) claim to have shown sub-10 nm diameters, but there are not data to support that assertion. The authors claim to have control of the nanowire diameters to less than 5 nm, but have not shown any data supporting that claim. The TE power factor measurements on Zn3P2 nanowires are only reasonably high (~28 uW/cm-K2) at temperatures of 525°K and are very low (nearly zero) at temperatures of 450K. What is worse is the temperature dependency of the power factor is very steep (high power factor temperature gradient) and this would make these materials very difficult to design and use in an operating TE device. The author(s) also did not describe the height dimensions of the 1 cm2 pellet that was tested. There is no discussion of the measurement systems used in obtaining the power factor data or what measurement systems are being used in determining the nanowire characteristics (i.e., diameters, etc.). It is not clear in this presentation how many of these TE pellets were fabricated and tested. It appears that only one has been fabricated so far.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer pointed out that there are no collaborations with outside organizations in materials synthesis techniques, material measurement and characterization, or in ultimate TE device design mentioned anywhere in the presentation. The second reviewer also stated that collaboration and coordination with other institutions need to be improved.

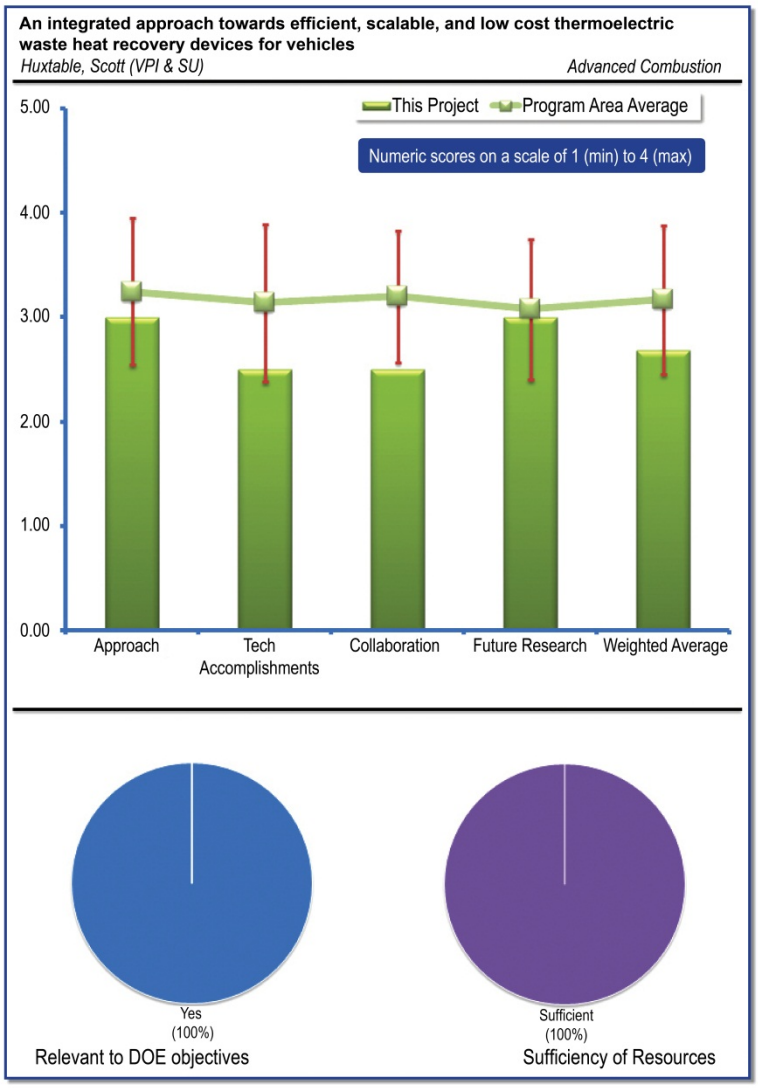
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that the author describes the future work in only general terms, but there are few specifics on how they plan to accomplish the work. In addition, milestones are insufficiently described and the time sequencing of activities and deliverables is not clearly described. Go/No-Go decision criteria are not described. There is no discussion of the barriers and challenges of "assembling the quantum wires on a large-scale into inorganic-organic hybrid thermoelectric devices by either tethering them to each other or to conducting polymer films through organic molecular linkers". This will not happen automatically and there needs to be much better discussion of how this will be accomplished, what the challenges are, and the techniques for overcoming any barriers to fabrication. No discussion on transitioning nanowire elements into an operating TE device that operates reliably over a large temperature differentials and the many thermal cycles characteristic of an automotive waste heat recovery system. There does not appear to be much planning to mitigate the risks of this technical approach.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that the resources appear sufficient for the scope of work undertaken and described in the presentation.

An integrated approach towards efficient, scalable, and low cost thermoelectric waste heat recovery devices for vehicles: Huxtable, Scott (Virginia Polytechnic Institute and State University) – ace072



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that this project is seeking to develop abundant, low-cost, bulk-scale oxide and silicide materials to be competitive with the state-of-the-art thermoelectric materials and enhance thermal management system performance for oxide- and silicide-based TE devices for vehicle waste heat recovery. They are targeting and addressing cost of TE systems, scale-up to practical thermoelectric devices, and thermoelectric device/system packaging. As such it is addressing important technical barriers in the Advanced Combustion Engines (ACE) Solid-State Energy Conversion program to increase waste heat recovery performance and diesel engine efficiency. The second reviewer noted that the project fully supports the overall DOE objectives of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that this team's approach is generally comprehensive and provides some new thoughts in thermal management. It is not clear how they will develop the layered cobalt oxides, such as NaxCoO2 and calcium cobalt oxide (Ca3Co4O9) and "design the novel microstructures" they seek. It is clear from their presentation and poster discussions that this team is focused on low-cost TE materials, they may not have the best thermoelectric (TE) performance but they have the potential to be inexpensive and abundant. Their thermal management work has some novel approaches to heat exchanger design and characterizing interface thermal resistances that could be useful. This team will investigate minimizing parasitic losses through interfaces and plan to use system models to address durability and lifetime of devices. This also could have some benefits in device/system design. There does not seem to be any attention on TE material structural properties or the effects of thermal cycling on TE materials. This reviewer sees this as a serious approach deficiency. The second reviewer felt that the project was well designed with good approach to overcome the barriers that could be encountered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer added that the project is still in the first phase; however, some progress has been demonstrated well. The second reviewer pointed out that there appears to be some coherent progress on TE materials development; developing, demonstrating, and

refining real-time data collection on vehicles; evaluating the dynamic response of heat exchangers; and preliminary analysis of heat exchangers. Their real-time data collection and dynamic response work should be useful in designing and developing TE devices and systems for vehicle waste heat recovery. Some of their heat exchanger work is quite similar to that already being performed by others in the field, so this is not a unique facet to their program. However, they also are investigating swirl impingement flow heat exchangers which offer some innovation in their work. The reviewer added that this team presents no thermoelectric property data to date, so it is not possible to evaluate how well their TE materials will work in a vehicle waste heat recovery system. There is not even a TE property chart on silicides or a comparison between their oxides and silicides, which their partner Romny Scientific should have (Note Slide #22 - "Our silicide materials are well established, thus we can produce working devices with those materials at a minimum."). So there should already be TE data available to report. There is a high-temperature Seebeck and electrical conductivity measurement system under construction, but this should have already been done to even propose in this field. This is definitely a problem for this team.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer noted that Virginia Tech University appears to only have Romny Scientific as an outside industrial collaborator. For all the TE materials and system design challenges they are taking on, it seems to this reviewer that they need more outside collaboration. There are other experts in the field that could assist them, and the poster presenter acknowledged this. This team realizes this and is attempting to establish closer ties to the government and industry leaders in this field and forming an advisory board. The second reviewer indicated that the collaboration and coordination effort with other institutions need to be improved.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer thought the proposed future work is reasonable and clearly demonstrates that the work plan can mitigate risk**.** A second reviewer indicated that their future work plans are technically sound. However, they like others in this review lack the specific targets and goals that should go with these plans. This team could benefit from more involvement from government/industry experts in this field. For example in Slide #20, "Modeling the combined TEG/heat exchanger/exhaust system dynamic response using substructure techniques" has already done by others in the field. They risk being duplicative, like others in this review have been or risk being duplicative.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were made concerning resources.

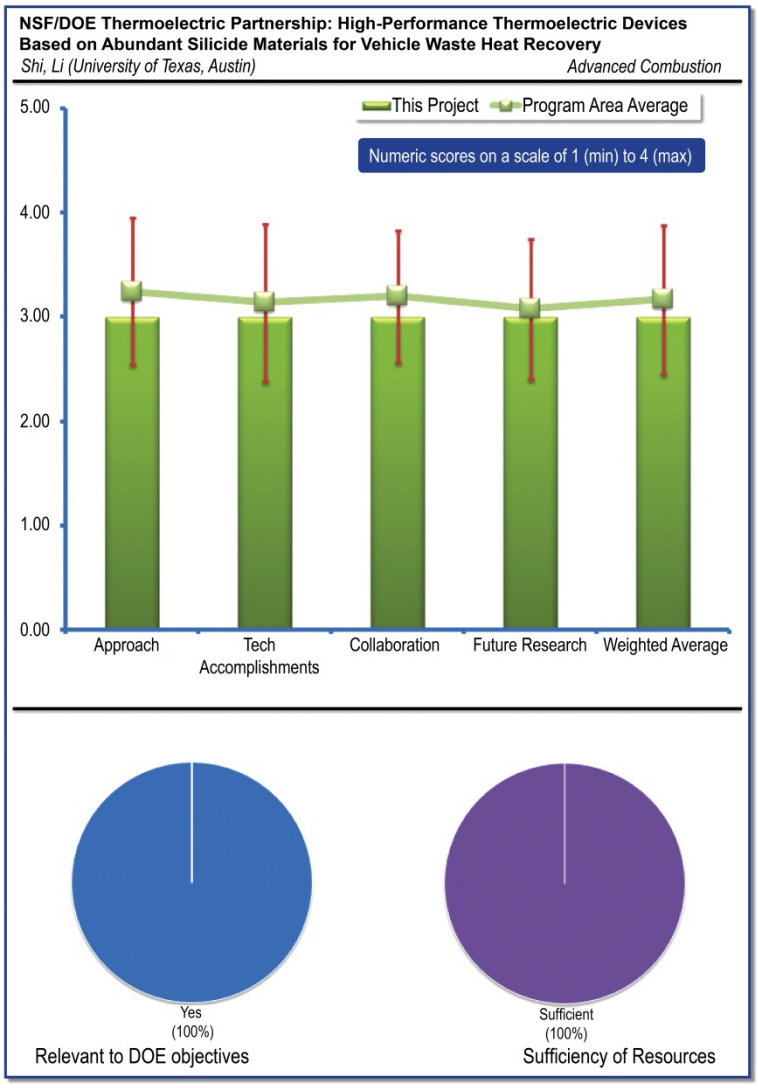
NSF/DOE Thermoelectric Partnership: High-Performance Thermoelectric Devices Based on Abundant Silicide Materials for Vehicle Waste Heat Recovery: Shi, Li (University of Texas, Austin) – ace073

Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer added that the project fully supports the overall DOE objectives of petroleum displacement. The second reviewer pointed out that this project is seeking to increase the thermoelectric (TE) performance, ZT, of abundant, low-cost, bulk-scale silicide materials to a level competitive with the state-of-the-art thermoelectric materials and enhance thermal management system performance for silicide-based TE devices in a diesel engine. As such it is addressing important technical barriers in the ACE Solid-State Energy Conversion program to increase waste heat recovery performance and diesel engine efficiency.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that the project team is seeking to synthesize and develop bulk Manganese Silicide (MnSi) 1.75and Mg2Si1-xSnx with nano-grains or nanoparticle inclusion via both solid state reaction and chemical conversion from diatomaceous earth to fabricate single-body silicide TE legs with gradient doping instead of a segmented design to eliminate interfaces. Their intent to study and investigate gradient doping is a noble goal and would be a useful outcome of this work. The project team intends to study and develop silicide interface and interconnect materials to enhance thermomechanical durability. However, they do not have any particular outside team collaborator with experience in this area, which is a project deficiency. No results or discussions surrounding this technical area are presented in this review material. This project team also intends to investigate and develop new heat exchanger designs to enhance thermal management performance; however, there is no outside team collaborator with experience in this area. No project results or discussions surrounding this technical area are presented in this review material. Another reviewer thought that the project was well designed with good approach to overcome the barriers that could be encountered.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer confirmed that technical accomplishment is great and the progress has been demonstrated well toward DOE goals. The second reviewer stated that the project team intends to study and develop silicide interface and interconnect materials to enhance thermomechanical durability. There is no outside team collaborator in this area and no results or discussions surrounding this technical area are presented in this review material. This project team also intends to develop new heat exchanger designs to enhance thermal management performance; however, there is no team collaborator with experience in this area. No project results or discussions surrounding this technical area are presented in this review material. The reviewer added that this work has shown only low ZT values for undoped higher manganese silicides (HMS) with MnSi phases so far, ZT ~ 0.1 at 700°K shown on Slide 11. The systems modeling work appears quite similar to other work done in ACE Waste Heat Recovery and Utilization projects funded in previous years and is quite preliminary in nature. That being said, it is the type of systems modeling work one would require for any set of new TE materials. The project team appears to be investigating all the normal exhaust flow locations for the TE waste heat recovery system that other projects have investigated in prior projects. Their one assumption that a TE hot-side heat exchanger can extract all the available heat (Slide 17) in the exhaust is highly idealistic. The reviewer asserts that this simply will not happen.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer indicated that the collaboration effort is excellent. The second reviewer noticed that there appears to be some collaboration with Oak Ridge National Laboratory to employ their high-temperature TE characterization facilities. However, there are major deficiencies in missing outside collaboration that are discussed above.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer pronounced the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that the project team is intending to develop thermodynamic systems models to optimize thermoelectric device locations in engine exhaust, heat transfer models for improving TE module performance, and integrate these as one model and to account for transient exhaust conditions. This system's modeling work is quite duplicative to similar work done on other TE waste heat recovery projects in the past. Once again, this project does not really address the structural properties of their proposed materials, which is a major deficiency of this project because these properties are critical to transitioning these materials into operating devices. There also are no discussions on the effect of thermal cycling on these materials, which is another critical characteristic required to transition these materials to operating TE devices. The project team intends to test silicide TE waste heat recovery devices in a 6.7 liter Cummins diesel engine, which is a good overall plan. They are evaluating various testing locations in the Cummins engine and they have evaluated exhaust temperatures as a function of brake load. There was no discussion however on how their thermal management systems would integrate with the Cummins engine.

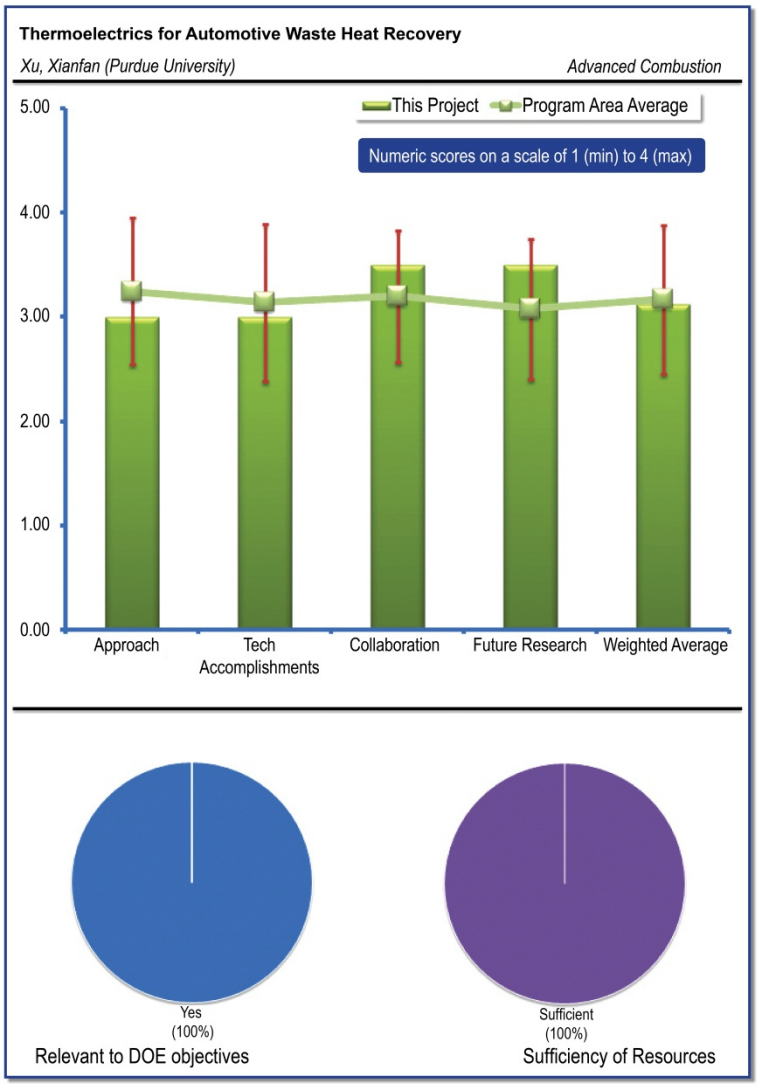
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No comments were made on resources for this project.

Thermoelectrics for Automotive Waste Heat Recovery: Xu, Xianfan (Purdue University) – ace074

Reviewer Sample Size

This project had a total of two reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer asserted that the project fully supports the overall DOE objectives of petroleum displacement. The second reviewer indicated that this project is addressing DOE's overall objective of petroleum displacement. It is addressing important technical barriers in the ACE Solid-State Energy Conversion program to increase waste heat recovery performance, diesel engine efficiency, and light-duty fuel economy improvements. However, this presentation does not clearly discuss what specific DOE Program Goals (i.e., What ACE and Solid State Energy Conversion goals & barriers) are being addressed in this project and how their project work relates to those goals and barriers. This presentation deficiency raises questions about whether the project PI's are clearly focused on the ACE goals and barriers.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer indicated that the project was well designed with good approach to achieve the objectives and at the same time overcome the barriers that could be encountered. The second reviewer noted that their slides discuss investigating three different TE materials for this application. It is highly unlikely that this project team can effectively investigate three different TE materials, develop thermal interface materials, investigate alternate heat exchanger designs, and perform metrology work with the project team indicated. Other groups around the world have investigated nanoscale oxide materials with little success at producing high-performance TE oxide materials that can be transitioned easily to operating TE devices. The poster presenter also said a number of times that their industrial partner (GM) wanted this team to focus on filled skutterudites, which has already been done extensively at GM on other OVT-funded waste heat recovery projects. It is not clear in this presentation what new work is planned beyond what GM has already done in this TE materials area. There is also no discussion presented on what the project goal is for TE materials development (i.e., what ZT value or other metric they expect to achieve). Furthermore there is no discussion on evaluation of the structural properties or thermal cycling characteristics of the potential material classes being investigated. Thermal interface approaches are described and appear worthwhile to investigate in this work. However, the reviewer added that heat exchanger work plans were not addressed very well in the presentation so it is not possible to evaluate what improvements are expected and how they relate to current state of the art. Some of the planned activities that were presented (i.e., diffuser optimization to eliminate flow

separation, use of fins to augment heat transfer) are quite basic to those skilled in the art, already quite well known, and should have already been addressed in GM prior work in their current OVT Waste Heat Recovery & Utilization Project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that the technical accomplishments are great and the progress has been demonstrated well toward DOE goals. The second reviewer noted that it appears this project has only been on-going since January 2011. Very little data are presented on what accomplishments have been made with TE materials development. In some cases they have shown a 59% reduction in thermal conductivity, but no data on Seebeck coefficient or electrical resistivity (Slide #15). Therefore it is difficult to draw conclusions on whether this is viable TE material or not. Their progress with Si-carbon nanotubes (CNT)-Ag Foil tests to obtain conversion to boron carbonitride (BCN) thermal interface materials appear to given inconclusive results at this time. The x-axis is not even properly labeled so it is difficult to evaluate completely what this team is trying to portray. This reviewer could guess what that x-axis is, but that would not necessarily be fair to the team, DOE program managers, or this review. This project team presented very little information on their heat exchanger design work. They showed one chart (Slide #20), but it did not describe what the color-coding represented. They did explain that their analysis results showed significant flow separation regions where reduced heat transfer occurred. This is a well-known phenomenon and there was no discussion on how it related to TE performance improvement in their specific design configurations. The reviewer added that in Slide #15, it is not clear how what is being presented relates to Ca3Co4O9 nanowires and sodium cobalt oxide (NaCo2O4) nanowire development and creating mechanically self-supporting, nanoporous networks of oxide thermoelectrics. The presenters must be more clear in connecting the "dots" and information. However, the reviewer also noted that the project team did show a successful metal/semiconductor laminate with TE materials (Slide #17). However, no effective thermal conductivity or TE property data was shown for this laminate, so one cannot conclude whether this would be an effective laminate approach or bulk TE material in an operating device. It was not clear how the twenty freestanding 14 µm bilayer foils 6 nm hafnium nitride (HfN)/ 6nm scandium nitride (ScN) superlattice related to the project goals. There is no indication of what TE materials are in the other pictures of laminate lay-ups presented in Slide #17 and how they relate to project goals. This reviewer is left with the general impression that much information is lacking here and prevents a complete review of this team's progress and results.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer indicated that there appears to be good collaboration planned with General Motors and Oak Ridge National Laboratory. Another reviewer agreed that collaboration effort with other institutions is excellent

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer added that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer thought that the future work (Slide #21) appears good, but once again there are no specifics on criteria and goals. "Investigate skutterudites with different filling strategies" is nice, but everyone working in skutterudites is doing that. The commenter questioned what is unique about this work. The reviewer noted that each item listed under Future Work (Slide #21) should have a target metric and goal and questions what they are trying to achieve.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were recorded on resources.

5. Fuels & Lubricants Technologies

The Fuels & Lubricants Technologies subprogram supports fuels and lubricants R&D to provide vehicle users with cost-competitive options that enable high fuel economy with low emissions, and contribute to petroleum displacement. Transportation fuels are anticipated to be produced from future refinery feedstocks that may increasingly be from non-conventional sources including, but not limited to, heavy crude, oil sands, shale oil, and coal, as well as renewable resources such as biomass, vegetable oils, and waste animal fats. The impact of changes in refinery feedstocks on finished fuels is an area of relatively new concern to engine manufacturers, regulators and users. Advanced engine technologies are more sensitive to variations in fuel composition than were earlier engines, in addition to facing tightening emissions standards. The goals are: (1) to enable post-2010 advanced combustion regime engines and emission control systems to be more efficient while meeting future emission standards; and, (2) to reduce reliance on petroleum-based fuels through direct fuel substitution or by non-petroleum-based fuels efficiency gains. These activities are undertaken to determine the impacts of fuel and lubricant properties on the efficiency, performance, and emissions of current engines as well as to enable emerging advanced internal combustion engines. These advanced engines operate in low-temperature combustion regimes that are expected to become more prevalent in the marketplace because of their higher efficiency and continually improving emissions performance. These activities are coordinated with and supportive of EPA's fuels and emissions-related activities.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Fuel and Lubricant Effects	Bunting, Bruce (Oak Ridge National Laboratory)	5-2	3.25	3.25	3.00	3.25	3.22
Fuels for Advanced Combustion Engines	Zigler, Brad (National Renewable Energy Laboratory)	5-4	3.50	2.75	3.25	3.50	3.09
Quality, Performance, and Emission Impacts of Biofuels and Biofuel Blends	McCormick, Bob (National Renewable Energy Laboratory)	5-6	3.80	3.60	3.40	3.40	3.60
Optical-Engine and Surrogate-Fuels Research for an Improved Understanding of Fuel Effects on Advanced-Combustion Strategies	Mueller, Chuck (Sandia National Laboratories)	5-8	3.00	3.25	3.50	3.00	3.19
Advanced Lean-Burn DI Spark Ignition Fuels Research	Sjoberg, Magnus (Sandia National Laboratories)	5-10	3.80	3.40	2.80	3.20	3.40
Non-Petroleum-Based Fuels: Effects on Emissions Control Technologies	Sluder, Scott (Oak Ridge National Laboratory)	5-12	3.25	3.00	3.25	3.00	3.09
Gasoline-like fuel effects on advanced combustion regimes	Szybist, James (Oak Ridge National Laboratory)	5-14	3.25	3.25	3.00	3.25	3.22
Chemical Kinetic Modeling of Non-Petroleum Based Fuels	Pitz, Bill (Lawrence Livermore National Laboratory)	5-16	3.50	3.25	3.50	3.25	3.34
Overall Average			3.42	3.22	3.21	3.23	3.27

Note: Italics denote poster presentations.

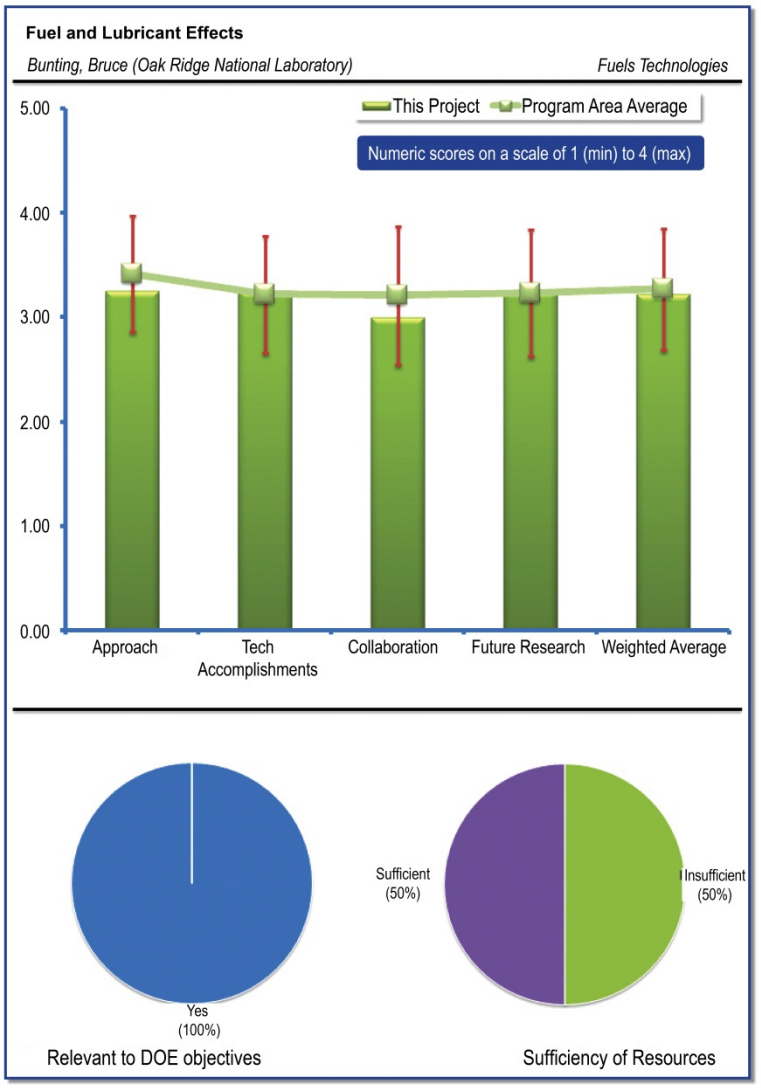
Fuel and Lubricant Effects: Bunting, Bruce (Oak Ridge National Laboratory) - ft001

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers indicated that the project contributes to achievement of the DOE petroleum conservation goal. One reviewer said the project is focused on improved efficiency. This reviewer added that it also emphasizes surrogate fuels and energy options and lubricants, and employs a systems approach. A second reviewer described the project as focused on improving fuel economy, which reduces the amount of fuel consumed, as well as supporting the increased use of renewable fuels and advanced lubricants. The third reviewer concurred that new fuels and more efficient combustion will result in petroleum displacement. The reviewer went on to say that the project appears to offer a path to fuel economy improvement, but that it does not provide tools to estimate fuel economy accurately. This reviewer suggested the project could be improved if it also sought means to estimate the accuracy with which fuel economy can be measured. The final reviewer said that as advanced, renewable fuels begin to be blended into conventional fuels, work performed under this project will be critical to understanding the effects of non-traditional blendstocks on engine performance and emissions.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Four reviewers commented on this question, also. One praised the performance of kinetic modeling prior to embarking on engine tests as a good approach. A second singled out the testing of various fuels in multiple engine platforms and the use of statistical modeling as indicative of a good approach to performing this work. The third reviewer noted that there was significant interaction with national labs/academia, but only limited interaction with the petroleum and lubricant industry. The final reviewer called for more fuels to be included to establish fundamental understanding, but said the approach will help overcome some barriers.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer noted good progress on testing a variety of fuels under advanced combustion conditions to establish links between performance and fuel properties. A second assessed that the addition of gasoline engine and gasoline/ethanol fuels had progressed well. The addition of 30 fuels to the project's database this year was termed a key deliverable by the third reviewer who went on to opine that the statistical work to determine how many fuel variables are needed to resolve fuel effects on global studies should be investigated further and shared. The last reviewer called for more emphasis on real-life fuel economy measurements and noted that kinetic mechanisms to mimic fuel effects were not reported.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers were largely agreed that this project demonstrated good collaboration and coordination with other institutions. One noted significant collaboration with LLNL, and the CRADA work with GM on ionic lubricants. A second reviewer noted that there was a wide range of collaborators and called their work well coordinated. Collaboration was termed outstanding by a third reviewer. The fourth said there appeared to be quite a number of interactions with various universities and some of the national labs, but that interactions with industry seemed fairly limited since the only ones mentioned in the presentation were paying members of Reaction Design's Model Fuel Consortia and GM (the latter in the lubes area).

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Three of the four reviewers offered comments on this question. One felt the new research area in ionic lubricants would offer great potential for improving both lubricant wear and fuel economy. Testing of cellulose-derived renewable fuels was deemed by this reviewer to be a critical area in which more data are needed. A second reviewer said that future work should include more fuels. The third wondered if results of the MIT consortium project would be available for public discussion. If not, this reviewer felt the project should not be listed or supported with DOE funds.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer deemed project resources sufficient for the planned program. A second, while considering that good use had been made of resources to date, felt that greater funding might be required to complete the work. A reviewer expressed the view that considerable additional work would be required to understand the effects of advanced renewables on emissions and fuel economy, as these blendstocks are incorporated into conventional fuels and lubricants. This reviewer also questioned whether more resources would be needed, especially as the ethanol “blend wall” was approached in 2012.

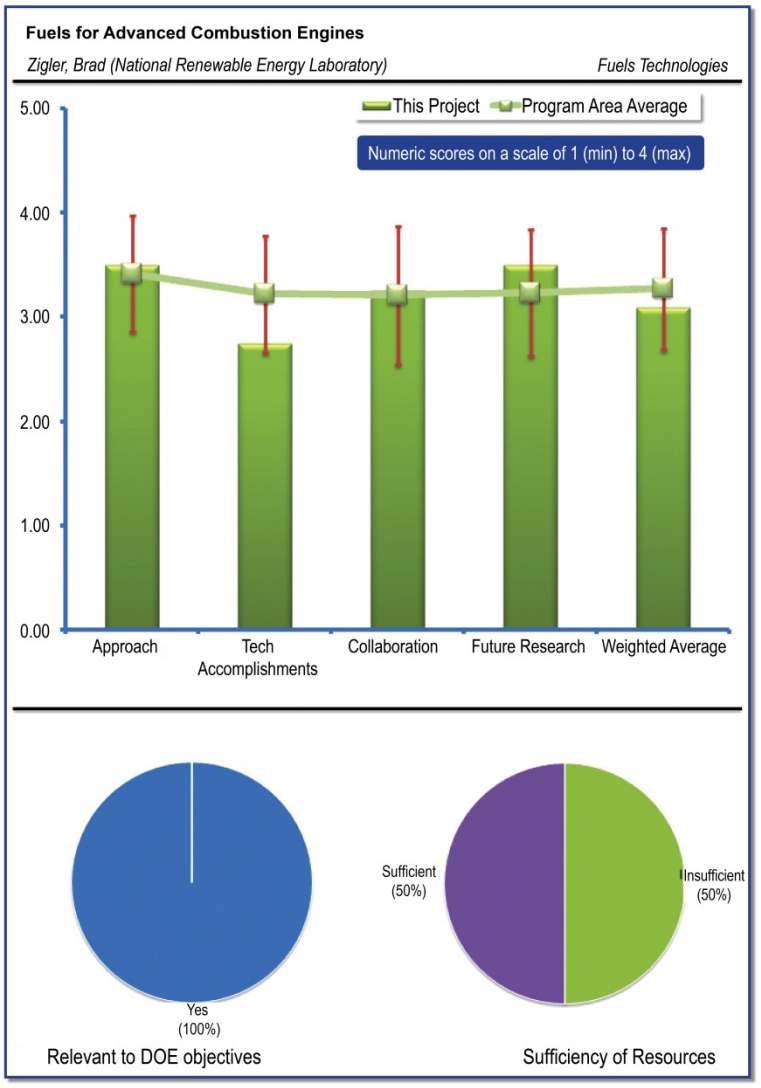
Fuels for Advanced Combustion Engines: Zigler, Brad (National Renewable Energy Laboratory) - ft002

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three of the four reviewers submitted comments on this question. Two responded with affirmative comments. One said fuels can enable improved and more efficient operation of advanced combustion engines, so this project has significant potential to promote development of cleaner, more efficient engines, which can directly displace petroleum. The second concurred in similar terms, noting that by enabling advanced combustion engines with improved fuel economy through understanding the fundamental relationship between fuel properties and combustion, the project could advance DOE's fundamental goal. However, this reviewer expressed the view that the project should include more alternative fuels such as biofuels and ethanol blends. The third reviewer said that the project would support the goal of petroleum conservation by characterizing and recommending sets of fuels to be used in a wide range of research studies.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All four reviewers commented. One termed the approach excellent, adding that multi-disciplinary work by many labs and outside partners is a key to enabling fuel characterization to support advanced combustion engine research. The second agreed, saying that having a standard set of fuels for a variety of combustion studies that draw on sound experimental design to span key fuel properties is a great idea. However, the reviewer continued, the fuels for advanced combustion engines (FACE) fuels composition dictated by the stakeholders is strange in some cases, with bi-modal composition rather than smooth variations across the boiling range. In a similar vein, the third reviewer said that development of a set of gasoline and diesel fuels, the characterization of their physical and chemical properties and their use by various researchers will constitute a good approach. Finally, the fourth reviewer noted the project's wide cooperative efforts among various organizations.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All four reviewers commented on this aspect of the project. The first praised the work done to characterize the diesel fuel set as very impressive. On the other hand, the reviewer lamented the slow progress in adding gasoline and advanced renewable fuels as disappointing but said that appeared to be due to lack of funding rather than to inadequate effort. The second and third reviewers'

comments supported both assessments expressed by the first. One noted that the project had completed significant work on FACE diesel and made progress on FACE gasoline; the other considered the technical accomplishments to have come rather slowly and thought they could be speeded up. The last reviewer viewed the research program as being clearly defined, noting the many activities that used the FACE matrix of fuels and termed the fuels characterization plan well-developed and -executed.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

All four reviewers appeared to approve of the project's collaboration and coordination with other institutions. A reviewer deemed this project to be one exhibiting the broadest collaboration of any seen. Another reviewer noted that a multifaceted array of organizations is participating in this project. One reviewer described the FACE program as an excellent example of public-private partnership serving to advanced societal goals. This reviewer felt there was one weakness, however, namely a lack of substantial university involvement, noting that universities are involved on the downstream end, rather than in the beginning with decision making on formulation and program strategy. The final reviewer acknowledged the collaboration of the auto and oil companies, the fuel blenders and researchers and encouraged continuing collaboration with academia and the CRC.

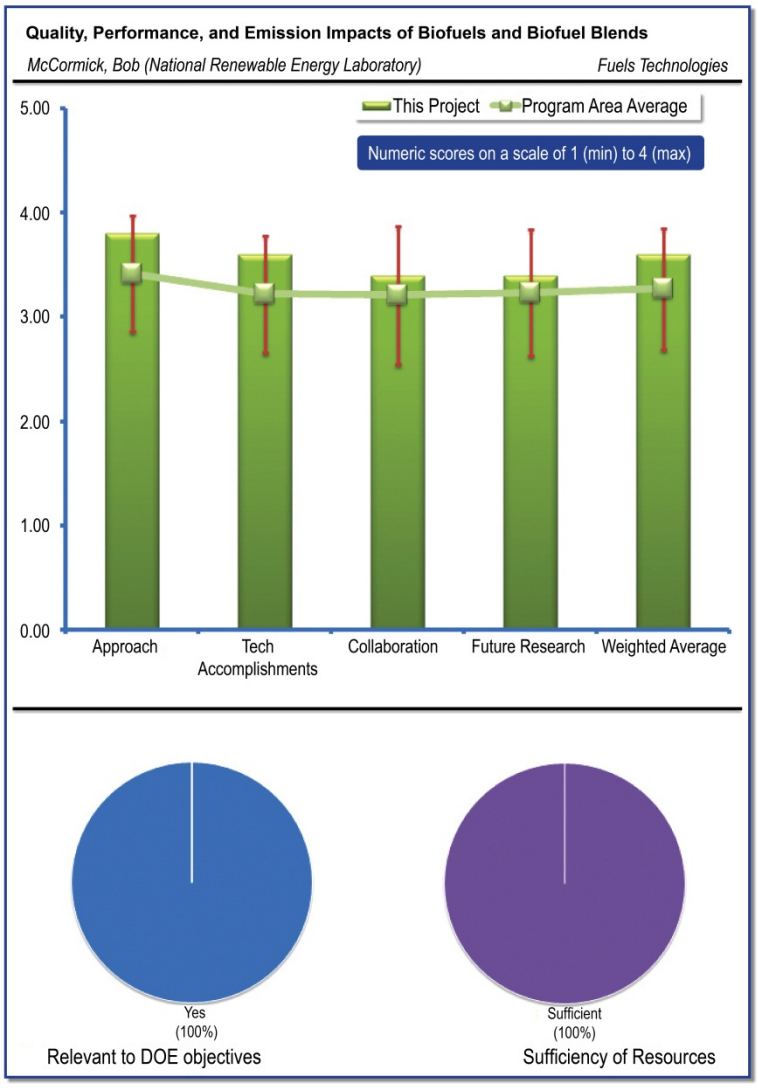
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The project's clearly defined goals were noted by a reviewer and another reviewer noted that future work would extend FACE diesel to include advanced alternative fuels and would complete development of FACE gasoline pursuant to its deployment. Two of the four reviewers made specific recommendations for future work under this project, one saying the proposed work with advanced alternative renewable fuels should be the top priority as these blend stocks start to become commercially viable. The second urged that the FACE working group should compare its engine-based data with other engine studies, using the FACE research fuels when possible.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer, noting the many tasks to be conducted, felt that insufficient resources were available to complete them. The second reviewer expressed a similar view, noting that funding had been stable in previous years, but that it had been cut for 2011. This reviewer commented that funding should be increased and more effort invested in getting university involvement in this project, since this activity offered excellent educational opportunities that are not being realized. The third reviewer was likewise concerned that continued or further cutbacks in funding will likely erode collaborative programs with industry through the CRC. The fourth reviewer considered that an apparent lack of funding is significantly delaying some of these research fuels available for advanced combustion engine testing.

Quality, Performance, and Emission Impacts of Biofuels and Biofuel Blends: McCormick, Bob (National Renewable Energy Laboratory) – ft003



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The four reviewers who provided comments were in general agreement that this project supports DOE's petroleum conservation goal. One said so explicitly, noting that this project, by examining biofuels that can displace petroleum, can directly displace petroleum use and does so now. The second agreed, saying the project's focus is on biofuels and biofuel blends whose use directly displaces petroleum. The third reviewer commented that biofuels and their blends increase the fuel supply, but suggested shifting project emphasis to hydrocarbon renewable fuels and considering long-chain alcohols. A fourth reviewer stated solve problems related to usage of biofuels and biofuel blends.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer approved of the approach, saying its focus on the technical problems preventing expansion of the market for current biofuels and their blends is good. The reviewer added that measuring the quality of these fuels is critical to overcoming barriers. The second agreed, calling the approach to overcoming barriers sound. The third reviewer commented at greater length, noting the project's examination of both first-generation biofuels (those in current use) and advanced biofuels, and its consideration of fuel quality effects, impurities and fuel properties. This reviewer further noted the project's broad and comprehensive scope, encompassing both the mundane, such as fuel quality, which is essential in view of past problems, and the subtle, such as the types of inorganics in biodiesel, their impacts on ash formation and the implications for DPF and SCR systems. The final reviewer spoke of the project's impressively broad scope and its wide industry collaborations.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said simply that eight significant technical goals were reached, without enumerating them. Another reviewer commented at greater length, noting the project's significant observations on biofuel impacts on clean vehicle systems (DPF SCR), and low-temperature behavior. This reviewer also pointed to the project's exploration of the properties and combustion and emissions behavior of emerging oxygenates, an area in which the reviewer urged greater university involvement because of the significant educational opportunity such exploratory work offers. Another opined that surveys of the quality of biofuels being sold in marketplace fills an important need. This reviewer joined the second in calling attention to the good progress made in understanding impacts of biofuels and impurities on engine and exhaust aftertreatment system performance. The fourth reviewer praised the work on B20 effects on DPF

and SCR durability and the effects of saturated monoglycerides as very relevant, mentioning a desire to see more information published on next-generation oxygenates and hydrocarbons. Finally, the fifth reviewer termed the effects of metals important.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer described the collaborating institutions as a broad team including industry-wide organizations – MECA, EMA and the CRC – other laboratories and a university, although urging more university involvement in this very important program. The second echoed this comment, adding the commercial partner BASF to the list of collaborators and deeming their efforts well-coordinated. The third likewise noted good collaboration with EMA and MECA member companies, and the fourth noted a multifaceted approach to involve relevant organizations.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The four reviewers offering comments on this topic agreed generally that the proposed future research was appropriate. One mentioned its well defined goals and targets, a second characterized planned work as excellent, suggesting it be expanded to include additional fundamental studies of the ignition behavior of some emerging oxygenates and their impacts on soot formation. This reviewer's expectation was that such work would help illuminate how these compounds might function in SI, CI and advanced combustion systems. The third reviewer recommended continued work with oxygenated diesel components and thermodynamic modeling of phase equilibrium. The fourth reviewer looked forward to the application of new analytical methods to advanced biofuels.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One of three commenting reviewers felt funding, which according to this reviewer had been relatively stable to date, should be maintained or expanded to permit greater involvement of academic collaborators. The second anticipated the possibility that additional funding might be needed. The third, however, saw no indication that funding was insufficient.

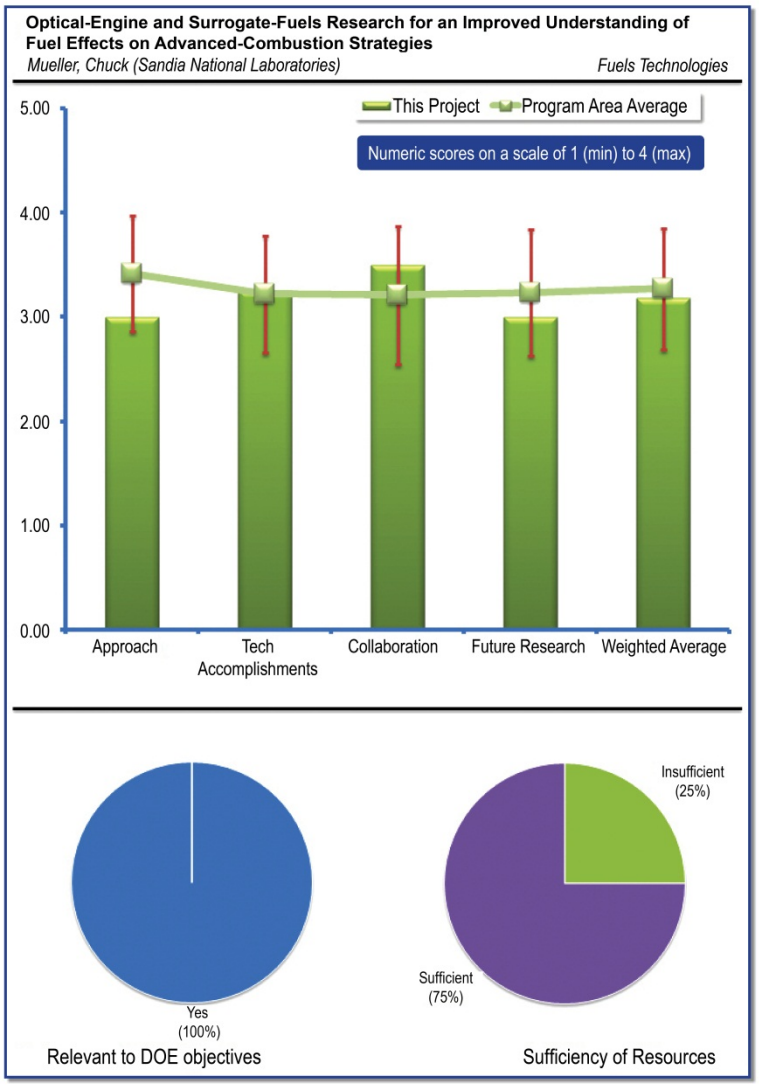
Optical-Engine and Surrogate-Fuels Research for an Improved Understanding of Fuel Effects on Advanced-Combustion Strategies: Mueller, Chuck (Sandia National Laboratories) –ft004

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three reviewers commented on this topic, two of whom agreed that the project supports achievement of the DOE goal. One pointed out that improved fundamental understanding of combustion and fuel effects should enable improved engine performance and design resulting in higher fuel economy and potentially in wider use of alternative fuels, both of which lead to less petroleum usage. In similar language, the second reviewer said that higher efficiency and clean combustion results in decreased use of petroleum-derived hydrocarbon fuels. A third reviewer remarked establish fundamental knowledge to create high efficiency/clean combustion engines. This seems to state the aim of the project, but does not explicitly state that achievement of that aim will advance DOE's petroleum conservation goal.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Four reviewers offered opinions on the approach to the work of this project. Two of them addressed the use of optically accessible engines as research tools specifically, and both approved of that approach. One said an optical engine with design similar to that of "real" engines seems to be a good tool for viewing combustion while having direct relevance to real "metal" engines. The reviewer added that development of improved surrogate fuels offering very similar performance to real fuels, but with fewer components, albeit more components than the simplest surrogates, should be very useful for improving understanding of fuel effects on engine performance and for improving engine and fuel design. The second reviewer offered a supporting opinion, agreeing that combining experimental work with optical engines is leading to a better understanding of fuel effects on advanced combustion strategies. However, the third reviewer was less sanguine concerning use of optically accessible research engines, opining that they may not be the ideal platform. Re-entrainment may be a problem with this approach and not all technical barriers may be overcome. Nonetheless, the reviewer noted that project milestones have been met. The final reviewer deemed the project to be a system approach to gathering fundamental knowledge.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All four reviewers noted project technical accomplishments and in general regarded them as significant. One cited the institution of enhanced lab capabilities; the completion of lean lifted flame combustion (LLFC) studies and the achievement of soot-free combustion with a two-hole fuel injector tip and the coordination and leadership of the CRC fuel program. The second reviewer commended the very good progress made in furthering understanding of issues with LLFC and potential solutions as well as good progress in diesel fuel surrogate development. Another reviewer deemed the ten-factor parametric study and Project 18 under the Advanced Vehicle/Fuel/Lubricants of the Coordinating Research Council (AVFL-18) good accomplishments. The last reviewer concurred, calling the parametric study of lean lifted flame combustion impressive, noting that it had identified two previously unknown barriers to LLFC.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All four reviewers offered generally positive assessments here. One cited the extensive collaboration beyond the national laboratory level, and a second observed fairly well coordinated participation of the CRC and Caterpillar. The third noted that some collaborations were mentioned in the presentation, including that with industry through the CRC program. The fourth reviewer noted a multifaceted matrix of organizations.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer opinions here were divided. One simply said the proposed plans sound good. The second noted that work on fuel and injection strategy effects on mixing-controlled combustion is an area still needing fundamental work. The reviewer anticipated that completion of the diesel surrogate fuel work should result in a very useful tool for researchers. The third reviewer noted that numerous programs plans were listed in the presentation but felt that some might not be realistic, citing examination of the oil-sands diesel fuel in the 2011/12 timeframe. The fourth mentioned the need to quantify fuel and injection strategy but felt the usefulness of diesel surrogate fuels to be open to question.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Only one reviewer commented, suggesting that larger funding could be required by anticipated laboratory upgrades.

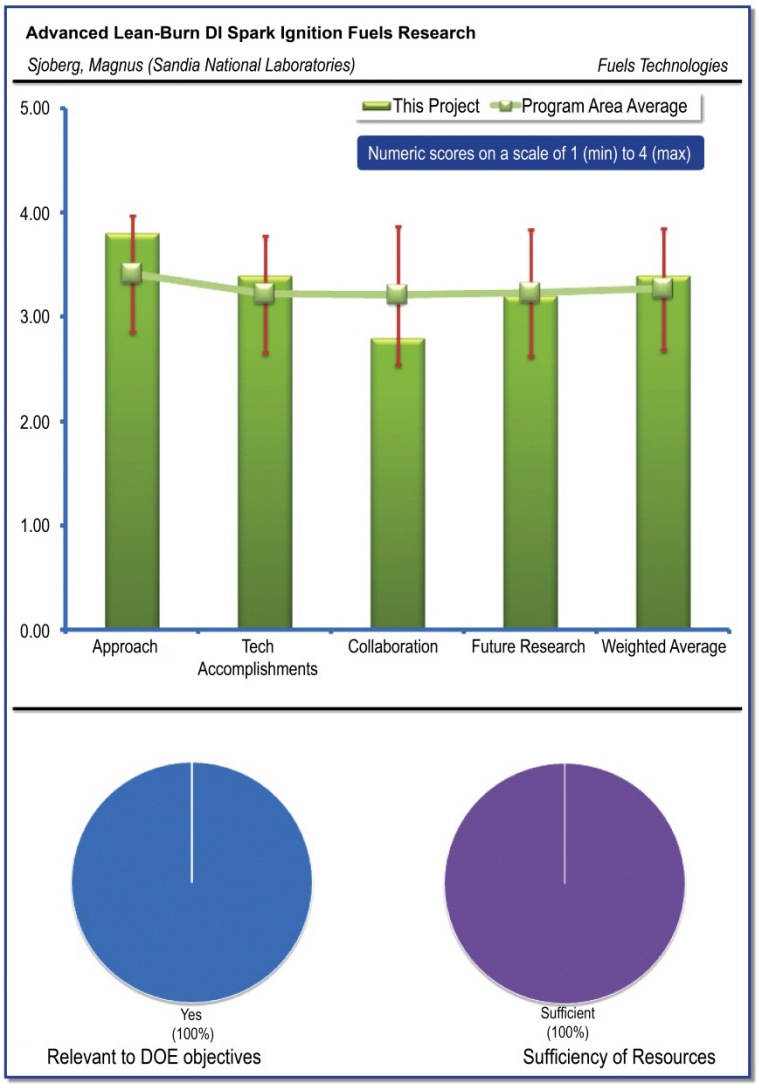
Advanced Lean-Burn DI Spark Ignition Fuels Research: Sjoberg, Magnus (Sandia National Laboratories) – ft006

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two of the four reviewers commenting on whether this project supports DOE's petroleum conservation goal were explicit in affirming that it does. One noted that advanced combustion has the potential to displace petroleum by permitting high-efficiency, lean combustion, including combustion of domestic alternative fuels. The other, noting the project's focus on improving engine efficiency using alternate fuels, said this will directly reduce amount of petroleum needed. The third reviewer linked combustion robustness and fuel efficiency, saying that both are important and that the project focuses on both, with the focus initially on E85. The fourth reviewer re-stated the goal and approach of the researchers conducting the project, saying it was to obtain fundamental knowledge of how emerging fuels will impact combustion of highly efficient LD engines, focusing on E85 and gasoline.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

In responding to this question, one reviewer commented at considerable length, and with strong approval of the approach employed in performing the project work. This reviewer said that the combination of highly skilled investigator and highly specialized, optically accessible engine creates the opportunity for transformative knowledge generation. Continuing, this reviewer noted that the engine design mimics the typical Sandia optical engine design, with industry input on combustion chamber design, employing a complementary metal engine for more conventional combustion studies and validation. The approach, in this reviewer's estimation, offers a great combination of commercial guidance in an advanced experimental platform. Consideration of improving gasoline, including E85, combustion, in a high compression-ratio engine provides the chance to raise SI engine efficiency dramatically, while relying on biofuel. Finally, the reviewer observed that considering levels of charge stratification to optimize combustion and efficiency improvements permits lower equivalence-ratio operation, which lowers pumping losses. The second reviewer commented in a similarly positive vein, albeit more briefly, saying the approach of using both optical and metal engines as well as modeling is excellent and deemed the study's parametric studies fairly robust. Echoing that reviewer, the third said the combination of metal and optical engines with modeling is important to understanding the impact of fuel properties. The fourth reviewer concurred, terming the combination of optically accessible and metal engines with modeling techniques to better understand the impact of renewable fuels on

DISI excellent. The fourth reviewer simply noted the combination of conventional and optical engines without comment on its appropriateness.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Three reviewers commented on the accomplishments of this project, one noting the impressive progress made on engine set-up and understanding TE, another saying it had made good progress for a program that has recently started, with a need to set up a laboratory and test engine. The third acknowledged that the research team had commissioned a test engine and initiated performance testing of the all-metal engine. The fourth reviewer noted the project was showing means of significantly improving gasoline and E85 combustion, albeit at light load. The reviewer described the experiments as well-thought-out, and anticipated that they are leading to authoritative results which will explain well where additional knowledge is needed and what is constraining further improvements.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Five reviewers commented. One praised the excellent project collaboration with industry and overseas partners. Four reviewers noted collaboration with General Motors, one observing that it involved both hardware and consultation, a second that GM appeared to be the most direct and frequent industry collaborator, with a third concurring, terming GM the primary industry collaborator. The fourth referred less specifically to collaboration with an OEM. Two reviewers mentioned project collaboration with universities, one citing the modeling and kinetics work specifically; one reviewer noted national laboratory involvement in the project. Three reviewers mentioned is collaboration with the AEC MOU working group but to one reviewer it was unclear how much direction and interaction had been obtained beyond the few questions brought up during the AEC MOU semi-annual meeting. Likewise, another reviewer observed that while the AEC MOU offered potential collaboration with the EMA and OEMs, that interaction appeared to be less than with other project collaborators.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Four reviewers commented on proposed future work in this project, two of them offering suggestions for that work. One of these opined that understanding low-speed pre-ignition should be made a high priority and speculated that engine oil may be playing a role in this phenomenon. The other recommended hardware alterations to allow deactivation of one valve to create swirl flow. Heat of vaporization, this reviewer went on, is an important factor in future fuels and needs to be pursued. The third reviewer expressed the view that variability (i.e., COV) is limiting the ability to operate at higher IMEP and high efficiency, which is seen in extended combustion duration (weak burning). Continuing work with the optical engine to probe the combustion process fundamentals will enable understanding of this process. That work will also study mid- and high-mid-range ethanol blends, which can address the blend wall challenge. The fourth reviewer found future work plans to be reasonable.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Only two reviewers spoke to this question, one saying that project support was apparently adequate and the other seeing no indication that resources are not sufficient/appropriate.

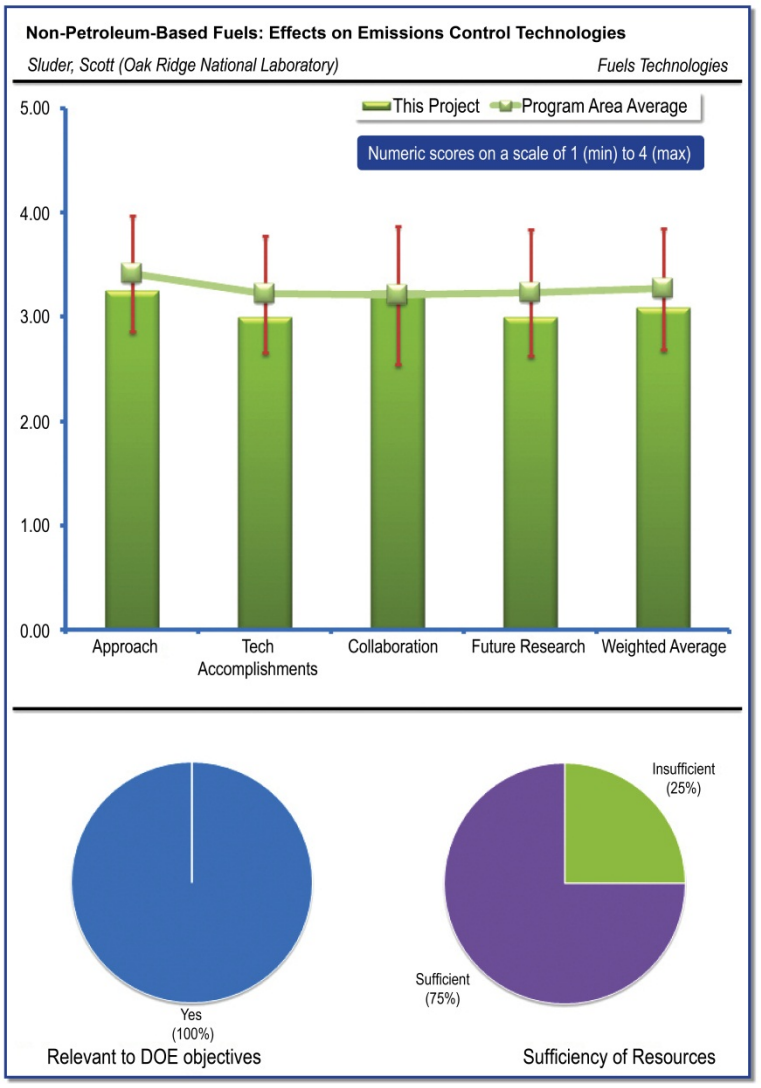
Non-Petroleum-Based Fuels: Effects on Emissions Control Technologies: Sluder, Scott (Oak Ridge National Laboratory) –ft007

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Of the three reviewers offering comments on this subject, one was explicit in crediting this project with support of DOE's petroleum conservation goal, observing that greater utilization of non-petroleum blend fuels (NPBF) will result in petroleum displacement and that optimization of the engine and emissions control system is necessary to enable use of fuels from new, emerging sources. The second reviewer, describing the focus of the project as being on identifying and understanding issues related to use of non-petroleum alternative fuels to enable development of solutions and wider use of alternative fuels, implied that DOE's goal would be supported by this work. The third reviewer's comment was apparently on the aim of the project, saying it is to gather data to support predictive tools regarding fuel properties vs. combustion and effective emissions control.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The project approach was endorsed by all four reviewers. One termed it a good approach, using both engine and bench-scale studies. Another agreed, saying the project brings together targeted, engine-based and bench reactor studies. The approach, this reviewer went on, helps address barriers to market penetration of NPBFs. The third reviewer felt that using engine-based and bench reactor studies to pursue an in-depth characterization of PM and HC emissions and their control represents a well-focused program. The final reviewer cited new characterization techniques.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer cited good progress in a number of areas without further elaboration. The other two were more specific, one mentioning NPBF effects on EGR cooler performance, the effect of sodium from biodiesel combustion on emissions control and regarded the project as moving well toward DOE goals. The third also mentioned sodium's impact on, emissions control systems, citing SCR specifically, and the evaluation of mechanisms of EGR cooler deposit formation and PM oxidation.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Again, three reviewers commented, one citing a wide spectrum of collaborators, another collaborations with several automakers (Ford, GM) and OEMs (Modine, MECA) and the third mentioning Ford and other OEMs, MECA, and academia.

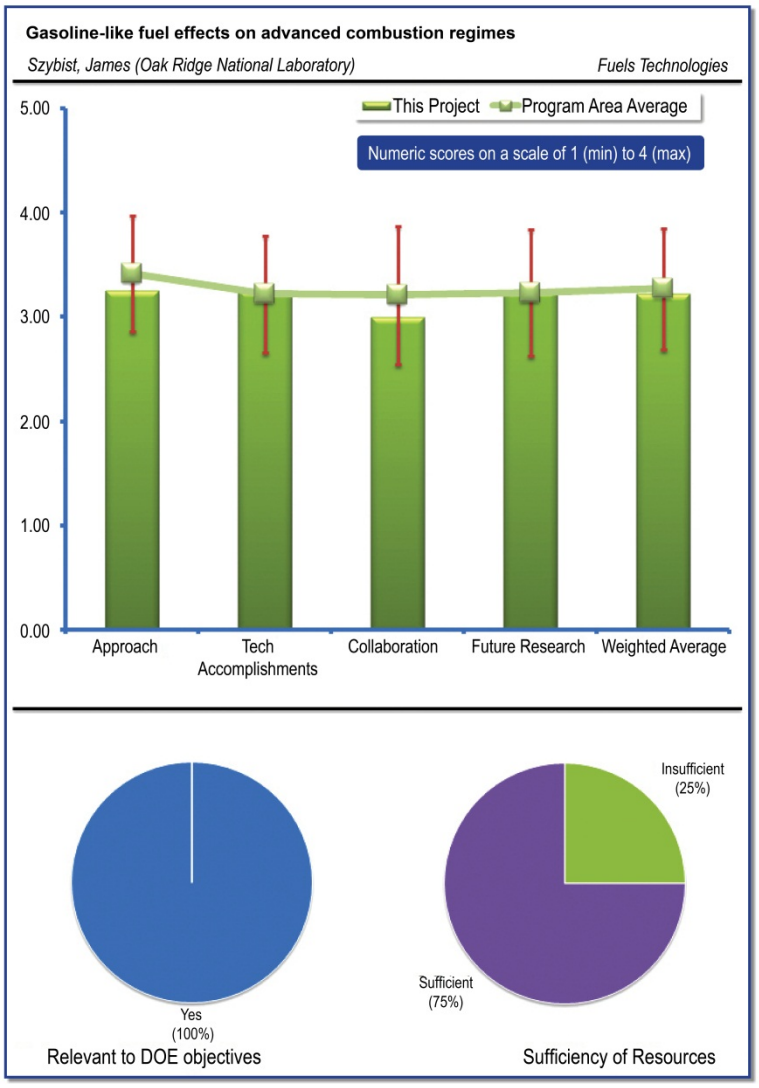
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Two reviewers suggested areas of research they felt should be part of this project's future work. One said the effect of turbocharger deposits on engine thermal efficiency should be investigated. The other called for additional industry input, mentioning the compatibility of emission control systems with lubricants and the efficiency of lubricants. The third endorsed study of soot oxidation and EGR fouling as areas of interest to industry and added that study of the effect of higher molecular-weight alcohols will be timely.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Opinion on this subject was divided. One reviewer said current funding seems sufficient, the second that the project needs more funding. The third observed that the funding level in 2011 has been reduced, and that future funding could be expected to remain at reduced levels. Additional funding would allow additional research, which the reviewer deemed critical to as these technologies and fuels are commercialized, especially given the potential corrosion issues attending biofuels use. It is not clear, in this reviewer's opinion, that this work can be conducted timely at current funding levels.

Gasoline-like fuel effects on advanced combustion regimes: Szybist, James (Oak Ridge National Laboratory) – ft008



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Better understanding of the effects of fuel properties and chemistries of advanced combustion regimes should enable improved engine efficiency, leading to decreased fuel consumption, according to one reviewer, who added that improving the efficiency of E85 use would lead to its wider use in future vehicles. The second reviewer, noting that fuel diversity is increasing due to the Energy Independence and Security Act of 2007 (EISA), mentioned fuel property effects on advanced combustion, RCCI and emissions and efficiency improvements. The last reviewer's comment was work towards real world.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two of four reviewers approved of the work approach, one calling it a good approach, of testing several different advanced combustion strategies, the other saying the work on reactivity controlled combustion seems well focused. The third reviewer dissented, saying the project approach was not well defined and wondered how many different areas were to be studied. The fourth reviewer simply observed that the project employs an ethanol-optimized engine for E20 and E85.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Three of four reviewers offered approving comments on the accomplishments and progress of this project, one citing its development of impressive technical data, the other noting good progress in several areas. The third said that the work on fuel effects for RCCI and spark-assisted HCCI is helping to overcome barriers to its implementation and fill gaps in engine map operation for advanced-combustion engines. The final reviewer's comment was that the early, near-optimal and late injection timing studies had been completed and noting that fueling and breathing strategies also affect particle emissions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer saw excellent collaboration with industry and universities, and a second saw collaboration with a few OEMs. A third reviewer noted the collaboration of the AEC/HCCI Working Group, the University of Michigan, Delphi, University of Wisconsin, and an unspecified OEM, and felt the collaboration was well-coordinated. The final reviewer commented that the project did not have many industrial partners.

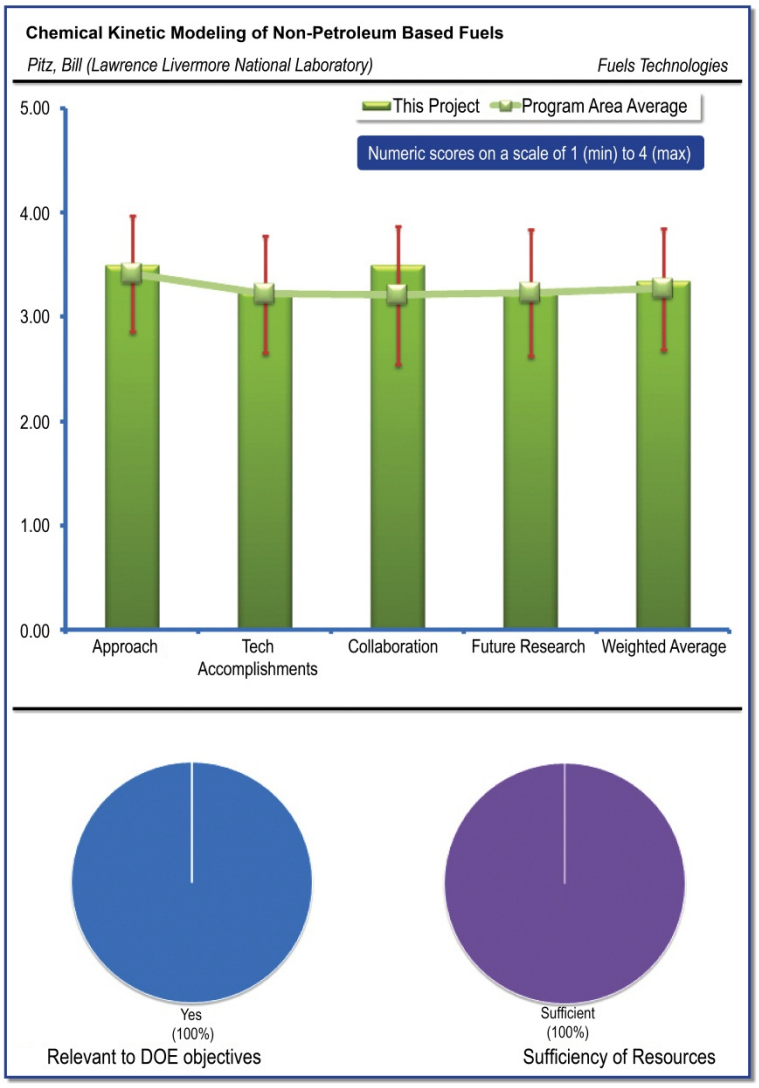
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer said the plans seem good. Another said simply OK. The third reviewer mentioned dual-fuel RCCI combustion, stoichiometric spark-assisted Homogeneous Charge Compression Ignition (SA-HCCI) and ethanol optimization. This reviewer added the words translate SA-HCCI efficiency benefits to real-world fuel economy improvement with modeling.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer offered the impression that quite a bit of work had been accomplished and progress made for $200,000, unless the total funding was larger and the results presented were from a larger program. A second reviewer called the work timely, said it was breaking new ground in the area of SA-HCCI and that there was considerable interest in the dual-fuel RCCI work. This reviewer mentioned that additional funds would expedite development of answers to some of the questions being uncovered in this research.

Chemical Kinetic Modeling of Non-Petroleum Based Fuels: Pitz, Bill (Lawrence Livermore National Laboratory) – ft010



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer said that understanding the chemical kinetics of combustion is even more important in advanced combustion and for unconventional fuels to achieve truly predictive simulation capabilities. In a similar vein, the second reviewer said this program is focused on development of kinetic models for nonpetroleum fuel components, which is important for their optimal use in existing engines and the design of future engines. The third reviewer commented high efficiency engines optimization of fuel formulations. One reviewer remarked replacement of petroleum.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said that the approach of mechanism development has proven very effective to support simulation, because the kinetic models are continually being updated and validated. The network of connections to the fundamental and applied combustion communities provides a technically rigorous and rapidly responding basis for mechanism development. The second reviewer lauded the excellent approach of developing fundamental kinetic models for fuel components; validating models with experimental data from other labs; reducing the mechanisms to reduce computing time and making mechanisms and models widely available. The development of fundamental kinetic models, this reviewer went on, seems very appropriate for the national labs. The third reviewer noted that model development is ongoing. Combine mechanisms, according to this reviewer, for representative fuel components to provide surrogate models for NPBFs. The final reviewer's comment was develop and improve kinetic models.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two reviewers noted project accomplishments with approval. One noted the completion of kinetic models for major components of biodiesel and for iso-pentanol, a new biofuel. These are extremely valuable accomplishments, this reviewer concluded, to support advanced combustion and combustion of non-petroleum fuels. The second reviewer was of similar opinion, saying that important contributions had been made, including completion of kinetic models development for some of the key C16 and C18 biodiesel components and the continuing development of kinetic models for butanol isomers. The last reviewer also mentioned the development of chemical models for butanol isomers and diesel surrogate fuels. The biodiesel model would also be useful.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One of the four reviewers perceived outstanding collaboration with academia and national labs. The second said the project was collaborating with many groups through application of the models to prediction of experimental results and for validation and improvement of the kinetic mechanisms. This reviewer also mentioned participation of project staff in the DOE- and industry-supported working groups. The third reviewer saw some collaboration with other national labs (such as Sandia) and with universities. Primary direct collaboration with industry appeared to the third reviewer to be through CRC working groups such as AVFL-18, with some input also appearing to be obtained at presentations made at AEC semi-annual meetings. The fourth reviewer cited the universities of Wisconsin and Michigan, University of Connecticut (UCONN), FACE and the AEC working group (WG).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Developing kinetic mechanisms for butanol isomers is an excellent goal, said one reviewer, since butanol can be made from lignocellulose and has many benefits over ethanol. This proposed work, this reviewer continued, should support future development of advanced and conventional combustion of butanol. Other areas of expansion of models reflect emerging new fuels such as DMF and algal fuels. A second reviewer called plans to develop mechanisms for other methyl esters, DMF and cycloalkanes worthwhile. The third reviewer named kinetic models for algae, biomass fuel, DMF, iso-pentanol and validation of mechanisms for large methyl esters.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One of three reviewers addressing this point said project funding has been stable despite the overall cuts in VTP. Given how important this work is to the entire engine/combustion community, that is very good news. The other two reviewers deemed funding sufficient.

6. Materials Technologies

Advanced materials, including metals, polymers, and composites, can play an important role in improving the efficiency of transportation engines and vehicles. Weight reduction is one of the most effective ways to increase the fuel economy of vehicles while reducing exhaust emissions. The use of lightweight, high-performance materials will contribute to the development of vehicles that provide better fuel economy, yet are comparable in size, comfort, and safety to today's vehicles. The advanced materials research conducted under the direction of the U.S. Department of Energy's Vehicle Technologies Program will help ensure the nation's transportation energy and environmental future by making affordable full-function cars and trucks that use less oil and produce fewer harmful emissions.

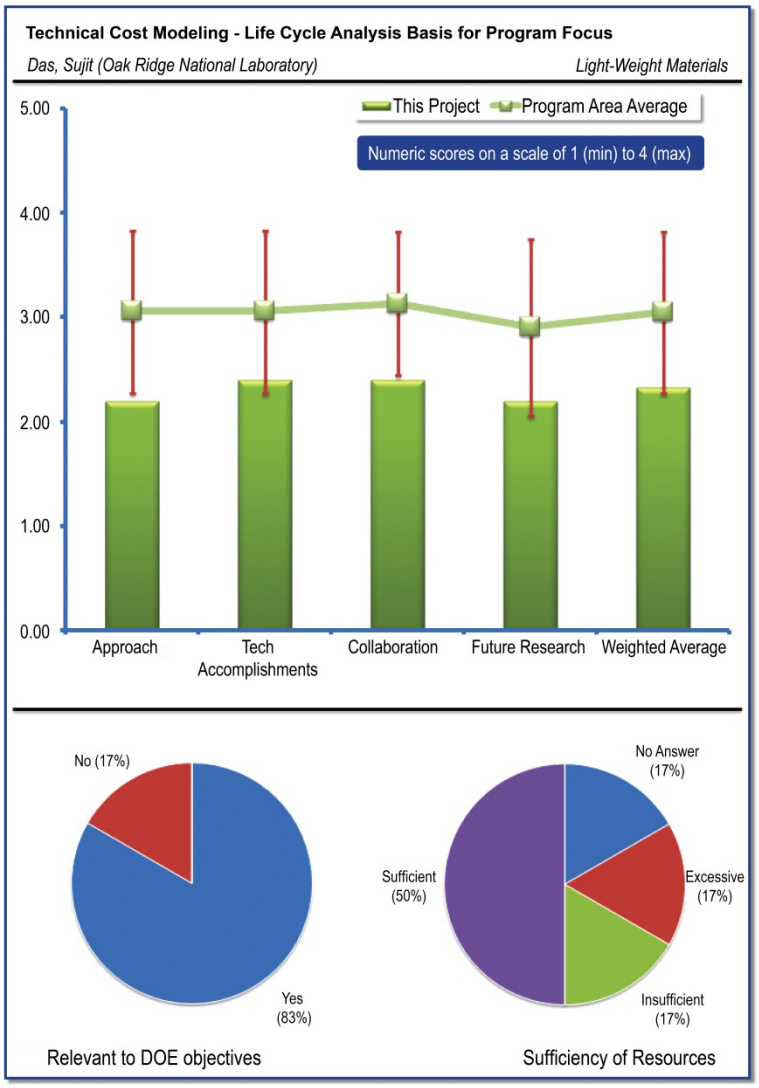
In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Technical Cost Modeling - Life Cycle Analysis Basis for Program Focus	Das, Sujit (Oak Ridge National Laboratory)	6-3	2.20	2.40	2.40	2.20	2.33
Low Cost Carbon Fiber Overview	Warren, Dave (Oak Ridge National Laboratory)	6-5	3.40	3.40	3.60	3.40	3.43
Carbon Fiber Technology Facility	Warren, Dave (Oak Ridge National Laboratory)	6-7	3.50	3.25	3.00	3.50	3.31
Lower Cost Carbon Fiber Precursors	Warren, Dave (Oak Ridge National Laboratory)	6-9	3.50	3.75	3.50	3.50	3.63
Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers	Warren, Dave (Oak Ridge National Laboratory)	6-11	3.00	3.00	2.50	3.25	2.97
Magnesium Front End Development (AMD 603/604/904)	Luo, Alan (USAMP/AMD)	6-13	3.00	3.00	4.00	3.00	3.13
Integrated Computational Materials Engineering (ICME) for Mg: International Pilot Project	Li, Mei (USAMP/AMD)	6-15	3.50	3.00	3.00	3.50	3.19
Fundamental study of the relationship of austenite-ferrite transformation details to austenite retention in carbon steels	Warren, Dave (Oak Ridge National Laboratory)	6-17	2.40	2.20	1.40	1.40	2.05
Dynamic Characterization of Spot Welds for AHSS	Feng, Zhili (Oak Ridge National Laboratory)	6-20	3.33	2.67	3.33	3.00	2.96
Analyzing Casualty Risk using State Data on Police-Reported Crashes	Wenzel, Tom (Lawrence Berkeley National Laboratory)	6-22	2.20	2.20	3.20	2.40	2.35
Materials Characterization Capabilities at the High Temperature Materials Laboratory: Focus on Carbon Fiber and Composites	Payzant, Andrew (Oak Ridge National Laboratory)	6-24	3.25	3.50	3.25	3.00	3.34
Materials Characterization Capabilities at the High Temperature Materials Laboratory and HTML User Program Success Stories	Lara-Curzio, Edgar (ORNL/HTML)	6-26	3.25	3.75	3.25	3.00	3.47
Multi-Materials Vehicle R&D Initiative Lightweight 7+ Passenger Vehicle	Wagner, David (USAMP/NDE Chrysler)	6-29	3.33	3.00	3.33	2.67	3.08

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Friction Stir Spot Welding of Advanced High Strength Steels II	Paxton, Dean (Pacific Northwest National Laboratory)	6-32	4.00	3.67	4.00	3.33	3.75
FSW & USW Solid State Joining of Magnesium to Steel	Warren, Dave (Oak Ridge National Laboratory)	6-34	3.50	3.50	3.00	3.50	3.44
High Strain-Rate Characterization of Mg Alloys	Warren, Dave (Oak Ridge National Laboratory)	6-36	3.67	3.50	3.00	3.50	3.48
Pulse-Pressure Forming of Lightweight Metals	Paxton, Dean (Pacific Northwest National Laboratory)	6-38	3.25	3.00	2.75	2.75	3.00
Ultra-Fine Grain Foils and Sheet by Large-Strain Machining	Paxton, Dean (Pacific Northwest National Laboratory)	6-40	2.67	2.67	2.67	2.67	2.67
Solid Oxide Membrane (SOM) Electrolysis of Magnesium: Scale-Up Research and Engineering for Light-Weight Vehicles	Derezinski, Steve (MOxST)	6-42	3.29	3.43	2.86	3.00	3.27
Diffusion Databases for ICME	Warren, Dave (Oak Ridge National Laboratory)	6-45	3.00	3.00	3.40	2.80	3.03
Southern Regional Center for Lightweight Innovative Design (SRCLID)	Horstemeyer, Mark (Mississippi St University)	6-47	2.00	2.33	2.33	2.33	2.25
Materials Informatics for the ICME Cyber Infrastructure	Paxton, Dean (Pacific Northwest National Laboratory)	6-49	2.20	2.40	2.80	2.40	2.40
Materials Characterization Capabilities at the High Temperature Materials Laboratory: Focus Lightweighting, Magnesium	Watkins, Thomas (ORNL/HTML)	6-51	3.60	4.00	4.00	3.40	3.83
AMD 405: Improved Automotive Suspension Components Cast with B206 Alloy	Osborne, Dick (USAMP/AMD)	6-54	2.33	2.33	3.33	2.67	2.50
AHSS Stamping Project - A/SP 050; Nonlinear Strain Paths Project - A/SP 061	Cullum, Terry (USAMP/ASP)	6-56	2.50	2.50	3.50	2.50	2.63
Advanced Materials and Processing of Composites for High Volume Applications (ACC932)	Houston, Dan (USAMP/ACC)	6-58	3.00	3.00	3.33	2.67	3.00
Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts	Stike, Jim (Materials Innovation Tech)	6-61	3.60	4.00	3.80	3.00	3.75
Overall Average			3.05	3.05	3.13	2.90	3.05

Note: Italics denote poster presentations.

Technical Cost Modeling - Life Cycle Analysis Basis for Program Focus: Das, Sujit (Oak Ridge National Laboratory) – lm001



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said the project has significant relevance to the DOE lightweight materials program, but did not address the matter of its relevance to DOE's petroleum conservation goal. Potentially, this reviewer continued, it is the most relevant, as it is the tool to access need and accomplishment. A second reviewer expressed the opinion that it is necessary to understand and prioritize various options available to a lightweight vehicle, which are known to improve fuel efficiency. LCA and TCM are known to provide directions for priority setting exercises. The third reviewer was emphatic that this project is not relevant to solving the challenges facing the nation regarding petroleum displacement. Each supplier and manufacturing company is better able than the PI to determine the costs and benefits of each potential technology. This work is not valuable to the industrial companies who will implement the lightweight solutions. One reviewer said it is important to understand the impact of component- level mass reduction on the vehicle-level potential mass, and one said cost is an important factor in any business and technical decisions in vehicle lightweighting. Neither comment addresses petroleum conservation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers were more or less critical of the project work approach. One said the system-level analysis seems too generic, with a lot of estimates which might affect the sensitivity of the modeling work. Need to provide more details of input and factors considered. A second reviewer found the approach to be slightly scattered, considering that there are too many subjects to address subject to sufficient (needed) level of detail. The benefit is establishing environmental and economic benefit of materials and process. This reviewer felt that with additional resources, scope could be expanded to include further scientific and numerical cost modeling efforts. A third reviewer, noting that the total cost of a process or material was estimated using information available in the literature. Perhaps, this reviewer suggested, it would be better to cross-check with actual data from industry partners. Involving them will be more beneficial. The fourth and final reviewer regarded the project's cost estimating approach as overly simplistic and felt it failed to address the two most important cost drivers - invested capital and assembly costs. Further, the discussion of mass compounding was not accurate. There are numerous ways to approach mass compounding from the historical teardown data, but the PI's discussion was over-optimistic at best.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One of the four comments presented by reviewers in this category addressed project accomplishments and progress explicitly. That reviewer said there had been good accomplishment, but that a tangible basis for a conclusion was lacking. Most papers, this reviewer went on, are written to demonstrate a strategic position of the funding or development agent. The remaining three reviewers' comments spoke as much to the work approach as to technical accomplishments. For example, one reviewer said the cost modeling approach is a mix of supplier input and literature data. A better approach, this reviewer suggested, would be technical cost modeling based on the process fundamentals, and not influenced by literature data which can be misleading. In the same vein, the third reviewer said the data used for the calculations are mostly from open source[s], but this needs to be fine-tuned with confirmation from the actual producers. For example, the information on the Chinese process may be a few years old and should be confirmed. The fourth called the "first order" relationship for the subsystem costs not relevant and often completely inaccurate compared to actual costs. Because this project uses data instead of getting to a legitimate technical cost model, the net results is not understandable from either the technical process or the commercial vantage point. Speaking more specifically, this reviewer continued: For the magnesium solid oxide membrane (SOM) process, the comparison from the small-scale and large- scale production is not legitimate. There is no currently available SOM production source, so comparing to aluminum is irrelevant.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Inter-institutional collaboration in this project, according to the first reviewer, seems to be good, given the sensitivity of cost analysis and the difficulty of data collection. Collaboration with the Canada Centre for Mineral and Energy Technology (CANMET) and other labs adds credibility and peer review opportunity, said the second reviewer, leveraging additional human and financial resources. The third reviewer suggested more involvement from industrial partners, as the data need to be confirmed by partners. The fourth reviewer, however, felt there was little mention of the collaborators or the data sources. How the three groups and the suppliers worked together was unclear, since which information came from which group and how they were reviewed and validated was never discussed.

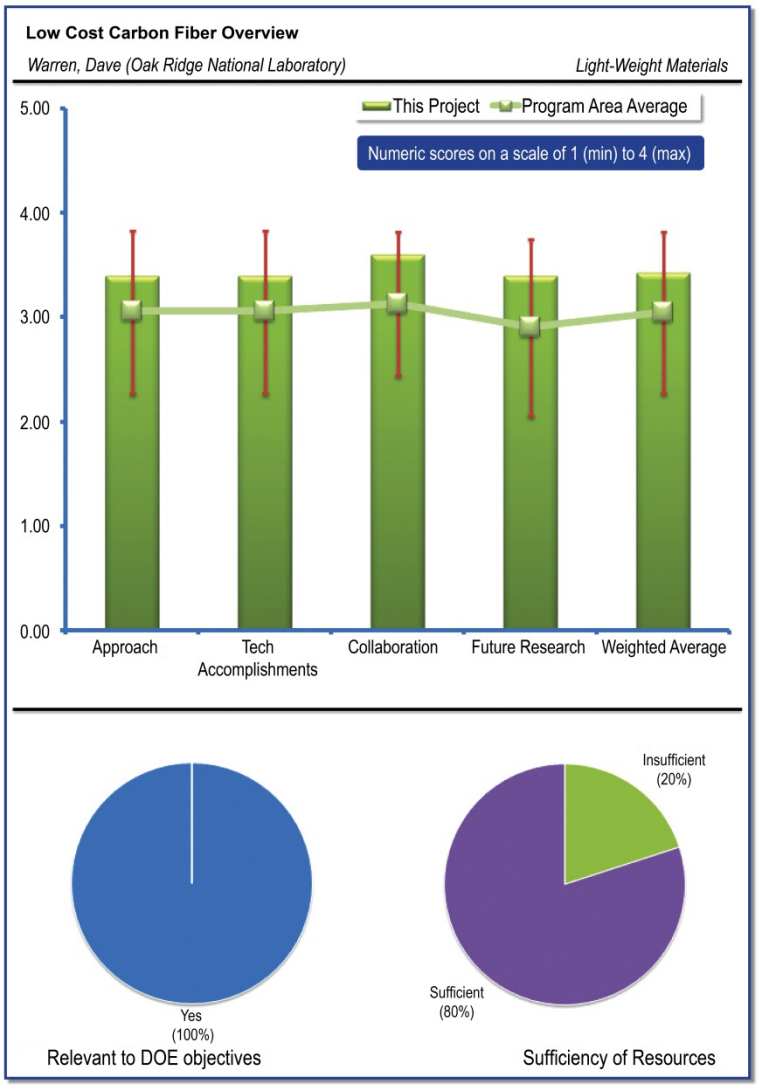
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

In general, the four commenting reviewers were not enthusiastic regarding proposed future research in this project. One recommended use of the Massachusetts Institute of Technology (MIT) technical cost modeling approach, rather than the mixed approach that is less reliable. A second reviewer suggested that sensitivity analysis of the process and materials be carried out, along with work on the multi-material. The third reviewer found the project to be lacking [a] vision for future. This area provides the opportunity for significant documented environmental and cost assessments. The future work, according to the last reviewer, is what "someone" has asked you to investigate. How the new initiatives are related is far from clear.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer opinion on this topic spanned the range of options, one reviewer deeming the resources insufficient, four considering them to be sufficient and one terming them excessive. The reviewer who thought resources to be insufficient recommended expanding project collaboration to include EU and broaden scope from literature review to a documented scientific and financial unbiased multinational resource. This effort would require a six-to ten-person, multi-year commitment. The reviewer who felt the project resources to be excessive said this is too much money to spend on a poorly executed project.

Low Cost Carbon Fiber Overview: Warren, Dave (Oak Ridge National Laboratory) – lm002



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

While not in all cases directly addressing petroleum conservation, the four reviewers' opinions were generally positive. Two comments did directly relate to the DOE goal of petroleum conservation and the manner in which this project supports it. One reviewer said the project, if successful in reducing cost of CF, would see much wider application of that material to automobiles which would drastically increase efficiency and reduce fuel usage and GHG emissions. Cost reduction, this reviewer went on, is a key enabler of more widespread usage of carbon fiber composites. The second reviewer agreed strongly with that assessment, saying carbon fibers are fundamental to the DOE objective of diminishing petroleum consumption, especially when taking into account that a 10% weight reduction will translate to about a 5% fuel consumption reduction. Any object that can be manufactured with carbon fibers will probably see the largest weight reduction, and thus the better fuel economy. This reviewer added his hope that the current economy would not compromise the future of this project. This reviewer referred to carbon fiber as an enabling material. Carbon fiber, according to the third reviewer, is an important lightweight material worth the investment. The last reviewer said this research, although not having a high impact today on petroleum displacement, could have a high impact in the future if CF composites utilization in the transportation industry increases. The manufacturing elements of this project, on the other hand, do offer energy savings which translates into reduced energy dependence, in this reviewer's estimation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers commenting on this aspect of the project were by and large approving of the work approach. One called it a very focused effort to drive down the cost of CF precursors and must continue only at an accelerated pace to drive the development of pre-preg to enable more CF applications in the transportation industry. The second reviewer said it appears the technical barriers have been identified. However, the program seems to be taking a "shotgun" approach to doing a little bit of everything rather than narrowing focus to critical-path items. The third reviewer thought it clear that the project can continue as structured and be successful in the end. The experimental part is outstanding but it seems to me the modeling effort is not at the same level. The comparison between the two is necessary for the overall understanding of progress to be made. This reviewer recommended that more effort be put into the modeling aspect of the project.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One of the three reviewers offering comments deemed the project to have made great progress, and urged that the technical center be opened and the product put out into the hands of the OEMs in all transportation industries. The second felt that the presentation was just a "stage setting" overview, and so found few specific examples of progress cited. Accordingly, that reviewer thought this question [i.e., on technical accomplishments and progress] did not appear to be relevant to the presentation, and was therefore difficult to quantify. The last reviewer offered the same comment as in the previous section, namely that while the project could continue as structured and be successful, the modeling effort did not appear to be at the same level as the experimental portion. This reviewer therefore recommended increased emphasis on modeling.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer noted simply that many collaborators were listed in the presentation, but the other two reviewers who commented termed the collaboration among the different parties excellent and the other cited outstanding collaboration with domestic OEMs and the U.S. Council for Automotive Research (USCAR).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two of the four reviewers addressing this question approved the proposed future work in fairly strong terms. One said that overall, it looks very good and recommended its implementation. The second awarded it another outstanding mark and urged that the results be delivered as soon as possible. The third reviewer cautioned that cost is only one small factor in the equation and that the technology of integrating this material (CF) into vehicle structure is more important. The last reviewer was unable to tell what the specific future plans are other than completing the CF Technology Center.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Four of five reviewers deemed project resources to be sufficient; one felt they were insufficient. The latter considered that the researchers needed to have more people to help them reach their goals in a timely manner. Of the reviewers who felt the project's resources were sufficient, one expressed the hope that DOE would continue to support this project as before. The other urged that the project delivery time be shortened, if possible.

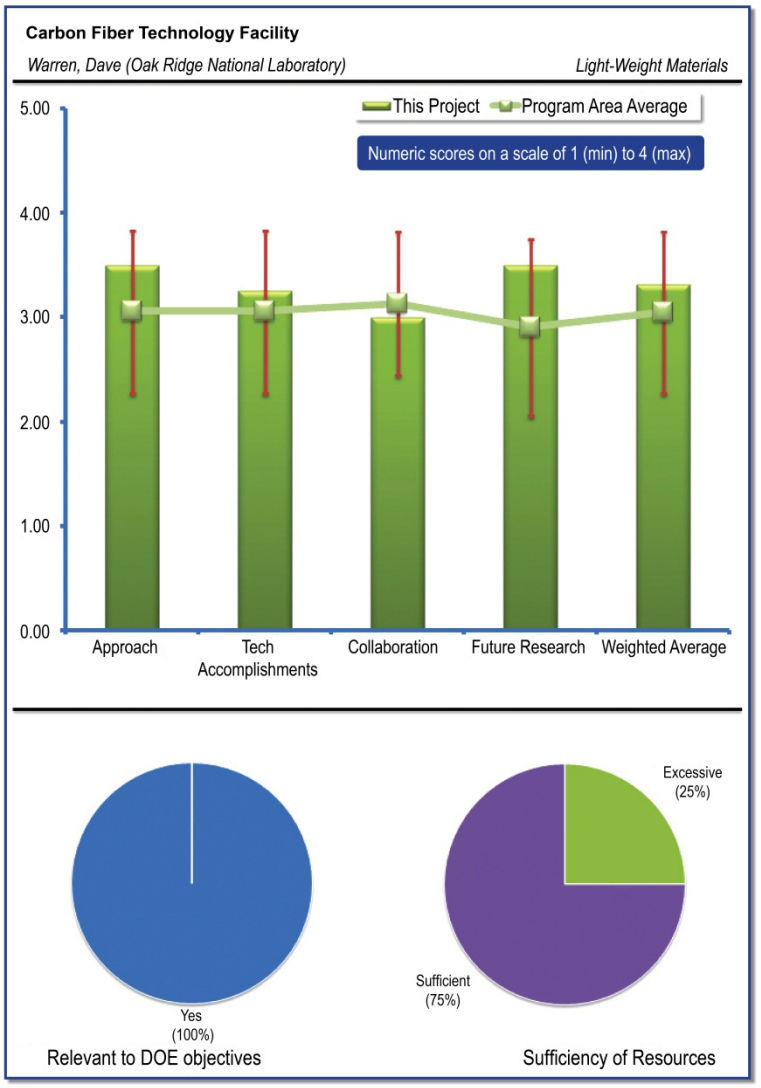
Carbon Fiber Technology Facility: Warren, Dave (Oak Ridge National Laboratory) – lm003

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two of the four reviewers spoke directly to the matter of petroleum conservation and greenhouse gas emission reduction, which are DOE's overarching goals. One said that based on both vehicle weight reduction (fuel economy) and energy reduction technology (infrastructure), this new CF processing facility will directly reduce petroleum dependence in the long term. The other said this facility will expedite development and commercial implementation of new techniques to produce lower-cost CF. That will enable more widespread application of CF in high- volume automotive production. That in turn can significantly reduce vehicle mass, improve vehicle efficiency and reduce GHG emissions. The other two confined their remarks to the commercialization of carbon fiber construction, one saying this small-scale carbon fiber equipment is a great way to verify the findings in the lab and pave the way for productionizing low-cost carbon fibers. The other termed it a necessary step toward commercialization.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer said the fact that this is a production scale-up for low-volume production of low-cost carbon fiber makes this very focused on industry needs. But the second reviewer, while noting that the project seemed to have taken into account the ability to implement all major relevant technologies (as envisioned or anticipated by ORNL) in various combinations, expressed the view that it would have been good to get suppliers involved early in the process rather than after the facility is built. Building a $34 million facility assuming suppliers will seek to use it in DOE co-funded demonstration projects, this reviewer said, seemed somewhat presumptuous. The final reviewer commenting termed the presentation a good show and tell. It looked promising, but this reviewer found the presentation to be light on technical details.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One of the three reviewers predicted that this project is on track to be outstanding, after the facility is up and running and producing the CF materials scoped as a part of the project. Further, this reviewer projected, this will be successful and thus, in future reviews, will receive an outstanding ranking. Echoing this, a second reviewer said the project objective is beyond what was presented today [at the AMR]. This reviewer looked forward to the next presentation to see whether the plant will deliver the prize. The third reviewer felt the project has made decent progress in the design and construction of the facility, once funds were received.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Two of three reviewers praised the collaboration exhibited in this project. One was particularly complimentary, saying that, as with all other ORNL projects, collaborations look outstanding. This lab seems to have a good culture to nurture such collaborations. The second reviewer's comment was of like sort: You [the project team] have listened to the transportation industry and are responding with the Carbon Fiber Test Facility (CFTF) scale-up. The third reviewer expressed reservations regarding project collaboration and with coordination, in particular. Collaboration is anticipated, but not demonstrated, adding that it seems it would have been appropriate and prudent to more fully engage suppliers before finalizing plans to ensure that the anticipated needs and concerns of all suppliers were addressed in the design of the facility.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Once scaled and producing CF materials, one reviewer said, this can become the model for next scale processing lab. There is no question that CF will deliver a 60% weight savings and it starts with the CFTF. The plan is good, in the second reviewer's estimation, if indeed there is supplier pull for the use of the facility, as opposed to technology push by DOE. The third reviewer, however, felt that the project team cannot really envision what they will do with that plant. Openness is the name of the game here, the reviewer continued, expressing the hope that the researchers will remain as open as possible. The project, in this reviewer's opinion, represents a very important endeavor.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Of the four reviewers weighing in on this topic, three felt project resources were sufficient and one viewed them as insufficient. Expanding on this, the reviewer who felt project resources to be inadequate said resources are adequate for building the facility. However, this reviewer did not see a viable plan for sustaining it without a substantial burden on future years' R&D budgets. For this reason, this reviewer deemed resources insufficient to get the job done in the long term. Additional funding should be provided over and above budget for research. Another reviewer described the project as appropriately scoped and sized for the current effort.

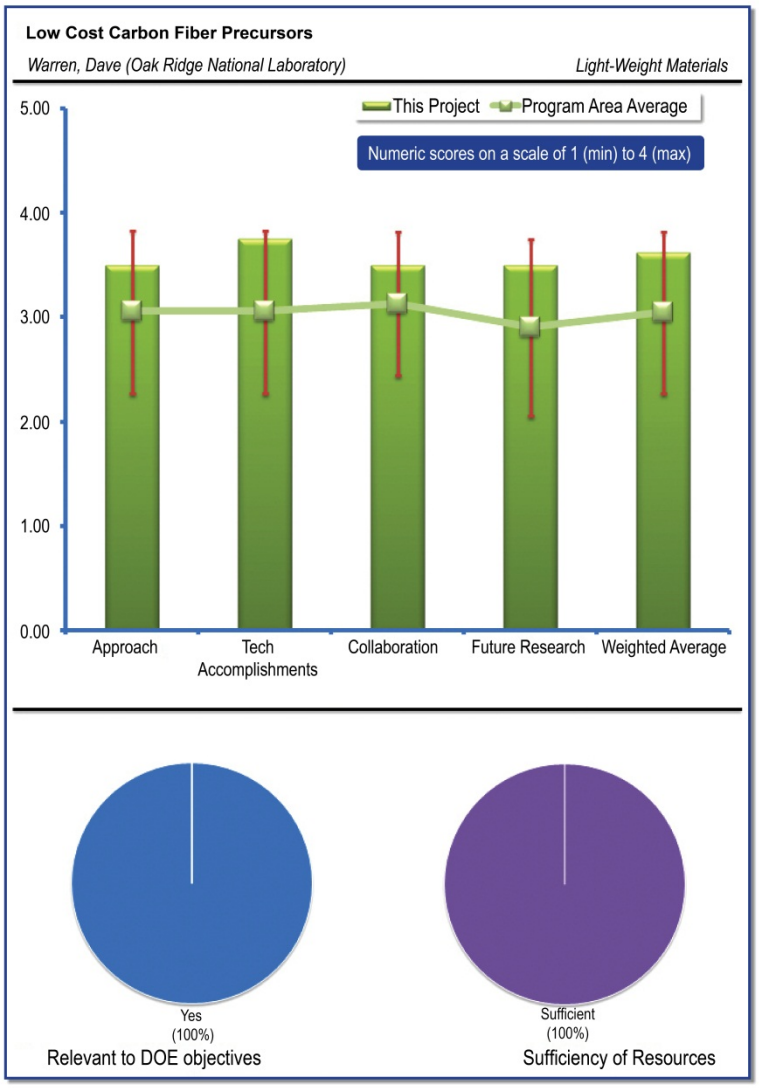
Lower Cost Carbon Fiber Precursors: Warren, Dave (Oak Ridge National Laboratory) - lm004

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Of the four reviewers responding to this question, only one mentioned petroleum conservation explicitly. One reviewer said a truly low-cost precursor (as seems possible with polyolefin) would eliminate a major barrier to much more extensive use of CF in high-volume automotive applications, thereby grossly reducing the weight of the automotive fleet. This would improve fuel economy and reduce GHG emissions. Another reviewer said the fact this project is looking at multiple sources for low-cost CF precursors adds to the technology tool box and portfolio of technologies to deliver CF composites. This is significant in delivering low cost carbon fiber (LCCF) to enable weight reduction in the transportation industries. The two remaining reviewers said, in one case, that this is a good collaboration with the industry to bring to production a lower-cost carbon fiber while work is in progress for more innovative and aggressive cost reductions. In the other case, the reviewer cited the project as offering good understanding and a good description of precursors and their physical properties.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Only two reviewers offered comments on this question. One said polyacrylonitrile (PAN) vs. linear low-density polyethylene (LLDPE) vs. lignin are all technologically advanced and delivering a package of low-cost carbon fiber opportunities and urged the project team to press on - good work. The second reviewer was less sanguine. This reviewer is unconvinced that the scale-ups of those precursors will be as "easy" as heard. Scale-ups are always problematic and difficult to master.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

By and large, all four commenting reviewers were complimentary of the project's progress and accomplishments to date. One, while acknowledging that it is difficult and would be inaccurate to assign one value because all of the projects presented have varying degrees of accomplishment. On average, this reviewer said the suite of projects would be rated "good." For example, polyolefin and textile carbon fiber precursors are very good, while lignin is a poor starting point. The second reviewer labeled project accomplishments and progress as very good. The chemistry of lignin, he continued, is very important and this is explained very clearly and comprehensively. The project team knows where they are going. The third reviewer commented on similar lines, saying that

making small prototype batches is the starting point and this project has not lost sight of the long-term goal to scale and test this in the CFTF that is being built.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

In commenting on this aspect of the project, one reviewer reiterated the comment offered in the preceding section, saying it is difficult and would be inaccurate to assign one value because all the projects presented have varying degrees of collaboration. On average, this reviewer judged collaboration overall to be "good." However, the textile-based work seemed to this reviewer to be too focused on a single company (FISIPE). The reviewer questioned how the industry in general will benefit if a unique process is developed for a specific supplier. The second reviewer commenting judged collaboration with universities and other industry research organizations to be excellent. The final reviewer's comment was that collaboration and coordination could probably be considered good, but that better representation could have been made.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Again, three of the reviewers offered comments on this topic. One was effusive, saying this project is good, bordering on outstanding. But, there may be too many precursors being studied. This reviewer urged the researchers to choose one or two, to narrow the scope and focus and deliver rather than dilute the R&D efforts. All are excellent projects, keep up the good work. The second reviewer generally concurred, deeming this a well-structured program and its proposed future work plan to be more than good. The last reviewer stated an impression that reviewers had been told that work in the CF Facility will start with a focus on textile-based precursor (e.g., FISIPE). It seemed more appropriate to focus on getting the "biggest bang" possible, which would come from the polyolefin precursor.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All reviewers considered the project to have sufficient resources to achieve its milestones. One reviewer reiterated an earlier comment in part, urging the project team to focus and deliver with existing resources.

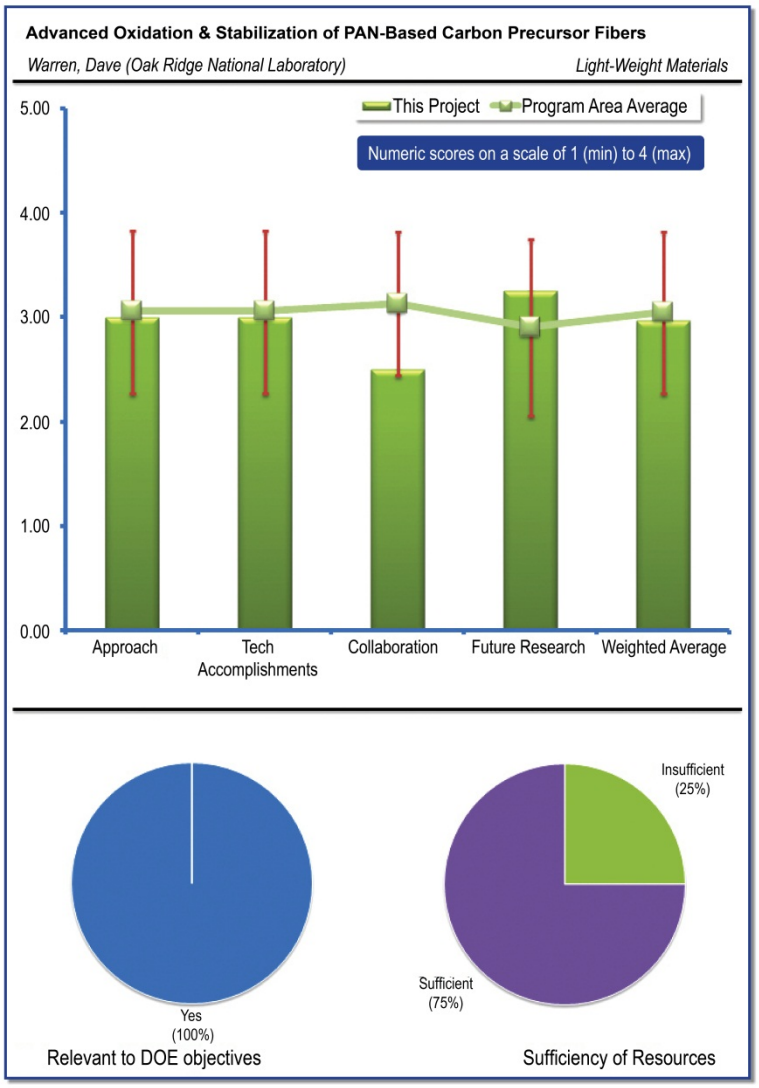
Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers: Warren, Dave (Oak Ridge National Laboratory) – lm006

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A single reviewer of the four offering comments was explicit concerning the project's relevance to DOE's petroleum conservation/greenhouse gas reduction goal. That reviewer said the project focuses on overcoming one of the key challenges for producing low-cost carbon fiber. The cost structure appears to be on target for low-cost carbon fiber. Without elaborating on his logic, the reviewer said the project is well aligned with the DOE petroleum displacement goal. Other reviewers' comments related entirely to carbon fiber cost reduction. For example, the second reviewer said reducing the cost of CF is important for the widespread use of the material for lightweighting purposes. This project is trying to reduce the time it takes to produce the final product. The third reviewer agreed, in somewhat greater detail, saying throughput is reflected in cost. Doubling to tripling rate of throughput of an 18% cost content is 10% increased throughput. The final comment was because it is part of making carbon fibers.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One of the four commenting reviewer approved the chemistry-based robust approach, saying it is delivering results for PAN oxidation. Basing the efforts on atmospheric pressure plasma also aligns with the overall goals for low-cost carbon fiber. Excellent efforts to troubleshoot the reactors to find the root cause of the shortfall in the performance of the fibers. The second reviewer said that the project employed a good technical approach to addressing the technical barriers. The final two reviewers offered some criticism of the work approach. One said it appeared to have been painfully discovered, which this reviewer took to be an indication that the model they are using is not at the level of the experimental capability. The last reviewer said the presentation illustrated the trials made to achieve the specification limits set in Phase I, but although those limits had not been achieved, the presentation claims Phase I is completed, something the reviewer said was not evident from the presentation or the discussion that followed it. The project is aimed at reducing the time it takes for oxidation of precursor, which was said to be diffusion-controlled, and thus possibly dependent on the thermal activation available during the process. If the new plasma process is not non-thermal, the reviewer asked, how is the diffusion increased to achieve lower time?

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The four reviewers generally agreed that the project had shown good progress. One said precisely that - good progress - the task/issue was resolved. Another, agreeing, said that in view of the carbonization difficulties, the accomplishment and the progress are outstanding. The third reviewer likewise was approving, commending the great effort to overcome the damage to the fibers. For the plasma-oxidized fibers, the issue is to determine the subtleties of how the mechanical properties are developed in the final carbon fiber. Determining the optimal process parameters for the conventional conversion shows diligent polymer engineering. The final reviewer noted that while the presentation claimed that the oxidation times are reduced, with good mechanical properties, nonetheless the minimum requirements of modulus, strength and strain have not yet been achieved.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

While one reviewer assessed good collaboration with commercial partner, another saw no partners listed. A third reviewer expressed the belief that this project would benefit from increased collaboration with other researchers and industry partners. Taking four to six months to solve a processing issue might lead to problems as the processes are scaled up. The final comment was not directed at project collaboration, per se. That reviewer said the researchers clearly need a better understanding of the processes relevant to this project, opining that they have to augment their modeling effort.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Noting the expectation that Phase I will be completed, one reviewer saw no plan presented for achieving the minimum requirements. Terming the last results very promising, the second reviewer expressed confidence the ORNL team will be able to produce "industrial quality" fibers as well as the less expensive fibers needed by the car industry, but cautioned that scaling is not guaranteed. A third reviewer noted strong plans for future work. Efforts to scale up these processes will need more diligent chemistry investigations for the pilot line. The final reviewer’s comment was plan to implement in pilot production plant is SUCCESS.

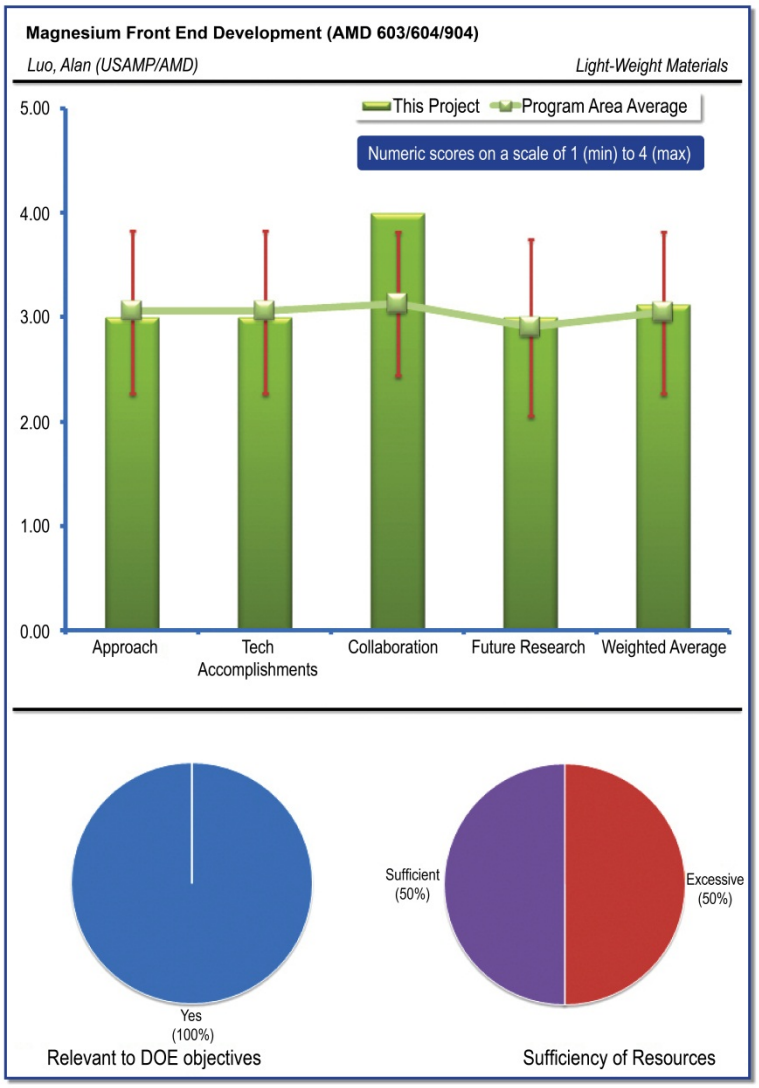
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All but one of the four reviewers felt project resources to be sufficient; the dissenter termed them insufficient. At this lab-scale stage, one reviewer commented, the resources appear appropriate for the research. A second reviewer expressed the belief that the scale-up will require a lot more experimental and modeling work. The final comment regarded an inference drawn from the presentation, namely that additional chemistry resources were included in the plan. This reviewer recommended hiring lab personnel to shadow and adopting innovation style. This style, in the reviewer’s estimation, is not available in academia and can only be attained via shadow training.

Magnesium Front End Development (AMD 603/604/904): Luo, Alan (USAMP/AMD) – lm008

Reviewer Sample Size

This project had a total of two reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

Only two reviewers responded to this question, one briefly and the other at considerable length. The first reviewer said that the project does support DOE's overall objective in petroleum displacement because it lightens structures. The second reviewer listed and described the aims of three separate, but related, task areas which were reported in the Magnesium Front End Research and Development (MFERD) project, specifically AMD 603, 604, and 904. AMD 603 (finished in FY2009) focused on: (1) Mg application in primary load-path body structures for mass saving with equivalent performance; (2) design and engineering simulation of Mg body structures; and (3) technical cost modeling of lightweighting with Mg applications. AMD 604 (finished in FY2010) focused on: (4)improved high-volume manufacturing techniques for Mg casting, extrusion, and sheet forming; (5)improved high-volume manufacturing techniques for joining and corrosion protection of Mg structures; and (6) improved knowledge base in Mg crashworthiness, NVH (noise, vibration and harshness), fatigue and durability. AMD 902 (ongoing) is focused on: (7) demonstration of Mg casting, extrusion, sheet and joining techniques in automotive body structures; and (8) performance validation of Mg crashworthiness, NVH (noise, vibration and harshness), fatigue and durability. This reviewer's conclusion was that these targets are clearly relevant to the DOE objectives for the Vehicle Technologies Program

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Again, two reviewers proffered comments, both in this case commenting at some length. One said this topic was addressed by an enumeration of the milestones to be achieved in each general task area and the combinations of partners assigned to the tasks. Though it would be a stretch to claim that the approach was strikingly novel (and the PI made no such claim), it is clear that the size and scale of this DOE project, the national and international scope of the efforts, and the number of players at work at any given time are all very comfortably within the "normal operating procedures" of GM. The second reviewer felt the work appeared to be good but expressed sharp frustration because the only metric provided was weight reduction. This reviewer wanted to see the technical specifications of the new front end parts versus those of a "standard" front end. After all, such an exercise only works when yield strengths and elongation are optimized for the proposed use.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

In keeping with the trend established so far in the review of this project, two reviewers commented. The first commented that, in summary, the following items were reported for the period under review: (1) Demo Design: generated six concepts and selected one final design for demo simulation, build and testing; (2) Crashworthiness: exercised and validated "best" material model in LS-DYNA for super-vacuum die casting (SVDC) AM60 alloy, and crash testing and simulation of Mg castings; (3) Noise, Vibration and Harshness (NVH): provided Viper dash panel parts (Mg die casting) to China and Canada for NVH analysis; verified acoustic performance (noise reduction) of Dodge Viper dash (bare and with current sound package); (4) Fatigue and Durability: completed round-robin fatigue testing Mg AZ31 friction stir spot welds of four labs in U.S., Canada and China; (5) Corrosion and Surface Finishing: established the model corrosion protection system for "demo" build and testing; completed OEM assessment and developed joint recommendation for cyclic corrosion testing of structural features, and corrosion test results of various fastener coatings; (6) Low-Cost Extrusion and Forming: identified a new high-ductility alloy: ZE20 (Mg-2%Zn-0.2%Ce) developed by GM; improved ductility (125% improvement) in ZE20 alloy; (7) Low-Cost Sheet and Forming: evaluated the formability of various Mg sheet materials produced by direct-chill (DC) cast and CC processes for demo build. (8) High-Integrity Body Casting: identified a high-strength, heat treatable magnesium alloy: NZ30 (Mg-2.5%Nd-0.5%Zn) developed in China; and (8) Welding and Joining: lap shear test results of Mg joints, selected the joining techniques (friction-stir welding, self-pierce riveting with and without adhesive) for demo build and testing; and completed the static testing of typical Mg joints. Having enumerated these eight items that had been reported, the reviewer proffered a one word summary: Excellent! The second reviewer felt the presentation provided insufficient information to permit a judgment, elaborating than an assessment would only be more positive when the reviewer had the necessary data to properly estimate such a work.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Repeating the response to the second question, one of the two reviewers deemed the collaborators in this project an impressive cast of players. The project is coherently defined and the (many) partners are very well co-ordinated. The second reviewer concurred, saying collaboration was extensive and appeared to be very good.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer described proposed future work in detail, as follows: MFERD Phase II (AMD904): (1) the "shock tower" demo final design, analyses and tested has been awarded to a general contractor; (2) the component manufacturing for the "demo" structure is scheduled for completion in 2011 Q2; (3) the final assembly and testing is scheduled for completion in 2011 Q3; and (4) project completion and reporting is scheduled for completion in 2011 Q3. This reviewer concluded that these plans had been cogently presented and are on target. The reviewer strongly urged DOE to direct special attention – and emphasis – to point (4), since in the final analysis it is the knowledge created by this effort (both scientific and technical/operational) that is likely to be the most valuable outcome. The second reviewer said if the project team continues to work while hiding the dominant factors, this reviewer did not see the point. Everybody, the reviewer charged, is learning something in his/her corner. The reviewer expressed the hope that the community is getting something out of it, but the real progress will only come with a strong and completely open program.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The two reviewers disagreed on the adequacy of project resources, one viewing them as sufficient, the other as excessive. The first said well handled - no problematic issues noted. The second said that, in view of the specifications presented, it is how it appeared to this reviewer.

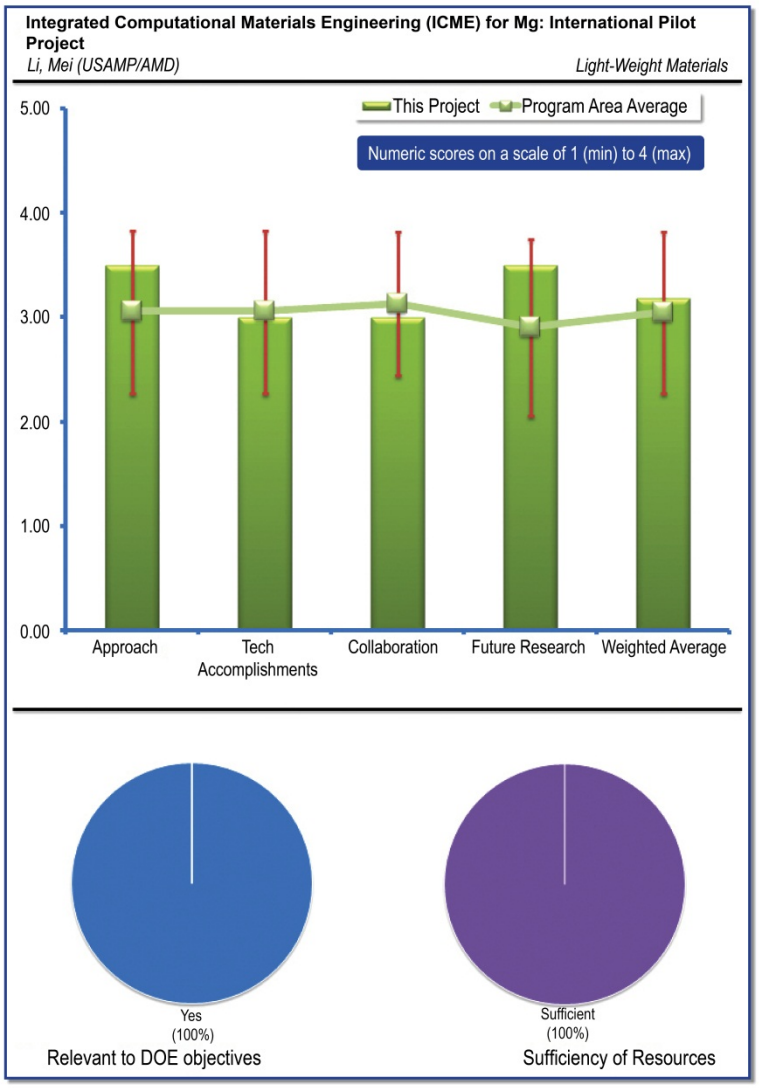
Integrated Computational Materials Engineering (ICME) for Mg: International Pilot Project: Li, Mei (USAMP/AMD) – lm012

Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The two reviewers were in general agreement on this aspect of the project evaluation. One commented simply that since Mg is a light material, then it automatically qualifies with DOE objectives. The second commented at extended length, saying that the Integrated Computational Materials Engineering (ICME) for Mg: International Pilot Project describes its relevance as follows: Application of Mg alloys in body applications may result in up to 45% mass savings. The development and utilization of ICME tools will enable an early assessment and optimization of the primary performance characteristics to ensure that key performance metrics are met. Development and utilization of ICME tools will enable optimization of manufacturing processes and design to reduce costs of Mg components. Current Mg alloys have limitations for use in some body applications. ICME tools will enable cost effective development of new alloys to meet cost/performance requirements. In summary, this reviewer found this to be a plausible case.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer described the specific goals of this project as follows: (1) establish, demonstrate and utilize an ICME knowledge infrastructure for magnesium in body applications for microstructural engineering, process and product optimization, and future alloy development; (2) attract materials researchers into Mg field and leverage their efforts by providing a collaboration space for coupling high quality data and models; and (3) identify and fill technical gaps in fundamental knowledge base. This reviewer then went on to list the aims of the proposed future work, the milestones and the dates by which they were to be met: In support of these goals, the project has defined the following milestones: (1) by March 2009: demonstrate a cyber-infrastructure data to enable integration and collaboration; (2) by March 2010: demonstrate substantial progress in all task areas and demonstrate integration with manufacturing simulation; (3) by September 2011: demonstrate ability of ICME tools to link manufacturing and predict performance of MFERD demonstration structure and validate the results by Dec 2012.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

From the accounts given during the review, one reviewer said, it is apparent that the team is making strong technical progress. For example: With respect to the calculated phase equilibria and diffusion task, the project established an extensible and self-optimizing

infrastructure and demonstrated a graphical user interface (GUI) for automation of thermodynamic modeling for selected binaries (Al-Mg, Mg-Ni, Mg-Zn) and ternary (Mg-Al-Zn). In the ICME for Mg Sheet task the project reported that it completed warm sheet stamping FEM simulations (with and without adiabatic heating) and developed the capability of simulating sheet stamping in new version of PamStamp2G with material model in numerical format, and also that they developed solute strengthening map of Mg from first principles. The second reviewer felt that such an exercise will only be good if it's compared with HSS (High-Strength Steel), AHSS (Advanced High-Strength Steel), and Twinning-Induced Plasticity (TWIP) steels.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The sole reviewer comment on project collaboration and coordination was positive, the reviewer saying that USAMP has assembled a good technical team, including Ford and GM, five universities, two national labs, and four technology providers. From the technical progress reported, the reviewer concluded, it is clear that this group is well-designed to handle the goals of this project.

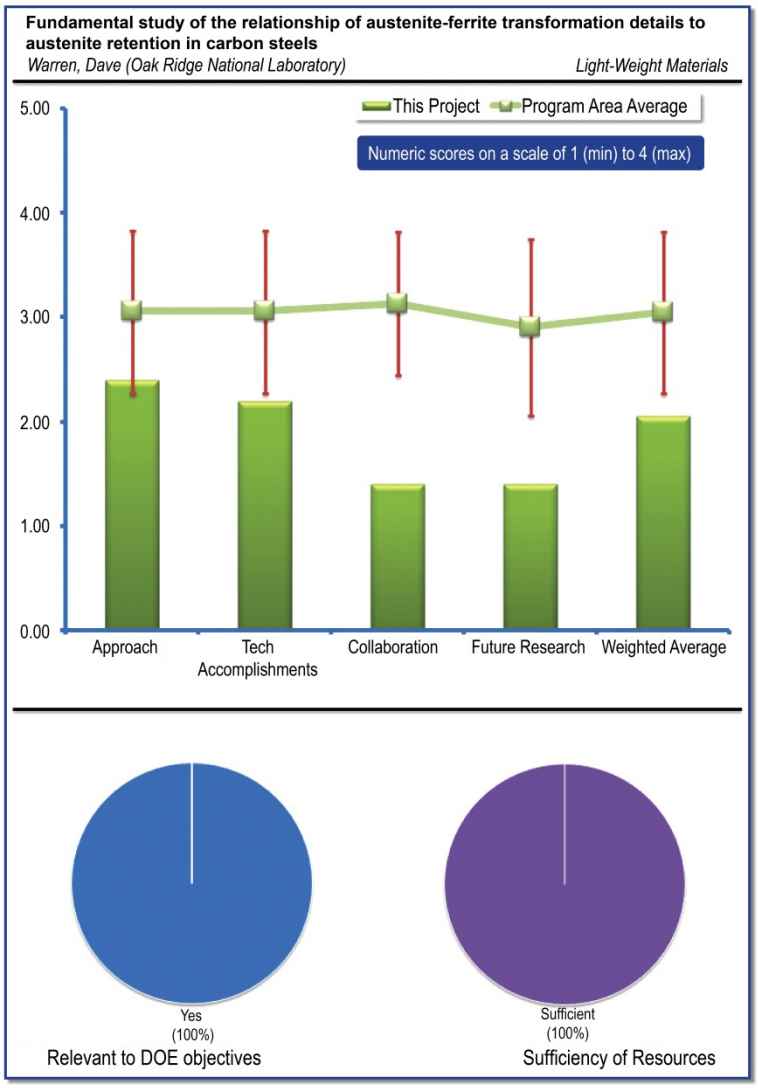
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer offered a summary, and then provided feedback on this project's future work . In general, the project plans to work with MFERD CAE demo team to implement the local properties (zone method, no anisotropy capability for CAE analysis) and develop user-subroutine to implement the ICME predictions on element level (MSU). Casting Team: process to properties models (yield strength and fatigue strength); casting process simulation (Ford and Tsinghua University); casting microstructure models (Tsinghua University); link MicroModel with Solution Treatment Mode (Ford); aging Model (Ford and University of Michigan); yield strength model (Ford, UofM and Tsinghua University)Fatigue strength model (UofM). Extrusion Team: process to properties to FEA model (post-forming yield strength, fatigue and stress-strain curves); extrusion process simulation (MSU); texture prediction using VPSC model in Hyper-extrude (MSU); develop the stress-strain relationship and yield strength (MSU); and post-forming fatigue strength model (MSU). Sheet Team: processing to properties to FEA model (localization, post-forming stress-train curves); stamping (bending) process simulation (MSU); texture prediction using VPSC model (MSU); develop the stress-strain relationship for AZ31(MSU and CANMET); and post-forming fatigue strength model (MSU). This reviewer commented that a 2008 report of the National Research Council (NRC) has identified ICME as a critically important area for research. They emphasize the potential impact of this technology on the Department of Defense materials deployment, but the civilian applications, such as those being conducted in this project and in others in the DOE Vehicle Technologies Program, are also highly significant. However, adoption of new materials in the vehicle manufacturing sector is a long and complicated process for a variety of reasons. It seems ICME technology, once it is more widely distributed and trusted by working engineers, could well be a key step toward accelerating the new material adoption process. In this reviewer's opinion, it is very important for both the ICME project participants and the DOE to use the moment to identify new materials rollout strategies. The second reviewer offered the assessment that it is good but comparisons should be a lot more developed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Both reviewers deemed project resources to be sufficient.

Fundamental Study of the Relationship of Austenite-Ferrite Transformation Details to Austenite Retention in Carbon Steels: Warren, Dave (Oak Ridge National Laboratory) – lm017



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five reviewers weighed in on this project; only one pronounced it directly relevant to the DOE goal of petroleum conservation. That reviewer said projects that support the development of Gen-III steels directly support the lightweight goals for DOE and petroleum displacement. The second said that the objectives of the project are as follows: (1) real-time characterization of austenite-ferrite transformation behavior during T/t conditions representative of processing advanced high-strength steel (AHSS); and (2) determine conditions that promote retained austenite. The proposers indicate that these goals will contribute to building the scientific foundation needed for the development of 3rd generation AHSS. The reviewer continued that the intent is to deliver: quantitative description of austenite-ferrite transformation behavior during simulated finishing operations, including the effects of carbon, manganese, and silicon; a quantitative description of alloying element partitioning between austenite and ferrite, and an assessment of how retained austenite can be maximized within constraints of normal sheet processing infrastructure. The project milestones are described as follows: (1) experimental and data analysis procedures are re-examined to determine possible sources of errors, and an approach for minimizing the effects of surface reactions will be established (finished October 2010); and (2) experimental alloys will be formulated and analyzed for the possibility of increasing retained austenite over commercial steel grades which generally contain around 10% (ongoing). This reviewer remarked that it was unclear how this project fit within the Vehicle Technology lightweighting initiative, but speculated that if less AHSS were required for an equally strong body build, then, this project could be regarded as relevant. Two reviewers deemed the project relevant to a much narrower goal, one saying the project objective of real-time characterization of austenite-ferrite transformation behavior is relevant to the development of Gen III AHSS, but not explicitly linking that either to lightweighting or to petroleum conservation and the other considering that the project supports the quest for Gen III steels. The final reviewer called the project applicable, but characterized the research as unsuccessful.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer reiterated the technical work approach conducted at the Advanced Photon Source, but offered no estimation of the value or appropriateness of that work. Another reviewer characterized the approach as exploratory. A third reviewer summarized that high-speed diffraction experiments were conducted at the Advanced Photon Source and the austenite-ferrite phase transformation behavior was characterized in situ under rapid heating/cooling conditions. Specimens are heated by resistance in vacuum, thermocouple

feedback is used for temperature control, and specimen grip is spring-loaded to maintain positioning. The APS synchrotron permits diffraction patterns at ~ 1 s intervals and calibrated Debye arcs are converted into plots of intensity versus d-spacing. Direct comparison method is used to determine phase fractions. There is a desire to get to the stated deliverables, but this reviewer did not feel there is a clear vision of how to achieve them: quantitative description of austenite-ferrite transformation behavior during simulated finishing operation; quantitative description of alloying element partitioning between austenite and ferrite; assessment of how retained austenite can be maximized within constraints of normal sheet processing infrastructure. Overall this reviewer approved of the approach, calling it good approach, but pointed out that not all the research had been successful. The fourth reviewer felt there was no clear vision of how to get to the stated deliverables, namely a quantitative description of austenite-ferrite transformation behavior during simulated finishing operation; a quantitative description of alloying element partitioning between austenite and ferrite, and an assessment of how retained austenite can be maximized within constraints of normal sheet processing infrastructure. The final reviewer offered comments in a similar vein, saying the approach seemed simplistic given the duration of the project to date. The approach and potential processes should have been much further developed. The obvious approaches of alloying and processing/heat treatment should have been more developed to explicitly describe how steels can be produced in the region of the strength- elongation plot. From the presentation, this reviewer was unclear on how the x-ray diffraction work produces information on the alloying and processing.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer concluded that the reported results indicated negative conclusions, but reiterated that the approach had been exploratory in the first place. The second reviewer, however, called the x-ray diffraction data a good start to characterizing the processing. However, since the project is over 65% complete, there should be more information on the results of the strength and elongation of the prototype systems. The drifting of ferrite volume fraction was shown but not explained against the equilibrium value. There are few clear deliverables that are leading to the stated goal of Gen-III steel developments. The third and fourth reviewers were in general agreement; one said there appeared to have been significant work done, but little substantial progress made, and the other commenting not successful. The final reviewer summarized that high-speed diffraction experiments were conducted at the Advanced Photon Source and the austenite-ferrite phase transformation behavior was characterized in situ under rapid heating/cooling conditions. Specimens are heated by resistance in vacuum, thermocouple feedback is used for temperature control, and specimen grip is spring-loaded to maintain positioning. The APS synchrotron permits diffraction patterns at aproximately 1 s intervals and calibrated Debye arcs are converted into plots of intensity versus d-spacing. The direct comparison method is used to determine phase fractions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The four reviewers were generally agreed that inter-institutional collaboration in this project was in need of improvement. One reviewer called for collaboration with steel companies and universities. Summaries at AS/P workshops, in this reviewer's opinion, are not sufficient collaboration. A second reviewer could discern no collaboration partners in the project. In the view of a third, the only information on this point is that the experimental techniques need to be improved before collaborations are established. The last of the four reviewers said that although the work was supposedly "summarized at AS/P-organized workshops for projects funded through NSF (National Science Foundation) to develop third-generation steels," there was no indication the work was in any way tied to the other Gen III efforts or was supported /endorsed by the researchers doing the other research.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

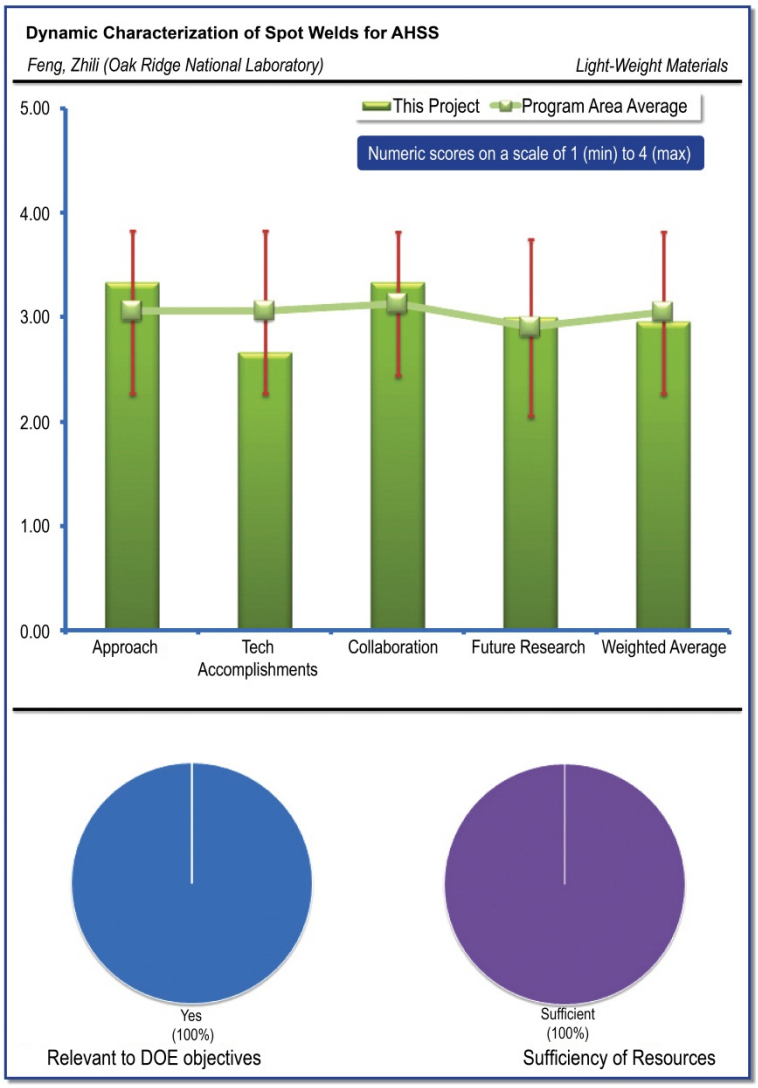
Reviewer opinion was virtually unanimous on this question. Most reviewers felt proposed future work was ill-defined and lacking specificity. The first commented that conventional diffraction facilities at the APS/synchrotron do not appear suitable for characterizing ferrite-austenite transformation behavior. Other facilities such as for transmission diffraction may be more appropriate. Use of neutron diffraction is also being considered. The second reviewer's assessment was similar. The project's plans are too general

and lack specificity, e.g., they only indicate generalities such as "experimental techniques need to be improved" and "Other facilities such as for transmission diffraction may be more appropriate." The third reviewer was unsure that careful consideration had been given to the potential techniques being proposed. The fourth reviewer's comment was that the proposed future work did not give specifics on the alloying systems and processing steps to achieve the Gen-III steels. The x-ray investigations are interesting to investigate the phases, but how the investigations are tied to achieving the results was not clear from this presentation. The final reviewer concluded that there was no future research proposed.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The five reviewers were unanimous in declaring project resources to be sufficient. In the view of one reviewer, the amount of work done seemed proportionate to the funding available. However, it was not clear to that reviewer that either the funding or the level of effort was sufficient to accomplish the stated goals of the project. The opinion of a second reviewer was that the research effort was sized for the investigation.

Dynamic Characterization of Spot Welds for AHSS: Feng, Zhili (Oak Ridge National Laboratory) – lm025



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All three reviewers characterized the aims of this project as important, but none made explicit reference to the petroleum conservation and greenhouse gas reduction goal of the Department of Energy. One reviewer said understanding and resolving AHSS joining issues is a very important effort in reducing the weight of vehicles by promoting the use of AHSS. Developing weld models for automotive crash simulation is important for vehicle lightweighting using AHSS, according to a second reviewer. And in the view of the third, advanced high strength steels (AHSS) are one of the essential materials for the weight reduction of vehicles. Before any material is used in vehicle structures it is necessary to understand the performance of the structure. This project is developing the models for predicting the bond strength and performance in AHSS.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two reviewers addressed themselves to this question, the first saying the approach to establish weld models based on testing results is excellent. The second endorsed the approach, observing that the project was attempting to validate models to predict the weld strength and performance by testing various steels and joining variables. The project, in this reviewer's estimation, covers many of the important factors.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A single reviewer commented, recommending that models be provided to automotive CAE communities for trial use and feedback.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

To this question, also, only one reviewer provided comment, saying that ASP and OEM partners are involved; the models are evaluated for real use by the OEM users who have access to the models right through the development process.

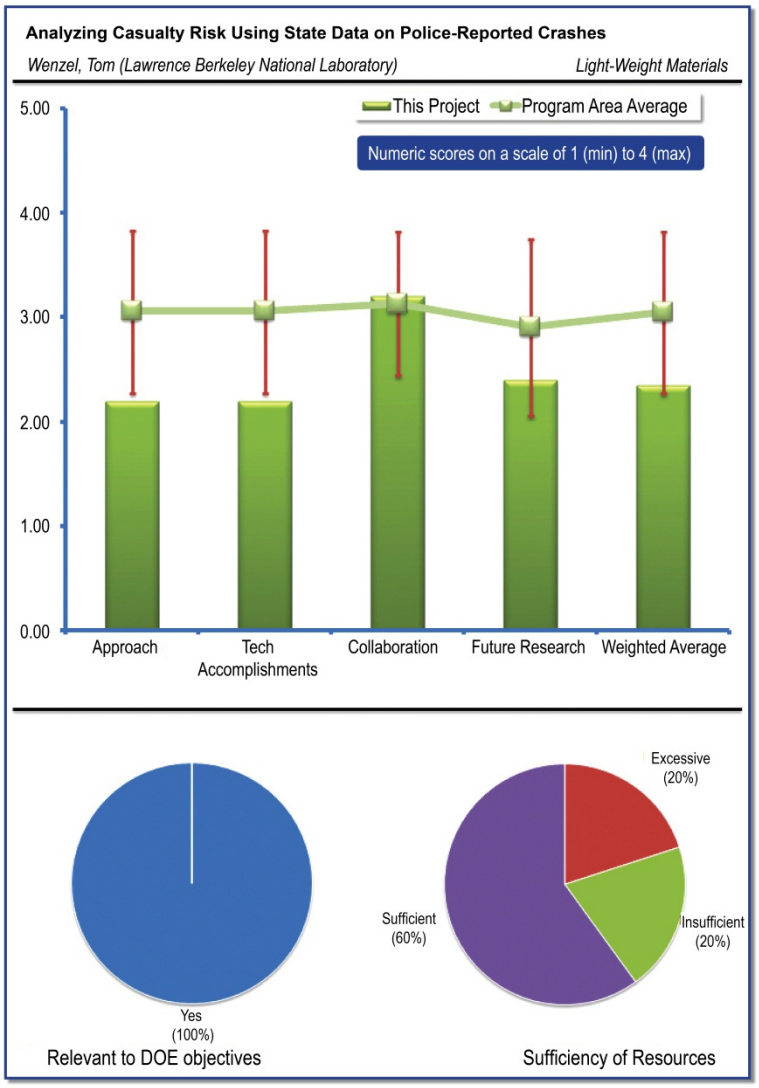
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The sole comment provided was an exhortation to keep going.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reveiwers provided any further comment.

Analyzing Casualty Risk Using State Data on Police-Reported Crashes: Wenzel, Tom (Lawrence Berkeley National Laboratory) – lm026



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

In general, reviewers approved of this project, although of the five who commented, only one directly addressed its relevance to petroleum conservation/greenhouse gas reduction. One termed it a proper data gathering exercise, adding that analysis of data can be very beneficial in educating consumers and guiding vehicle manufacturers. A second termed it simply an important area. The third commented at greater length, opining that the policy of lightweighting should be applied with due consideration of passenger safety. This study, he continued, is aimed at developing a model to predict the effect of lightweighting on the likelihood of fatalities occurring in crashes. Although the data are incomplete, this can shed light on the impacts. The fourth reviewer considered the project objectives well founded. The final reviewer identified the difficulty of determining the project's relevance to the broader DOE goals. It was difficult to choose a yes or no answer to the question of that relevance. The reviewer felt sure that looking at how vehicle weight affects project future fatalities and Abbreviated Injury Severity score of severe-to-fatal (AISP4+) injuries is a critical factor to be addressed in CO_2 rulemaking and averred his full support for this work. The reviewer regarded the funding as small compared to projects targeted at overcoming the challenges facing vehicle lightweighting and viewed it as money well spent. Nonetheless, the reviewer found this an almost impossible question to answer. The project will be an important portion of a national dialogue on societal needs for reducing CO_2 reduction as well as fatalities and serious injuries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Three of four reviewer expressed reservations concerning the approach to this work. One reviewer doubted that the approach to data analysis would lead to any compelling conclusion. The second reviewer pointed out that the data do not take into consideration factors such as number of passengers, operator experience and other causes of crashes. Crashes involving DUI (Driving Under the Influence) are excluded, and other factors such as seat belt use are not considered, resulting in conclusions being skewed against some categories. The data presented in the annex indicate that compact and sub-compact cars are involved in more accidents, which is not explained fully. If more holistic data analysis is not undertaken, this study could be used against lightweighting. The third reviewer found it apparent that analysis of the data will result in inconclusive and statistically insignificant conclusions. Potentially, cooperative states/regions could collect specific data over a multi-year time period. Basically, this reviewer's recommendation was to stop and start over. However, not all reviewers agreed in their assessments of the work approach. The fourth reviewer deemed this solid work on good statistical grounds. It is important, in this reviewer's estimation to detail the assumptions and clearly state the challenges,

using historical data to predict future fatalities and injuries. The potential paradigm shift when moving to a different architecture is difficult. The reviewer urged the project team to clearly state the difficulties in making predictions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All reviewers agreed that project accomplishments had been meager and/or difficult to evaluate. One reviewer said that not many actual results were presented. A second reviewer was more emphatic: None, this reviewer said, no accomplishment is apparent. Hard to judge the approach and results. A third reviewer described the study as the analysis of information available on the number of fatalities and crashes from 13 states. Even though this reviewer deemed the analysis commendable, the reviewer called for more detailed. The fourth reviewer felt the project team's conclusion so far does not shed light on the effect of lightweighting a given line of vehicles. The final reviewer offered detailed suggestions for modifying the work approach, suggesting the inclusion of "rifle shots" of vehicle performance to see if there is sufficient data to separate NCAP 5-star from 4-star from 3-star vehicles in the crash mode. This reviewer also urged that the total numbers of annual fatalities and serious injuries in the researchers' regressions be compared to the total across the country. An important variable is whether the occupant was wearing a seat belt. Most states supply this data. Since over 60% of fatalities are occupants not wearing seat belts, it was not clear to this reviewer that vehicle weight effect can be separated from seat belt use. The reviewer urged clarity in future reports as to what data is included and what is excluded from the regressions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer opinion was mixed on this aspect of the project. Of the three offering comments, two reviewers commended collaboration, one noting good interaction among the government agencies (EPA, NHTSA, etc.) but calling for more consultations with industry associations and other user groups. The second concurred, noting good work with NHTSA and with individual states as necessary. The third observed that the project involved many agencies and data sources, terming this a significant component of the problem.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Again, assessments of the three commenting reviewers were mixed. The first reviewer's comment was "clear on future potential work." Two expressed disappointment with the proposed future work. One reviewer did not see any plans to get to a convincing conclusion one way or another, and the other offering the comment no vision.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented that resources are deemed good at this point. However, this reviewer felt there could be much more effort here and suggested detailed "case studies" that might generate much more important data. Another option to address is the engineering evaluation of reduced weight vehicle through analytical models. The second reviewer recommended that all funding be stopped.

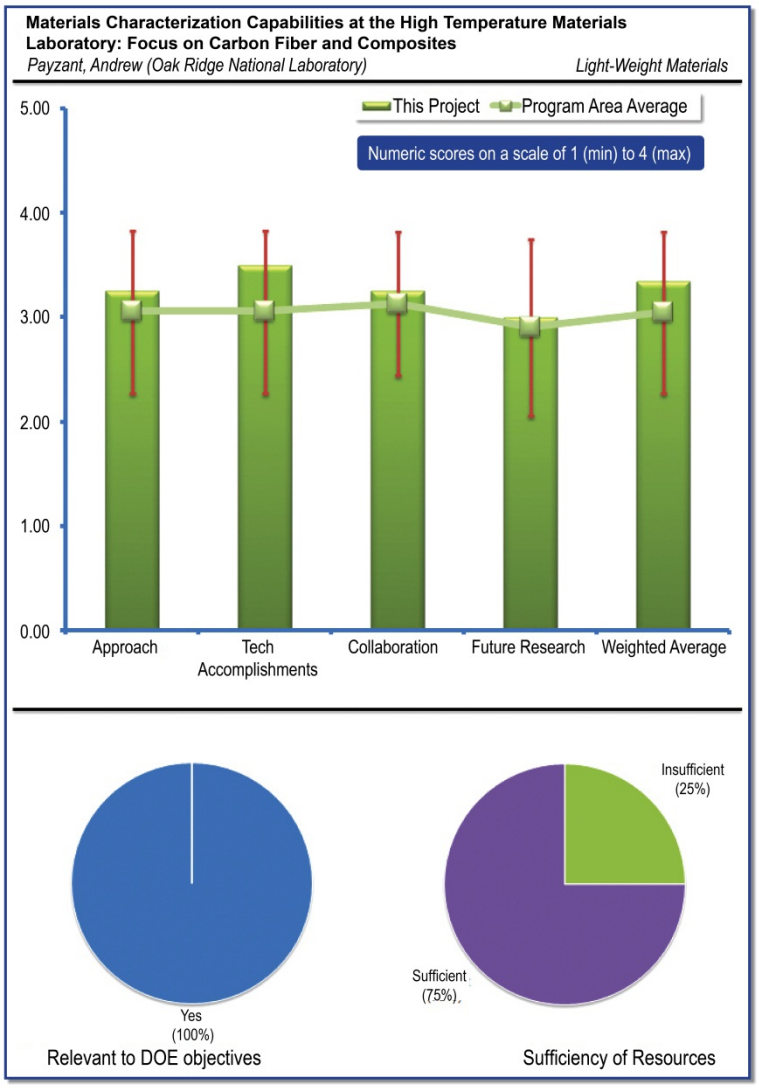
Materials Characterization Capabilities at the High-Temperature Materials Laboratory: Focus on Carbon Fiber and Composites: Payzant, Andrew (Oak Ridge National Laboratory) – lm027

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three deemed the project to be supportive of the primary DOE goal. One said the project's support of the goal was indirect but that the work is required to reduce development time and achieve results using a scientific approach. A second commenter responding affirmatively said testing of carbon fibers is necessary and therefore it fits very well with the DOE objectives of petroleum displacement. The third reviewer commended a good effort on characterizing materials to support the overall DOE goals. The reviewer also praised great collaboration with other ORNL carbon fiber project teams to support the greater goals. The fourth reviewer said that characterization of materials to understand their performance is important. Understanding the relation between the structure and performance allows the materials to be used effectively in lightweighting applications.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two reviewers expressed enthusiastic approval of the work approach employed in this project. One called it outstanding, an excellent approach to characterizing the fiber oxidation process. Multiple scale analysis/characterization tools and expert scientist produced very positive results. Consideration of incorporating into production process as quality assurance tool is very forward thinking. This concept should be applauded and replicated in DOE methodology. The second reviewer cited a good technical approach for investigating the material properties in-situ. X-ray diffraction is an excellent probe choice. Ability to use multiple and diverse tools gives the HTML (High-Temperature Materials Laboratory) a unique capability along with Raman, XPS (X-ray Photoelectron Spectroscopy), et al. The third reviewer's comment partially seconded that view; the HTML's capabilities enable ORNL to better characterize those carbon fibers, the reviewer said, which bodes well for the future. The reviewer urged improved back-and-forth between the making and the testing of these fibers. The fourth reviewer observed that characterization of materials using various analysis techniques was presented. No problem solving is involved, and the approach is direct.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Of the four reviewers commenting on this aspect of the project, two advanced positive or strongly positive assessments. One called the project outstanding – a new method of oxidation resulted from collaboration with process scientist. The other cited great results to

help ORNL carbon fiber team by looking at carbon/graphite formulation under process conditions and under load. The ability to investigate the graphite orientation gives great insight to the formulation process. The third reviewer said it is good but it could be more extensive. Moreover, SAXS (Small-Angle X-ray Scattering) and better Small-Angle Neutron Scattering (SANS) would be more appropriate. Carbon is better "seen" with neutrons than with x-rays. Moreover, ORNL has one of the best SANS instruments in the world, this reviewer said, adding his hope that that facility would be better used for this project. The fourth reviewer noted that the work had revealed internal structure of carbon fibers as it is changed by various processing steps. The team had designed a set-up to study this evolution in-situ.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Only two reviewers commented on this question. One cited great collaboration with the ORNL carbon fiber team and noted good responsiveness to the needs of the carbon fiber processing team. The other expressed the hope that project collaboration would improve with time, but felt that, to date, it was not at the level of that demonstrated by the carbon fiber production team at ORNL.

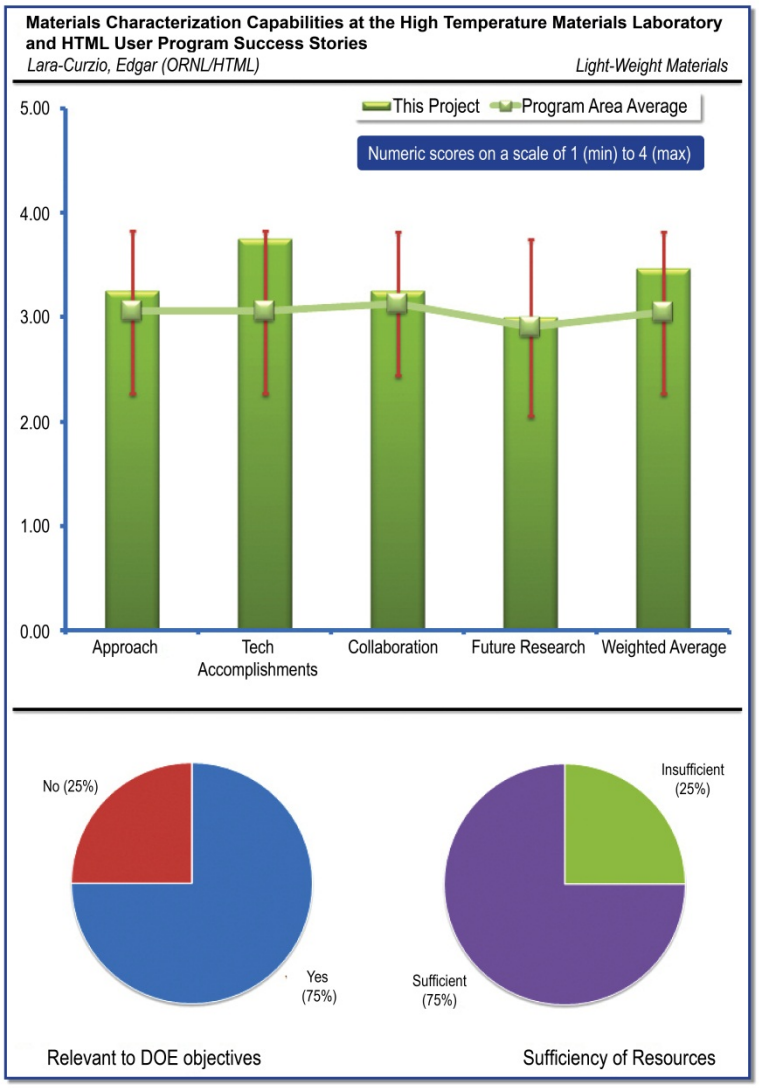
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

As to proposed future research, three reviewers offered opinions. One called that work very promising. Very good and a necessary addition to the carbon fiber project. The second noted that the projects are transient in nature and completed as they come in queue. The requirement for future cannot be anticipated. The third noted that the project researchers have year-over-year commitment to continue support for materials investigations.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer termed them insufficient; two commented that the resources are sufficient. The former reviewer felt the project needs a 15 to 25% increase to keep facilities current and at the state of the art. Resources to continue carbon fiber support will need to grow as the overall CF efforts increase. DOE should invest in FY12, FY13 to have the support infrastructure in place to address as-yet unforeseen issues with the carbon fiber production facility. One of the latter reviewers felt the presentation provided insufficient detail permit a clear assessment of the adequacy of resources.

Materials Characterization Capabilities at the High Temperature Materials Laboratory and HTML User Program Success Stories: Lara-Curzio, Edgar (Oak Ridge National Laboratory/High Temperature Materials Laboratory) – lm028



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two of four responding reviewers answered this question in the affirmative. One said that through use of its unique expertise and instrumentation, HTML is able to characterize the properties and performance of virtually any material that can be used to reduce the weight of vehicles, thereby increasing their efficiency and decreasing the amount of fuel needed to propel them. The resources are similarly used for propulsion materials, energy storage and thermoelectric conversion, to increase the energy efficiency of transportation. The other agreed, remarking that the efforts of HTML support the DOE goals for lightweight materials for vehicles and therefore the overall goal for petroleum displacement. The third reviewer concurred with a remark made by the presenter that the concentration of the HTML's capabilities and expertise in one location make the HTML User Program a unique national asset. This reviewer offered the following description of the HTML and its work: The HTML is a DOE-Designated National User Facility. The Vehicle Technologies Program funds the operation of the HTML User Program to maintain world-class expertise and instrumentation capabilities for materials characterization to work with industry, universities and national laboratories to address critical technical barriers to achieving the goals of the VT Program. The HTML User Program capabilities are also being utilized to support Vehicle Technologies Program projects at ORNL in the program's technology areas of Lightweight Materials, Propulsion Materials, Energy Storage, Power Electronics & Electric Motors, Emission Controls and Solid State Energy Conversion. The fourth reviewer was unable to discern the relationship of diffusion rate to vehicle lightweighting.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two reviewers commented favorably on the work approach employed in this project. One said all the examples cited appear to have been well formatted, executed and managed. The other advanced the opinion that keeping the equipment and researchers at the state of the art is critical to continuing to advance the efforts to use lightweight materials in automotive vehicles. The third considered the work to be basic research which seemed to be general data base and knowledge development without specific focus on resolving barriers. The fourth reviewer's comment was a description of the approach HTML users employ in seeking use of the HTML facilities. This reviewer delineated that process as follows: A user agreement (proprietary or non-proprietary) is required prior to starting a user project. Access to the HTML User Program is provided through a formal proposal process. Proposals are reviewed by an internal review committee and evaluated based on technical merit, relevance of the proposed research to the mission of the Vehicle

Technologies program, non-competition with the private sector, organizations based in the U.S. The research is completed within 24 months, and it involves one or more user visits to the HTML.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer found the example accomplishments from the user projects impressive. It is critical to industry to have these investigative tools and researchers available to characterize materials and surfaces. The second reviewer said the presentation included an extensive list of small (mean size about $60K) projects selected according to the criteria set out above and which from all indications were then effectively monitored and conducted. According to the third reviewer, the accomplishments were substantial in a wide array of materials. The last reviewer agreed that capability had been demonstrated but that potential applications need be identified. For example, enhanced corrosion resistance or improved anisotropy need be in the vision

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Two reviewers offered positive assessments of the collaboration exhibited in the projects described in the presentation. One cited extensive collaboration with industry (18 companies), universities (25), and National Labs (6). Another cited great efforts and examples of collaboration. The HTML's open and proprietary projects represent excellent examples of university and industry collaborations, this reviewer concluded. Agreeing with the first reviewer, the third reiterated the examples of collaboration during FY2010 with 18 companies, 25 universities, and 6 national laboratories and expanded on them, citing 68 user projects addressing critical technical barriers to achieving the goals of DOE's Vehicle Technologies Program. Some 96 researchers, 63% of them first-time users, visited the HTML for a total of 716 research days. The HTML also supports the education and preparation of the next generation of scientists and engineers. During FY2010, students and professors from 25 universities participated in the HTML User Program. Five of those students earned their Ph.D. degrees and one earned her M.S. degree based in part on research they conducted through the HTML User Program. Users cost-share projects through direct involvement with HTML staff members during the development of the user project; funding their time and travel to the HTML; costs of materials provided by the user and the research performed prior to the user project; subsequent collaboration with HTML staff and members to analyze and publish the results. The final reviewer termed the presentation an academic exercise.

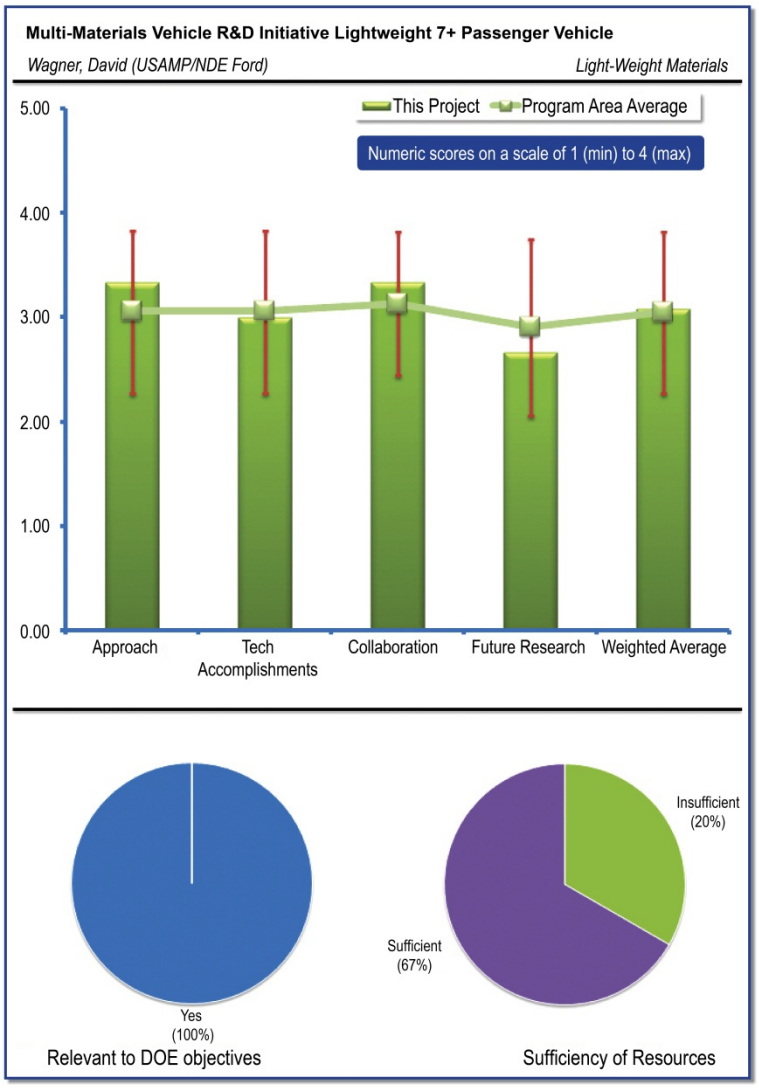
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

According to the first reviewer, marketing efforts will continue to be focused on developing collaborations with Vehicle Technologies Program stakeholders and other sponsors to address the proposed budget reduction in FY12. The HTML User Program will continue its collaborations with industry, universities, and national laboratories to address critical barriers to achieving the goals of DOE and EERE. The development of special tools to enable the *in situ* characterization of materials and processes will continue. These include high-speed extensometry to measure deformation of materials and structures at high strain rates, and hot stages and environmental cells to monitor the evolution of microstructures in physical processes, in real time, with atomic resolution, at elevated temperatures and controlled environments, using electrons, X-rays and neutrons for imaging and diffraction. This reviewer commented that the HTML effort seems to be a well-conceived and very clever way to reduce the administrative "overhead" associated with handling a large number of small, very narrowly defined, short-duration projects. While no direct financial discussion was provided in the review, back-of-the-envelope arithmetic suggests HTML is an effective organization with substantial community support. This reviewer was surprised to learn that a FY12 reduction (of some unspecified amount) is being considered and unclear why this was being contemplated. A second reviewer found difficult to assess the future plans for the user facility due to the uncertainty as to what new work will be proposed. This reviewer endorsed the continued development of the specialty tools to enable the *in situ* characterization of materials and processes, such as the ability to measure deformation of materials and structures at high strain rates, etc. Concurring in part with both of the previous comments, the third reviewer observed that future work strongly depends on the needs of industry. This reviewer encouraged further development of future plans for equipment and capital improvements. The fourth reviewer did not feel that a clear direction in future work had been identified beyond database development.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer deemed resources to be insufficient, and three reviewers considered resources sufficient. The former reasoned that as the automotive industry continues to move to more lightweight materials, the need to understand fundamental material behavior and interactions between materials is critical and that the HTML should therefore be fully funded to maintain the best equipment for material characterization. The second reviewer, who believed current resources to be adequate to proposed work, reiterated a concern about impending funding decreases for FY2012. This concern was echoed by another of the reviewers who regarded current funding to be adequate for current tasking. Saying it was difficult to gauge the sufficiency of funding, this reviewer said funding appeared to have been appropriate and adequate for the past couple of years at around $5M per year). However, the $972K funding anticipated for FY '12 (as shown in Dr. Schutte's opening presentation), seemed unreasonably low. The fourth reviewer noted the need for a financial budget of $200k for rotation device. Human resources seem appropriate.

Multi-Materials Vehicle R&D Initiative Lightweight 7+ Passenger Vehicle: Wagner, David (USAMP/NDE Ford) – lm029



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two of the three reviewers of this project affirmed the relevance of this project to the DOE's petroleum conservation and greenhouse gas reduction goals. The first reviewer summarized that the overall Multi-Materials Vehicle (MMV) objective is to develop lightweight materials technologies and full vehicle weight strategies for cost-effective, large-scale implementation in vehicles that meet consumers' needs while providing increased fuel efficiency. Continued this reviewer, the focus is to lightweight a 7+ Passenger vehicle and thus to determine weight reduction required, using vehicle performance / fuel economy simulation analysis, to enable a current production vehicles to achieve fuel economy improvements when retrofitted with a smaller current production gasoline engine and a state of the art transmission, while maintaining the performance metrics of the current production vehicles (0-60 mph time, towing on grade, etc) and to achieve 40-45% fuel economy improvement (from 24.3 mpg to 34-35 mpg) for a 7-passenger minivan and an 8-passenger Crossover Utility Vehicle (CUV) to achieve 20-25% fuel economy improvement (from 24.7 mpg to 30-31 mpg). This reviewer called the data provided by this project directly relevant to the goals of the lightweighting effort and increasing energy efficiency. The second agreed that it qualifies with respect to DOE objectives. However, this reviewer felt the study to be limited to an extent sufficient to call its value into question. This reviewer urged that its focus be widened to include consideration of the effect of transmission weight reduction, which he felt may exert a very significant impact. Together with size and weight reductions of the transmission, lubrication will have to be considered. The last reviewer, speaking with respect to the Multi-Material Vehicle (MMV), said this type of precursor analysis is needed to establish scope and achievable goals/milestones. With regard to NDE (Non-Destructive Evaluation), the reviewer noted that structural aluminum castings offer the lowest cost ($/pound) mass savings.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Three reviewers offered comments on this aspect of the project. They were generally positive in the evaluations. The first reviewer summarized that simulations of vehicle performance and fuel economy determined the appropriate weight reductions to achieve the targeted fuel economy improvements. Two engine selections were made for each vehicle, each with different peak power ratings. Each vehicle was simulated at three distinct starting (prior to weight reductions) weight classes. The EPA equivalent test weight (ETW) is the vehicle base curb weight plus an additional 300 pounds rounded to the nearest EPA weight class. The gross vehicle weight rating (GVWR) is the vehicle curb weight plus additional passengers and luggage. The gross combined weight rating (GCWR)

is the GVWR weight plus additional weight to account for trailer towing. The six performance criteria required of the newly configured vehicles were four acceleration tests (five-second distance, 0-30 mph, 0-60 mph, and 0-100 mph times), hill climb ability at 55 mph (including trailer tow), and top speed. The newly configured vehicles had to meet or exceed the current production vehicle's performance in these six customer relevant performance metrics. This reviewer called the approach a well thought-out and narrowly focused engineering study which has provided the community with useful data. The second rated the approach to the two parts of the presentation separately. The Multi-Material Vehicle (MMV) work was deemed outstanding, terming the "paper study" methodology a necessary step to determine scope and feasibility of large projects. This reviewer rated the NDE section slightly lower – good. The reviewer found the computer-aided engineering (CAE) predictive approach interesting and recommended the future focus be part-specific, including variable section thickness and complex geometry. The third reviewer said the two authors gave a good description of what they did, and why, for this "small" project. This reviewer felt the project clearly called for much more and that it should be much more comprehensive, to include transmission, lubrication and functionality of, and within, the vehicle.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Of the three reviewers, one repeated the rankings given to the two parts of the project under the previous criterion, rating the accomplishments of the MMV project outstanding. This "paper study" achieved the goal to determine scope and feasibility of large projects. A 2,000 lb. mass reduction seems difficult to achieve and thus OEM interest is limited by time/effort. The NDE section of the work this reviewer rated as good; progress is good, justifying further work. Opportunity to reduce inspection costs associated with detecting shrinkage is enabling, however, ability to detect oxide films and heat treat condition is very enabling and provides significant occupant safety and further mass reduction. Typically, these are critical areas. This reviewer felt that lack of funding and limited time had limited the accomplishments of this project. The second reviewer considered MMV 903 to have completed all project deliverables. According to this reviewer, the minivan must reduce between 500 lb (11%) if aggressive aerodynamic actions can be implemented and 2250 lb (50%) to move from 24.3 mpg to 34.5 mpg with a current production gasoline engine. The uplevel CUV must reduce 2,000 lb (42%) to move from 24.7 mpg to 30.5 mpg with a current production gasoline engine. The weight reductions calculated for the minivan (500-2,250 lb.) and for the CUV or Crossover Utility Vehicle (2,000 lb.), this reviewer noted, are based on simulations to meet fuel economy plus vehicle acceleration, top speed and trailer tow requirements. However, they do not consider meeting safety, durability, noise, vibration and harshness, vehicle dynamics, or other requirements. In the reviewer’s opinion, this raises the question of what would happen if "safety, durability, noise, vibration and harshness, vehicle dynamics, or other requirements," or some carefully chosen subset of them, were taken into account. What would happen if we were to approach lightweighting from the ground up, that is, designing it in from the very beginning?

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Only two reviewers weighed in on this topic. Both rated project collaboration highly. One, noting that Chrysler, Ford and GM were OEM project partners and that FEV, Inc. had also collaborated, this reviewer assessed good collaboration on a narrowly focused project. The other reviewer was highly complementary, rating collaboration in both the MMV and NDE areas outstanding. The former is a paper study which included commercially available software to predict vehicle mass and performance of various powertrains. Likewise the NDE the reviewer considered collaboration on the NDE phase of the project outstanding. This reviewer cited excellent involvement of supply-base insuring current methods and short time to commercial application.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

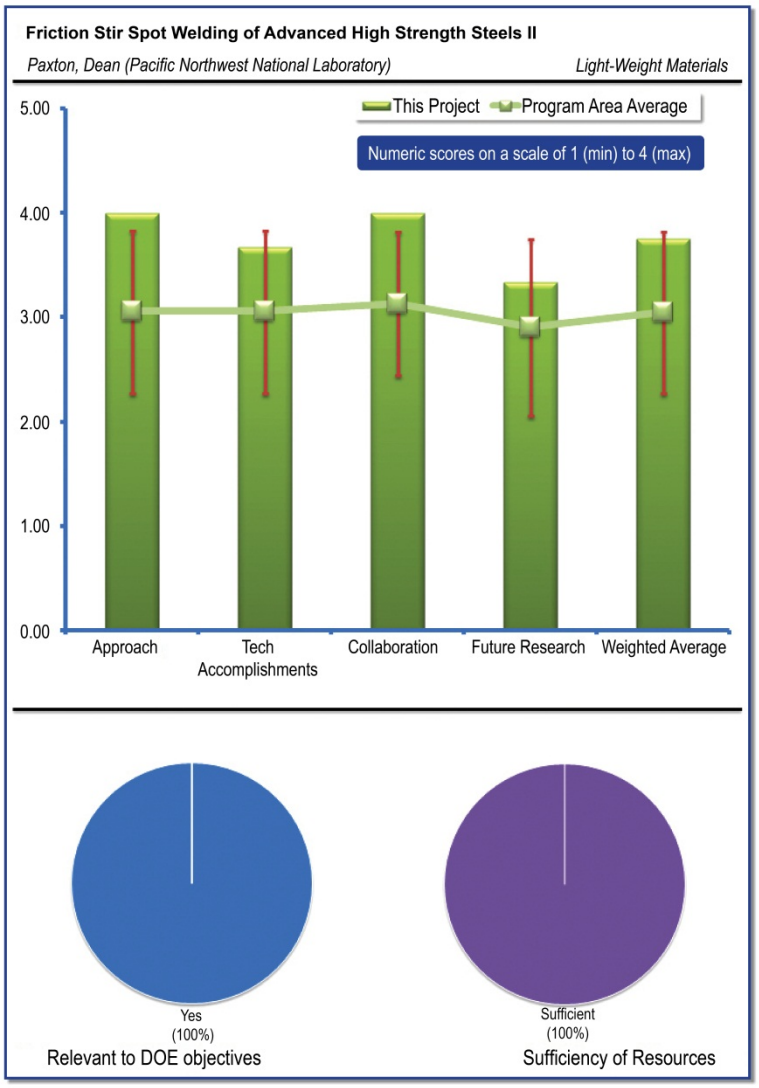
Noting that there are no plans to continue the project, as the final report on Lightweight 7+ Passenger Vehicle R&D Project has been delivered, one reviewer expressed interest in the final report and the hope that its distribution would not be restricted. The second reviewer rated future MMV work good, and commented that no further action was planned/required. This reviewer gave the same rating (good) to the NDE phase of the work, but felt that area needs improvement and should include a complex casting with variable wall such as an aluminum front cradle. This reviewer recommended focusing on detection of oxide film, shrinkage, gas porosity and the ability to detect age hardened condition (i.e., quenched - T5 vs. F condition) in lieu of CAE predictive modeling. Finally, the third

reviewer credited the authors with giving an idea of what remains to be done, but the reviewer was left with the impression that it is over. This reviewer felt this project should be the introduction of a much more involved project in which modeling leads to real testing.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer felt resources to be sufficient, and a second reviewer thought resources were insufficient. The former remarked that the resources were obviously adequate. The latter felt that if DOE's plans for displacing petroleum use are serious, this project should be restructured and markedly expanded.

Friction Stir Spot Welding of Advanced High Strength Steels II: Paxton, Dean (Pacific Northwest National Laboratory) – lm030



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two of the three reviewers who commented rendered opinions on the relevance of this work to DOE's goals. One said simply that it is very relevant; the other that improving the spot welds on advanced high strength steels (AHSS) supports the DOE objectives for weight reduction and petroleum displacement, offering no support for this judgment. The third reviewer remarked that Future Body-In-White (BIW) assemblies will be hybrids of many materials. Some of those, especially Advanced High Strength Steels (AHSS), are presenting a challenge to conventional joining methods. Friction Stir Spot Welding (FSSW) may enable implementation of additional alloy combinations and stack-ups that provide additional weight and cost savings. The objectives of the project are: (1) to enable joining of AHSS alloys in unequal metal thickness stacks; (2) to develop more comprehensive information about mechanical properties (including T-peel behavior, cross-tension strength, fatigue strength, and impact behavior) of AHSS joints produced via FSSW; (3) to determine comparative information related to stir tool durability, weld quality and supply chain support; and (4) to Identify remaining issues preventing high production deployment. If successful, this project will demonstrate that friction stir spot welding (FSSW) is an acceptable cost-effective alternative for AHSS that are difficult to resistance spot weld (RSW) and that FSSW may enable down-gaging of sheet thickness through unequal/dissimilar material stacks. The project milestones are: to achieve structural joints with FSSWs in AHSS that are problematic to achieve with RSW; to demonstrate tool life of probable materials and the joining cost associated with FSSW based on wear studies to update the comparative cost model; and to complete the evaluation of process deployability, including compatibility with current machinery and manufacturing techniques.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

In this section, two reviewers proffered judgments on the approach to research presented. One termed it a solid technical approach. The other said the approaches taken within this project are great. They are moving the technology toward industrial implementation. The investigation on joint characterization and especially tool life and process deployment are well aligned to get to the best results. The third reviewer remarked that the FSSW process development task initially requires OEM selected alloys, especially alloys with problematic RSW (Resistance Spot Welding) performance characteristics and dissimilar stack-ups (alloy/thickness). The second task is the characterization of the joint interface, specifically to determine the functional relationships between process parameters and joint properties. This task also needs to evaluate the influence of coatings on process and weld strength parameters. The third task is tool durability. The fourth, and final task, is assess process deployment by collaborating with

equipment and tool manufacturers and by validating FSSW parameters with respect to existing industrial technology (robots, pedestal stations, etc.).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Very good accomplishment was the judgment of one reviewer. The other considered that the accomplishments achieved on tool durability/life and tooling cost while watching the weld quality provide important results for taking this technology to the industry. This reviewer regarded the tooling cost results as especially encouraging. The surface wear results versus the strength over number of welds he also found very encouraging. Also, the variety of the stack-ups and material mix show the robustness of this process. The third reviewer predicted that the work on joining of dissimilar AHSS combinations would have near-term impact and applicability. This reviewer remarked that in order to support low-cost tooling development, the direct injection molding of silicon nitride was done. This process does introduce volume sensitivity. Also, PCBN tools are being designed for FSSW. Updated cost comparisons were produced and plots demonstrating the functional relationship between tool cost and durability to reach cost parity with RSW. Tool wear characterization included wear studies of PCBN composite materials. Lap shear strength was maintained above AWS minimum (11.09 kN/ 2,493 lbs) for more than 1000 welds in DP980.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two of the three reviewers rated project collaboration very good and wonderful, respectively. The second reviewer singled out collaboration with the tooling suppliers for particular praise, saying it has brought a level of seriousness to the results. The third reviewer listed the project collaborators with apparent approval - the USCAR joining team (GM and Chrysler), commercial automotive sheet vendors (ArcelorMittal, GeStamp-HardTech, and US Steel), tool manufacturers and material providers (MegaStir and Ceradyne), and universities (Brigham Young University and the University of Michigan).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Three reviewers commented on proposed future work in this project. On reviewer commented that the tool durability characterization effort will complete PCBN variations and test DIM SiN materials. The project will also provide feedback (tool loads, wear characteristics, torque, etc.) to tool manufactures allowing for the next leap in tooling technology. In order to resolve issues for the FSSW joining of dissimilar materials, functional relationships between process parameters, tool materials and joint strength will be determined. The joint interface will be evaluated (including coating effect, and fracture surfaces) to improve overall weldability. Finally, the project team will work with equipment and tool suppliers to outline problems currently preventing deployment and identify final work needed commercialize the technology. This reviewer reasoned that since FSSW is a solid-state process which is known to cause significant changes in the microstructure of the materials, it seems likely in the case of dissimilar metals that the identification and analysis of suitable process parameters (tool rotation speeds, clamping forces, the effects of frictional heating, etc., etc.) will be very difficult. This reviewer, assuming the project team intends to investigate stacked sheet lap joints in order to measure weld strength, asked if any investigation of suitable assembly rules for these structures would be undertaken. The second reviewer recommended that future work focus on robotic application to permit production use of developed welding techniques. The third reviewer noted that the proposed future work addresses the questions raised within this project. Investigating more coatings and more materials is important, in this reviewer's opinion, as is continued focus on tooling life and cost. Continuing efforts on joint characterization and strength and fatigue life from the multitude of materials and stack-ups will be important to getting to a robust process.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer noted that resources are sufficient to get to the end of this project. This reviewer urged that follow-on efforts be fully funded, also.

Friction Stir Welding (FSW) & Ultrasonic Welding (USW) Solid State Joining of Magnesium to Steel: Warren, Dave (Oak Ridge National Laboratory) – lm031

Reviewer Sample Size

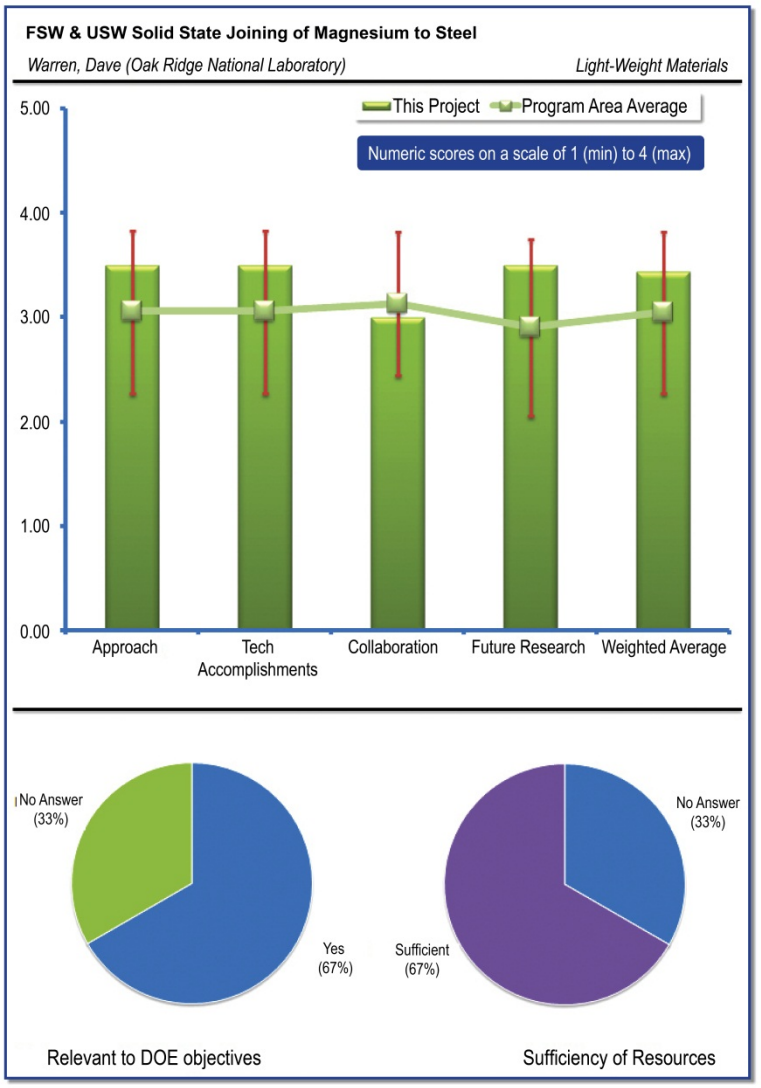
This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt the project was relevant because effective technologies for Mg-steel bonding will support strategies for vehicle weight reduction. Another said the joining of mixed materials is a critical enabling technology to increase the amount of magnesium that can be included into high volume automotive structures reducing weight of vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt the approach for investigating both the friction stir weld and the ultrasonic welding for magnesium and steel was robust and complete. A second reviewer felt that the current approach of examining the corrosion and microstructure were critical to understanding the joints and suggested examining more stack ups with different grades and coatings on the steel.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer stated ORNL is working very efficiently to better understand the engineering properties of Mg and especially the fracture events at the Mg/steel interface. Another reviewer stated that the achievements to date on fractography, tool design, characterization of the interfaces, the fatigue tests on FSW were all solid and push the project to the end goal The final reviewer voiced concern that there was no information on the corrosion yet and the project was almost over, and offered that it takes over three months to generate corrosion results and a few more months to evaluate and react.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Opinions on collaborations were generally positive. Among the comments were that the there is good collaboration with automotive companies and the USAMP magnesium research team as held regular conference calls are held with OEMs, actively followed by GM and Chrysler and Ford has an open invitation. Guidance is provided for technical activities. Results are shared with Magnesium Front-End Project participants. University of Michigan is supporting fatigue testing, analysis, and modeling. One reviewer offered that there should be more collaboration with friction stir and ultrasonic welding tool suppliers.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer recommended the highest priority be placed on corrosion performance and mitigation. This reviewer offered that although all current project tasks are important for the lightweighting effort, the static and dynamic testing of hybrid joints is critical and that the test protocol should also consider the impact of corrosion (and perhaps other aging-related effects) on hybrid joint strength. Another reviewer suggested that additional work should be with AM60B die cast magnesium since it is the most likely for large magnesium parts.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated that the project should continue to be supported, and resources for collaboration especially with the auto companies should be expanded.

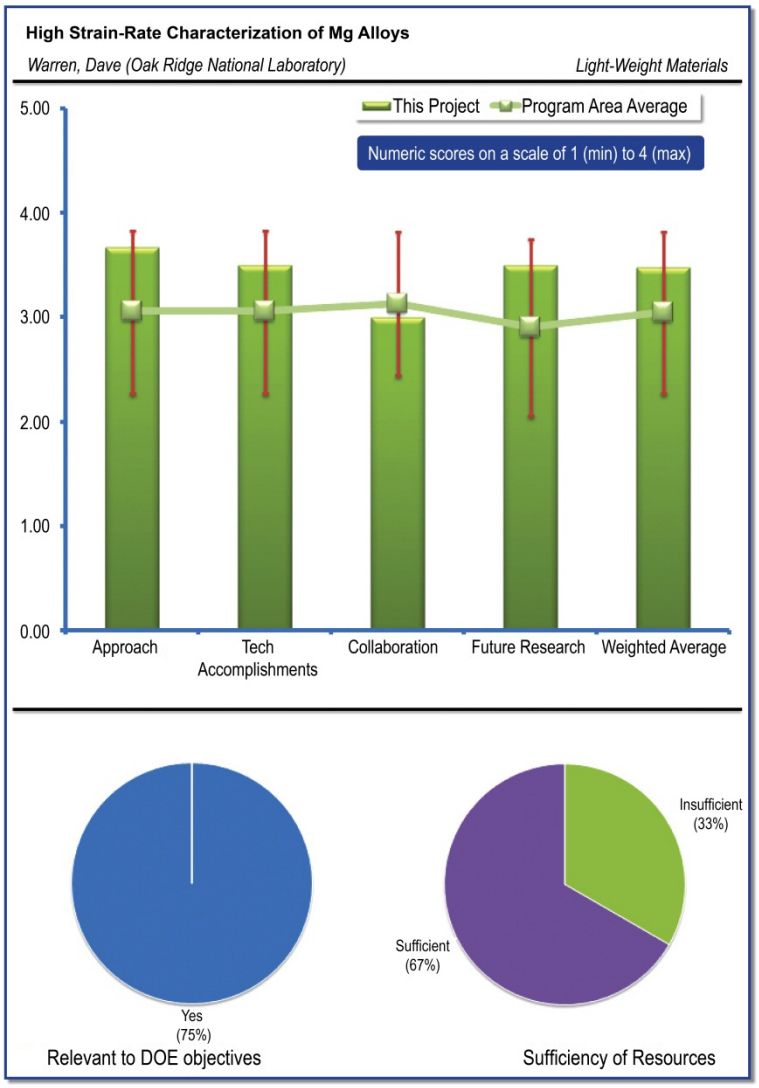
High Strain-Rate Characterization of Mg Alloys: Warren, Dave (Oak Ridge National Laboratory) – lm032

Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project develops enabling technologies and material data for the use of Mg alloys in automotive structural applications. Another said understanding the high-rate behavior of Mg alloys is very important in automotive lightweighting. A third reviewer indicated magnesium is one of the lightweight materials and can be used in vehicles to reduce the mass. Understanding of the behavior of magnesium under high strain loads is important. A fourth reviewer offered that high strain rate material properties and correlation of CAE predictive modeling is required for commercialization of lightweight components comprised of Mg alloys. The final reviewer said that this by enabling better material's characterization during catastrophic events, it not only support DOE's goal but also improve on safety.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers felt that the project is using a sound approach to developing test methods suitable for characterizing material performance at high strain rates. One reviewer commented that this experimental approach provides an excellent tool to investigate the crack initiation, propagation and final of Mg alloys under high strain rate which is very important to understand the trustworthiness behavior of Mg alloys. Another reviewer stated that this research may become the prototype of future testing procedure where true on-scale models with proper material's attributes will be tested. A third reviewer agreed with the research observation that in the not-too-distant future new sensors will “gradually take over” and that these sensors will be based on some formulation of multi-function microsystem (nanosystem) technology where the key obstacle will be the development of suitable packaging. The reviewer continued that this project is opening up a very interesting window on (near) real-time in situ materials-based metrology. Some issues and recommendations were also raised. One reviewer noted a need to incorporate CAE and ICME to gain scientific value in order to avoid weakness caused by a lack of documented bases of sample origin and quality. A second reviewer offered that multiple data sources for each measured quantity as well as the ability to verify measurements throughout the range of strain rates of interest.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

All reviewers stated generally that there was good progress on many fronts. One reviewer commented that the high strain rate testing development is unique in nature due to the fact that it can be stopped at any time, and stated that it is important to see the fracture initiation in magnesium since its fracture behavior differs from commonly used materials such as aluminum and steels. Several reviewers found issues with the approach or offered recommendations. One reviewer advised to focus on final stages of fracture to understand the failure mechanisms of Mg alloys to establish the material model for crash simulation and develop new Mg alloys for improved crashworthiness. Another reviewer felt that more progress could have been made quicker if done in conjunction with other National Labs.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Opinions on collaborations were generally positive. One reviewer noted that the project is working on alloy samples provided by the automotive industry and has very good collaboration with industrial and academic partners. A second reviewer said that ORNL knows how to do it! Some reviewers had concerns and offered recommendations. One reviewer remarked that they saw limited "cooperation" but little or no true "collaboration". This reviewer continued that OEMs provided material that is of interest to Magnesium Front End project; however there is no other apparent interaction between OEMS, MFERD, or other related projects such as ICME work at USAMP or Mississippi State University. Another reviewer cautioned even though the project has involved with Magnesium Front End team, additional industrial and academic partners should be included to reduce the redundancy in efforts

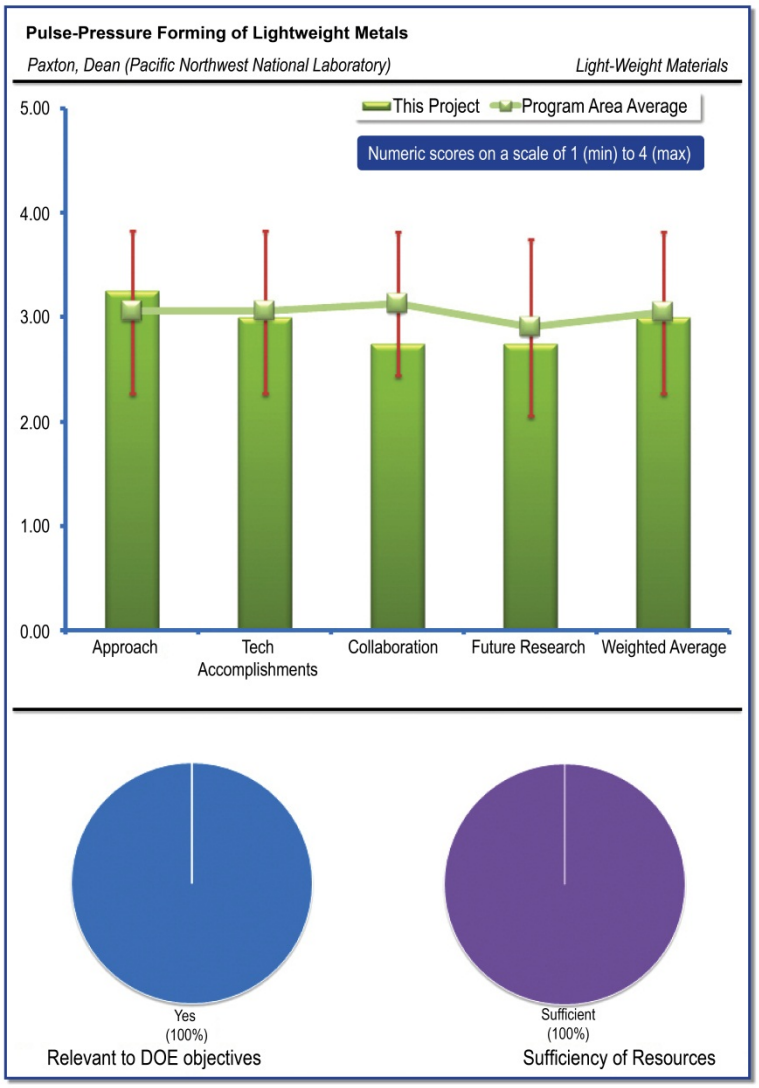
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer indicated that the current plans include 1) in-depth characterization of damage evolution in Mg alloys of interest to automotive designers at various strain rate conditions, loadings and initial microstructures; (2) design new methods for tailored strain application under intermediate strain rates; (3) advance technology for intermediate strain rate testing in tension, shear and multi-axial loading configurations; (4) essential for development and calibration of advanced material models for lightweight materials; (5) the damage models require wide region of stress states and loading paths; (6) support development of forming technologies and new material processes such as asymmetric rolling for Mg alloys; (7) development of methods for characterization of fracture/failure properties of Mg sheet materials; the highest priority placed on gasoline/ethanol work. A second reviewer applauded the good plan going forward and recommended a 5-year program to realize tangible objectives or a focus on multiple activities. A third reviewer asserted focus on establishing failure models and failure mechanisms of Mg alloys. A final interviewer warned of a future limitation in the proposed work involving magnesium only, offering that more work can be done to compare other materials using the newly developed test piece and process.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that additional funding was needed for continued work on AM60 castings and new alloys. Another reviewer commented that the lab resources were sufficient, but that an additional partner was needed to add predictive modeling to the project.

Pulse-Pressure Forming of Lightweight Metals: Paxton, Dean (Pacific Northwest National Laboratory) – lm033



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers generally supported relevance to DOE objectives. The first reviewer felt any technology that gets aluminum and AHSS into autos in a cost effective manner meets the objectives. Another observed that better formability at a fast rate is a valuable tool. A third reviewer suggested that improving formability of light metals (Al and Mg) is important to vehicle lightweighting. The final reviewer asserted that formability is an issue for magnesium which can be used to reduce the vehicle weight. If the cost of forming of magnesium can be reduced then its use can be increased.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally were cautiously critical of the approach. One reviewer indicated that the rapid strain rate deformation processes are evaluated, even though there are no confirmed test methods available to measure the strain rates developed during the rapid strain rate deformation processes studied in this project; the researcher is trying to measure them using conventional test methods; and a new approach may be needed to tackle the problem. The reviewer continued by pointing out that efforts to develop constitutive equations and models to predict the performance are a little premature because there is no way of confirming these models are available now. Another reviewer cautioned that although it was a decent design of test with an interesting indication of increased formability of Mg at high rates, unfortunately there was no not follow up.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers comments were generally not complimentary relative to the accomplishments of this project. One reviewer offered that the accomplishments were relatively limited; off the shelf metrology and a custom tool were used, so the innovation beyond the driver technology is not high. A second reviewer offered that there was a good understanding of the process and short comings of current evaluation technologies; however, further developments are needed to completely understand the strain evolution during PPF processing.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer commented that the coordination was not elaborated upon extensively, but seemed to be there. A second reviewer commented that even though OEM members are involved in the process, their involvement is only technical guidance. This reviewer further recommended that other researchers involved in PPF forming and experts in other pressure assisted processing areas, such as joining or explosives, be approached for collaboration, or consulted for their opinions.

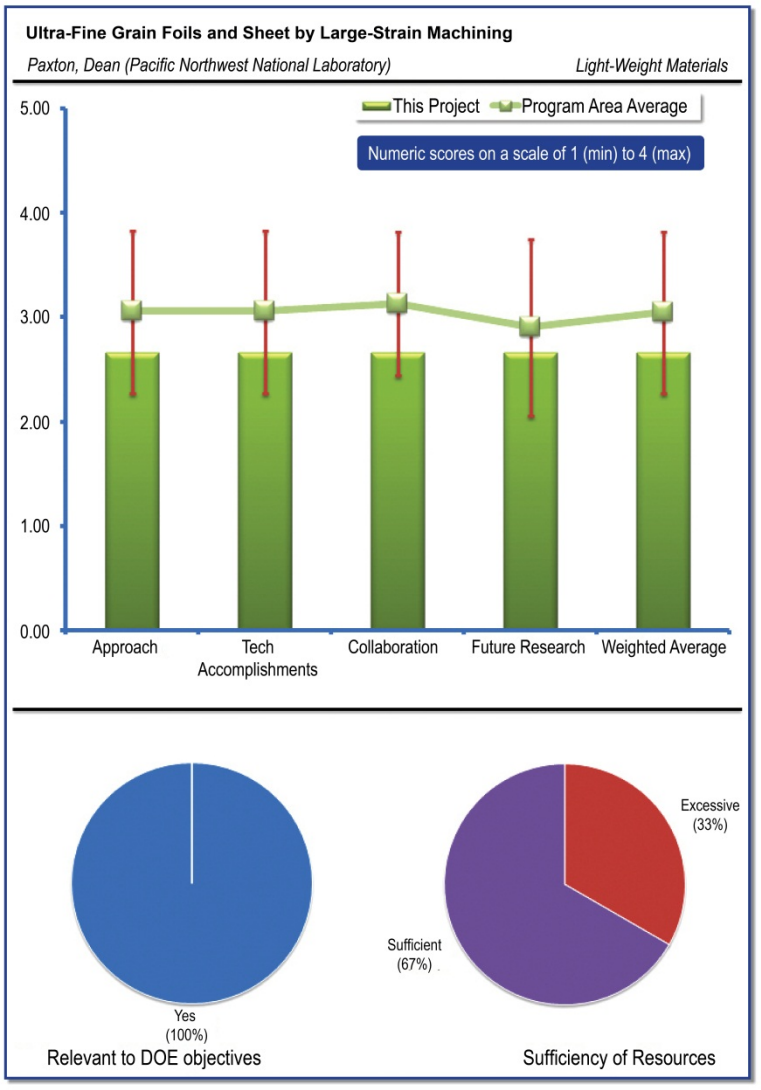
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer suggested testing the formability of Mg alloys to make sure that this technique is beneficial to Mg alloys and cost effective compared to other techniques such as warm stamping.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers did not comment on resources.

Ultra-Fine Grain Foils and Sheet by Large-Strain Machining: Paxton, Dean (Pacific Northwest National Laboratory) – lm034



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt the project was relevant as it could potentially lead to Low-cost and more formable Mg sheets, which is important for vehicle lightweighting. A second reviewer stated that it has a good potential for sheet making. A third reviewer added low-cost and more formable Mg sheet is important for vehicle lightweighting. The final reviewer said development of wrought magnesium is important as the use of magnesium in vehicles will reduce weight and as the project is a long-term, high- risk project, it is relevant to the DOE portfolio.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the concept is interesting and similar to the equal angular channel extrusion with large plastic strain applied, but probably easier to be up-scaled. Another reviewer said that the project is aimed at developing an understanding of the grain formation in a high shear forming process of magnesium. But the effort is still in small scale and most of the work is carried out in the university labs, and the role of the DOE lab needs to be clear. This reviewer questioned whether the project is restricted to a characterization only.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that only limited samples have been made and suggested that large samples be made for formability evaluation. A second reviewer expressed that the formation of fine grains due to large shear stresses developed during machining is proved in this work and further suggested that as the thickness of the machined chip is increased, the shear stress may not be severe in the outer edge and the grain size will be variable. This effect needs to be studied before scale-up is tried.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer commented that the project is aimed to collaborate to understand a process which is patented by the university partners. Even though the material suppliers are involved, their technical contribution will be limited

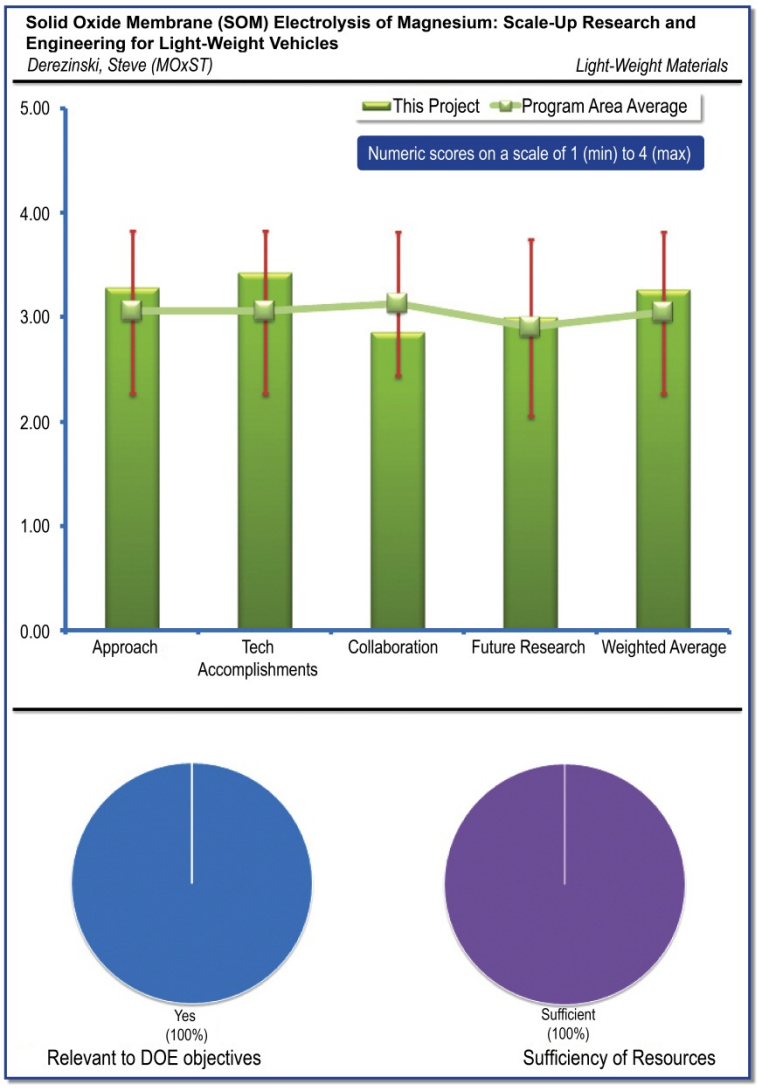
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer recommended testing the formability of the material. A second reviewer cautioned that it is necessary to understand more fundamental issues before scaling-up is tried in future.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first and second reviewers thought the project team made good use of resources. The third reviewer had some reservations about resources for this project, considering them excessive. One reviewer voiced a specific concern about resources, stating that the project looks like only characterization in the labs and most of the work is contracted out to universities. The process is patented (not to the labs); total cost need to be shared by the team members.

Solid Oxide Membrane (SOM) Electrolysis of Magnesium: Scale-Up Research and Engineering for Light-Weight Vehicles: Derezinski, Steve (MOxST) – lm035



Reviewer Sample Size

This project had a total of seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt the project was relevant and stated that the ability to produce a low cost Mg without significant negative environmental impact would significantly increase the attraction of and application of Mg to vehicles, thereby reducing vehicle mass, increasing their efficiency and reducing their emissions. This technology can be a major enabler for such Mg. Another said that low-cost domestic supply of primary Mg is critical to the national interests of the United States. A third reviewer expressed that the commercial use of magnesium and environmental benefits associated with GHG footprint is significantly related to primary reduction of MgO. A fourth reviewer stated that magnesium is proven to reduce the weight of the vehicles and improve the efficiency, so it is necessary to reduce the cost and impact on environment during primary metal production. A fifth reviewer indicated support and concerns, stating yes this project is needed to satisfy DOE objectives in diminishing petroleum consumption because it concerns magnesium, a much lighter than materials currently in use, but no it does not because it is material processing production without any use in mind. This reviewer's understanding of DOE objectives is that magnesium, as a basic material, is the starting point. Otherwise, this reviewer acknowledges that this is a good project, but questions whether this project is at its place here. The final reviewer explained that this project attacks the need for magnesium production. Magnesium at low cost and low emissions will help reduce weight in automotive industry.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers agreed that this project has a solid approach to scaling from concept to commercial scale. One reviewer indicated that although problems have been identified, they are well understood and are being addressed. Some reviewers also identified concerns. One reviewer commented that the researcher should watch side products of MgCl2 and SO2. This reviewer remarked that SO2 is not environmental-friendly. A second reviewer was complimentary of the current work but skeptical about the scale-up stating that approach is excellent at the lab level. The scale up process is too optimistically presented and it is doubtful that it will be as straightforward as they said.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

A reviewer stated generally that there was substantial progress in areas such as Zirconia robustness, FEA modeling and scale-up. A second reviewer indicated that significant developments has been achieved in increasing the cell operating time and efficiency and that the planned scale up for large scale production is a good step but is a long way from commercial production. Another reviewer commented that achievements with respect to goals are outstanding. A fourth reviewer commented that there was significant accomplishment to date and that the project is totally dependent on third-party funding.

Although most reviewers were satisfied with the achievements, one reviewer offered some concerns and recommendations. This reviewer stated that the durability and robustness testing is not yet at a level to confirm the next scale up step, and remarked that the small scale tests are encouraging but still not convincing for the next step. Additionally, this reviewer remarked that efforts on material impurities based on chemistry look encouraging, but the reviewer would like to see testing to confirm assumptions and estimates. Finally the reviewer suggested the theoretical energy budget is appealing but this reviewer would like to see the measured energy-in and product-out data from the small scale process.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Opinions on collaborations were generally mixed. One reviewer stated that the research team has a limited number of collaborators, but appeared to be the appropriate organizations and fruitful cooperation and collaboration. A second reviewer offered that there was good collaboration with ORNL and Boston University as well as industrial partners MOxST for raw material supply and volume reduction/primary with metal production contingent on successful business negotiations. A third reviewer felt that the work is very promising; however, it is unclear from the presentation whether there was good collaboration or not. One reviewer explained that the collaboration efforts are comparatively less due to commercially sensitive nature as this work is on a patented process. The reviewer further commented that this is out of the scope of pre-competitive research and should be minimally supported by VT.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The reviewers were generally supportive of the proposed future plans tempered by some concerns about the optimism of the scale up and the appropriateness of VT funding for a commercial level plan. The first reviewer commented that this is an excellent project which gives this reviewer a very strong sense that MOxST is committed to the eventual development of an industrial-scale family of devices. The point was made by several reviewers at the review meeting that there will surely be several “big steps” between the current prototypes and anything approximating the quantity of material needed in the end-game. The project team seems to understand the implications of this observation. This reviewer summarized the critical actions as follows: The first task is to optimize zirconia (YSZ) formulation and process for long-term operation in molten salt. A new larger-scale prototype configuration will be designed, built and tested. Then metal will be produced using the prototypes and testing will be done to determine the composition and suitability of the material for vehicle parts. Further refinements will be done for technical, cost, energy, GHG and other emissions modeling. Finally, the project will begin site selection and development for pilot plant. A second reviewer offered that there is a clear vision of the path to scale up to pilot scale and production scale, with a good understanding of, and plans to do, what is needed to make such scale up possible. A third reviewer was cautiously optimistic stating that the project is completed with the future plan including 1kg/day for casting trials, providing a bulk supply of 500 lbs. in 2012, the success of which is critical to demonstrate the capability to scale the process and cost. There were some cautionary concerns also identified by one reviewer: (1) there will undoubtedly be technical issues in the future which will affect the timing of this venture, but (2) the most critical issue now is the securing of “patient” capital. Even though this project is in early days, it is not too early to start working on the “time to profitability” calculations. At this point, the complexities of the current Mg market and other unknown cost factors (such as the transport costs of bulk material, etc.) make it difficult to determine the intermediate-term financial viability of this proposal. Another reviewer had concerns about supporting a commercial venture, saying a primary metal manufacturing project does not necessarily need to be supported by the VT program alone. The fundamental material development can be supported while the scale-up and commercial level

production need to seek other partners as this will reduce the support for other projects. A third reviewer offered the critique that the future prospects for the project are very good but the scale-up is not fully estimated; it is being presented as no problem! Scale-ups are always a big challenge.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that this project appears to be a fruitful "investment", in fact achieving a good return for the money spent thus far. A second reviewer commented that the resources are adequate for the work, and a third reviewer stated that the project is over, so the funding was sufficient.

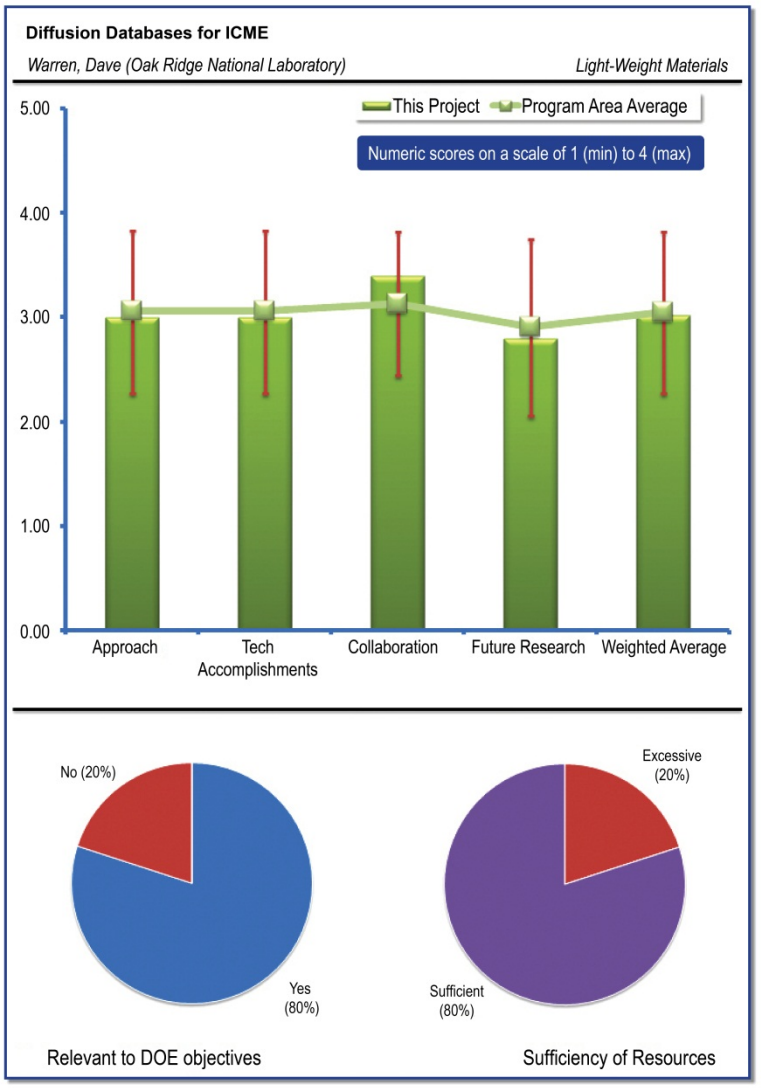
Diffusion Databases for ICME: Warren, Dave (Oak Ridge National Laboratory) – lm036

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer emphasized that verified diffusion data are essential in alloy design, and having this information available is also essential for the ICME formalism to function. Having this information generally available will stimulate research into lightweighting via alloy development. This reviewer commented that the project is working on a technologically relevant alloy system (Mg-Al-Zn-Mn). A second reviewer commented that this could shed light on the micro structure of metals. Another reviewer strongly supported the connection to DOE goals, stating that the ICME project overall and the diffusion project in particular support the DOE goals for weight reduction and petroleum displacement. This information will assist with the development of new magnesium alloys. The final reviewer felt the project was relevant, but with a caveat. This reviewer stated that this project addresses a very fundamental issue of developing data useful for alloy development modeling; however, the problem is far removed from the outcome of petroleum displacement. Even though the research of this nature is needed this should not be the priority for VT program.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers felt that there was value in the research approach but limited innovation. The first reviewer felt that this was a relatively brute force approach using existing technology; plowing through the measurements, fairly low innovation, but the data are of value. A second reviewer offered that the mobility database using diffusion couples is a well-established technique, that the tracer diffusion approach is a newer, more expensive technique, and that the project should try to best use the both techniques in developing "robust" database of computational alloy development. A third reviewer commented that the project uses the state-of the art techniques available as well developing new methods for analysis. A final reviewer offered that using the multiple tracer isotopes for the project provides multiple paths to reach the project goals. The thin film tracer approach appears robust for the magnesium diffusion mechanisms. Using SIMS for the diffusion measurements gives the data necessary for the diffusion characterizations. These tracer diffusion measurements supplies key parameters for the magnesium systems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that there was clear definition of technical accomplishments and progress. The investigations on sputter roughness and the resulting oxide growth give the necessary surface for the process to yield robust results. The efforts on the vacuum equipment

and polished angle sampling were creative approaches to overcome the challenges. The second reviewer commented that the new technique to measure the diffusion distances was novel. Other reviewers were more critical. The third reviewer stated that for a program that has been running for a number of years, the output seems small. The presentation had many forward looking plans, and the project is ending in a few months. Some issues were encountered with their measurements that were due to sputtering mechanism problems, but it seems to have taken a very long time to sort these things out. The path forward is not well described. The grain boundary diffusion work seems to have not been started at all. The final reviewer indicated that so far only limited results have been presented with the hope to see more results next year.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Opinions on collaborations were generally supportive. The first reviewer asserted that the project is doing a great job working collaboratively across the large and diverse ICME project web of investigators. The ties to universities and industry are appropriate. A second reviewer said that there was excellent collaboration. A third reviewer applauded the fact that many university researchers were involved; this helps develop new talent for future materials science research which is necessary. The final reviewer found it was very hard to determine how well coordinated the work was from presented material.

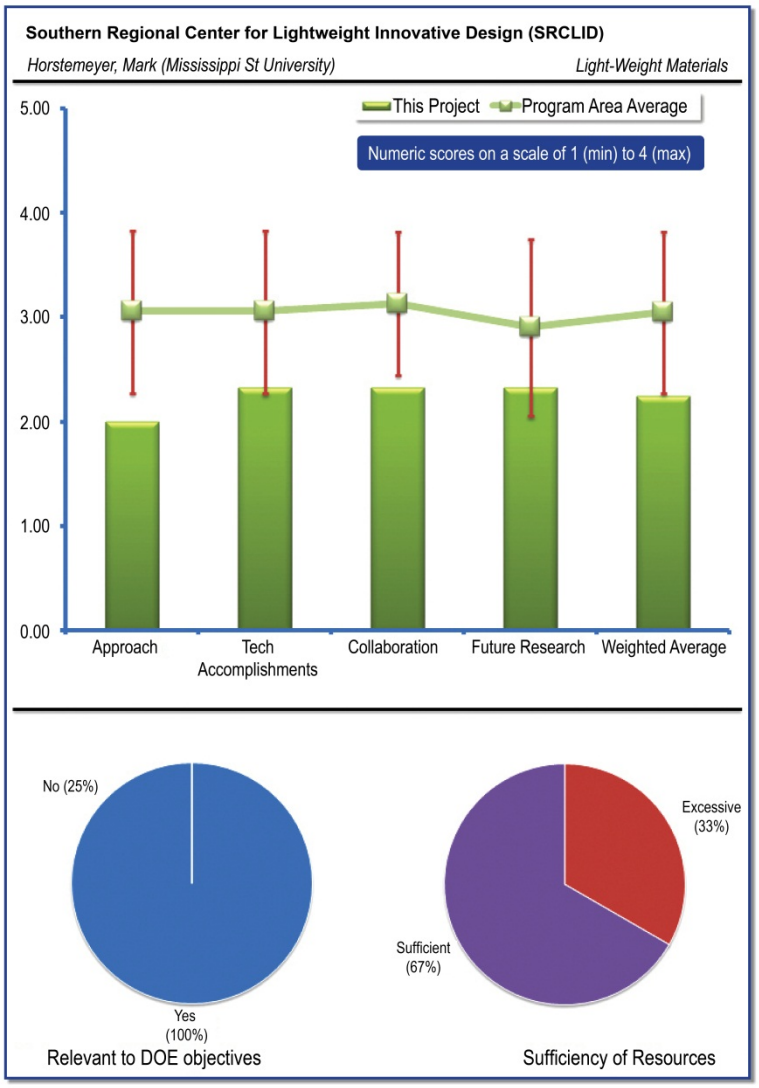
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer affirmed the proposed work on the MG-AL-ZN-MN systems is appropriate and useful indicating that the smaller efforts on the rare earth elements are also appropriate. The second reviewer recommended expanding the Mg-Al-Zn system to include Mg-Nd and Mg-Ce systems as both systems have shown excellent potential for high-strength alloys. Although rare earth elements (Nd and Ce) are expensive, there is a need to understand these systems to develop lower-cost alternative systems for high strength/ductility applications. A third reviewer offered that availability of materials for the proposed testing need to be confirmed before finalizing the plan (such as isotopes of al for tracer) and a final reviewer remarked that the future work plan seems to be only "give us more money and we'll try to finish" a much larger matrix.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer remarked that funding appears sufficient for the project. Another reviewer remarked that the PI mentioned not having $150K for a rotation stage, but other than that the reviewer was unable to discern the resources. The final commenting reviewer remarked that even though the research is good and needed, it does not fit in the mandate of VT; there are no in-kind or cost share partnerships involved.

Southern Regional Center for Lightweight Innovative Design (SRCLID): Horstemeyer, Mark (Mississippi State University) – lm037



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt the project was relevant as it addressed many topics related to lightweighting of vehicles. Another reviewer remarked that the project is developing a database for modeling manufacturing of multiple materials. A final reviewer indicated that the project only looks at the design optimization, which is only one small aspect of the challenge of petroleum displacement; the work is only marginally relevant to the DOE objectives. The exclusion of aluminum and multi material joining are significant holes in the project.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that the twelve projects are only loosely aligned to the overall vision and DOE goals. For the computational manufacturing efforts, the approach is not clear and the passing of information is weak from step to step. The approach for the projects was not clearly stated, so the evaluation is difficult. Too much of the approach is still planned in the future. It is not clear what are the near term steps for the current approach. The stated mission is to provide a design optimization and a design methodology for lightweight components and systems but the design aspect was never addressed in this presentation. A second reviewer stated that the project itself is a program with projects on magnesium, steel and composites, with the goal of developing manufacturing database and predictive models to use these materials for lightweighting.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer found that the accomplishments of this project are not clear. The information and models appear still to be in the future and are not available now. The presentation was not clear on what has been completed and what are the near term deliverables. The prediction of mechanical properties from tech processing are still referred to in the future tense, what (hopefully) can be achieved sounds great but little has been accomplished at this time. The fatigue models were not clearly compared to the data so the accomplishment cannot be evaluated. Additionally, the results from this project are not clear compared to the USAMP LM012 ICME project. The predictions of the tensile response of AM30, for example, were good but these are particularly difficult. A second reviewer offered magnesium projects are well explained and the roles of the participants are laid out. Modeling to assist manufacturing and design process (casting, extrusion and sheet forming) is important. This reviewer noted that no steel projects are discussed. The

final reviewer noted that natural fiber SMC was reported to have absorb of only 1.2wt% in 24 hours. The actual test results showed over 5%. Additionally, it should have been tested for a longer term moisture exposure. The PI should have known better.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer commented that there are many collaborators listed but the connections and the roles & responsibilities of each collaborator were not clearly stated. A full list of collaborators and their roles would have been helpful. A second reviewer offered that in case of magnesium, having MFERD project as the primary partner will enable effective tech transfer.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer observed that the future work seems aligned to the objectives, and asserted that the participation in the magnesium front end project needs to be accelerated so that the information can be of value before the project ends in September 2011. This reviewer added there still seems to be a need for the outside "pull" for certain efforts and technologies. There was no clear discussion of the testing and model to lab comparisons. There was no list for term deliverables. Another reviewer stated that even though the project is aimed to develop a cyber-infrastructure, it is not explained who will be the final user after the end of the project, or how the database will be maintained after the end of the project. An open source will be very difficult to maintain so a partner who can find a market for these datasets need to be identified.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer stated that the presentation did not discuss the resources of either DOE cash or other funding sources. This reviewer commented that since the project has been running for so many years the results showed to date seemed slim regardless of the funding. A second reviewer affirmed that no information was provided for the financial / resources.

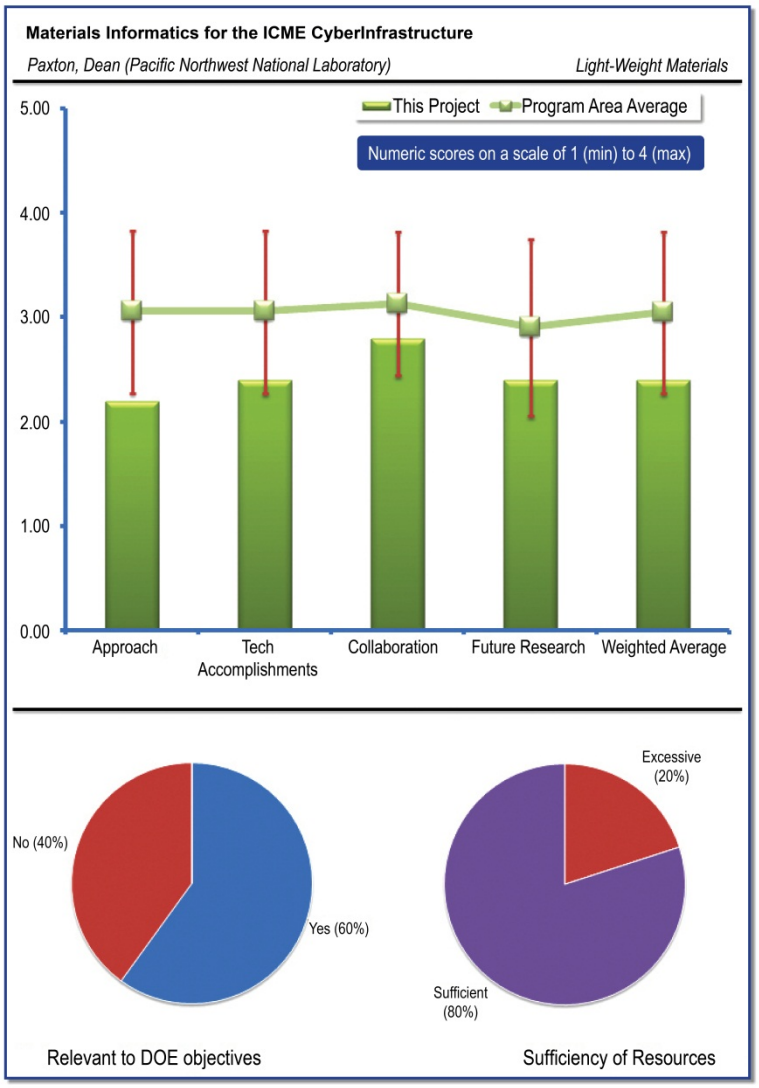
Materials Informatics for the ICME CyberInfrastructure: Paxton, Dean (Pacific Northwest National Laboratory) – lm038

Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers had mixed feedback. One reviewer remarked that this project is an enabler for managing and transferring data so it supports the base ICME efforts for analysis and computational materials science, and another reviewer remarked collecting materials information for a proper math modeling is a key to reducing confusion in this field. The third reviewer said the notion of having a network of validated models and data has obvious uses and desirability, but this reviewer had no real idea what this project is doing beyond project planning after listening to the PI's intro. Another reviewer was not sure at this point how useful this effort is going to be in helping us given the fact that only limited data are available. The final reviewer remarked the project is far removed from the petroleum displacement. The data set validation is necessary but needs to be addressed by different forums.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers felt there were some good aspects to the approach, but were generally not optimistic about the value of the project. The first reviewer stated that the vision for the materials infrastructure is valuable, but how the project is addressing the needs for informatics is not clear from this presentation. Identifying gaps in a sample problem is interesting but it is not clear that this method will yield a robust set of tools for future projects. A second reviewer agreed that developing a tool to identify the existing gaps in the data sets for materials is a good idea. A third reviewer reflected that this approach would be more useful if a large amount data are available; however, Mg-ICME being at early stage, this reviewer did not see a lot of value in applying this type of techniques. The fourth reviewer remarked I was unable to tell what these researchers actually did.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer remarked that the project proved the process developed is working well, and is identifying the knowledge gaps. Other reviewers generally saw minimal progress. One reviewer remarked that limited results or applications have been presented. A second reviewer remarked that the PI is talking about an unending list of what things need to be or need to have, but this reviewer was unable to tell what the group DID. The final reviewer said the data structure and hierarchy is now in place. The tools to assess completeness

are now at the initial level. The tie to the larger ICME efforts is not clear from this presentation. According to this reviewer, the presentation was not clear on the recent accomplishments from this fiscal year or equivalent period. The tools to evaluate and density map of data and materials are valuable for assessing completeness. The tools are not as far along as the time on the project.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Opinions on collaborations were generally mixed. A reviewer applauded good effort in collecting and analyzing the data from many collaborators. Another reviewer remarked that the partners were described but the PI did not go into much detail on what the interaction was other than providing access to data and repositories. A third reviewer added good effort on collaborating with the diverse group that is ICME. This reviewer added concerns with the presentation; for example the lead collaborator was listed as Ford - John Allison. Dr. Mei Li has been the Ford leader on ICME for 1 year.

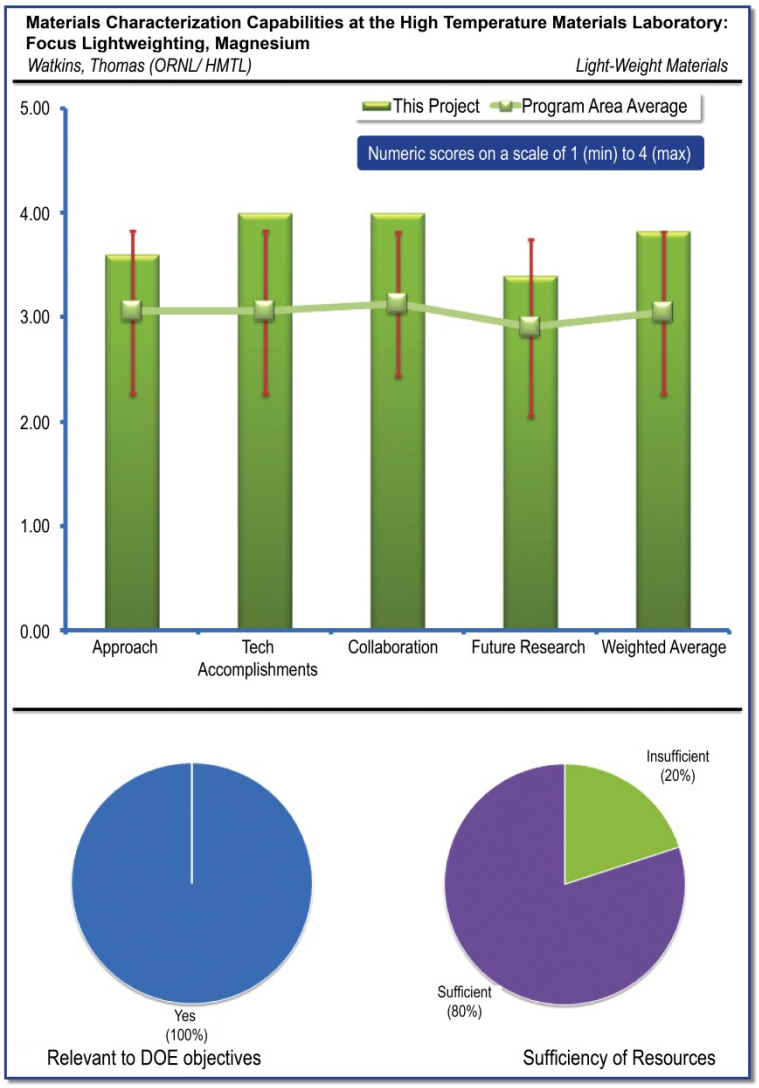
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer offered that the proposed future work on multi repository combining data sets will be the key deliverable from this project. The tools for data completeness and visual representations will give good insights. The project is near completion but there appears to be much work left to accomplish. The second reviewer recommended holding this effort until more and complex data/models are generated for Mg-ICME. Project is a low priority at this time.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that time and money are adequate for this effort.

Materials Characterization Capabilities at the High Temperature Materials Laboratory: Focus Lightweighting, Magnesium: Watkins, Thomas (Oak Ridge National Laboratory/High Temperature Materials Laboratory) – lm039



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers felt that the project supports DOE objectives. The first reviewer felt this effort is directly in line with the Vehicle Technologies Lightweighting effort because the HTML is a DOE Designated National User Facility. The Vehicle Technologies Program funds the operation of the HTML User Program to maintain world-class expertise and instrumentation capabilities for materials characterization to work with industry, universities and national laboratories to address critical technical barriers to achieving the goals of the DOE Vehicle Technologies Program. The HTML User Program capabilities are also being utilized to support Vehicle Technologies Program projects at ORNL in the program's technology areas of Lightweight Materials, Propulsion Materials, Energy Storage, Power Electronics & Electric Motors, Emission Controls and Solid State Energy Conversion. The Magnesium Elektron North America user project, the primary focus of this presentation, is focused on the feasibility of developing industrially viable processes for producing shear rolled sheet. In particular, this project addresses technical barriers related to manufacturability and also adds to knowledge of the performance characteristics of advanced magnesium alloys. The second reviewer stated that HTML in general provides unique capabilities that allow very accurate and detailed characterization of lightweight materials. The example user project that was supported demonstrates the ability to provide information needed to model the performance of Magnesium. Such information will enable more widespread use of Mg, thereby reducing the weight of and increasing the efficiency of automobiles. The third reviewer said the testing and material characterization efforts on magnesium directly support the DOE lightweight vehicle and overall petroleum displacement goals. Having clear understanding of the microstructure and the mechanical properties is valuable to industry. The fourth reviewer expressed the availability of the world-class facilities to public users is very important to advance the technologies in the United States. The final reviewer remarked that this is an excellent program.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally applauded the program's approach. One reviewer stated that the project has an outstanding approach to characterize material for potential lightweighting benefit. The second reviewer applauded the project as well thought out and well executed. The third reviewer also felt it was a good approach to work with industrial/academic partners. A fourth reviewer detailed support, saying the investigations on the microstructure and mechanical properties are necessary and sufficient for the project. Using X-ray diffraction and electron back-scattering diffraction to investigate the texture, microstructure and crystallography are good

choices for this investigation. Getting to a forming limit diagram for AZ31 is a great goal. The final reviewer also provided detailed praise for the approach, saying that the investigations on the microstructure and mechanical properties are necessary and sufficient for the project. Using X-ray diffraction and electron back-scattering diffraction to investigate the texture, microstructure and crystallography are good choices for this investigation. Getting to a forming limit diagram for AZ31 is a great goal.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers stated generally that there was good progress. The first reviewer commented that the presentation included an extensive list of small (mean size about $60K) projects which were selected according to the criteria set out above and which from all indications were then effectively monitored and conducted. During FY2010, the HTML User Program managed 17 characterization projects in Lightweight Materials, and this poster presentation highlights one of them. The Magnesium Elektron North America user project is focused on the feasibility of developing industrially viable processes for producing shear rolled sheet. In particular, this project addresses technical barriers related to manufacturability and also adds to knowledge of the performance characteristics of advanced magnesium alloys. Magnesium Elektron was able to take advantage of a wide array of materials characterization capabilities available to industry users through the HTML User Program, which maintains world-class expertise and unique instrumentation gathered in one convenient location. The results from this investigation are a fundamental component of the process to produce new materials or materials with improved properties. A second reviewer indicated the accomplishments of getting confirmation on tilting the basal plane confirms the concept for getting better formability. Other techniques confirm orientation and basal plane distribution and size. These techniques will help guide the forming limit development and guide the sheet processing to reach the larger goal of creating more formable AZ31 sheet. A third reviewer commented that the project was customer and results driven. A fourth reviewer felt that the results will provide a better understanding of the benefits derived from sheer rolling, and a final reviewer stated that equipment and manpower to operate scientific equipment will result in innovation in America.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Opinions on collaborations were very positive. One reviewer applauded that during FY2010, the HTML User Program collaborated with 18 companies, 25 universities, and 6 national laboratories on 68 user projects addressing critical technical barriers to achieving the goals of DOE's Vehicle Technologies Program. There were 96 researchers, 63% of them first-time users, who visited the HTML for a total of 716 research days. The HTML also supports the education and preparation of the next generation of scientists and engineers. During FY2010, students and professors from 25 universities participated in the HTML User Program. Five of those students earned their Ph.D. degree and one earned her M.S. degree based in part on research they conducted through the HTML User Program. This reviewer commented that users cost-share user projects through direct involvement with HTML staff members during the development of the user project; funding their time and travel to the HTML; costs of materials provided by the user and the research performed prior to the user project; subsequent collaboration with HTML staff and members to analyze and publish the results. Continued this reviewer, through a project funded by DOE's Industrial Technologies Program, ORNL and Magnesium Elektron are collaborating on implementing industrial-scale shear rolling. The characterization research conducted through the HTML User Program supports a research-scale mill developed by ORNL's Materials Processing research group. Data gathered during the HTML characterization studies will be included in the operations plan for a new Magnesium Electron mill to be scaled up in the summer of 2011. A second and third reviewer commented that it is all about collaboration, and a third reviewer remarked that this is the true definition of collaboration. The fourth reviewer added obviously strong collaboration with Magnesium Elektron North America (MENA) in the example project. Also appears to be strong support from (as evidenced by use by) 18 companies, 25 universities, and 6 national laboratories in FY10. The final reviewer affirmed by saying great collaboration with industry, Elektron Magnesium, on the materials characterization for magnesium sheet.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers emphasized the continued characterization of rolled samples. One reviewer commented the project will continue to characterize rolled samples with XRD and EBSD and to complete fabrication of heated biaxial forming dome press for forming limit

diagram (FLD). The project will also be involved in technology transfer. A second reviewer stated solid plans for continued characterization for the rolled samples. Generating the forming limit diagram will also be a solid contribution. A third reviewer commented that the plans for next activities are logical and well developed. A final reviewer observed that the User Lab is and will be utilized by the scientific community.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer remarked that the resources for HTML should be expanded as the development of magnesium and other lightweight materials expands. The second reviewer thought that the resources are adequate for the work, and stated that the HTML is organized into six User Centers: Materials Analysis, Diffraction, Tribology Research, Residual Stresses, Mechanical Characterization, and Thermography & Thermophysical Properties. A third reviewer commented that the work should continue, but the resources were not known from the presentation. The fourth reviewer felt that the appropriate level of funding was available to support the unique and useful capability of the HTML, and a final reviewer commented that the project was well equipped, and well–staffed.

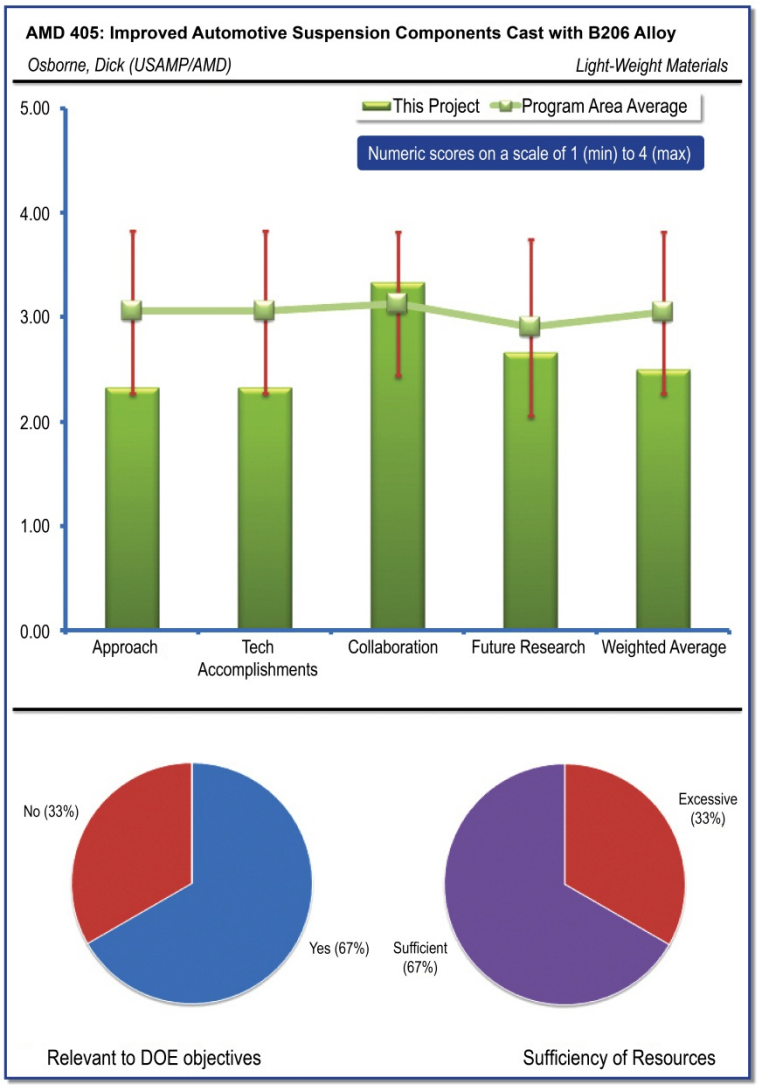
AMD 405: Improved Automotive Suspension Components Cast with B206 Alloy: Osborne, Dick (USAMP/AMD) – lm040

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally thought that the project supports DOE objectives. The first reviewer commented that high strength aluminum alloys support DOE objectives for petroleum displacement as AMD704 Low cost fasteners are required for Mg applications in MMV systems. A second reviewer stated that the B206 casting is being introduced as a less expensive substitute for 6082-T6 forging. The final reviewer stated that the objective of this project is to facilitate vehicle lightweighting by providing lower cost cast B206 aluminum alloy automotive suspension components with equivalent mechanical properties and performance as forged aluminum. Ferrous material solutions dominate suspension components due to strength, stiffness and cost benefits. Forged aluminum solutions are attractive with respect to strength but are at a disadvantage due to cost and diminished domestic supply base. Castings offer reduced cost and a larger domestic supply base but need improved mechanical and fatigue properties to be considered as an alternative to ferrous solutions. The technical target is to cast automotive control arms with mechanical properties and fatigue equivalent to that of a baseline 6082-T6 forged control arm.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers conveyed mixed opinions about the approach. One reviewer provided detailed assessment of the approach, stating the most common means of attaching magnesium components to automotive steel structures is to isolate the steel from magnesium through use of aluminum washers, spacers and/or fasteners. The difference in electrochemical potential is less between aluminum and magnesium than it is for steel and magnesium, thereby generating less galvanic corrosion. To be considered as an alternative to aluminum isolation, nano-ceramic coated steel fasteners must induce less galvanic corrosion than aluminum. The project established a two phase approach. (1) Apply nano-ceramic coatings to steel coupons, evaluate the galvanic current between the coated steel coupon and magnesium and compare results against aluminum coupled with magnesium. If the nano-ceramic coated steel coupons exhibited less galvanic corrosion than aluminum then Task 2 can begin. (2) Task 2: Apply nano-ceramic coatings to steel fasteners, evaluate the galvanic and general corrosion of the coated steel fasteners against magnesium using a modified VDA test (salt-spray), and compare against aluminum fasteners mounted against magnesium. The VDA test is a European corrosion test. A second reviewer asserted that AMD405 had a very poor approach in that the presentation reflects positive results but no data were presented. For AMD704, the reviewer commented that the fastener corrosion approach was exploratory without an experimental design. A third reviewer commented that in spite of the confusion of the combination of two projects, the authors finally manage to give some coherence to the presentation.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer stated that the Design of Experiments was completed and showed that the SiN nano-ceramic coating has the most significant impact on galvanic current and was not overly sensitive to coating layer thickness. Tested multilayer coating thickness is shown in the slides. Nano-ceramic coated steel using a multi-layer coating of silicon oxide, aluminum oxide and UV curable topcoat exhibited less average galvanic current (0.55 mA/cm2) than 6061 aluminum (1.26 mA/cm2) when coupled with magnesium in a salt water solution. The project demonstrated the concept feasibility of nano-ceramic coatings to isolate steel from magnesium. Initial VDA testing shows less mass loss for multilayer SiN-AlO-UVAlO nano-ceramic coating. About AMD405, one reviewer stated that results were not been presented. Additionally, AMD704 had inconclusive results, with no standard test for the application. A third reviewer stated that replacing aluminum alloy by another aluminum alloy is difficult to rate well as there is no lightweighting benefit, but otherwise, the progress has been good.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Opinions on collaborations were mixed. One reviewer said reasonable collaboration, listing collaborators on this project as USAMP, Alfred University, Kamax Auto Parts Co., Ltd. (KAMAX); Visteon; and General Fasteners. A second reviewer stated that for AMD704, collaboration included fastener suppliers and OEM's. For AMD405, this reviewer felt that the project was prematurely closed. A third reviewer stated that the impression was of reasonable collaboration but that the presenter was not very clear on it.

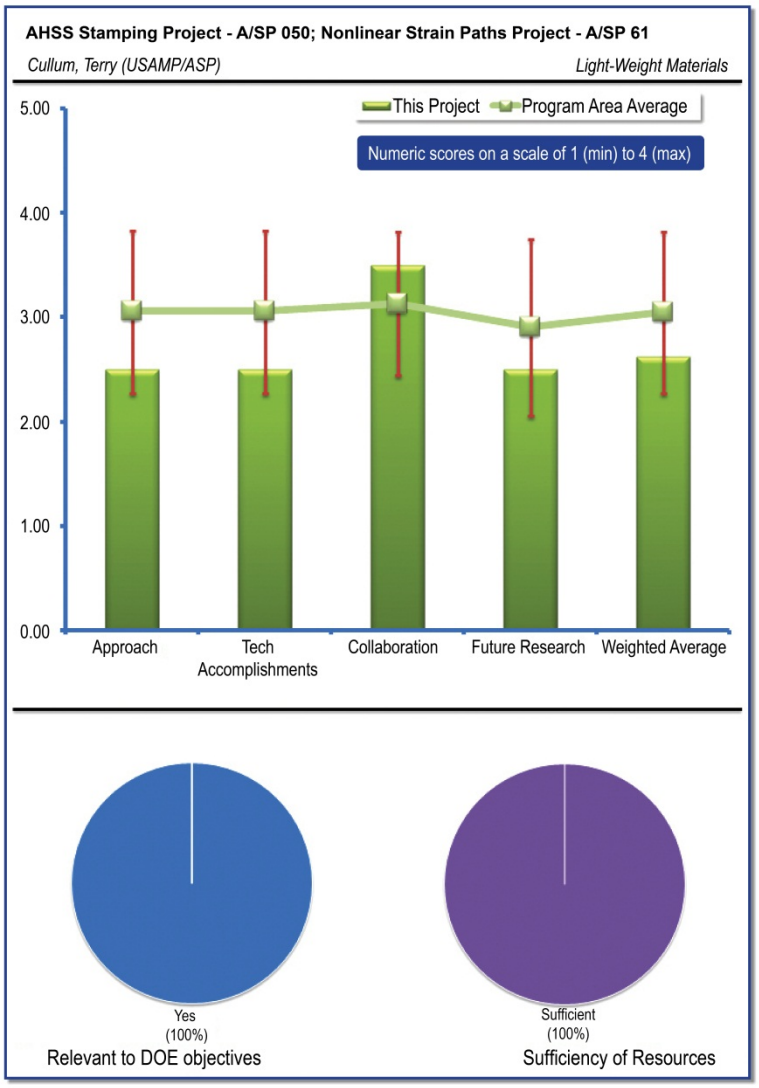
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviews of future plans were mixed. One reviewer indicated that the successful conclusion of this work will demonstrate the concept feasibility of nano-ceramic coatings for use on steel fasteners as a means of mitigating galvanic corrosion between magnesium and steel. Future work would be to demonstrate the technical feasibility of using nano-ceramic coated steel fasteners on magnesium substructures. It will also establish the ability of nano-ceramic coatings to achieve reliable torque/tension requirements. This reviewer recommended a useful next step will be to evaluate residual torque of assembled joints with nano-ceramic coated fasteners and to determine if nano-ceramic coatings have sufficient durability to resist damage induced by handling and assembly as well as assembly stress. The general corrosion performance of nano-ceramic coated fasteners will be evaluated. The second person commented that there should be more projects of this kind because these are the ones which will keep a lid on prices. For AMD405, one reviewer remarked project is closed, no further plan towards commercialization. This reviewer questioned, did we waste tax payers money? For AMD704, this reviewer remarked, no real plan, did we waste tax payer money?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer thought that resources were adequate to the task. A second reviewer remarked that AMD405 had no tangible results, and that for AMD704 there were minimal tangible results and plan. The final reviewer remarked that work should be continued, but introduced as not being “lightweighting!”

AHSS Stamping Project – A/SP 050; Nonlinear Strain Paths Project – A/SP 061: Cullum, Terry (USAMP/ASP) – lm041



Reviewer Sample Size

This project had a total of two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers felt the project was relevant to DOE objectives. One reviewer stated that the use of advanced high strength steels in vehicles is an enabler for lightweighting. Both stamping and understanding of material performance after complex forming and heating operations are relevant for applications. A second reviewer acknowledged any project with AHSS supports DOE objectives because higher strength and elongation properties of these materials mean less material while improving on safety.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers felt that although there was some concern in the past, the current approach is clear and effective. One reviewer stated that the non-linear strain path is planned well and the project is aiming to solve a critical material problem. AHSS Stamping is a long running project; even though the current approach is quite clear the past performance could not be judged and in future projects should have limited scope, duration and budget so that the outcomes can be measured effectively. A second reviewer found that overall, the approach is very good. One aspect this reviewer did not hear about was that regardless of the strength, formability, cracking, etc., what is the minimum sheet thickness the industry can work with. This reviewer opined that the potential of AHSS is not fully realized yet.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that the accomplishments are very good; the examples are very telling.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Among the comments were that this is an AS P project with steel manufacturers and OEM participation; however, the stamping project does not have in-kind contributions listed. On the other hand the non-liner strain project is well supported by industry participation. A second reviewer indicated collaborations were very extensive.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer pointed out that the stamping project should be completed this year and recommended that any gaps to be studied should be defined and started a new project. A second reviewer also noted that the project is almost over and recommend it should be continued. This reviewer also suggesting seeing comments made in response to question #2.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that since the project is almost over and achieved goals, it should have been sufficient.

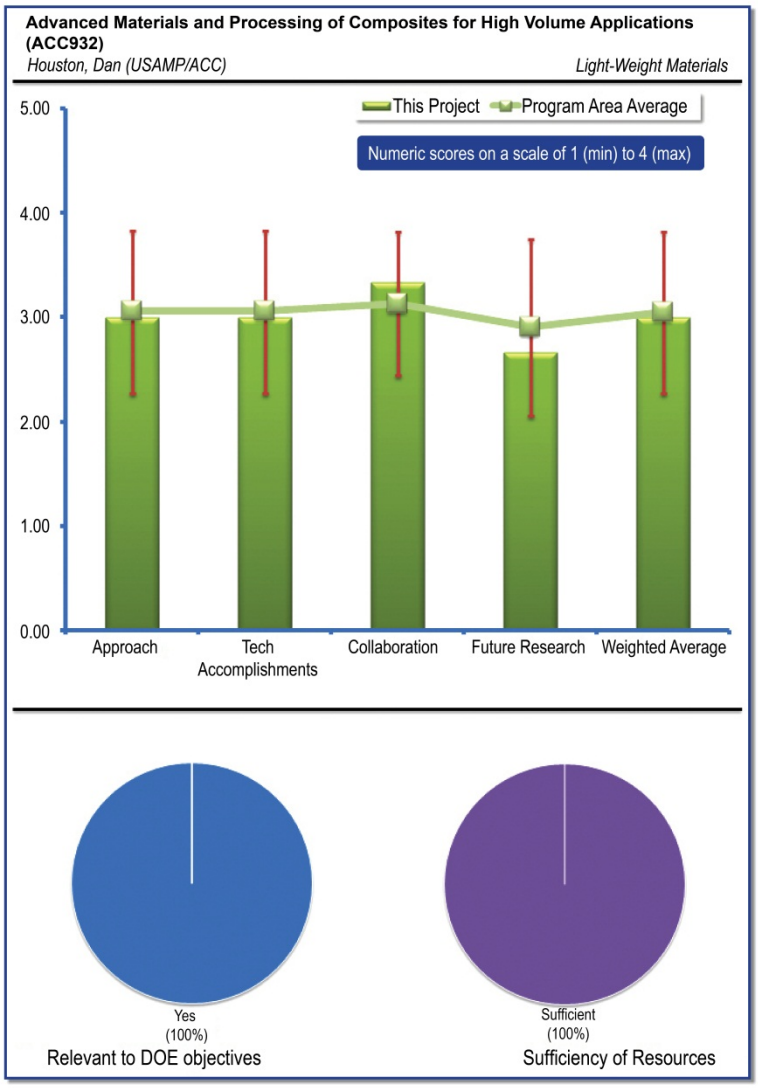
Advanced Materials and Processing of Composites for High Volume Applications (ACC932): Houston, Dan (USAMP/ACC) – lm046

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers thought the project supports DOE objectives. The first reviewer stated that the project is in line with the objectives of the Vehicle Technologies lightweighting effort because the objective of this project is to use composite materials to decrease the mass of high-volume automotive structures, at acceptable cost. The reviewer summarized the project goals as: (1) guide, focus, and showcase the technology research of the ACC working groups; (2) design and fabricate structural automotive components with reduced mass and cost, and with equivalent or superior performance to existing components; (3) develop new composite materials and processes for the manufacture of these high volume components. Another reviewer said carbon fiber composites can reduce the weight of vehicles significantly; this project is aimed to optimize the production process. A third reviewer said this project fits DOE objectives given the fact that work represents applications of lightweighting materials and processes into real use.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

This reviewer commented that this is a large project with a great number of focus areas and urges that the structure of the project or review of such projects be broken down into several parts in order to reduce the reviewer effort and to improve project performance. This reviewer was positive about the approach and provided a summary of the approach to this project to substantiate support and concerns. This reviewer summarized the approach as follows: The project targets two automotive structures, a structural composite underbody and a lightweight composite seat, as well as the materials and processes required to produce them. The underbody project will design, analyze, fabricate, and test a structural composite underbody for a large rear-wheel-drive vehicle. The primary research outcomes of this project are: A 2-minute cycle time (100k vehicles per year, 2 shift operation); methods of joining and assembly of the underbody to the vehicle; processes for fabricating oriented reinforcement within the time window; the seat project focuses on a second row seat which combines the functions of a seat (both with and without an integrated restraint system) and a load floor. The seat must save mass, be cost competitive at volumes from 20k to 300k, and the seat back must fold flat to create a load floor. The objectives for Advanced Materials and Processing of Composites for High Volume Applications (ACC 932) are: (1) Carbon Fiber Sheet Molding Compound SMC: develop high-performance, cost-effective, carbon fiber SMC materials and associated processing techniques for high-volume automotive components to implement both Class-A and structural applications that allow significant weight savings coupled with superior mechanical performance. (2) Bond-Line Read-Through (BLRT): enable implementation of minimum thickness composite closure panels to eliminate weight added for appearance by developing a validated FE model that can

predict, and therefore allow design optimization of, the severity of BLRT distortions based on part design. (3) Direct Long Fiber Technology direct compounded long fiber thermoplastics (DLFT) & Long Fiber Injection LFI Thermoplastics: determine processing parameters, customize master batch formulations for Nylon material, establish composite material properties, investigate processing equipment and tooling design and develop Tier-1 supplier interface. Another reviewer remarked that the presentation was a multiple-project presentation; at least four projects were coupled together. Projects included structural under-body and composite seat; body line read through; composite fiber SMC; and direct long fiber Technology – thermoplastic. While the first project is a demonstration project others are process optimization in nature. The third reviewer remarked that it was very difficult to present a good approach when so many sub-projects are being summarized. The authors managed to give a flavor but it was somewhat discontinuous.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer applauded that the work on this project has been excellent. The reviewer stated that the technical accomplishments for Focal project 4 are: completed final design of composite seat; completed CAE for all loading requirements; completed molding and assembly of 30 sets of seats, 22 of which were tested; and achieved a 23% weight reduction for the seat structure compared to a typical steel seat structure. The technical accomplishments for the Structural Composite Underbody task are: the technical cost model; the manufacture and assembly of the underbody for $5/kg saved, based on TCM of steel and composite systems; the successful mold and delivery of over a dozen underbodies for assembly and testing; and the non-destructive evaluation of impact damage from steel ball drops. The e technical accomplishments for the Carbon Fiber SMC are: molding of full underbody part, which replaces 16 steel parts, saving 11.5 kg mass (31%); development of a high strength glass fabric SMC; weld bonding assembly scenario demonstrated; technical cost model indicates $5/kg mass saved; design methodology demonstrated for crush of surrogate part; design of test methodology and fixturing; final design, CAE, molding and assembly of seats, showing 23% mass savings relative to steel seat; and static and dynamic testing of seat assemblies. The second reviewer stated that the demonstration projects are completed and the parts are being evaluated. In CF SMC project the feasibility of SMC is proven; however, OEM needs to pay for the mold development mentioned in the future work. Also part fabrication should be supported by the OEM funds rather than DOE funds. The third reviewer observed that the presented results show good progress with respect to what is but also the difficulties in combining all these materials. The talks also made clear that a lot more needs to be done before these new materials and techniques can be implemented into productions of "ordinary" vehicles.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Opinions on collaborations were generally very positive. One reviewer commented that collaborations appear to be very good. The second reviewer remarked that many OEM and Tier 1 suppliers are involved with the ACC and the tech transfer is quite aggressive with plant trials and testing. A third reviewer said that the OEMs GM and Ford are listed by subprojects. The collaborators for the Focal Project 4 are Multimatic, Continental Structural Plastics (CSP), Century Tool and Gage, ORNL, University of Massachusetts-Lowell, IBIS , Camanoe, Composite Products, Inc; Altair Engineering, Chelexa Design, RCO Engineering, and MGA Research. This reviewer remarked that the collaborators for the Carbon Fiber SMC tasks are Continental Structural Plastics (a Tier One supplier), Zoltek (carbon fiber manufacturer), and Huntsman (epoxy resin system).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

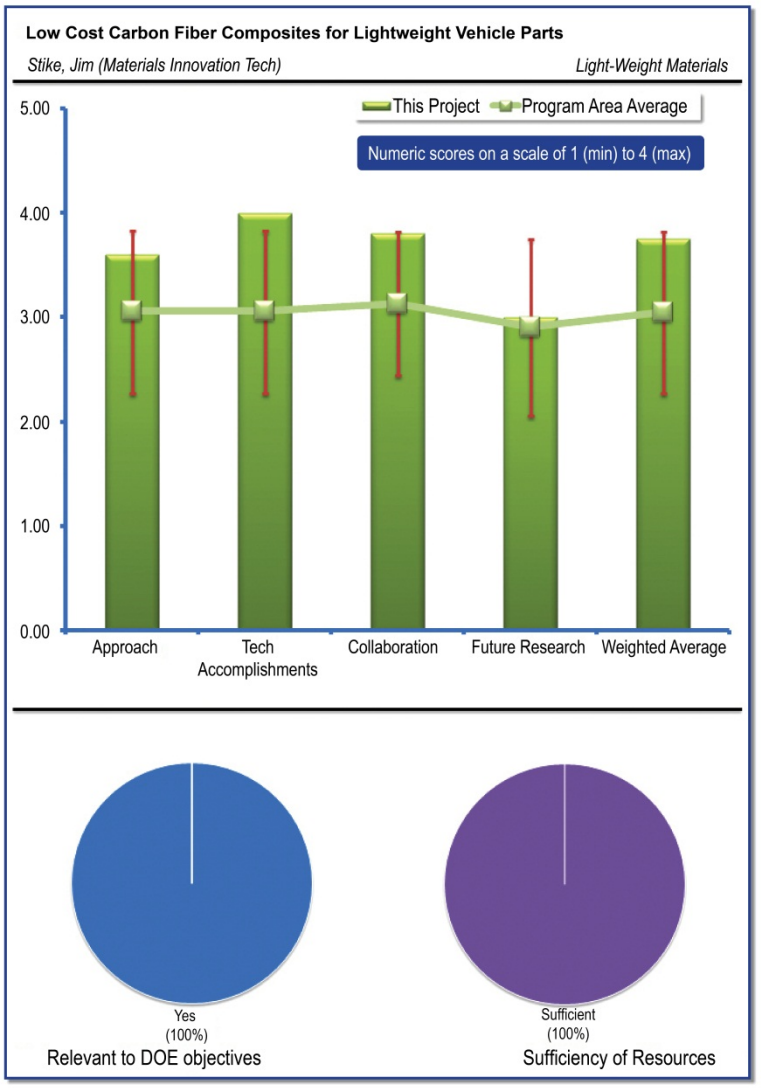
The first reviewer remarked that future efforts for Carbon Fiber SMC will be: to continue to refine understanding of critical compounding variables, such as compaction pressure, resin viscosity, and resin/fiber ratios; using lower cost carbon fibers, evaluate low cost methods to de-bundle the carbon fibers, such as bundle spreading, air blasts, de-tensioning, and an alternative chopper system; to study additives and resin modifications to enhance the surface appearance of the molded material; and to mold developmental parts for potential OEM applications. Focal Area 4 future efforts will be: molded underbodies will be assembled and tested in static and dynamic modes, with the results compared to the analysis; develop a realistic automation scenario for efficient high volume preform preparation; complete comparison of test results and analysis of the composite seat; and develop and carry-out work

plan for additional testing and verification as needed for automotive integration. A second reviewer noted that all four projects are planned to be completed this FY or shortly after that. While the BLR is complete, DLFT is expected to finish end of this year. The third reviewer said that the case was not clearly made whether this needs to be continued. This reviewer believes that it should be pushed further.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that this effort should be expanded for the industry to start producing such improved vehicles.

Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts: Stike, Jim (Materials Innovation Tech) – lm047



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt the project was relevant and stated that this project is well aligned with the DOE goal of reducing petroleum dependence as it investigates the opportunities of carbon fiber composite parts for lightweighting of vehicles. The second reviewer offered that the use of CF in both thermosets and thermoplastic applications offers more opportunities to lightweight the vehicle and Materials Innovations is developing the right next-generation process to enable more, wider application of CF plastics. A third reviewer concurred, stating that it is necessary to prove the capability of a material by conducting a demonstration project; the cost competitiveness of parts manufacturing is an important enabler; this project is aimed at delivering answers to these questions. The fourth reviewer added that the application of carbon fiber components is key to achieving cost reduction goals post-2020. The final reviewer suggested that the three-dimensional engineered preform (3-DEP) technology is a great method to produce net shape preform using virgin or reclaimed carbon fibers.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers felt the approach was sound. One reviewer said that the project is a pilot scale demonstration project, and it is trying to build a large industrial size equipment for trials. The technology is being proven with small size components and seems feasible. A second reviewer felt that it was a very good approach, probably due to commercial opportunities; however, barriers and limitations were not disclosed. This reviewer also recommended a FOA for a larger focused program with clear objectives and deliverables over a 3-5 year period. A third reviewer stated that the 3-DEP attacks the main barrier of net shape production of preforms. The robustness and dimensional stability of the 3-DEP process is a key element for high volume parts. Using the slurry molding process delivers the pre-forms accurately. A final reviewer said excellent progress to date; the project is well on the way to demonstrating low volume applications to prove the process out.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All reviewers stated that there was very good progress relative to the objectives. One reviewer applauded the great progress on overcoming the barriers and challenges. Good progress on the design and initial forms for the four target parts. The roll goods efforts appear to be ahead of schedule and a success. Congratulations on the Innovation Award. The second reviewer added that the project

has proven the process and the properties achieved are comparable to other processes; even though high quality surface finish is not guaranteed, the process has potential for weight saving; also use of recycled fibers in the process will increase the environmental benefits. however, relying on recycled fibers alone will not be advisable as not much source is available for obtaining recycled carbon fibers. This reviewer recommended that the cost analysis needs to be done for new fibers as well. The third reviewer affirmed stating significant effort has been expended designing and fabricating equipment, which is a significant technical accomplishment, but limited material characterization. Possibly, technical accomplishments reflect personnel technical capabilities. A fourth reviewer emphasized success with the due process approach, i.e., developing CF materials using both thermsets and thermoplastic processes.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Opinions on collaborations were very positive, with one concern about differing industry requirements possibly driving diverging objectives. One reviewer applauded the excellent involvement of others, potentially to a fault. Aerospace and automotive have diverging property and cost needs/objectives. Recommend separation of projects to address specific industrial application/needs. A second reviewer asserted good collaboration with the key suppliers for automotive parts. Excellent ties to the supply base for resins, molders, and tier one suppliers, and the success with international automotive components (IAC) is impressive. Good work with the planned CFD efforts. A third reviewer commented that many fiber suppliers and manufacturers are involved in the project along with OEMs, and the final reviewer remarked demonstrated collaboration with government labs, OEM's and suppliers.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer recommended the highest priority be to align the needs for three different processing approaches for making parts. Having the hardware available for investigating the processing and dimensional stability of large runs of parts should give the cost and performance data that industry needs for commercial decisions. The second reviewer offered that the duration of funding limits the opportunity for future research proposals and recommended a large FOA focused on development and commercial demonstration. A third reviewer recommended that various thermoplastics should be considered only along with the right-sizing compatibility with the selected thermoplastics. Otherwise the composite will fail in durability and cause a setback in this field. A fourth reviewer stated that it is a scale-up for production so more private investment is needed compared to government funding. The government funding has proven the technology and it is necessary for the industrial partners support the development further. The final reviewer commented that the project had good plans for the future to develop the process… press on.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer felt that additional human and financial resources could result in focused application of technology. A second reviewer recommended that the project should be additionally funded to investigate the multiple processes so that the robustness, dimensional stability, and mechanical performance can all be evaluated.

7. Materials Technologies: Propulsion Materials

Advanced materials, including metals, polymers, composites, ceramics, and intermetallic compounds, play an important role in improving the efficiency of transportation engines and vehicles. Improvements in engine efficiency and vehicle weight reduction are among the most effective ways to increase vehicle fuel economy and reduce exhaust emissions. The development of propulsion materials is an enabling technology that helps reduce the weight and improve the efficiency, durability, and performance of advanced internal combustion, diesel, hybrid, and battery electric vehicles. The advanced materials research conducted under the direction of the U.S. Department of Energy and the Vehicle Technologies Program will help ensure the nation's transportation energy and environmental future by making affordable full-function cars and trucks that use less oil and produce fewer harmful emissions.

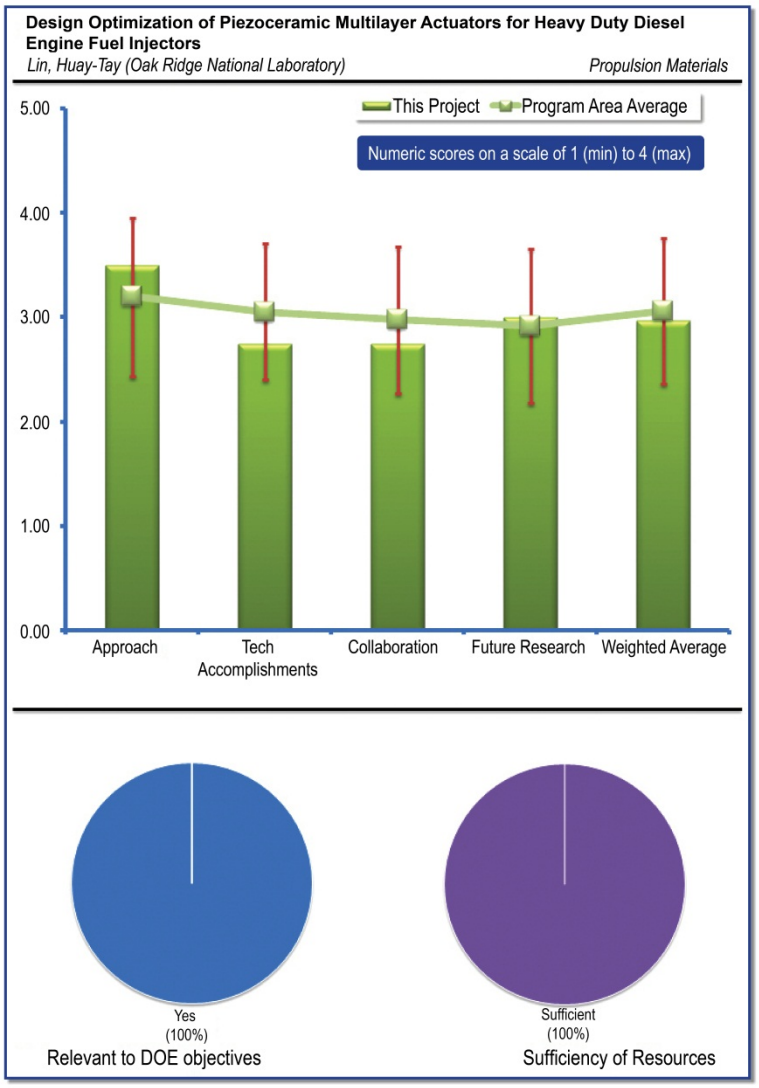
In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Design Optimization of Piezoceramic Multilayer Actuators for Heavy Duty Diesel Engine Fuel Injectors	Lin, Huay-Tay (Oak Ridge National Laboratory)	7-3	3.50	2.75	2.75	3.00	2.97
Fatigue Enhancements by Shock Peening	Lavender, Curt (Pacific Northwest National Laboratory)	7-5	3.75	3.75	3.25	3.25	3.63
Fuel Injector Holes	Fenske, George (Argonne National Laboratory)	7-7	3.50	3.50	3.25	3.00	3.41
Tailored Materials for Advanced CIDI Engines	Grant, Glenn (Pacific Northwest National Laboratory)	7-9	3.50	3.50	3.25	2.75	3.38
NOx Sensor Development	Glass, Robert (Lawrence Livermore National Laboratory)	7-11	3.33	3.00	3.00	3.33	3.13
Low Cost Titanium - Propulsion Applications	Lavender, Curt (Pacific Northwest National Laboratory)	7-14	2.33	2.00	2.33	3.00	2.25
Friction and Wear Enhancement of Titanium Alloy Engine Components	Blau, Peter (Oak Ridge National Laboratory)	7-16	3.25	3.25	3.25	3.25	3.25
Erosion of Radiator Materials by Nanofluids	*Routbort, Jules (Argonne National Laboratory)*	*7-18*	*3.25*	*3.00*	*3.50*	*3.25*	*3.16*
Materials Issues Associated with EGR Systems	Lance, Michael (Oak Ridge National Laboratory)	7-20	2.67	2.67	4.00	3.33	2.92
Durability of Diesel Engine Particulate Filters	Watkins, Thomas (Oak Ridge National Laboratory)	7-22	3.33	3.00	2.67	2.33	2.96
Catalysts via First Principles	Narula, Chaitanya K. (Oak Ridge National Laboratory)	7-24	3.00	3.33	2.67	2.33	3.04
Thermoelectric Mechanical Reliability	Wereszczak, Andrew (Oak Ridge National Laboratory)	7-26	2.50	2.75	3.25	2.75	2.75
Thermoelectrics Theory and Structure	Singh, David J. (Oak Ridge National Laboratory)	7-28	3.33	3.67	3.00	2.67	3.38
Proactive Strategies for Designing Thermoelectric Materials for Power Generation	Hendricks, Terry (Pacific Northwest National Laboratory)	7-30	3.33	3.67	3.33	3.33	3.50

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Materials for HCCI Engines	*Muralidharan, Govindarajan (Oak Ridge National Laboratory)*	*7-32*	*2.33*	*2.67*	*2.33*	*2.00*	*2.46*
Hydrogen Materials Compatibility for the H-ICE	*Pitman, Stan (Pacific Northwest National Laboratory)*	*7-34*	*3.25*	*3.00*	*2.75*	*3.00*	*3.03*
Materials-Enabled High-Efficiency Diesel Engines	*Kass, Mike (Oak Ridge National Laboratory)*	*7-36*	*2.67*	*2.33*	*3.00*	*2.33*	*2.50*
Materials for High Pressure Fuel Injection Systems	*Blau, Peter (Oak Ridge National Laboratory)*	*7-38*	*3.33*	*3.67*	*3.33*	*3.33*	*3.50*
Materials for Advanced Engine Valve Train	*Maziasz, Phil (Oak Ridge National Laboratory)*	*7-40*	*3.00*	*3.00*	*3.33*	*3.33*	*3.08*
Compact Potentiometric NOx Sensor	*Singh, Dileep (Argonne National Laboratory)*	*7-42*	*3.25*	*3.00*	*2.50*	*3.00*	*3.00*
NDE DEVELOPMENT FOR ACERT ENGINE COMPONENTS	*Sun, Jiangang (Oak Ridge National Laboratory)*	*7-44*	*3.25*	*3.50*	*3.00*	*2.75*	*3.28*
Ultra-Fast Chemical Conversion Surfaces	*Erdemir, Ali (Argonne National Laboratory)*	*7-46*	*4.00*	*4.00*	*3.33*	*3.33*	*3.83*
Catalyst Characterization	*Watkins, Thomas (Oak Ridge National Laboratory)*	*7-48*	*2.75*	*2.25*	*2.75*	*2.50*	*2.47*
Ultra-High Resolution Electron Microscopy for Catalyst Characterization	*Allard, Larry (Oak Ridge National Laboratory)*	*7-50*	*3.50*	*3.25*	*3.00*	*3.00*	*3.25*
Low-Friction Hard Coatings	*Erdemir, Ali (Argonne National Laboratory)*	*7-52*	*3.25*	*3.50*	*3.25*	*3.25*	*3.38*
Residual Stress Measurements in Thin Coatings	*Singh, Dileep (Argonne National Laboratory)*	*7-54*	*3.00*	*2.75*	*2.25*	*2.75*	*2.75*
Durability of ACERT Engine Components	*Lin, Hua-Tay (Oak Ridge National Laboratory)*	*7-56*	*2.50*	*2.50*	*3.00*	*2.25*	*2.53*
Life Cycle Modeling of Propulsion Materials	*Das, Sujit (Oak Ridge National Laboratory)*	*7-58*	*2.60*	*3.00*	*3.20*	*2.60*	*2.88*
Non-Rare Earth magnetic materials	Mcguire, Michael (Oak Ridge National Laboratory)	7-60	3.50	3.00	2.50	3.00	3.06
Low-Cost Direct Bonded Aluminum (DBA) Substrates	*Lin, Hua-Tay (Oak Ridge National Laboratory)*	*7-62*	*3.00*	*2.67*	*2.67*	*3.00*	*2.79*
Improved Organics for Power Electronics and Electric Motors	*Wereszczak, Andy (Oak Ridge National Laboratory)*	*7-64*	*3.67*	*3.00*	*3.00*	*3.33*	*3.21*
Materials for Advanced Turbocharger Designs	Maziasz, Phil (Oak Ridge National Laboratory)	7-66	3.33	3.00	3.33	3.00	3.13
Engine Materials Compatibility with Alternate Fuels	*Pawel, Steve (Oak Ridge National Laboratory)*	*7-68*	*3.33*	*3.00*	*3.33*	*3.00*	*3.13*
Biofuels Impact on DPF Durability	*Lance, Michael (Oak Ridge National Laboratory)*	*7-70*	*4.00*	*3.67*	*2.67*	*3.33*	*3.58*
Electrically-Assisted Diesel Particulate Filter Regeneration	*Lance, Michael (Oak Ridge National Laboratory)*	*7-72*	*3.67*	*3.00*	*3.00*	*2.67*	*3.13*
Assessment of Nanofluids for HEV Cooling Applications	*Routbort, Jules (Argonne National Laboratory)*	*7-74*	*3.33*	*2.33*	*2.00*	*2.67*	*2.58*
Overall Average			3.20	3.05	2.97	2.92	3.06

Note: Italics denote poster presentations.

Design Optimization of Piezoceramic Multilayer Actuators for Heavy Duty Diesel Engine Fuel Injectors: Lin, Huay-Tay (Oak Ridge National Laboratory) - pm001



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the effort is designed to assist Cummins and other manufacturers to develop advanced diesel injection systems. Success in this effort could significantly impact fuel economy. Precise timing and control directly impact injection timing and control. A second reviewer thought that fuel injectors controlled by piezoceramic stacks are instrumental in reaching improved fuel efficiency; as such this is an enabling technology that supports the DOE objective. A third commentator expects piezo injector technology to be required for combustion engines, which will be around for the next 10-20 years. To achieve targeted improvements in thermal efficiency, internal combustion engines will need materials which can achieve higher peak cylinder pressure, fuel injection pressure, survive multiple fuel formulations, and which are well defined and ready for design use. The fourth reviewer thought that the project is questionable, appearing to be a basic research effort with undefined user potential for commercial applications. The project also uses exotic manufacturing and testing processes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter provided description of the technology and the research. The injector employs a lead zirconate titanate film (PZT) actuation system as a sort of on-off valve for fuel injection. The PZT element is the central component of the injector. Its operation under relevant conditions is important to characterize, and this work is concerned with this problem. The research includes efforts to examine performance under high temperature through fatigue test and mechanical strength. Accelerated test methods are being developed to enable rapid qualification of piezo-actuators. Mechanical data on PZT actuators, testing and mechanical strength experiments, and the effects of dielectric breakdown are being studied. The second two commentators liked the approach to performing the work, the first saying that it is a clear and no nonsense approach to develop materials in support of advanced fuel injection system with pressures > 2800 bar. The other reviewer thought the chosen approach is straightforward for fatigue testing, but that the mechanical loading conditions during testing are rather different from the conditions found in the actual injector. A FEM analysis should be performed to create an insight in the differences in loading conditions between practice and test rig. The final reviewer couldn't disagree with the overall technical work. The science seems sound. However, the relevancy to DOE objectives and potential for commercial applications remained unclear. The 2010 technical approach suggested a fuel injector; however, the 2011 approach suggested a testing regime for a PZT stack. There was no indication of any direct correlation between the two research years.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One of four panelists found that electric, mechanical, and thermal responses of PZT can now be tested under real life conditions with varying electric loading. Significant data supplied to support work in developing standard tests and some good candidates. However, the panelist thought that it would be good to have related the testing back to the 2800 bar goal. Cummins or one of the other partners should be able to provide this link. According to a second panelist, the project shows new results, primarily in the test procedure. However the list of future activities is approximately the same as during the 2010 evaluation. Missing is a comment on the progress towards an accelerated test procedure. This was mentioned as future work during the previous evaluation. A third panelist found that a range of testing was carried out, including developing an "electronic liquid bath", determining the effect of electric field and test procedures for processing data (to standardize it). A lot of work seems to have been done over the past year. However, the rationale was a bit obscure. A suite of tests and data were reported. The effort does seem worthwhile but the PI could have done a better job in framing the motivation for the approach taken. No doubt, the PIs have a good understanding of what is needed to achieve success. The communication of that understanding was not evident from what was presented. In the main, it seemed like a lot of testing but little thread to tie it together. Things like "piezoelectric coefficient", "dielectric coefficient" were mentioned. It was not evident why it was important to obtain this information. The final reviewer sees no indication of any potential commercial application. There appears to be no direct correlation to overall improvement in fuel economy, no fuel efficiency data. The research project appears to change the fuel injector material. No indication was given of how this project will improve the fuel injector material, or of how this will be manufactured, or how it will be tested, using what test equipment, and to what quality standard.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers said that the collaboration with Cummins and the suppliers of the material, Kinetic Ceramics, Inc., EPCOS, is very good. As such, there is a direct tie with industry. One evaluator said that while the PI and his industrial partners have evidently developed a plan that will benefit their industrial partners, they need to do a better job to show the importance of their data and why it is worth the investment. Another evaluator thought that they should possibly partner with an injector supplier to provide additional funding and design guidance toward fuel economy goal.

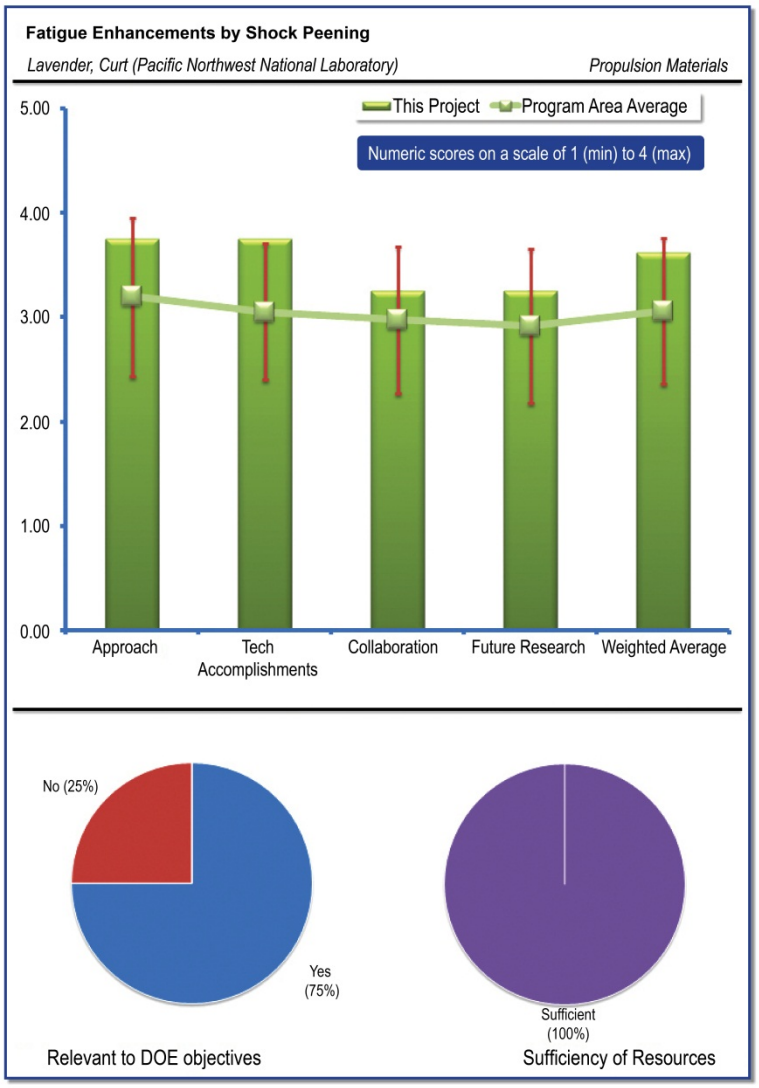
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said that the future work will include developing accelerated testing methods, further study of piezoelectric and mechanical reliability of PZT ceramics, fabrication of additional PZT stack fatigue test frames, etc. To an extent, this follows the trajectory of the past work. The second reviewer thought the proposed future work is clearly needed to reach the final goal; however, limited time is available to finalize all proposed activities. The third reviewer stated that the goal is to commercialize the technology, and that there is need to encourage Cummins to prepare and show injector design optimization activities which come out of this work.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The three commenting reviewers thought that this project is well-funded for the results obtained, that the resources mentioned should be sufficient to finalize the project, and that this effort, being supported at 300K/yr, seems OK though no doubt overhead takes a lot of this.

Fatigue Enhancements by Shock Peening: Lavender, Curt (Pacific Northwest National Laboratory) – pm002



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer wrote that this project concerns the effect of waterjet shock peening on fatigue of materials. The objective is to improve engine efficiency by increasing injection pressures and durability of reciprocating parts. A second reviewer stated that it deals with technology to improve engine efficiency with turbo machinery. A third reviewer sees this project evaluating potential technologies to increase the durability and/or strength of traditional engineering materials. This will allow for higher pressures resulting in improved fuel efficiencies. The fourth reviewer thought that this project is questionable and not indicating fuel economy increase. It appears to be a durability project to enhance service life of a specific engine part.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter believed that this project's technical approach is reasonable. It does include a large suite of testing and measurement, and a component to improve the cost-effectiveness of the laser shock peening (LSP)/water jet peening (WJP) processes. The approach takes an established material and attempts to improve its fatigue performance by surface treatment, and to compare the results with traditional materials. A system evaluation of water jet peening and demonstration of increased design stress and component demonstration are performed. The materials include steel and aluminum. The second commenter thought this project is very well planned and executed. Results based data with good datum, clear benefits, and identified target application of technology to begin use near term. The third reviewer believed that the approach is well suited to characterize the fatigue performance of surface treated materials. The characterization of relevant processing parameters is well defined. The third commenter also suggests that the ground process should be described in more detail since this is a parameter that can cause variation in fatigue performance. The last commenter has no issues with the technical approach. The project appears to be focused primarily on enhancing service life of a specific part, but gave no indication of any overall fuel economy improvements.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first evaluator stated the status of the project, where the PIs have developed fatigue life laser shock peening protocols and showed 12% increase in high cycle fatigue and 50% increase in rolling contact fatigue. The PIs focused on A354 aluminum alloy for the WJP studies and showed significant improvement in fatigue performance. Nice results were shown on the effect of WJP on stress amplitude. The work progressed to translation of the tool and processing parameter development. They have also shown good progress

to develop a more complete understanding of the effects of surface treatment on material performance. The second evaluator sees that water surface treatment has clearly positive impact on first target application, and knowledge of material processing and characteristics will enable use of aluminum by others for other applications. The third evaluator said that the chosen surface treatment shows a significant improvement in fatigue strength, especially in case of WJP. This was only possible through well controlled production of specimens. This provides insight in future process specification for future components to be treated by this process. The final evaluator believes that although the accomplishments are noteworthy, the overall goal is unclear - as no final choice of material was indicated. If the project goal was to select a peening or other technology, then the project suggests a lighter weight material could be selected while maintaining or enhancing the service life of the specific engine part. No indication of a lighter weight material selection process. The presentation included no indication of any manufacturing change plan, no indication of any service life projections, and no indication of any quality control standards during manufacturing of end product.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All of the observers agreed that there was no issue with collaboration or coordination with Cummins, the South Dakota School of Mines, or equipment suppliers. One reviewer suggested that the PIs should further explore deployment of their concept for full scale evaluation with Cummins. Another reviewer said that a wider spread of the technology amongst Tier 1 and OEM's will have an improved effect on overall fuel efficiency would be an improvement.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

All of the reviewers believed that the project should be able to finish the final phase of its work before funding terminates at the end of the year. One reviewer goes on to specify that the future work will include continuing with testing of components treated by the WJP process, development of consolidated and defect free welds of friction stir processing (FSP) cast iron with same processing parameters, investigation of potential tool designs to overcome graphite alignment observed in FSP of cast iron, and completing a final report.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One commenter said that with DOE funding and partners this project is sufficiently funded. Another said that this year the funding was at the level of 150K, which is a reasonable cost. The 50% Cummins cost share is very good as well. The third simply stated that the funding should be allowed to terminate on schedule.

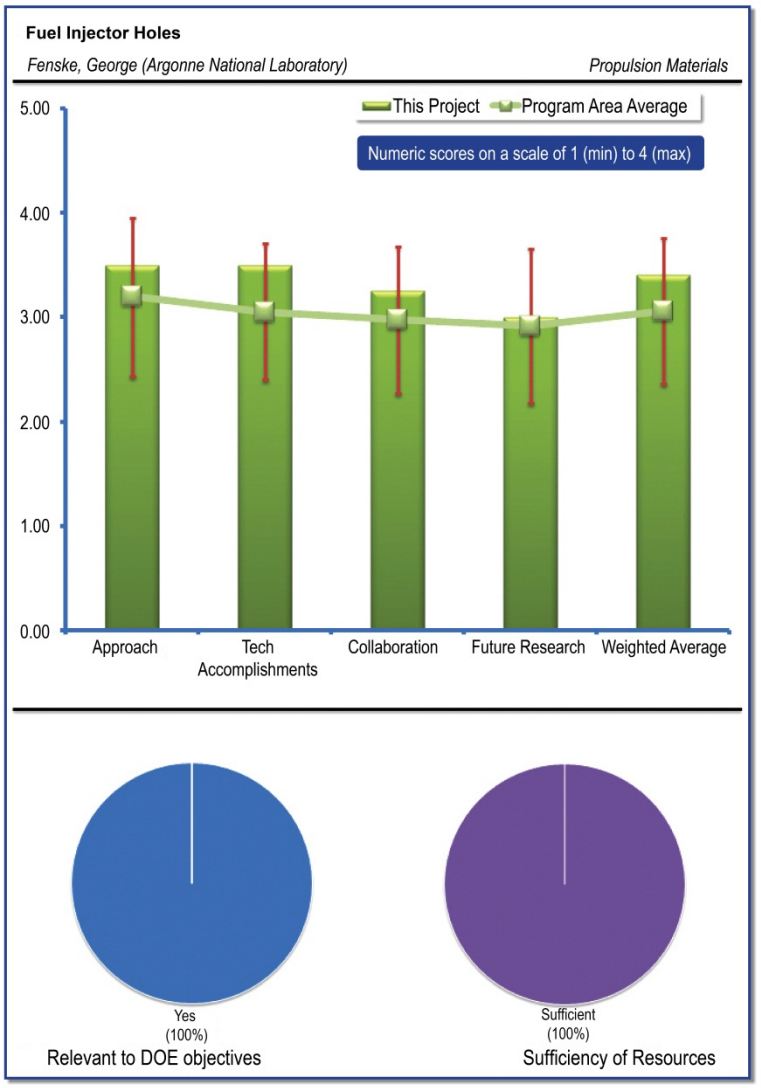
Fuel Injector Holes: Fenske, George (Argonne National Laboratory) – pm003

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers commented that this project supports DOE's objectives. The first reviewer stated that the ultimate goal is to reduce in-cylinder emissions and to improve atomization, and that both are important for efficient operation of engines. The second reviewer saw the reduction of in-cylinder formation of particulates as primarily affecting emissions, and the improved combustion and mitigation of after-treatment fuel consumption as primarily affecting efficiency. The third reviewer said that this project results in more efficient combustion of diesel fuel due to improved atomization and flow into the combustion chamber. In the third reviewer's opinion the efficiency gains are a secondary benefit, with the reduction in particulate formation being the primary benefit. Nevertheless, the benefits are a win-win: improved emissions, reduction in cost for after treatment systems and improved fuel economy. The reviewer believed that the design improvements being realized by this project are very necessary. The final reviewer thought that this project addresses a technology that is enabling an improved combustion, which will lead to improved fuel efficiency



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commenter said that it is a novel idea to take traditional electro-motive diesel (EMD) injector holes and coat them with electroless Ni to reduce hole size to less than 50 microns. Another reviewer said that they have done a pretty good job describing the issues and addressing the concerns. The approach is practical and straightforward, and they do a good job proving the benefits of their approach and results. The video clips they used in the presentation were quite impressive, showing clearly how the coatings were uniform and sound. One reviewer commented that the PIs began their work with identifying potential micro-orifice fabrication techniques and identified an electroless nickel (EN) deposition process for coating. The main objective has been to develop a methodology to reduce the droplet size in injectors. The approach is to improve injector design. The orifice size is on the order of 50 micrometers. This past year the PIs demonstrated an x-ray absorption imaging technique for nondestructive evaluation of an internal coated orifice, and a method to coat the interior surface of small injector orifices using the EN process. The final reviewer stated that the approach is straightforward, and that during the project new approaches were chosen like the nickel plating in industrial facilities. This could be foreseen and so faster progress would have been possible.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

All panelists had positive impressions of the progress of this project. The first reviewer said that progress has been very good. The major hurdles appear to have been overcome. It appears that future work will have little concern with major obstacles and will focus more on optimizing design. A second reviewer thought that the PIs addressed and resolved some early issues that were found regarding coating adhesion. The solution apparently was found in the precleaning/etching, control of solution chemistry and post-deposition annealing. They also transferred their technology to a commercial industrial plater/coater. Flow visualization studies demonstrated enhanced flow characteristics. Development of multi-size orifices was also pursued. A third reviewer thought that the project demonstrated an improved atomization by smaller orifices. It is likely that an improved emission is realized opening up the possibility of improved fuel efficiency. The multi orifice diameter option could also open up further fuel efficiency improvement by a reduction in injection pressure. Higher pressures generally result in an overall improved fuel efficiency but there also an increase in parasitic losses to create the high pressure. The final panelist concluded that the project demonstrated that it was feasible to coat interior surfaces of small injector orifices using EN, addressed and resolved early issues related to coating adhesion, transferred concept/technology to industrial plater/coater, demonstrated enhanced flow characteristics in single-size orifices (100, 75, and 50 µm) at 3000 bar, demonstrated x-ray absorption imaging technique for non-destructive analysis (NDA) of internal coated orifice surfaces, and evaluated American Society for Testing and Materials (ASTM) Method G32-09 to determine cavitation erosion performance of plated nozzles.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said that the project does not appear to have a significant amount of industry collaboration; however, it did not appear to be necessary given the scope of the project to date. Future collaboration will be necessary, since it precludes going into production. Another commenter said that the success of the project is demonstrated by an increasing number of participants. A third reviewer stated that the primary collaborator seems to be the EPA. Sandia also has capabilities for these sorts of visualizations. Beyond the EPA, it was somewhat vague on precisely who the collaborators were, for example the OEMs. The linkage to industry should be developed in their continuing work. The final reviewer thought that the project had good collaboration efforts with Imagineering Finishing Technologies, fuel system OEMs, an Engine OEM, small business (for integration of EN process into nozzle production line), and finally the EPA.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Two commenters stated that the proposed future work involves near term and far term efforts. Two reviewers both described that for the near term, the EPA will do further flow visualization tests, second generation multi-size orifices will be developed for an OEM, cavitation erosion studies will be carried out, and x-ray imaging for in-situ characterization will be pursued. Longer term will concern engine emission tests with an OEM, integration of the nozzle into an engine, and combustion studies. A reviewer commented that the PI should endeavor to get his technology integrated into an engine to evaluate performance. This task was listed as longer term but given the length of the project it should be pushed up. A second reviewer commented that the mentioned activities are in line with the project approach. However, a more systematic approach should also be incorporated to evaluate the potential of injection pressure reduction. A third reviewer said that several details are being addressed with the proposed future work. Collaboration with OEMs will be needed to push toward commercialization.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One commenter advised that the investment so far has been 1.6M, and in FY 10 it has been 400K. This seemed a bit high, but the payoff could be high if it can be quantitatively demonstrated that the nozzle treatment methods lead to a concrete improvement of emissions as envisioned. A second reviewer thought that the resources appear to be appropriate for this project. The third commenter said the resources look sufficient. This reviewer also noted that the end date of the project has shifted 2 years in comparison to the 2010 evaluation.

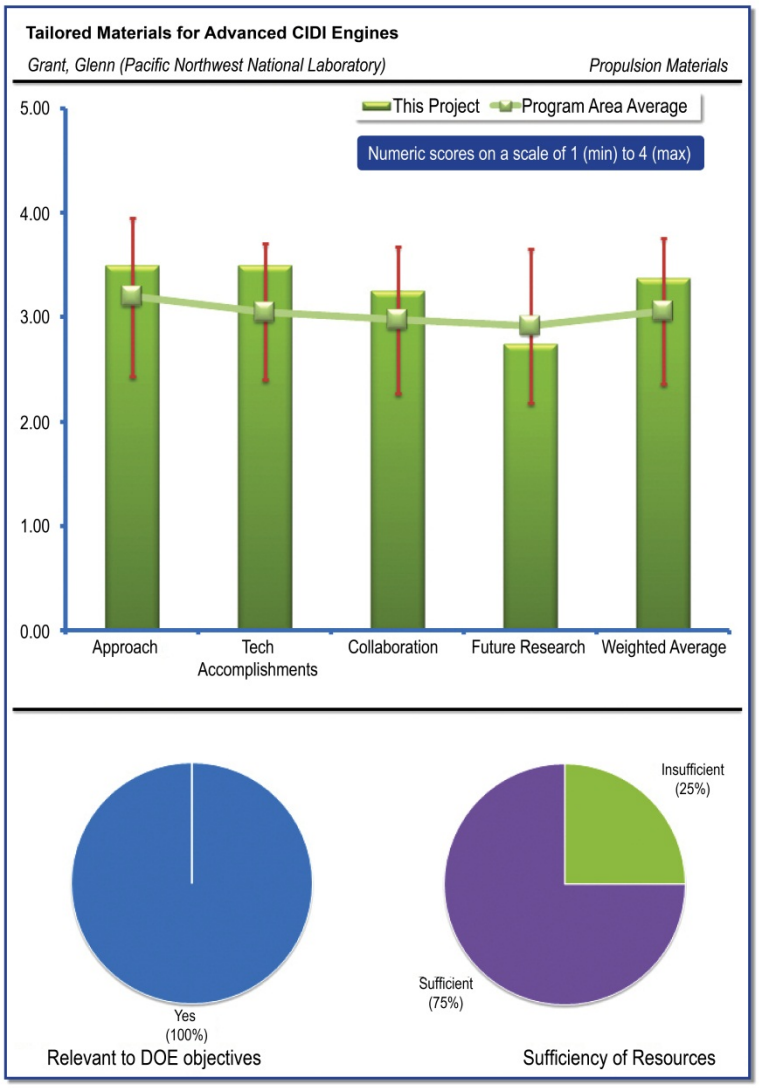
Tailored Materials for Advanced CIDI Engines: Grant, Glenn (Pacific Northwest National Laboratory) – pm004

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers agreed that this project meets DOE objectives. The first reviewer stated that this process concerns surface modification technique of conventional materials to achieve higher efficiency performance. Bowl rim fatigue failure is a problem that this project addresses. Durability and cracks often occur under high pressure operation. A second reviewer thought this project was in line with goals because it aims to increase the thermal efficiency, mechanical efficiency, and durability of engine materials through the development of a new surface engineering technology. It also aims to achieve high strength materials and lighter weight materials, and reduce power train cost. A third commenter said that this project does support DOE objectives, with several other benefits that indirectly support DOE objectives (e.g., durability, cost). The final commenter affirmed that the project improves the surface of materials leading to higher allowable loads resulting in reduced fuel consumption.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that the approach appeared to be well laid out, with well-defined benefits. Significant progress had been made, demonstrating their ability to overcome the major obstacles. A second reviewer held that the technical barriers were well addressed for the Aluminum friction stir process. For the steel related friction stir welding the approach was a standard one, unfortunately there will be a need for a novel approach; otherwise the outcome will be disappointing. Perhaps friction stir welding (FSW) and steel is not a good combination. A third reviewer commented that the project is based on a very novel idea to improve base aluminum piston without going to steel. The project is primarily investigating FSP, a new technology that can produce functionally graded surfaces with unique and tailored properties that will allow propulsion materials to withstand higher temperatures and pressures without losing appreciable strength, hot hardness, or wear resistance, and exhibit improved resistance to thermal fatigue. The final reviewer stated that over the past year the PI experimentally applied the FSP for aluminum materials, quantified performance advantages, and developed FSP tools and parameters to allow surface modification of steels. Friction Stir processing (a process that modifies the microstructure of a material) is a new approach to improve durability. This project over the past year concerned this process for aluminum, specifically materials used in pistons and heads. The systems investigated included cast hypo-eutectic aluminum with no introduction of any new component materials; FSP of eutectic Cu-Ni aluminum alloys by “stirring in” various

quantities of carbon nanotubes and nanofibers; and FSP of 6061 alloys to develop mixing parameters. Fatigue improvements by a factor of two, along with significant wear resistance were shown. A bowl-rimmed piston was investigated.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

All four commentators agreed that progress has been good, the first commenter relaying that in FY 11, the PIs performed a number of testing studies to improve the microstructural and mechanical properties that most influence thermal fatigue (i.e., CTE, conductivity, and, to a lesser extent, high temperature strength). The PI wanted to find the best methods of stirring in particulate into the aluminum substrate while producing the most homogeneous and highest particulate loading possible. They carried out tests using carbon fiber in place of nanotubes and found that long fibers were fragmented distributed reasonably well. Good bonding was achieved between the aluminum and the carbon fiber fragments with no reaction zones (aluminum carbide) noted. A second commenter thought the FSP process has been demonstrated in this project to significantly improve fatigue performance of current low-cost, engine materials, potentially allowing them to operate under highly aggressive combustion regimes anticipated in the next generation of energy efficient engines, especially combustion regimes that will require higher Peak combustion pressures like HCCI. The second commenter also said that the experimental work on aluminum alloys has shown significant increases in fatigue lifetime and stress-level performance using friction processing alone, and has shown the potential to create mechanically mixed alloys of aluminum and carbon nanotubes or fibers that may provide unique properties to specific areas of engine components. A third commenter believed that the progress on the project has been very good. With this progress, it is important for future work to demonstrate the DOE goal benefits - the engine efficiency benefits are implied, but should be more explicit. The final commenter understood that this project represents a significant step forward in Friction stir welding of Aluminum piston materials. This will allow a wider operating window for this type of pistons. Aluminum pistons have a higher potential in improving the fuel efficiency compared to the steel alternatives seen nowadays in HD applications.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first evaluator confirmed that this project is a CRADA with Caterpillar at 50% cost-sharing, which is good. The first evaluator thought the collaboration with academia (Missouri and Brigham Young University [BYU]) showed a good return on investment with student projects. The second evaluator agreed that collaboration appears to be good, which is important with a project like this. This reviewer also stated that more collaboration may have greater benefits since FSP should have benefits in various components of light vehicle engines as well. Another reviewer stated that the only cooperation mentioned is with Caterpillar. This reviewer thought that a wider consortium involving universities and piston manufacturers would improve the deployment of the results of the project. The final reviewer listed the collaborators as Caterpillar, Missouri University of Science & Technology, BYU, and PNNL.

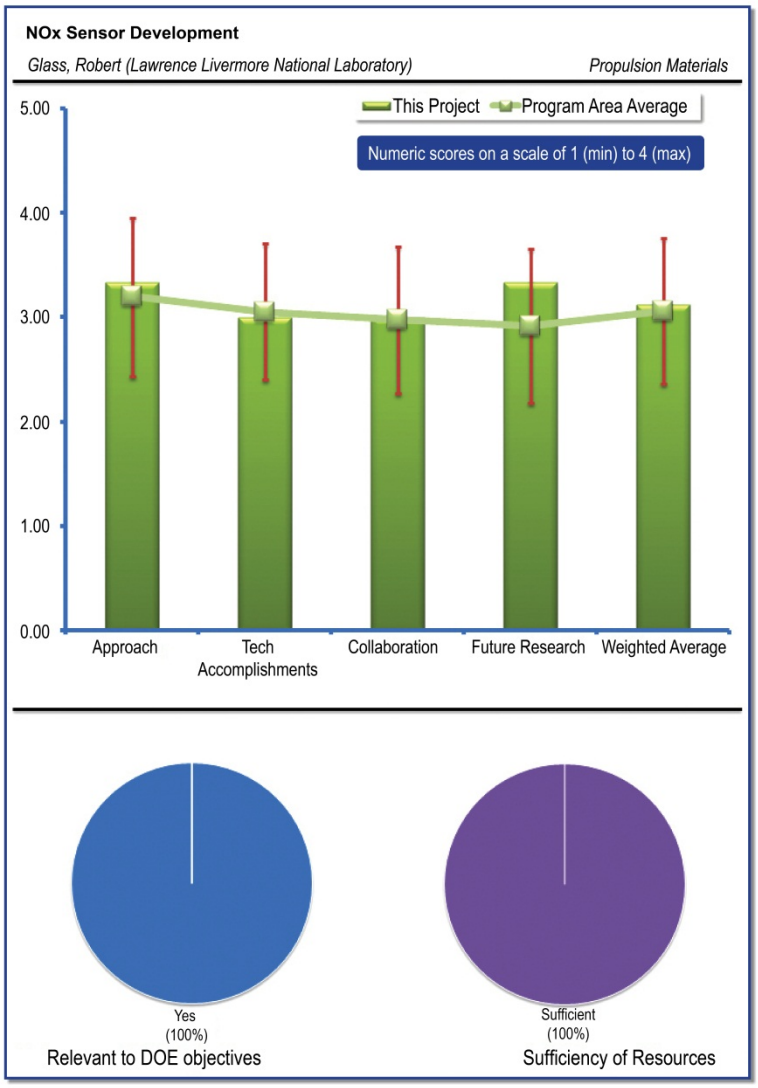
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer commented that the future work will concern reporting and data transfer, which (in the electronic version) was a bit vague. Another reviewer stated that the future work includes project reporting and data transfer to industrial partners, but that the PI may want to conduct thermal fatigue testing of FSP aluminum pistons in the bowl rim areas. A third believed that the future work explained during the oral presentation seemed to be appropriate and beneficial. In this reviewer's opinion this project appeared to be worthwhile and will definitely result in efficiency gains. A fourth reviewer understood that no future research was proposed, which was understandable since the project was already 90% finished.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that resources appear to be sufficient for this project, another reviewer thought that the resources look appropriate for the amount of work to be completed in the remaining time frame, and a third evaluator stated that the funds were used for students and scientists. At 150K the cost seems a bit low. The collaborations with academia were good and represent a good return on the investment.

Nitrogen Oxide (NOx) Sensor Development: Glass, Robert (Lawrence Livermore National Laboratory) – pm005



Reviewer Sample Size

This project had a total of six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers agreed that increased use of diesel will lower oil consumption. The first reviewer stated that a durable, reliable, economical and accurate NOx sensor is essential from an emissions standpoint. This is an enabling project rather than a project that results in direct fuel economy advantages. However, implementation of this technology will contribute to the greater use of efficient, environmentally friendly diesel vehicles. A second panelist believes that the ability to accurately measure NOx is critical to optimizing both combustion strategies and engine architectures for maximizing fuel efficiency while meeting emissions requirements. Important commercial parameters were identified, including reliable operation, known performance over time, and cost. Success with this project will have significant impact. A third reviewer concluded that NOx sensing can be an enabler for emissions control and monitoring. Specifically, it facilitates management of SCR or LNT processes to minimize fuel losses due to regeneration activities. The fourth reviewer affirmed that the project involves in developing a sensor for diesel engines with low cost base, and that diesel will improve energy efficiency and reduce oil consumption. The final commenter concluded that accurate, responsive and sensitive NOx sensors can contribute to the close control of engine emissions and minimize the impact of NOx control on engine fuel efficiency. Their application to diesel engines in particular could help minimize one of the barriers to wider adoption of diesels. As noted in the presentation, if a third of the U.S. light-duty vehicle (LDV) fleet could be converted to diesel engine power, the U.S. transportation petroleum demand could be reduced by as much as 1.5 MMbbl/day. By the same mechanistic reasoning, a 2/3 replacement of LDV SI engines with diesels could reduce petroleum demand by 3 MMbbl/day. It should be borne in mind that other factors, technical and non-technical, probably have as much or more to do with the broad acceptance of diesels in the LDV sector.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer stated that this project is well focused, laying out the barriers and approach clearly. A second reviewer believes that the project, even though had to be restarted after five years of work on other material, has shown great improvements in the past two years. The team is developing a new sensor (with new material, processing and final product) for NOx detection which is showing high promise. The third reviewer affirmed that the project is complex, and that a brief description of the history indicates various roadblocks that were encountered. To the team's credit, a new, clever approach was taken, looking at the alternative current (AC) impedance and phase angle response. The fourth respondent pointed out that the sensor designs discussed have been in play for over 10 years. The novel approach using frequency to identify species is an interesting idea; however, the basic approach is based on the

datum of the sensors impedance. Durability data from O2 sensors (a very similar design) indicate wide changes in sensor impedance "drift" over aging. This information was ignored by the researcher and the impacts have not been considered until the end when in fact this may be a show stopper for the technology. It may be that due to the new concept, the changing impedance of the sensor over time is not a concern, or that advances have been made to address this issue so the variation is limited; however, none of these items were addressed in the research, discussed in the presentation or properly responded to during questions. The mentioning of the "drift issue" in future work "Preliminary solution for drift issues by appropriate materials choice, pre-use aging, experimental protocol, and design" indicates that the researchers were/are aware of this critical issue, but have chosen to take it on tomorrow.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that the accomplishments have been excellent, laying out the various alternatives and their advantages. Rather than choosing just one path, a multi-faceted approach is giving results that can be compared, contrasted and justified. The second reviewer commented that recent progress has been significant relative to earlier years work. The new approach of phase angle response looks very promising. Several technical challenges remain, including response characterization over time. This reviewer agreed with the researchers that a curve fit better than a two slope approximation will easily improve the cross-sensitivity results. A third reviewer relayed that the process to manufacture the sensor for the use is being developed; the prototype production indicates the feasibility of mass production. The fourth panelist considered the gas flow bench data and preliminary dyno data to show good results, however, this type of data has been also available for over 10 years with voltaic Au and other Zirconia based O2/NOx sensors. The novel sensor system achieves some improvements in sensitivity to NO, H20 and O2, and now what is needed as 10 years ago are 1. demonstrated long term performance and durability on an engine across multiple sensors (not done); and 2. demonstrated ability to meet cost targets including a reasonable manufacturing method, (partially complete). These 2 items have been the challenges for O2 sensor based NOx sensors for over a decade and are not significantly addressed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Five commentators all look forward to finding out about future collaboration. A first commenter understood that only one OEM was involved, but negotiations with other Tier 1 suppliers was encouraging; hopefully the technology is transferred to many players to promote the widespread use of the invention. A second reviewer deemed the project's collaboration to be good. Commercialization pathways are being addressed with other companies as well. A third commenter agreed that collaboration with a supplier is necessary for commercialization. The 2011 presentation indicates that several appropriate suppliers are engaged. A fourth reviewer thought that the collaboration with Ford and a "U.S. Part supplier" appeared to be working well. Additional input from other OEMs, Universities or National Labs for design and testing will expedite commercialization. The final reviewer was looking forward to learning more about prospective collaboration with the named and particularly the unnamed "commercialization entities" mentioned in the 2011 presentation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first evaluator concluded that future work appears to be targeted toward implementation. This is what future work should be focused on. The proposed work is truly necessary for implementation. A second evaluator believed that the future planned work makes sense. The significant effort to commercialize appears to be well understood. Plans are in place for refinement of materials used and processing methods, improved bench tests, and engine/vehicle testing. A third reviewer relayed that the commercialization path is identified but the material down-selection is still not completed. A fourth commenter acknowledged that cost was a significant issue raised in the overview. The project needs a path to target cost since it is raised as a major barrier. A fifth reviewer thinks that the future work outlined seems rather vague. More specific information would have helped to understand the specific areas that will be focused on to advance the sensor design. The sixth and final opinion was that the proposed work for 2012 is good; however, two items have been the challenges for NOx sensors for over a decade and are not significantly addressed: demonstrated long term performance and durability on an engine across multiple sensors (not done), and demonstrated ability to meet cost targets (partially complete).

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Three reviewers believed the resources appear to be appropriate, sufficient for development prototyping, or that the project has good support from Ford, DOE, and national lab facilities. One reviewer further stated that suppliers are engaged. The fourth respondent stated that based on the good technical progress to date, it must be concluded that resources are at least sufficient. Every effort should be made to seek the maximum levels of co-funding from prospective commercialization partners (Delphi, Emisense, etc.) as the work progresses, in view of the likelihood of significant cuts in DOE funding availability in the next fiscal year(s).

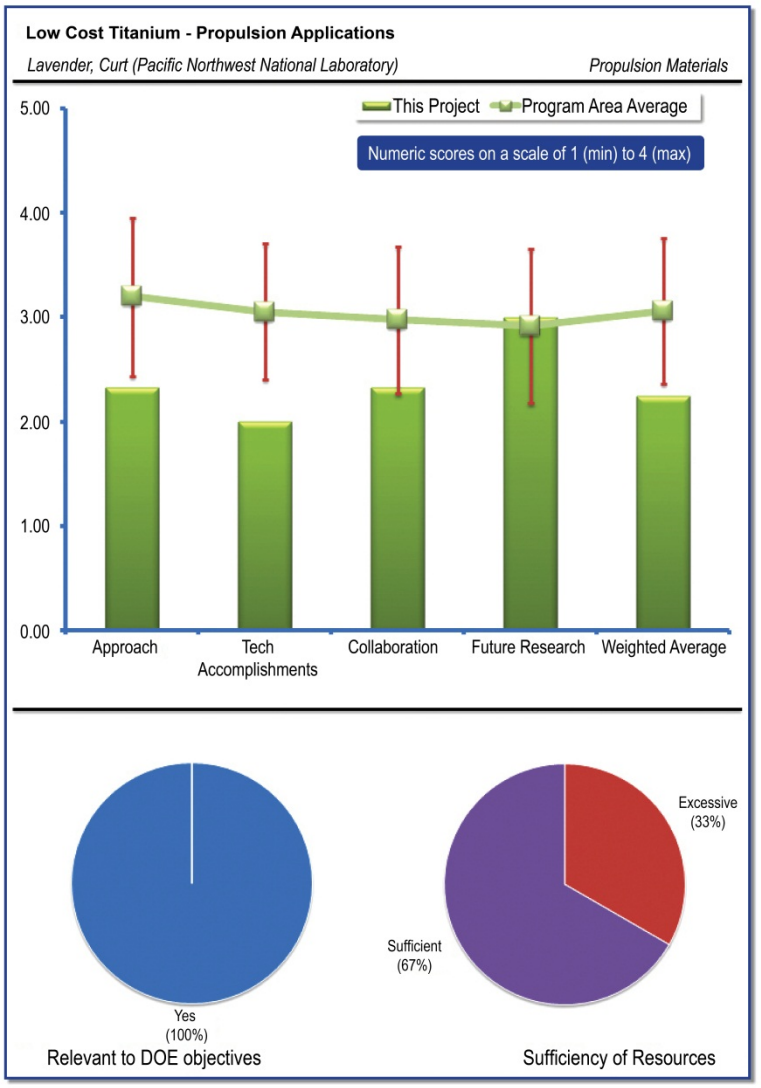
Low Cost Titanium – Propulsion Applications: Lavender, Curt (Pacific Northwest National Laboratory) – pm006

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All three reviewers agreed that this project supports DOE objectives. The first stated that in view of the excellent mechanical properties of titanium and its engineering alloys and especially its very high strength-to-weight ratio, it would seem this project offers the potential to achieve significant vehicle mass reductions, which will clearly enhance fuel efficiency, albeit indirectly. The presentation also mentioned the possibility of directly increasing engine efficiency by exploiting the high-temperature properties of Ti. The second panelist reported that this project supports lightweighting of engines and vehicles, which should reduce fuel consumption. The third reviewer concluded that titanium can be used in two ways: to reduce the weight in structure as well as improve energy efficiency of powertrains. Cost is a barrier to overcome for increased use of Ti. This project is aimed to reduce the cost and increase the use saving fuel consumptions.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had different opinions as to how to overcome the cost barrier for titanium that this project is concerned with. The first reviewer described the project as being aimed primarily at reducing the cost of Ti vehicle parts, as cost is seen as the principal barrier to more widespread use of the metal. This is certainly important, but the reported work seems to be concentrated much more strongly on the technical processing of Ti alloys and the resultant properties. Relatively little information was reported this year on cost reduction and the cost analysis phase appears only to be getting started. This reviewer regards this to be an imbalance of emphasis. Also, as noted in last year's review, it would be reassuring to have the issue of end-of-life recycling of Ti alloys and their separation from the dominant ferrous and aluminum alloys currently used in vehicle/engine construction. If this is not seen as an issue, that should be addressed and stated explicitly. The second reviewer stated that first and most important is the lightweighting impact and expected fuel economy result. Since it is not clear whether the result of the estimate is or not significant, then this work may not be a priority and should stop. The initial study should not be difficult to do and could be as simple as a material substitution assumption for the entire engine. For example: Engine weight with Steel: xxxx#, engine weight if engine mass changed to Titanium tttt #. Savings = , Fuel economy =. The commissioning of a University Study is good to get a more detailed result for rotating vs. non-rotating, but some number should be available. The third reviewer confirmed that the barrier for titanium use is the cost; by using a low cost titanium (but

not necessarily low quality) this project is aimed to reduce that barrier. It involves setting the benchmark for the material by comparing the new product with existing Ti64 alloy data base.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer reported that the properties of conventional alloys produced using the new powder material is completed. The processing of this material has posed some challenges (cracking during drawing) that have been resolved. However, new formulations of alloys need to be undertaken as the requirements for auto industry may be different from aerospace industry. Also some of the alloying elements (Vanadium) may be expensive and difficult to process increasing the cost of the material. The other reviewer responded that it was difficult to see results from work. Major achievements are not related well.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first evaluator responded that this project collaborates with the University of Michigan, and uses ADMA for cost models. The second reviewer claimed that some fourteen vehicle and engine OEMs have made limited production runs of Ti-based parts. In view of this implicit expression of interest, it seems wider collaboration with OEMs should be sought. Cummins is the only OEM now collaborating with the investigators. Broader collaboration could also offer the potential of greater cost sharing with DOE.

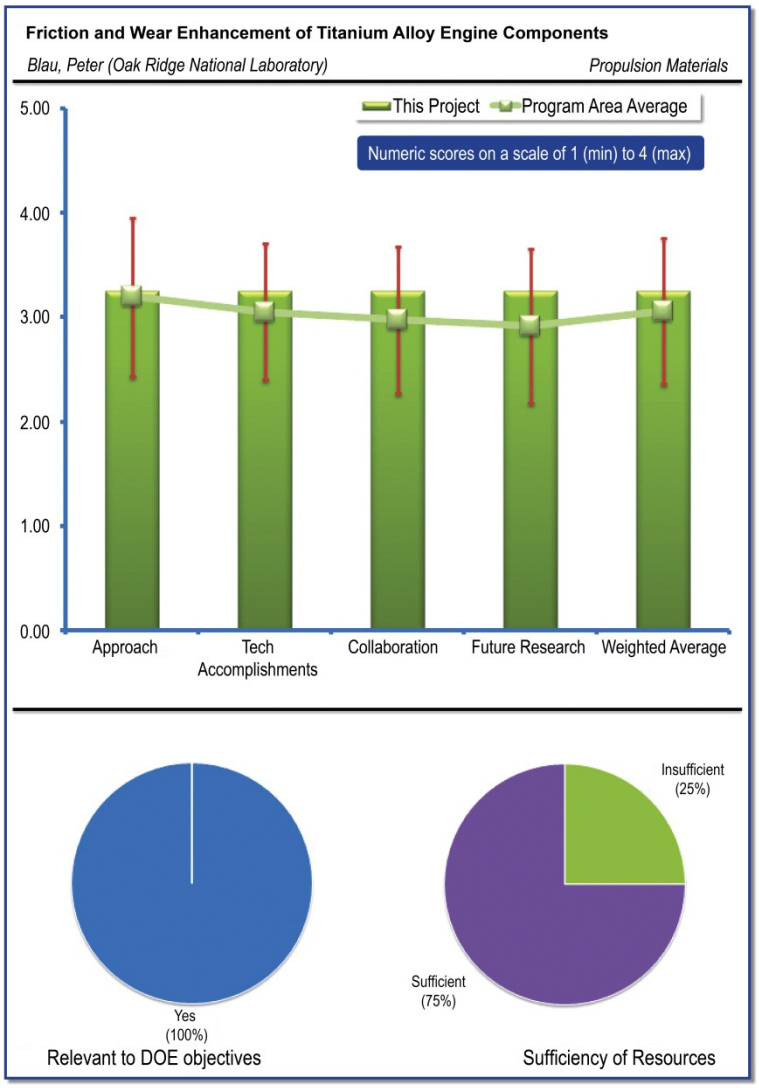
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that as noted above, it seemed that a significant part of proposed future work should have been completed earlier - the cost modeling in particular. The potential of the TiH2 powder approach to Ti alloy production to reduce cost at various production scales should also have been explored before now. Another reviewer concluded that no future vision is presented for the product; the project is expected to be completed with some more data generation but without identifying a product or path forward. A CRAD, as has been done in other areas of the Propulsion Materials (PM) sub-program, would be worthwhile. The third commenter thought the future to be well mapped; however, the steps maybe should be series not parallel. This reviewer provides an example: 1. Estimate weight reduction - fuel savings.2. Estimate cost impacts - practicality.3. Perform engineering work. 4. Refine 1,2 Currently skipped 1, 2.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

A reviewer stated that the project partnered with Cummins and suppliers. Another reviewer commented that in view of the emphasis that has been placed to date on fabrication and processing techniques and characterizing the resulting alloy properties (in lieu of cost analyses), project resources may not be excessive so much as poorly directed.

Friction and Wear Enhancement of Titanium Alloy Engine Components: Blau, Peter (Oak Ridge National Laboratory) – pm007



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All evaluators agreed that use of titanium reduces engine component weight, while enhancing service life. One evaluator said that doing so indirectly supports DOE goals. Another panelist considered this project to be exploring various concepts that will lead to a greater use of titanium alloys in engine components, including for connecting rods, valves, crankshafts, bushings, etc. The focus on Ti is based on its improved resistance, high strength and weight. A third reviewer reasoned that substitution of materials with higher specific strength (strength per unit weight) is a viable path to lightweighting engine components, thereby improving freight efficiency. The use of titanium for a reciprocating engine component such as a connecting rod has the added benefit of reducing inertial forces, which may allow an additional opportunity for reducing mass. The fourth evaluator deemed that for Ti alloys to achieve broad use in engine parts (in particular), and if their advantageous properties are to contribute to mass reduction and the ability to operate at higher temperatures and stress levels, their tribological properties must be at least as good as current materials. This project is aimed at identifying coatings and surface treatments that will enable Ti alloys to meet that standard.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

According to one reviewer, the approach taken in fy11 has been to complete friction and wear studies of coatings and treatments which passed screening tests of 2010; completing construction of a variable load bearing test apparatus; extensively evaluating a suite of materials using bench-scale tests; identifying a commercial diesel engine connecting rod as a candidate for replacement with a surface engineered Ti-based version; and constructing a rotary bearing test system. According to another reviewer, the technical challenges for successfully using titanium for connecting rods in reciprocating engines are several. A primary technical challenge of a titanium part acting as a structural component to transfer loads to the crankshaft has already been met in racing applications using a machine from billet approach. The proposed approach considers HIP or sintering from powder, which holds the promise for reduced cost. Cost is a significant challenge to overcome for widespread adoption in the transportation industry, which this project addresses via process. Tribological challenges at the connecting rod small and big ends as well as wear (fretting) at the big end joint have been identified and are being investigated. One reviewer could not argue with the application technical barriers or the project milestones. This appeared to be a replacement of one material for another. This reviewer suggested a review of how to manufacture the Ti material, quality control standards, and availability of Ti material and suppliers.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One commenter considered the objective to be completing the friction and wear studies of coatings and treatments that passed the screening tests of last year; materials screening (applying ASTM standard G133); wear tests of flat Ti and bearing steel slider measured; building a variable-load bearing test (VLBT) test system; friction and weal tests. These objectives seem to have been met throughout the past year. Another reviewer felt that the researchers described a logical approach, starting with previous literature surveys and developing an understanding of other's progress and issues. The project outline is traditional in that bench testing is the next step given the completion of a variable load test rig over the past year. Down-selection of promising approaches is planned, followed by scaled-up validation tests (presumably in running engines).

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said that the collaborations are reasonable: Cummins, NASA; ANL; Eaton Phygen; and ORNL. The collaborations may be considered more informal (e.g., providing materials, advice, co-authoring of conference papers) than solidified through, for example, CRADAs. The PI has signed a non-disclosure agreement (NDA) with Cummins. Another commenter said that up to this point, collaboration seems to be limited to other government groups within ORNL and the High Temperature Materials Laboratory(HTML). This is appropriate given where the project presently resides but will represent a limitation if one or more industrial partners are not involved or consulted for realistic design considerations and operating conditions (loads, lubrication/tribology). It seems that the project would benefit from more formal industrial collaboration. The respondent was of the impression that this project has gone as far as an NDA, which this reviewer considered to be a start, but more on the informal side compared to a CRADA.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer commented that the PI wants to continue bench scale tests and apply the variable load testing of coatings and treatments, and "confirm" plans for scale up of concept validation in year 3, "if funding permits." Variable load testing of the leading candidates' coatings and treatments would also be pursued. The panelist suggested that the PIs could outfit an engine with a Ti connecting rod now, even before more detailed evaluations are complete, in order to assess performance and to determine if perceived benefits are in fact realized. A second reviewer suggested a review at the end of phase II. Determine if this is better continued by private industry or if there is a direct correlation between DOE goals and private industry needs. A third reviewer commented that the research plan was logical and traditional (a proven approach). One or more external partners are needed to provide real-world engine guidance. Manufacturing and cost considerations can be given further attention down the road following successful identification of candidate approaches. The next phase of research is focusing on friction/wear bench testing. Thus the project would benefit from strong participation of a tribologist. This is particularly true since studies of time-varying lubrication regimes are explicitly planned. A key consideration in the thermal management of the connecting rod bearings is heat conduction from the lubricant film through the bearing material into the connecting rod material. Continued this reviewer, the thermal conductivity of titanium is significantly lower than steel by almost an order of magnitude. The impact will be higher oil film temperatures and lower oil viscosity leading to reduced minimum oil film thicknesses. The fourth reviewer thought that because the presentation suggested funding for Year 3 of this project is tentative, it may be an opportune point at which to hand this project off to industry. Questioned this reviewer, if proposed testing of the 8 candidate surface treatments/coatings does not produce a production-feasible "winner," is there a Plan B?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer concluded that the research needs for this project are clear and can be accelerated with additional resources. While the resources are appropriate for the planned level of work, the scope, pace, and sense of urgency can easily be increased. The second reviewer deemed the cost of $150K seems reasonable. The investment in building the VLBT hardware seems to be worthwhile if it facilitates testing under realistic load-bearing conditions.

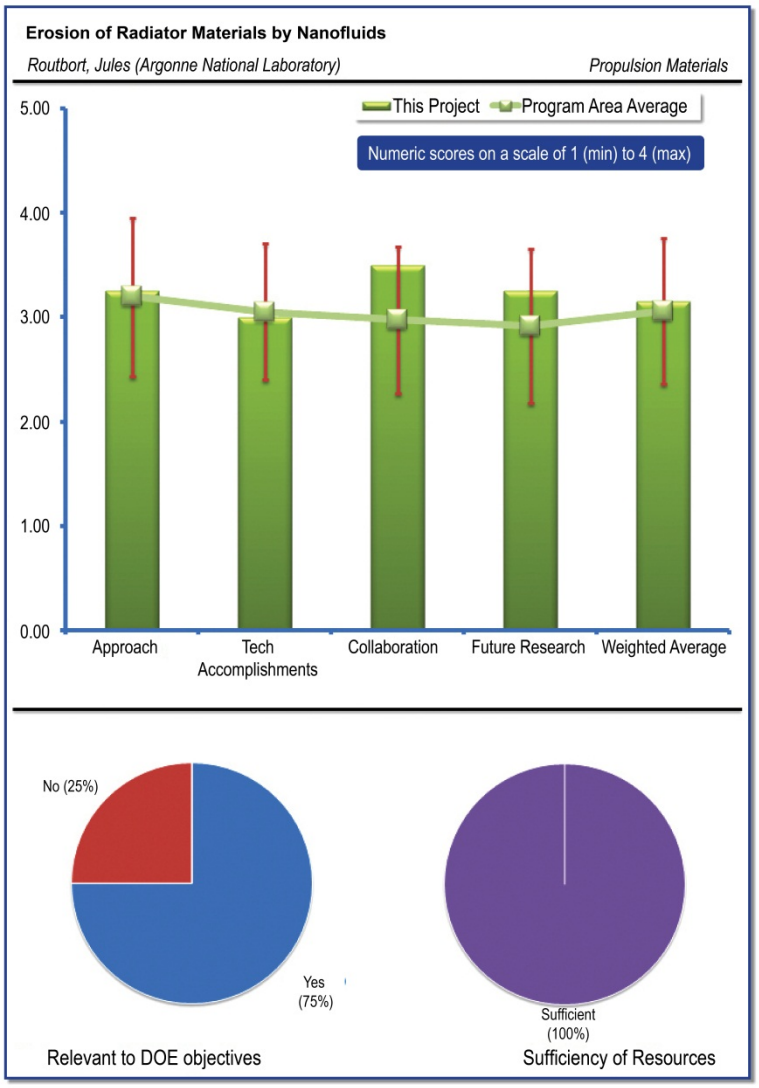
Erosion of Radiator Materials by Nanofluids: Routbort, Jules (Argonne National Laboratory) – pm008

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer described that nanoparticle-loaded heat transfer fluids, with demonstrated capability to increase heat transfer, could result in smaller heat exchangers (radiators), pumps, etc. This could reduce vehicle mass, frontal area and hence fuel consumption, provided they did not also significantly increase fluid pumping power or reduce engine cooling system longevity via erosion, etc. The second reviewer explained that there is an opportunity for lower friction/higher performance cooling fluids in terms of electronics cooling. Higher performance coolants allow lower weight and smaller systems to improve fuel efficiency. Electrification of the vehicle is supported by more efficient cooling. The third evaluator detailed that nanomaterials in automotive coolants have the potential to be significantly better thermal fluids than traditional ones. This will help optimize the weight of auto radiators and thereby make the vehicles lighter and more energy efficient. The final observer saw no apparent relevance to petroleum displacement from the presentation or poster.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that development of bench-scale test apparatus for rapid evaluation of heat transfer fluids was a good initial approach. The second commenter agreed that the project displayed a clear approach relating back to DOE objectives, having well defined requirements, test set up, and parameterization. The third asked reviewer questioned, why not do all the nanoparticle concentrations in all the fluid combinations? It would be good to know which provided the best performance -thermally 1st and then its erosion. The fourth reviewer called this project a 3 at best. According to this reviewer, Slide 9 of the presentation is perhaps the most telling for the status. There was no erosion after hundreds of hours of pumping. So, with no apparent erosion, it is questionable what value added is gained in continuing this effort.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

According to the first reviewer, the project achieved all objectives relating to evaluation of nanoparticles in cooling systems. The first reviewer also related that the project developed effective measurement equipment which can be reused for future work. No erosion or plugging was observed at tested solution levels. The other respondent again rated the project a 3 at best, questioning what value is gained to overall engine technology other than prolonged engine service life, as well as doubting the relevance to DOE goals.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer concluded that several collaborating organizations appear to be materials suppliers only, and others' contributions appear to have ended at this point in project. The other reviewer believed the project to be very well-partnered and leveraged, and listed partners: TARDEC, Michelin, DOE, Saint Gobain (partner in DOE Office of Industrial Technologies [OIT] project to develop manufacturing capacity for nanofluids), Nanoscale, Sasol (supplied Al2O3 nanoparticles), Ashland Oil (Valvoline), new partner in OIT project, graphitic based nanofluids request to partner in Tardec project in FY12 – 13.

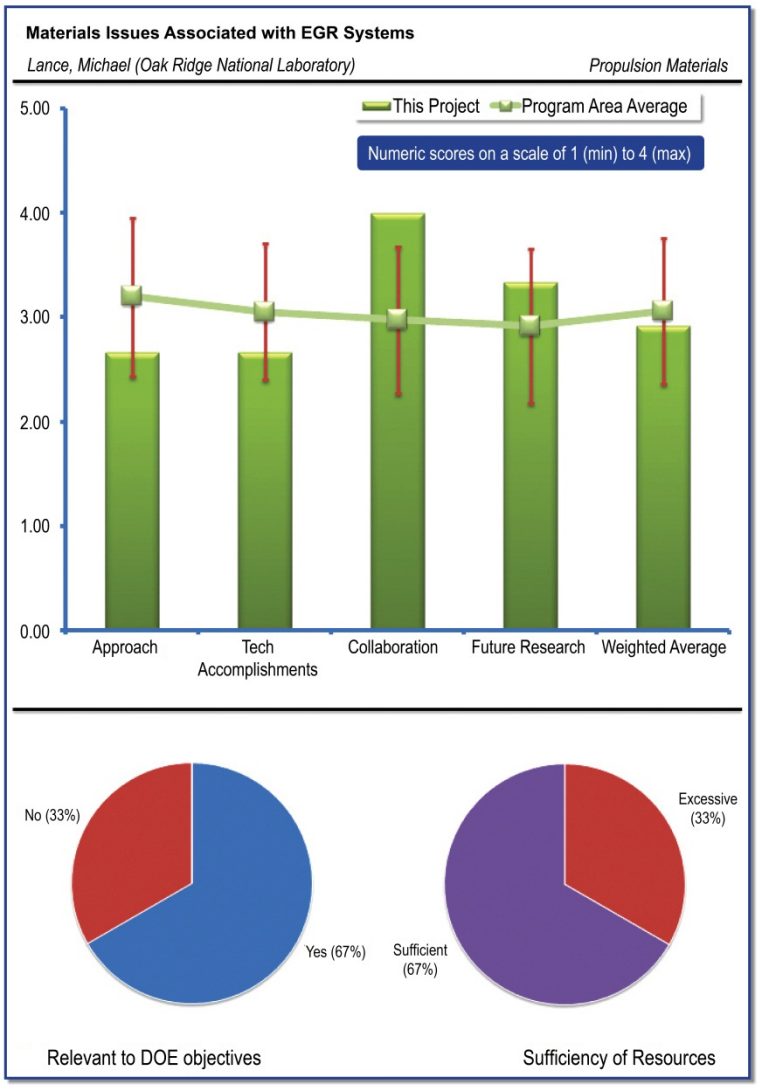
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer saw this project as developing a good tool set and performance database for an emerging and valuable technology. The other reviewer cautioned that any future work should be critically reviewed. Given the barriers and the accomplishments to date, suggests the project should be terminated, a final report written, and a model created to compare with any future nanofluids for use in radiators.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that the funding is well used. Based on the results, it is a great use of funds.

Materials Issues Associated with EGR Systems: Lance, Michael (Oak Ridge National Laboratory) – pm009



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first evaluator stated that the project focuses on solving the problems with respect to fouling of EGR coolers. Fouling leads to sub-optimized engine management settings and extra fuel consumption, so solving this problem will improve fuel efficiency. The final reviewer commented that meeting EPA standards for NOx and PM emissions with little or no fuel economy penalty requires the use of EGR and EGR coolers. EGR coolers have historically become restricted or plugged resulting in poor NOx performance and/or high maintenance costs. This project is an enabler for improving plugging performance of EGR coolers. The third reviewer believed that the statements concerning the centrality of EGR made in the presentation cannot be gainsaid, and it must be acknowledged that EGR is used universally in current-technology engines and will likely remain in universal use to control NOx emissions of all or most future-technology engines. However, according to this reviewer, this project does not appear directly to support the petroleum displacement objective of DOE vehicle technology R&D. Rather, it aims to find means whereby the level of new-engine NOx control can be maintained over the life of the vehicle. This goal, if successfully achieved, may prevent deterioration of new-engine efficiency, but that is not considered by this reviewer to represent additional petroleum displacement

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer considered the project to have a good approach to performing the work of understanding formation. Possibility to learn from data which has been accumulated on intake valve deposits due to fuel injection targeting and "internal EGR" backflow across the intake valves. The other reviewer felt that the approach shows some specific weaknesses based on the fact that there was little information on the specimens coming from the industry making a good evaluation difficult.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer acknowledged that the problem addressed is relatively complex. The theory on the development of the fouling layer had to be developed during the project. Now a better understanding is available making it possible to define future work more clearly. The other reviewer described how the project created a bench top reactor to generate controlled deposit formation but did not consider the engine combustion quality in the formation of deposits. When performing engine mapping, they took advantage of specific conditions which generate PM, High HC and other materials. This reviewer added that efforts should be considered to understand how these

engine based parameters could be improved to improve fouling. Filter smoke number (FSN) and HC ppm were lower at "Heavy Duty" operation point but the deposits were worse. If the flow was the same across the EGR, why are the deposits worse with lower PM, HC?

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All three panelists were pleased with the collaboration. The first evaluator stated that a wide consortium is involved. Necessary experts are consulted when needed. The second reviewer praised the extensive list of collaborators in this project as an indication of the universal and keen interest and concern over long-term EGR cooler performance of engine builder and vehicle producers. The third reviewer felt it was good that all in the industry are interested and taking advantage.

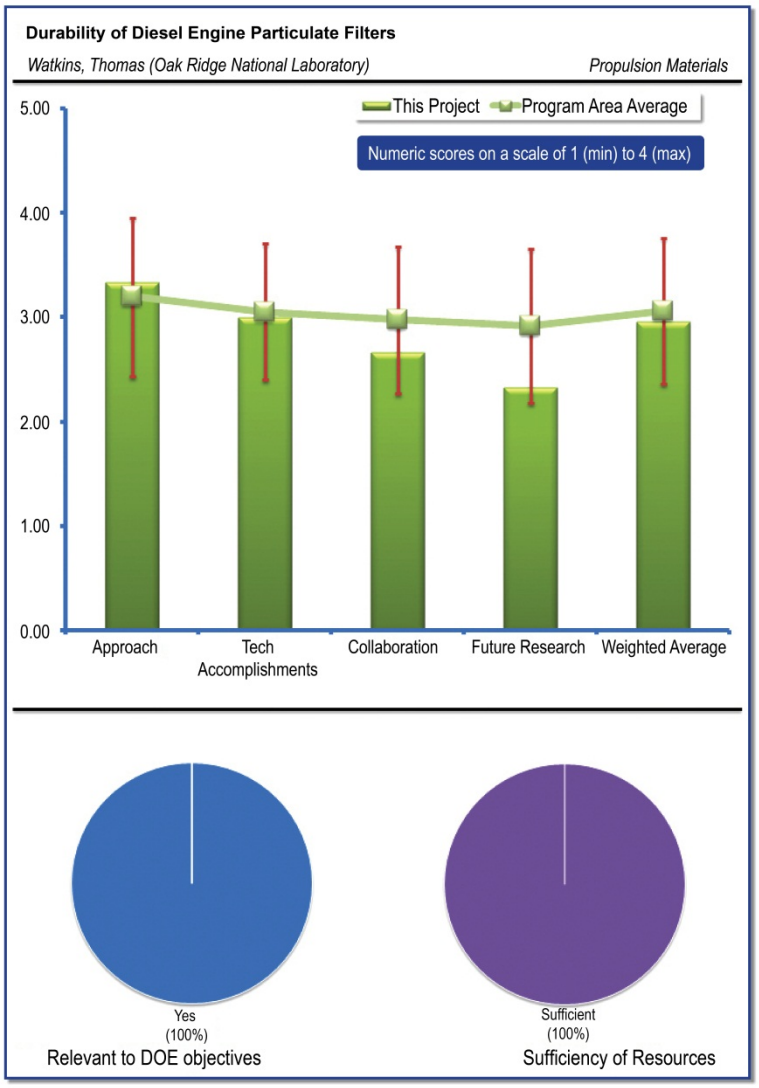
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Three reviewers commented positively on the future research. One reviewer stated that the future work planned built on the lessons learned from the earlier stages of the project. A more focused approach is provided, resulting in an increased change on success. A second commenter believed the proposed collection of field-returned EGR coolers for inspection and analysis in the second phase of this project is logical and likely to yield key information. The third reviewer opined that it is very good to begin solutions with Modine for heat exchanger geometries. This reviewer suggested the project consider partnering with a combustion team to identify chemical composition and other exhaust parameters which drive deposit formation.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented that funding looks adequate, another commented that the project is well funded, and the third reviewer said that considering the value of this research to the engine and vehicle builders (to whom it is critically important), it could be argued that the current level of DOE (i.e., public) funding is excessive.

Durability of Diesel Engine Particulate Filters: Watkins, Thomas (Oak Ridge National Laboratory) – pm010



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers clarified how this project is close to DOE goals, and the other described that the project attempts to optimize the regeneration of DPFs via advanced materials. One reviewer commented that the project has assessed the regeneration strategies that can be implemented with advanced materials to determine the petroleum displacement impact. Another reviewer declared that one clear remark has to be made. The project focuses on optimization of durability. This optimization should be complemented with a fuel efficiency related parameter like back pressure to ensure an optimum for both fuel efficiency and durability. The project promotes the use of diesel engine resulting in an overall improvement of fuel efficiency of the fleet. The final reviewer stated that although this project does potentially reduce fuel consumption, there are only weak linkages to petroleum reduction goals in that after treatment devices which are more durable will require less regeneration and thereby reduce fuel consumption. The fuel consumption improvement appears to not be significant when compared to the goals. 600 gallons / rated life (100,000 - 1,000,000 miles for HD trucks) yields at best a 0.6 Mpg (100,000 miles) or 0.06 Mpg if useful life is assumed to be 1,000,000 miles. Increased consumer use of clean diesel will not be impacted by this project. Significant (additional) reduction in diesel engine/system cost are needed to justify consumer acceptance.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer described the approach as building up the material knowledge from base material at ambient conditions towards coated components at elevated temperature. The influence of stress rate is not taken into account. The second reviewer thought the premise of reducing regeneration the approach was good, and likely to result in more durable catalyst materials, more resistant to thermal shock materials (faster regen). The third panelist felt the approach to be well-designed. The integration of Cummins via a CRADA agreement increases the probability of this research being integrated into a commercial product. This activity has been recently refocused to address the recent issues identified by the accelerated deployment of DPF into the commercial marketplace. The determination of the current technology baseline will greatly assist the researchers when designing the DPF to achieve the durability goals.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

According to one reviewer, after the refocus of the effort away from Aluminum Titanate and towards other SiC substrates, it appears that this project is on path to achieve the target milestones. It appears that the down-selection of SiC substrate material is ahead of schedule and this project has potential to be completed in advance of the scheduled completion date. A second reviewer commented that within this project a lot of data are produced by means of complex measurements; this is an important step forward. One of the barriers will be to find the optimum solution with respect to durability and fuel efficiency. The third reviewer reported that the results presented did not demonstrate success at meeting goals. Raw data presented did not convey significant conclusions. The "new thermal shock" ranking methodology was utilized and the model explained. The Ansys model is a good idea, but no conclusion relating model to results.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer said that the consortium is rather limited but shows a good vertical integration from knowledge institute over Tier 1 supplier towards an OEM. The second reviewer thought collaborations with Corning and Cummins were good. Clear tie-in to application integration, commercialization, fuel economy reduction, and industry use of models/tools/databases developed in this work are needed. A third reviewer considered there to be an excellent relationship between Cummins and ORNL via a CRADA agreement. The establishment of a closer agreement between ORNL and Corning (the emission control manufacturer) would greatly improve the collaboration with industry. According to this reviewer, from the presentation given by Thomas Watkins, ORNL and Corning only communicate informally once a year in January. A more formal agreement between ORNL and Corning would increase the likelihood of the integration of this research into a commercial product.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first panelist concluded that in the proposed future work a number of relevant measurements are defined. An interpretation of the results into a model or guideline should be made. A second panelist relayed that the goals for industry here are to develop models, tools, and databases. There are words which point to these activities by continuing to evaluate samples, but the big picture results are not clear. This reviewer suggests that larger picture, possible results-based activities could be: Provide data to Ansyis model to optimize design xxx for substrate shape/material improving durability by xx hours; thermal shock model used to rank 10 candidates for substrates and provide a summary report of top candidates: A, B, C. A third panelist reported that firm decision points or Go/No-Go evaluations were not presented. From what Mr. Watkins stated during the presentation, it appeared that a SiC material (Mullite) has been identified. If this is in fact true and the research team believes that the durability goals can be met with this material, the effort should focus on using this material and begin activities to design durable DPFs with this material to achieve the 1,000,000 mile useful life.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first respondent claimed that this type of work is relatively costly, so the budget is in line. A second reviewer commented that if there is continued monetary cost share interest from industry, then this is supported at the level needed. The third evaluator suggested that if work is moving forward faster than planned, DOE should consider terminating funding when the goals are achieved.

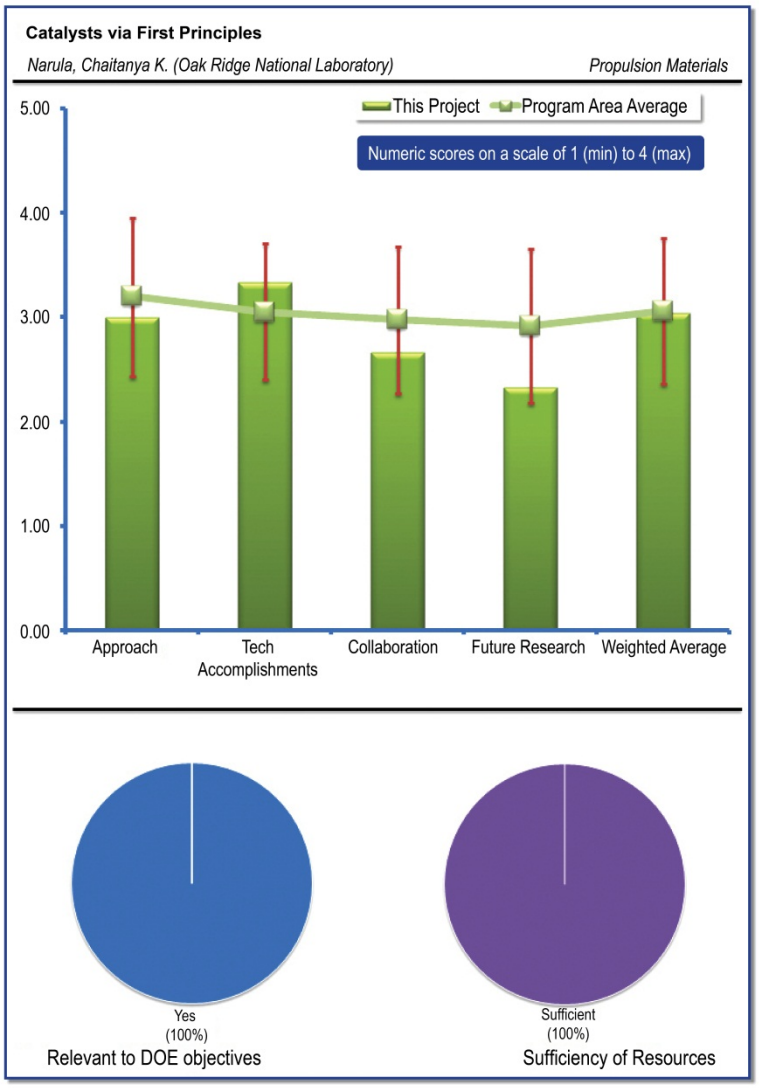
Catalysts via First Principles: Narula, Chaitanya K. (Oak Ridge National Laboratory) - pm011

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers explained how the project meets DOE goals. The first reviewer stated that it is likely that this work will accelerate catalyst discovery and development and improve catalyst performance, both initially and over the life of the catalyst. This can result in reduced cost, reduced catalyst size (volume and mass) and enhanced engine emissions control. These improvements can have indirect effects on petroleum consumption (particularly reductions in catalyst mass) and perhaps enable other developments, such as leaner engine operation, that will directly affect fuel use efficiency. The second reviewer explained that there is a link between emission controls for NOx and fuel economy capability. Fuel economy and cost improvements are possible with breakthrough technologies which do not require regeneration or SCR with ammonia injection. The third affirmed this project was concerned with demonstrating that catalyst systems can be designed from a "first principle theoretical models" approach and to carry out a range of experimental and theoretical studies to optimize the catalyst structure through nanostructure characterization.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter reasoned that although the direct link to fuel economy is weak, this approach to make designer materials and to allow modeling of the results is outstanding. A second commenter provided a lengthy summation of the approach: A "first principles" modeling approach for designing platinum clusters on oxide supports, and zeolite catalysts is being pursued. The experimental approach includes synthesis of Pt nanoclusters, interaction with various gases, and zeolite catalysts. Scanning transmission electron microscopy (STEM) analysis is being used to determine Pt particle sizes; the atomic make-up of the nanoclusters comprises 10 to 20 atoms. Gas phase studies of Pt clusters show that atoms are held together more strongly as the cluster size increases. The simulations (apparently using density functional modeling) show some disagreement on the bulk ceramic structure which is currently being further investigated. The effect of CO and NO oxdiation on structural changes on ceramic substrates is being investigated, as is the influence of nanoparticles, and the incorporation of heteroatoms in metal exchanged zeolite which was shown to affect the NOx conversion temperature. The second commenter said that the approach of developing catalysts by design may be an emerging field. At the same time, many are pursuing the general problem of "materials by design" (reviewer's quote). The PIs did not mention much about other groups doing fully numerical simulation of materials, even though the applications may not necessarily be the one targeted here, for example whether or not their tools are unique or simply redirected from other fields. The rating reflects a concern that the

approach is well known and only an application of existing theoretical approaches are being brought to bear on this problem rather than developing an entirely new approach. Whether or not new ground is being broken is uncertain.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

According to the first reviewer, some barriers that seem to have been overcome include that a combination of theory, experimental studies, and nanostructural characterization can advance catalyst discovery process. These accomplishments are consistent with the approach. Some of the technical accomplishments include the following: catalyst by design is effective in reducing development time in speeding up the discovery process; single atoms and 10-20 atom Pt agglomerates can influence CO oxidation; Pt occupied a position between two surface oxygen atoms above aluminum; CO oxidation can occur by O2 addition and O insertion intermediates; and a new bimetallic mordenite framework inverted (MFI) zeolite was shown to exhibit high NOx conversion. The second reviewer was pleased with some key findings and universally usable approaches, and remarked Modeling/ Results Reuse and applicability of data is very good. Catalyst by design approach is effective to speed up the discovery process. New hetero bimetallic MFI zeolites exhibit high NOx conversion at 150 C.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought that the work with John Deere was useful, though a bit vague. The publications were extensive though did not evidence a substantive collaboration with the John Deere (no co-authorship, if appropriate). A second reviewer pointed out that catalyst suppliers and developers would seem to be logical collaborators in this work, but the sole current collaborator from the private sector is an engine/vehicle builder. The third evaluator concluded that although John Deere was engaged for direct application, other OEMs can certainly benefit from this approach. Get them engaged! Co DOE-Industrial Technologies Program (ITP) funding is very good leveraging.

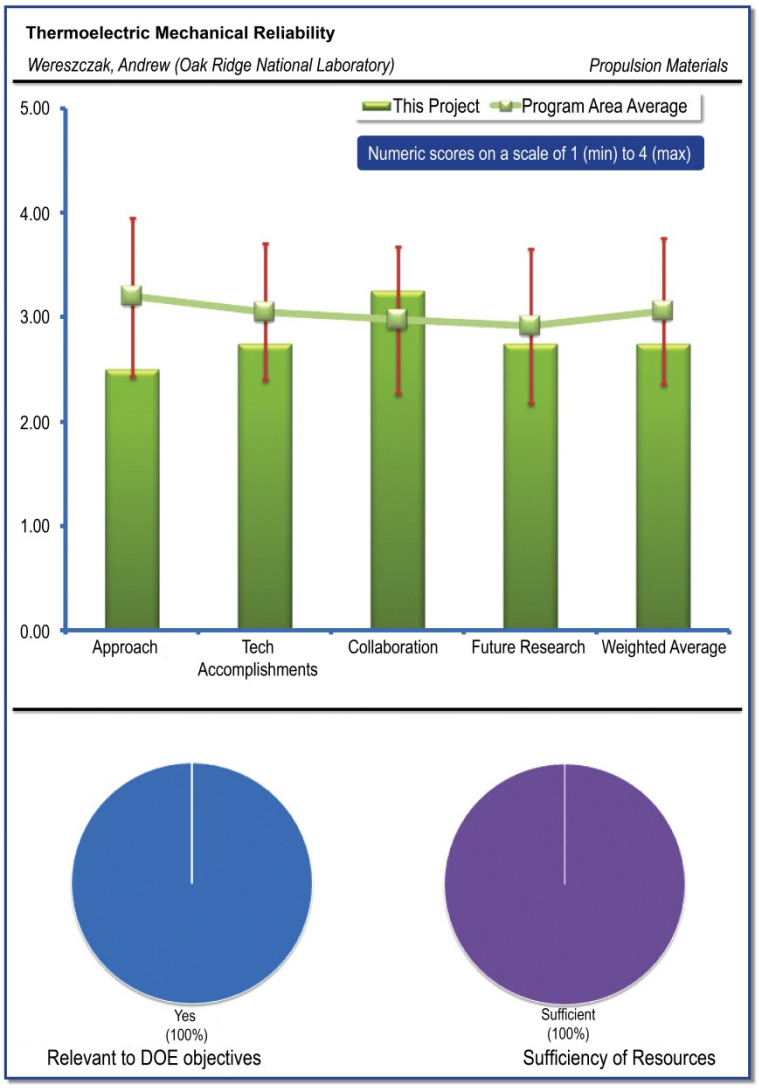
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Doubts about future research were expressed by all reviewers. One reviewer felt that although the plans were good, the presenter needed to reiterate or explain their significance. A second evaluator pointed out that the project will end at the close of the next fiscal year; will it have produced practically applicable results by that time, and if so, who will apply them? Deere produces no LDVs and only a relatively small number of heavy-duty diesel (HDD) engines. The third reviewer reported that the PIs would like to study several aspects in future work including CO, NOx and HC oxidation mechanisms on Pt/?-Al2O3systems (and they mention "Theoretical models"), and bimetallic systems to alleviate Pt sintering, again by a "theoretical studies" approach. The plan is a bit vague on what gaps in the past work will be quantitatively addressed in the future work, and what the significance is of this work. Furthermore, simply stating that the PI wants to carry out "synthesis of sub nanometer particles" does not provide much information of how material synthesis would fold into the theoretical approach, or how the analysis would guide the synthesis efforts. The reviewer concludes by reiterating that the project is now in its 7th year, and one would hope that a real catalyst could be designed, tested and put in the field with the approach of this project.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer thought that the funding of $300K appears to be more than adequate for the proposed tasks. A second reviewer stated that at $300K for 2010 and 2011, this project would appear to have more than ample funding, particularly if this funding level has been maintained since project inception 7 years ago. The third reviewer considered leveraging of resources to be well done.

Thermoelectric Mechanical Reliability: Wereszczak, Andrew (Oak Ridge National Laboratory) – pm012



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project concerned exploring thermoelectric materials for on-board power generation in automobiles. In this way, there will be some savings in fuel economy. The second reviewer explained that the ability to generate usable electrical energy from the otherwise wasted heat output of an IC-engine vehicle would clearly help to save petroleum by unloading the vehicle alternator. Likewise, the use of thermoelectric materials (TEMats) to cool power electronics and reduce the parasitic loads associated with that function would help make EVs and HEVs more practical and perhaps speed their penetration into the national LDV fleet. It might be that neither effect would be huge, but both or either would be directionally helpful. The third reviewer believed that heat recovery can contribute significantly to the energy efficiency and impact petroleum displacement costively.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer thought the project approach, involving characterization of material, was clear. The other evaluator stated that the approach concerns measuring thermomechanical and thermophysical properties of candidate (brittle) thermoelectric materials. The data are considered to be useful to enhance the design of a TEG. This year, the PIs have developed a property database on thermoelastic property data as a function of temperature. The materials are Marlow's p and n type material. The weakest link is the TE material but there are other elements such as the role of bonding and interfaces. This reviewer continued, bonding is included but interfaces are not considered in the plan. This may be a shortcoming that could be addressed by including efforts to evaluate the efficacy of interfaces to provide sound electrical and thermal contacts across different material systems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that the thermomechanical characteristics of available TEMats seem to be a principal factor limiting their application to practical systems, which justifies the project approach. The second reviewer responded that the effect of surface flaws on the properties was evaluated. By enhancing the surface quality, the tensile properties were shown to improve significantly. Since TEMats are inherently brittle any surface flaw is tend to initiate cracks easily. However, it was presented that the machining improved the high temperature strength as well which could not be explained. This reviewer suggested that more testing needs to be done to confirm the results. The third evaluator summarized the progress, reporting that the materials are skutterudite materials. High temperature strength data were obtained. A method was developed to eliminate residual stresses. The accomplishments are rather

narrowly developed in keeping with the objectives. At the same time, the problem of TEGs for waste heat is far more than just strength and mechanical properties and elimination of thermal shock. Even if this problem is solved, the more traditional questions will remain (interfaces, ZT, etc.). There are competing effects of high k required as counterbalanced by the need for a low k for high ZT. The PIs thereby focus on enhancing the tensile strength. The need to consider CTE of the TE materials is in part driven by the design of the TEG itself, where de-bonding could occur by mismatch in material differences. This reviewer continued, other TEG designs leverage material expansion to essentially squeeze the interfaces as temperature is increased (e.g., the BSST TEG design, which also reduces interface effects). The design for being able to probe properties of small material samples is very good. The development of a method to nondestructively test residual stress is also good.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All three of the respondents were concerned about a lack of collaboration with end users. The first stated that the project has a CRADA with one supplier, but most of the work was characterizing the material developed by the supplier. Involving more industries including users would be beneficial. The second agreed that the collaboration with Marlow, who provided TE materials, was excellent, but more effort should be made to work with General Electric (GE) to actually integrate a TE device into a vehicle. The third respondent said that even indirect participation in the project by a major automobile builder (GM) is desirable. Does the absence of other engine/vehicle producers suggest that thermoelectric recovery of waste heat is a low-order priority among that group, or has wider collaboration simply not been sought?

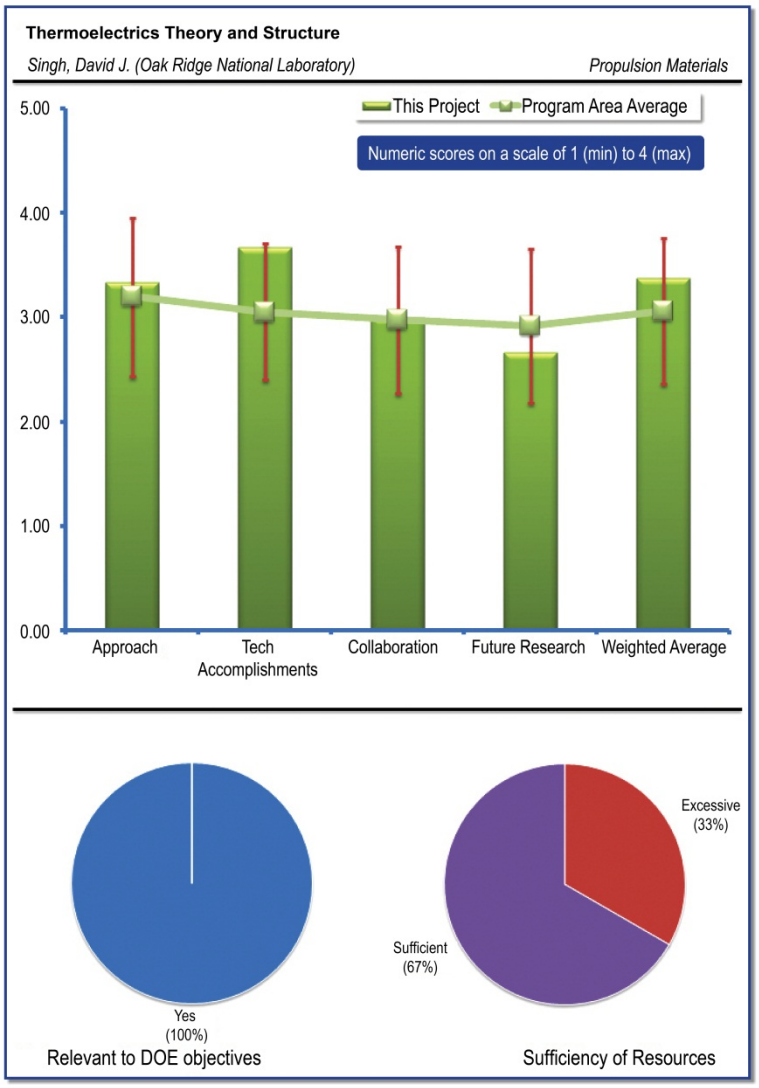
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said that continuing work will examine strength of high temperature TE materials. Mechanical property evaluation will be pursued for next generation TE materials. It is encouraged that a component be devoted to interface characterization, both for electrical and thermal contact resistance.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented that the budget of 150K is reasonable, especially given the collaboration with Marlow.

Thermoelectrics Theory and Structure: Singh, David J. (Oak Ridge National Laboratory) – pm013



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer saw direct correlation to DOE goals and petroleum displacement. The second evaluator thought this project relevant by virtue of its potential to improve fuel economy in automotive systems by converting the waste heat from the exhaust to electricity. The ability to predict performance of TE materials is quite relevant.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All observers positively reviewed the approach of this project. The first reviewer was excited about the potential for low cost thermoelectric that can be designed. The second evaluator reported that the presentations suggestions improved evaluations techniques have dispelled generally held opinions on certain elemental combinations. Technical approach appears capable of meeting overall project goals. This project was suggested to TARDEC for review. The third reviewer considered the broad approach essential to identify new materials by applying density functional theory to develop materials with high ZT. The approach seems to be one of "materials by design." The base case was a tellurium-based TE material.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said that this project should definitely continue. The second reviewer concluded that the past work appeared to have shown that it is possible to "design" TE materials to meet specific targets. The PI predicted a ZT of 1.5 for PbSe materials at 1000K which turned out to be close to measured values at 800K. This year, new skutterudites were predicted with detailed transport calculations. An enhancement was found by modification of the band structure. The results also showed that PbSe was an excellent TE material with proper doping. ZT values are predicted to exceed 1.2 at 800K.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer said that this project's collaborations are primarily ones of data sharing and communications of results. Ultimately, it will be important to transition these materials to automotive systems. A plan and path to that end was not given. This appears to keep the present study centered in a rather research-oriented direction.

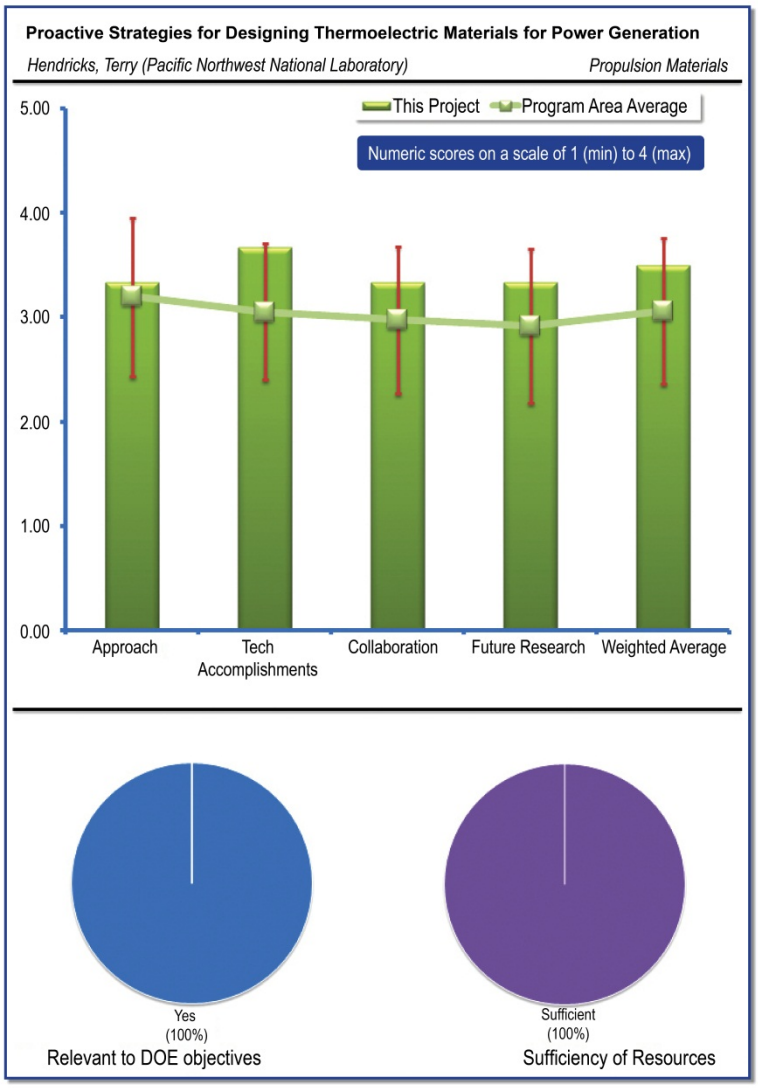
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first evaluator asked, since the project has a few promising materials and the program is set to end in FY12, why not focus on optimizing these and not searching for other potential materials? The second reviewer commented about the suggested suite of materials. This reviewer suggested focusing efforts on solving one problem and use application before trying to find skutterudites for multiple applications. This reviewer also noted that it looks like PM 014 could support this effort. The third evaluator concluded that the future work will include such activities as "seek ways...", do "detailed calculations..." and "survey other low cost...". These tasks are non-specific and do not provide much to go on regarding gaining an understanding of precisely what the PI has in mind with these buzz phrases. The third reviewer wanted to encourage the PI to be far more specific regarding quantifying the methodology, formulations, analyses, etc., behind these rather vague words.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that the cost of $400K seems a bit high relative to other projects in this program, especially given its emphasis on simulation.

Proactive Strategies for Designing Thermoelectric Materials for Power Generation: Hendricks, Terry (Pacific Northwest National Laboratory) – pm014



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer relayed that the broad goal is to develop TE skutterudite materials that will meet targeted performance goals of ZT >1.6 at 600K or higher. If successful, such an activity will be relevant for improving fuel economy in vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter remarked that the project ended in December 2010. The second reviewer asked if there was any concern about the use/dependence on the rare earth cerium in this design. The third evaluator stated that the materials selected are skutterudites comprised of cobalt alloys because of their ability to accommodate multiple rattler systems. The collaboration with Oregon State University (OSU) concerns characterizing the materials at higher temperatures than in the past. PNNL is characterizing system level performance. The suite of instrumentations at OSU appears to be extensive and based on commercial systems. This reviewer continued, the material characterization efforts seem to be well in hand. There was some uncertainty on potential anisotropic effects and the extent to which the metrology could decouple measurements (e.g., thermal conductivity) in different directions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said the question is not applicable, as the project ended in December 2010. It supported PM 013. The second reviewer was curious about any lot-to-lot variation/reproducibility. Thermal cycling slides show 2 samples -were they prepared from the same batch of starting materials or separately? The third reviewer reported that extensive arrays of data were presented, some of which show that ZT values approaching 1.6 at > 600K are realized. The other data are also extensive (e.g., CTE, E, Poisson's ratio, etc.). The effects of thermal cycling are perhaps the most important outcome of the results obtained this past year. The thermal conductivity may increase or decrease with repeated cycling. This sort of information is very important to know (and rarely reported or perhaps not even known). More effort should be devoted to understand the mechanisms responsible for this effect. The PI is encouraged to share his thoughts with others in the field on this effect, and is strongly encouraged to write a paper for an archival journal on the effect.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer reiterated that the project ended in December 2010. A second commenter stated that the collaborations are crucial to the success of the effort. PNNL and OSU are doing material thermal and electrical characterization; PNNL has characterized system-level benefits of material compositions; Tellurex and ZT plus are commercialization and technology transfer partners.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer was curious what the chances for success are in creating the TE p/n couple, and what will be the risks and mitigation strategies. A second reviewer understood that future work will focus on cobalt n-type materials, high temperature structural characterization and ZT reproducibility. Fabrication of high density samples and completing a TE module are planned. They have already completed experiments to measure CTE. Another reviewer said they had no comment on proposed future research, since the project ended in December 2010.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said that the budget is about right for the tasks reported, and another reviewer remarked that this question is not applicable.

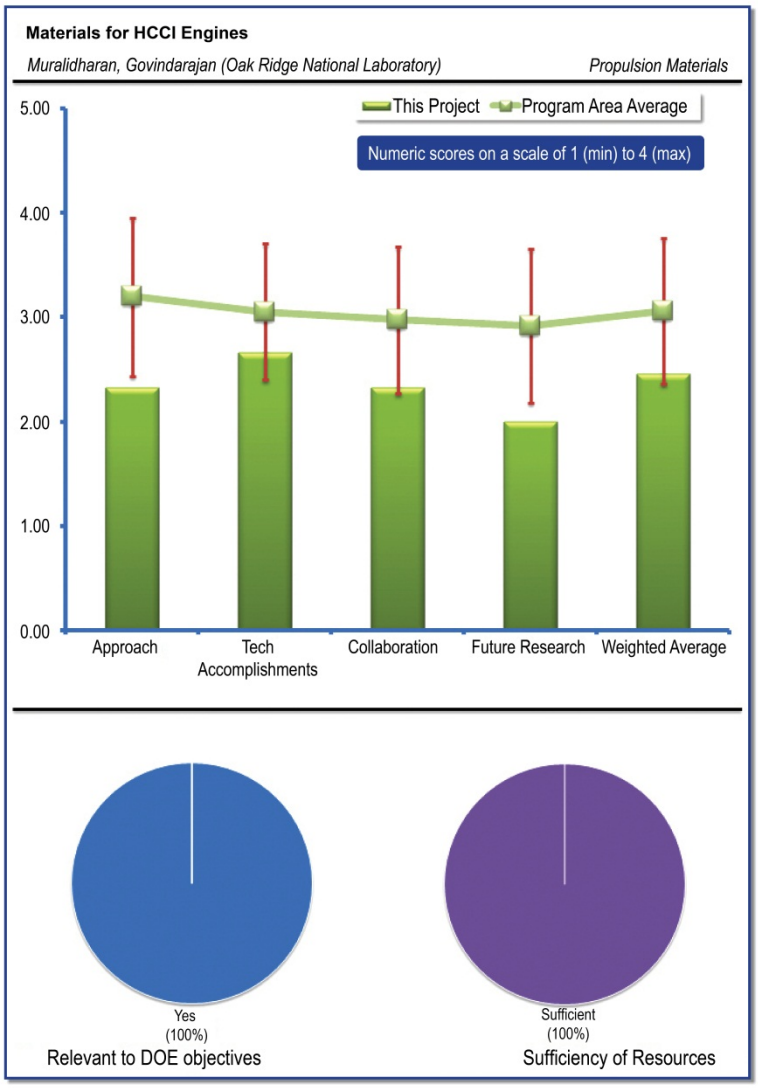
Materials for HCCI Engines: Muralidharan, Govindarajan (Oak Ridge National Laboratory) – pm018

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers thought the project supported objectives, with one reviewer commenting that development of material for high temperature applications is always useful to improve the engine efficiency, and a second reviewer commenting that producing valve materials capable of operating at higher temperatures will allow engines to operate more efficiently. The third evaluator deemed the project's support of goals questionable. This reviewer elaborated that there may be a correlation but it was not apparent from the presentation. It appears to be a materials identification and characterization effort. Project does not indicate any petroleum displacement, fuel economy improvements, etc. It does indicate the need for advanced materials for exhaust valves based on higher performance engines.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer believed that producing valves capable of operating at 870C will likely result in fuel efficiency gains. However, the targets of improving passenger vehicle fuel economy by 25% and commercial vehicle engine efficiency by at least 20% appear to be unrealistic and untested. The actual efficiency gains could be measured prior to valve fatigue failure, which would demonstrate the efficiency gains this project would actually achieve. This reviewer explained that once the actual gains have been demonstrated, then the development of high temperature valves can be rationalized. If the efficiency gains are found to be minimal but engine life is extended, then the project goals should be modified and the project should be judged based on the revised goals. A second reviewer concluded that the problem is to increase the operating temperature of the engines and the solution provided is developing new material. Also, the preferred path is using Ni as the major alloying element. The presentation should have included the rationale for this decision. The second reviewer asked, why not other materials, what is advantage of nickel alloys and what is known so far? Nickel alloys are used in aerospace for long time and we understand the material more clearly. The third reviewer found the approach to be questionable. The project appears to focus on identifying new alloys without any consideration to transition to manufacturing, or how to manufacture the new alloys into exhaust valves. It appears to be focused on a material improvement to one specific part, no apparent consideration to fuel displacement.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer believed that progress has been good in developing high temperature exhaust valve materials. The other evaluator stated that the alloy development is more empirical; it is acceptable that the data available for modeling may not cover all the ranges that need to be evaluated. However, it did not mention whether any of the new data is being used to modify and strengthen existing data bases for future modeling.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer thought that collaboration appeared to be good. Another reviewer saw some very limited coordination, which appeared to be consultation in nature, but saw no apparent direct collaboration.

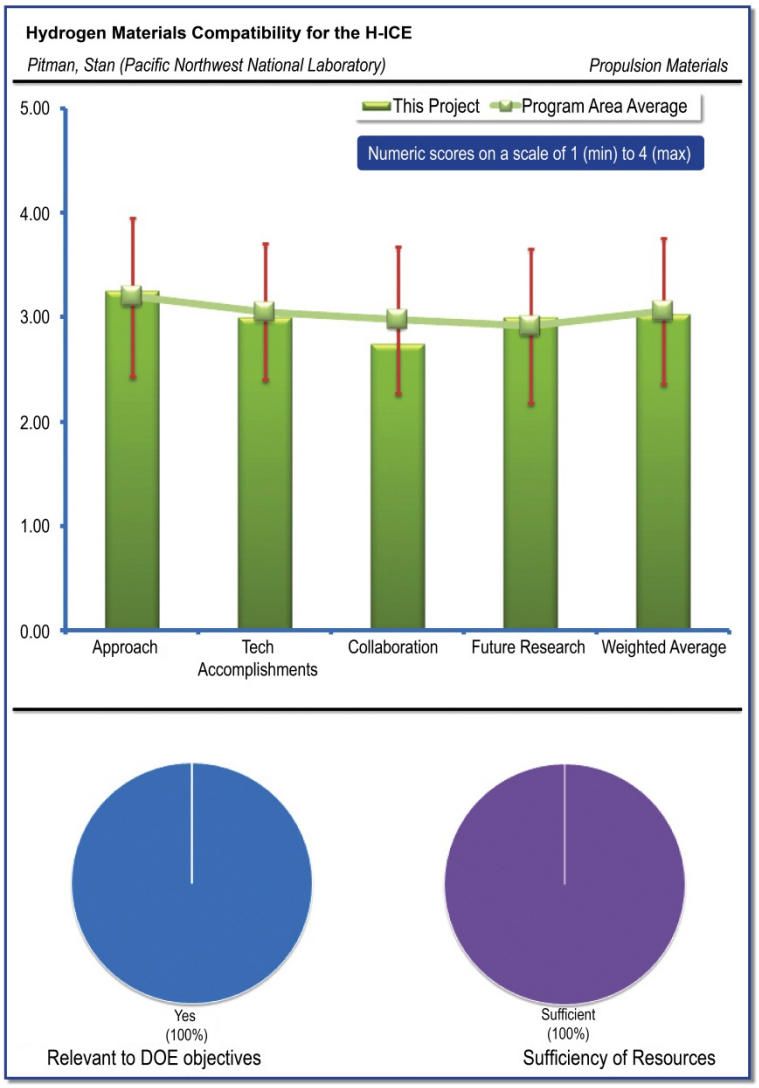
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer reported that some discussions have been carried out with potential manufacturers, but no specific collaborations were mentioned. The second evaluator refers to his note above, stating that the actual gains that would be realized with completion of this project should be quantified through testing to demonstrate the actual efficiency improvements that would be attained. Another reviewer said the project was questionable, and that it appeared to be the development of more alloys, with no end product suggested.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that the resources appear to be sufficient to achieve the milestones stated. Another evaluator commented consider writing the findings and final report and terminating this effort.

Hydrogen Materials Compatibility for the H-ICE: Pitman, Stan (Pacific Northwest National Laboratory) – pm019



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Commenting reviewers agreed that this project supports DOE goals. One reviewer stated that this project focused on improved performance and reliability of fuel injectors for Hydrogen Internal Combustion Engines that are not petroleum fueled. A second reviewer said that hydrogen generated by non-petroleum sources used for internal combustion engines would be an alternative to fuel cells, and would have desirable applications. The third reviewer explained that fuel cells using Hydrogen will allow full displacement of petroleum when generated with Nuclear power. Nuclear electric and H2/Electric vehicles are the 2050 solution.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Respondents were positive about the approach to this project. The first reviewer claimed that the approach appears to be very appropriate for the goal of the project. A second evaluator thought the approach is correct to detect the root cause of the issue with H2 damage to piezeo-electric devices. The third respondent stated that this project evaluates piezo damage based on materials selection of piezo and electrode material with ion scattering (elastic recoil detection analysis [ERDA]/Rutherford backscattering spectrometry [RBS]) and SEM.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that the progress of this project appears to be very good. Their ability to identify a metal with excellent resistance to hydrogen damage will be determined by the results of this project. A second reviewer responded that there was good progress to identify root cause and potential materials which perform best. Mechanism implies that all known materials will be impacted and may not be practical for use. A third panelist stated that the work performed included: Evaluating Pb diffusion in 5 different PZT/metal systems with RBS; Evaluating H uptake with ERDA in 5 different PZT/metal systems; and looking at surface blistering and Rb surface migration with SEM/energy-dispersive X-ray spectroscopy (EDX). The final reviewer asked, what if materials are used to absorb hydrogen before it reacts with piezoelectric materials? This will reduce the amount of hydrogen entering the materials and cause blisters and lead segregation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought that collaboration is good, and appears appropriate for this project. A second reviewer stated that PNNL partnered with Westport International and Ford Motor Co. on this project. The third replied that it was only Westport innovations, and Ford is mentioned peripherally. It is possible that this project could leverage universities, injector suppliers, industry groups or others for interest and knowledge related to this issue.

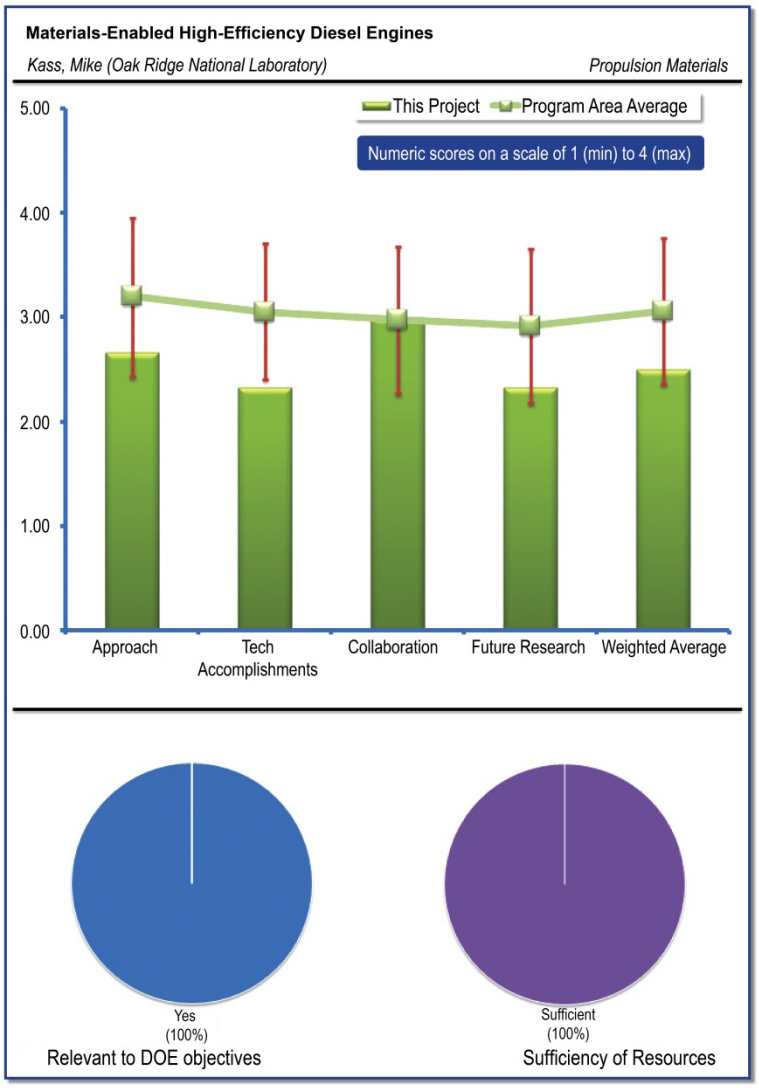
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first evaluator said that because the mechanism indicates that all known materials will be impacted without protection, some sealing mechanism or material may be an additional source for additional work. A second reviewer thought that the proposed work to be done appears to be appropriate for accomplishing the goals of this project. The third evaluator stated that this project will be ended in FY2011. The proposed future work included: complete ERDA/RBS and SEM damage studies on remaining barium titanate (BTO)/metal (5 types) systems; H diffusion studies in PZT and BTO with NMR to complement earlier neutron work; and compiling report evaluating H2 materials compatibility.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer said funding for 2011 is $100K. Another reviewer thought the resources appear to be sufficient. The third reviewer believed that to complete planned work the existing funding is sufficient. Additional funding may be considered for work to identify alternative solutions for protecting piezo devices.

Materials-Enabled High-Efficiency Diesel Engines: Kass, Mike (Oak Ridge National Laboratory) – pm020



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer remarked that this project meets DOE goals. This reviewer stated that higher-temperature/pressure operation is a straightforward means of raising diesel engine efficiency which is, in turn, an aid to petroleum conservation. It can also raise specific power which could enable some reduction of engine size and mass, which indirectly benefit fuel conservation. Both approaches are enabled by higher-performance engine construction materials.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

No comments on approach were entered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that it appeared significant time and funds were required to address problems with test equipment. This is unfortunate, but such problems are often inevitable and must be dealt with. Consideration is being given to production application of an improved turbocharger turbine design tested in this project. This is a potentially significant technical accomplishment. The second reviewer commented that there was too little technical data to be able to evaluate the program. No preliminary data, no discussion as to what to expect. "Essentially no difference in the recession for either the standard or Ni-alloy valves" - so what is the value add-cost? Manufacturability? The third reviewer relayed that this project has focused on characterization of material developed earlier at ORNL; however what is the operating temperature for these engines? There is another project trying to develop new material for 860C while this project is testing an existing material. It may be that one of them is not necessary.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer offered that Caterpillar has provided considerable in-kind support to this project and planned future work calls for further support of this kind from Cat. The other evaluator stated that this effort is part of a CRADA with one OEM, but there may be a need to involve many more companies so that the tech transfer will be effective.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One evaluator said that all of the work/results seem future-loaded, which is very difficult to evaluate. The other reviewer stated that to date, special alloy exhaust valves seem to have delivered equivalent performance to that of the stock valves. How will their potential to tolerate higher-temperature operation be evaluated? Likewise, the stainless steel manifold Cat will provide later for evaluation is a lower-cost alternative to the current design. This reviewer commented that cost reduction is desirable, but is the manifold anticipated to offer equivalent performance or improved performance at lower cost, and how will that be assessed?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No comments on resources were entered.

Materials for High Pressure Fuel Injection Systems: Blau, Peter (Oak Ridge National Laboratory) – pm021

Reviewer Sample Size

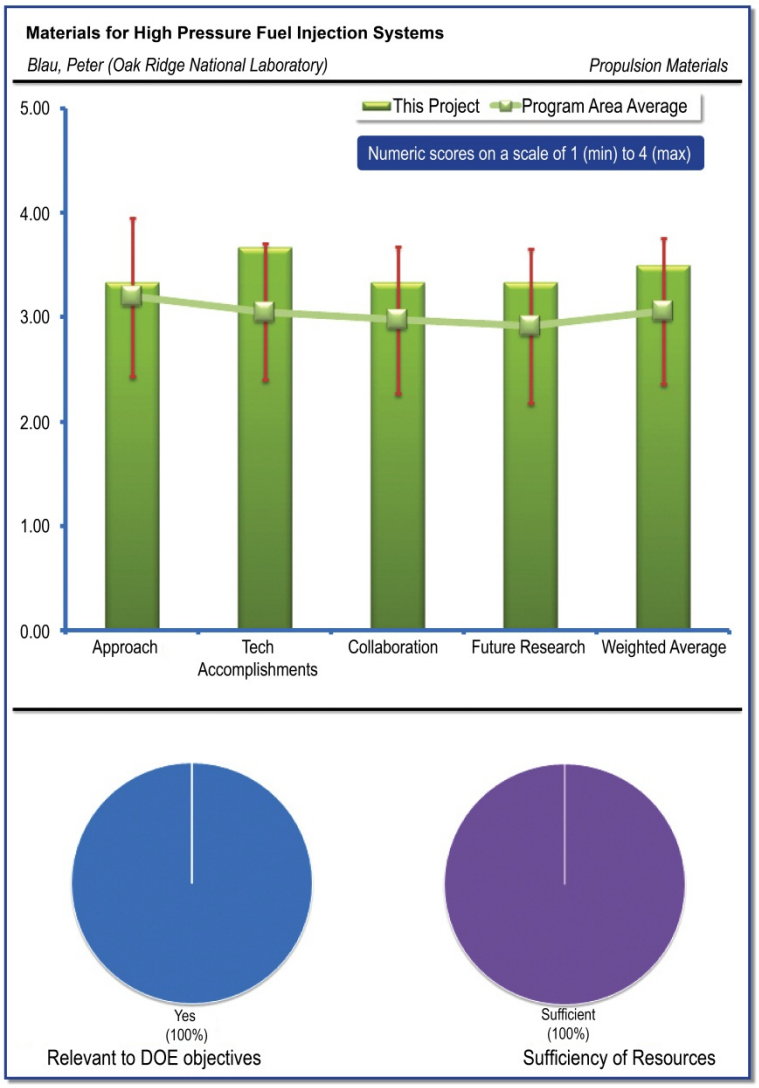
This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer said that the recent history of diesel engine technology development has shown that higher injection pressures, at least within limits, can be helpful in improving engine-out emissions, operating flexibility and fuel efficiency. It remains to be seen if raising injection pressures to levels as high as 2800-3000 bar will be as valuable as the increase to the range of 2000 bar has been, but the work undertaken in this project will be necessary to make that determination.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer said that this is a concluding project which appears ready to transition to the manufacturer.



Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that this is a concluding project, and a second reviewer stated that excellent progress has been shown by a series of logically ordered goals and steady progress in meeting milestones.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One evaluator stated that it is limited to one manufacturer. The second reviewer understood that the CRADA partner in this effort pioneered the trend to very high injection pressures in HDD engines and has contributed on the order of a 50% cost share.

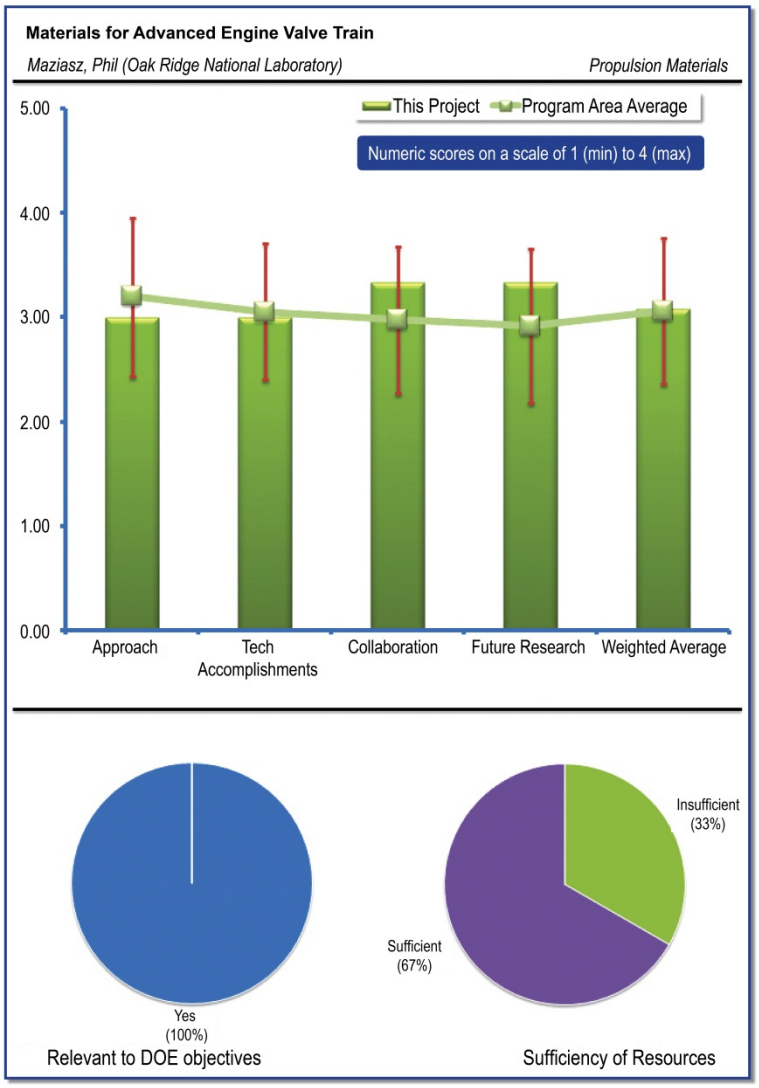
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer pointed out that this section is not applicable as this is a concluding project. This reviewer continued a curiosity of this effort is to determine the performance of the injectors using various fuel formulations. Consider that diesel fuel can vary from one country to another in the same region, have differing contaminants, and could have been delivered/pumped from any handy source into the vehicles fuel tank.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No comments were entered.

Materials for Advanced Engine Valve Train: Maziasz, Phil (Oak Ridge National Laboratory) – pm022



REVIEWER SAMPLE SIZE

This project had a total of three reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

The first reviewer concluded that this project will allow for improved thermal efficiency of internal combustion engines. A second panelist affirmed that the project is aiming at higher heat resistance of valve materials, which allows for higher combustion temperatures, which in turn will lead to further fuel efficiency improvement. The third reviewer commented that future engine combustion strategies will most likely result in higher temperatures in order to achieve improved fuel efficiency. This work may be considered enabling technology.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

All reviewers liked the approach. The first evaluator commented that the approach of this project is to reduce the increased wear between exhaust valve and seat inserts through the use of improved alloys. This appears to be a practical approach to resolving their defined problem. A second reviewer felt that this project is well planned. Progress is evident and milestones are being met. The second reviewer especially liked presentation Slide 6 which showed normalized wear rates for the valve seat insert and the mating exhaust valve as a material couple. The wear rates for the valve and the mating seat may not be independent. The third panelist thought that within the project there is a link between base material properties, rig testing and engine testing. This will lead to a better understanding of the phenomena that are responsible for wear of valve/valve seat pairs. One aspect is not mentioned for the material selection; heat conductivity of the valve and seat. This has an influence on the actual operating temperature of the valve the best heat resistant material is not necessarily the best choice.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer thought that the accomplishments and progress appear good. The method chosen was to test several alloys to determine which performs the best. This approach will determine the best alloy for this application among the candidates, but there are potential alloys not being considered that are not being tested. A second reviewer felt that a path forward was clearly defined, so in the future a higher heat resistance valve will be possible. The tests are time consuming making it difficult to assess intermediate results. The third commenter believed that the 2011 summary mentions previous clearly identified root causes of wear attack. While there is only limited space to present results, the root cause definition actually comes across more as a hypothesis than proven. The underlying

physics and root cause confirmation may exist, but are not evident in either the 2011 or 2010 presentations. While it is always preferable to understand why things work, it must also be recognized that it is not a necessary condition.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Two of three panelists were pleased with collaboration and the third offers suggestions. The first two reviewers said that collaboration appears to be appropriate for this project; and that the collaboration between the two partners is good however the number of project partners is limited. The third reviewer reasoned that supplier involvement is a critical element for commercialization. Otherwise, the work might be considered a science experiment with no impact on actual products. Valve seat and exhaust valve suppliers have provided prototypes.

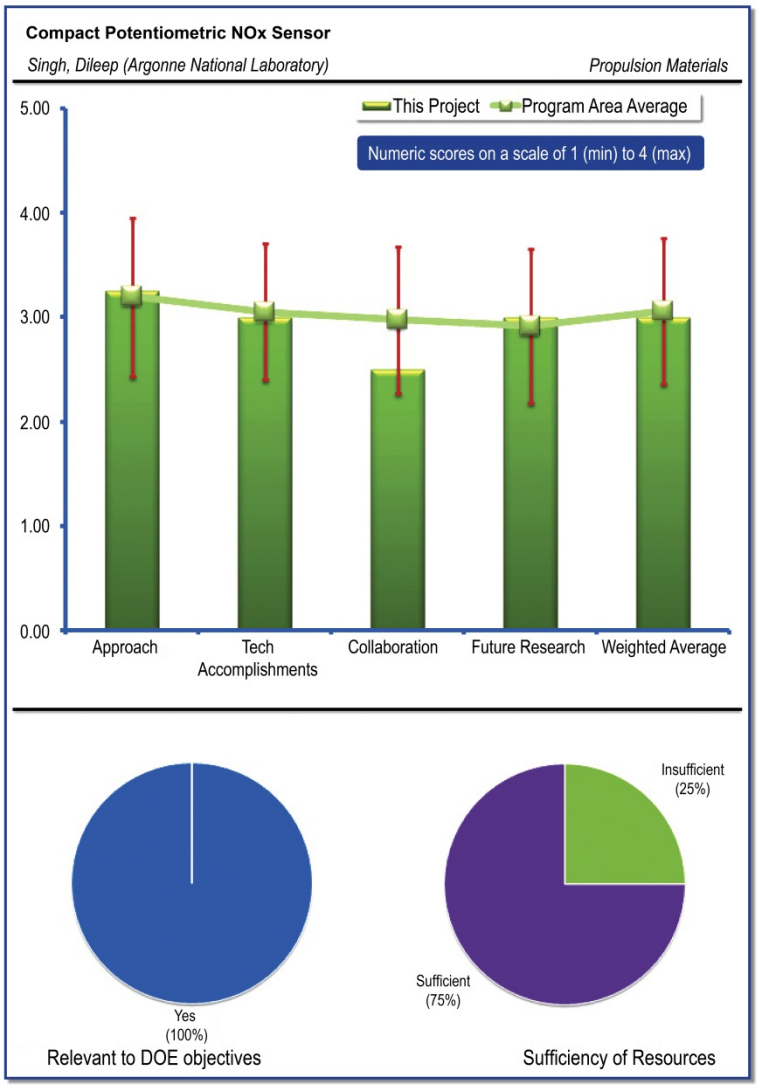
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Three respondents offered views on future research. The first reviewer saw it as a clear follow-up on the work already done. The second evaluator stated that future research appears to be able to accomplish goals. Alternate alloy optimization may be something to consider for additional improvements, assuming that any additional gains would be worthwhile. The third reviewer's response was that the validation plans made sense - downselect using bench tests, perform accelerated wear testing on test rigs, followed by running engine evaluation. A split test might be considered in order to confirm relative improvements in wear rate under the same operating conditions.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers were of the opinion that the resources and budget appear to be sufficient for the scope of this project. The third evaluator qualifies this by stating that the funding level is sufficient up to the point of running engine validation. Engines are expensive and for the fuel to run endurance tests even more so. Funding for validation for release to production is insufficient. It might be mitigated by "piggy back" testing on other tests that are already paid for.

Compact Potentiometric NOx Sensor: Singh, Dileep (Argonne National Laboratory) – pm023



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers explained the project in relation to DOE goals. The first reviewers explained that real-time monitoring of combustion products in the exhaust stream provides information that is critical to controlling combustion, minimizing regulated pollutant production and maximizing combustion efficiency, which minimizes fuel consumption. The second reviewer acknowledged that NOx sensing will enable engine and after treatment control strategies which reduce fuel consumption.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two respondents were pleased with the approach. The first reviewer said that the project appears to be on track for potential prototyping and shoot off testing with other competing technologies in FY12. This reviewer suggested such a shoot off. The second reviewer felt the issues identified to solve materials concerns were good: non-Pt based sensor; optimizing materials; and devising joining methods with zirconia sensor. Missing are critical issues related to automotive applications: performance on an engine for control; repeatability; susceptibility to noise; durability performance in the presence of contaminants; thermal cycling; thermal shock; and water impingement.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that interest of sensor manufacturers in technology and possible licensing agreements indicates technical accomplishments have been significant. The second respondent felt it great work to identify a substitute material. Needed are: performance on an engine for control; repeatability; susceptibility to noise; durability performance in the presence of contaminants; thermal cycling; thermal shock; and water impingement. Most problematic in all previous attempts to make this type of sensor were: durability (cracking, aging performance, loss of coatings, loss of heaters); variation (fresh sensors: sensor to sensor variation aged: Sensor to sensor and degradation factor amplitude / consistency); and signal strength (signal to noise).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent concluded that an identifiable manufacturing and distribution industrial base was apparent. The second panelist thought that the lack of industry support for such a key sensor was striking. Questioned this reviewer, are there no sensor suppliers ready to work together with Argonne to perfect this technology identify true costs?

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The two responses given were positive about future research. The first reviewer stated that the path forward is very good. The second evaluator pointed out that the effort terminates in FY12. As mentioned above, the reviewer suggested a shoot off of best O2/ NOx sensor technology. Tests should include criteria for reliability, durability, and maintainability. Also, ease of servicing and removal, method of manufacturing, availability of materials, and overall cost to manufacture should be evaluated. Consider that this item may be on an engine used in another country with totally different atmospheric standards.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer responded that there has been very good progress and significant technical accomplishments on a relatively modest budget. The second reviewer thought that it will take much more than $100K to truly implement this work, and that additional sources and partners should be pursued.

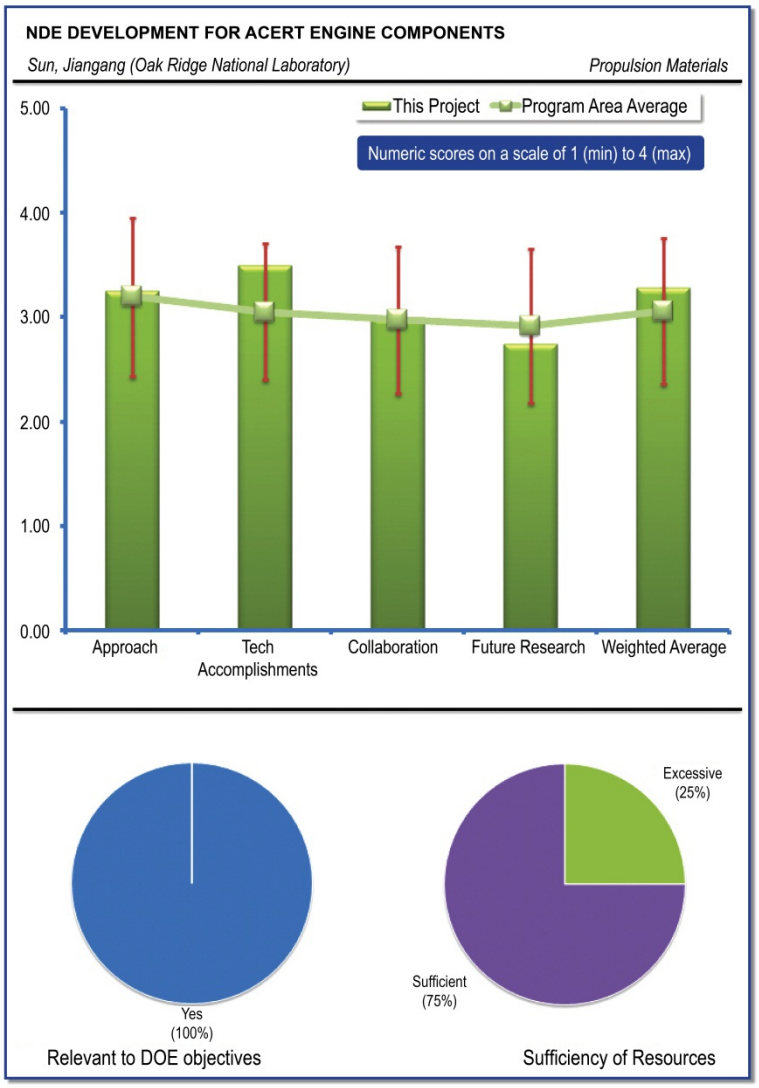
Non-Destructive Evaluation (NDE) Development for Advanced Combustion Emission Reduction Technology (ACERT) Engine Components: Sun, Jiangang (Oak Ridge National Laboratory) – pm024

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three reviewers offered explanations as to how this project enables DOE goals. The first reviewer reported that this is an enabling project. While it will not directly result in energy efficiencies, it will enable the use of designs that will allow greater energy efficiencies. The second evaluator agreed that high temperature materials and processing are key enablers for higher efficiency IC engines. This project prepared tools and has identified one real world solution in turbocharger manufacturing. The third reviewer thought the project supported the DOE objective, but only partially. The presentation suggested a correlation between the NDE for turbine engine components; however, the presentation failed to provide a compelling rationale for any direct correlation to DOE overall goals or petroleum displacement.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Three reviewers were pleased with the approach. The first reviewer thought this project's approach appears to be well focused. A second evaluator agreed with the need for NDE for turbine parts; this supports other turbine engine hardening efforts. The third reviewer found this project to have a perfectly stated and well supported goal, one of the most concise this reviewer had seen: "Develop rapid, reliable, and repeatable NDE methods to support the material enabled high efficiency diesels program (ACERTTM program) to achieve the VT Program Goal of 50% engine efficiency by 2015." The third reviewer also suggested seeking industry input for real world solutions to turbos, structures, and coatings.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Three commentators left positive responses. The first reviewer thought accomplishments have been good, and expected that this NDE procedure can be used for other applications to improve efficiencies as well. A second reviewer felt that using high resolution imaging diagnostic methods were excellent, as well as its correlation to faster, lower cost ultrasonic methods. The third reviewer stated that this effort is part of a CRADA project, and was delivering characterization, in this case NDE. This reviewer thought the development test process was good, and could be used for other materials or products.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Two reviewers left positive comments for this question. The first reviewer thought that collaboration is very good. A second panelist stated that this effort leveraged technology and know-how from medical imaging to improve results. This project was focusing on needs of industry through Cummins partner as well as universal applications. The third reviewer commented that collaboration was limited to one manufacturer and ORNL.

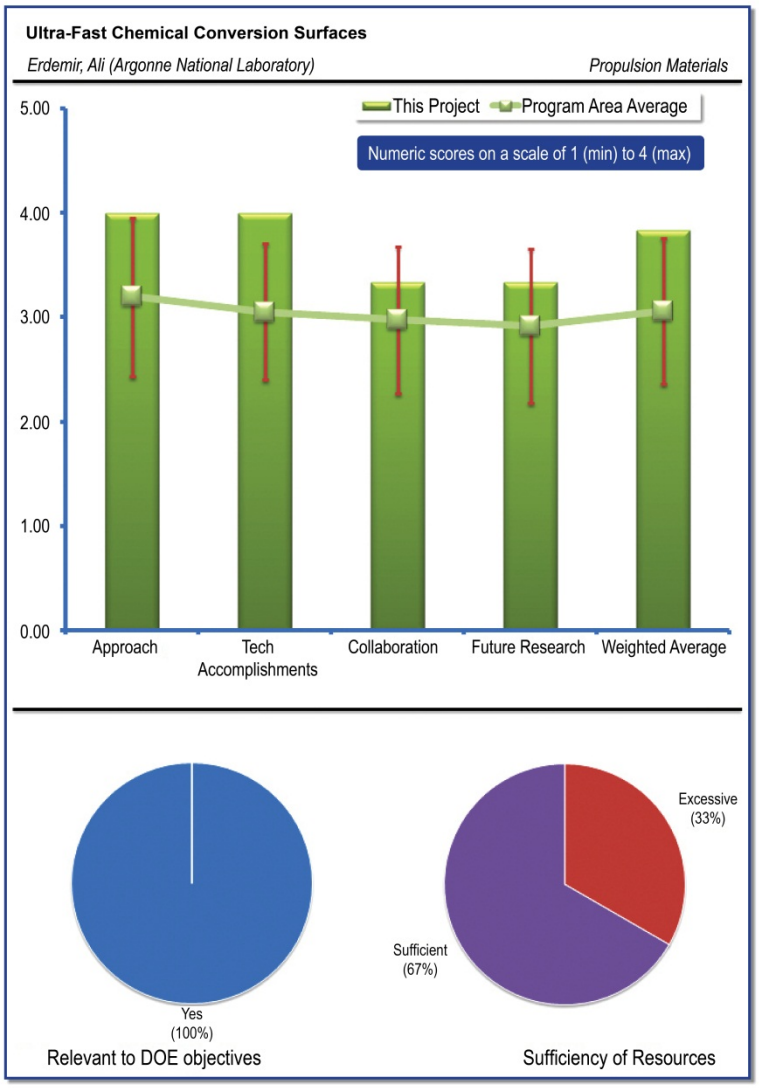
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Three reviewers were pleased with the future research. The first reviewer felt that proposed future research is well focused. If these NDE methods can be used to evaluate other joining methods not covered by the scope of this project, there may be more applications to consider (e.g., the evaluation of spot welds). A second panelist was of the opinion that this researcher was performing excellent activities, and that follow on was needed for expanded scope and use of x-ray and ultrasonic NDE. The third evaluator stated that the presentation indicated the project is at 80% funding while indicating continued efforts through FY15. He suggested a review of the continued relevance to DOE goals.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer reported that the resources appeared to be sufficient for the defined project. The second panelist thought the project to be well funded, but additional funding could be used for expanded scope with additional manufacturers to refine the x-ray / Ultrasonic NDE and database for characterization of material properties, joining, and durability.

Ultra-Fast Chemical Conversion Surfaces: Erdemir, Ali (Argonne National Laboratory) – pm027



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that it supports DOE goals indirectly. The overall result is enhanced durability and service life. Bluntly, the process will make the borided surface harder with less friction thus increasing the engine efficiency. A second evaluator confirmed that the project at this time indirectly supports the objective of petroleum displacement. The focus is on a process technology. The objective will be met when the tribological properties and cost to implement align with commercial production. The final panelist stated that reduction of friction in engines will increase their mechanical efficiency, permitting more of the fuel energy released to be delivered to the drivetrain. Reduced wear will permit this advantage to be maintained over a greater part of the engine life.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The three reviewers had positive remarks about the approach. The first reviewer reported no apparent technical barriers, and suggested prioritizing the work to boride critical parts while scaling up for other, larger engine components. The second reviewer found the approach to be very well focused as far a process technology development project. At that time, there was little mention of how/where the surface modification will ultimately affect wear or friction. This should be added to the plan as a future phase. The third reviewer thought that the approach to this work appears to offer the promise of a process readily adaptable to the requirements of the automotive industry and effective in meeting the goals of wear resistance and friction reduction.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that once the development thrust is prioritized to specific engine parts, the developer should consider if the project could be accelerated and by how much. Additionally, if the process is successful on specific parts, then by analogy the same could be said of larger parts. This may only require emphasis on the scale up and the establishing of manufacturing quality control standards. The second reviewer's score was based on the process development, as the application was not well addressed. Process - The accomplishments are promising so far. The ability to batch process as well as not requiring a line of sight for application gave this process a distinct advantage over other processes. Application - At present, the project might be considered to be a process looking for an application. The underlying hypothesis of improving wear and friction seems to be "try it and see." This impression can be addressed by more clearly articulating plans for post process development.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

All three reviewers saw potential for more collaboration. The first reviewer said that at this time, coordination is limited the national lab and one contractor. Project seems to indicate potential for other manufacturers once the process has demonstrated full scale up operation and production. The second panelist thought that for the process and its development, collaboration with industry is appropriate. It would help to align with a component supplier or engine manufacturer to assist with application selection, design requirements, operating conditions, and validation. The third reviewer relayed that only one industry collaborator was named, but participation by "others" was mentioned.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said that given the project plan in the presentation and the comments above on prioritization and simultaneous scale up, this reviewer suggests the project could transition to industry in late FY12 or early FY13. The reviewer also suggested the project re-evaluate its milestones for early FY13 transition to industry, and that DOE review the project in FY12 for potential of completion in FY13. The second commenter responded that no specific components or tribological interfaces were defined, nor were the failure modes that may be affected explicitly addressed. This may be due to where the project presently resides in process development. The commenter would have expected articulation of one or more candidate applications, with a description of the issue to be addressed and the outcome anticipated.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One respondent remarked that resources look appropriate. Another reviewer asked that given the excellent progress made to date, could this project be terminated and the process and results turned over to industry before the scheduled 2014 end date? Doing so would conserve DOE funds and it would appear that industry interest should be high.

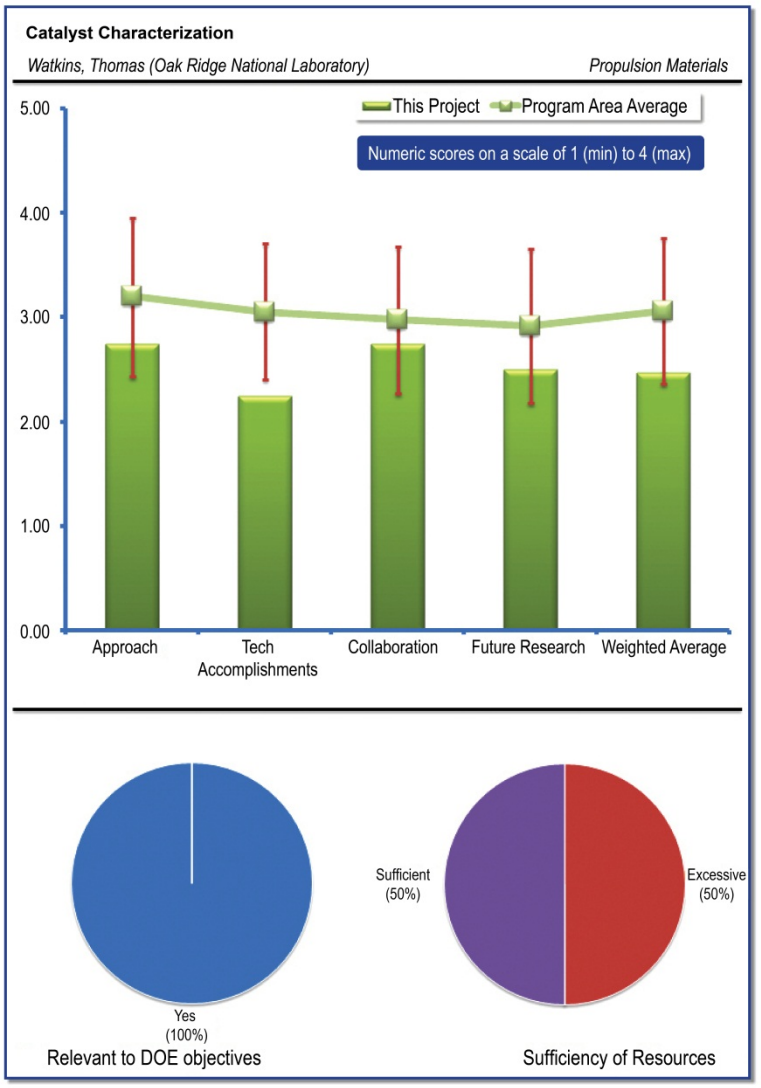
Catalyst Characterization: Watkins, Thomas (Oak Ridge National Laboratory) – pm028

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three reviewers explained how the DOE objective relates. The first reviewer claimed that a better understanding of NOx control over the lifetime of the catalyst will widen the operating window of the combustion system leading to reduction of fuel consumption. A second commenter explained that advanced catalyst formulations enable use of lean combustion technologies and limited fuel penalty due to regeneration, flow restriction, or durability life issues can result in petroleum displacement. The third evaluator stated that, in common with other catalyst characterization projects, this project can be expected to support the DOE petroleum conservation goal indirectly by (possibly) enabling effective emission control of alternative-combustion-regime engines. The current and planned objectives of this research vis-a-vis ammonia slip catalysts specifically; however, seems to this reviewer to be unrelated to petroleum displacement. Presumably, the project, now entering its ninth year, has dealt previously with technical issues of greater relevance to the DOE goal.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Commenters praised the approach. The first reviewer said that the chosen approach is solid: Characterization of the material after several stages is a proven approach. Difficulty remains in predicting the outcome. The second commenter deemed the approach to be well known and reasonable: test catalysts to understand atomic mechanisms for adsorption and aging; seek the atomic mechanisms and chemistry of adsorption and regeneration processes; seek to understand the thermal and hydrothermal aging processes and other degradation mechanisms throughout the lifecycle of the catalytic material.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Of the four commenting reviewers, only one thought progress was good, clarifying that it is in comparison to the somewhat poor 2009 results. First ideas to improve have been generated. A second reviewer reported that this is a ten-year, five million dollar program, and this reviewer would have liked to see where these catalysts are implemented and show the investment impact. It was not clear. A third panelist commented that there were no significant findings here for broad applicability. Claimed contribution to improvement of Dodge Pickup after-treatment was vague and not well supported. The fourth reviewer pointed out that concerning ammonia slip catalysts specifically, as the presentation notes, ammonia is not currently a regulated automotive engine emission. Moreover, this

reviewer is not aware that engine and vehicle manufacturers regard current means of controlling ammonia slip as inadequate or punitively expensive.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought OEM and supplier partners were good (being Cummins and Johnson Matthey). The second reviewer stated that good collaboration is established. The consortium has a good mix of OEM, Tier 1 and research institutions. The final reviewer felt that although Johnson Matthey is a logical and potentially valuable collaborator in any catalyst characterization project, the presentation did not suggest that company's involvement goes beyond technical consultation and information exchange. Cummins' motivation for involvement in this subject area is obvious, but Cummins is a catalyst user, not a catalyst producer.

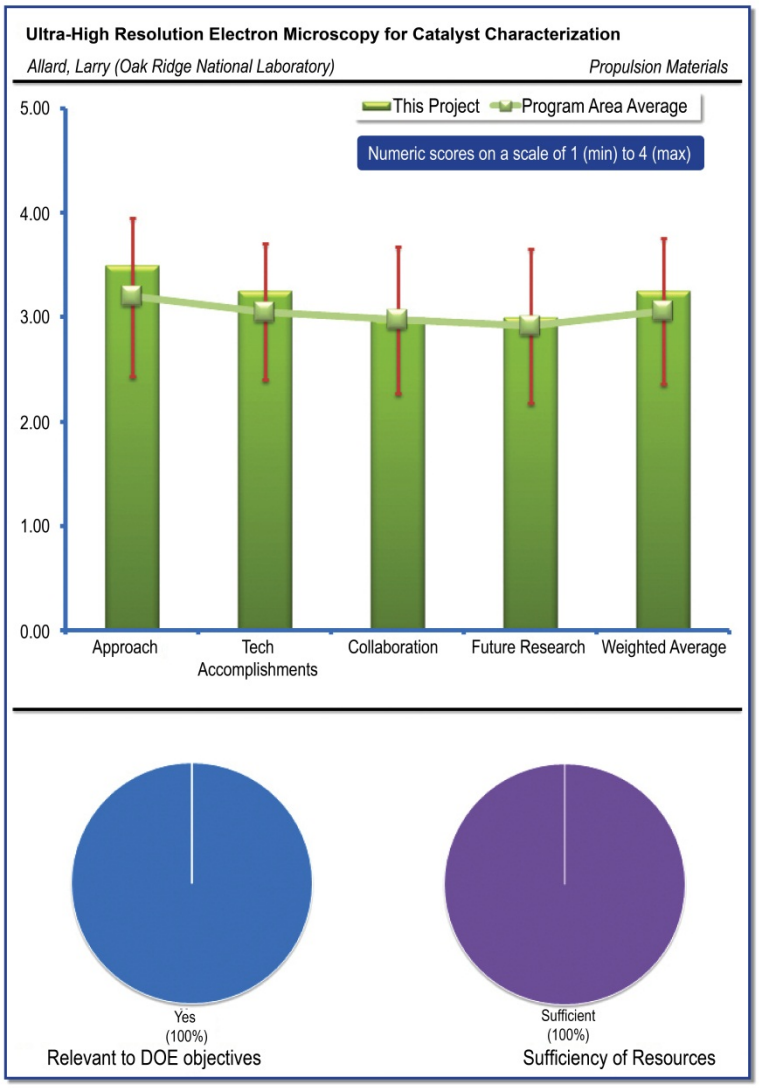
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two commentators thought follow-up appears reasonable, and the third raised questions. The first reviewer said that the future work appears to be a straightforward follow up on the results booked so far. The second reviewer was of the opinion that the proposed follow-on work for the next year is a logical extension of the work reported; however, the third item: "Assist Cummins to competitively produce engines which attain the required prevailing emissions standards etc., etc." strikes this reviewer as an excessively narrowly focused objective. Cummins' support of this project has been substantial (> $2M), but one would hope that ORNL would aim its efforts more broadly at the engine/vehicle manufacturing community. The third evaluator expressed concern that most of future work has vague language or work which appears to be outside of the scope of the project. More powerful is "Lifetime prediction Model to be available for ammonia oxidation (AMOX) catalyst after hydrothermal aging studies complete. Model will be able to predict xxx for use by xxx design engineers to optimize catalyst formulations including wash coat, loading, and substrate. Utilize in situ capabilities to xxxx? Assist Cummins to competitively produce engines by date?

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer considered the resources to be sufficient for the characterizing activities. A second reviewer thought that based on the 2011 presentation and the work reported, the funding level seemed excessive for the scope of the work and its stated aims. The third reviewer believed that DOE should consider if this project may be included with other similar projects with larger scope/ goals and higher division of labor/ more collaborations.

Ultra-High Resolution Electron Microscopy for Catalyst Characterization: Allard, Larry (Oak Ridge National Laboratory) – pm029



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three reviewers explained how this project meets DOE objectives. The first reviewer stated that in common with most catalyst characterization studies, this project will eventually support the DOE petroleum displacement goal indirectly if its results can enable commercialization of alternative-combustion-regime engines or other technologies that increase the efficiency of prime movers or (perhaps) petroleum refining so as to increase yields of transportation fuels from crude. The second reviewer saw some potential reduction in fuel consumption with advances in catalyst technologies to address NOx with reduced or eliminated regeneration. The third panelist considered catalysts necessary for the operation and improved efficiency of diesel engines.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer relayed that the project is developing processes and attachments for electron microscopes for analysis of reactions. The technique can be used for other applications even beyond the vehicle technology area. A second opinion was that ultimately, it is necessary to understand catalytic processes and mechanisms at the atomic level, where they occur. Sub-Angstrom microscopy is one of a very few available tools to enable such understanding. The third reviewer stated that this project's goal is to focus on understanding and modeling of catalytic processes at atomic level and in use.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent thought that reasonable developments have been achieved over the last year. A second reviewer commented that the discussion and clear depiction of the reaction rates single atoms vs. clusters vs. typical catalysts was nicely done. The third reviewer relayed that "test equipment to measure in situ results has been achieved: Gen 3 environmental cell capability." This may enable other critical research to multiply output. Specific optimizations or improvements in material technology should be mentioned or discussed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two panelists mentioned the impressive list of partners. The first reviewer thought that collaboration was excellent, and that the project had support from many stakeholders and researchers, as indicated from the presentation. The second panelist thought that the

presentation was heavily oriented toward technical accomplishments and descriptions of experimental apparatus and techniques. Therefore it was difficult to assess the degree of coordination with the impressive list of "partners" other than ProtoChips.

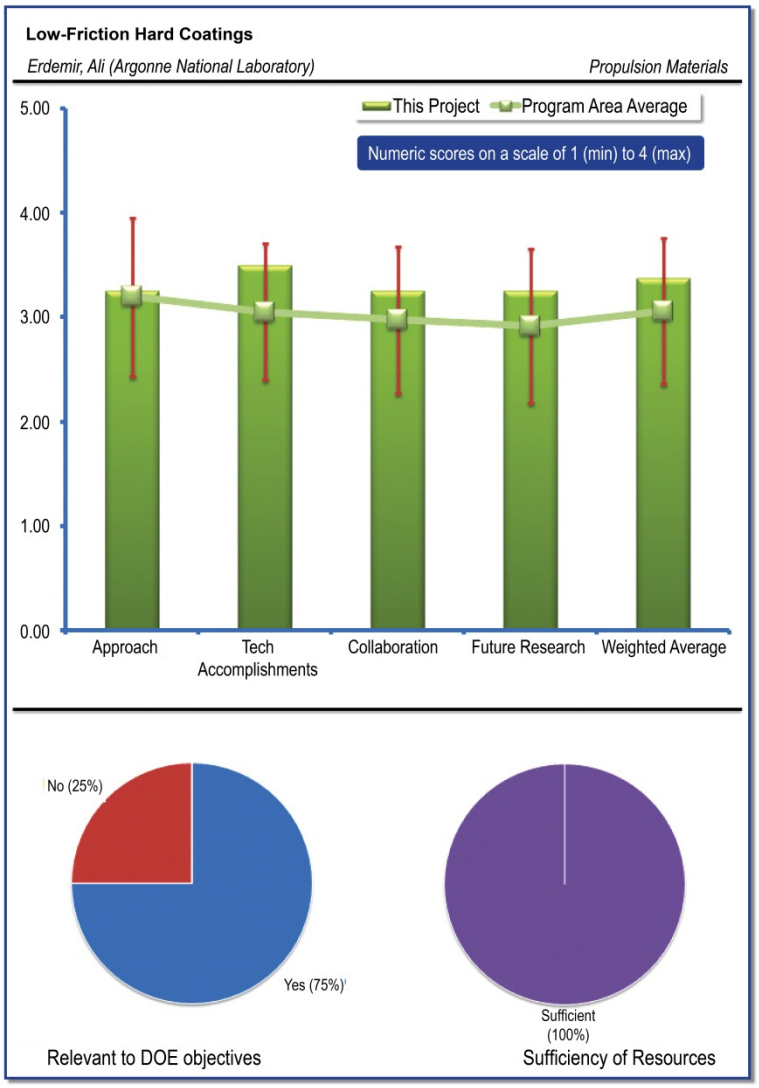
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The two responses for future research were positive. A first reviewer said: Excellent. Expanded capability for static and dynamic flow, nano particles, and dispersed catalytic species. The second reviewer commented that proposed future work seems to be essentially "more of the same." Given the impressive technical achievements of the past year's work, this is probably the appropriate approach.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first panelist reported that funding had been increased from DOE but the amount of leverage from external partners is minimal. A second panelist hoped private-sector collaborators in the coming years work will offer increased cost sharing.

Low-Friction Hard Coatings: Erdemir, Ali (Argonne National Laboratory) – pm030



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that reduction of engine and drivetrain friction is a straightforward way to increase drivetrain mechanical efficiency, which will directly reduce fuel consumption. Increasing the durability and performance retention of anti-friction-treated drivetrain parts will permit this fuel economy advantage to be retained over the useful life of the vehicle. A second reviewer thought that reducing the friction in engine components can improve efficiency but the technology may be far from application. A third reviewer concluded the goal of this project was to design, develop, and implement low-friction and super-hard coatings to increase fuel economy, durability, and environmental compatibility of advanced engine systems. The final reviewer stated that this project enables the use of efficient, longer lasting designs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer predicted that the field trials and dynamometer tests being conducted will provide performance data under actual life conditions. A second reviewer claimed that the results of the approach to this work speak for themselves. A third reviewer considered the project approach to be well thought out. The fourth reviewer thought the approaches to be good and logical: the steps being to identify and optimize deposition conditions that are most critical in physical, mechanical, and tribological properties of super hard and low friction coatings; develop reliable deposition protocols for large-scale manufacturing of MoN-Cu and near-frictionless diamond like carbon coatings; demonstrate durability and performance in engine applications; and demonstrate large-scale production, cost competitiveness, and commercial viability.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two of the three respondents found good progress, the third questions the applicability. The first reviewer thought the accomplishments and progress to be excellent. A second reviewer said that outstanding progress was made in many fronts: Successful demonstration of superhard nanocomponent (SHNC) coatings on a large number of actual engine parts using lab-and commercial-scale deposition systems with production-scale loads; verification of superior tribological properties of SHNC coatings in a variety of engine components; validation of superior performance in field and fleet of cars (currently underway); and scale-up and commercialization efforts in their final stages. The third reviewer relayed that the coatings are reported to induce severe wear on other surfaces; if this is the case then application of these coatings on some surfaces will reduce the tolerances and cause loss of efficiency. Patent applications can indicate the innovativeness of the process but not the applicability of the technology.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

All four reviewers thought collaboration to be good, while one wondered about unnamed OEMs. The first panelist stated that collaboration is excellent with firms and organizations able to test the results of this project under field conditions. A second reviewer thought that collaboration appeared to be appropriate for this project. A third evaluator felt there was great collaboration among Argonne, coater, and many engine OEM's: Galleon International – Hauzer Techno Coating – Several engine OEMs, including transaxle and fuel injection system manufacturers, engine part suppliers, racing teams, and car manufacturers – and Argonne National Laboratory. The fourth reviewer reported the presentation mentioned talking with many OEMs, but no names were provided. Two companies, coating developers are involved indicating the usefulness of the technology.

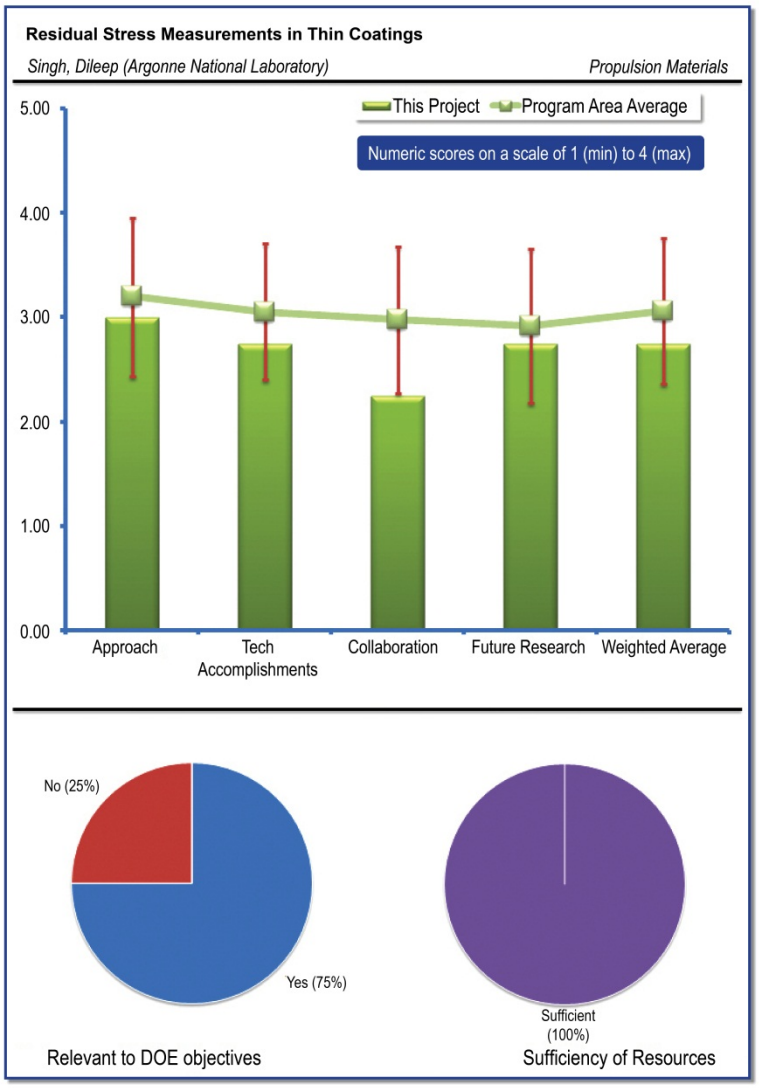
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Two commentators liked proposed research. The first reviewer thought this project was well laid out. The future work is well defined and appears to be appropriate. The second reviewer responded that the proposed future research looked good. Long-term durability of the coating under actual engine operation conditions is still yet to be demonstrated. The actual benefits of fuel consumption data need to be gathered, and the project needs to show the cost benefits of this new coating process.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated that resources appear to be appropriate for this project.

Residual Stress Measurements in Thin Coatings: Singh, Dileep (Argonne National Laboratory) – pm031



REVIEWER SAMPLE SIZE

This project had a total of four reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

Reviewer feedback was positive. The first reviewer thought that this project does not appear directly to support petroleum displacement, but as it complements other work in the area of low-friction, high-durability coatings for drivetrain parts, it can be viewed as indirectly supporting such goals. A second reviewer commented that this is an enabling technique that allows accurate measurements of thin coatings that can be used to reduce friction and wear of engine components. A third reviewer agreed that this is an enabling project which will enable design efficiencies through the better use of coatings. The final reviewer felt that the friction reduction coating process was far from the application in real life conditions. Any savings proposed will not be realized in a short time.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

Two of three responses praised the approach, the first reviewer claiming that the approach appears to be excellent, and the other evaluator said that the following approach looks fine. The key challenge will be how to correlate the measurements to the actual durability of coating. The second reviewer also went on to suggest developing or refining high energy x-rays for profiling residual strains in thin coatings by measuring the change in the lattice parameter of the coating constituents, depositing low friction high wear resistance coatings and profile residual stresses, developing nanoindentation & scratch-based techniques to measure hardness, fracture toughness, and adhesion energy of thin coatings, and relating residual stresses, mechanical & tribological properties, and processing to coating durability. The third reviewer stated that this project used various testing methods and characterization technologies to measure the quality of the coatings on surfaces. It was claimed, though not explained, that the residual stresses are important in controlling the performance of anti-friction coatings.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Two of the three responding panelists saw progress. The first reviewer responded that progress toward improving adhesion through measurement of residual stresses appears to be very good. A second reviewer saw good progress made in the project: Cross-sectional micro-diffraction have been used for studying strain gradient in nanocrystalline MoNCu films deposited on silicon and steel substrates. As-deposited MoN film is under in-plane compression; effects of Cu additions on coating adhesion and tribological performance was investigated; and coating processing variables and resulting properties are correlated to their structure and can be

used to optimized for enhanced tribological performance by optimizing adhesion energy. The third reviewer thought that the interface between the substrate and the coating is not explained well but the quality of the coating was analyzed; the reason for spalling needs to be related to the interface strength.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought that collaboration appears appropriate for this project. A second reviewer stated that this effort has some partners who had provided coatings for evaluation, as well as internal collaboration with other groups in ORNL. A third panelist concluded per the presentation that collaboration with industrial organizations will increase in the coming year. To date, however, there did not appear to have been strong collaboration/coordination with other institutions and organizations. The final panelist felt that this project was mainly to support another internal project within ANL, and that the project needs to seek industrial partners.

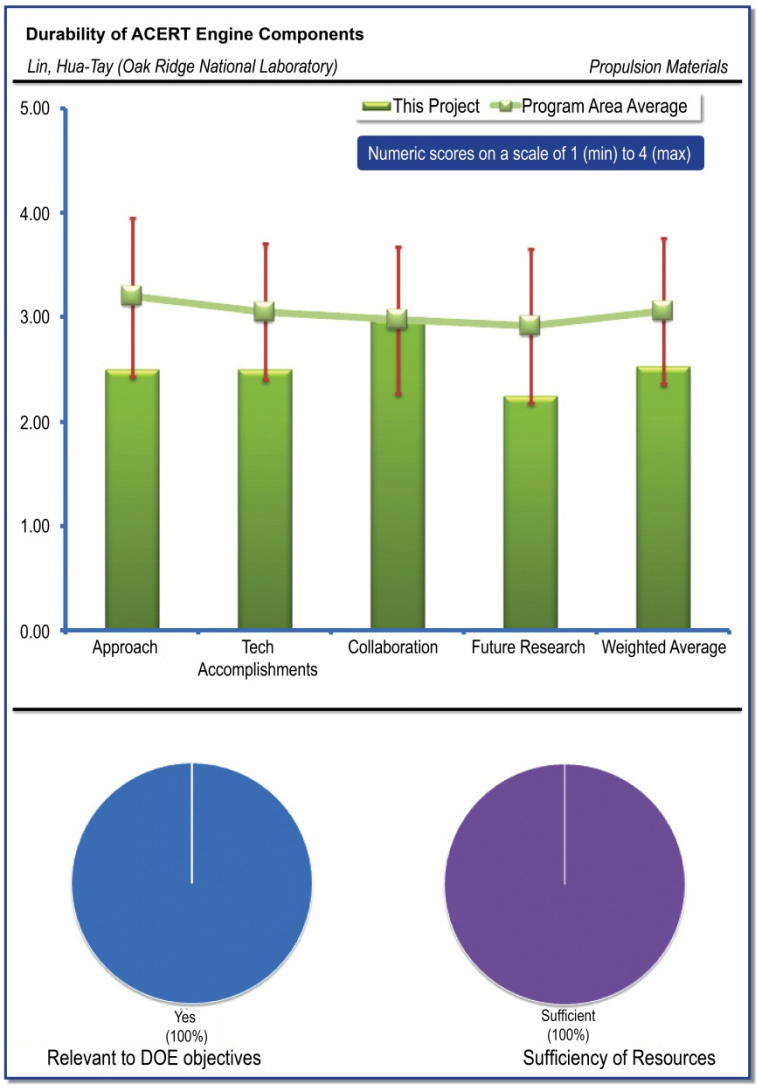
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers liked the proposed future research. One reviewer said that future work proposed appears to be well laid out. The other evaluator thought the proposed future approach looks fine. The proposed future research is to include: Complete adhesion energy evaluations for TiC and ZrN; complete mechanical properties of TiC and ZrN coated samples for varying processing conditions; measurement tribological performance for TiC, and ZrN coated samples; correlation of the measured residual stresses in ZrN, TiC coatings to tribological properties and processing; and initiation of discussions with coating manufacturers for collaboration.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer responded that resources appear to be appropriate for this project.

Durability of Advanced Combustion Emission Reduction Technology (ACERT) Engine Components: Lin, Hua-Tay (Oak Ridge National Laboratory) – pm033



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that improving the thermal efficiency of engines can contribute significantly to the petroleum displacement. A second reviewer considered there to be several elements to this research, one of which is application of thermal barrier coatings to an exhaust manifold. Fuel efficiency will be improved by preserving thermal energy for downstream turbomachinery and, in the near future, waste-heat recovery systems. The final commenter thought that this program, now apparently complete, was relevant to DOE's petroleum conservation goal since it explored means to protect HDD engine components from higher temperatures resulting from operation either in new combustion regimes or from straightforward high-temperature/pressure operation, both of which can increase thermal efficiency and/or power density. The final reviewer also thought that it was unusual to review a project retrospectively when all chance of modifying its direction or approach was gone. Though the reviewer acknowledged that this exercise was not necessarily without value, as it may yet offer insights into how future projects of a similar nature can be improved, the reviewer opined that it is kind of weird, nonetheless.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A range of sentiments from three reviewers were expressed. The first reviewer responded that the project objective is to examine the cause of failure in material used for components in diesel engines. Diverse examples are presented including testing of ceramic materials and thermal barrier coatings. A second panelist concluded that the approach employed in this project probably should be evaluated as lying somewhere between "good" and "outstanding"; “very good," perhaps. The third evaluator thought that the 2011 presentation did not convey a well-focused approach. Work jumped from exhaust valves to turbocharger wheels to exhaust manifolds. Any of these would have been worthy of a separate project. This impression may simply be a consequence of how the presentation was constructed as a summary of research effort over the life of the project. The approach has the flavor of guess and try, which is especially evident in the exhaust manifold thermal barrier coating (“we tried a coating and it spalled”). A deliberate approach based on the underlying physics was not obviously conveyed by the presentation. Research aimed at an understanding of the physics became more evident in the development of the Al-oxide coating and process.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first observer felt that some good work has resulted from this project. Durable thermal barrier coatings can be of immediate benefit to fuel efficiency. The benefit from the exhaust valve work (beyond speculation of durability of alternate materials) and the turbocharger wheel work is not evident in the presentation. A possible outcome is that the knowledge and learnings gained in the work on these two components are not documented and shared beyond the one industrial partner. It is possible that this was done in the earlier years of this project. If so, the current presentation is just deficient in summarizing the technical findings. The second reviewer found that the technical accomplishments were probably useful, ultimately, despite the results, which appear to have been somewhat disappointing. Is there ongoing effort to evaluate ORNL's alternative thermal barrier coating technique? The performance of the thermal barrier coating (TBC) assessed in this program appears to have been unacceptable for industrial application. The final reviewer stated that the project is mostly characterization and testing of various materials used in engines. No conclusions are drawn from the failure of TBC or the fatigue failure of ceramic valves. This was a very simple testing and data analysis project. A new coating process has been reported as developed at ORNL. Is there any Intellectual Property (IP) protection process being followed for this new invention?

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first evaluator stated that this project was part of a CRADA and only one OEM is involved. A second commentator thought that collaboration was clearly evident with the industrial partner Caterpillar. The third reviewer deemed that the collaboration with a HDD engine manufacturer was appropriate. However, the specific industrial partner has since exited the on-highway truck engine market in the USA.

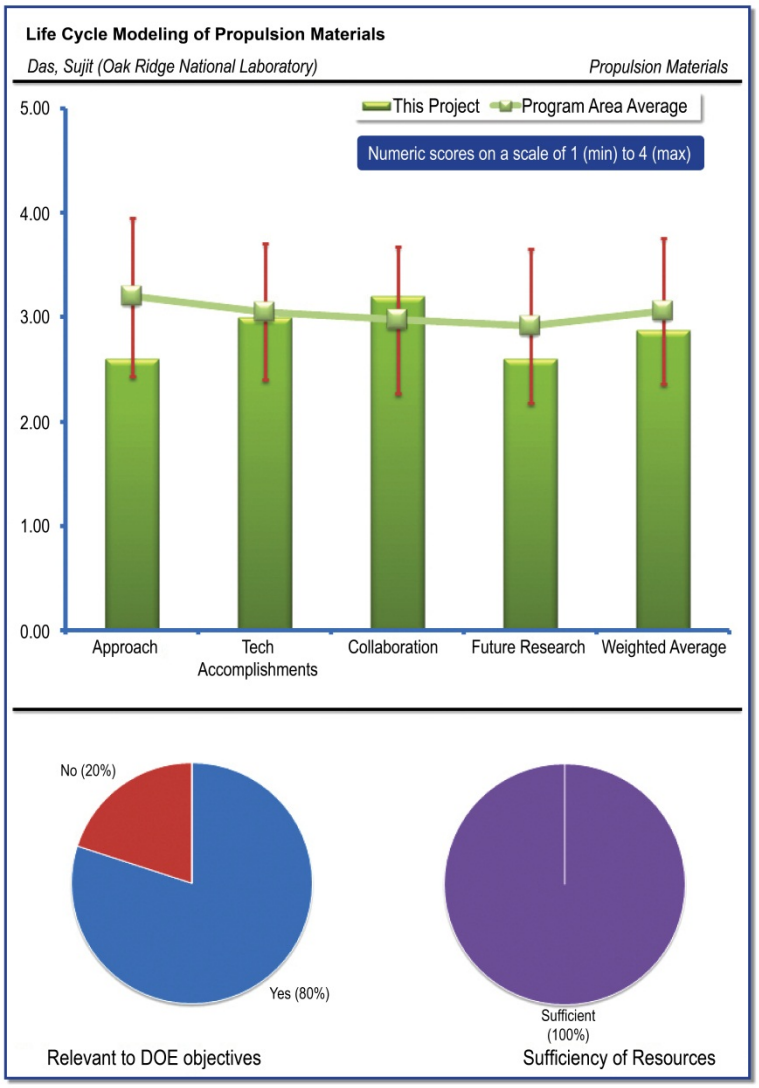
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The first commenter stated that this project was listed as completed in September 2010. Future plans are for development and commercialization by the industrial partner. The second commenter reiterated that this was a completed project, and a third evaluator reported that no follow-on work was presented.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer commented that the Al-oxide coating looks promising. This reviewer does not think the coating’s performance or process was developed as far as would be required for commercial application. The project scope leaves this in the hands of the industrial partner.

Life Cycle Modeling of Propulsion Materials: Das, Sujit (Oak Ridge National Laboratory) – pm034



Reviewer Sample Size

This project had a total of five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Only one reviewer directly disputed this project's support of DOE goals. A first reviewer stated that this project looks at the impact of lightweighting versus using lightweight materials on the GHG and fuel consumption of the engines. A second evaluator believed that either downsizing or lightweighting will lead to DOE's objective of improved fuel efficiency. This project attempts to quantify which approach may be better and under what circumstances and assumptions. The project has a second goal of understanding the energy benefits of CF8C+ cast austenitic stainless steel. The third reviewer commented that the project enables a cost optimized choice of future materials options and design principles, which is critical information for bringing the innovations to the market and reducing fuel consumption. The final reviewer said that it was difficult to see how this project supports the DOE goal of petroleum displacement, even indirectly. While life-cycle analysis of the relative fuel consumption/energy/environmental benefits of vehicle lightweighting vs. engine downsizing, etc. is potentially illuminating, this project is unlikely to influence those decisions, which will be made by individual vehicle/engine builders based on a host of factors of which life cycle (LC) is only one. Nonetheless, the stark contrast in life-cycle costs and environmental impacts of engine turbocharging/downsizing vs. engine lightweighting is significant and probably worth considering in other Propulsion Materials projects. The same is true of the project's findings concerning the LC impacts of magnesium in engine construction.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A variety of comments were made by four reviewers. The first reviewer thought that a lot of assumptions were made in doing the life cycle modeling in determining GHG emission and cost benefits. The second panelist concluded that this project takes a systems level view to the effectiveness of an approach for achieving fuel efficiency. It is important to look at more than one component in isolation. The third evaluator felt the approach to be straightforward, however, a larger sample size for establishing the baseline and downsized engines would increase the insight and value of the outcome of the project. The fourth reviewer was left wondering why one of the project's two focuses was on utility steam and combustion turbine construction materials when the project is sponsored by the Vehicle Technologies Program.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first of four responding panelists thought that good progress was made, especially with respect to the comparison between baseline and downsized. The energy saving prediction for CF8C+ for 2020 to 2025 should take into account that new material developments will occur. Most likely more cost effective material solutions will become available or engine developments may ask for new solutions. The second reviewer concluded that some progress was made in doing life cycle analysis on lightweighting versus downsizing. It is interesting to see that there was only 1% fuel economy improvement by substituting lightweight materials. The second reviewer found it interesting that life- cycle modeling determined the relative energy, GHG emissions, and cost-effectiveness benefits of two competing lightweighting engine design options, i.e., downsized and turbocharged vs. lightweighting using magnesium; F8C+ has been demonstrated successful in several high-temperature applications, including its cost-effectiveness and so a life cycle energy assessment in potential future markets is consequential; and that several analysis levels considered, starting with raw material manufacturing and ending with component use and recycling. The third panelist reported that the project reached a conclusion that engine downsizing is a preferred approach compared to component lightweighting from both energy and cost perspectives. This conclusion is logical and is consistent with how the market is moving.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Responding reviewers saw good collaboration. The first panelist thought that while most of the work seemed to have been done by ORNL, the level of collaboration is appropriate for a project of this nature. The partners are serving as sources of information and review of work. The second observer reported that a large consortium is contributing to this project with a good representation of the value chain. The third reviewer stated that there was good collaboration among several entities: Honeywell Turbo Technologies – identification of market and energy savings potential of CF8C+ in automotive market; Siemens –turbine manufacturer; MetalTek International –high alloy casting components manufacturer; FEV Inc. –turbocharged and diesel automotive engine manufacturer; University of Tennessee, Knoxville, TN –life cycle analysis of alternative lightweight engine designs; and several high alloy raw material and component manufacturing suppliers

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Four reviewers saw logical plans, although one questioned the premise, and the fifth offered future direction. The first reviewer considered the plans to evaluate the life cycle costs of higher capability materials to be consistent with the industry direction moving towards higher operating temperatures and pressures. The second analyst thought the topics mentioned were of clear interest and built on already available results. For this specific project it was difficult to assess the relation with the plan since it has no clear finishing date. The third observer saw a good future plan including life cycle impacts of alternative materials and materials-processing techniques that enable development of higher-efficiency conventional powertrains for ground transportation; viability of advanced propulsion materials in advanced powertrains such as hybrids and fuel cell vehicles; life cycle analyses considering economic, energy, and environmental impacts of advanced propulsion materials' manufacturing technologies with an emphasis on aluminum, magnesium, titanium, and ceramics; and advanced propulsion materials' potential in heavy-duty vehicles. The fourth panelist expressed continuing concerns regarding the premise of the work itself, although the proposed future research follows logically from the results of work performed to date. The final reviewer suggested that methods for assessing durability and cost-effectiveness needed be considered for future analysis.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One commenter thought the level of resources to be sufficient for a project of this type. Another reviewer said the budget must be sufficient for this amount of analysis. A third reviewer thought funding for work performed to date and proposed future research in this area is at least sufficient, if it is granted that the work contributes meaningfully to the attainment of DOE/EERE goals.

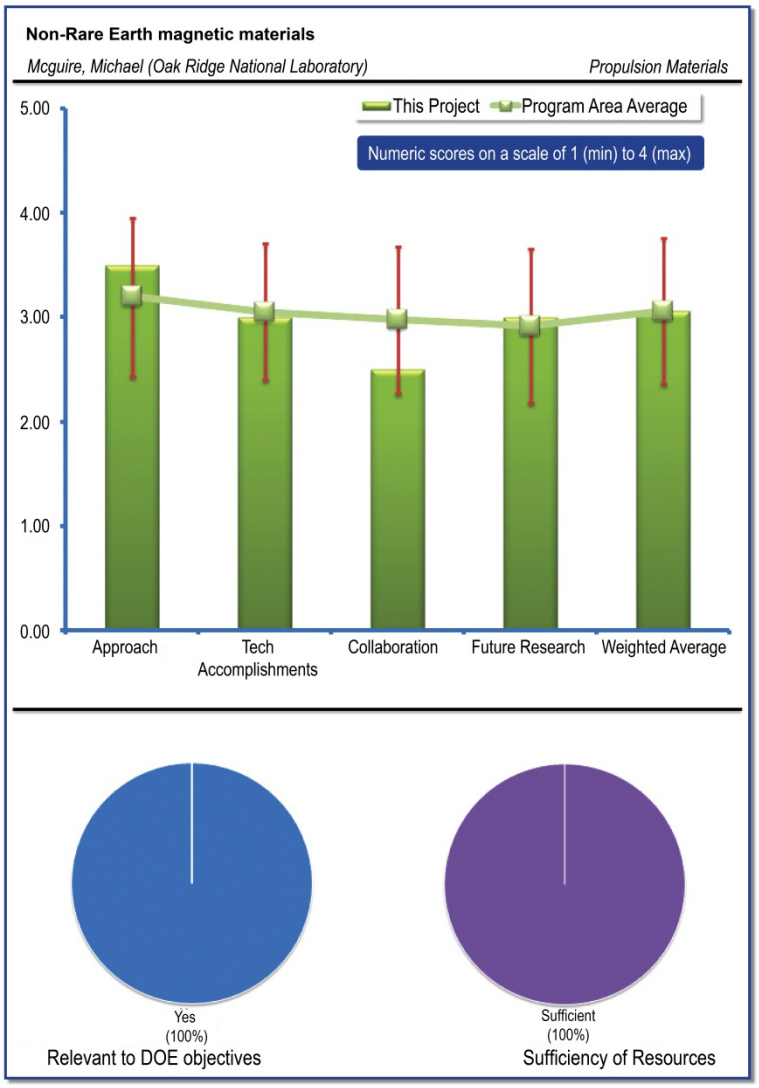
Non-Rare Earth Magnetic Materials: Mcguire, Michael (Oak Ridge National Laboratory) – pm035

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Three evaluators explained how this project supports DOE objectives. The first reviewer thought this project to be highly relevant, supporting DOE goal of petroleum displacement and dependence on petroleum products. The second evaluator stated that reducing or eliminating rare earth materials can have significant impact on reducing the traction motor's cost. The third reviewer explained that high-performance permanent magnets represent are a very large factor in the cost of electric motors for electric and hybrid-electric vehicles, which is a major barrier to their wider adoption. EVs and HEVs, if deployed in significant numbers could effect considerable petroleum displacement. The cost of rare earth elements in turn is a significant factor in the cost of high-performance permanent magnets. Moreover, according to this reviewer, rare earth elements are obtained largely from non-domestic sources at present, and this isn't expected to change much anytime soon. Therefore, determining if effective, domestically available and lower-cost substitutes to these materials can be found is important.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first of three commentators stated that establishing a go/no go decision point in the next year of the project is an excellent idea. By that time, it should be clear whether the project approach is worth pursuing. The second reviewer thought the approach appeared to be technically sound. This reviewer suggested that while trying to identify the magnetic material, investigators should consider how to manufacture the end composition magnet and to what quality control standard. This may be a high risk/high payoff effort, but the effort could only produce a laboratory curiosity if the end product magnet cannot be produced on a large scale. The third panelist claimed not to be an expert on the topic, but it seemed that the material scanning/selection process is done in a methodical well thought through way.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer reported good progress in producing samples of various materials and quantifying the properties. The second panelist thought that while the overall project is technically sound, the accomplishments suggest significant hurdles to overcome - beginning with the optimum crystal composition. No suggestion on any other elemental combinations. The second reviewer did suggest reviewing any strategic ores for possible sources of scarce elements. The third respondent agreed that, as the author indicates,

"It is likely that the most significant advances will come with the discovery of entirely new materials." This program had a good start on addressing this critical issue of non-rare earth element magnetics.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers suggested expanding collaboration. The first reviewer thought this effort needs to be more coordinated with the efforts taking place at Ames National Lab trying to solve the same problem. The second reviewer stated that this project seems to be conducted wholly within ORNL and the OR Associated Universities. This is not necessarily a criticism; wider collaboration may not be advisable or necessary.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter acknowledged that there does not appear to be any great interest at this time. Interest may depend upon achieving an optimum magnetic crystal composition. The second reviewer thought there was good recognition of the possibility of requiring new materials, and planning on doing this in FY2012.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were made on resources.

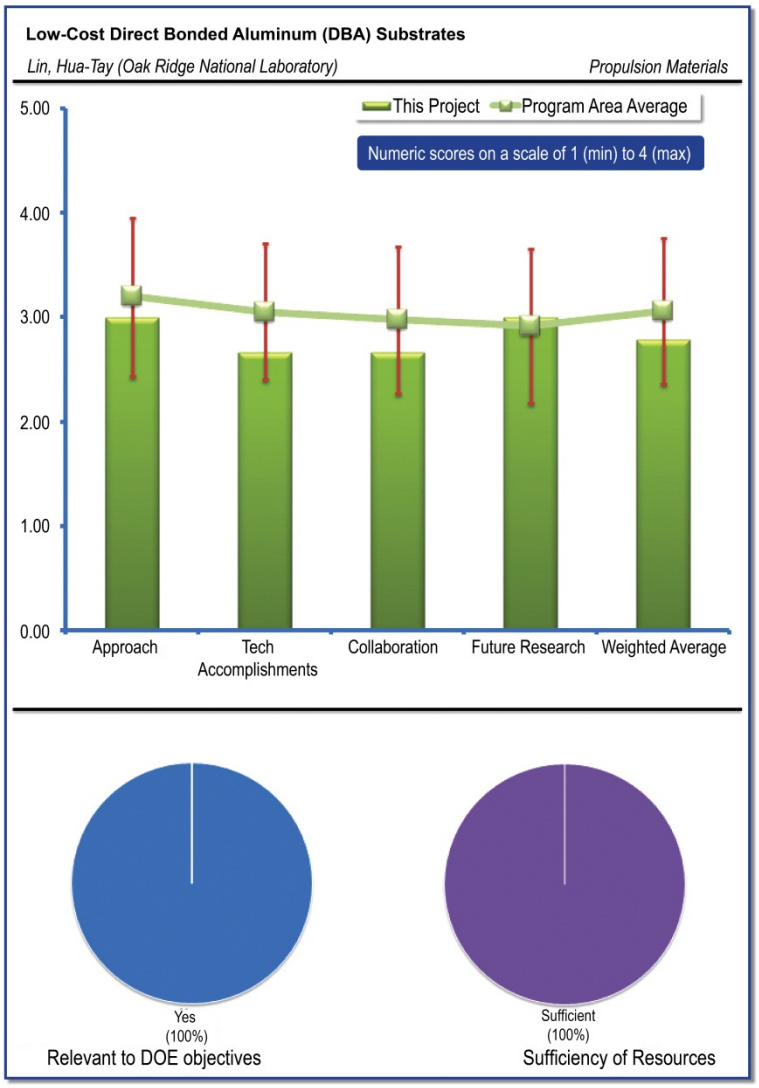
Low-Cost Direct Bonded Aluminum (DBA) Substrates: Lin, Hua-Tay (Oak Ridge National Laboratory) – pm036

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Two reviewers discussed how the project relates to DOE goals. The first evaluator explained that ensuring the viability of high-power electronics in electric and hybrid-electric vehicles is a key to the feasibility of placing significant numbers of such vehicles in the national fleet. If that can be achieved, considerable petroleum displacement can be expected. A key to the durability and reliable function of heavily loaded power electronics is managing the heat they produce. DBA substrates may play a key role in that function. The second analyst surmised that the main focus is to reduce the cost of DBA substrates used in power electronics. The goal is to develop a low-cost bonding/assembly technique to significantly reduce the cost (a factor of 10 is targeted). This has the potential to reduce the PEV (HEV/PHEV/EV) vehicle costs from $500/vehicle to $50, which will incrementally help to increase PEV adoption, and thus petroleum reduction.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Two respondents described the approach. The first reviewer noted the presenter's reference to "Use ORNL's in-house unique processing capabilities to fabricate innovative DBA substrates using a process that is amenable for mass production and that produces high adhesive strength of the ceramic-metal interfaces." However, according to the reviewer, there is no way to determine exactly what the development pathway is, since it is not discussed. The second respondent reported that the project is focused on addressing the two major factors affecting DBA, 1) AIN substrate material fabrication, and 2) Al-AIN bonding techniques. In both cases the goal is to significantly reduce the cost. Collaborations are intended to push the ultimate results into U.S. manufacturing (breaking the Japanese supplier monopoly) to create a low-cost, high-quality local supply for the U.S. power electronics manufacturers and customers. U.S. jobs will also be created by domestic manufacturing base.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All three reviewers thought it too early to tell the accomplishments, one reviewer said that work on the project had just began, so the progress was fine. The presentation showed the intended work plan, but no results. A second evaluator thought that, strictly speaking, it was probably too early in this project (16% complete) to assess its technical accomplishments. However, the "good" rating is

justified prospectively on the basis of the focused and logical approach to the work. The third reviewer agreed that it was too early in the development to evaluate the program. Results were still not there.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that collaboration outside ORNL is anticipated to commence in the next fiscal year. Analogous to Item 3, above, the score in this category reflects the fact that this project in its very early stages, rather than any perceived deficiency. The second reviewer reported the project team (materials scientists/engineers) is coordinating with the ORNL National Transportation Research Center (NTRC) (engineers) to bring the understanding of the whole vehicle performance. NTRC's direct contacts/existing collaborations with automotive OEs/suppliers gave the project team more direct access to industry for data, samples, and direction. General Motors and Delphi are collaboration targets since they are major U.S. power electronics manufacturers/suppliers.

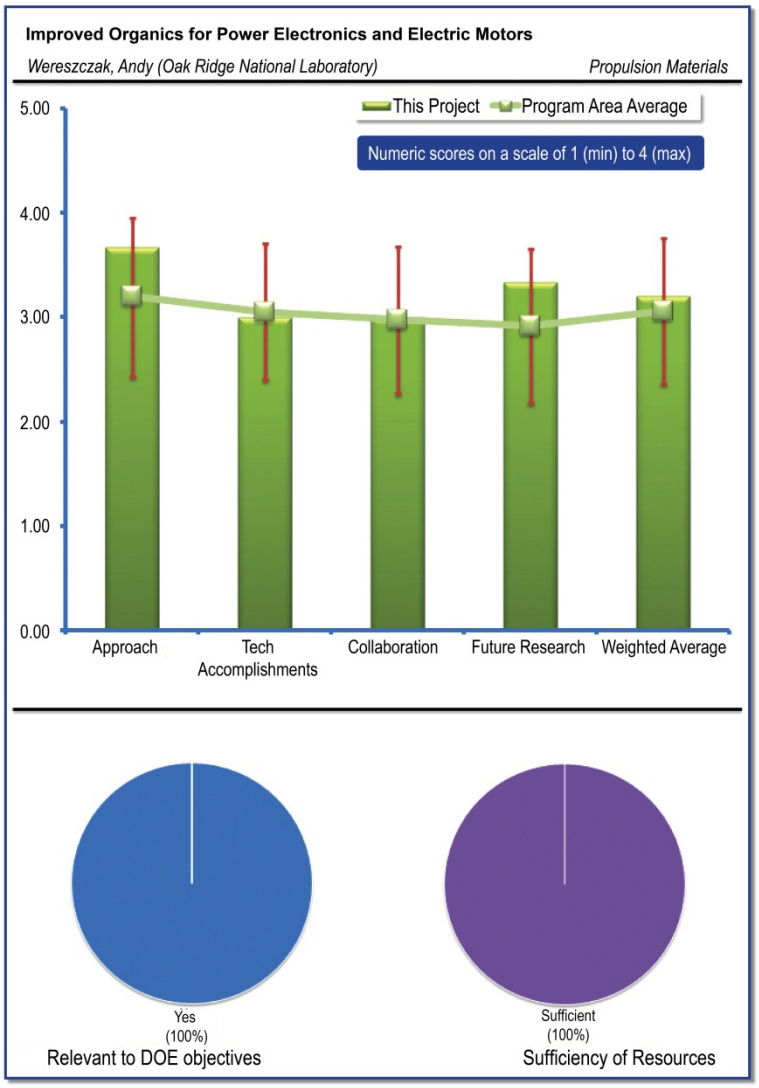
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panelist responded that since work on this project just began, all of the proposed work is future work. The proposed research plan looks sound.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer believed that resources for current work and work proposed for the next fiscal year are probably sufficient. As substrate fabrication gets going, additional funding might be desirable. The other reviewer relayed that project materials costs were estimated at ~$120K (40%), so the remaining funds cover roughly 0.4 man-years, which seems appropriate for the amount of work and potential benefits. The researcher felt that the goals could be accomplished with this level of funding. Collaborations being pursued with General Motors and Delphi could likely result in cost-shared material donations which would increase usable labor budget.

Improved Organics for Power Electronics and Electric Motors: Wereszczak, Andy (Oak Ridge National Laboratory) – pm037



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that ensuring the viability of power electronics in electric and hybrid-electric vehicles is a key to the feasibility of placing significant numbers of such vehicles in the national fleet. If that can be achieved, considerable petroleum displacement can be expected. A key to the durability and reliable function of heavily loaded power electronics is managing the heat they produce. Organic molding compounds can be expected to play a key role in that function. The second reviewer concluded that the use of modified high-thermal conductivity epoxies has the potential to allow for significant redesigns to power electronic hardware to simplify the part numbers, part designs/sizes, and cooling schemes. The end result is that the complexity, mass, and cost of power electronics would decrease. As such, the technology being investigated is an enabling technology for design improvements. This reviewer continued that lower cost will incrementally result in higher PEV adoption and thus petroleum reduction. The reduced component size and mass will incrementally result in a smaller more energy efficient vehicle.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent thought the approach appeared to be logically designed. The second reviewer said the approach appeared acceptable to identify materials for thermal management strategies.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter thought that it was too early to evaluate this program. Another evaluator agreed, saying that strictly speaking, it is probably too early in this project (16% complete) to assess its technical accomplishments. However, the "good" rating is justified prospectively on the basis of the focused and logical approach to the work. A third reviewer pointed out that work on the project began in March 2011, so only 2 months of work has occurred, so the progress is fine.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first observer reported that one private-sector collaborator was identified; assessing coordination between that organization and ORNL is not possible based on available information, but it is assumed that ORNL will make good use of the partner's capabilities. The second observer stated that the project team (materials scientists/engineers) is coordinating with the ORNL NTRC (engineers) to bring the understanding of the whole vehicle performance. NTRC's direct contacts/existing collaborations with automotive

OEs/suppliers gave the project team more direct access to industry for data, samples, and direction. According to this reviewer, General Motors is listed as a partner, but is more of an "interested party" in the data and results. The project team will also work with epoxy manufacturers, although this may be on a supplier/customer level.

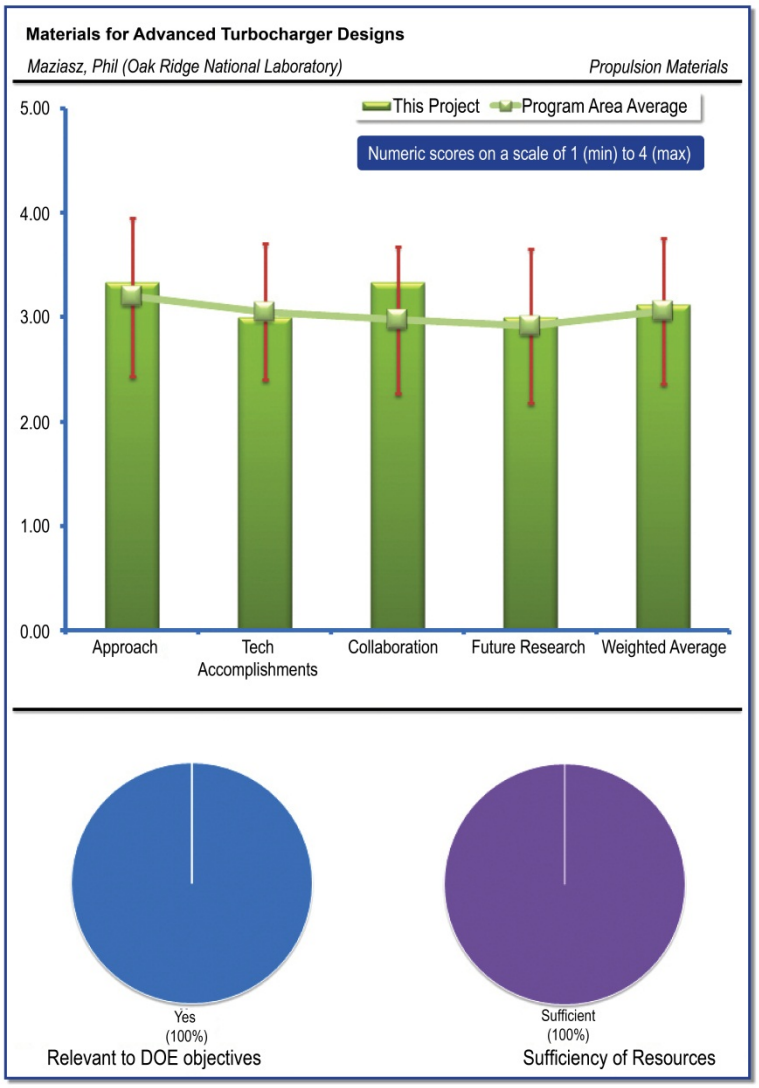
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A commenter stated that since work on this project just began, all of the proposed work is future work. The proposed research plan looks sound.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One panelist reported that project materials costs were estimated at ~$40K, so the remaining funds cover roughly 0.5 man-years, which seems appropriate for the amount of work and potential benefits. The researcher felt that the goals could be accomplished with this level of funding.

Materials for Advanced Turbocharger Designs: Maziasz, Phil (Oak Ridge National Laboratory) – pm038



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer claimed that this project appeared to be able to directly improve engine efficiencies. The second panelist concluded the project focused on improving the heat resistance of components by means of improving the material properties. This will lead to improved fuel efficiency. The third panelist responded that turbocharging is a thoroughly proven technique for increasing the maximum power density of IC engines and that, in turn, permits significant engine downsizing with concomitant petroleum fuel conservation potential. Raising the temperature tolerance of turbocharger components allows those devices to be applied to more highly stressed (thermally and mechanically) engines, which also increases power density and thermal efficiency. It also allows the weight of the turbo to be decreased, with further fuel conservation benefit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent thought the approach for this project makes a lot of sense. ORNL appears to have a good understanding of the issue. The second respondent judged the approach to show much emphasis on improving the performance of the housing. An equal important or perhaps even more important aspect is improving the performance of the wheel. No approach is given to improve the performance of the wheel only a study of the residual stresses was mentioned. For the residual stress measurement activity a further experiment could add significant value; measuring the residual stresses after a short time operating the assembly in a turbo application.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first panelist reported that good progress has been made, and an improved design appears inevitable. The second reviewer commented that the material was developed in an earlier project, and a number of material data was already available at the beginning of the project. Only first experiments on measuring residual stresses were available.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought that collaboration appears to be appropriate for the project. The second reviewer reported that only cooperation with Honeywell was mentioned, and that a wider group of potential users of the material could improve the contribution

to reduction of fossil fuel import. The third reviewer considered Honeywell to be an obvious choice of industrial partner for this project, who appears to be interested in commercializing the results of this research. Its 50% cost share is also commendable.

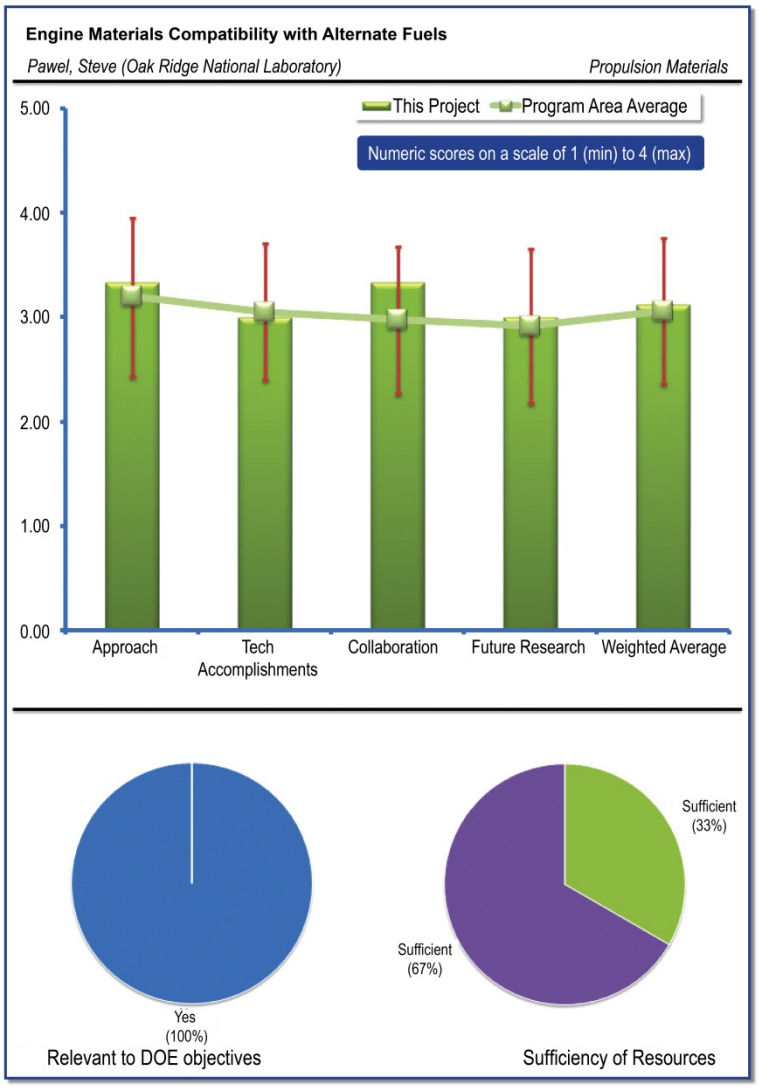
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first panelist deemed future work to be appropriate. The lion's share of the improvements has already been done, and the validation of the alloy proposal appears to be appropriate. The second panelist concluded that total turbo system improvement measurements are not incorporated.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first respondent thought resources appear to be appropriate. The second reported that the budget is in agreement with work mentioned.

Engine Materials Compatibility with Alternate Fuels: Pawel, Steve (Oak Ridge National Laboratory) – pm039



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer concluded that use of alternative (non-petroleum-based) fuels self-evidently supports the objective of petroleum displacement. A second evaluator believed that an understanding of the long-term material effects of alternative fuels (ethanol in this case) on engine components is critical to the long-term market acceptance of ethanol fueled vehicles which reduce petroleum fuel usage. Enabling higher ethanol blend percentages further reduces petroleum usage, so also meets DOE's goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that with respect to the ongoing literature search portion of this project, this reviewer recommended consulting the final report on ethanol fuels prepared for the DOE Alternative Fuels Utilization Program by Union Oil of California. Notwithstanding its age (1979), it represents solid research that may still be of use to this project. If it is no longer available through the National Technical Information Service (NTIS), the reviewer's personal copy can be made available (Ethanol Fuel Modification for Highway Vehicle Use -Final Report; ALO-3683-T1). The second reviewer considered the combination of lab testing of material coupons and field aged samples to be good. Field test samples are provided by partner USCAR members as well as ORNL track and dynamometer aging. A correlation between the time effect difference between accelerated dyno/track testing and real-world use needs to be developed to ensure results are realistic; the researcher acknowledged this and is including it in the research. This reviewer continue to remark, the in-situ test method will provide interesting real world, and real-time information. The researcher mentioned that the test matrix is limited by the funding, and that additional funding would allow the inclusion of non-metal parts (e.g., hoses and gaskets), post-combustion chamber components, and a wider range of ethanol blends that would include high-level blends. The apparent current focus on lower-level ethanol blends may be too limited and not fully be meeting the intended project goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer reported that work on project started about a year late, so has only been in place for about seven months. The second reviewer said that if this project was started in December 2010, seems too early to be able to evaluate the program.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first panelist thought that major U.S. automakers are obviously excellent choices of collaborators and cost share is good, also. The second panelist explained that a CRADA has been established between ORNL and USCAR (General Motors is prime, Ford and Chrysler also participate). The OEs lead the determination of which parts should be studied. The OEs also contribute new and field-aged representative parts and provide a technical resource to ORNL. The collaboration seems to be well organized and functions well to focus on the industry's needs. The researcher was asked whether they had a direct connection with Brazil to tap into their long experience with high ethanol levels. The researcher responded that they get information (not data) third hand from Brazil (i.e., Brazil original equipment [OE] --> U.S. parent OE --> USCAR --> ORNL). The reviewer did not get the impression that this was effective and that there may be a lot of prior learning by Brazil that can speed the work (and reduce the cost and development time) in the States.

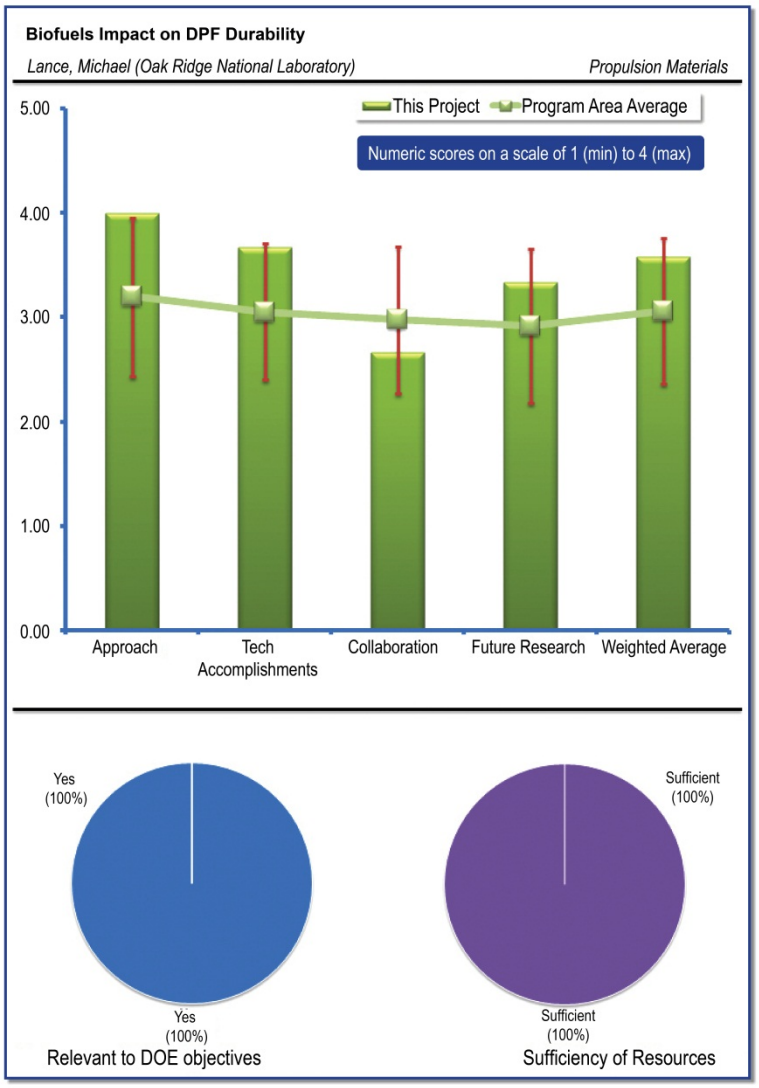
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One evaluator relayed that the researcher mentioned that the test matrix is limited by the funding, so does not include non-metal parts (e.g., hoses and gaskets), post-combustion chamber components, and a wider range of ethanol blends that would include high-level blends. It was implied that including these was necessary, but was not done because of financial constraints.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer estimated funding to cover ~0.75 engineer-years, so given the extensive dyno/track sample aging the funding seems appropriate for the work. The researcher mentioned that the test matrix is limited by the funding, and that additional funding would allow the inclusion of non-metal parts (e.g., hoses and gaskets), post-combustion chamber components, and a wider range of ethanol blends that would include high-level blends. It was implied that including these was necessary, but was not done because of financial constraints. This reviewer suggested reevaluating whether these materials and ethanol blends are necessary so the project evaluates all relevant components.

Biofuels Impact on DPF Durability: Lance, Michael (Oak Ridge National Laboratory) – pm040



REVIEWER SAMPLE SIZE

This project had a total of three reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVES? WHY OR WHY NOT?

The first reviewer thought that this project supports the petroleum displacement objective, albeit somewhat indirectly. Diesel-engine vehicles offer the potential for significant petroleum displacement, but must be equipped with PM filters and will assuredly be exposed to alternative fuels during their lives. Therefore, the effects of biodiesel-blended fuel on their emission control systems must be understood and means developed to ameliorate any damaging effects. The second panelist said that compression ignition engines decrease petroleum use, using biofuels in them further reduces petroleum usage, so the project goal to understand the DPF aging/damage from biodiesel is critical to ensure long life to minimize the lifecycle costs for consumers so they choose this powertrain/fuel option.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

The first respondent said that the approach was good and detailed, using real-world engines to load PM and then performing detailed laboratory analyses to determine the effects. The second respondent deemed the experimental plan to determine the effects of biodiesel blends on engine components to be well laid out. Identifying microstructure and material property changes will be critical to be able to devise strategies to improve engine performance.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first panelist commented that the presentation noted that sodium and potassium are known to be present in biodiesel. This suggests that the alkaline catalysts (NaOH, KOH) used in biodiesel production are not being fully removed from the finished product. Was it conclusively shown that the biodiesel used in the test program met all specifications of ASTM D 6751? The second panelist noted that significant effort and progress has been made.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer concluded that from the presentation, it was not possible to evaluate the degree of collaboration/coordination with the industrial partners in this project, but those have certainly been well chosen, and it can probably be assumed that good coordination exists between them and ORNL. Another reviewer responded that GM is listed as a project partner, but they are involved only through the sharing of ORNL results to GM because they have an interest in the results. GM is not actively involved. NGK provides ORNL with samples to test, but also is involved by performing characterization tests that ORNL cannot do. Discussions with

NGK regarding corrosion also occur, but it is unclear the level of overall collaboration. For this project, this level of collaboration may be all that is necessary.

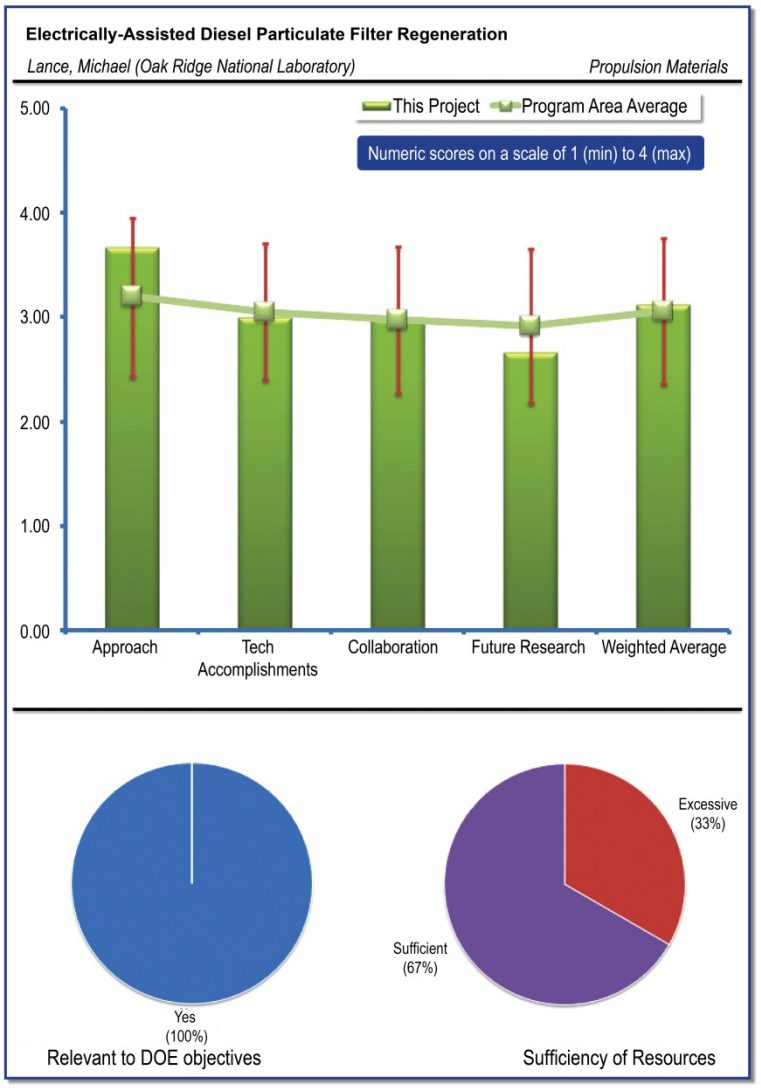
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer predicted that future tasks will focus on DPF degradation and regeneration effects. Given that a significant amount of effort and progress has been made in the first 50% of the project, the remaining tasks do not appear to require the remaining 1.5 years.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer found that funding level certainly seemed adequate, at the least. Total ($1.05 M) strikes this reviewer as possibly slightly excessive. The second reviewer relayed that the researcher felt that the funding level was sufficient to accomplish the project goals. Given that there is a lot of engine testing which requires a long time and detailed lab testing, this reviewer agreed that the funding seems appropriate.

Electrically-Assisted Diesel Particulate Filter Regeneration: Lance, Michael (Oak Ridge National Laboratory) – pm041



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer claimed a significant reduction of the fuel consumption penalty associated with periodic regeneration of DPFs in light-duty vehicles would clearly reduce the petroleum consumption of these already-fuel-efficient vehicles, further increasing their commercial appeal, which could increase their penetration of the national fleet. The second reviewer responded that regeneration DPFs requires additional fuel to heat the DPF and remove particles. The electrically heated DPF has potential to reduce regeneration times and save fuel.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent thought the approach was straightforward and correct. The other respondent was impressed by the very detailed and comprehensive approach. But is it all necessary? GM would seem to have a very promising pre-commercial system in its electrically-assisted diesel particulate filter (EADPF). While it is desirable to understand its operation in detail and to be able to predict such things as its probable life, is such in-depth understanding a prerequisite for successful commercialization?

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A panelist responded that the program demonstrated improved DPF regeneration time by 95% with a regeneration efficiency of 95% as well. A direct fuel savings estimate would help to quantify the impact of the savings. It is expected to be about 1% but no data was presented. Fiber optic sensor capability developed may be reused, and knowledge was gained about measuring stress in DPF substrates.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent referred to the note above, that GM would seem to have identified a promising approach to DPF regeneration in LDVs. Likewise, its 50% cost share in the project funding is commendable. It is not clear, however, that GM needs DOE help in testing, developing and commercializing this system. The second panelist listed GM and the University of Wisconsin as collaborators.

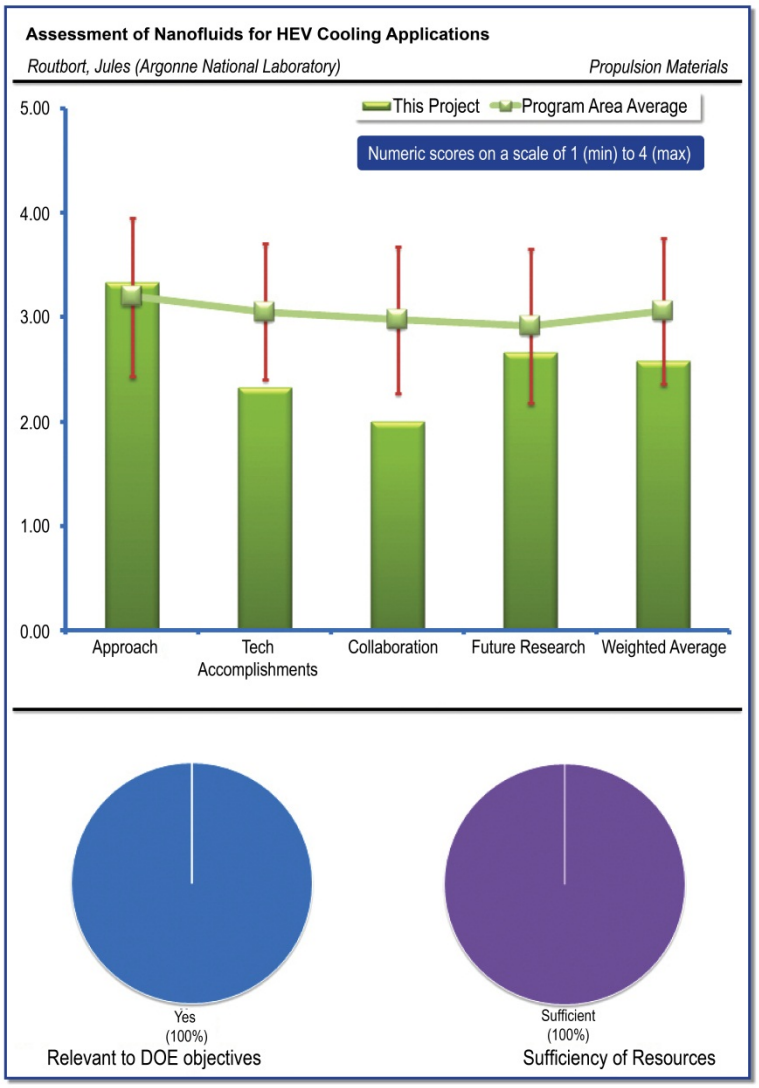
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first panelist described the system integration being pursued: Controls, Fuel Penalties for DPF and EADPF (electric option) as well as design properties for as and metallurgy for heater. The future research should also consider operating cost. Is fuel savings per vehicle life expected to pay for the electric heater? Are other technologies better solutions? (e.g., combustion tech. with less PM)

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first respondent thought this project well-funded; the other respondent felt that even with industrial partner cost share, the funding devoted to this project seem to be surplus to the requirement for successful commercialization.

Assessment of Nanofluids for HEV Cooling Applications: Routbort, Jules (Argonne National Laboratory) – pm042



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first evaluator believed that thermal management of EV and HEV power electronics is a key to the practicality and optimization of these vehicles, which offer the potential of very significant per-vehicle petroleum displacement. The second evaluator stated that the main project focus is to improve the heat transfer performance used to cool power electronic components. This has the potential to eliminate the low-temperature cooling loop, which reduces the system component count, cost, complexity, and underhood packaging. Reducing PEV (HEV/PHEV/EV) vehicle costs will incrementally help to increase PEV adoption, and thus petroleum reduction. According to this reviewer, the secondary focus (or for a follow-on project) is to evaluate the low-cost nanofluid for engine cooling use. This could further reduce radiator component sizes which could improve vehicle aerodynamics, and thus fuel consumption.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer considered it difficult to evaluate a project such as this, which is essentially no further along than the very early planning stage, but the approach seems logical and well directed. The second reviewer claimed the approach shown in the presentation only includes the work to-date, not the overall project. Discussions with the presenter show that the completed works, as well as the future work plans, seem to be a well-designed and straightforward method to achieve the goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer clarified that the rating for this question was merely a reflection of the fact that the projects has not actually begun and therefore cannot be expected to have shown "accomplishments and progress" other than the generation of a research plan which, as noted above, seems to be well thought out. The second reviewer noted that the continuing resolution limited the funds and time available to make progress, so only ~$100K has been spent to date. Initial modeling show that a high heat transfer nanofluid coolant has the promise to reach the heat transfer rates required to cool PEV power electronic components. Test quantities of the low-cost graphitic based nanofluid particle developed are being manufactured by Valvoline for ANL to test. Valvoline may become a project partner. If successful, Valvoline may also mass-produce the high heat transfer nanofluid coolant.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted that here again, it should be understood that the rating in this category reflects no deficiency in the project, but merely the fact that it has not begun and research partners have not yet been identified or recruited. The presentation indicated that both will be done as and when the project proceeds. The second reviewer reported that test quantities of the low-cost graphitic based nanofluid particle developed are being manufactured by Valvoline for ANL to test. ANL is in discussions with Valvoline to establish an NDA, as well as to become a project partner by establishing a CRADA. If successful, Valvoline may also mass-produce the high heat transfer nanofluid coolant.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that future work plans in the presentation are not well organized or detailed. The presenter elaborated that year 2 goals are essentially the first bullet on Slide 13, and year 3 is bullet 2 on page 13. The direction and plan is focused in the right direction, but the description is very high-level so does give the level of discussion needed.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first panelist assumed that if the project proceeds, sufficient funding will be allocated to it to ensure its success. The second panelist affirmed that the resources are suitable for simple modeling and fluid evaluation. The more detailed and labor intensive work in years 2 and 3 may require some additional funding to accomplish the project goals.

8. Technology Integration

The Technology Integration subprogram accelerates the adoption and use of alternative fuel and advanced technology vehicles to help meet national energy and environmental goals and accelerate dissemination of advanced vehicle technologies through demonstrations and education. This subprogram's efforts logically follow successful research by industry and government and help to accelerate the commercialization and/or widespread adoption of technologies that are developed in other VT program areas. Deployment activities linked to R&D also provide early market feedback to emerging R&D.

Subprogram functions include both regulatory and voluntary components. The regulatory elements include legislative, rulemaking, and compliance activities associated with alternative fuel requirements identified within the Energy Policy Acts of 1992 and 2005 (EPACT 1992 and EPACT 2005), as well as the Energy Independence and Security Act of 2007 (EISA). Voluntary efforts include demonstration of advanced technology vehicles to verify market readiness and public information, education, outreach and technical assistance efforts. VTP works with public/private partnerships between DOE and local coalitions of key stakeholders across the country (such as through Clean Cities) to implement strategies and projects that displace petroleum. In addition, the annual DOE/EPA Fuel Economy Guide publication and related data dissemination efforts (required by law) are produced, along with the website www.fueleconomy.gov.

Education aids in overcoming institutional barriers to widespread use of advanced vehicle technologies and alternative fuels, and serves to train the next generation of participants in this technology sector. Activities such as the Advanced Vehicle Competitions (EcoCAR) and Graduate Automotive Technology Education (GATE) encourage the interest of university student engineers and engage their participation in advanced technology development.

EcoCAR: The NeXt Challenge: EcoCAR is a three-year engineering competition sponsored by the Vehicle Technologies Program and General Motors (GM). EcoCAR, which began in 2008 and concludes in 2011, challenges students to reengineer a 2009 Saturn Vue. The Challenge involves engineering a system that reduces fuel consumption and lowers emissions by using advanced vehicle technologies. This is state-of-the-art training and allows students to mirror the real-world development process used by GM and other auto manufacturers from around the world.

Automotive X Prize: DOE has partnered with the Automotive X Prize to develop an educational outreach program aimed at engaging students (kindergarten-12) and the public in learning about advanced, energy-efficient vehicles. The Automotive X Prize (AXP) is an open competition with the goal of inspiring a new generation of super-efficient vehicles that dramatically reduce oil dependence and greenhouse gas emissions. DOE is providing $3.5 million over three years for this outreach effort.

Graduate Automotive Technology Education (GATE): DOE established the GATE Program in 1998 to train a future workforce of automotive engineering professionals knowledgeable about, and experienced in, developing and commercializing advanced automotive technologies to help overcome technology barriers preventing the development and production of cost-effective, high-efficiency vehicles for the U.S. market. To that end, DOE has eight designated GATE Centers of Excellence at U.S. universities that address hybrid electric vehicle drivetrains and control systems, lightweight materials, advanced combustion engines, alternative fuels, fuel cells, and advanced energy storage.

EPAct Transportation Regulatory Activities: VTP manages several transportation-related regulatory activities established by the Energy Policy Act of 1992 (EPAct), as amended by the Energy Conservation Reauthorization Act of 1998, EPAct 2005, and the Energy Independence and Security Act of 2007 (EISA). These activities seek to reduce U.S. dependence on imported oil through the use of alternative fuels and alternative fuel vehicles (AFVs) in fleets, as well as through the use of other petroleum-displacement methods. EPAct 1992 defined certain fuels as alternative fuels and directed DOE to undertake regulatory activities that focus on building an inventory of fleet AFVs in Metropolitan Statistical Areas/Consolidated Metropolitan Statistical Areas, which were selected to serve as launching pads for alternative fuels and advanced vehicle technologies.

Clean Cities: Clean Cities advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum consumption in transportation. Clean Cities has a network of approximately 100 volunteer coalitions, which develop

public/private partnerships to deploy alternative and renewable fuels, idle reduction measures, fuel economy improvements, and emerging transportation technologies.

In August 2009, DOE announced the selection of projects supporting two program areas under ARRA: transportation electrification education; and clean fuels, vehicles and infrastructure development. With funding totaling $39 million, the 10 ARRA-funded Advanced Electric Drive Vehicle Education activities support educational programs to substantially reduce petroleum consumption. Activities under this program include engineering degree and certificate programs, emergency responder and safety training, consumer and K-12 educational outreach, developing and providing teaching materials, and training service personnel, vehicle mechanics, and supporting infrastructure.

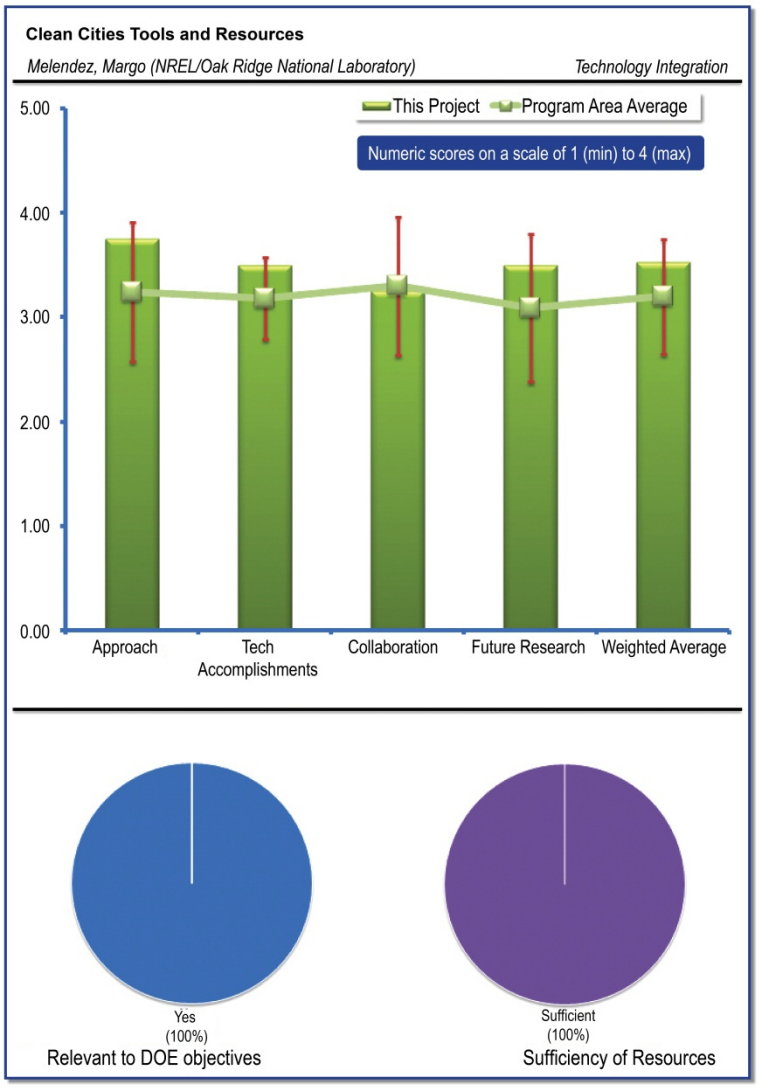
Additionally, the Department announced the selection of 25 projects totaling nearly $300 million that will speed the transformation of the nation's fleet. These projects will place more than 8,000 alternative fuel and energy efficient vehicles on the road, and establish hundreds of refueling locations/recharging sites across the country, which are both activities that support efforts to reduce petroleum consumption. Activities include development of alternative fuel infrastructure and alternative fuel corridors; alternative fuel vehicle deployment, including deployments of light-duty alternative fuel vehicles and vehicle conversions; upgrades to existing alternative fuel infrastructure; technical training; and education and outreach. For this merit review, these projects were included as Technology Integration poster presentations, and were not reviewed.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Clean Cities Tools and Resources	Melendez, Margo (National Renewable Energy Laboratory/Oak Ridge National Laboratory)	8-4	3.75	3.50	3.25	3.50	3.53
Clean Cities 2009 Petroleum Displacement Awards	Scarpino, Michael (National Energy Technology Laboratory)	8-6	3.75	3.00	3.25	2.25	3.13
Penn State DOE Graduate Automotive Technology Education (Gate) Program for In-Vehicle, High-Power Energy Storage Systems	Anstrom, Joel (Pennsylvania State University)	8-8	3.50	3.50	3.50	3.25	3.47
UC Davis Fuel Cell, Hydrogen, and Hybrid Vehicle (FCH2V) GATE Center of Excellence	Erickson, Paul (University of California-Davis)	8-10	2.75	3.25	2.75	3.00	3.03
The University of Tennessee's GATE Center for Hybrid Systems	Irick, David (University of Tennessee)	8-12	3.25	3.25	3.50	3.25	3.28
University of Illinois at Urbana-Champaign's GATE Center for Advanced Automotive Bio-Fuel Combustion Engines	Lee, Chia-fon (University of Illinois at Urbana-Champaign)	8-14	3.75	3.25	3.50	2.75	3.34
Center for Lightweighting Automotive Materials and Processing	Mallick, P.K. (University of Michigan-Dearborn)	8-16	2.00	1.67	3.00	2.33	2.00
GATE Center for Automotive Fuel Cell Systems at Virginia Tech	Nelson, Doug (Virginia Tech)	8-18	3.67	3.67	3.00	4.00	3.63
GATE Center of Excellence at UAB in Lightweight Materials for Automotive Applications	Vaidya, Uday (The University of Alabama at Birmingham)	8-20	2.67	3.00	3.33	2.67	2.92

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
EcoCAR the Next Generation	De La Rosa, Kristen (Argonne National Laboratory)	8-22	3.67	3.67	4.00	3.67	3.71
OSU GATE Project	Guezennec, Yann (Ohio State University)	8-24	3.00	4.00	3.33	3.33	3.58
Overall Average			3.25	3.25	3.31	3.09	3.24

Clean Cities Tools and Resources: Melendez, Margo (National Renewable Energy Laboratory / Oak Ridge National Laboratory) – ti003



Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewer feedback was positive. The first reviewer said on-road vehicles account for most of the petroleum consumed in the U.S. To reduce petroleum consumption significantly, the focus of attention must be on cars and trucks. That is precisely the focus for the three website initiatives presented. These initiatives provide high quality, unbiased information on actions that reduce petroleum use. Another reviewer commented that the tools presented are very helpful to fleets that are looking to make the switch to alternative fuels.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked that the tools for collecting, displaying and communicating information have been continually refined since these initiatives commenced in the 1990s. Additionally, the reviewer stated that with the Alternative Fuels and Advanced Vehicles Data Center (AFDC) and the Fuel Economy Guide, individual consumers have access to easily understandable and objective information to support decisions which help achieve better fuel economy and increased use of alternative fuels. This reviewer said accessing of NREL's on-line tools often leads to extensive interaction with users of the tools; this results in continual improvement and responsiveness to the needs of a variety of users. Another reviewer commented that deployment covers many areas. This reviewer continued that they like the approach and that focus on updating online tools is critical these days. The last reviewer noted that NREL needs to find a better way to get the word out on all of their products. This reviewer asked if they could use Clean Cities TV to hold monthly town hall type meetings.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said they were always amazed at the vast array of tools NREL provides. Another reviewer said that combining its expertise with ORNL's excellent survey and modeling abilities, NREL produces exceptional information products. Adding that in total, the three websites (AFDC, FuelEconomy.gov and Clean Cities) have millions of visits each year and use is increasing with awareness of, and respect for, the information provided. The next reviewer noted that the presentation has 10 accomplishment slides. This reviewer added that each one was packed with content (e.g., information tools, technical support mechanisms, data displays, samples of graphics, feedback forums and initiatives, examples of website upgrades and additions, etc.). This same reviewer continued that the oral presentation conveyed a sense of continued enthusiasm and excitement about the initiatives being presented;

the employment of leading edge information systems technologies; and the on-going interactions with numerous stakeholders. Another reviewer said that updates on website were impressive but it was not clear how much data sharing tools have been deployed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers had mixed opinions concerning the collaboration and coordination with other institutions. The first reviewer said that partnerships, collaborations and routine interactions have been established with literally hundreds of stakeholders and website users (e.g., vehicle producers, Clean Cities Coordinators, trade associations, Federal and state government agencies, universities, media organizations and others). The first reviewer continued by saying that industry and other media managers are turning to NREL-managed websites as a credible source of information. This reviewer added that these government websites have been featured by others, such as CNN Money, and NREL has been approached by Google about collaborating on development and communication of EV information. The second reviewer addressed the Google topic, saying that the GeoEVSE initiative with Google sounds exciting if it can be deployed. The last reviewer was not aware of any collaboration or coordination with others, especially with EPA or the Federal Aviation Administration (FAA), both of which have funds available for alternative fuels.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that development of NREL's websites and results is on-going: e.g., work is being done to improve the content and value of EV and PHEV information. The reviewer provided another example stating that a re-designed Clean Cities website will be launched soon, and work will be done on the AFDC website. The second reviewer noted that future Internet plans sound like they would enable quicker and more reliable information sharing that would be easy to maintain for DOE. This reviewer added that it sounds like a lot of hurdles need to be overcome first though, and that widgets are needed to allow other websites to link to the information seamlessly. This same reviewer suggested a website to bring together all the information that is becoming available on E15. The last reviewer commented that there is always something on the back burner at NREL and they already have a long list of projects.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer had detailed comments concerning resources and felt it was a judgment call. The reviewer stated that their scores indicated their view that outstanding results are being achieved with the resources currently provided. The first reviewer elaborated that they felt that more funds are not needed and, while initiatives could probably get by with fewer resources, this would slow website improvements and valuable collaborations with stakeholders would be reduced. This same reviewer applauded these initiatives commenting that they are likely among the best in Vehicle Technologies from a benefit/cost perspective (if that metric could be accurately measured). The second reviewer remarked that resources are sufficient, but more emphasis should be placed on supporting field staff that can put the vehicles on the road.

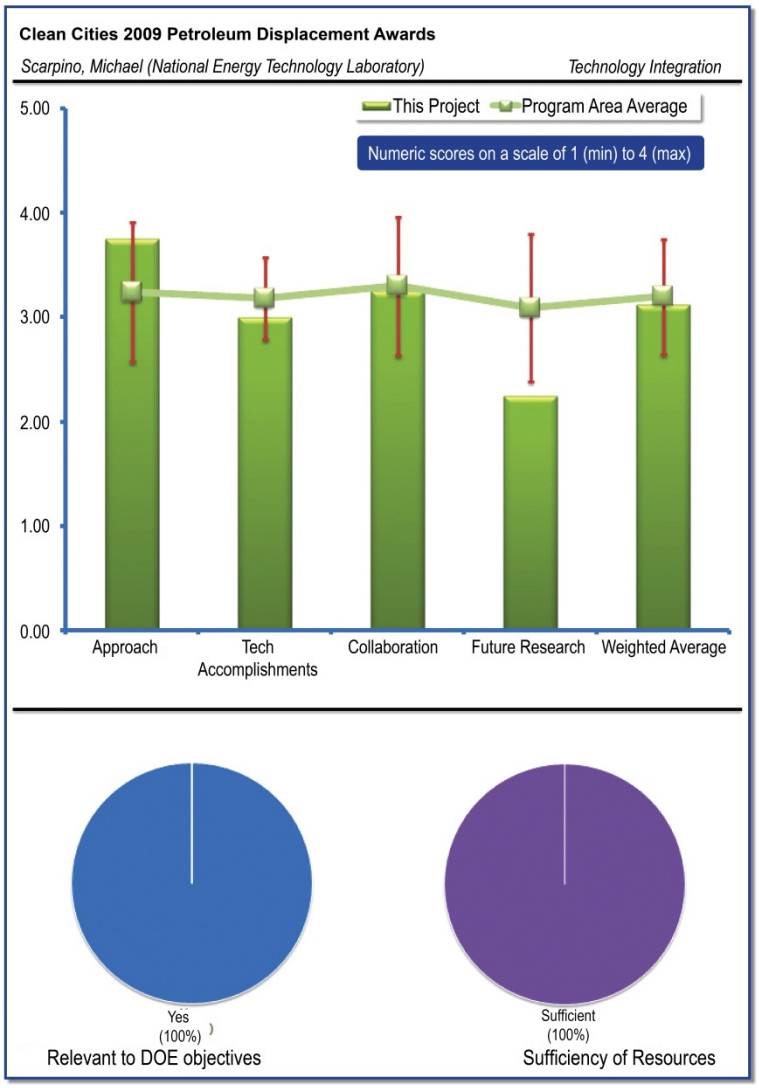
Clean Cities 2009 Petroleum Displacement Awards: Scarpino, Michael (National Energy Technology Laboratory) – ti0004

Reviewer Sample Size

This project had a total of four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers' comments were generally positive. The first reviewer stated that on-road vehicles account for most of the petroleum consumed in the United States and continued to remark that to reduce petroleum consumption significantly, the focus of attention must be on cars and trucks which is precisely the focus of the initiatives covered in this session. The first reviewer elucidated that the primary objective of the $298.5 million DOE ARRA program is to increase the use of alternative fueled and fuel-efficient vehicles, in order to reduce dependence on imported petroleum. The same reviewer noted that the $13.7 million DOE Clean Cities Petroleum Displacement Program has the same key objective that these are the most heavily funded vehicle deployment initiatives in the history of DOE. The second reviewer asserted that this project directly places alternative fuel vehicles on the road.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said the following four points provide evidence of a sound strategy: (1) Multiple projects (25 ARRA and 23 non-ARRA); (2) Awards resulting from competitive solicitations; (3) A requirement that a designated Clean Cities coalition be included with each project application; (4) Projects dispersed across the U.S. The first reviewer said it was good that the program encompasses vehicle acquisition, infrastructure development, training and data collection. The same reviewer elaborated that despite the size of ARRA program (more than $800 million with cost share) and the number of projects, the task and sub-task descriptions on slides 6 through 9 are logical, understandable and believable. Additionally, the first reviewer pointed out that three areas of interest -- vehicle acquisition, refueling infrastructure and education -- are covered in the non-ARRA Clean Cities petroleum displacement initiative and that the presentation did not include task descriptions and milestones for this initiative. The first reviewer then noted that the activities associated with each area of interest were identified. The second reviewer expressed that they would like to see a better balance of projects distributed equally among the various fuel types. In particular, the second reviewer suggested that more emphasis should be placed on propane as a vehicle fuel.

Question 3: Characterize your understanding of the Technical Accomplishments and Progress Toward Overall Project and DOE goals.

The initial reviewer complemented the presenter by saying that responding to such a large infusion of funds is a major management challenge and that those responsible have responded well. This reviewer continued stating that the number of compressed natural gas and liquefied petroleum gas vehicles being subsidized, as a percentage of the total, is surprising and it would be useful to understand the factors contributing to that result. The initial reviewer added that the metrics for which information is presented on the ARRA program are about vehicles and stations, rather than petroleum displaced and emissions reduced. This same reviewer then asked if it is too soon to provide data on metrics more directly related to DOE goals, and recommended that this issue be considered in future reviews. The second reviewer commented that it was an excellent approach of looking at shovel ready projects for grants. This reviewer asked about the justification for some funding grants being slanted to Clean Cities and public municipalities over private companies. The third reviewer stated that additional ARRA funding resulted in more project activity in one year than the previous 12-13 years combined, but was extremely disappointed to see that all of the 2011 competitive grant funding would be devoted to electric vehicle readiness. The third reviewer favored more diversity among fuel and technology types. The last reviewer briefly stated that timeliness is difficult to review and analyze.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer stated that this is a no-brainer because there are hundreds of collaborators and partners associated with the two initiatives presented e.g., state agencies, Clean Cities coalitions, local governments, fleets, fuel companies, utilities and universities. The reviewer continued that the total cost share exceeds 60%. The second reviewer said that this is an area that needs improvement. Two reviewers indicated that the program could benefit from increased visibility/participation at industry & trade events and interagency collaborative Federal government meetings.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer mentioned that the activities for the coming year are stated in general terms. This reviewer said recognition of the importance of project monitoring is indicated, which is a plus, and that DOE will need to follow through on its intentions in this regard. The first reviewer noted that there is not much on data collection in the presentation, other than a general statement that there is lots of reporting and documentation. This reviewer recommends that plans for data collection and analysis be fully developed and shared with those responsible for ARRA project data at NREL. The first reviewer concluded by saying there should be extensive interaction with NREL staff on this topic. The second commenter thought that industry will probably hit the ethanol blend wall in 2012. This reviewer asked what the program is doing to promote use of more ethanol and E15. The last commenter observed that all FY-2011 Clean Cities grant funding was targeted for electric vehicle initiatives and noted that this lack of diversity did not provide any alternative pathways for consideration, thus limiting the effectiveness of future planning efforts.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer was pleased to see these initiatives taking advantage of the capabilities and commitment of those engaged in Clean Cities and remarked that the presenter did an outstanding job covering initiatives that include 48 individual projects. The first reviewer continued, stating that this is a judgment call, and the number of projects selected for funding match the large amount of resources provided. This same reviewer pointed out that a related issue is whether nearly a billion dollars, including cost share, is sufficient to stimulate additional market activity and accelerate significant petroleum displacement in transportation. This reviewer went on to say that dividing the ARRA program resources by the number of vehicles results in about $100,000 per vehicle. This reviewer added that this includes funding for training and education, which likely has excellent benefit/cost ratios. The reviewer continued that DOE's managers and staff are doing an outstanding job with the hand they were dealt, but the implications of this simple calculation deserve exploration. The second reviewer said that Clean Cities seems to be sufficiently staffed though they would like to see more action and fewer meetings.

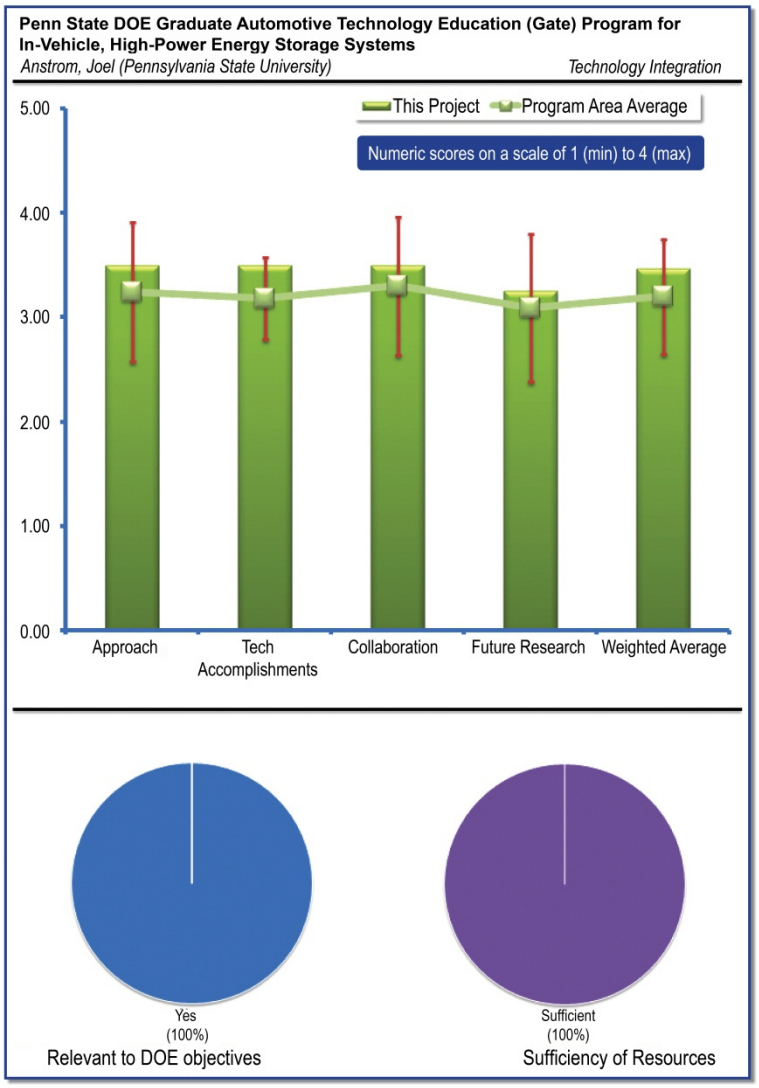
Penn State DOE Graduate Automotive Technology Education (Gate) Program for In-Vehicle, High-Power Energy Storage Systems: Anstrom, Joel (Pennsylvania State University) – ti006

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall the reviewers provided positive feedback concerning the Graduate Automotive Technology Education (GATE) program. The initial reviewer commented on the purpose by noting that the training of the next generation of engineers on advanced automotive technologies is focused on petroleum-replacing/reducing technologies. This reviewer continued saying that it is good that Penn State University's stated focus is on placing graduates within industry. Another reviewer explained that, while it does support the development of future engineers to develop fuel efficient technologies in transportation, the presenter did little in the way of communicating this message. This same reviewer stated they would assume that the students understand the policy implications of the nation's dependence on imported oil. The final reviewer acknowledged that the GATE Center is focused on developing engineers and scientists that can develop and deploy energy storage systems in future vehicles, which is critical to achieving petroleum reduction.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said that this was a broad program, technology-wise, and remarked that it has maybe a bit too many technologies -- resulting in a very complex program structure across many technology centers. The first reviewer continued that at the same time, Penn State University relies heavily upon pre-existing structure within the university (established technology centers), and then GATE coordinates among them for the student opportunities. The second reviewer pointed out that there was not a lot of discussion as to what the technical barriers are and why those three areas are selected. The second reviewer then questioned if this was a need that is not addressed in many other schools and asked wondered what makes this unique to the engineering world. The final reviewer asserted that Penn State University has integrated many related activities in vehicle technologies and solar technologies to make this a very impressive activity. Also, Penn State University is providing education opportunities in energy storage from a broad range of approaches, including the development of the storage technology and the integration of it into a vehicle.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked that it appears as if Penn State University's GATE program has had the best student rate of participation and graduation, although it is hard to compare since the time frames are not always listed and the panelist concluded that they have

met the goals that they have set out to achieve. The second reviewer remarked that there are an impressive number of students and they have attracted a reasonable amount of funding in addition to the GATE funding. The final reviewer strongly believed this curriculum is self-sustaining and would continue without U.S. Department of Defense (DOD) funding. The final reviewer noted that the project is accomplishing a great deal in vehicle competitions, but at the same time, as included in the presentation, Penn State University does not appear to have developed many courses for the formal curriculum, especially given GATE involvement since 1999. This reviewer added that Penn State University has appeared to succeed using DOE-funded GATE positions as a basis for additional GATE positions funded by other organizations. This reviewer noted that graduates were placed in the auto industry and national/government labs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer thought that the GATE program has strong collaboration betweenANL, GM and MathWorks. This reviewer questioned if this was due to the EcoCar program or the GATE initiative. The first reviewer finished by stating that a stronger description of how the GATE program works with EcoCar would have been helpful, more at the academic level between professors. The second reviewer summarized that there is good integration with the Solar Decathlon team and other related activities at Penn State University. The final reviewer noted that Penn State University is working with other universities plus DOE and General Motors through EcoCar, and that given the broad range of technologies within the Penn State University GATE effort, might expect to see a bit more outside coordination than currently exists. The reviewer continued that as the presentation moved on, the reviewer saw some additional coordination with national labs, state, industry, and others, though it seemed a bit more project-by-project than overall approach to coordination. This reviewer concluded that they are basically largely coordinating when needed, except for a few outreach events/workshops.

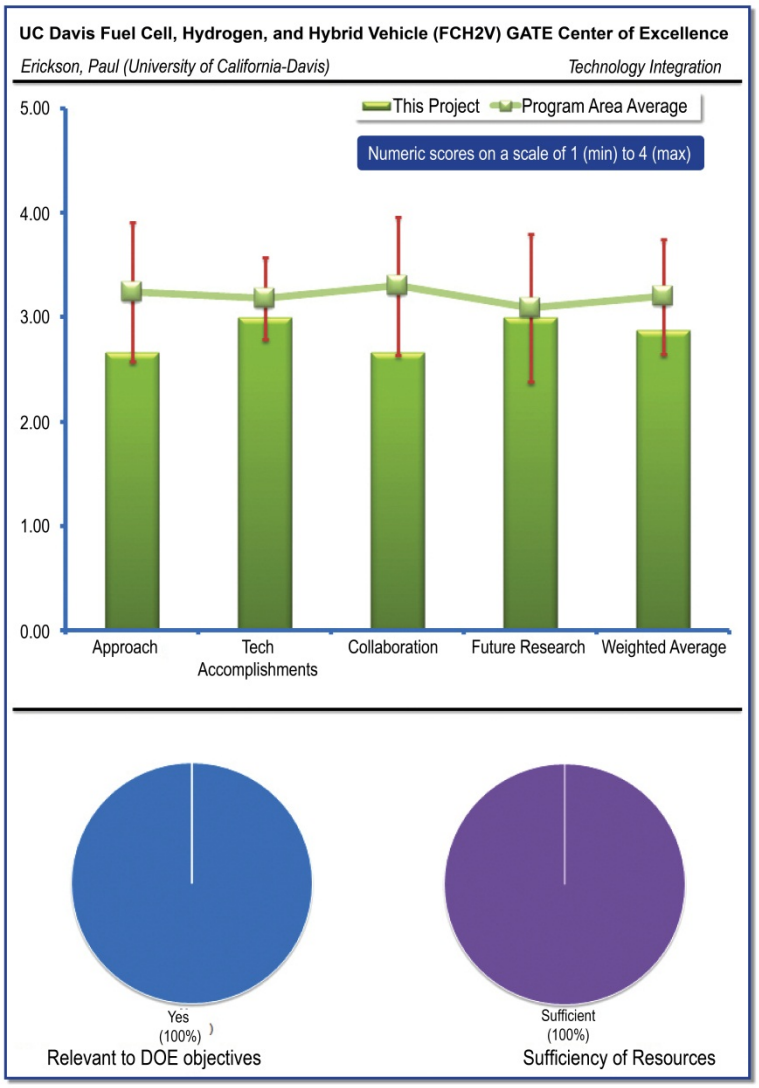
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that Penn State University is mostly promising more of the same, but is also looking to expand to new partners. The second reviewer thought that this activity is headed in the right direction and would like to see Penn State University review the relevant DOE technical barriers and show how they are addressing these barriers. The final reviewer did not get a sense of what needs improvement and asked if there is a way to accelerate growth in the number of graduates without losing quality. The reviewer queried if there were any metrics on new partnerships that they want to develop or improve upon, or new courses to develop. This reviewer questioned how they engage their partners in getting feedback or from the students.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer observed that Penn State University is not claiming any funding barriers, plus Penn State gets additional funding from DOT, NASA, NSF, Defense Advanced Research Projects Agency (DARPA), DOE, the Commonwealth of Pennsylvania, and claim highly leveraged funding. The second reviewer said the resources are appropriate and additional resources would require more graduate school applicants desiring to get into this area which is unfortunately not the situation.

UC Davis Fuel Cell, Hydrogen, and Hybrid Vehicle (FCH2V) GATE Center of Excellence: Erickson, Paul (University of California-Davis) – ti007



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer commented that the center is training the next generation of engineers in fuel cells, hybrids, and hydrogen, and conducts government/industrial-supporting research and coordination. The first reviewer commented the UC Davis program attempts to cross-train across policy and technical areas and future efforts will go back to primary focus on automotive technology side, and de-emphasize policy. The initial reviewer concluded that UC Davis focuses on the number of fellowships as its key measure of success. The second reviewer said that it has grown an educated workforce in advanced automotive engineering, while the third reviewer said that fuel cell vehicle and HEV technologies are critical for the next generation automotive engineers.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The initial commenter said that the program appears to realize difficulty in cross-training for policy and technical engineering areas and is going back to primary focus on technical side. This reviewer surmised that due to long-term involvement in GATE, they seem to have the mechanics (organizational aspects) of running a GATE program under control and noted that the program requires students to develop detailed research plans with their applications. The second reviewer also reflected that fellows must develop a research plan and will study courses in fuel cell and hybrid components; vehicle and energy systems; and fuel pathway analysis—a good cross section of academic studies. The same reviewer noted that a limited number of fellows since 1999, with only three to five supported each year (2005 and beyond). The third reviewer stated that HEV and fuel cell vehicle technologies are somewhat complimentary at the electrical drive interface; however, UC-Davis left the reviewer with the impression that UC-Davis is somewhat overwhelmed trying to maintain two centers, or two thrust areas rolled into one center.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer had the opinion that graduating three to five students per year and getting them into automotive or automotive related industries is impressive. The second reviewer stated that three students were fully supported from 2010-2011 awards, plus three from 2009-2010 awards and two students were partially supported. The second reviewer added that previously there were three in 2008-2009 and four in 2007-2008 and before this four to five students per year, some awarded multiple years. The reviewer commented there was a strong focus in presentation on what each is or was researching and that they expect 36 Masters of Science

(M.S.) and 21 Ph.D. candidates through 2011 to be hired by auto industry and universities. The reviewer noted that there are 40 classes available and the presentation was a bit light on details concerning specific accomplishments, at least at a programmatic level. The final reviewer pointed out that they had merged the two GATE centers in 2005, but is having difficulty with engineering students becoming involved in the policy area, which is unfortunate. The reviewer went on to say that the program developed different courses after the merger and they would like to see more students participate in the program.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer remarked that collaborations are primarily within other parts of UC-Davis. The reviewer added that there is some industrial funding coming in, but considering the program and the depth of UC-Davis transportation expertise, the reviewer would have expected more. The second reviewer stated that the GATE program collaborates well within the University, across multiple programs and with non-technical organizations (policy through Institute of Transportation Studies [ITS]) and based upon presentation, not much collaboration shown outside of the University. The final reviewer thought the collaboration with ITS-Davis was a brilliant idea but it is unfortunate that it is not working and wondered if the student still takes the full fuel cycle analysis course. The reviewer continued there was not a lot of ongoing collaboration with industry and it seems students are being placed, but the reviewer is not sure throughout the course of the academic years what collaboration with the private sector is transpiring on behalf of the students or center. The reviewer said there was only one example of industry cost share and would recommend a direct correlation of where the students are placed in the list of organizations provided.

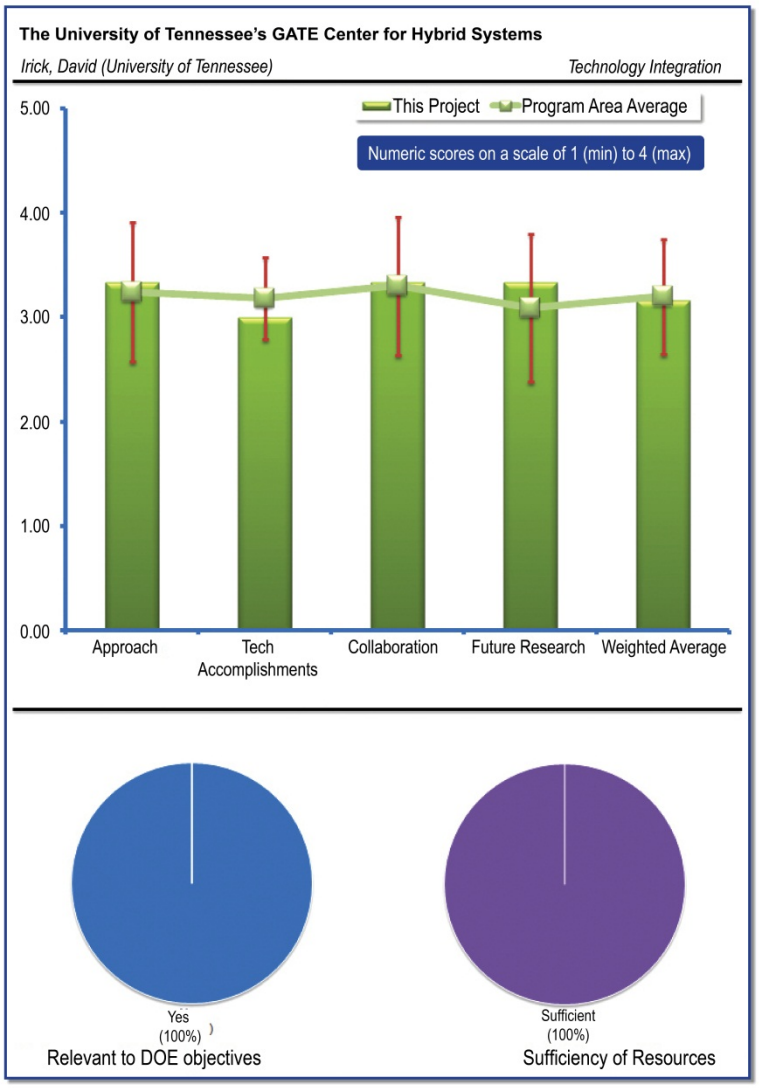
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that based upon the presentation, more of same promised, but the GATE program appears to have the system down and went on to say that future focus is more on hybrid technologies, which probably makes sense based upon industry and government changing focus somewhat away from H_2 and fuel cells. The second reviewer said that it will decouple itself from the ITS, but not sure how that will enable more students to graduate from this program they added that the next important step is to focus on hybrid propulsion systems and course development will ensue over the next year. The final reviewer acknowledged that the GATE program has plans to refocus their efforts and concentrate on vehicle technologies and the reviewer would like to see UC-Davis review the relevant technology barriers identified by DOE and state how they are addressing these barriers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Most of the reviewers felt no additional funding was needed but one disagreed with this view. The first reviewer expressed that the GATE program did not go forward with EcoCar due to lack of support from university and difficulty with securing laboratory space. The reviewer felt that limitation on numbers of students was solely due to funding, although partially-funded students include outside (leveraged industry) funding. At the same time, the numbers of students is relatively consistent throughout life of UC-Davis program, so it is hard to say that funding is insufficient at this time. The first reviewer acknowledged that the GATE program was able to leverage efforts with numerous in-house programs and labs, plus on-campus H_2 refueling station. The second reviewer agreed by adding that there was no evidence in the presentation that additional funding would advance their activities. The final reviewer said UC-Davis asked for no-cost extension so they may have more than they need.

The University of Tennessee's GATE Center for Hybrid Systems: Irick, David (University of Tennessee) – ti008



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewer's responses were generally positive. The first reviewer pointed out that training engineers in hybrid technologies is a key need within industry to help reduce petroleum use. The second reviewer noted that they are educating a workforce of advanced automotive engineers. The final reviewer stated that focus on powertrain and power electronics for hybrid vehicles is critical for the next generation of vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said that the project provided a dual program: fellows and research assistants and tied very closely to student competitions and fellows serve as team leads for student competitions (particularly EcoCar); they added that competitions were implemented as senior design projects. The first reviewer concluded that long-term involvement shows that, like others in GATE, they've got the system down. The second reviewer noted that it appears that new courses are continuing to be developed and expanded and testing and laboratory facilities are being developed or expanded and there are three departments which are part of the GATE center. The reviewer wondered if it is possible to include more students in the program. The final reviewer commented that University of Tennessee has good integration across the mechanical engineering and electrical engineering departments but more industry involvement would be beneficial which could be accomplished through guest lecturers, an industrial advisory board or several other approaches.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that the university developed five specific courses under GATE program, which focus on hybrid systems and IC engines, and continued that there have been 28 students through program since 1998, roughly two-three total (fellows and assistants) per year and graduates have gone onto national labs and industry. The reviewer said that according to the presentation, current/recent focus has been on facilities and expanding capabilities and they are moving into new facility (after a fire in 2006) and it will be a significant improvement from previous facility (there will be grants from industry to help). The reviewer noted that there was less emphasis in the presentation on specific programmatic accomplishments outside of the facility. The first reviewer added that the presenter was refreshingly candid concerning one major barrier facing the program, which was the university's desire to chase after "fad" NSF technologies, rather than providing a consistent commitment to long-term appropriate technologies likely to provide

significant impact. The second reviewer stated that the number of courses developed and number of students graduating is good. The final reviewer would like to see industry partners take a more active role in strategic planning and correcting any barriers to implementation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

All reviewers felt that collaboration with other institutions was generally good. The first reviewer specified that the GATE program is collaborating with other University of Tennessee (UT) campuses, plus with DOE, ORNL, ANL, INL, and industry. The second reviewer noted that the GATE program had good partnerships with labs, other DOE programs, and industry, and would like to know the direct correlation between student graduates and placements between industry and academic institutions. The final reviewer said that the collaboration with ORNL and support from Denso is good.

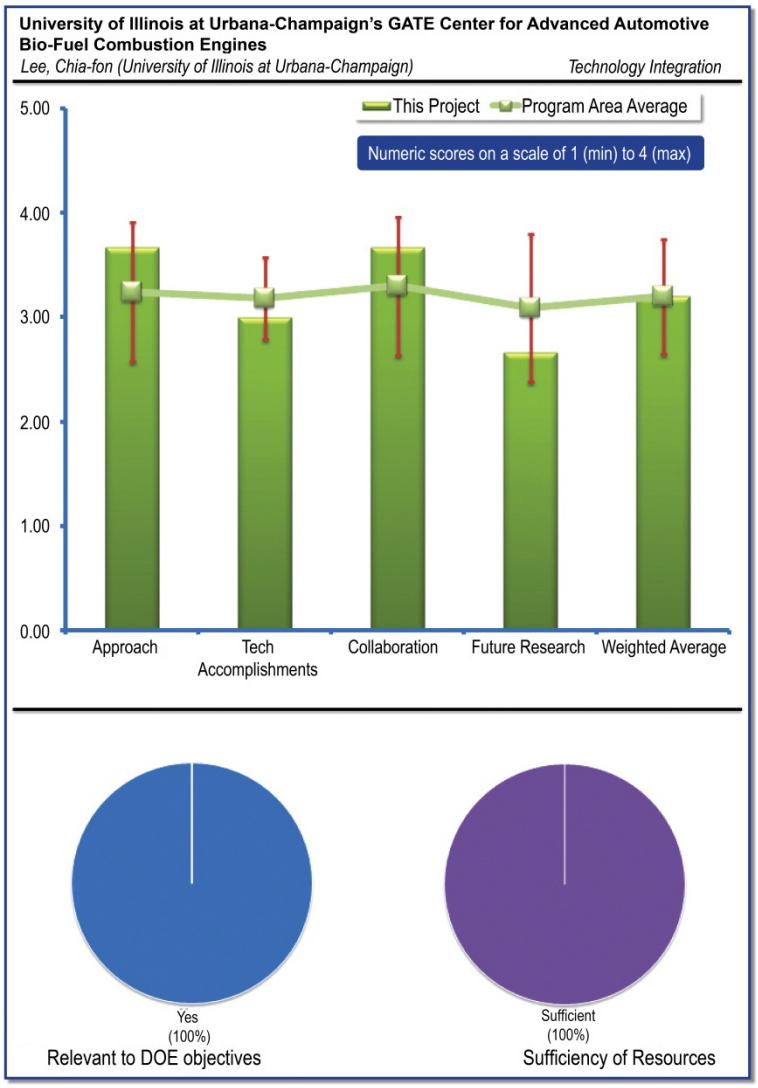
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer pointed out that according to presentation, they're promising largely more of same, but also adding EcoCar2 and that the presentation includes a slight mention of new activities once established in new facility, with additional capabilities. The second reviewer stated they seem to have good direction for knowing what future steps to take; good synergy with EcoCar2; good industry partners and laboratories. The second reviewer went on to say they are adding an advanced power control systems facility and have a coherent explanation of current and planned research. The final reviewer acknowledged that they had a good focus on continuing to develop courses but the commenter would like to see University of Tennessee-Knoxville review the relevant technology barriers identified by DOE and state how they are addressing these barriers.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers generally agree that the current funding is adequate. The first reviewer stated that they have obtained some resources from industry (Denso) to support development of new facility and have obtained $2.5M in funding from government and industry (including from student competitions), plus $600k from the University. The reviewer adds that they did not do EcoCar1, but are doing EcoCar2. The second reviewer noted that the program has leveraged a lot of resources and it will be critical to demonstrate needs future rounds of funding. The final reviewer commented the balance of funding available to students whom desire this curriculum is about right.

University of Illinois at Urbana-Champaign's (UIUC)GATE Center for Advanced Automotive Bio-Fuel Combustion Engines: Lee, Chia-fon (University of Illinois at Urbana-Champaign) – ti009



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All the reviewers feel that this GATE program is beneficial for a variety of reasons. The first reviewer explained that training next generation of engineers on biofuel combustion is critical for increased replacement of petroleum. Another reviewer supports the development of advanced biofuels under the Renewable Fuel Standard, as amended (RFSII) by educating more automotive engineers to enter the workforce with a background in advanced biofuels and its effect on combustion. The final reviewer asserts that biofuels have the highest probability of becoming a sustainable transportation fuel.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that that UIUC appears to have utilized funding to develop a program, courses and syllabus, which is then offered to many more students than some other GATE programs (46 from 2007-2010, approximately 10 to 11 per year). The reviewer went on the point out that 12 Ph.D. students have graduated to date (plus 12 M.S.), and went to industry, universities and national labs and are adding five M.S. students in the new program. The first reviewer also stated that program is cross-cutting research required of students, including technical, economic, and legal issues for biofuels, which should result in more well-rounded students. The second reviewer thought that performance measure of evaluation from students is important to making continual improvements to the curriculum and placing students with industry partners as interns is also important to future employment with these stakeholders. The final reviewer said that UIUC is building on their core competencies and supplementing DOE funding with industrial partnerships.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer briefly stated that it is an impressive list of publications. The second reviewer said that the program is continuing to develop new courses -- one added this year, one modified, adding that UIUC is looking at water emulsified fuels for power generation applications. This reviewer has concerns on the ultimate viability/usefulness of such fuels. The second reviewer said the presentation included specific accomplishments, including results from many research efforts in biofuels area and that the presenter was clearly focused on showing the program's accomplishments, perhaps since UIUC hasn't been in GATE as long as some of the other universities. The second reviewer's only concern is that presentation needs to be pared down a bit and actually had *too* much detail on

accomplishments, although some detail is appropriate. The final reviewer stated that the goal or barrier was to develop a set curriculum to develop automotive engineers with a background in advanced biofuels and its effect on engines, but wondered what the barriers were within the institution that have been addressed. This reviewer also said that there was much talk about the technology and research work, but questioned if the students' research played a role in its success, stating that this was unclear. The reviewer elaborated that there was only one new course developed and one course modified; and questioned if there had been any substantial improvement and if the additional students in the lectures series is really making a significant difference. This reviewer felt that all of these were questions that should be more fully addressed next time.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The initial reviewer said that numerous identified partners include international universities, plus U.S. and international auto/fuel industry members. Another reviewer thought the GATE program had many good stakeholder partnerships, including international partners, but wondered how many students have went on to full employment with each of the institutions listed as partners and stated that it would be better to show direct correlations. The reviewer concluded that the intern program was a good start with Caterpillar Inc. The final reviewer stated that the program has a very strong list of corporate partners.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the presentation included specific plans for Phase III -- algae fuels, chemical kinetics of bio-butanol, and combustion efforts utilizing plasma -- and that it was good to see specifics provided, which is perhaps a function of not being an original GATE university. The second reviewer asserted that there was not much of a discussion in this area, but the presenter ran out of time. This reviewer stated that according to the presentation, the industry advisory board will look at curriculum to suggest needed changes which is a good idea and the reviewer would like to see how much more effectively the students could be placed in engine manufacturing or fuels industry. The third reviewer said that adding and actively involving an industrial advisory board will be very beneficial and they would like to see UIUC review the relevant technology barriers identified by DOE and then state how they are addressing these barriers.

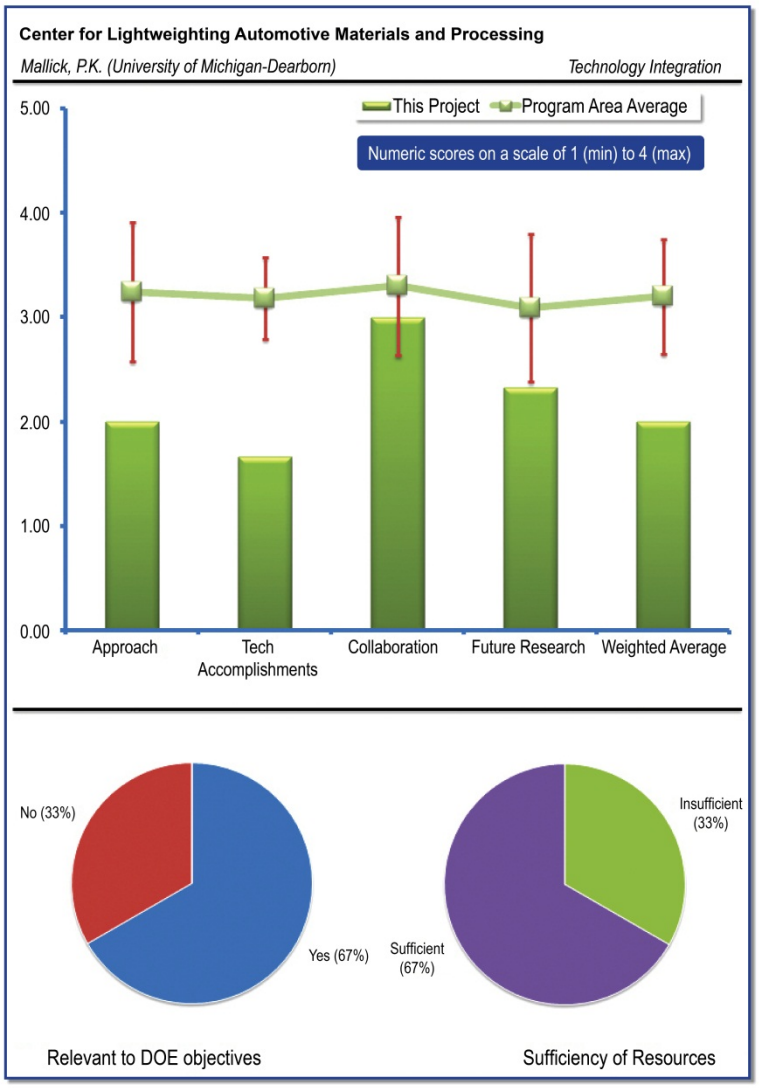
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewers concluded that no additional funding was necessary. The first reviewer said that funding was 80% DOE and 20% university and there is no indication of concerns about funding in presentation. Another reviewer stated that there was no evidence presented that additional funding would result in improved quality or quantity of graduates, and the final reviewer commented that the project had good private resources.

Center for Lightweighting Automotive Materials and Processing: Mallick, P.K. (University of Michigan-Dearborn) – ti010

Reviewer Sample Size

This project had a total of three reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer said the project meets DOE goal of creating graduate courses in lightweight automotive materials and that lightweight automotive materials contribute to petroleum displacement. Another reviewer agreed that making vehicles lighter is one path to displace petroleum and students experienced in lightweight materials for vehicles are needed. The final reviewer said they were unable to determine if the results of this project meets the criteria, since the award criteria for the review was unknown (not furnished) to the reviewer and, since the lion's share of the project is directed towards research and not education, as the presenter admitted. The reviewer questioned if this meets the criteria for what the grant was originally intended for and if it is a research or education grant. It appeared to this reviewer that education is a very secondary goal for this grant and the funds have been used primarily to conduct research. The reviewer added that, in terms of petroleum displacement there are no metrics developed, hypothesized or real that can be used to determine effectiveness, concluding that the presentation was much more of a technology and research brief rather than a presentation oriented to education. This reviewer stated that when questioned about the funds use in terms of research as opposed to education the reviewer's response was that doing research is the same as education. The reviewer felt the problem with this is that the funds are going toward reducing the department's overhead as DOE funds are used as an adjunct to pay professor salaries instead of orienting the funds towards education, internships or the like.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked that Professor Mallick edited a book on materials, design and manufacturing for lightweight vehicles but there is no indication how this book is being included into the research, development, design or manufacturing processes of car companies. The second reviewer stated that the presenter did not identify why DOE or the auto industry needs engineers trained in the lightweight automotive materials; rather, the presenter cited the barrier as the university not having a Ph.D. automotive program. The third commenter said that the university implemented a Ph.D. program, which will help with providing experienced students for research projects and were focused on developing graduate student classes, seminars, and sponsored research.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked that the rating for this is fair because new courses have been developed for the program at a cost of approximately $30,000, or one month's professor's salary, for each course developed. That means that out of $886,000 for total project funding only 3% has been used for education course development and the rest is research funding. The second reviewer noted that four objectives were cited: developing a new graduate course, continuing research and publications, offering two assistantships, and organizing and holding one technical workshop. However, half the presentation was devoted to research projects, and it was not clear which were supported by GATE funds and which were funded by outside organizations. The second reviewer concluded that the benefit to the students was not evident. The third reviewer stated that there were plenty of research projects but it was difficult to determine the performance indicators since the number of students graduated and number of students taking the classes, and number of students hired in the area was not presented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Three reviewers agreed that there was collaboration taking place in the program. The first reviewer said that they collaborated with industry partners, universities, and laboratories during seminars and research projects. The second reviewer acknowledged a good amount of collaboration among the various partners associated with the program in terms of numbers of participants and the value each brings to the table. The final reviewer said that collaboration with PNNL, Chrysler, Ford, the U.S. Automotive Materials Partnership (USAMP), and AISI was cited in one place, and in another place those organizations plus Washington State University, Texas A&M at Qatar, the Masdar Institute in Abu Dhabi, and Ulsan Institute in South Korea. The reviewer commented that it was not clear in most cases of the roles of the research partners or the objectives or focus of the collaborations.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first analyst said the program is building upon past years and another course will be developed, another seminar, and more research areas. The second analyst stated that both past work and proposed future work is heavily oriented towards research, without a clear identification of the roles for the students. If a significant amount of the GATE funds are used to support faculty research, this does not support the DOE goals. According to the final reviewer, it is hard to say, since the presentation was mostly a technical research presentation about lightweight materials. Their goal is to conduct more research in 2011 and the reviewer is not sure if that is what the money was supposed to be used for.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer says that the total project is $700,000 of DOE funding with $180,000 matched by the university, or 25%. The resources appear well spent. The second reviewer stated that funding is higher than other institutions for less or the same results. The final reviewer would hold funding on this project until an assessment can be made by DOE personnel about whether the funds are being properly used. This reviewer questioned if this is a research directed grant or an education directed grant, and if it is the later, then the funds have been improperly used.

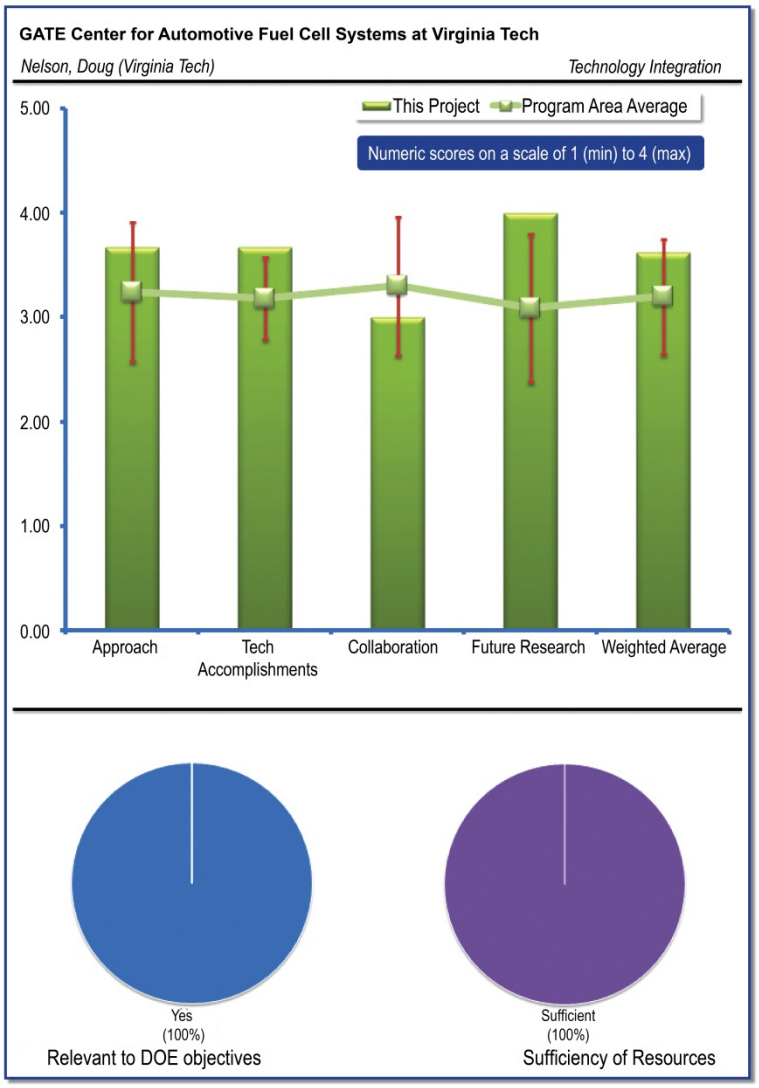
GATE Center for Automotive Fuel Cell Systems at Virginia Tech: Nelson, Doug (Virginia Tech University) – ti011

Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The second reviewer said fuel cells are a major research and development effort at DOE, which has a major objective of petroleum displacement and this activity directly addresses the DOE educational objective for fuel cell systems. The second reviewer said that fuel cells are one path for petroleum displacement, but there still are many technology barriers for fuel cells and engineers working in this area would help to provide breakthrough research in fuel cells. This reviewer noted that students did not get hired into fuel cell jobs, but were hired into automotive projects. The final reviewer commented that one has to look at the goal of petroleum displacement as a long term requirement that is addressed by this grant. It is addressed in terms of the future influence that students will have on the development of lightweight, more utilitarian vehicles in the next 10 to 15 years and therefore does meet that requirement insofar as education contributions to future outcomes.



Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer commented that barriers were clearly defined for this project, and include insufficient supply of graduate engineers with proper background and the need for new knowledge in critical technologies, e.g., durability and water transport. The second reviewer commented that barriers were clearly identified: insufficient supply of graduate engineers with the proper background and the development of new knowledge in fuel cell durability and water transport. The third reviewer said the project seems like a very organized effort, worked with research efforts and utilized the graduate student support, provided by the GATE program, very effectively to bring in and keep quality students.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked that there are five new courses that have been developed in the area of automotive fuel cell technology and 19 students have been funded by the grant and three times that many have attended at least one of the courses as an elective but not matriculated in a fuel cells related major. This reviewer adds that this is an admirable achievement and the funds have been dedicated 100% towards education. The next reviewer stated that education objectives of curriculum development, student research,

and industry interaction are clearly stated, so that progress was easy to follow. The final reviewer said that two classes were developed and two others (Senior Design) covered some of fuel cells and four students have been hired in automotive fields.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

There were mixed opinions on the quality of collaboration. The first reviewer said that there was a major partnership with General Motors Fuel Cell Program, as well as fuel cell developers. The second reviewer stated that there was a good collaboration with EcoCar and a limited number of industry/GATE projects on fuel cells. The reviewer commented that the GATE program has been more focused on vehicle systems. The final reviewer said it appears that most of the collaborations with other institutions were in the form of attendance at symposiums and forums rather than partnering with organizations to deliver more educative programs.

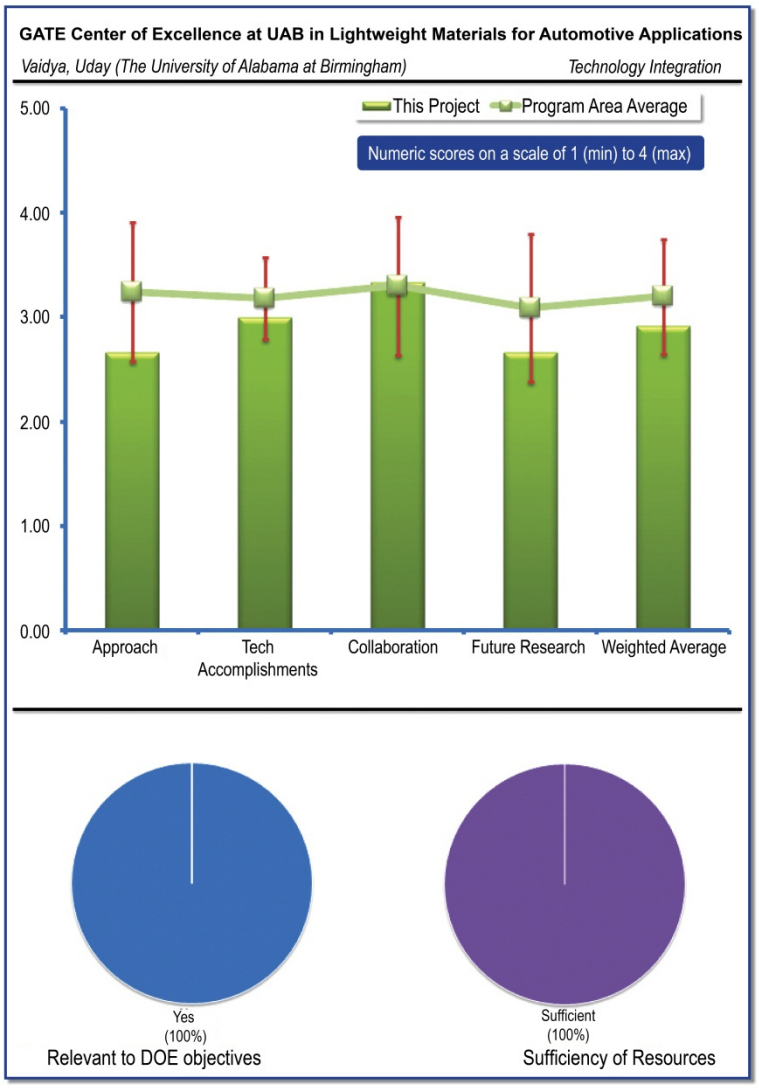
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Two of the reviewers said that the grant is 100% complete and no future activities are planned. The third reviewer gave credit for how well this year's work focused on previously defined objectives. The reviewer mentioned that the program is being completed in May 2011 and that proposed future work makes sense.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated that the resources appeared to be sufficient and recommended an additional grant be made to Virginia Tech to enhance and keep the project going. The presenter stated that the program has made excellent progress and the reviewer is encouraged that that all the funds were used as imagined, specifically towards educating students. The second reviewer agreed that the project made effective use of DOE GATE funds, with a cost share of 25%. The final reviewer explained that there was adequate funding for the number of classes developed and students graduated.

GATE Center of Excellence at UAB in Lightweight Materials for Automotive Applications: Vaidya, Uday (The University of Alabama at Birmingham) – ti012



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally agree that this project is valuable. The first reviewer asserted that automotive lightweight materials are important for petroleum displacement and this activity meets a DOE education objective. A second reviewer explained that making vehicles lighter is one path to displace petroleum and students experienced in lightweight materials for vehicles are needed. The third reviewer said that the project appears to be academically sound but notes that this is not his field of expertise.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer had very detailed comments that said the approach to recruiting students to graduate schools appears to be working well. The project shows signs of good recruitment and good investment in capability-building at the undergraduate level; however, the project does not put into operation the concept of a pipeline in a sufficiently wide-reaching manner. This reviewer further expands, saying that pipeline activities seem to focus primarily on traditional classroom-based training for undergraduates and this element of training students could be improved by establishing some contacts with industry and maybe pursuing some programming that focuses specifically on career development. The reviewer went on to state that a pipeline concept could also be improved by integrating historically black colleges and universities (HBCU) and community college partners in more substantive ways—perhaps with an option for students at these institutions to do a summer research internship at UAB. The first reviewer continued, commenting that the workshops for these students are a good component of the program but won't necessarily prepare students from either audience in a rigorous enough manner in succeed in a graduate program. The second reviewer expressed that barriers were not identified during the presentation and said that the presenter responded to queries with discussions about problems with GATE funding, not how UAB uses GATE funds to address technical barriers. The final reviewer stated that it seems like a very well-organized GATE program at UAB and the program integrated work with workshops/seminars and student projects.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer stated that there were an impressive number of graduate students supported by the GATE program, a good number of graduate courses had been developed, and that the undergraduate student pipeline is an innovative approach. This reviewer added that some stated goals (manufacturing, virtual classroom) were not addressed or not addressed well. The second reviewer noted that a

large number of courses (seven to eight) had been developed and there is a nice graduate program that provides a GATE certificate if four of the courses are taken. The second evaluator adds that there are a good number of student-funded and research projects in lightweight materials. The final evaluator said the program has clearly made progress in research, has resulted in a number of curricular opportunities, and has incorporated a large number of students at UAB. Although, the final reviewer is not sure the program is using its connections to partner institutions as effectively as it could be.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Most reviewers' comments concerning collaboration and coordination were positive. The first reviewer expressed that there was good partnering with auto companies, suppliers, ORNL, and small businesses. The second reviewer stated that there was a very good collaboration structure between the university and other institutions, industries, and laboratories. The third reviewer said that, in terms of industry, the Honda Pilot project is an excellent example of collaboration between academia and the private sector and the virtual classroom and hands-on workshops are also excellent examples of letting students see what industry is like. The third reviewer went on to say that, in terms of partnerships with non-UAB academic institutions, ideas for collaboration are good, but the model appears to be mostly a top-down distribution of knowledge from UAB to other institutions—that is, the collaboration with other institutions relies primarily on UAB offering workshops for partner institutions. This reviewer concludes that, while there is certainly coordination, it is unclear if there is true collaboration within these partnerships.

QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer explained that this seems like a program (new classes taught, student certificates, etc.) that will continue even without GATE funding, which shows the benefit the GATE funding provided and how well UAB utilized that funding. The second reviewer pointed out that the program appears to be creating new research goals while planning to continue existing educational programming and the approach is sound, but it might be nice to see some degree of novelty in student-focused components. The final reviewer stated that there was only one bullet on the last slide: UAB is applying for a five-year renewal to expand impact in low-cost carbon fiber, biocomposites and application development for automotive to align with CAFE standards and medium/heavy truck. No explanation and no discussion during the presentation.

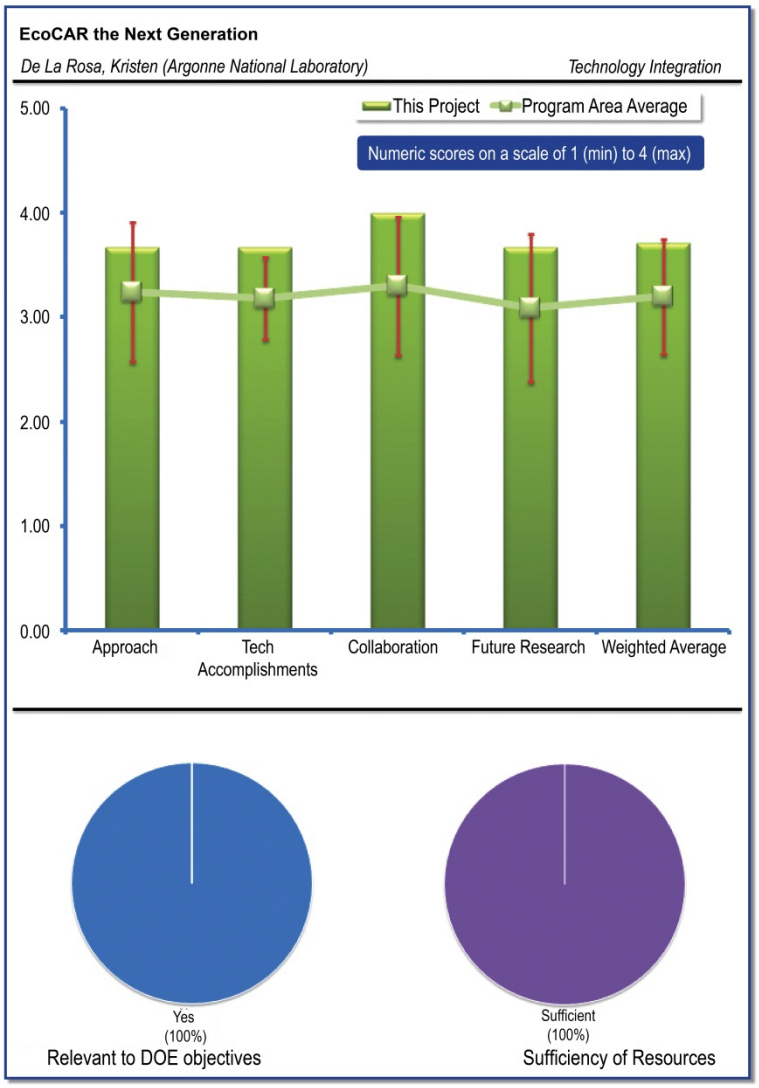
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Opinion on resources varied widely. One reviewer said that the resources appear effectively spent although there was no information on cost sharing. Another reviewer said this GATE program looked like a very good investment and much was achieved. The final reviewer said that the program will need a new grant to continue plans and has applied for it.

EcoCAR the Next Generation: De La Rosa, Kristen (Argonne National Laboratory) – ti013

Reviewer Sample Size

This project had a total of three reviewers.



Question 1: Does this project support the overall DOE objectives? Why or why not?

Evaluators were overall supportive of this project. The first reviewer is confident that this project fully supports the objectives of petroleum displacement and the genesis of the project was done more than 20 year ago and uses a build-a-little, test-a-little philosophy that is truly experientially based. The first reviewer adds that it could be called a Live In-Field Simulation or proof-of-concept whereby schools and partnering organizations actually are required to design, build and test their concepts. The reviewer continues that the students gain a tremendous insight into dealing with challenges that arise and actually seeing their work result in something. This reviewer concludes by stating that measurement is key, as the cars are subjected to numerous tests and overall this is great concept and great work. The second reviewer stated that the size of the competition and the number of students included in the project—combined with what appears to be a rigorous system of checks and balances prior to the competition—suggest that there should be novel findings in a number of the projects submitted as part of the EcoCar competitions. The third and final reviewer said that workforce development leading to engineers and scientists that will develop and deploy automotive technologies of the future is critical to petroleum savings.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer explained that, in terms of the participants who are members of each school team, one point made during the presentation was that these young men and women are the most sought after new hires by a number of the participating companies and so they immediately bring their influence into a GM or another company who is dealing with challenges much like the ones they faced in developing their special car. This reviewer added that, in terms of lessons learned while developing each automobile, it seems that there is a direct input from those who are supporting the development from each of the participating organizations. The second reviewer said that the size of the competition -- and the fact that its requirements and standards are being continually refined through contact with government, industry, and academia--suggests a great training opportunity for students further praising the program as novel for its attention to community outreach and public relations. This evaluator concluded by noting that the use of a technical inspector/reviewer(s) before the team can come to competition also makes a nice training intervention—and can catch problems and find teaching moments efficiently. The final reviewer acknowledged that directing the schools to follow the same processes as GM has been a major step forward and will provide a better educational experience.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer referred to one comment made during the presentation that noted that one team had built a car with a resulting 100+ miles per gallon, this is not imagined or theorized results but actual results. The reviewer explained that developing insights into these types of technical breakthroughs speaks highly about the success of this type of project. The second reviewer stated that program components are well-conceived, well-organized, and appear to be meeting all objectives and felt that this presentation demonstrated the clearest effort to think carefully about student learning outcomes and to create the right environment to achieve them. The reviewer added that it is also clear that there is significant anecdotal data that the student placement record is very high and suggests the program might consider putting some resources into tracking official placement data or doing other assessment work to continue to highlight its successes. A third reviewer explained that refinement of the rules to be more technology neutral is very good.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer was not sure there are any other programs in the entire grant cycle that can compare with this project and said their in-kind cash contribution is $75 million and other funds of $7.3 million outside of the $4.3 million from DOE, adding that their industry partners represent some of largest auto makers and suppliers, including the government of Canada. A second reviewer noted that competition involves strong links to GM and involves students with both GM goals and objectives and DOE goals and objectives and the program also integrates 16 different universities, thereby offering opportunities for students from a wide range of places and giving them the chance to interact with each other and their respective faculties. The second reviewer explained that the program seems to be especially strong in its efforts to create an industry-like environment for students to work in, through the partnership with GM. The final reviewer noted that the sponsor list and external contributions have grown impressively.

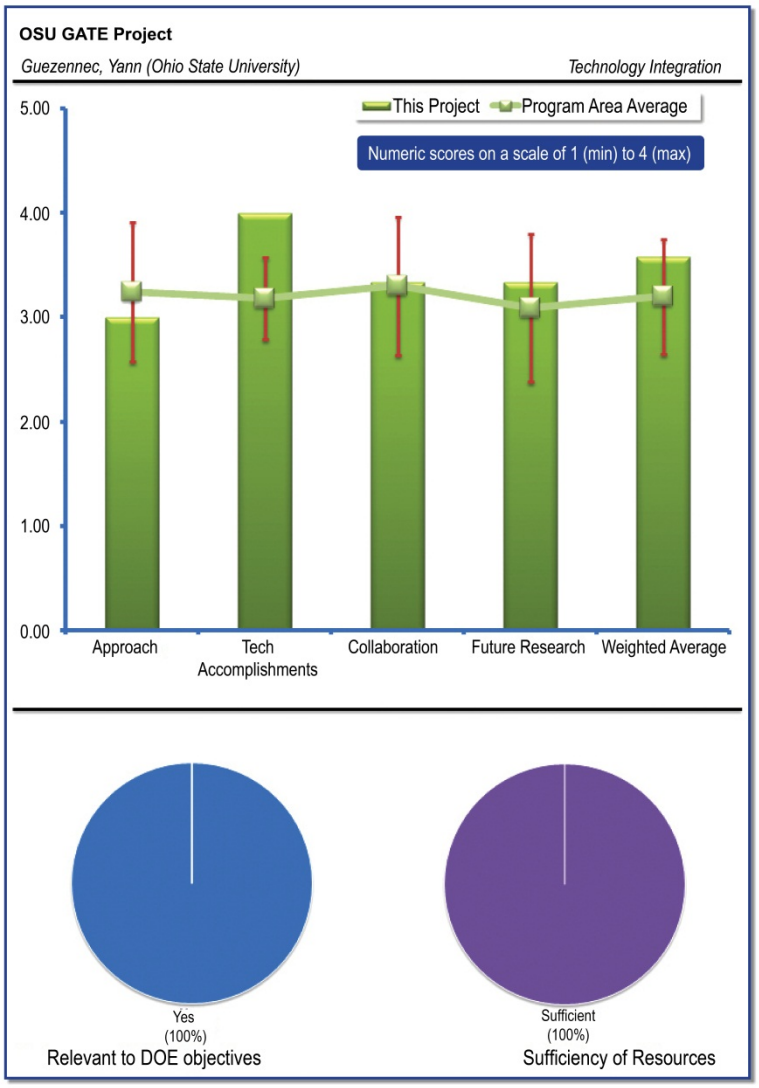
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said the planned future activities are both aggressive and achievable; they are focused on barriers and have the talent, the will, professionalism and dedication to assure that they will succeed, no matter the challenge. This reviewer is convinced that a program of this sort that provides real hands-on learn-by-doing-opportunity is in and of itself the best type of motivation for those involved. The reviewer continued, driving down a road in a modified vehicle getting upwards of 70, 80 or even 100 MPG gives participants a sense of real meaning and of making a difference, it is a reward unto itself and the reviewer is confident that those proposed future activities will be met and achieved. The second reviewer stated that future work seems to suggest careful and thoughtful refinement in the tradition already established to create ongoing competition series. The third reviewer noted that enhancements to Ecocar2 will make the process and results more realistic and result in even better researchers entering the workforce.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

The first reviewer observed that with most of the funds coming from outside of DOE, this is a poster child project, meaning this represents how effective and efficient government can really work with a truly collaborative based partnership and it represents an amazing example of 21st Century leadership that is creating a movement or force for change. The second reviewer affirmed that they seem to know what kind of funds they need to continue the program; and they have a record of continuing the program for more than 20 years. The final reviewer stated that additional funding might enable more schools to join the competition, but that would create a burden on the sponsors while adding only marginal value.

Ohio State University GATE Project: Guezennec, Yann (Ohio State University) - ti015



Reviewer Sample Size

This project had a total of three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All of the reviewers agreed that this technology should be pursued. The first commenter said modeling, control, and systems integration of automotive systems is critical to successful commercializing of advanced technology vehicles, which in turn meets the DOE petroleum displacement objective. The second reviewer stated that system integration is huge for petroleum displacement and many of the job opportunities in the automotive industry are for system integration. The final reviewer stated that the project appears academically sound but this is not his area of expertise.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first evaluator suggested it is a very well organized project and was a great approach. The second reviewer pointed out that technical barriers are not identified and the barrier identified is funding needed to be stretched over an additional year. The reviewer added that there have been considerable accomplishments, so it is hard to determine the significance of the identified barrier. The third reviewer explained that the program is well-developed and well-organized, makes excellent use of resources from other existing programs, and appears fairly simple though—graduate fellowships and coursework. The third reviewer added that there is not much in terms of programmatic innovation and given the grant's focus on training students for industry, it would also be nice to see more links to private sector partners specifically for the career development of the GATE students.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said the objectives were clearly stated: student recruitment, curriculum development, student research, vehicle competitions, and placement of graduates and says the accomplishments were easy to follow. The second reviewer stated that (1) a good number of classes developed (2) program provided funding for many graduate students (3) program integrated GATE with many other programs (EcoCar, buckeye bullet, etc.). A third reviewer explained that the program shows a lot of progress in curriculum development and course offerings.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer stated that there appear to be very strong partnerships with industry in terms of research agenda development and funding and partnerships with industry to create new graduate fellowships are nice program components. The reviewer added that it is

unclear how much career development programming accompanies these partnerships. This reviewer stated that partnerships with other universities seem to come primarily through participation in new research grants together and there does not appear to be a strong collaborative component in the existing program. The second reviewer said there are several good collaborations, but they could have used more elaboration. The third reviewer stated that it was very strong work with EcoCar and a land speed record vehicle.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that there was only one bullet indicating that a new GATE proposal was submitted in April, but no elaboration. Another reviewer said that there will be continued involvement in EcoCar. A third reviewer said future activities appear to be continue existing programs, continue advancing research.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer said that the resources were well spent and that a recurring theme is that DOE funds flow intermittently, creating problems for the university. The reviewer added that this is likely true for all GATE universities and consequently DOE should address this problem. The second reviewer stated that they have exceeded many of the milestones required by the GATE program. A third reviewer explained that the program requires a new grant to continue programs and has applied for it.

9. Acronyms

The following list of Acronyms cited within the report is provided as a reference for readers.

Acronym	Definition
1D or 1-D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional
3-DEP	Three Dimensional Engineered Preform
5-Cycle	Light-duty testing conducted on a chassis dynamometer
A123	A123 Systems
ABR	Advanced Battery Research
AC	Alternating Current
ACCESS	Advanced Combustion Concepts Enabling Systems and Solutions
ACE	Advanced Combustion Engines
ACEC	Advanced Combustion and Emissions Control
ACERT	Advanced Combustion Emission Reduction Technology
ACES	Advanced Collaborative Emissions Study
ACI	AC Impedance
ADMA	ADMA Products, Inc.
AE	Acoustic Emission
AEC	Advanced Engine Combustion (Sandia National Laboratories)
AFDC	Alternative Fuels and Advanced Vehicles Data Center
AFR	Air Fuel Ratio
Ag	Silver
Ah	Ampere-hour
AIS4+	Abbreviated Injury Severity score of severe-to-fatal
Al	Aluminum
ALMS	American LeMans Series
AMOX	Ammonia Oxidation
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APEEM	Advanced Power Electronics and Electric Machines Program
APRF	Advanced Powertrain Research Facility
APS	Advanced Photon Source
Ar	Argon
ARC	Accelerated Rate Calorimetry
ARL	Army Research Laboratory
ARPA-e	Advanced Research Projects Agency-Energy
ASAP	As Soon As Possible
AS/P	Automotive Supplier / Provider
ASI	Area-specific Impedance
ARRA	American Recovery and Reinvestment Act

Acronym	Definition
ASTM	American Society for Testing and Materials
AT	Aftertreatment
ATP-LD	Advanced Technology Powertrains for Light-Duty Vehicles
ATR-FTIR	Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy
AVFL-18	Project 18 under Advanced Vehicle/Fuel/Lubricants of the Coordinating Research Council
AVTA	Advanced Vehicle Testing Activity
B20	Biodiesel blend of 20% neat biodiesel
BAS	Bioanalytical Systems, Inc. electrochemical detector
BASF	BASF The Chemical Company
BATT	Batteries for Advanced Transportation Technologies
BCN	Boron carbonitride
BDB	Benzodioxaborole
Bi2Te3	Bismuth(III) telluride
BES	DOE Basic Energy Sciences
BET	Brunauer-Emmett-Teller
BEV	Battery Electric Vehicle
BIM	Bonded Interface Material
BLRT	Bond Line Read Through
BMEP	Brake mean effective pressure
BMS	Battery management system
BP	Boiling Point
BRN	Basic Research Needs
BSFC	Brake specific fuel consumption
BSST	BSST Thermoelectric Temperature Control Solutions
BTE	Brake thermal efficiency
BTO	Barium Titanate
BYU	Brigham Young University
C8	Aromatic hydrocarbon with eight carbon atoms
C	Degrees Celsius
C	Carbon
C2H2	Acetylene
CA50	Crank Angle of 50 percent mass fraction burned
Ca3Co4O9	Calcium cobalt oxide
CAE	Computer Aided Engineering
CAEBAT	Computer-Aided Engineering for Electric Drive Vehicle Batteries
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CASE	Case Western Reserve University
CB	Carbon Black
CBS	Characteristic-Based Split
CD	Charge Depleting

Acronym	Definition
CE	Coulombic Efficiency
CFD	Computational Fluid Dynamics
CFS	Combustive Flow Simulation
CFTF	Carbon Fiber Test Facility
CHA	Chabazite
CHAdeMO	Direct current fast charger for batteries
CI	Compression Ignition
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CLOSE	Collaborative Lubricating Oil Study on Emissions
cm	Centimeters
CMC	Carboxymethyl cellulose
CMS	Carboxymethyl starch
CNG	Compressed Natural Gas
CNF	Carbon Nano-Fibers
CNT	Carbon Nanotubes
CO	Carbon Monoxide
COTS	Commercial Off The Shelf
COV	Coefficient of Variation
COVIMEP	Coefficient of Variation of the Indicated Mean Effective Pressure
CR	Compression ratio
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CS	Charge Sustaining
CTE	Coefficient of thermal expansion
CV	Cyclic voltammetry
CVD	Chemical Vapor Deposition
DARPA	Defense Advanced Research Projects Agency
DBA	Direct Bonded Aluminum
DEC	Diethyl carbonate
DERC	Diesel Engine Research Consortium
DeNOx	Reduction of nitrogen oxides
DDC	Detroit Diesel Corporation
DF-2	Diesel Fuel
DFT	Density Functional Theory
DI	Direct Injection
DISI	Direct injection spark ignited
DLFT	Direct Compounded Long Fiber Thermoplastics
DMHP	Dual Mode Hybrid Powertrain
DNS	Direct Numerical Simulation
DOC	Diesel oxidation catalyst
DOD	Department of Defense

Acronym	Definition
DoD	Depth of Discharge
DOE	Department of Energy
DOW	Dow Chemical Company
DP	Dual Phase
DPF	Diesel particulate filter
DRIFTS	Diffuse Reflectance Infrared Fourier Transform Spectroscopy
DSC	Differential Scanning Calorimetry Analysis
E10	10 percent ethanol blend with gasoline
E15	15 percent volume ethanol blend with gasoline
E20	20 percent ethanol blend with gasoline
E85	85 percent ethanol blend with gasoline
EADPF	Electrically-assisted Diesel Particulate Filter
EC	Ethylene carbonate
ECN	Engine Combustion Network
ECU	Electronic Control Unit
EDAB	Electric Drive and Advanced Battery and Components Testbed
EDLC	Electric Double-Layer Capacitor
EDV	Electric Drive Vehicle (HEV, PHEV, BEV)
EDX	Energy-dispersive X-ray spectroscopy
EERE	Energy Efficiency and Renewable Energy
EGR	Exhaust Gas Recirculation
EISA	Energy Independence and Security Act of 2007
EMD	Electro-Motive Diesel
EMS	Ethylmethylsulfone
EMS	PEV/Energy Management System
EN	Electroless nickel
EO	Engine Out
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPCOS	EPCOS Electronic Components, Modules, and Systems
EPRI	Electric Power Research Institute
ERDA	Elastic Recoil Detection Analysis
EREV	Extended Range Electric Vehicle
ES	DOE Energy Storage Program
ESM	Electrochemical Strain Microscopy
ESS	Energy Storage System
ETW	EPA Equivalent Test Weight
EUMD	End Use Measurement Device
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental Equipment
FAA	Federal Aviation Administration

Acronym	Definition
FACE	Fuels for Advanced Combustion Engines
FC	DOE Fuel Cell Technologies Program
FCV	Fuel Cell Vehicles
Fe	Iron
FE	Fuel Efficiency
FEERC	Fuels, Engines, and Emissions Research Center
FEM	Finite Elements Model
FEMS	Trifluoroethylmethylsulfone
Fe-Z	Iron zeolite
FFV	Flexible fuel vehicle
FFVA	Fully Flexible Valve Actuation
FIE	Fuel Injection Equipment
FLD	Forming Limit Diagram
FMC	FMC Corporation
FMVSS	Federal Motor Vehicle Safety Standards
FSN	Filter Smoke Number
FSP	Friction Stir Processing
FSW	Friction Stir Welding
FTP	Federal Test Procedure
FY	Fiscal Year
GaN	Gallium Nitride
GATE	Graduate Automotive Technology Education
GDCI	Gasoline Direct Injection Compression Ignition
GE	General Electric
GeoEVSE	Google-electric vehicle charging installation partnership
GDI	Gasoline Direct Injection
GHG	Greenhouse gases
GITT	Grid Integration Tech Team
GM	General Motors Corporation
GTDI	Gasoline Turbocharged Direct Injection
GT POWER	Gamma Technologies, Inc. computer-aided engineering software
GUI	Graphical User Interface
GWP	Global Warming Potential
HAN	Home Area Network
HBCU	Historically Black Colleges and Universities
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HD	Heavy-duty
HDD	Heavy-duty diesel
He	Helium
HECC	High Efficiency Clean Combustion

Acronym	Definition
HEDGE	High Efficiency Dilute Gasoline Engine
HEV	Hybrid Electric Vehicle
HfN	Hafnium nitride
HIL	Hardware in the Loop
HMI	Human Machine Interface
HMS	Higher Manganese Silicides
HP	Higher-order Ploynomial Approximation
HPL	High Power Lithium
HPLB	High-Pressure, Lean Burn
HT	High Temperature
HTMI	high temperature melt integrity
HTML	High Temperature Materials Laboratory
HV	High Voltage
HVAC	Heating Ventilating and Air Conditioning
HW	Honeywell
HWFE	Highway Fuel Economy
H2	Hydrogen
IAC	International Automotive Components
IC	Internal Combustion
ICE	Internal Combustion Engine
ICP	Inductively-coupled Plasma
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated-gate bipolar transistor
IMEP	Indicated Mean Effective Pressure
INL	Idaho National Laboratory
IP	Intellectual Property
IPM	Interior Permanent Magnet
IR	Infrared
ISFC	Indicated Specific Fuel Consumption
ISO	International Organization for Standardization
ITE	Indicated Thermal Efficiency
ITP	DOE Industrial Technologies Program
ITS	Institute of Transportation Studies
JCI	Johnson Controls Inc.
JM	Johnson Matthey
JMI	John Marvin Inc.
JPL	Jet Propulsion Laboratory
K	Potassium
K	degrees Kelvin
K	Thousand
KAIST	Korea Advanced Institute of Science and Technology

Acronym	Definition
KAMAX	Kamax Auto Parts Co., Ltd.
kg	Kilogram
KIVA	Internal combustion engine simulation code (Los Alamos)
KULI	Software package for thermal modeling
kWh	Kilowatt hour
L	Liter
LBNL	Lawrence Berkeley National Laboratory
LC	Life Cycle
LCCF	Low Cost Carbon Fiber
LD	Light-duty
LDD	Light-duty Diesel
LDRD	Laboratory Directed Research and Development
LDV	Light Duty Vehicle
LEESS	Lower Energy Energy Storage System
LES	Large Eddy Simulation
LEVIII	State of California Low-Emission Vehicle III regulations
LFP	Lithium iron phosphate
LG	LG Chem
Li	Lithium
LLC	Limited Liability Company
LLFC	Lean Lifted Flame Combustion
LLNL	Lawrence Livermore National Laboratory
LLDPE	Linear Low-Density Polyethylene
LLV	Long Life Vehicle (used by USPS)
LMR-NMC	lithium- and manganese-rich transition metal oxides
LNMO	Lithium Nickel Manganese Oxide
LNT	Lean NOx Trap
LSP	Laser shock peening
LT	Low Temperature
LTC	Low Temperature Combustion
LTO	Low Temperature Oxide (form of silicon dioxide)
M	Million
M&S	Modeling and Simulation
MC550	Mesoporous hard carbon
MCE	Multi-cylinder Engine
MCMB	Mesocarbon Microbeads
MD	Medium-duty
MECA	Manufacturers of Emissions Control Association
MEI	Magnetic-electro Imaging
MEMS	Methoxyethyl methyl sulfone
MENA	Magnesium Elektron North America

Acronym	Definition
MFI	Mordenite Framework Inverted
MIT	Massachusetts Institute of Technology
MNC	Metal-Nitrogen-Carbon
MnSi	Manganese Silicide
MO	Molecular Orbital
MOU	Memorandum of Understanding
MS	Masters of Science
MSCl	Methanesulfoneyl chloride
MSF	Methanesulfoneyl fluoride
MSU	Michigan State University
MTU	Michigan Technology University
NA	North America
NaCo2O4	sodium cobalt oxide
NASA	National Aeronautics and Space Administration
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NDA	Non-Destructive Analysis
NDA	Non-Disclosure Agreement
NDE	Non-Destructive Evaluation
NEC	National Electrical Code
NETL	National Energy Technology Laboratory
NFAC	National Full-Scale Aerodynamics Complex
NFPA	National Fire Protection Association
NG	Natural Gas
NGK	NGK Spark Plugs USA
NH3	Ammonia
NHTSA	National Highway Traffic Safety Administration
NiMH	Nickel-metal hydride
NIST	National Institute of Standards and Technology
NMC	Nickel manganese cobalt
NMEP	Net Mean Effective Pressure
NMR	Nuclear Magnetic Resonance
NOx	Nitrogen Oxide
N2	Nitrogen
N2O	Nitrous Oxide
NPBF	Non-petroleum Blend Fuels
NRC	National Research Council
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
NSR	NOx Storage/Reduction
NTC	Negative Temperature Coefficient
NTIS	National Technical Information Service

Acronym	Definition
NTRC	National Transportation Research Center
NVH	Noise/vibration/harshness
NVO	Negative valve overlap
OE	DOE Office of Electricity Delivery and Energy Reliability
OE	Original Equipment
OEM	Original Equipment Manufacturer
OIT	DOE Office of Industrial Technologies
ORC	Organic Rankine cycle
ORMAT	Ormat Technologies Inc.
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
OSU	Oregon State University
OVT	Office of Vehicle Technologies
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)
PAH	Polycyclic Aromatic Hydrocarbon
PAN	Polyacrylonitrile
PASS	Passive Ammonia SCR System
PbTe	Lead(II) Telluride
PCCI	Premixed Charge Compression Ignition
PDF	Adobe Portable Document Format
PEV	Plug-in Electric Vehicle
PFI	Port Fuel Injected
PGM	Precious-group metals
PHEV	Plug-In Hybrid Electric Vehicle
PHEV40	Plug-In Hybrid Electric Vehicle with a 40-mile range on a single charge
PI	Principal Investigator
PIV	Particle Image Velocimetry
PLC	Programmable Logic Controller
PM	Particulate Matter
PM	Propulsion Materials
PN	Particulate Number
PNA	Polynuclear Aromatics
PNNL	Pacific Northwest National Laboratory
PREA	Partnership for Roadway Electrification & Automation
PRESICE	Combustion Model
PSAT	Powertrain Systems Analysis Toolkit
PSD	Particle Size Distribution
PSE gPROMS	Process Systems Enterprise Limited (PSE) advanced process modeling
PV	Photovoltaic
PVdF	Polyvinylidene Fluoride
PZT	Lead zirconate titanate film

Acronym	Definition
RAPTR	Regenerative Air Preheating and Thermochemical Recuperation
RB	Reverse Blocking
RBIGBT	Reverse Blocking Insulated Gate Bipolar Transistor
RBC	Route Based Control
RBS	Rutherford Backscattering Spectrometry
RCCI	Reactivity Controlled Compression Ignition Combustion
RCF	Rapid Compression Facility at the University of Michigan
RCM	Rapid Compression Machine
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RNG	Renormalization Group
RFSII	Renewable Fuel Standard, as amended
RON	Research Octane Number
RPM	Revolutions Per Minute
RSM	Response Surface Methodology
S	Sulfur
SACI	Spark Assisted Compression Ignition
SAE	Society of Automotive Engineers
SAFT	The Saft Group
SANS	Small Angle Neutron Scattering
SA-HCCI	Spark-Assisted Homogeneous Charge Compression Ignition
SBR	Styrene butadiene rubber
ScN	Scandium nitride
SCR	Selective Catalytic Reduction
SEI	Solid electrolyte interface
SEM	Scanning Electron Microscope
SEP	Smart Energy Profile
SHNC	Superhard Nanocomponent
Si	Silicon
SI	Spark Ignition
SiC	Silicon Carbide
SLA	Sealed Lead Acid
SLMP	Stabilized Lithium Metal Powder
SNL	Sandia National Laboratories
SO2	Sulfur Dioxide
SO3	Sulfite
SOC	State of Charge
SOD	Superoxide Dismutase
SOI	Start of Injection
SOM	Solid Oxide Membrane
SOP	Standard Operating Procedure

Acronym	Definition
SP	Single Phase
SPX	SPX Service Solutions
SSITKA	Steady State Isotopic Transient Kinetic Analysis
STEM	Scanning Transmission Electron Microscopy
SUNY	State University of New York
SWRI	Southwest Research Institute
T2B2	Tier 2 Bin 2 Emissions Standards
TACOM	Tank-automotive and Armaments Command
TARDEC	Tank Automotive Research, Development, and Engineering Center
TBC	Thermal Barrier Coating
TDL	Tunable Diode Laser
TE	Thermoelectrics
TEG	Thermoelectric Generator
TEM	Transmission Electron Microscope
TEMats	Thermoelectric Materials
TGA	Thermogravimetric Analysis
TiO2	Titanium dioxide
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
TWIP	Twinning-Induced Plasticity
TWC	Three-way Catalyst
UAB	University of Alabama Birmingham
UC	University of California
UCLA	University of California, Los Angeles
UCON	University of Connecticut
UDDS	Urban Dynamometer Driving Schedule
UHC	Unburned Hydrocarbons
UIUC	University of Illinois at Urbana-Champaign
UL	Underwriters Laboratories
UM	University of Michigan
UNLV	University of Nevada Las Vegas
USABC	US Advanced Battery Consortium
USAMP	U.S. Automotive Materials Partnership
USCAR	United States Council for Automotive Research
USDA	United States Department of Agriculture
USPS	United States Postal Service
USW	Ultrasonic Welding
UT	University of Tennessee
V2G	Vehicle to Grid
VDA	Verband der deutschen Automobilindustrie or Association of German Automobile Manufacturers
VGC	Vehicle to Grid Communication
VGCF	Vapor-grown Carbon Fiber

Acronym	Definition
VLBT	Variable-load Bearing Test
VPI & SU	Virginia Polytechnic Institute and State University
VT	Vehicle Technologies
VTC	Vehicle to charger
VtG	Vehicle to Grid
VTP	Vehicle Technologies Program
VVA	Variable Valve Actuation
Wh	Watt hour
WHR	Waste Heat Recovery
WJP	Water Jet Peening
WPAFB	Wright-Patterson Air Force Base
WPT	Wireless Power Transfer
WWMP	World Wide Mapping Point
X-Prize	Progressive Automotive X-Prize Competition
XAFS	X-ray Absorption Fine Structure
XPS	X-ray Photoelectron Spectroscopy
WG	Working Group
XRD	X-ray Diffraction (Crystallography)
Z	Zinc
ZCSI	Z-source Current Source Inverter
ZT	Thermoelectrics figure of merit (measure of efficiency)

10. Cross-Reference of Project Investigators, Projects, and Organizations

Cross Reference, Sorted by Project Investigator

Page Number	Principal Investigator; Organization. Project Title (Session)
2-61	Abraham, Dan; Argonne National Laboratory. Diagnostic Studies on Li-Battery Cells and Cell Components (Energy Storage Technologies)
2-49	Abraham, Dan; Argonne National Laboratory. Novel Electrolytes and Additives for PHEV Applications (Energy Storage Technologies)
4-35	Aceves, Salvador; Lawrence Livermore National Laboratory. Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines (Advanced Combustion Engine Technologies)
2-10	Alamgir, Mohamed; LG Chem, Michigan. A High-Performance PHEV Battery Pack (Energy Storage Technologies)
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8-6	National Energy Technology Laboratory; Scarpino, Michael. Clean Cities 2009 Petroleum Displacement Awards (Technology Integration)
3-36	National Institute of Standards and Technology; Hefner, Allen. Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters (Power Electronics and Electrical Machines Technologies)
8-4	National Renewable Energy Laboratory/Oak Ridge National Laboratory; Melendez, Margo. Clean Cities Tools and Resources (Technology Integration)
1-53	National Renewable Energy Laboratory; Barnitt, Robb. Analysis of Battery Wear and V2G Benefits Using Real-world Drive Cycles and Ambient Data (Hybrid and Vehicle Systems Technologies)
1-51	National Renewable Energy Laboratory; Barnitt, Robb. Medium- and Heavy-Duty Electric Drive Vehicle Simulation and Analysis (Hybrid and Vehicle Systems Technologies)

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3-42	National Renewable Energy Laboratory; Bennion, Kevin. Electric Motor Thermal Management (Power Electronics and Electrical Machines Technologies)
3-52	National Renewable Energy Laboratory; DeVoto, Doug. Physics of Failure of Electrical Interconnects (Power Electronics and Electrical Machines Technologies)
1-70	National Renewable Energy Laboratory; Gonder, Jeffrey. Advanced HEV/PHEV Concepts (Hybrid and Vehicle Systems Technologies)
1-17	National Renewable Energy Laboratory; Gonder, Jeffrey. Analyzing Fuel Saving Opportunities through Driver Feedback Mechanisms (Hybrid and Vehicle Systems Technologies)
1-61	National Renewable Energy Laboratory; Gonder, Jeffrey. Real-World PHEV Fuel Economy Prediction (Hybrid and Vehicle Systems Technologies)
2-153	National Renewable Energy Laboratory; Kim, Ge-Heon. Numerical and Experimental Investigation of Internal Short Circuit in a Li-ion Cell (Energy Storage Technologies)
4-92	National Renewable Energy Laboratory; Lawson, Doug. Collaborative Lubricating Oil Study on Emissions (CLOSE Project) (Advanced Combustion Engine Technologies)
3-28	National Renewable Energy Laboratory; Lustbader, Jason. Air Cooling Technology for Power Electronic Thermal Control (Power Electronics and Electrical Machines Technologies)
1-49	National Renewable Energy Laboratory; Markel, Tony. Plug-In Electric Vehicle Integration with Renewables (Hybrid and Vehicle Systems Technologies)
5-6	National Renewable Energy Laboratory; McCormick, Bob. Quality, Performance, and Emission Impacts of Biofuels and Biofuel Blends (Fuels & Lubricants Technologies)
3-54	National Renewable Energy Laboratory; Moreno, Gilbert. Two-Phase Cooling Technology for Power Electronics with Novel Coolants (Power Electronics and Electrical Machines Technologies)
3-58	National Renewable Energy Laboratory; Narumanchi, Sreekant. Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate (Power Electronics and Electrical Machines Technologies)
3-40	National Renewable Energy Laboratory; Narumanchi, Sreekant. Thermal Performance and Reliability of Bonded Interfaces (Power Electronics and Electrical Machines Technologies)
2-135	National Renewable Energy Laboratory; Pesaran, Ahmad. Computer-Aided Engineering for Electric Drive Vehicle Batteries (CAEBAT) (Energy Storage Technologies)
1-46	National Renewable Energy Laboratory; Rugh, John. CoolCab Test and Evaluation (Hybrid and Vehicle Systems Technologies)
1-58	National Renewable Energy Laboratory; Rugh, John. Integrated Thermal Management for Electric Drive Vehicles (Hybrid and Vehicle Systems Technologies)
3-56	National Renewable Energy Laboratory; Rugh, John. Integrated Vehicle Thermal Management â€“ Combining Fluid Loops in Electric Drive Vehicles (Power Electronics and Electrical Machines Technologies)
1-55	National Renewable Energy Laboratory; Rugh, John. LDV HVAC Model Development and Validation (Hybrid and Vehicle Systems Technologies)
2-155	National Renewable Energy Laboratory; Smith, Kandler. Battery Thermal Modeling and Testing (Energy Storage Technologies)
1-4	National Renewable Energy Laboratory; Walkowicz, Kevin. Medium and Heavy-Duty Vehicle Field Evaluations (Hybrid and Vehicle Systems Technologies)
5-4	National Renewable Energy Laboratory; Zigler, Brad. Fuels for Advanced Combustion Engines (Fuels & Lubricants Technologies)
2-73	Naval Surface Warfare Center; Smith, Patricia. High Energy Density Ultracapacitors (Energy Storage Technologies)

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4-118	Navistar International Corp.; Jadin, Dennis. Supertruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer (Advanced Combustion Engine Technologies)
1-31	Navistar, Inc.; Friesner, Jan. Development and Deployment of Generation 3 Plug-In Hybrid Electric School Buses (Hybrid and Vehicle Systems Technologies)
1-112	Navistar, Inc.; Gosbee, Darren. Advanced Vehicle Electrification (Hybrid and Vehicle Systems Technologies)
1-102	Navistar, Inc.; Jadin, Dennis. SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer (Hybrid and Vehicle Systems Technologies)
2-27	NC State/NLE; Zhang, Xiangwu. New High-Energy Nanofiber Anode Materials (Energy Storage Technologies)
2-89	North Carolina State University; Henderson, Wesley. Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes (Energy Storage Technologies)
7-50	Oak Ridge National Laboratory; Allard, Larry. Ultra-High Resolution Electron Microscopy for Catalyst Characterization (Materials Technologies: Propulsion Materials)
7-16	Oak Ridge National Laboratory; Blau, Peter. Friction and Wear Enhancement of Titanium Alloy Engine Components (Materials Technologies: Propulsion Materials)
7-38	Oak Ridge National Laboratory; Blau, Peter. Materials for High Pressure Fuel Injection Systems (Materials Technologies: Propulsion Materials)
4-48	Oak Ridge National Laboratory; Briggs, Tom. High Efficiency Engine Systems Development and Evaluation (Advanced Combustion Engine Technologies)
5-2	Oak Ridge National Laboratory; Bunting, Bruce. Fuel and Lubricant Effects (Fuels & Lubricants Technologies)
3-30	Oak Ridge National Laboratory; Burress, Tim. A New Class of Switched Reluctance Motors without Permanent Magnets (Power Electronics and Electrical Machines Technologies)
3-9	Oak Ridge National Laboratory; Burress, Tim. Benchmarking of Competitive Technologies (Power Electronics and Electrical Machines Technologies)
1-22	Oak Ridge National Laboratory; Chambon, Paul. PHEV Engine Control and Energy Management Strategy (Hybrid and Vehicle Systems Technologies)
3-11	Oak Ridge National Laboratory; Chinthavali, Madhu. Wide Bandgap Materials (Power Electronics and Electrical Machines Technologies)
4-46	Oak Ridge National Laboratory; Curran, Scott. High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines (Advanced Combustion Engine Technologies)
2-143	Oak Ridge National Laboratory; Dai, Sheng. Hard Carbon Materials for High-Capacity Li-ion Battery Anodes (Energy Storage Technologies)
2-75	Oak Ridge National Laboratory; Daniel, Claus. In-situ characterization and diagnostics of mechanical degradation in electrodes (Energy Storage Technologies)
2-123	Oak Ridge National Laboratory; Daniel, Claus. Intercalation Kinetics and Ion Mobility in Electrode Materials (Energy Storage Technologies)
7-58	Oak Ridge National Laboratory; Das, Sujit. Life Cycle Modeling of Propulsion Materials (Materials Technologies: Propulsion Materials)
6-3	Oak Ridge National Laboratory; Das, Sujit. Technical Cost Modeling - Life Cycle Analysis Basis for Program Focus (Materials Technologies)
1-47	Oak Ridge National Laboratory; Daw, Stuart. Advanced PHEV Engine Systems and Emissions Control Modeling and Analysis (Hybrid and Vehicle Systems Technologies)
4-59	Oak Ridge National Laboratory; Daw, Stuart. CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR (Advanced Combustion Engine Technologies)

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4-43	Oak Ridge National Laboratory; Daw, Stuart. Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes (Advanced Combustion Engine Technologies)
6-20	Oak Ridge National Laboratory; Feng, Zhili. Dynamic Characterization of Spot Welds for AHSS (Materials Technologies)
3-48	Oak Ridge National Laboratory; Hsu, John. Integration of Novel Flux Coupling Motor and Current Source Inverter (Power Electronics and Electrical Machines Technologies)
3-7	Oak Ridge National Laboratory; Hsu, John. Novel Flux Coupling Machine without Permanent Magnets (Power Electronics and Electrical Machines Technologies)
1-93	Oak Ridge National Laboratory; Jones, Perry. Dynamometer Testing of USPS EV Conversions (Hybrid and Vehicle Systems Technologies)
7-36	Oak Ridge National Laboratory; Kass, Mike. Materials-Enabled High-Efficiency Diesel Engines (Materials Technologies: Propulsion Materials)
1-6	Oak Ridge National Laboratory; Knee, Bill. Truck Duty Cycle and Performance Data Collection and Analysis Program (Hybrid and Vehicle Systems Technologies)
7-70	Oak Ridge National Laboratory; Lance, Michael. Biofuels Impact on DPF Durability (Materials Technologies: Propulsion Materials)
7-72	Oak Ridge National Laboratory; Lance, Michael. Electrically-Assisted Diesel Particulate Filter Regeneration (Materials Technologies: Propulsion Materials)
7-20	Oak Ridge National Laboratory; Lance, Michael. Materials Issues Associated with EGR Systems (Materials Technologies: Propulsion Materials)
2-146	Oak Ridge National Laboratory; Liang, Chengdu. Carbon/Sulfur Nanocomposites and Additives for Li/Sulfur Batteries (Energy Storage Technologies)
3-32	Oak Ridge National Laboratory; Liang, Zhenxian. Power Device Packaging (Power Electronics and Electrical Machines Technologies)
7-56	Oak Ridge National Laboratory; Lin, Hua-Tay. Durability of ACERT Engine Components (Materials Technologies: Propulsion Materials)
7-62	Oak Ridge National Laboratory; Lin, Hua-Tay. Low-Cost Direct Bonded Aluminum (DBA) Substrates (Materials Technologies: Propulsion Materials)
7-3	Oak Ridge National Laboratory; Lin, Huay-Tay. Design Optimization of Piezoceramic Multilayer Actuators for Heavy Duty Diesel Engine Fuel Injectors (Materials Technologies: Propulsion Materials)
7-40	Oak Ridge National Laboratory; Maziasz, Phil. Materials for Advanced Engine Valve Train (Materials Technologies: Propulsion Materials)
7-66	Oak Ridge National Laboratory; Maziasz, Phil. Materials for Advanced Turbocharger Designs (Materials Technologies: Propulsion Materials)
7-60	Oak Ridge National Laboratory; Mcguire, Michael. Non-Rare Earth magnetic materials (Materials Technologies: Propulsion Materials)
3-50	Oak Ridge National Laboratory; Miller, John. Motor Packaging with Consideration of Electromagnetic and Material Characteristics (Power Electronics and Electrical Machines Technologies)
1-96	Oak Ridge National Laboratory; Miller, John. Wireless Plug-in Electric Vehicle (PEV) Charging (Hybrid and Vehicle Systems Technologies)
7-32	Oak Ridge National Laboratory; Muralidharan, Govindarajan. Materials for HCCI Engines (Materials Technologies: Propulsion Materials)
2-148	Oak Ridge National Laboratory; Nanda, Jagjit. Studies on the Local State of Charge (SOC) and Underlying Structures in Lithium Battery Electrodes (Energy Storage Technologies)

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7-24	Oak Ridge National Laboratory; Narula, Chaitanya K.. Catalysts via First Principles (Materials Technologies: Propulsion Materials)
4-77	Oak Ridge National Laboratory; Parks, Jim. Efficient Emissions Control for Multi-Mode Lean DI Engines (Advanced Combustion Engine Technologies)
4-80	Oak Ridge National Laboratory; Partridge, Bill. Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines (Advanced Combustion Engine Technologies)
7-68	Oak Ridge National Laboratory; Pawel, Steve. Engine Materials Compatibility with Alternate Fuels (Materials Technologies: Propulsion Materials)
6-24	Oak Ridge National Laboratory; Payzant, Andrew. Materials Characterization Capabilities at the High Temperature Materials Laboratory: Focus on Carbon Fiber and Composites (Materials Technologies)
7-28	Oak Ridge National Laboratory; Singh, David J.. Thermoelectrics Theory and Structure (Materials Technologies: Propulsion Materials)
5-12	Oak Ridge National Laboratory; Sluder, Scott. Non-Petroleum-Based Fuels: Effects on Emissions Control Technologies (Fuels & Lubricants Technologies)
1-98	Oak Ridge National Laboratory; Smith, David. The ArvinMeritor Dual Mode Hybrid Powertrain (DMHP): Opportunities and Potential for Systems Optimization (Hybrid and Vehicle Systems Technologies)
1-42	Oak Ridge National Laboratory; Smith, David. Vehicle Systems Integration (VSI) Research Laboratory at ORNL (Hybrid and Vehicle Systems Technologies)
4-90	Oak Ridge National Laboratory; Storey, John. Measurement and Characterization of Unregulated Emissions from Advanced Technologies (Advanced Combustion Engine Technologies)
3-5	Oak Ridge National Laboratory; Su, Gui-Jia. A Segmented Drive Inverter Topology with a Small DC Bus Capacitor (Power Electronics and Electrical Machines Technologies)
3-46	Oak Ridge National Laboratory; Su, Gui-Jia. Converter Topologies for Wired and Wireless Battery Chargers (Power Electronics and Electrical Machines Technologies)
3-3	Oak Ridge National Laboratory; Su, Gui-Jia. Inverter Using Current Source Topology (Power Electronics and Electrical Machines Technologies)
7-44	Oak Ridge National Laboratory; Sun, Jiangang. NDE DEVELOPMENT FOR ACERT ENGINE COMPONENTS (Materials Technologies: Propulsion Materials)
4-106	Oak Ridge National Laboratory; Szybist, James. Expanding Robust HCCI Operation (Delphi CRADA) (Advanced Combustion Engine Technologies)
5-14	Oak Ridge National Laboratory; Szybist, James. Gasoline-like fuel effects on advanced combustion regimes (Fuels & Lubricants Technologies)
4-82	Oak Ridge National Laboratory; Toops, Todd. Emissions Control for Lean Gasoline Engines (Advanced Combustion Engine Technologies)
4-104	Oak Ridge National Laboratory; Toops, Todd. Neutron Imaging of Advanced Engine Technologies (Advanced Combustion Engine Technologies)
2-125	Oak Ridge National Laboratory; Unocic, Ray. In-Situ Electron Microscopy of Electrical Energy Storage Materials (Energy Storage Technologies)
3-34	Oak Ridge National Laboratory; Wang, Fei. High Power Density Integrated Traction Machine Drive (Power Electronics and Electrical Machines Technologies)
6-11	Oak Ridge National Laboratory; Warren, Dave. Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers (Materials Technologies)
6-7	Oak Ridge National Laboratory; Warren, Dave. Carbon Fiber Technology Facility (Materials Technologies)

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6-45	Oak Ridge National Laboratory; Warren, Dave. Diffusion Databases for ICME (Materials Technologies)
6-34	Oak Ridge National Laboratory; Warren, Dave. FSW & USW Solid State Joining of Magnesium to Steel (Materials Technologies)
6-17	Oak Ridge National Laboratory; Warren, Dave. Fundamental study of the relationship of austenite-ferrite transformation details to austenite retention in carbon steels (Materials Technologies)
6-36	Oak Ridge National Laboratory; Warren, Dave. High Strain-Rate Characterization of Mg Alloys (Materials Technologies)
6-5	Oak Ridge National Laboratory; Warren, Dave. Low Cost Carbon Fiber Overview (Materials Technologies)
6-9	Oak Ridge National Laboratory; Warren, Dave. Lower Cost Carbon Fiber Precursors (Materials Technologies)
7-48	Oak Ridge National Laboratory; Watkins, Thomas. Catalyst Characterization (Materials Technologies: Propulsion Materials)
7-22	Oak Ridge National Laboratory; Watkins, Thomas. Durability of Diesel Engine Particulate Filters (Materials Technologies: Propulsion Materials)
7-26	Oak Ridge National Laboratory; Wereszczak, Andrew. Thermoelectric Mechanical Reliability (Materials Technologies: Propulsion Materials)
7-64	Oak Ridge National Laboratory; Wereszczak, Andy. Improved Organics for Power Electronics and Electric Motors (Materials Technologies: Propulsion Materials)
8-24	Ohio State University; Guezennec, Yann. OSU GATE Project (Technology Integration)
6-26	ORNL/HTML; Lara-Curzio, Edgar. Materials Characterization Capabilities at the High Temperature Materials Laboratory and HTML User Program Success Stories (Materials Technologies)
6-51	ORNL/HTML; Watkins, Thomas. Materials Characterization Capabilities at the High Temperature Materials Laboratory: Focus Lightweighting, Magnesium (Materials Technologies)
1-81	Pacific Northwest National Laboratory; Gowri, Krishnan. Testing and Validation of Vehicle to Grid Communication Standards (Hybrid and Vehicle Systems Technologies)
7-9	Pacific Northwest National Laboratory; Grant, Glenn. Tailored Materials for Advanced CIDI Engines (Materials Technologies: Propulsion Materials)
7-30	Pacific Northwest National Laboratory; Hendricks, Terry. Proactive Strategies for Designing Thermoelectric Materials for Power Generation (Materials Technologies: Propulsion Materials)
1-44	Pacific Northwest National Laboratory; Kinter-Meyer, Michael. Analysis of maximizing the Synergy between PHEVs/EVs and PV (Hybrid and Vehicle Systems Technologies)
7-5	Pacific Northwest National Laboratory; Lavender, Curt. Fatigue Enhancements by Shock Peening (Materials Technologies: Propulsion Materials)
7-14	Pacific Northwest National Laboratory; Lavender, Curt. Low Cost Titanium - Propulsion Applications (Materials Technologies: Propulsion Materials)
4-61	Pacific Northwest National Laboratory; Lee, Jong. CLEERS Aftertreatment Modeling and Analysis (Advanced Combustion Engine Technologies)
6-32	Pacific Northwest National Laboratory; Paxton, Dean. Friction Stir Spot Welding of Advanced High Strength Steels II (Materials Technologies)
6-49	Pacific Northwest National Laboratory; Paxton, Dean. Materials Informatics for the ICME Cyber Infrastructure (Materials Technologies)
6-38	Pacific Northwest National Laboratory; Paxton, Dean. Pulse-Pressure Forming of Lightweight Metals (Materials Technologies)

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6-40	Pacific Northwest National Laboratory; Paxton, Dean. Ultra-Fine Grain Foils and Sheet by Large-Strain Machining (Materials Technologies)
4-110	Pacific Northwest National Laboratory; Peden, Chuck. Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials (Advanced Combustion Engine Technologies)
4-69	Pacific Northwest National Laboratory; Peden, Chuck. Degradation Mechanisms of Urea Selective Catalytic Reduction Technology (Advanced Combustion Engine Technologies)
4-67	Pacific Northwest National Laboratory; Peden, Chuck. Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials (Advanced Combustion Engine Technologies)
7-34	Pacific Northwest National Laboratory; Pitman, Stan. Hydrogen Materials Compatibility for the H-ICE (Materials Technologies: Propulsion Materials)
4-65	Pacific Northwest National Laboratory; Rappe, Ken. Combination and Integration of DPF-SCR Aftertreatment Technologies (Advanced Combustion Engine Technologies)
4-112	Pacific Northwest National Laboratory; Stewart, Mark. Fuel-Neutral Studies of Particulate Matter Transport Emissions (Advanced Combustion Engine Technologies)
2-87	Pacific Northwest National Laboratory; Zhang, Jason. Development of High Energy Cathode Materials (Energy Storage Technologies)
8-8	Pennsylvania State University; Anstrom, Joel. Penn State DOE Graduate Automotive Technology Education (Gate) Program for In-Vehicle, High-Power Energy Storage Systems (Technology Integration)
3-18	Pennsylvania State University; Lanagan, Michael. Glass Ceramic Dielectrics for DC Bus Capacitors (Power Electronics and Electrical Machines Technologies)
1-124	Peterbilt; Lawyer, Bruce. Demonstration of Highly Efficient and Clean Class 8 Trucks (Hybrid and Vehicle Systems Technologies)
4-145	Purdue University; Xu, Xianfan. Thermoelectrics for Automotive Waste Heat Recovery (Advanced Combustion Engine Technologies)
4-134	Robert Bosch; Yilmaz, Hakan. Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles (Advanced Combustion Engine Technologies)
4-11	Sandia National Laboratories; Dec, John. HCCI and Stratified-Charge CI Engine Combustion Research (Advanced Combustion Engine Technologies)
3-16	Sandia National Laboratories; Dirk, Shawn. High Temperature Polymer Capacitor Dielectric Films (Power Electronics and Electrical Machines Technologies)
4-84	Sandia National Laboratories; Larson, Richard. Development of Chemical Kinetic Models for Lean NOx Traps (Advanced Combustion Engine Technologies)
4-8	Sandia National Laboratories; Miles, Paul. Low-Temperature Automotive Diesel Combustion (Advanced Combustion Engine Technologies)
5-8	Sandia National Laboratories; Mueller, Chuck. Optical-Engine and Surrogate-Fuels Research for an Improved Understanding of Fuel Effects on Advanced-Combustion Strategies (Fuels & Lubricants Technologies)
4-5	Sandia National Laboratories; Musculus, Mark. Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling (Advanced Combustion Engine Technologies)
4-20	Sandia National Laboratories; Oefelein, Joe. Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research (Advanced Combustion Engine Technologies)
2-69	Sandia National Laboratories; Orendorff, Chris. Evaluation of Abuse Tolerance Improvements (Energy Storage Technologies)
4-14	Sandia National Laboratories; Pickett, Lyle. Low-Temperature Diesel Combustion Cross-Cut Research (Advanced Combustion Engine Technologies)

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5-10	Sandia National Laboratories; Sjoberg, Magnus. Advanced Lean-Burn DI Spark Ignition Fuels Research (Fuels & Lubricants Technologies)
4-17	Sandia National Laboratories; Steeper, Richard. Automotive HCCI Engine Research (Advanced Combustion Engine Technologies)
4-22	Sandia National Laboratories; Van Blarigan, Peter. Free-Piston Engine (Advanced Combustion Engine Technologies)
2-32	Sion Power; Mikhaylik, Yuriy. Protection of Li Anodes Using Dual Phase Electrolytes (Energy Storage Technologies)
1-118	Smith Electric Vehicles; Mackie, Robin. Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification (Hybrid and Vehicle Systems Technologies)
1-109	South Coast Air Quality Management District; Miyasato, Matt. Plug-In Hybrid Electric Medium Duty Commercial Fleet Demonstration and Evaluation (Hybrid and Vehicle Systems Technologies)
2-81	SUNY-Binghamton; Whittingham, M. Stanley. The Synthesis and Characterization of Substituted Olivines and Layered Manganese Oxides (Energy Storage Technologies)
3-44	Synthesis Partners; Whaling, Christopher. Inverter Cost Analysis and Marketing Intelligence (Power Electronics and Electrical Machines Technologies)
4-139	Texas A&M University; Vaddiraju, Sreeram. NSF/DOE Thermoelectric Partnership: Inorganic-Organic Hybrid Thermoelectrics (Advanced Combustion Engine Technologies)
8-20	The University of Alabama at Birmingham; Vaidya, Uday. GATE Center of Excellence at UAB in Lightweight Materials for Automotive Applications (Technology Integration)
2-6	TIAX LLC; Barnett, Brian. PHEV and LEESS Battery Cost Assessment (Energy Storage Technologies)
4-135	University of California at Los Angeles; Ju, Yongho. Integration of Advanced Materials and Interfaces for Durable Thermoelectric Automobile Exhaust Waste Heat Harvesting Devices (Advanced Combustion Engine Technologies)
4-137	University of California at Santa Cruz; Shakouri, Ali. Thermoelectrics Partnership: High Performance Thermoelectric Waste Heat Recovery System Based on Zintl Phase Materials with Embedded Nanoparticles (Advanced Combustion Engine Technologies)
8-10	University of California-Davis; Erickson, Paul. UC Davis Fuel Cell, Hydrogen, and Hybrid Vehicle (FCH2V) GATE Center of Excellence (Technology Integration)
2-86	University of Cambridge; Ceder, Gerbrand. First Principles Calculations and NMR Spectroscopy of Electrode Materials (Energy Storage Technologies)
4-75	University of Connecticut; Gao, Puxian. Three-Dimensional Composite Nanostructures for Lean NOx Emission Control (Advanced Combustion Engine Technologies)
4-73	University of Houston; Harold, Michael. Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems (Advanced Combustion Engine Technologies)
8-14	University of Illinois at Urbana-Champaign; Lee, Chia-fon. University of Illinois at Urbana-Champaign's GATE Center for Advanced Automotive Bio-Fuel Combustion Engines (Technology Integration)
4-51	University of Michigan; Assanis, Dennis. A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines (Advanced Combustion Engine Technologies)
2-109	University of Michigan; Sastry, Ann Marie. Modeling-Thermo-electrochemistry, Capacity Degradation and Mechanics with SEI Layer (Energy Storage Technologies)
8-16	University of Michigan-Dearborn; Mallick, P.K.. Center for Lightweighting Automotive Materials and Processing (Technology Integration)
2-97	University of Rhode Island; Lucht, Brett. Development of Electrolytes for Lithium-ion Batteries (Energy Storage Technologies)

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8-12	University of Tennessee; Irick, David. The University of Tennessee's GATE Center for Hybrid Systems (Technology Integration)
2-95	University of Texas at Austin; Goodenough, John. Search for New Anode Materials (Energy Storage Technologies)
2-83	University of Texas at Austin; Manthiram, Arumugam. STABILIZED SPINEL AND POLYANION CATHODES (Energy Storage Technologies)
4-143	University of Texas, Austin; Shi, Li. NSF/DOE Thermoelectric Partnership: High-Performance Thermoelectric Devices Based on Abundant Silicide Materials for Vehicle Waste Heat Recovery (Advanced Combustion Engine Technologies)
2-91	University of Utah; Smith, Grant. Molecular dynamics simulation and ab intio studies of electrolytes and electrolyte/electrode interfaces (Energy Storage Technologies)
4-54	University of Wisconsin; Reitz, Rolf. Optimization of Advanced Diesel Engine Combustion Strategies (Advanced Combustion Engine Technologies)
6-58	USAMP/ACC; Houston, Dan. Advanced Materials and Processing of Composites for High Volume Applications (ACC932) (Materials Technologies)
6-15	USAMP/AMD; Li, Mei. Integrated Computational Materials Engineering (ICME) for Mg: International Pilot Project (Materials Technologies)
6-13	USAMP/AMD; Luo, Alan. Magnesium Front End Development (AMD 603/604/904) (Materials Technologies)
6-54	USAMP/AMD; Osborne, Dick. AMD 405: Improved Automotive Suspension Components Cast with B206 Alloy (Materials Technologies)
6-56	USAMP/ASP; Cullum, Terry. AHSS Stamping Project - A/SP 050; Nonlinear Strain Paths Project - A/SP 061 (Materials Technologies)
6-29	USAMP/NDE Chrysler; Wagner, David. Multi-Materials Vehicle R&D Initiative Lightweight 7+ Passenger Vehicle (Materials Technologies)
8-18	Virginia Tech; Nelson, Doug. GATE Center for Automotive Fuel Cell Systems at Virginia Tech (Technology Integration)
4-120	Volvo; Tai, Chun. High Fuel Economy Heavy-Duty Truck Engine (Advanced Combustion Engine Technologies)
4-141	VPI & SU; Huxtable, Scott. An integrated approach towards efficient, scalable, and low cost thermoelectric waste heat recovery devices for vehicles (Advanced Combustion Engine Technologies)

11. Project and Program Statistics Calculations Overview

A numerical evaluation and comparison of each project within the program areas necessitates a statistical comparison of the projects utilizing specific criteria. A representative set of reviewers was selected to evaluate each project based upon the criteria. Given this information, each evaluation criterion's sample mean and variance can be calculated utilizing the following formulas respectively:

$$\bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}$$

$$Var(\bar{x}_j) = s_{\bar{x}_j}^2 = \frac{1}{(n-1)}\sum_{i=1}^{n}(x_{ij} - \bar{x}_j)^2$$

where x_{ij} is an individual reviewer's score for that criterion and n is the number of reviewers for the given project. These values can then be used to extend the evaluation to the entire program. The sample mean for each project criterion is represented in the graph by their respective bar value.

The program area mean and the average of the project variances for each evaluation criterion were then calculated as follows:

$$\bar{X} = \frac{1}{m}\sum_{j=1}^{m} \bar{x}_j$$

$$E[Var(\bar{x}_j)] = \frac{1}{m}\sum_{j=1}^{m} Var(\bar{x}_j)$$

where m is the number of projects in a program area. This method of calculation allows each project to weigh evenly on each evaluation criterion of the program area. The criteria means and average of the project variances values for each subprogram area (e.g., Hybrid and Vehicle Systems Technologies, Advanced Combustion Engine Technologies, Technology Integration, etc.) are represented on each project graph as the Program Area Average line and the red error bar ranges, respectively. In some sense, the red error bars provide a range by which projects can be evaluated by their criteria with respect to an entire subprogram area's performance.

These calculations were only performed for the numeric values supplied for questions 2 through 5. Questions 1 and 6 are represented by pie charts below the combination bar/line graph.