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

WIND AND WATER POWER PROGRAM

2011 Water Power Technologies Peer Review Report

U.S. Department of Energy

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2011 Water Power Technologies Peer Review Report
November 2011

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Executive Summary

The U.S. Department of Energy (DOE) Wind and Water Power Program (also referred to as the program) convened a peer review meeting of marine and hydrokinetics (MHK) experts, conventional hydropower (CH) experts, national laboratory researchers, and DOE program staff from November 1-4, 2011 at the Hilton Alexandria Mark Center located in Alexandria, Virginia. The purpose of the meeting was to review the progress and accomplishments of marine, hydrokinetic, and conventional hydropower projects funded by the program, as well as to provide input on the strategic direction of the program. Peer review provides program managers, staff, and researchers with an objective review and advice to enhance the management, relevance, effectiveness, and productivity of the program's research, development, demonstration, deployment, and analysis activities.

Below are condensed summaries of the key findings of the 2011 MHK and CH Peer Review Panels and lessons learned from the 2011 peer review process. For more detailed comments, please see Section 2.0 Recommendations and Key Findings of the Peer Review Panels and Section 7.0 Lessons Learned from the 2011 Water Power Peer Review Meeting Process.

Some of the key findings of the 2011 Water Power Peer Review Marine and Hydrokinetic Panel are listed below:

- Funding additional MHK environmental field work projects, including projects evaluating whales, collisions, acoustics and other areas to generate empirical evidence is recommended.
- Research on MHK infrastructure requirements, including harbors and manufacturing capacity should be funded.
- The program should institute central decision making and a central effort for MHK reference model development. Checks and balances on reference models and data are required, including coordination of quality assurance/quality control (QA/QC), data control and other issues.
- Better communication and information transfer of environmental information from the MHK cost reference model are required.
- The program should commission an independent panel to take a deeper dive to review apparent redundancies among certain MHK projects.
- Given limited funding, the near term focus of the program should be on getting MHK projects in the water to ensure the short and long term viability of the industry; projects focused exclusively on serving large commercial deployments far in the future should be a secondary priority.

Some of the key findings of the 2011 Water Power Peer Review Conventional Hydropower Panel are listed below:

- An increased focus on bringing end-users into CH projects is recommended.
- A document depository that tracks CH project technology transfer activities would be a useful tool for the program.
- The program should require projects developing CH forecasting tools to utilize sites that clearly need better forecasting and that will exercise a large portion of the toolset.
- The two CH demonstration sites managed by WAPA will not take full advantage of the toolset project and thereby make it difficult to identify success of the toolset project.
- The program should consider supporting rigorous scientific and economic evaluation of various externally-imposed operational constraints and water use tradeoffs that can have a major detrimental impact to the amount of renewable energy available from conventional hydropower.
- The program should continue to emphasize that hydropower facility owners and operators

contend with multiple resource objectives and priorities that change over time.

Some of the lessons learned from the 2011 Water Power Peer Review process are listed below:

- The global objectives of the program are very good and peer reviewers universally believe that program funding is critical to advancement of the MHK and CH industries. The main points are on target and the research teams are focused on their objectives.
- The program should continue to improve its focus on transfer of information, both from its research projects to end-users and stakeholders as well as from the program to peer reviewers.
- The program should verify modeling projects via peer review of the models. This will provide a "reality check" of model intent and design along with underlying assumptions, the declaration of model inputs, equations, and independently generated outputs.
- QA/QC protocols should be developed for data and information and require projects to: 1) address this issue, 2) comment on the quality of data and information, and 3) understand how results may be affected by QA/QC issues.
- The program should communicate with principal investigators (PIs) several months before the peer review meeting to stimulate the PIs to start thinking about the peer review process and preparing their materials.
- The use of peer review by the program is also a very commendable approach to continuous improvement, especially the inclusion of both programmatic and technical reviews.
- The overlapping of MHK and CH sessions created time pressure that resulted in a less effective review.
- The three step process (review before, review at, review after) requires that the materials from the PI be submitted on time. Reviewers should be subjected to either a process where you come in cold and do a lot of work at and after the review, or one where you heavily prepare ahead of time and have a lighter week at the review, but they should not be subjected to both.
- Project information should be provided to the reviewers in a timelier manner to improve the effectiveness of the peer review process.
- The program should convene all reviewers in either the main meeting room or a breakout room 30 minutes prior to the start of the meeting/presentations in order to explain the scoring process and define the Technology Readiness Level (TRL) projects. In addition, reviewers should be given several minutes between presentations to complete scoring and notes to maintain their focus on presentations rather than trying to draft and score simultaneously.
- Reviewers weren't comfortable sitting in the front row with a laptop scoring the projects. A different room design is preferred for next year to ensure confidentiality of reviews.

The following document represents the Water Power Peer Review Panel’s detailed observations and findings, the response from the Water Power Program to those findings, and supporting meeting materials, including agendas and a list of participants. Peer reviewers provided both quantitative and narrative evaluations of the materials and projects presented at the meeting, although not every reviewer provided narrative evaluations for every project or review category. The comments herein are the most direct reflection of the reviewers’ written evaluations, and where possible have been included verbatim. Consistent with DOE’s guidance and best practices for peer review, there was no requirement for the group to reach a consensus on recommendations. Reviewers were screened to ensure no conflicts of interest existed with regard to the specific projects for which they submitted reviews. Reviewers recused themselves if they worked on projects, had other relationships with project team members, or if they had a financial interest in the subject matter.

Program Response

Dear Colleague:

This document summarizes the comments provided by the peer reviewers at the U.S. Department of Energy (DOE) Wind & Water Power Program Fiscal Year (FY) 2011 Water Power Annual Peer Review meeting, held on November 1-4, 2011 in Alexandria, VA. In response to direction from the Under Secretary of Energy, this review process provides evaluations of the program's projects in applied research, development and demonstration, and analysis of marine and hydrokinetic and conventional water power technologies.

We on the DOE Water Power Team have thoroughly studied the recommendations of the reviewers, and they will be taken into consideration as we generate future work plans. The tables below list the projects presented at the review, the final evaluation scores, a summary of comments from reviewers, and a summary of major actions to be taken by the program during the upcoming fiscal year. The projects have been grouped according to Program Technology Area (Marine and Hydrokinetic, and Conventional Hydropower) and then by the five evaluation criteria. The weighted scores are based on a 4-point scale. To furnish all principal investigators (PIs) with direct feedback, all evaluations and comments are provided to each presenter; however, the authors of the individual comments remain anonymous. The PI of each project is instructed to fully consider these summary evaluation comments, as appropriate, in their project plans.

I would like to express my sincere gratitude to the reviewers. You make this report possible, and we rely on your comments to help make project decisions for the new fiscal year. I would also like to express my admiration and appreciation of the tremendous efforts on the part of the PIs, their partners, and all of their colleagues in the marine and hydrokinetic and conventional hydropower industry. It is your dedication and commitment that will allow these technologies to succeed.

Thank you for participating in the FY 2011 Peer Review meeting, and we look forward to your future participation.

Sincerely,

Michael C Reed

Michael C. Reed
Water Power Technologies Lead
U.S. DOE Wind & Water Power Program

Marine and Hydrokinetic Projects

Please see Sections 4.1 and 4.2 for all detailed peer reviewer comments on individual MHK Projects

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
University of Washington: Puget Sound Pilot Tidal Energy Project	3.9	3.7	Project partners have a practical and relatively well conceived project schedule given current industry experience and knowledge in this area. Utilizing a more pragmatic can-do approach focused on project completion, the PI has been an effective communicator within both the MHK and the utility industry. This project helps demonstrate that the MHK industry is maturing and of potential interest to utility partners.	The program is aware that there is concern regarding this project's potential impact on resident killer whales, and has discussed the issue with the project team and relevant permitting agencies at length. Mitigation strategies are being drafted accordingly.
University of Washington: Acoustic Effect of Hydrokinetic Tidal Turbines	3.9	3.6	This project is well planned and in alignment with DOE objectives, and it offers a good mix of partners/collaborations. The methodology of the project appears to be transferrable to different locations; however there are some concerns that regulatory agencies may still question the results.	University of Washington, OpenHydro, SMRU, and NOAA are collaborating to develop a methodology for assessing the effects of turbine noise on fish and marine mammals in the context of quantified ambient noise at a site. This methodology and a case study will be submitted to a peer reviewed journal by the end of March.
Ocean Power Technologies: Advanced, High Power, Next Scale, Wave Energy Conversion Device	2.8	2.6	Given the current state of the industry and economic environment, this project supports the goals of the DOE Water Program. The project is on target to meet set completion date, and it supports the deployment of a potentially viable MHK technology. There are some questions as to how the device will be scaled up without exponentially increasing the size of the device. Additionally, the discussion of how the goals of the project will be achieved appeared to be vague and light on specifics/details.	The program will address any potential scale up issues through follow-on work and future projects (i.e. grant awarded under FY10 TRL FOA). Technical details considered as proprietary information will be evaluated by the program in future reviews.
Ocean Power Technologies: PB500, 500 kW Utility-Scale PowerBuoy Project	2.8	2.2	This project supports the deployment of a potentially commercially-viable MHK technology in the midst of a challenging economic environment. Given the information provided, the project schedule and approach appear to be generally effective. It was noted by the review panel that this project was difficult to score due to the proprietary nature of the project and the lack of information presented. For instance, it was unclear to the review panel as to who this project is collaborating with. There was no mention of industry or academic partners.	The program recently completed a stage-gate review of this project to approve the final year of funding. The stage-gate review included a deep dive into the project team and technical information including information considered as proprietary. The project team is collaborating with DOE national laboratories as part of the Technical Management Team.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Ocean Power Technologies: Reedsport PB150 Deployment and Ocean Test Project	2.7	2.5	Conflicting comments from the review panel were submitted regarding this project's relevance to DOE goals. Based on the comments submitted by the review panel, the approach of this project appears to be logical and well thought out. Additionally, the project appears to be advancing towards its goals. The project appears to have a fair amount of collaboration. However, there was some sentiment from a few reviewers that the information presented about the approach was vague, and that presentation and written project description was very guarded regarding the work and results.	The program will hold a stage-gate review of this project later in the fiscal year to approve the final year of funding. The stage-gate review will include a deep dive into any proprietary technical information and the project team.
Princeton Power Systems: Marine High-Voltage Power Conditioning and Transmission System with Integrated Energy Storage	3.4	3.0	Combining three existing approaches into a single solution appears to be a potentially successful solution. The project appears to be on schedule and within budget. Additionally, this project has identified several groups that will benefit from the results of this project including end users, utilities, rate payers, and a few others. The potential technology transfer with offshore wind may be something that should be explored.	The project is nearing completion. The program will use the comments to guide future projects. The program will work to identify any opportunities for leveraging this development for offshore wind applications.
WaveBob: Wavebob Advanced Wave Energy Conversion Project	3.6	2.9	This project is assessing a new technology in advance of a commercial scale demonstration, which supports DOE's acceleration goals. Some information with regards to the research approach seemed to be incomplete and a little vague. The project is still in its early stages at this time. There was some delay during the contract negotiations. Overall, it was a little difficult for reviewers to evaluate this project since the main PI did not give the presentation. The presenter was not very familiar with the project and was not able to answer many questions from the review panel.	The program has conducted a full review of the project subsequent to the Peer Review, wherein the PI identified his PTO subcontractor, and described in detail the Switched Reluctance technology he is using. The project focuses on the development of the PTO, stability of the device and optimization of the mooring design. Future work involves a scale model demonstration and a full-scale design and demonstration.
Northwest Energy Innovations: WETNZ MultiMode Wave Energy Converter Advancement	3.6	3.0	This technology has the potential to provide an innovative solution to advancing the MHK sector. This project is well-structured and has strong collaboration between multiple private and public groups. Some of the reporting of information appeared to be a little vague, particularly in regards to progress and achievements to date.	The program held a comprehensive stage gate review for this project. This meeting allowed for an in depth discussion of all aspects of the project and a review of progress to date. The project team is actively working on revised strategies for managing scope & budget going forward and is answering a number of technical and programmatic questions that mirror the reviewers' detailed comments. The program agrees that permitting is on the critical path for this project and is proactively taking steps to assist the project team with managing the schedule risk.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Vortex Hydro Energy: Advanced Integration of Power Take-Off in Vortex Induced Vibrations Aquatic Clean Energy (VIVACE)	3.6	3.0	This project represents an innovative technology that is aligned with DOE goals and offers good potential. The project has a reasonable and well-planned approach. Limited information was provided regarding future research, and reviewers noted that it is too early to say if the project will be successful. One reviewer cautioned that the project is looking to develop the efficiency of the device but may not be addressing the environmental impacts of the device.	The program believes the current state of maturity warrants a focus towards efficiency improvements of the technology. As this technology matures, the program understands that environmental considerations will become increasingly important to the successful commercialization of this technology.
Free Flow Power: The Water to Wire Project (W2W)	3.6	3.3	The project involves a technology that is specifically designed for river systems. The technical approach seems very practical and well-reasoned, and the project offers a smart licensing strategy to focus on 5 lead projects under ILP and to use data from initial studies to inform information needs at other sites. The project has a good balance of private industry members, but what will be transferred (regarding the technology) was not clear to all panel members. The panel feels this is a very solid project doing good underpinning technology development at a large scale.	The program has transitioned detailed deployment and permitting information from the project team. The project team has worked with NREL, SNL, and ORNL allowing the Labs to leverage FFP deployments to gather additional data. As an example, SNL will be deploying inflow characterization equipment with the device in FY12 Q3. This will produce 'first of its kind' data that will be 100% public.
Principal Power: WindWaveFloat	2.9	3.0	This project assessed four different types of power take-off to harness energy. It was not clear to the panel that this project would actually advance the objectives, goals, or approaches of the program. The technical approach seemed very sound, and collaborations with NREL and the University of CA Berkeley were noted. The integration of wind and wave energy production presents a huge opportunity to increase the efficiency of MHK projects. To date, there have been a limited number of tests undertaken so current data are lacking.	The number of tests undertaken under this project was adequate to complete the scope of work approved. This project has been completed and is entering the closeout process.
Dehlsen: Aquantis 2.5MW Ocean Current Generation Device	3.8	3.3	This project is directly aligned with the program’s goals and objectives. The project has an impressive plan and schedule, but is still in the earlier stages. There are numerous partners involved in this project, and plans are to communicate the results at workshops and conferences. Project strengths include the knowledgeable project team leading this effort, including the wind background on the team, and the fact that the project is breaking unknown ground and can potentially make a significant impact in this emerging sector. Some perceived weaknesses include mooring challenges and research integration.	Activities to address mooring challenges are included in the project scope and are currently underway. The program will work with Dehlsen to investigate opportunities for research integration and information dissemination.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Dehlsen: Aquantis C-Plane Ocean Current Turbine Project	3.6	3.4	This is an excellent project that is well planned and in full alignment with program objectives. The project appears to be on schedule, but is still in the early stages. Some reviewers were not clear regarding the approach of this project, and it was recommended that the PI develop a plan to disseminate information. The project incorporates well recognized and respected project partners.	The program will work with Dehlsen to investigate opportunities for research integration and information dissemination.
Dehlsen: Siting Study Framework and Survey Methodology for Marine and Hydrokinetic Energy Projects in Offshore Southeast Florida	3.3	3.3	This project is a good use of limited funding in what appears to be a well-designed siting study. Environmental and physical siting in Gulf Stream will lead to valuable information. This project does need more integration with other projects in the program and previous work.	The program will work to disseminate the final report from this study to related projects in our portfolio. Results will also be incorporated into the international Annex IV database.
Columbia Power Technologies: Direct Drive Wave Energy Buoy	4.0	3.5	An excellent and well planned project in full alignment with DOE objectives. Data from this project presents a good real-time in-the-field baseline for researchers in the MHK industry. Project information has been shared in several forms and is ongoing with the labs.	No response
RE Vision: An Assessment of Projected Lifecycle Cost For Wave, Tidal, Ocean Current, and In-Stream Hydrokinetic Power in the United States over Time	3.1	3.1	The efforts of this project will provide utilities with information to understand the potential costs associated with this industry. Overall the approach is good, but it lacks discussion on device developer input and it is not clear that industry is sufficiently developed to create useful or accurate data for the longer term.	The program is aware of the small number of industry cost data points available today but supports the awardee's decision to publish a final report with preliminary estimates as a starting point for future discussion and refinement. Furthermore, the program has requested that detailed descriptions of assumptions and methods be discussed more fully in the final report, which will be published by the end of 2012. Through this, the basis for differences between these results and any future data and analyses will be evident.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Sandia National Laboratories: Development of Reference Models and Design Tools (LCOE Models)	3.0	2.8	One of this project's purposes is to identify ways to reduce costs, which is supportive of program goals. A good approach to "standardize" reference models that can be implemented in different areas of the country; however, there was no detail as to QA/QC or developer input. There is a significant cost associated with this tool, but it appears to be a "road map" on what needs to be assessed - a very large budget for this. It was not clear if device developers were involved with the model development.	The program is currently engaging with the MHK industry via Webinar meetings to gather feedback prior to the release of Reference Models 1 and 2. Feedback has informed the project team of areas of interest to the industry, and where greater transparency in final reporting would be of value. For reference models 3 and above, the program recognizes a clear need, and will act on gathering industry feedback on the Reference Model approach (e.g. to matching and modeling of device performance for the wave climate) earlier in the process. This will allow for adjustments to models prior to completion. In addition, the program is relying on communication with developers to determine how the Reference Model framework (particularly the resulting cost breakdown structure) can be used as a basis for identification and discussion of areas with clear pathways for cost reduction through known and anticipated technical and market innovations.
National Renewable Energy Laboratory: FY 09 Lab Call: Supporting Research & Testing for MHK	2.9	2.9	This project has a strong team in place and has received some level of industry input, however it was very confusing as to whom is managing this project and how information is exchanged between partners. The researchers appear to have addressed the dominant MHK technologies. The project approach was somewhat vague and unclear to the reviewers.	The program will hold mid-year teleconferences with each national laboratory, in which the process for management and information exchange, between labs, and with industry, will be made clear. Furthermore, all national laboratories submitting work statements for future funding will be expected to include clear milestones and deliverables.
Sandia National Laboratories: FY 09 Lab Call: Research & Assessment for MHK Development	2.8	2.8	Various challenges to the industry are being looked at via this project, including those pertaining to materials and coatings. Models will not significantly advance us past regulatory hurdles; agencies like NMFS require site-specific (or at least ocean tested) data. So this research should be focused on industry needs and questions and it was not clear to the panel that this project would advance the program's immediate goals.	The program will provide direction to national laboratories to conduct future work in line with a strategic vision. The direction will be to focus on tasks deemed critical in the near term, versus those that will become more valuable to the program and industry needs after the first generation of devices have been developed and tested.
Florida Atlantic University: SNMREC Offshore Testing Facility—Small Scale Turbine Testing and Development	3.5	3.4	This project is geared toward in-water testing which is critical at this time and can assess multiple levels of technology development. It is well targeted, planned, and focused. It should eventually allow various current technologies to be tested here. It appears that there has been regulatory uncertainty that has slowed the permitting process.	The program is aware of the regulatory uncertainties the project has faced and will continue to investigate opportunities to reduce uncertainty for this and other projects into the future.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
University of Hawaii: Hawaii National Marine Renewable Energy Center (HINMREC)	3.2	2.8	This project provides an ideal site to test OTEC devices and has a strong group of collaborators. There was only a limited discussion of the project approach, and the effort appears to be spread across several areas. The project leverages existing facilities/infrastructure as much as possible. The project appears to be doing similar research as the national labs with no crossover of information. Is there duplication with this effort?	The program held a workshop with NNMREC, HINMREC and SENMREC in June 2011. Roles of each NMREC was discussed at that workshop, along with potential overlap with national labs. The program will address concerns of duplicity with the recipient and will address any possible overlap with national labs to the greatest extent possible.
Oregon State University and University of Washington: Northwest National Marine Renewable Energy Center (NNMREC))	3.5	3.3	The project is a good approach to assessing technical, environmental, and social aspects in both the Puget Sound and off the coast of Oregon. If successful, this project would provide a strong research and development platform. There is a good mix of utility, academic, and national lab collaboration. University of Hawaii and OSU appear to be working towards the same cause - collaboration between these entities would maximize funding benefits.	The program held a workshop with NNMREC, HINMREC and SENMREC in June 2011. The workshop helped to align test center visions and highlighted possible areas for collaboration. The test centers found the workshop to be valuable and it is intended to be held annually. To date, NNMREC and HINMREC have collaborated on numerical modeling of WECs. Other possible areas identified include sharing information on how to deal with liability, certification, standardization, design requirements, fiscal and technological viability of developers, salvage plans, and permitting. Additionally, sharing test protocols and ocean energy curriculum could have value in the future.
Sound & Sea Technology: Advanced Anchoring Technology	3.5	3.1	This project will allow MHK developers to secure devices in more ideal locations. The project addresses an issue of high importance to the MHK industry. Research integration efforts were detailed and comprehensive. Ideal for deep mooring; however, mooring near reefs/outcrops would involve consultation with NOAA and incur potential impacts with EFH.	No Response
Atargis Energy: Cycloidal Wave Energy Converter TRL Advancement to Level 4	3.1	2.8	This is potentially a break-through technology for the MHK sector, but little information was provided to fully assess. The project addresses new WEC technology advancing from TRL 3 to TRL4. More information is required to be reported on the project in order to assess quality and progress.	The program’s mission is to fund a wide variety of technology types spanning all TRL levels. The program seeks to evaluate all technology types. This project has yet to achieve technical maturity that would require ocean testing. The program recognizes that higher TRL work should include ocean testing.
U.S. Synthetic Corporation: The Development of Open, Water Lubricated Polycrystalline Diamond Thrust Bearings for use in MHK Energy Machines	2.8	3.3	Bearings are an integral part of machinery, and further understanding of design and materials to be used in marine environments is helpful, however they may not be a priority for the MHK sector of the program. Oil-based lubricants do not appear to have been identified by key regulators as a critical near-term issue. Once the industry has established demonstration projects and is at the next phase (commercial expansion), this may become a more important hurdle.	No Response

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Turner Hunt Ocean Renewable: THOR's Power Method for Hydrokinetic Devices	3.1	3.0	The project is in alignment with the DOE Program. The project offers a potential method to increase power output for technologies. It presents a somewhat theoretical approach to modeling depth factors related to energy output. Too little information was presented to properly assess the progress of this project; however results have been positive thus far.	No Response
Sunlight Phototonics: Tidal Energy System for On-shore Power Generation	2.9	2.8	This project is looking at other ways to utilize tidal power with land-based generation and is assessing another means for power takeoff and increase efficiencies. There is little awareness of the needs of the MHK sector. There is a lack of discussion of the next steps for actual deployment.	The program will discuss the needs of the MHK sector with the recipient. The project is scheduled for completion. As part of the final deliverable, the program will request the recipient to discuss next steps for actual deployment.
Resolute Marine Energy, Inc: Development of a wave-actuated power take-off device for electricity generation	3.1	3.0	Research by PI presupposes point absorber technologies will be the future of MHK. Project offers a high value at a low cost to DOE. It was uncertain as to when a demonstration project would be available.	The program is satisfied with work completed for this effort to date
Semprus Biosciences: Environmentally Benign and Permanent Modifications to Prevent Biofouling on Marine and Hydrokinetic Devices	2.8	3.0	This is a relatively low cost study of an issue important to the MHK industry. Anti-fouling coating toxicity does not appear to be a current regulatory barrier to getting early projects in the water. At a large commercial deployment scale, anti-fouling paint could raise concerns, so this program may be very useful in terms of minimizing cumulative impacts. It does appear to be duplication with a national lab project.	The program will address concerns of duplicity with the recipient and will address any possible overlap with national labs to the greatest extent possible.
Shift Power Solutions: Protective, Modular Wave Power Generation System	2.8	2.6	Far too little information was provided to fully assess this project. There is a concern that the cost of permitting is underestimated for a field deployment. On the other hand, the use of breakwater or pier structures is an area not otherwise represented in the DOE funding portfolio and could prove valuable.	The program is aware of the concern for the cost of permitting for a field deployment and we will bring this to the recipient's attention, however, a field deployment is not necessary for this project under the TRL 1-3 scope of work.
M3 Wave Energy Systems : Simple, Scalable, and Submerged	3.1	3.2	This project is in full alignment with DOE objectives and supports technology development from TR2 and TR3. It covers an area that is otherwise missing from the portfolio of DOE-funded projects. It is not clear how they could evaluate LCOE from these type of unique devices without a referencing its approximate efficiency.	The project is complete and a final report has been submitted. Investigators assumed 33% capacity factor for calculation of LCOE. Due to early stage of technology, this assumption provides a reasonable target for annual energy production to evaluate LCOE. Future research and testing will improve estimation of annual energy production to include device efficiency.

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Relevance Score	Final Score	Summary Comments	Program Response
Whitestone Power & Communications: Poncelet Kinetics RHK100 Prototype Development Project	3.0	2.8	The project did not display a well-structured approach, and lessons learned from this project may have limited utility in the lower 48 states. This project focuses on the development of a small-scale riverine device that will enable devices to be deployed in remote locations. It looks at high sediment loads and harsh conditions.	The project is complete and final report has been submitted. The team has examined the potential for technology deployment in Hawaii and lower 48 states. The program sees value from project results for other riverine and remote turbine deployments with similar barriers and other water power technologies that may utilize permanent magnet generators.
Bayer Material Science: River Devices to Recover Energy with Advanced Materials (River DREAM)	3.1	3.1	This project is an innovative idea with the artificial muscle being applicable to the wave energy development. In full alignment with DOE objectives. The somewhat theoretical approach to MHK is not clear as to how this would be made operational.	No Response.
Free Flow Energy: Submersible Generator for Hydrokinetics	3.1	2.8	This is a MHK-specific project that can be utilized by various industry members; however, Free Flow does not appear to have solicited industry input on what their needs are. Standardized generator design specific to MHK offers significant benefits to the industry. The approach lacked a discussion with the device developers to solicit their needs/wants.	This project has been completed. The program will make efforts to ensure device developer feedback is solicited for future projects of similar nature.
University of California: Active Flow Control on Bidirectional Rotors for Tidal MHK Applications	3.2	3.1	This project will enable turbine developers to improve the efficiency of their devices. The project uses a horizontal axis turbine capable of generating with flow in two directions with use of microtab, and is looking to reduce lift to drag coefficient. Use of a Bi-Directional drive, while appealing, has still eluded the major wind turbine manufacturers. The effort has as a good project team and appears to be on schedule and budget.	No Response.
University of Missouri: Remote Monitoring of the Structural Health of Hydrokinetic Composite Turbine Blades	3.4	3.2	Various turbine developers may be able to utilize this technology. The project appears to be in full alignment with DOE goals. The acoustic signal is novel approach and may have applications for sensors in the MHK sector. The effort focuses on reducing O&M costs by remote monitoring of turbine blade, and is an interesting use of a blade monitoring and communications.	No Response.
Lockheed Martin: OTEC Cold Water Pipe-Platform Sub-System Dynamic Interaction Validation	3.2	3.2	The cold water pipe work is in alignment with the program. The cold water pipe is a key part of any OTEC project. Software modeling for validation of OTEC applications would appear to have value to developers.	No Response.

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Makai Ocean Engineering, Inc.: Modeling the Physical and Biochemical Influence of Ocean Thermal Energy Conversion (OTEC) Plant Discharges into their Adjacent Waters	3.2	3.2	This project is assessing the potential eutrophication impacts from the discharge plume. Developing a plume model is necessary to predict potential reaction from a nutrient rich plume, and this effort is a focused attempt at modeling and analyzing OTEC plumes. The impact of OTEC discharge plumes will be of significant interest to regulators. It was not clear if NOAA will support the development in the regulatory approach. Also, impending project deadlines may prove to be challenging to complete.	In past reports outlining environmental concerns for OTEC deployment, NOAA has stated a need for improvements to existing plume models, including a need for the incorporation of biogeochemical data, which this project is attempting to do. The Program considers this project to be in line with programmatic goals to reduce market barriers to the commercial development of ocean renewables by meeting regulatory needs and working directly with regulatory agencies (NOAA). The project sought a no-cost extension due to an unexpected need to run significantly more model simulations on plankton growth than originally planned, but will be completed before the extended deadline.
Alden Laboratories: The Potential Impacts of OTEC Intakes on Aquatic Organisms at an OTEC Site Currently Under Development (Port Allen, Kauai)	2.5	2.6	There are significant concerns regarding the lack of input from the National Marine Fisheries Service (NMFS) to develop the field sampling design. It was not clear that there are any links with industry of other OTEC projects or whether results will be applicable to offshore OTEC, which is a likely area for industry growth. There also appear to be regulatory and siting issues.	This project was funded under a solicitation which was meant to address site- and project- specific issues, which in this case, was for a land-based OTEC facility in Port Allen, Kauai, though some of the information will also be applicable at sites which are ecologically similar OTEC sites. The project has experienced delays due to difficulties in obtaining NEPA concurrence and these delays have been entirely outside of the project PI's control. The project leads have collaborated with NMFS as much as possible throughout the course of the project and criteria for intake screens were based on EPA Clean Water Act regulations.
Scientific Solutions: Underwater Active Acoustic Monitoring Network for Marine and Hydrokinetic Energy Projects	3.8	3.3	This project has good alignment with program goals, and the technology is applicable to various MHK devices (e.g., wave or tidal). This effort will be helpful in resolving marine species interaction questions and overcoming specific and real regulatory barriers under the ESA and MMPA. Good adaptation of existing technology for MHK projects.	This project is will be deployed with another DOE funded project – ORPC's TidGen. The program recognizes the need for continued and frequent interaction between SSI, DOE, ORPC and other stakeholders as both projects proceed on parallel technology development and permitting pathways. The program is satisfied with the interactions between SSI and ORPC to date and has increased the frequency of DOE interaction with SSI as they prepare for their final environmental reviews prior to deployment.
Pacific Energy: Active Acoustic Deterrence of Migratory Whales	3.3	2.9	The project deals with a potentially high visibility issue that is important to the MHK industry and is an excellent risk mitigation project for the entire sector, Looking at an important issue that all marine energy projects will have to deal with. The project has experienced both regulatory permitting and technical challenges. Limited information was provided on why there were permit delays and why an Environmental Assessment (EA) was required for the deployment of this single mooring device.	Although pinger devices have been used in the fishing industry to deter marine mammals from nets and other equipment, this project is testing the same type of technology in a new context (i.e. MHK device) with a specific species and location. This project did not involve the development of a brand new technology, but rather applies an existing technology to a new use. The EA was required for the acoustic harassment issue rather than the mooring device.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Columbia Power Technologies: Benchmark Modeling of the Near-field and Far-field Wave Effects of Wave Energy Arrays	3.3	3.2	This project is in good alignment with program objectives. This project takes us a step closer to understanding potential effects of wave energy converters (WECs) on near shore current and sediment transport, which are critical regulatory issues that must be addressed. There is danger that this work overlaps with the Sandia array work.	Sandia National Laboratories collaborated with Columbia Power Technologies on this project to inform Sandia's array modeling tool development. Following the completion of CPT's planned tank testing, Sandia provided funding for an additional round of tests for this purpose. As such, there is no danger of overlap, but rather an opportunity for collaboration.
Harris Miller Miller & Hanson: Environmental Effects of Sediment Transport Alteration and Impacts on Protected Species	3.3	3.3	This project shows a reasonable link to the program's objectives, and offers resource characterization and environmental support to permit a tidal project. It is a good multi-stakeholder MHK project involving community partners.	No Response.
Lockheed Martin: OTEC resource assessment	3.6	3.5	This project provides a more definitive assessment of available worldwide resources for ocean thermal energy conversion (OTEC) and is a good use of a web-based tool. These types of resource databases are very important to future OTEC developments. There is a good blend of private, academic, and national lab balance to the team. Given the current lack of operational OTEC projects, analysis of deep-water resources could be somewhat premature.	No Response.
Georgia Tech Research Corporation: Assessment of Energy Production Potential from Ocean Currents along the US Coastline	3.6	3.2	A well planned project in full alignment with DOE objectives. It is critical that this information is shared with other web-based resources. The Navy is doing something similar in the next couple of years. Will there be any overlap of information exchange? This effort would benefit significantly from international collaboration.	The program intends to ensure that there is increased interaction with the Navy and other researchers working in this area.
Electric Power Research Institute: A First Assessment of U.S. In-Stream Hydrokinetic Energy Resources Since the 1986 NYU Study	3.9	3.3	An excellent and well planned project in full alignment with program objectives. It is a good resource assessment work that is a timely update of in-stream MHK resources. Device developers were included in this project via expert workshops, and federal agencies (USACE and USGS) were included in the Expert Workshop. This work really needs to show the "practical resource" to be fully useful.	The program agrees that assessment of a "practical" resource using detailed financial site development models and fully considering competing water uses and environmental concerns would be very useful. However, compiling necessary data to do that would require resources greater than those currently allocated to the project, and would also require making decisions on likely potential tradeoffs, which are often incredibly location-specific.
Electric Power Research Institute: Assessment of the Environmental Effects of Hydrokinetic Turbines on Fish: Desktop and Laboratory Flume Studies	3.6	3.3	This project is using knowledge of traditional hydro experience and is a good, realistic and practical piece of work. The project has good links with the regulators. The project uses a well-respected Industry research organization for this type of resource interaction study. It is now clear how transferable the results are over a range of different turbines.	This project involved flume testing of 3 different turbine designs and found similar results among all 3 designs for the effects of blade strike on fish, which increases program confidence that the information is transferrable to different turbine designs.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Ocean Renewable Power Company: OCGen™ Module Mooring Project	3.7	3.0	This is a well-planned project in full alignment with DOE objectives. Mooring issues are critical to advancing commercialization. This research has clear benefits to MHK developers. It wasn't clear as to how this study would support the MHK industry as a whole, but it would improve ORPC more so.	The program agrees that dissemination of the results of this project is valuable to the MHK industry and this feedback will be conveyed to the project team during the next quarterly teleconference. Technical deliverables generated by this project will be made available on the Office of Science and Technical Information's (OSTI.gov) website. The program concurs with reviewer comments on pursuing other forms of dissemination / data sharing and will take action on this recommendation.
Ocean Renewable Power Company: TidGen™ Power System Commercialization Project	3.9	3.3	This project is a strong step forward to moving this industry to a commercial stage. A well planned project in full alignment with DOE objectives. Need to get commercial projects with power to grid - this is money well spent. A grid connected project would be a significant milestone for the MHK Program. This project should link with the sound and sea foundation project.	The program agrees that successful completion of this project will be a significant milestone for the MHK Industry in the United States. The required federal investment is deemed to be commensurate with both the project's scope and also reflects the initial challenges that must be overcome to attain commercial, grid-tied MHK devices. The program will share the reviewers' comments and recommendations with ORPC during the next quarterly project teleconference. The program will also conduct a formal stage gate review for this project in the near future and use that as an opportunity to gauge what types of corrective actions have been taken to address the reviewers' concerns.
Clean Energy States Alliance: Marine Energy Technology Advancement Partnership (METAP)	3.7	3.4	This is a well-planned project in full alignment with DOE objectives. It is a great idea for project - fostering this collaboration is invaluable. The development of a collaborative approach to meeting state and federal policies is an excellent value for the money. This is a win-win project.	No Response.
Georgia Tech Research Corporation: Assessment of Energy Production Potential from Tidal Streams in the United States	3.5	3.4	This is a well-planned project in full alignment with DOE objectives. Assessments are critical to showing market potential. A resource assessment is somewhat similar to other DOE funded studies, but has stopped short of giving a practical resource.	The program agrees that assessment of a "practical" resource using more detailed financial models and considering environmental concerns would be very useful. However, compiling necessary data to do that would require resources greater than those currently allocated to the project, and would also require making decisions on likely potential tradeoffs, which are often incredibly location-specific.
Electric Power Research Institute: Wave Energy Resource Assessment and GIS Database for the U.S.	3.4	3.2	The project incorporated data from NOAA and is working with them to develop a longer-termed picture. This builds on the original EPRI wave study. The project assessed 50 m or deeper. However, devices are typically in 50 m or shallower and this work does not deal well with shallow water.	The program fully realizes that the project imperfectly characterizes shallow-water wave resources, and that the 51 month period of record used for the hindcast could be extended. However, these factors could not be addressed given the budgetary and time constraints of the project. The program will evaluate the utility of potentially conducting follow-on work to address these issues in the future.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Pacific Northwest National Lab: Categorizing and Evaluating the Effects of Stressors (KMS and ERES)	3.3	3.0	This work will become a predictive model as data become more readily available. Evaluation of key stressors is important to financing of deployment of MHK technologies. Long-term, the approach is good, but this project is still in the early stages. FERC has developed a similar process - it is unclear as to how this is different. This work may scare regulators by covering far too many things that may be affected. There is concern that this will be cited as identifying real risks, when it is simply prioritizing based on information needs.	There has been a significant amount of outreach to regulators for input and feedback on risk assessment. Given the lack of data available for analyses through ERES (Environmental Risk Evaluation System), this effort is being deemphasized until more information is available. The Tethys portion of the project is critical to gathering these data, and resources will be focused on this effort in the near-term.
Pacific Northwest National Lab Annex IV: Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal, and Current Energy Systems (2.1.1.3 PNNL Annex IV)	3.4	3.1	This project draws on international experience and represents a good way to leverage existing MHK data to include international information sources. The searchable database will help advance the study, permitting, and analysis stages. The approach and target LCOE appear to be clear. One weakness is that there have been a number of MHK environmental monitoring and data collection studies funded by the DOE, several of which may have been aggregated into one or two larger research projects.	There have been two primary data collection efforts funded by the program (Tethys and Annex IV) which have involved an integrated approach. These two efforts must be maintained as separate entities due to international data-sharing requirements. These databases will function as tools to increase availability and access to otherwise disparate MHK environmental data sources. These databases will mainly be limited to environmental research on MHK technologies, but will also have the ability to incorporate analogous information from other ocean industries or research, though data collection efforts will not be focused on those areas in the short-term upon recommendation of industry and academic experts.
Argonne National Lab: Categorizing and Evaluating the Effects of Stressors (all Conceptual Model work)	2.6	2.4	The aim is to support NEPA requirements, but it is difficult to see how this will benefit those writing NEPA documents. NEPA is clearly a significant hurdle and was mentioned by several presenters as a source of delay. This does not appear to support the development of the MHK industry nor support those that would write NEPA documents. It appears that this project anticipated that there would be more data available than there clearly is. There is concern that the project will raise more questions than it answers.	This project uses a general risk assessment method developed by the EPA (*Guidelines for Ecological Risk Assessment - 1998,* EPA/630/R095/002F), and adapted to identify the stressors and receptors that may experience the most significant adverse impacts from MHK development. This is important information for projects seeking NEPA concurrence. The potential environmental impacts in the assessment were identified by Argonne National Lab, utilizing informal consultation with individuals in the regulatory community and extensive literature reviews (including information on monitoring plans developed for the small number of final license applications submitted to FERC). Though data on some MHK stressors and receptors are lacking to date, this project provides the framework for input of those data when they do become available and has helped identify high priority environmental issues and gaps for future research.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Sandia National Laboratories: Tools and Methods to Measure and Predict Environmental Impacts (2.1.2.1 SNL Hydrodynamic Modeling, 2.1.2.2 SNL Sediment Transport Dynamics, 2.1.3.2 Acoustic Modeling)	3.0	3.1	This is a well-planned project in full alignment with DOE objectives. This project casts a wide net in an effort to understand and predict flow and noise impacts in ocean, tidal and river systems, which will be important at the commercial-scale level but may not be useful to industry pioneers in getting initial projects in the water. With limited funds and time, we should focus instead on specific projects and their specific technical and regulatory hurdles. This is one of numerous MHK metadata collection and analysis studies funded by the DOE.	This project does not involve a metadata collection effort; rather, lab and field measurements are being collected to validate novel MHK-specific environmental analysis tools. It will be critical to have the ability to predict potential alterations to flow, sediment transport, water quality, and acoustics in the presence of MHK devices in order to accelerate the permitting process and get projects in the water. This research is being performed in collaboration with other labs, industry, regulators, NMRECs, and universities to avoid duplicative efforts and increase knowledge sharing.
Pacific Northwest National Lab: Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.2 – Effects on Physical Systems (2.1.2.1 PNNL Hydrodynamic Modeling, 2.1.2.3 PNNL Water Quality and Food Web)	3.0	3.0	This is a well-planned project in full alignment with DOE objectives. This information should be helpful over the long term, but it does not advance getting projects in the water which should be the top priority for DOE in the near term. Research integration efforts appear to be somewhat poorly documented, and there is some uncertainty as to how this study feeds into the large national lab projects.	Current efforts within the program are working to better align related research projects, and prioritize future work based upon industry needs. Although this work is similar to other modeling efforts within the program's portfolio, the model output from this work will be of a different resolution than others and can potentially be used for different purposes. This modeling tool will help get projects in the water by satisfying Clean Water Act requirements (which may be quite stringent in tidal estuaries), and will become increasingly useful as the industry moves from pilot to commercial scale projects. Also, results from this tool have already shown that very minimal impacts are expected to be associated with pilot-scale tidal deployments.
Oak Ridge National Lab: Acoustics, Toxicity, Benthic Habitat Alteration (2.1.3.2 ORNL Acoustics, 2.1.3.3. ORNL Toxicity, 2.1.3.4 ORNL Benthic Habitat Alteration)	2.7	2.9	A significant data gap in the MHK industry is a device's noise signature and its potential effect on the surrounding environment. This effort needs to have a more MHK-specific approach. Only some of the work is in full alignment with the program. This will be relevant to NEPA and cumulative impacts at later stages, but we question whether this is needed to get initial projects in the water.	The program will be making modifications this year to make these projects more directly applied to MHK-specific concerns. Though toxicity is an issue studied by other industries, this work has tested both novel and existing coatings being considered specifically by MHK developers. The partnering labs on this work were involved in the same proposal; they are involved in similar tasks with monitoring activities around deployed devices, but each partner focuses on a specific aspect of the monitoring to combine for a more comprehensive view of the potential environmental impacts of MHK devices and there is no overlap in tasks.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Pacific Northwest National Lab: Identification , Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework - Direct Effects on Aquatic Animals (2.1.3.1 ORNL EMF, 2.1.3.2 PNNL EMF, 2.1.3.3 PNNL Acoustics)	3.2	2.9	These experiments are key to closing data gaps and meeting regulatory information standards, and are part of the basic acoustic research protocols needed to further MHK. It is uncertain as to what the acoustic study will add to the already large body of literature on this subject. Perhaps this should be funded in part through DOE's wind program.	While the program recognizes the large body of acoustic work, the scientists performing this research are experts in the field and this research answers a previously unanswered question of the effects of MHK-produced noise on marine organisms. Because MHK noise is distinct from that of offshore wind, co-funding may not be a preferred option. Research efforts between ORNL and PNNL are intentionally similar in order to be comparable; PNNL is focusing on EMF experimentation on marine animals and ORNL is focusing on similar experimentation on freshwater animals.
Pacific Northwest National Lab: Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.7: Permitting and Planning (2.1.7.1 PNNL Regulatory Assistance, 2.1.7.2 PNNL Community and Stakeholder Outreach, 2.1.7.3 PNNL Spatial Planning)	2.5	2.4	This study does not appear to add anything new to the knowledge base of the regulatory/permitting approach to getting MHK devices into the water. Written materials indicate that the research is to streamline regulatory permitting processes and environmental assessment of MHK project impacts. Contrary to written materials, the project does not involve streamlining efforts and will not result in concrete recommendations to change any process.	To the best of our knowledge, this project represents the first systematic analysis of the costs and drivers of MHK projects currently seeking licensure which have been found to be significant. This study will help inform research priorities for DOE as well as increase general understanding of the cost and time-intensive issues driving current project regulatory processes. Work covered under this project also includes engagement on CMSP (Comprehensive Marine Spatial Planning) and stakeholder outreach efforts. This project is intended to primarily inform the program and communicate information about program activities in order to increase the program’s efficiency in identifying and funding the highest priority environmental topics affecting the MHK permitting process. DOE is not a regulatory agency and thus, does not have statutory authority to streamline the regulatory permitting process.
Ocean Renewable Power Company: Abrasion Testing of Critical Components of Hydrokinetic Devices	3.6	3.2	Findings from this study will benefit both ORPC as well as other developers deploying in high silted areas exposed to potential abrasion issues. This project is critical to moving forward in tidal and river sites in Alaska, where most of the MHK energy resource is located.	No response.
Ocean Renewable Power Company: Acoustic Monitoring of Beluga Whale Interactions with Cook Inlet Tidal Energy Project	3.8	3.0	Beluga whale interaction/impact issues must be addressed to advance the MHK industry in Cook Inlet. Given the significant tidal resources in this area, this area of research seems appropriate for supporting MHK project development efforts. It wasn't conveyed clearly enough the interaction ORPC has with NOAA from design of studies through to potential mitigation measures if the device is deployed	The program recognizes that documenting the communication / interaction of the project team with other stakeholders and agencies as they conduct their work is very important. A significant amount of collaboration has already occurred on this project. This recommendation will be conveyed to the project team on the next quarterly call.

Conventional Hydropower Projects

Please see Sections 5.1 and 5.2 for all detailed peer reviewer comments on individual MHK Projects

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Argonne National Laboratory: Water-Use Optimization	3.4	2.8	An important strength of this project is the vision of an integrated toolbox to increase efficiency of hydroplants and improve environmental performance. The challenge will be in making the products, particularly software support, available to hydro industry and regulated river managers. There are a lot of technical barriers to overcome to make the tools usable and available for use by others.	To guide the development of this complex but important project, the program assessed the industry's needs via a workshop. To address the needs, a multi-laboratory project team was competitively selected, representing some of the best talent in the world in advanced hydropower operations. Additionally, the project is being reviewed by experts from other governmental agencies and industry. The optimization toolset envisioned is very different from existing tools in that it uses a common database and can be customized by the end user. During the tool development, end user feedback will be solicited to further improve the toolset's usability. The toolset is targeted at planners and operators who will have experience in plant operations but may not be experts in the areas such as forecasting, environmental sciences, water movement, fluid mechanics, and solving complex engineering algorithms. DOE funded demonstration projects will validate the tool's performance and provide feedback for further toolset refinement. Technology transfer will take place via industry workshops and conferences. As the project progresses to the next stage of implementation the program anticipates an increased emphasis on model refinement to improve usability, additional demonstrations, model documentation and training, publication of results, and review by professional and industry peers. The project is actively managed consistent with the program project management objectives.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Oak Ridge National Laboratory: Hydropower Advancement Project (HAP): Audits and Feasibility Studies for Capacity and Efficiency Upgrades	3.8	3.3	This is potentially a high-value project in terms of how it can contribute to the quantification of possible increased hydropower. The technical approach is well thought out and the project team understands the issues and limitations of the analysis. There are some complications with getting meaningful assessments. Progress to date is significant to date and is mostly on schedule. Monitoring data is not as available as anticipated.	The program will continue to be actively involved with the management of the project and work with ORNL to develop measures to mitigate risk to ensure that the all project components will deliver results in the required time frame. The program recognizes there may be some complications with dissemination of all results in view of the sensitive nature of data being collected and analyzed. Detailed assessment reports will be provided to the project owners with all sensitive data included. Reports developed for public dissemination will be dependent on the agreement of project owners. With regard to the assessment process, refinements will be made as experience is gained. Furthermore, the HAP assessment methodology will undergo external review by technical experts from USACE, USBR, and industry. Initial assessments have shown critical assessment data is usually available. Facilities are willing to provide sensitive data as long as agreements ensure that the data will be protected from public disclosure. Other areas of concerns from the detailed comments will be reviewed with the project team and modifications to the project plan will be made where necessary.
Oak Ridge National Laboratory: Non-Powered Dams Resource Assessment	3.8	3.5	This project identifies practical locations and helps re-enforce the message that additional hydro is possible. Cleans and upgrades quality of the database. The strength is the promise of being able to obtain an evaluation of many sites. Existing data bases were found to have errors, especially for small dams, making estimates for power generation on small headwater dams with low levels of confidence. The project is completed and no future research is planned.	No Response
Oak Ridge National Laboratory: Climate Change Assessment	3.5	3.7	This project completed quickly and within budget, provides valuable information to the hydropower industry. Collaboration and teamwork among multiple federal agencies. Project summary and presentation was very well done. The complexity of the subject and the continuing dynamic changes make these forecasts very, very speculative.	No Response

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Pacific Northwest National Laboratory: Integrated Basin Scale Opportunity Assessment Initiative	3.4	3.1	This project has the involvement of many federal, industry, research and stakeholder constituents. This project can raise awareness of what a relicensing process involves. It needs more focus on tradeoff analysis which will be a key aspect of identifying opportunity scenarios. It was not clear regarding what the path forward will be on the results of this effort.	Numerous stakeholders are involved in the project to review results, and help to evaluate and craft the content of a final report, scheduled for completion at the end of 2012. The program intends to involve stakeholders in a workshop on the decision support and visualization/tradeoff tools. Also, to a large extent the process for evaluating identified opportunities has not been established, which is why this pilot assessment is being conducted. The intention is to fully document the process in a final report (both successes and difficulties), and to evaluate the utility of DOE and/or other federal agencies supporting assessments in other regions around the country.
Natel Energy: SLH Timing Belt Powertrain	3.4	2.6	This project has a reasonable design and plan. However, it involves a lot of complicated machinery and moving parts, which means lots of points for possible failure. There may also be potential water quality issues. At this time, the key component, manufacturing sources, appears to be under control. Additional costs on sales, marketing, customer support and electrical distribution systems may change the costs.	The SLH device is a complex machine. To improve the reliability and performance of the SLH, the project addresses improving the timing belt component. Through incremental improvements such as this, the SLH technology will become less complex and more ready for deployment. The reviewers had concerns regarding fish passage in the SLH. The program recognizes the need to evaluate fish passage capabilities hydropower technologies, but that is not in the present scope of the project. The program is aware that Natel Energy is performing some preliminary fish passage analysis on their own.
Hydro Green Energy: Laboratory Demonstration of a New American Low-Head Hydropower Turbine	3.6	2.7	Some of the reviewers felt that this project was difficult to evaluate because of the lack of information provided. Licensing and installation issues cannot be evaluated until a unit is installed successfully. The pilot project should answer questions on licensing and installation. The development of a concept and taking it to field demonstration is impressive, and the coordination that is needed between the two parties performing the project appears to be adequate.	The purpose of this project is to evaluate the mechanical design of the technology in the lab environment. Information from the lab testing will be used in the commercial demonstration, being separately funded by DOE. The program plans to evaluate licensing issues during the commercial demonstration. Because this project was just being initiated, details regarding project implementation were limited.
Walker Wellington: W4e Hydropower Turbine Generator system validation	3.5	3.1	This project supports the overall DOE objectives. It focuses on Design for a wide range of flows and heads. Independent lab testing. Uses known test protocol and known test laboratory. Communications appear to be sufficient for a test. The number of people involved is reasonable for a project like this.	No Response

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Near Space Systems: Small Hydropower Research and Development Technology Project	3.5	2.6	Project has potential for small hydro, but is short on supporting facts and engineering. Economics are unclear but questionable at this point. Out-of-the-box thinking. Possible small hydro design using PMG concept and plastic materials.	This project has not yet started. The project objective is to develop an innovative design of a small hydropower turbine using existing water distribution systems. The information necessary to fully review the economics of the technology were not available for the peer review, as the project was not yet initiated.
New Mexico State University: Scalable Low-head Axial-type Venturi-flow Energy Scavenger	3.5	3.1	This project can take advantage of irrigation low head drops. Promise for low cost hydro power. Communications for a project of this type seem to be planned. Budget seems quite small for the scope. Maintenance is a concern.	No Response
Weisenberger Mills: Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site	3.0	2.8	Another promising demonstration for low cost power generation at small hydro sites. Direct application of existing technology, but not sure how generically transferable it is, or beneficial to industry. Project appears focused on a specific site rather than on transferability to other generic locations.	This project has just started; the objective of this project is to demonstrate the feasibility of the variable speed Permanent Magnet Generator (PMG) and its efficiency power curve, and the project's use in other small hydro applications. The project team will be working with the University of Kentucky Center for Applied Energy Research for data analysis and technical evaluation of the results.
Earth By Design: 51-Mile Hydroelectric Power Project Demonstration of new methodologies to reduce the LCOE for small, hydropower development	3.4	3.0	This project supports the DOE objectives. Project has significant cost sharing; good test site. Pump manufacturer and has pump background. Engineering support and project funding are stronger than most other projects. ORNL participation in evaluation stage. Good schedule and cash flow description. Vague descriptions of what is being done. The implementation test was not clear.	This project has not yet started. The project proposal includes a detailed description of project scope which includes testing at the time of commissioning.
Percheron Power: Proof of Power Project on Potholes East Canal (POP-PEC)	3.6	3.2	This project should provide for generation in conduits with essentially no environmental impacts. Proven deployment internationally. Novel concept may be suitable at numerous low head applications. Concept well proven in the 50 installations. Testing protocol not identified. No generator details or connection costs noted. This may be substantial in remote areas.	No Response
Hydro Green Energy: Real World Demonstration of a New American Low-Head Hydropower Unit	3.4	3.2	The project supports the objectives of the DOE. Good combination of project "partners" to advance this project. Evaluates a small hydro concept through install and test. This is a clearly defined project after licensing. The time to completion is short thus the risk is reduced.	No Response

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Sacramento MUD: Construction Support for New Slab Creek Power House Project	3.4	3.3	This project seeks to minimize by using existing civil structures as much as possible. All required elements for a successful project appear to be in place. Communications for a project of this type seem to be planned. All required elements for a successful program seem to be in place. Project is site specific. Perhaps only the licensing process is usable at other projects.	This project has not yet started; the program agrees that all hydropower projects are site specific and recognizes the importance of technology transfer. SMUD's project plan specifically includes development of a technology transfer plan. Knowledge gained from the regulatory and licensing process will be fully documented along with the lessons learned from project execution for dissemination.
Natel Energy: SLH-100 demonstration project at Monroe Drop	3.3	2.8	This project supports the objective of bringing new inexpensive hydropower technologies into commercial readiness. It can facilitate low head hydro on existing irrigation canals throughout the western U.S. The generators would appeal to people with an independent nature. Device appears to have limited application in real world applications without significant modifications and protections. Existing technologies appear to have far less maintenance difficulties.	This project has not yet started. The program agrees that the turbine design includes multiple moving parts but the modular design of the component (turbine cartridge) should reduce overall operation and maintenance costs. The program recognizes the need for testing of the powertrain. Natel has already performed some preliminary testing using the timing belt powertrain with future testing planned
Sacramento MUD: Geotechnical Investigation and Value Stream Analysis for the Iowa Hill Pumped-Storage Development	3.5	3.1	This project moves a potential PS project along toward its next decision point. The program has a good chance for success with identified risk factors. All communication and coordination necessary for the single project appears to be covered. Collaboration among DOE, SMUD, EPRI, FERC. Not so applicable to other projects.	This project has not yet started. This project has two components - 1. Geotechnical investigations and 2. Determination of true value of pumped storage hydropower to the grid. The program believes that value stream analysis model, especially with the incorporation of the conventional gas units comparisons would make this relevant and valuable for other similar PSH projects. The geotechnical investigations which will help to make further implementation decisions. The importance of such investigations will be studied and documented for dissemination.
Electric Power Research Institute: Quantifying Full Value of Hydro in Transmission Grid	3.8	3.7	This project has participation by many industry, scientific and government entities, including individual agreement with many. Project is very organized, with knowledge gaps, approaches, schedules, deliverables documented. A strong team of investigators focused on results that can make a difference. The reports should provide a good evaluation of hydro in WECC.	No Response

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Argonne National Laboratory: Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the U.S.	3.7	3.0	This project adds capabilities needed for grid simulation. This project has ambitious goals to provide higher quality modeling for PSH and CH as well as an impressive list of resources involved. This is a complex project with lot of interactions and a big objective with short time duration to complete. Not a weakness, but certainly a flag that this project will need a good eye on its monthly progress.	This project has not yet started. This is a collaborative effort between DOE and the awardee. The program recognizes the complexity of this project. DOE will be working closely with the project team from inception to completion of the project. In addition, the project includes a requirement for a technical working group to provide consultation to the development of the model and perform regular reviews and evaluations at various stages during project development.
University of Minnesota: Turbine Aeration Physical Modeling and Software Design	2.7	2.2	Limited information included in the presentation. It was difficult to judge. No two page project summary was submitted by the team. No presentation was given by the PIs at the meeting. The team is composed of a renowned university hydraulics laboratory working with a major hydro turbine supplier. The project has not yet started.	The program regrets that information on this project was not provided to the reviewers. The program also takes note of comments regarding the effectiveness of using a closed loop testing rig for evaluating DO uptake, and the ability to accurately measure uptake in such a system; the program intends to address these comments with the project team before the commencement of work.
Pacific Northwest National Laboratory: Sensor Fish Re-design to Support Advance Hydropower Development	3.7	3.7	The sensor will be very important for validating turbine performance (mortality) when passing fish. This project is based on existing technology and the only real risk is in finding supplier who will reduce costs. There appears to be an immediate need for a new sensor fish. There appears to be no arguments about producing a new one that will meet the needs of the users.	No Response
Electric Power Research Institute: Deployment and Testing of the Alden Hydropower Fish-Friendly Turbine	3.8	3.7	This project has a great research design and is well documented. Strong project team with demonstrated excellent accomplishments to date. Communications and coordination have been successful. The reviews did not note a weakness with this project.	No Response

Projects shaded in purple are Lower TRL projects that were evaluated using slightly different metrics.

Project Title	Rele-vance Score	Final Score	Summary Comments	Program Response
Oak Ridge National Laboratory: Enviro hurdles- Instream flow	3.6	3.1	This project leverages the vast experience of the research team with environmental flows to benefit hydropower. The results of this project could potentially be quite useful to the industry. Much analysis and conclusions must be done in a very limited timeframe. There is a concern over the barriers to communications regarding environment issues.	The program believes that this project will be able to complete the majority of tasks as scheduled and within the existing budget. There is the potential that some work will be shifted to FY2013, but that will largely depend on budgetary considerations. It is not expected that the project will have resolved all issues surrounding environmental flow mitigation, but the project is on track to provide analyses and tools that can be used to answer questions about adapting (instead of abandoning) peaking operations to minimize the environmental impacts of altered flow regimes. In order to meet the broader needs, the project will continue to focus on stream classification (based on flow and geomorphology) and ecological response on basin and regional scales. In order to ensure that project results are generically useful and transferable, stream classifications will be posted on a website where users will be able to determine the classification of any steam in the country; this classification will help define the flow regime boundaries based on a variety of flow metrics within which a stream can operate and still provide the expected environmental services. Tools (spreadsheet and computer code) will also be made publically available for calculating metrics of sub-daily flow variation and for assessing that variation relative to other streams and to environmental flow needs.

1.0 Introduction

Objective review and advice from peers—“peer review”—provides Department of Energy (DOE) managers, staff, and researchers with a powerful and effective tool for enhancing the management, relevance, effectiveness, and productivity of all Office of Energy Efficiency and Renewable Energy (EERE) research, development, demonstration, deployment, and supporting business management programs. The 2004 EERE Peer Review Guide[1] defines a peer review as:

> *A rigorous, formal, and documented evaluation process using objective criteria and qualified and independent reviewers to make a judgment of the technical/ scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects.*

This definition is drawn from definitions used by the U. S. Department of Energy, National Academy of Sciences (NAS), the White House Office of Management and Budget (OMB), the U.S. General Accounting Office (GAO), and other federal agencies and institutions. It clearly distinguishes in-progress peer review from other types of peer review, such as merit review to select winners of competitive solicitations or readiness (stage gate) reviews to determine when a technology is ready to move to the next phase of development, as well as from other management activities such as quarterly milestone reviews or budget reviews.

The Wind and Water Power Program (the program) mission is to research, test, evaluate and develop innovative technologies capable of generating renewable, environmentally responsible, and cost-effective electricity from water resources. The program supports research and development (R&D) on a wide range of advanced water power technologies, with the objective of better understanding their potential for energy generation, and identifying and addressing the technical and non-technical barriers to achieving this potential.

The program works to develop and to accelerate market adoption of these advanced water power technologies that include:

- **Marine and hydrokinetic (MHK) technologies,** which capture energy from waves, tides, ocean currents, the natural flow of water in rivers, and marine thermal gradients without building new dams or diversions.
- **Conventional hydropower (CH) generation technologies**, which use dams, diversionary structures, or impoundments to generate electric power from water resources.

The program's vision is that effective and efficient investments of DOE resources will: 1) enable a robust and competitive marine and hydrokinetic industry in the United States that contributes to our nation's energy portfolio, 2) enable a dynamic domestic conventional hydropower industry that generates substantially cleaner renewable electricity than it does today, and 3) serve a vital role in stabilizing the nation's electric grid, integrating high proportions of variable renewable resources, and capitalizing on the latest technology advances to operate efficiently and with improved environmental performance.

Congress has supported research and development for both conventional and new emerging water power technologies through the Energy Policy Act of 2005 and the Energy Independence and Security Act. The budget history for water power activities begins in 2008 because the Wind and Water Power Program's hydropower activities were closed out after 2006. Funding resumed in 2008, at which time the program

[1] Peer Review Guide, Based on a Survey of Best Practices for In-Progress Peer Review, August 2004

restructured its water power activities to include both conventional hydropower and marine and hydrokinetic technologies. Between 2008 and 2010, the program funded 14 conventional hydropower projects and 73 marine and hydrokinetic projects. In fiscal year 2011, the Water Power Program's budget was $30 million, with $21.5 for marine and hydrokinetic technologies and $8.5 million for conventional hydropower technologies. Figure 1.1 illustrates the recent Water Power budget history.

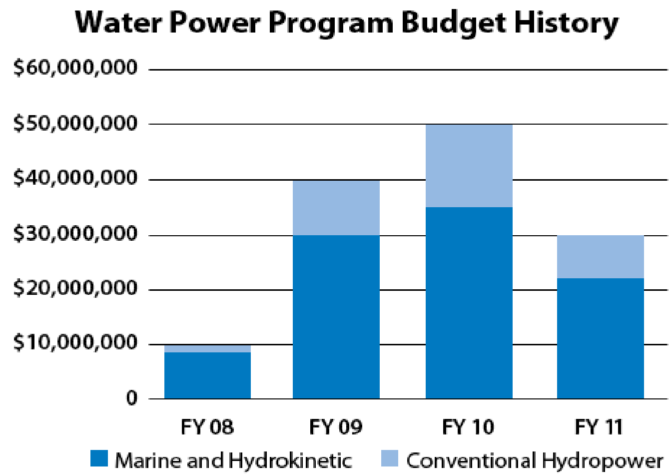


Figure 1.1 Water Power Budget History

The DOE Water Power Peer Review meeting was held November 1-4, 2011 at the Hilton Alexandria Mark Center located in Alexandria, Virginia. The purpose of the meeting was to: 1) evaluate DOE-funded conventional hydropower and marine and hydrokinetic R&D projects for their contribution to the mission and goals of the Water Power Program, and 2) to assess progress made against stated objectives. At the review, approximately 85 projects were presented, representing a DOE investment of over $100 million over the last few years. The findings from the peer review process will be considered by program managers, staff, and researchers in setting priorities, conducting operations, and improving projects. In addition to the formal review, this event was an excellent opportunity for the water power community to share ideas and solutions to address challenges facing the hydropower and marine and hydrokinetic energy industries.

The objectives of the 2011 peer review meeting were to:

- Review and evaluate the strategy and goals of the Water Program.
- Review and evaluate the progress and accomplishments of the program’s conventional hydropower and marine and hydrokinetic projects funded in FY2009 through FY2011.
- Foster interactions among the national laboratories, industry, and academic institutions conducting research and development on behalf of the program.

A rigorous peer review was conducted as a four-day event. The first two days focused on reviewing and evaluating marine and hydrokinetic projects. On the third day, concurrent tracks or session were held for marine and hydrokinetic and conventional hydropower projects. Some of the projects presented in both the marine and hydrokinetic and conventional hydropower sessions were part of the program’s “Lower Technology Readiness Level (TRL)” group. Several of the Lower TRL projects are in their initial start-up phase, therefore the presentations for these projects were typically much shorter and many were conducted via conference call. On the fourth day, marine and hydrokinetic and conventional hydropower reviewers convened in separate locations to provide an initial summary of their findings to the Water Power Technologies Lead and other program staff, and to discuss their initial impressions of the reviewed projects.

The following document represents the observations and findings of the Water Power Peer Review Panels, the response from the Water Power Technologies Lead to these findings, and the supporting meeting materials, including an agenda and list of participants. In accordance with the DOE Peer Review Guide Section 6.0[2], peer reviewers provided both quantitative and narrative evaluations of the materials and projects presented at the Peer Review. The comments herein are the most direct reflection of

[2] Peer Review Guide, Based on a Survey of Best Practices for In-Progress Peer Review, August 2004

reviewers' written evaluations, and where possible have been included verbatim.

1.1 Peer Review Panel Members

Peer review panel members (hereafter called reviewers or panel members) are peer experts from a variety of water power-related backgrounds and organizations, including laboratories, industry, and academia. Reviewers were screened to ensure no conflicts of interest existed with regard to the specific projects for which they submitted reviews. Reviewers recused themselves if they worked on projects, had other relationships with project team members, or if they had a financial interest in the subject matter.

Table 1.1: 2011 Peer Review Panel Members

Name	Affiliation
2011 Water Power Peer Review Chairperson	
Michael Murphy	HDR Engineering Incorporated
2011 Marine and Hydrokinetic Peer Review Panel Members	
Cherise Oram	Stoel Rives LLP
Henry Jeffrey	The University of Edinburgh
Cameron Fisher	Ecology and Environment, Inc.
Thor Hinckley	Portland General Electric
2011 Conventional Hydropower Peer Review Panel Members	
Richard Fisher	Voith Hydro, Inc.(retired)
Greg Lewis	Duke Energy Carolinas, LLC
Dale Osborn	Midwest ISO
Clair Stalnaker	United States Geological Survey (retired)
Edith Zagona	University of Colorado Center for Advance Decision Support for Water and Environmental Systems (CADSWES)

Reviewers received briefing materials via email and a Microsoft SharePoint site approximately four weeks prior to attending the meeting. This information included a 2011 Water Power Peer Review Plan (reviewer instructions), an agenda, the PowerPoint presentations submitted to date to the panel members by the principal investigators for the projects to be reviewed, 2-page project summary documents, a review of the overall goals of the program, conflict of interest forms, nondisclosure agreement forms, honorarium and travel reimbursement forms, and the Microsoft Excel Evaluation Workbooks (electronic format) for conventional hydropower projects, marine and hydrokinetic projects, and an overall programmatic review.

1.2 Analysis Methodology

In accordance with DOE EERE Peer Review Guide Section 6.0[3], the Peer Review Panel chose to submit both quantitative (i.e., numerical scores) and qualitative (i.e., narrative accounts) evaluations as part of their review of the materials and projects presented , although not every reviewer provided narrative evaluations for every project or review category. The comments herein are the most direct reflection of their written evaluations, and where possible have been included verbatim. The project evaluation forms

[3] Peer Review Guide, Based on a Survey of Best Practices for In-Progress Peer Review, August 2004

were distributed to the Peer Review Panel members prior to the meeting, along with detailed guidance on how to complete the forms.

Since the "relevance to overall DOE objectives," or the degree to which the project supports the objectives, goals, and approaches of the Water Power Program, is included as a stand-alone metric in this analysis, each of the larger MHK and CH projects received two cumulative scores. The second score is comprised of the weighted average of the following metrics: 1) approach, 2) technical accomplishments and progress, 3) research integration, collaboration, and technology transfer, and 4) proposed future research. The Lower TRL projects (for both MHK and CH) received two cumulative scores, one for its "relevance to overall DOE objectives," and a second score that is comprised of the weighted average of the approach and project implementation.

The panel was asked to rate marine and hydrokinetic and conventional hydropower projects in the following weighted categories:

1. **Relevance to Overall DOE Objectives:** the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. (Stand Alone Metric)
2. **Approach**: the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. (Weight = 30%)
3. **Technical Accomplishments and Progress:** – degree to which the project has progressed compared to the latest project schedule and goals. (Weight = 30%)
4. **Research Integration, Collaboration, and Technology Transfer:** with industry/universities/other laboratories – the degree to which the project interacts, interfaces, or coordinates with other institutions and projects, and the degree to which projects are disseminating the results of the R&D. (Weight = 20%)
5. **Proposed Future Research:** the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and when sensible, mitigating risk by providing alternate development pathways. (Weight = 20%)

The panel was asked to rate the "Lower TRL" marine and hydrokinetic and conventional hydropower projects in the following weighted categories:

1. **Relevance to Overall DOE Objectives:** the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. (Stand Alone Metric)
2. **Approach**: the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. (Weight = 80%)
3. **Project Implementation:** the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed research or technology, and when sensible, mitigating risk by providing alternate project management pathways. Also, the degree to which projects have achieved any notable accomplishments or encountered setbacks (for those projects which are underway and have completed a significant amount of work). (Weight = 20%)

Additionally, the program evaluation forms were designed to capture input regarding the following criteria:

1. **Objectives:** how well do program objectives align with industry needs?
2. **Barriers:** has the program identified the critical barriers to sustaining hydropower development and deployment?
3. **Approaches:** are current program approaches appropriately and effectively designed and implemented in order to achieve objectives and overcome technical and non-technical barriers?
4. **Projects:** has the program formed an effectively balanced portfolio of projects that will

contribute to achieving its goals and objectives?

5. **Communication & Collaboration:** the degree and impact that program interaction has on industry, universities, federal agencies, as well as comparable international actors and other stakeholders.

For project evaluations, numerical scores were based on a four point scale, with the following qualitative descriptors given for the numerical scoring index:

- **4 – Outstanding**. Project is critical to supporting the objectives, goals, and approaches of the program.
- **3 – Good**. Most project aspects support the objectives, goals, and approaches of the program.
- **2 – Fair**. Project partially supports the objectives, goals, and approaches of the program.
- **1 – Poor**. Project provides little support to the objectives, goals, and approaches of the program.

For the program evaluation, numerical scores were based on a four point scale, with the following qualitative descriptors given for the numerical scoring index:

- **4 – Outstanding**. All program objectives fully support industry needs.
- **3 – Good**. Most program objectives support industry needs.
- **2 – Fair**. Some program objectives support industry needs.
- **1 – Poor**. Very few program objectives support industry needs; objectives should be re-evaluated and revised.

A maximum final overall score of 4 signifies that the project satisfied the above mentioned four criteria to the fullest possible extent, while a minimum score of 1 implies that the project did not satisfactorily meet any of the requirements of the five criteria mentioned above.

The individual criterion scores for the marine and hydrokinetic and conventional hydropower projects are reflected in the bar graphs in Section 4 and Section 5 respectively. Additionally, the formulas listed below were used to calculate the overall weighted average scores of the larger MHK and CH projects in order to provide a means for comparing a project's final overall score equivalently to other projects:

$$
\begin{aligned}
\textit{Final Project Score}_{MHK} = {} & [\textit{Reviewer 1 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 2 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 3 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 4 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 5 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20)/5
\end{aligned}
$$

$$
\begin{aligned}
\textit{Final Project Score}_{CH} = {} & [\textit{Reviewer 1 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 2 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 3 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 4 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 5 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20) + \\
& \textit{Reviewer 6 } (Score1*0.30 + Score2*0.30 + Score3*0.20 + Score4*0.20)\ /6
\end{aligned}
$$

The formulas listed below were used to calculate the overall weighted average scores of the Lower TRL projects in order to provide a means for comparing a project's final overall score equivalently to other projects:

$$\textit{Final Project Score}_{MHKLowerTRL} = [\textit{Reviewer 1}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 2}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 3}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 4}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 5}(Score1*0.80 + Score2*0.20)\ /5$$

$$\textit{Final Project Score}_{CHLowerTRL} = [\textit{Reviewer 1}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 2}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 3}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 4}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 5}(Score1*0.80 + Score2*0.20) + \textit{Reviewer 6}(Score1*0.80 + Score2*0.20)\ /6$$

The project comparisons illustrated in the report are criteria based. Figure 1.2 represents a sample project score graph. Each rectangular blue bar in the chart represents that project's average score for one of the five designated criteria. These scores (blue bars) are then compared with the related maximum, minimum, and average scores for the same criterion across all Technology Development and Market Acceleration projects. The black line bars, which overlay the blue rectangular bars, illustrate the maximum, average, and minimum scores (range of scores) for each metric for all of the projects evaluated.

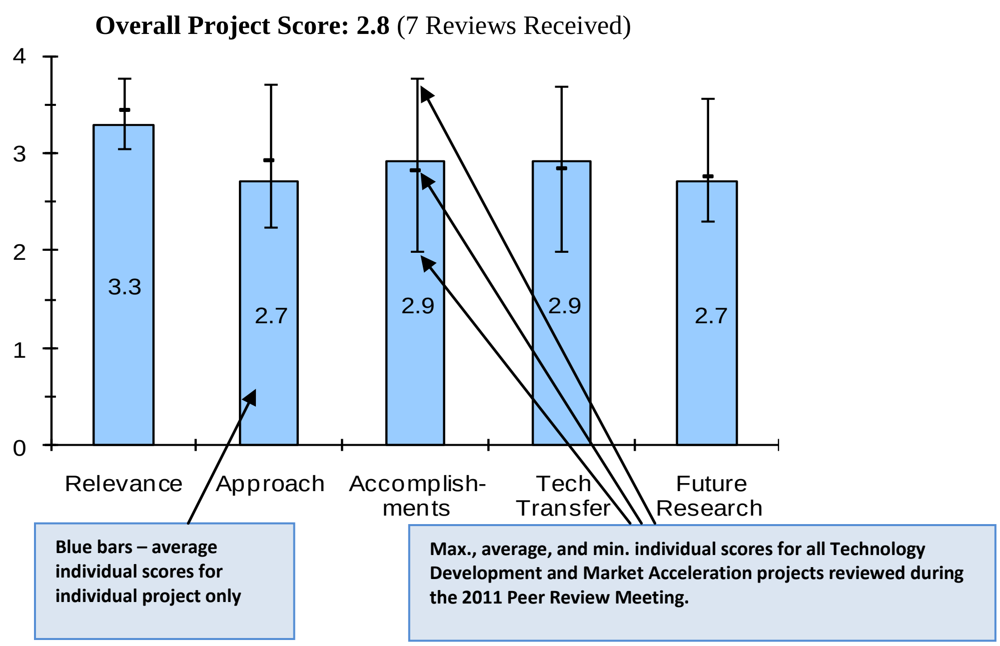


Figure 1.2. Project Score Graph with Explanation

For clarification, consider a hypothetical review in which only five projects were presented and reviewed in a sub-program; Table 1.2 displays the average scores for each of the project's five rated criteria.

Table 1.2: Sample Project Scores

	Relevance (stand-alone)	Approach (30%)	Accomplishments (30%)	Tech Transfer (20%)	Future Research (20%)
Project A	3.4	3.0	2.9	2.7	2.8
Project B	3.1	2.8	2.7	2.7	2.5
Project C	3.0	2.4	2.7	2.9	2.6
Project D	3.4	2.6	3.0	3.1	2.5
Project E	3.6	2.8	3.1	3.2	2.7
Max	3.6	3.0	3.1	3.2	2.8
Average	3.3	2.7	2.9	2.9	2.7
Min	3.0	2.4	2.7	2.7	2.5

The Project A chart would contain five blue rectangular bars to represent the values listed for Project A above. A black line bar indicating the related maximum, minimum, and average values for each criterion would overlay each of the blue bars to facilitate comparison with other projects in the sub-program. In addition, each project's criterion scores would be weighted and combined to give a final, overall project score that could be meaningfully compared with those of other projects.

Finally, the reviewers were asked to provide qualitative comments indicating specific strengths or weaknesses of the project, along with recommendations for additions/deletions to the work scope. These comments, along with the quantitative scores, were placed into a database for easy retrieval and analysis. These comments are summarized in the following sections of this report.

The qualitative analyses provided in this report are individual comments made by the reviewers, as consolidated by the U.S. DOE for brevity and merging comments with commonalities, and do not represent consensus opinion on the subject matter.

The following sections of this report provide:

- An overview of the Peer Review Meeting Agenda,
- Key findings of the Peer Review Panel,
- An overall review of the 2011 Water Power Program activities,
- Quantitative and qualitative analyses of the Marine and Hydrokinetics and Conventional Hydropower projects, including Lower TRL projects that were reviewed. Analyses include a summary of qualitative reviewer comments as well as graphs and tables showing overall scores for each of the projects,
- Quantitative and qualitative analysis of the Peer Review Panel's overall evaluation of the program,
- Lessons learned from the 2011 Water Power Peer Review Meeting Process,
- A meeting attendee list,
- General project and program evaluation forms, and
- Results from surveys submitted by meeting attendees.

1.3 Water Program Peer Review Agenda

Tuesday, November 1, 2011 Marine and Hydrokinetic Projects *[Magnolia C]*

12:00 PM	**Meeting Registration**	
12:45 PM	**Marine and Hydrokinetic Peer Review Introduction**	**Michael Reed DOE-HQ**
1:15 PM	Snohomish PUD No 1 (TRL 7 8 System) – Puget Sound Pilot Tidal Energy Project *1:30 PM: Panel Q&A*	Brian Polagye, University of Washington
1:35 PM	Acoustic effect of hydrokinetic tidal turbines *1:45 PM: Panel Q&A*	Brian Polagye, University of Washington
1:50 PM	Advanced, High Power, Next Scale, Wave Energy Conversion Device *2:00 PM: Panel Q&A*	Dr. Philip R. Hart, Ocean Power Technologies
2:05 PM	Ocean Power Technologies (TRL 5 6 System) – PB500, 500 kW Utility-Scale PowerBuoy Project *2:15 PM: Panel Q&A*	Dr. Philip R. Hart, Ocean Power Technologies
2:20 PM	Ocean Power Technologies (TRL 7 8 System) – Reedsport PB150 Deployment and Ocean Test Project *2:35 PM: Panel Q&A*	Dr. Philip R. Hart, Ocean Power Technologies
2:40 PM	15 Minute Break	
2:55 PM	Princeton Power Systems (TRL 5 6 Component) – Marine High-Voltage Power Conditioning and Transmission System with Integrated Energy Storage *3:05 PM: Panel Q&A*	Mark Holveck , Paul Heavener, Princeton Power Systems
3:10 PM	WaveBob (TRL 5 6 System) – Advanced Wave Energy Conversion Project *3:20 PM: Panel Q&A*	Roger Bagbey, on behalf of WaveBob
3:25 PM	Northwest Energy Innovations (TRL 5 6 System) – WETNZ MultiMode Wave Energy Converter Advancement Project *3:35 PM: Panel Q&A*	Justin Klure, Northwest Energy Innovations

3:40 PM	Vortex Hydro Energy (TRL 5 6 System) – Advanced Integration of Power Take-Off in VIVACE *3:50 PM: Panel Q&A*	Gus Simiao, Vortex Hydro Energy
3:55 PM	The Water to Wire Project *4:05 PM: Panel Q&A*	Edward Lovelace, Free Flow Power
4:10 PM	WaveWindFloat *4:20 PM: Panel Q&A*	Alla Weinstein, Principal Power
4:25 PM	15 Minute Break	
4:40 PM	Aquantis 2.5MW Ocean Current Generation Device *4:50 PM: Panel Q&A*	Alex Fleming, Dehlsen
4:55 PM	Dehlsen (TRL 5 6 System) – Aquantis C-Plane Ocean Current Turbine Project *5:05 PM: Panel Q&A*	Alex Fleming, Dehlsen
5:10 PM	Siting of hydrokinetic project in offshore southeast Florida *5:20 PM: Panel Q&A*	Alex Fleming, Dehlsen
5:25 PM	Adjourn	

Wednesday, November 2, 2011 Marine and Hydrokinetic Projects *[Magnolia C]*

7:30 AM	Continental Breakfast and Registration	
8:30 AM	Direct Drive Wave Energy Buoy *8:40 AM: Panel Q&A*	Ken Rhinefrank , Columbia Power Technologies
8:45 AM	Assessment of Projected Life-Cycle Costs for Wave, Tidal, Ocean Current, and In-Stream Hydrokinetic Power *8:55 AM: Panel Q&A*	Mirko Previsic, ReVision
9:00 AM	Development of Reference Models and Design Tools (LCOE Models) *9:20 AM: Panel Q&A*	Rich Jepsen, SNL
9:30 AM	10 Minute Break	
9:40 AM	FY 09 Lab Call: Supporting Research & Testing for MHK *10:00 AM: Panel Q&A*	Albert LiVecchi, NREL (including
10:10 AM	FY 09 Lab Call: Research & Assessment for MHK Development *10:30 AM: Panel Q&A*	Rich Jepsen, SNL (including other
10:40 AM	10 Minute Break	
10:50 AM	Southeast National Marine Renewable Energy Center (FAU) *11:00 AM: Panel Q&A*	Susan H. Skemp, Florida Atlantic University
11:05 AM	National Marine Renewable Energy Center (UH) *11:25 AM: Panel Q&A*	Richard Rocheleau, University of
11:30 AM	Northwest National Marine Renewable Energy Center (OSU/UW) *11:50 AM: Panel Q&A*	Belinda Batten , Oregon State and
11:55 AM	Lunch	
1:00 PM	Sound & Sea Technology (TRL 4 Component) – Advanced Anchoring Technology *1:05 PM: Panel Q&A*	Dallas Meggitt, Sound & Sea Technology
1:07 PM	Atargis Energy (TRL 4 System) – Cycloidal Wave Energy Converter *1:12 PM: Panel Q&A*	Stefan Siegel, Atargis Energy

1:14 PM	US Synthetic Corp (TRL 4 Component) – The Development of Open, Water Lubricated Polycrystalline Diamond Thrust Bearings for use in Marine Hydrokinetic (MHK) Energy Machines *1:19 PM: Panel Q&A*	Craig Cooley, U.S. Synthetic Corporation
1:21 PM	Turner Hunt Ocean Renewable (TRL 4 System) – THOR's Power Method for Hydrokinetic Devices *1:26 PM: Panel Q&A*	Turner Hunt, Turner Hunt Ocean Renewable
1:28 PM	Sunlight Photonics (TRL 4 System) – Tidal Energy System for On-shore Power Generation *1:33 PM: Panel Q&A*	Allan Bruce, Sunlight Photonics
1:35 PM	Resolute Marine Energy, Inc (TRL 1 2 3 Component) *1:40 PM: Panel Q&A*	Allan Chertok, Resolute Marine
1:42 PM	Semprus Biosciences (TRL 1 2 3 Component) *1:47 PM: Panel Q&A*	Zheng Zhang, Semprus
1:49 PM	Shift Power Solutions (TRL 1 2 3 System) *1:54 PM: Panel Q&A*	Jane Vvedensky, Shift Power
1:56 PM	M3 Wave Energy Systems (TRL 1 2 3 System) *2:01 PM: Panel Q&A*	Mike Morrow, M3 Wave Energy
2:03 PM	12 Minute Break	
2:15 PM	Whitestone Power & Communications (TRL 1 2 3 System) – Whitestone Poncelet RISEC Project *2:20 PM: Panel Q&A*	John R. Hasz, Steven Selvaggio, Whitestone Power & Commun.
2:22 PM	Bayer Material Science (TRL 1 2 3 System) – River Devices to Recover Energy with Advanced Materials(River DREAM) *2:27 PM: Panel Q&A*	Dr. Brent Crenshaw, Bayer Material Science
2:29 PM	Free Flow Energy (TRL 1 2 3 Component) – Design and Development of a Cross-Platform Submersible Generator Optimized for the Conditions of Current Energy Conversion *2:34 PM: Panel Q&A*	Robert S. Cinq-Mars, Free Flow Energy
2:36 PM	Regents of the University of CA (TRL 1 2 3 Component) *2:41 PM: Panel Q&A*	C.P. "Case" van Dam, University of

2:43 PM	Curators of the University of Missouri – Missouri S&T (TRL 1 2 3 Component) *2:48 PM: Panel Q&A*	Joshua L. Rovey, University of Missouri
2:50 PM	OTEC Cold Water Pipe-Platform Sub-System Dynamic Interaction Validation (OPPSDIV) *2:55 PM: Panel Q&A*	Matt Ascari, Lockheed Martin
2:57 PM	Modeling the Physical and Biochemical Influence of Ocean Thermal Energy Conversion Plant Discharges into their Adjacent Waters *3:02 PM: Panel Q&A*	Patrick Grandelli, Makai Ocean Engineering
3:04 PM	Impacts of OTEC intakes on Aquatic Organisms *3:14 PM: Panel Q&A*	Tim Hogan, Alden Laboratories
3:19 PM	Scientific Solutions (TRL 5 6 Component) – Underwater Active Acoustic Monitoring Network for Marine and Hydrokinetic Energy *3:29 PM: Panel Q&A* Projects	Dr. Peter J. Stein, Scientific Solutions
3:34 PM	16 Minute Break	
3:50 PM	Active Acoustic Deterrence of Migratory Whales *4:00 PM: Panel Q&A* Projects	Steven R. Kopf, Pacific Energy
4:05 PM	Wave Tank WEC Array Analysis *4:15 PM: Panel Q&A* Projects	Ken Rhinefrank , Columbia Power Technologies
4:20 PM	Sediment transport impact on protected species *4:30 PM: Panel Q&A* Projects	Stephen Barrett, Harris Miller Miller & Hanson
4:35 PM	Adjourn	

Thursday, November 3, 2011 Marine and Hydrokinetic Projects *[Magnolia]*

7:30 AM	Continental Breakfast and Registration	
8:30 AM	OTEC resource assessment *8:40 AM: Panel Q&A*	Matt Ascari, Lockheed Martin
8:45 AM	Ocean current resource assessment *8:55 AM: Panel Q&A*	Kevin Haas, GTRC
9:00 AM	In-stream hydrokinetic resource assessment *9:10 AM: Panel Q&A*	Paul Jacobson, EPRI
9: 15 AM	Enviro effects of hydrokinetic turbines on fish *9:25 AM: Panel Q&A*	Paul Jacobson, EPRI
9:30 AM	10 Minute Break	
9:40 AM	OCGEN Module Mooring *9:50 AM: Panel Q&A*	Jarlath McEntee, Ocean Renewable Power Company
9:55 AM	Ocean Renewable Power Co (ORPC) (TRL 7 8 System) – TidGen (TM) Power System Commercialization Project *10:10 AM: Panel Q&A*	Jarlath McEntee, Ocean Renewable Power Company
10:15 AM	CESA/Marine Energy Technology Advancement Partnership *10:25 AM: Panel Q&A*	Hoyt Battey, DOE-HQ
10:30 AM	Tidal Energy Resource Assessment *10:40 AM: Panel Q&A*	Kevin Haas, GTRC
10:45 AM	Wave Energy Resource Assessment *10:55 AM: Panel Q&A*	Paul Jacobson, EPRI
11:00 AM	Categorizing and Evaluating the Effects of Stressors (KMS and ERES) *11:15 AM: Panel Q&A*	Andrea Copping, Jennifer States, PNNL
11:20 AM	10 Minute Break	

11:30 AM	IEA Annex IV– Assessment of Environmental Effects and Monitoring Efforts *11:40 AM: Panel Q&A*	Andrea Copping and Hoyt Battey, PNNL and DOE-
11:45 AM	Categorizing and Evaluating the Effects of Stressors (all Conceptual Model work) *11:55 AM: Panel Q&A*	Mark Grippo, SNL (ANL Sub)
12:00 PM	Lunch	
1:00 PM	Effects on the Physical Environment (Hydrodynamics, Sediment Transport, and Water Quality) *1:15 PM: Panel Q&A*	Jesse Roberts, SNL
1:20 PM	Effects on the Physical Environment (Hydrodynamics, and Water Quality/Food Web) *1:35 PM: Panel Q&A*	Zhaoqing Yang, PNNL
1:40 PM	Effects on Aquatic Organisms (Acoustics and Toxicity) *1:55 PM: Panel Q&A*	Mark Bevelheimer, SNL (ORNL Sub)
2:00 PM	Effects on Aquatic Organisms (EMF, Acoustics and Physical Interaction) *2:20 PM: Panel Q&A*	Andrea Copping, PNNL (and Subs)
2:25 PM	Permitting and Planning *2:35 PM: Panel Q&A*	Simon Geerlofs, PNNL
2:40 PM	15 Minute Break	
2:55 PM	ORPC Alaska (TRL 4 Component) – Abrasion Testing of Critical Components of Hydrokinetic Devices *3:00 PM: Panel Q&A*	Monty Worthington, Ocean Renewable Power Company
3:05 PM	Beluga Whale interactions with Tidal Energy *3:15 PM: Panel Q&A*	Monty Worthington, Ocean Renewable
3:20 PM	Adjourn	

Thursday, November 3, 2011 Conventional Hydropower Projects *[Walnut]*

7:30 AM	Continental Breakfast and Registration	
8:30 AM	**Conventional Hydro Peer Review Introduction**	**Michael Reed, DOE-HQ**
8:55 AM	Water -Use Optimization (Entire Project) *9:55 AM: Panel Q&A*	John Gasper, ANL (other Labs also)
10:05 AM	(HAP) Hydropower Advancement Project: Audits and Feasibility Studies for Capacity and Efficiency Upgrades *10:35 AM: Panel Q&A*	Rajesh Dham and Brennan Smith, ORNL
10:45 AM	15 Minute Break	
11:00 AM	Non-Powered Dams Resource Assessment *11:15 AM: Panel Q&A*	Brennan Smith, ORNL
11:20 AM	Climate Change Assessment *11:35 AM: Panel Q&A*	Mike Sale, ORNL
11:40 AM	Basin Scale Opportunity Assessment *11:55 AM: Panel Q&A*	Simon Geerlofs, PNNL
12:00 PM	Lunch	
1:00 PM	FY 11 CH FOA Topic 1.1 Small Hydropower (System and Component Model Development) (5 Projects) *1:30 PM: Panel Q&A*	TBD, U.S. DOE Golden Field Office
	• SLH Timing Belt Powertrain	HQ or Project PI, Natel Energy
	• Laboratory Demonstration of a New American Low-Head Hydropower Turbine	HQ or Project PI, Hydro Green Energy
	• W4e Hydropower Turbine Generator system validation	HQ or Project PI, Walker
	• Small Hydropower Research and Development Technology Project	HQ or Project PI, Near Space
	• Scalable Low-head Axial-type Venturi-flow Energy Scavenger	HQ or Project PI, New Mexico State University

1:50 PM	FY 11 CH FOA Topic 1.2 Small Hydropower (Innovative System Testing) (5 Projects) *2:30 PM: Panel Q&A*	TBD, U.S. DOE Golden Field Office
	• Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site • 51-Mile Hydroelectric Power Project Demonstration of new methodologies to reduce the LCOE for small, hydropower development • Proof of Power Project on Potholes East Canal (POP-PEC) • Real World Demonstration of a New American Low-Head Hydropower Unit • Construction Support for New Slab Creek Power House Project	HQ or Project PI, Weisenberger Mills HQ or Project PI, Earth By Design HQ or Project PI, Percheron Power HQ or Project PI, Hydro Green Energy HQ or Project PI, Sacramento MUD
2:50 PM	15 Minute Break	
3:05 PM	FY11 CH FOA Topic 4 SLH-100 demonstration project at Monroe Drop *3:15 PM: Panel Q&A (1 Project)*	TBD, U.S. DOE Golden Field Office
	• SLH-100 demonstration project at Monroe Drop	HQ or Project PI, Natel Energy
3:20 PM	FY 11 CH FOA Topic 2.1 Pumped Storage Hydropower (Project Development Support) (1 Project) *3:35 PM: Panel Q&A*	TBD, U.S. DOE Golden Field Office
	• Geotechnical Investigation and Value Stream Analysis for the Iowa Hill Pumped-Storage Development	HQ or Project PI, Sacramento MUD
3:40 PM	Quantifying Full Value of Hydro in Transmission Grid *4:10 PM: Panel Q&A*	Tom Key, EPRI

4:20 PM	FY 11 CH FOA Topic 2.2 Pumped Storage Hydropower (Detailed Analysis to Demonstrate Value) (1 Project) *4:35 PM: Panel Q&A*	TBD, U.S. DOE Golden Field Office
	• Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the U.S.	HQ or Project PI, ANL
4:40 PM	10 Minute Break	
4:50 PM	FY 11 CH FOA Topic 3.1 Environmental Mitigation Technology (System and Component Model Development) (2 Projects) *5:00 PM: Panel Q&A*	HQ PI, U.S. DOE Golden Field Office
	a. Turbine Aeration Physical Modeling and Software Design b. Sensor Fish Re-design to Support Advance Hydropower Development	HQ or Project PI, University of Minnesota HQ or Project PI, PNNL
5:05 PM	FY 11 CH FOA Topic 3.2 Environmental Mitigation Technology (Innovative System Testing) (1 Project) *5:15 PM: Panel Q&A*	TBD, U.S. DOE Golden Field Office
	• Deployment and Testing of the Alden Hydropower Fish-Friendly Turbine	HQ or Project PI, EPRI
5:20 PM	Enviro Hurdles: Instream Flow *5:35 PM: Panel Q&A*	Mark Bevelheimer, ORNL
5:40 PM	Adjourn	

2.0 Recommendations and Key Findings of the Peer Review Panels

Key Findings and Opportunities for Enhancement

Some of the key findings of the 2011 Water Power Peer Review Marine and Hydrokinetic Panel (MHK) are listed below:

1. **Regarding the "meeting DOE goals" metric, the current need is to get some of the projects into the water and to get them permitted.** Given limited funding, the near term focus of the program should be on getting MHK projects in the water to ensure the short and long term viability of the industry; projects focused exclusively on serving large commercial deployments far in the future should be a secondary priority.
2. **Regarding the environmental work being conducted by the program, the MHK Panel feels that the best projects are those out in the field generating empirical evidence.** The MHK Panel encourages the program to do more projects involving whales, collisions, acoustics, etc.
3. **The program's modeling projects should continue to be improved through verification via peer review of models providing a "reality check" of model intent and design along with underlying assumptions, the declaration of model inputs, equations, and independently generated outputs.** Since the information will eventually be public in a report, there needs to be a quality assurance/quality control (QA/QC) check before this happens. Someone should be setting the tone for QA/QC, data control issues, etc. Something like this would also be useful on the Conventional Hydropower side.
4. **A communications protocol that outlines the proper procedure for how participants in the program communicate with each other as well as outside the program should be developed by the program.** There is not enough communication or transfer of information, mainly on the environmental side in regards to the cost reference model.
5. **An independent panel should conduct a deeper dive/review into the effectiveness of the redundancies of certain efforts and/or projects.** There appeared to be some redundancies in some projects, and principal investigators weren't always aware of what each was doing.
6. **What is missing from the program is an area investigating the issues pertaining to infrastructure requirements, harbors, capacity, etc.** The program should conduct a physical resource assessment to look at these issues.
7. **There is an opportunity to mitigate against the environmental community in putting an MHK device in the water**. The program should look to the potential issues that could impact getting MHK devices in the water.
8. **Bio-fouling and some of that work is really low hanging fruit and some of it has already done**. The program should focus on efforts specific to this industry.

Some of the key findings of the 2011 Water Power Peer Review Conventional Hydropower Panel are listed below:

1. **Overall there were a number of noted improvements.** It was very clear that the program and principal investigators listened to the peer reviewers.
2. **Regarding coordination of projects with DOE, significant improvement was noted by the panel.** Overlap areas seem to be minimized and this is something that DOE should be commended for.
3. **The soft projects with unclear agendas, action items, etc. seem to have been minimized.**
4. **There seemed to be an elimination of projects that claim "0 budget" when they require much Federal staff time.** This is much more representative of the "real world."
5. **A number of projects made a good effort at technology transfer.** A document depository showing what's going on with the projects throughout the year would be a great benefit to

reviewers.

6. **The program should require projects that include quantitative planning and analysis, or developing models that perform quantitative planning and analysis, to address risk and reliability due to uncertainty of future conditions such as climate variability and change, water availability, changing land use, and future economic conditions.**
7. **A few improvements in the communication process will be helpful to stay up to date on what is occurring within the projects.**
8. **The Toolset presentation improved a lot from last year to this year, and the project seems to have coalesced into a good concept and seems to be going down the correct path. However, not all of the parts and pieces are quite there yet.** The demonstration sites that were chosen for the toolset seem to make it difficult to identify the success of the project. A site requiring better forecasting and utilization of a larger portion of the toolset should be chosen. The two sites managed by the WAPA will not take full advantage of the project. Additionally, holding a webinar to engage the intended end-users would help in a feedback process. This would mitigate the risk of going through all this research and ending up with few users.
9. **The program should continue to emphasize that hydropower facility owners and operators contend with multiple resource objectives and priorities changing over time.** Looking at hydropower issues as a tradeoff between energy production and environmental quality could leads to the oversimplification of the issues that does not account for other resource objectives, such as drinking water, irrigation, recreation, fishing, downstream development, and others.
10. **The program should continue to objectively support the rigorous scientific and economic evaluation of various externally imposed operational constraints and water use tradeoffs that can have a major detrimental impact to the amount of renewable energy available from conventional hydro.** Raising awareness of the true impacts and total costs of water use tradeoffs is absolutely critical to the DOE objective to increase the contributions of conventional hydropower to the U.S. renewable energy portfolio.
11. **Adjustments to the peer review meeting schedule to allow some ebb and flow for the large projects should be considered.** Principal investigators of ongoing projects could have benefitted from having more time to present. The principal investigators of new projects seemed to have sufficient time to present, and principal investigators of projects that were wrapping up or ending had just the right amount of time to present.

3.0 Water Power Activities

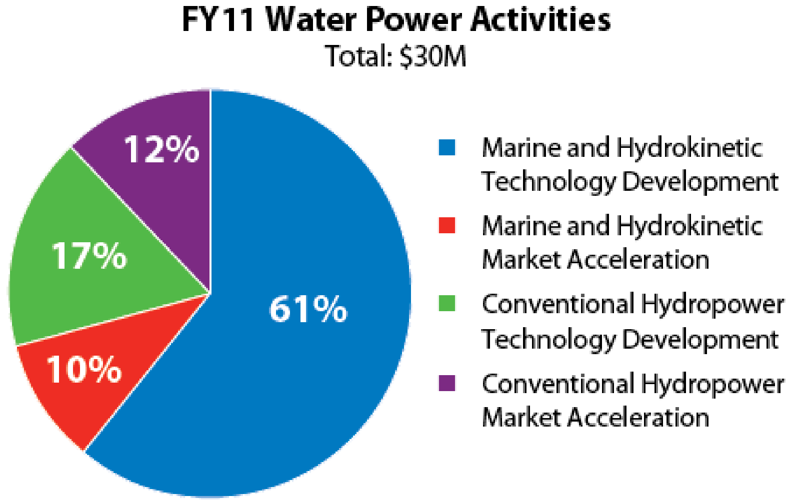


Figure 3.1 FY11Water Power Activities

Water power is the nation's largest source of clean, domestic, renewable energy. Water power technologies harness energy from rivers and oceans to generate electricity for the nation's homes and businesses, and can help the United States meet its pressing energy, environmental, and economic challenges. Water power technologies fall into two broad categories: marine and hydrokinetic and conventional hydropower technologies. Marine and hydrokinetic technologies capture energy from waves, tides, ocean currents, free-flowing rivers, streams, and ocean thermal gradients. Conventional hydropower uses dams or impoundments to store river water in a reservoir. The water is released through a turbine to generate electricity.

The Wind and Water Power Program (the program) is one of ten programs within the Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) and includes the water power activities. The mission of the Wind and Water Power Program is the responsible stewardship of national resources to increase the development and deployment of reliable, affordable, and environmentally sustainable wind and water power technologies to realize the benefits of domestic renewable energy production. The mission of the water power activities is to develop and employ novel technologies, improved operational procedures, and rigorous analysis to assess the potential extractable energy from domestic rivers, estuaries, and coastal waters and help industry harness these renewable, emissions-free resources through environmentally sustainable and cost-effective electricity generation.

Figure 3.1 illustrates the budget breakdown for water power activities in FY2011. The program focuses on the development of each technology, addressing technical barriers to device design, development, testing, evaluation, and integration; and market acceleration, which addresses nontechnical barriers to the development, siting, and deployment of the technologies. Figure 3.2 illustrates the current structure of the Wind and Water Power Program.

The program works with industry, universities, other federal agencies, and DOE's national laboratories to promote the development and deployment of technologies capable of generating environmentally sustainable and cost-effective electricity from the nation's water resources. The program conducts applied research, testing, and demonstration of advanced conventional hydropower technologies to improve generating capacity and reduce potential environmental effects. These upgrades will increase generating efficiency and reduce adverse environmental effects at the hydropower facilities. The program also undertakes technology development and testing activities to prove advanced concepts and to support future full-scale projects.

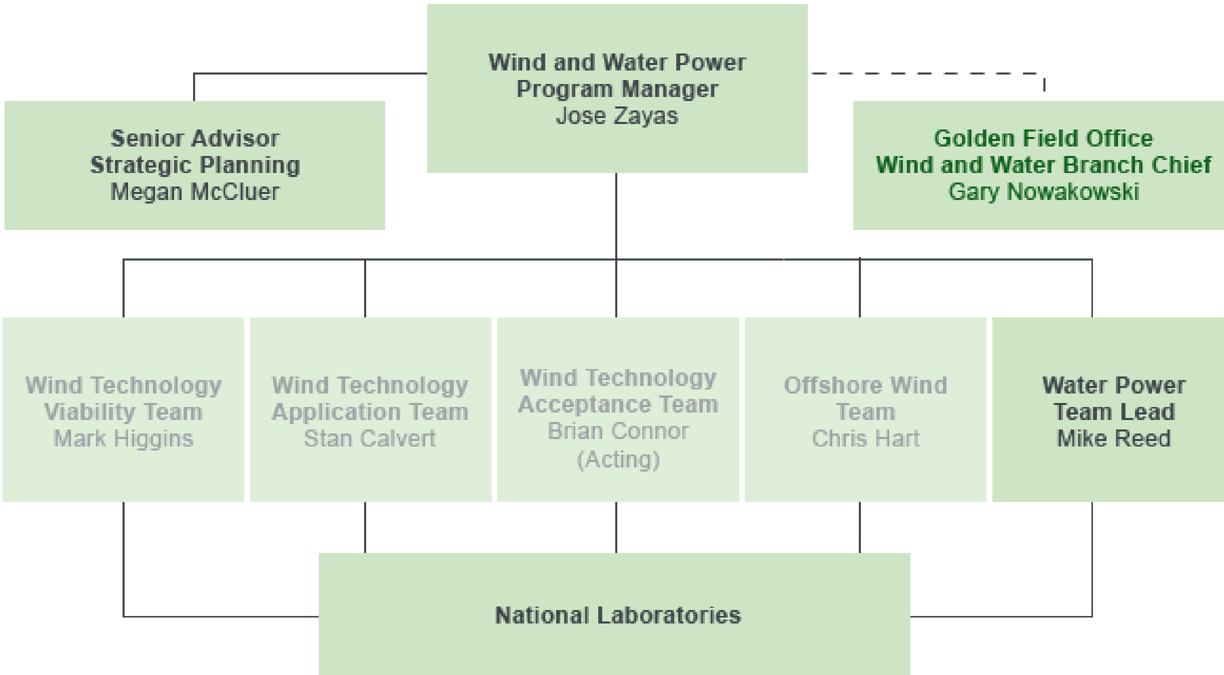


Figure 3.2 Wind and Water Power Program Structure

Finally, the program undertakes a range of research and testing activities that provide the scientific basis for improving hydropower technologies, from the development of hardware to software and analytical methods. Hydropower plant operators can use these products and studies to improve their facilities' generation capacity and environmental performance.

The program works to reduce the time and costs associated with permitting hydropower projects, to better quantify the potential magnitude, costs, and benefits of hydropower generation, and to identify and address other barriers to hydropower deployment. One key aspect of this work is assessing the nation's hydropower resources, including the potential for increased generation and capacity at existing hydropower facilities and non-powered dams as well as the potential for new low-impact and small hydropower generation. Another aspect of the program's work is the design, development, and testing of new ways to reduce potential adverse environmental effects of hydropower generation. These include effects on fish populations, water quality, and river habitats. Finally, the program works to quantify the benefits of effective and cost-competitive conventional hydropower technologies and to communicate those benefits to policy makers and stakeholders.

The program supports the development and testing of a wide variety of marine and hydrokinetic systems and components, from proof-of-concept studies through full-scale demonstration projects. Program funding has supported the research and development of devices such as wave power buoys, tidal power turbines, oscillating water column wave energy converters, and ocean thermal energy conversion components. The program also develops tools and models that support the design, development, and optimization of marine and hydrokinetic devices. These projects will help maximize efficient electricity generation at marine and hydrokinetic power plants while mitigating potential environmental effects. In addition, the program has established university-led National Marine Renewable Energy Centers to facilitate in-water testing of marine and hydrokinetic devices and components. These centers will have open-water test berths as well as laboratory facilities that will allow researchers to investigate marine and hydrokinetic devices in real-world conditions.

To accelerate the market development of marine and hydrokinetic technologies, the program works to reduce the time and costs of siting marine and hydrokinetic power projects and to identify and address barriers to their deployment. The program is also assessing the potential extractable energy contained in the nation's waves, tides, ocean currents, rivers, streams, and ocean thermal gradients. Finally, the program is conducting economic analyses to quantify the benefits of the widespread deployment of effective and cost-competitive marine and hydrokinetic systems. These activities include assessing industry research and development needs, identifying policy mechanisms and market designs that will support accelerated deployment, and providing information and training to potential members of the marine and hydrokinetic industry and other stakeholders.

The following sections of this report provide summaries and analyses of the marine and hydrokinetic and conventional hydropower activities that were reviewed during the 2011 Water Power Peer Review meeting. Analyses include a summary of qualitative reviewer comments as well as graphs and tables showing overall scores for each of the projects. The qualitative analyses provided in the following sections are individual comments made by the reviewers, as consolidated by the U.S. DOE for brevity and merging comments with commonalities, and do not represent consensus opinion on specific projects or presentations.

4.0 Marine and Hydrokinetic Activities

Marine and hydrokinetic (MHK) technologies convert wave motion; free-flowing ocean, tidal, and river currents; and marine temperature changes into energy. In the United States (U.S.), marine and hydrokinetic technologies are at a very early stage of development but hold significant promise for adding to our nation's renewable energy portfolio. The key objectives of the U.S. Department of Energy (DOE) Wind and Water Power Program (referred to as the Water Power Program or the program) MHK activities are to: 1) confirm resource availability and assess potential environmental impacts, 2) identify promising technology leaders, and 3) effectively target research and development R&D investments to reduce key cost drivers.

The key barriers facing MHK activities are:

- Cost and performance data does not yet exist to establish baseline levelized cost-of-energy.
- Technologies are not yet cost competitive.
- Device functionality and performance has not yet been demonstrated.
- Lack of data on environmental risks to permitting and deployment.

The technical approaches utilized by the program to address the key barriers facing MHK activities are to:

- Accurately characterize national resources to allow for effective portfolio prioritization.
- Reduce costs and improve performance.
- Determine baseline levelized cost of energy and identify technology leaders.
- Coordinate information sharing and leverage international expertize.

Below are brief overviews and summaries of the key marine and hydrokinetic activities that are currently being supported by the Water Power Program.

Summary of Marine and Hydrokinetic Technology Development Activities
The program supports the development of marine and hydrokinetic devices, which capture energy from waves, tides, ocean currents, the natural flow of water in rivers, and marine thermal gradients, without building new dams or diversions.

Component and Device Development
The program works closely with industry and DOE’s national laboratories to advance the development and testing of marine and hydrokinetic devices. In 2008, the program funded projects to develop and test point absorber, oscillating wave column, and tidal turbine technologies. The program also funds component design, such as techniques for manufacturing and installing cold water pipes critical for ocean thermal energy conversion (OTEC) systems.

Device testing
Rigorous device testing is necessary to validate and optimize prototypes before beginning full-scale demonstration and deployment. The program supports device testing by providing technology developers with information on testing facilities. Technology developers require access to facilities capable of simulating open-water conditions in order to refine and validate device operability.

The program has identified more than 20 tank testing operators in the U.S. with capabilities suited to the marine and hydrokinetic technology industry. This information is available to the public in the program's Hydrodynamic Testing Facilities Database.

The program also supports the development of open-water, grid-connected testing facilities, as well as resource assessments that will improve simulations done in dry-dock and closed-water testing facilities.

National Marine Renewable Energy Centers
The program has established two university-led National Marine Renewable Energy Centers to be used for device testing. These centers are located on coasts and will have open-water testing berths, allowing researchers to investigate marine and estuary conditions.

Array Design, Development, Modeling and Testing
Optimal array design, development, modeling and testing are needed to maximize efficiency and electricity generation at marine and hydrokinetic power plants while mitigating nearby and distant impacts. Activities may include laboratory and computational modeling of mooring design or research on device spacing.

Technology Characterization and Evaluation
The geographies, resources, technologies, and even nomenclature of the U.S. marine and hydrokinetic technology industry have yet to be fully understood or defined. The program characterizes and assesses marine and hydrokinetic devices, and then organizes the collected information into a comprehensive and searchable Web-based database, the Marine and Hydrokinetic Technology Database. The database, which reflects intergovernmental and international collaboration, provides industry with one of the most comprehensive and up-to-date public resources on marine and hydrokinetic devices.

The program works to foster a commercial market for marine and hydrokinetic energy devices. Market acceleration efforts include project siting activities as well as market assessment and development activities.

Summary of Marine and Hydrokinetic Market Acceleration Activities
The program works to foster a commercial market for marine and hydrokinetic energy devices. Market acceleration efforts include project siting activities as well as market assessment and development activities.

Project Siting
Proper project siting is necessary to minimize environmental impacts and expedite the permitting process for marine and hydrokinetic devices. The program funds assessments of the potential environmental impacts of device deployment, including navigational and competing-use impacts. The program is creating guidelines to help device developers navigate the regulatory process, as well as a framework for identifying critical project siting information and assessing potential environmental, navigational and competing-use impacts.

Environmental Impact Assessment
The program supports research into the effects of marine and hydrokinetic technologies on aquatic ecosystems and how to avoid or mitigate such effects when possible. The Energy Independence and Security Act of 2007 calls for the Department of Energy to prepare a report to Congress that addresses the effects of marine and hydrokinetic energy projects, including potential environmental impacts, options to prevent adverse impacts, potential roles for environmental monitoring and adaptive management in mitigating impacts, and necessary components in adaptive management. The report is a cooperative effort with the Department of Commerce (working through the National Oceanic and Atmospheric Administration) and the Department of the Interior.

Public Outreach
The program engages stakeholders to solicit input on the technology development and market acceleration activities most effective in furthering the deployment of advanced water power technologies. The program uses input from Congress and other federal agencies; attends and contributes to annual industry conferences and other events to explain program activities and solicit feedback; and engages stakeholders to determine critical project siting information.

Intergovernmental Collaboration
The Department of Energy has taken a leading role in convening federal agencies to discuss ongoing marine and hydrokinetic resource use and technology development. Federal agencies actively involved in these discussions include the Federal Energy Regulatory Commission, Bureau of Ocean Energy, National Park Service, National Oceanic and Atmospheric Administration, U.S. Coast Guard, Department of the Navy, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service. These agencies share information on a large range of issues, including project news, financial opportunities for marine and hydrokinetic technologies, mapping, and coordinating rules and regulations.

The Department of Energy and the Department of Interior in particular are actively collaborating on broader interagency measures to enable more expeditious and efficient deployment of marine and hydrokinetic technologies. In 2010, the two agencies signed a Memorandum of Understanding to prioritize and facilitate environmentally-responsible deployment of commercial-scale offshore wind and marine and hydrokinetic energy technologies on the Outer Continental Shelf. The Memorandum of Understanding states that the agencies will collaborate on activities such as formal and informal information exchange; stakeholder engagement; research on technical, environmental and other questions of mutual interest; joint evaluation and development of standards and guidelines; and the dissemination of any relevant products to decision-makers.

Market Assessment and Development
The program funds activities that will reduce marine and hydrokinetic energy costs and technical and project risks to help accelerate the commercial deployment of these technologies.

Resource Assessments
The amount of energy that can be extracted from marine and hydrokinetic resources is not fully known. The program supports assessments for wave, tidal, current, in-stream hydrokinetic and ocean thermal energy gradients in a number of locations across the U.S.

Standards Development
The emerging marine and hydrokinetic energy industry requires the development of national and international technical standards to ensure the international compatibility, interchangeability and basic safety of devices and to enable comparison and evaluation of technologies. The program works with the International Electrotechnical Commission's Marine Energy Committee to develop international standards for the marine energy industry worldwide.

The program funds Science Applications International Corporation to serve as the U.S. representative to the Committee. The program also funds the Marine Energy Committee's U.S. Technical Advisory Group, which coordinates and develops the U.S. position and input for the Committee through the Department of Energy's National Renewable Energy Laboratory.

Technology Roadmapping
The program funds the Department of Energy's National Renewable Energy Laboratory to develop a marine and hydrokinetic energy roadmap that will include a technology strategy, a commercialization

strategy, and a deployment strategy. These strategies will be coordinated and linked to achieve the mutual vision of industry stakeholders.

Economic Analysis
The program seeks to fill data gaps necessary for industry advancement by collecting and analyzing cost and economic data for marine and hydrokinetic technologies. The program funds the Department of Energy's National Renewable Energy Laboratory to adapt the Jobs and Economic Development Impacts model to predict job creation and economic activity generated by the water power industry in the United States. The program also plans to fund life-cycle cost assessments of project installed capital cost, operations and maintenance cost and the future cost of energy.

Table 4.1 below lists the marine and hydrokinetic projects reviewed during the 2011 Peer Review meeting, including the principal investigator and budget for each project.

Table 4.1 Marine and Hydrokinetic Projects

Project Name	Principal Investigator	FY10 (DOE Funds)	FY11 (DOE Funds)	Total Funding	Duration (Years)
Acoustic Effect of Hydrokinetic Tidal Turbines	Brian Polagye	$213,000	$291,000	$594,000	2
Advanced, High Power, Next Scale, Wave Energy Conversion Device	Dr. Philip R. Hart	$199,902	$992,053	$1,500,000	2
PB500, 500 kW Utility-Scale PowerBuoy Project	Dr. Philip R. Hart	$0	$166,267	$2,400,000	2
Reedsport PB150 Deployment and Ocean Test Project	Dr. Philip R. Hart	$0	$111,467	$2,409,293	4
Marine High-Voltage Power Conditioning and Transmission System with Integrated Energy Storage	Mark Holveck, Paul Heavener	$0	$479,000	$599,799	1.5
Wavebob Advanced Wave Energy Conversion Project	Roger Bagby, on behalf of WaveBob	$0	$439,975	$2,400,000	2
WETNZ MultiMode Wave Energy Converter Advancement	Justin Klure	$909,259	$909,260	$1,818,519	2
Advanced Integration of Power Take-Off in Vortex Induced Vibrations Aquatic Clean Energy (VIVACE)	Gus Simiao	$0	$146,000	$999,955	2
The Water to Wire Project (W2W)	Edward Lovelace	NA	$815,416	$1,384,503	2
WindWaveFloat	Alla Weinstein	$907,000	$452,000	$1,359,000	2
Aquantis 2.5MW Ocean Current Generation Device	Alex Fleming	$65,744	$774,258	$4,128,337	2
Aquantis C-Plane Ocean Current Turbine Project	Alex Fleming	$0	$243,000	$4,005,625	3
Siting Study Framework and Survey Methodology for Marine and Hydrokinetic Energy Projects in Offshore Southeast Florida	Alex Fleming	$170,478	$396,061	$600,000	2
Direct Drive Wave Energy Buoy	Ken Rhinefrank	$573,000	$601,000	$1,417,990	3
An Assessment of Projected Lifecycle Cost For Wave, Tidal, Ocean Current, and In-Stream Hydrokinetic Power in the United States over Time	Mirko Previsic	NA	NA	$500,000	1
Development of Reference Models and Design Tools (LCOE Models)	Rich Jepsen	$343,000	$1,800,000	$2,140,000	3
FY 09 Lab Call: Supporting Research & Testing for MHK	Albert LiVecchi	$239,000	$1,707,000	$5,816,000	3
FY 09 Lab Call: Research & Assessment for MHK Development	Rich Jepsen	$414,000	$1,736,000	$4,200,000	3
SNMREC Offshore Testing Facility—Small Scale Turbine Testing and Development	Susan H. Skemp	$250,000	$250,000	$500,000	1
Hawaii National Marine Renewable Energy Center (HINMREC)	Richard Rocheleau	$441,000	$1,305,000	$3,300,000 (BP-1) $2,200,000 (BP-2)	3

Project Name	Principal Investigator	FY10 (DOE Funds)	FY11 (DOE Funds)	Total Funding	Duration (Years)
Northwest National Marine Renewable Energy Center (OSU/UW)	Robert Paasch	$1,800,000	$2,538,000	$6,249,995	6
The Potential Impacts of OTEC Intakes on Aquatic Organisms at an OTEC Site Currently Under Development (Port Allen, Kauai)	Tim Hogan	$40,534	$84,031	$594,961	2.5
Underwater Active Acoustic Monitoring Network for Marine and Hydrokinetic Energy Projects	Dr. Peter J. Stein	$399,000	$201,000	$600,000	2
Active Acoustic Deterrence of Migratory Whales	Steven R. Kopf	NA	NA	$593,846	3
Benchmark Modeling of the Near-field and Far-field Wave Effects of Wave Energy Arrays	Ken Rhinefrank	$163,364	$115,758	$598,154	2.5
Environmental Effects of Sediment Transport Alteration and Impacts on Protected Species	Stephen Barrett	$300,000	$300,000	$600,000	2
OTEC resource assessment	Matt Ascari	$16,000	$273,000	$500,000	2
Assessment of Energy Production Potential from Ocean Currents along the US Coastline	Kevin Haas	$56,000	$159,000	$372,627	3
A First Assessment of U.S. In-Stream Hydrokinetic Energy Resources Since the 1986 NYU Study	Paul Jacobson	$81,613	$102,451	$499,978	2
Assessment of the Environmental Effects of Hydrokinetic Turbines on Fish: Desktop and Laboratory Flume Studies	Paul Jacobson	$401,048	$45,951	$447,408	1.5
OCGen™ Module Mooring Project	Jarlath McEntee	$222,274	$53,849	$1,034,534	2
TidGen™ Power System Commercialization Project	Christopher R. Sauer	$0	$2,515,428	$10,000,000	3
Marine Energy Technology Advancement Partnership (METAP)	Karin Sinclair	$540,000	$0	$540,000	1.5
Assessment of Energy Production Potential from Tidal Streams in the United States	Kevin Haas	$218,000	$144,000	$469,500	2.5
Wave Energy Resource Assessment and GIS Database for the U.S.	Paul Jacobson	$214,834	$85,273	$499,668	3
Categorizing and Evaluating the Effects of Stressors (KMS and ERES)	Andrea Copping, Jennifer States	$40,000	$200,000	$3,450,000	3
Annex IV: Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal, and Current Energy Systems	Andrea Copping and Hoyt Battey	$120,000	$57,100	$227,100	2
Categorizing and Evaluating the Effects of Stressors (all Conceptual Model Work)	Ihor Hlohowskyj	$61,000	$244,000	$612,000	3
Tools and Methods to Measure and Predict Environmental Impacts	Jesse Roberts	$120,000	$478,000	$1,200,000	3
Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.2 – Effects on Physical Systems	Zhaoqing Yang	$90,000	$155,000	$3,450,000	3
Acoustics, Toxicity, Benthic Habitat Alteration	Mark Bevelheimer	$150,000	$150,000	$1,191,000	3
Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework - Direct Effects on Aquatic Animals	Andrea Copping	$160,000	$535,000	$3,450,000	3
Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.7: Permitting and Planning	Simon Geerlofs	$0	$167,000	$3,450,000	3
Abrasion Testing of Critical Components of Hydrokinetic Devices	Monty Worthington	$0	$89,000	$240,000	1.5
Acoustic Monitoring of Beluga Whale Interactions with Cook Inlet Tidal Energy Project	Monty Worthington	$371,731	$128,156	$600,000	2

Project Name	Principal Investigator	FY10 (DOE Funds)	FY11 (DOE Funds)	Total Funding	Duration (Years)
Marine and Hydrokinetic Lower Technology Readiness Level (TRL) Projects					
Puget Sound Pilot Tidal Energy Project	Brian Polagye	$0	$0	$10,000,000	3
Advanced Anchoring Technology	Dallas Meggitt	$0	$240,000	$239,899	1.5
Cycloidal Wave Energy Converter TRL Advancement to Level 4	Stefan Siegel	$0	$380,400	$500,000	1.5
The Development of Open, Water Lubricated Polycrystalline Diamond Thrust Bearings for use in Marine Hydrokinetic (MHK) Energy Machines	Craig Cooley	$0	$119,397	$146,984	0.5
THOR's Power Method for Hydrokinetic Devices	Turner Hunt	$31,000	$311,000	$400,000	1.5
Tidal Energy System for On-shore Power Generation	Allan Bruce	$0	$300,000	$400,000	1.5
Development of a wave-actuated power take-off device for electricity generation	Allan Chertok	$0	$37,900	$258,558	1
Environmentally Benign and Permanent Modifications to Prevent Biofouling on Marine and Hydrokinetic Devices	Zheng Zhang	$0	$160,000	$160,000	1
Protective, Modular Wave Power Generation System	Jane Vvedensky	$0	$240,000	$240,000	1
M3 Wave's DMP: Simple, Scalable, and Submerged	Mike Morrow	$5,374	$149,359	$299,972	1
Poncelet Kinetics RHK100 Prototype Development Project	John R. Hasz, Steven Selvaggio	$0	$142,050	$142,050	1
River Devices to Recover Energy with Advanced Materials (River DREAM)	Dr. Brent Crenshaw	$0	$12,006	$240,000	1.5
Submersible Generator for Hydrokinetics	Robert S. Cinq-Mars	$0	$160,000	$160,000	1
Active Flow Control on Bidirectional Rotors for Tidal MHK Applications	C.P. "Case" van Dam	$22,065	$25,332	$158,336	2
Remote Monitoring of the Structural Health of Hydrokinetic Composite Turbine Blades	Joshua L. Rovey	$0	$159,972	$200,001	1.5
OTEC Cold Water Pipe-Platform Sub-System Dynamic Interaction Validation	Matt Ascari	$0	$36,000	NA	NA
Modeling the Physical and Biochemical Influence of Ocean Thermal Energy Conversion (OTEC) Plant Discharges into their Adjacent Waters	Patrick Grandelli	$0	$120,000	$240,000	1.5

4.1 Marine and Hydrokinetic Project Evaluations

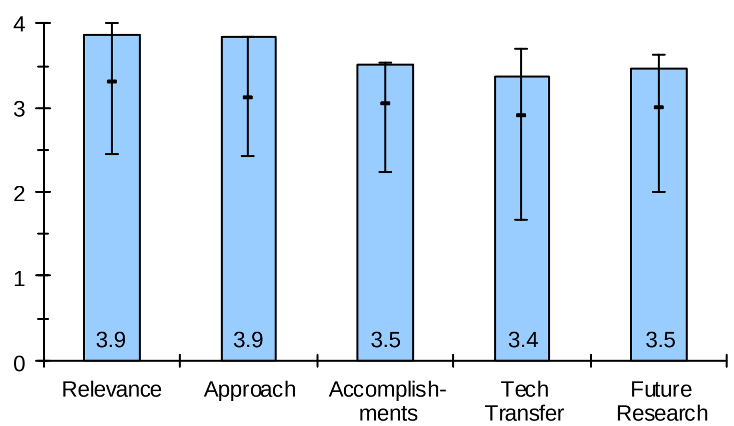
Table 4.2 below lists the average score per category and the averaged weighted score for each larger marine and hydrokinetic (MHK) project that was evaluated by the MHK Peer Review Panel. Individual MHK project evaluations are also included in this section.

Marine and Hydrokinetic Projects	Relevance to Overall DOE Objectives	Approach	Technical Accomplishments and Progress	Research Integration, Collaboration, and Technology Transfer	Proposed Future Research	Average Weighted Score
Acoustic Effect of Hydrokinetic Tidal Turbines	3.9	3.9	3.5	3.4	3.5	**3.6**
Advanced, High Power, Next Scale, Wave Energy Conversion Device	2.8	2.5	3.1	2.2	2.5	**2.6**
PB500, 500 kW Utility-Scale PowerBuoy Project	2.8	2.5	2.2	1.7	2.4	**2.2**
Reedsport PB150 Deployment and Ocean Test Project	2.7	2.6	2.8	2.2	2.4	**2.5**
Marine High-Voltage Power Conditioning and Transmission System with Integrated Energy Storage	3.4	3.1	3.1	2.7	2.9	**3.0**
Wavebob Advanced Wave Energy Conversion Project	3.6	2.9	2.9	2.6	3.0	**2.9**
WETNZ MultiMode Wave Energy Converter Advancement	3.6	2.9	2.9	3.1	3.3	**3.0**
Advanced Integration of Power Take-Off in Vortex Induced Vibrations Aquatic Clean Energy (VIVACE)	3.6	3.1	3.0	3.1	2.9	**3.0**
The Water to Wire Project (W2W)	3.6	3.5	3.3	3.0	3.2	**3.3**
WindWaveFloat	2.9	3.2	3.3	2.7	2.5	**3.0**
Aquantis 2.5MW Ocean Current Generation Device	3.8	3.8	3.1	2.8	3.3	**3.3**
Aquantis C-Plane Ocean Current Turbine Project	3.6	3.7	3.2	2.9	3.6	**3.4**
Siting Study Framework and Survey Methodology for Marine and Hydrokinetic Energy Projects in Offshore Southeast Florida	3.3	3.3	3.4	3.4	3.1	**3.3**
Direct Drive Wave Energy Buoy	4.0	3.7	3.5	3.3	3.2	**3.5**
An Assessment of Projected Lifecycle Cost For Wave, Tidal, Ocean Current, and In-Stream Hydrokinetic Power in the United States over Time	3.1	3.0	3.4	2.9	2.9	**3.1**
Development of Reference Models and Design Tools (LCOE Models)	3.0	2.8	2.8	2.8	2.9	**2.8**
FY 09 Lab Call: Supporting Research & Testing for MHK	2.9	2.7	3.0	2.8	3.1	**2.9**
FY 09 Lab Call: Research & Assessment for MHK Development	2.8	2.9	3.0	2.6	2.7	**2.8**
SNMREC Offshore Testing Facility—Small Scale Turbine Testing and Development	3.5	3.5	3.3	3.2	3.5	**3.4**
Hawaii National Marine Renewable Energy Center (HINMREC)	3.2	2.9	2.6	3.0	2.6	**2.8**
Northwest National Marine Renewable Energy Center (OSU/UW)	3.5	3.3	3.0	3.5	3.5	**3.3**
The Potential Impacts of OTEC Intakes on Aquatic Organisms at an OTEC Site Currently Under Development (Port Allen, Kauai)	2.5	3.0	2.4	2.8	2.3	**2.6**
Underwater Active Acoustic Monitoring Network for Marine and Hydrokinetic Energy Projects	3.8	3.5	3.2	3.1	3.4	**3.3**
Active Acoustic Deterrance of Migratory Whales	3.3	3.0	2.6	3.0	3.0	**2.9**
Benchmark Modeling of the Near-field and Far-field Wave Effects of Wave Energy Arrays	3.3	3.3	3.2	3.0	3.2	**3.2**
Environmental Effects of Sediment Transport Alteration and Impacts on Protected Species	3.3	3.4	3.2	3.2	3.2	**3.3**
OTEC resource assessment	3.6	3.4	3.5	3.5	3.6	**3.5**
Assessment of Energy Production Potential from Ocean Currents along the US Coastline	3.6	3.2	3.1	3.3	3.6	**3.2**
A First Assessment of U.S. In-Stream Hydrokinetic Energy Resources Since the 1986 NYU Study	3.9	3.5	3.2	3.2	3.5	**3.3**
Assessment of the Environmental Effects of Hydrokinetic Turbines on Fish: Desktop and Laboratory Flume Studies	3.6	3.4	3.5	2.9	3.2	**3.3**
OCGen™ Module Mooring Project	3.7	3.3	2.9	2.7	3.1	**3.0**
TidGen™ Power System Commercialization Project	3.9	3.3	3.3	3.0	3.4	**3.3**
Marine Energy Technology Advancement Partnership (METAP)	3.7	3.5	3.3	3.7	3.1	**3.4**
Assessment of Energy Production Potential from Tidal Streams in the United States	3.5	3.4	3.6	3.1	3.5	**3.4**
Wave Energy Resource Assessment and GIS Database for the U.S.	3.4	3.1	3.2	3.3	3.5	**3.2**
Categorizing and Evaluating the Effects of Stressors (KMS and ERES)	3.3	2.8	3.3	2.9	2.9	**3.0**
Annex IV: Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal, and Current Energy Systems	3.4	3.1	3.3	3.0	2.8	**3.1**
Categorizing and Evaluating the Effects of Stressors (all Conceptual Model work)	2.6	2.5	2.4	2.5	2.2	**2.4**
Tools and Methods to Measure and Predict Environmental Impacts	3.0	3.0	3.4	2.8	3.1	**3.1**
Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.2 – Effects on Physical Systems	3.0	3.4	3.2	2.4	2.9	**3.0**
Acoustics, Toxicity, Benthic Habitat Alteration	2.7	2.8	3.0	2.7	3.0	**2.9**
Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework - Direct Effects on Aquatic Animals	3.2	2.9	3.0	2.8	2.9	**2.9**
Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.7: Permitting and Planning	2.5	2.4	2.5	2.8	2.0	**2.4**
Abrasion Testing of Critical Components of Hydrokinetic Devices	3.6	3.4	3.3	3.1	3.1	**3.2**
Acoustic Monitoring of Beluga Whale Interactions with Cook Inlet Tidal Energy Project	3.8	3.5	2.5	3.3	2.9	**3.0**

Table 4.2 Larger Marine and Hydrokinetic Project Scores

Project Name: Acoustic Effect of Hydrokinetic Tidal Turbines
Craig Collar; Snohomish Public Utility District

Overall Project Score: 3.6 (5 Reviews Received)



Brief Summary of Project

The noise produced by operating tidal turbines has the potential to adversely affect marine life through behavioral disturbances or, in extreme cases, physical injury. Consequently, acoustic effects are a high-priority consideration for the siting and permitting of tidal energy devices. Evaluating the effect of turbine noise requires information about: (1) existing ambient noise at a particular site to place the turbine noise in context, (2) the received levels of noise from the tidal energy project, (3) the presence of marine animals with sensitivity to noise, and (4) the likely effect of this noise on marine animals. This information is often site-specific, with limited existing baseline information from energetic tidal sites or established study methods to collect these data. The objective of this study is to improve the level of understanding in all four of these areas and to provide a template for future acoustic effect studies at other tidal energy sites. Through the acquisition of site-specific baseline data, the project has a direct benefit to the Snohomish Public Utility District's proposed development in Admiralty Inlet. The collected data are also in the public domain.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- The effect of noise on marine animals is a priority consideration for siting MHK devices.
- An excellent and well planned project in full alignment with DOE objectives.
- The effect of MHK projects on marine mammals is a key uncertainty that is holding back development. Acoustic issues are one of the primary areas needing study - perhaps the highest priority.
- Highly relevant given the ongoing study of the Snohomish PUD MHK turbine deployment.
- Project partners including the University of Washington (UW) and Pacific Northwest National Laboratory (PNNL) lend credibility to this research.

Question 2: Approach to performing the research and development

This project was rated **3.9** on its approach.

- Appreciate that methodology applicable to transfer to different locations.
- A well planned approach.

- Studies were clearly developed with the end use by NMFS in mind (i.e., using a "worse than the worst case scenario)."
- Project approach and techniques are well conceived, logical and appropriate given marine traffic in this area.
- Employing both marine based (Sea Spyder) and land based (AIS) data collection adds credibility.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.5** based on accomplishments.

- A good technical partnership has been formed.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.4** for technology transfer and collaboration.

- A good mix of industry (Sno PUD) and academic (UW and PNNL) partners
- A well-integrated project.
- NMFS was consulted in development of the methodology. Information will be folded into public licensing and permitting process.

Question 5: Proposed future research

This project was rated **3.5** for proposed future work.

- Very well planned future work.

Strengths and weaknesses

Strengths
- Methodology appears transferable to different locations.

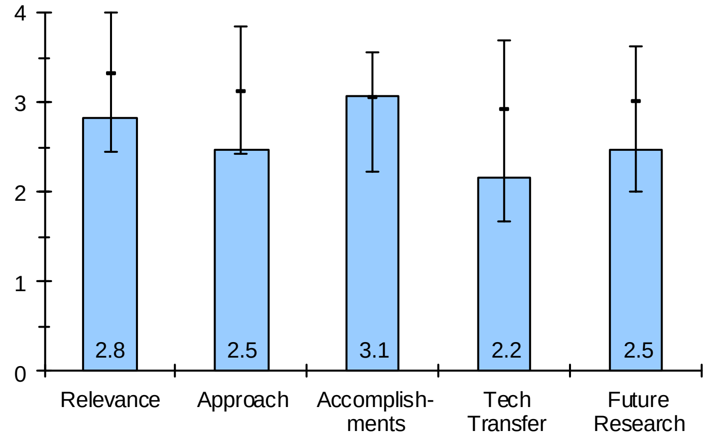
Weaknesses
- Concerns that regulatory agencies, while approving methodology, may still question results.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Advanced, High Power, Next Scale, Wave Energy Conversion Device
Dr. Philip R. Hart; Ocean Power Technologies, Inc.

Overall Project Score: 2.6 (5 Reviews Received)



Brief Summary of Project

The purpose of this project is to demonstrate the scalability of Ocean Power Technologies' intellectual property and demonstrated ocean operations experience to produce a cost effective design of a 500kW PowerBuoy. This project advances the PB500 design from TRL 3 to TRL 4 by achieving the following objectives: 1) scale up the current power production per unit from 150kW to 500kW, 2) increase the power extraction efficiency, 3) develop a robust and survivable design, and 4) increase modularity and minimize installation/maintenance complexity to enhance reliability and reduce lifecycle cost.

The specific endpoints of this effort will be to:

- Conduct survival wave tank modeling and testing to understand design loading conditions.
- Conduct operational wave tank modeling and testing to understand operational characteristics, power generation and power output efficiency of competing float shapes and structural arrangements.
- Evaluate three leading technology solutions for each Power-Take-Off subsystem/system, analyze the technologies and provide a score card matrix to select the best and final solution.
- Conduct risk mitigation testing of each subsystem/system on the best and final solution as required and complete FMECA analysis.

This project benefits:

- Ocean Power Technologies in allowing the expansion of its technology.
- The renewable energy industry by increasing the use of domestic power source for electric power generation.
- The ocean wave energy community in expanding the acceptance and support of this form of abundant and environmentally friendly power.

This project addresses several challenges. Although design analyses show that it possible to scale up the current technology to produce power at a reduced per kWh rate over the current 150kW PowerBuoy, scaling up introduces:

- Higher survival and operational loads.
- Implementation, installation and maintenance complexities.
- Product deployment and retrieval challenges.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.8** for its relevance to DOE objectives.

- Given the current state of the industry and economic environment this project and its objectives and goals supports the DOE Water Program.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- Discussion on how OPT will assess the design of their power take off system design is vague.
- Given OPT's background and experience the projects approach and objectives seem appropriate.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.1** based on accomplishments.

- Project is on target to meet set completion date.
- It would appear that this project has made excellent progress.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.2** for technology transfer and collaboration.

- Very little on specifics as to who OPT have collaborated with.
- Given the extremely proprietary nature of this project it is doubtful that dissemination of this information would have any practical benefits.

Question 5: Proposed future research

This project was rated **2.5** for proposed future work.

- Given the focused and somewhat proprietary nature of this project research, I have to assume that the outcomes support future project deployments

Strengths and weaknesses

Strengths
- Project is on target to meet set completion date.
- Supports deployment of a potentially viable MHK technology.

Weaknesses
- Unclear as to how this device will be scaled up from 150 kV to 500 kV without exponentially increasing the size of the device.
- Without giving away corporate-specific details, the overall discussion was vague on specifics as to how OPT will achieve their goals.
- It was very hard to review this project properly as both the presentation and written description was very guarded with regard to work done and results achieved.

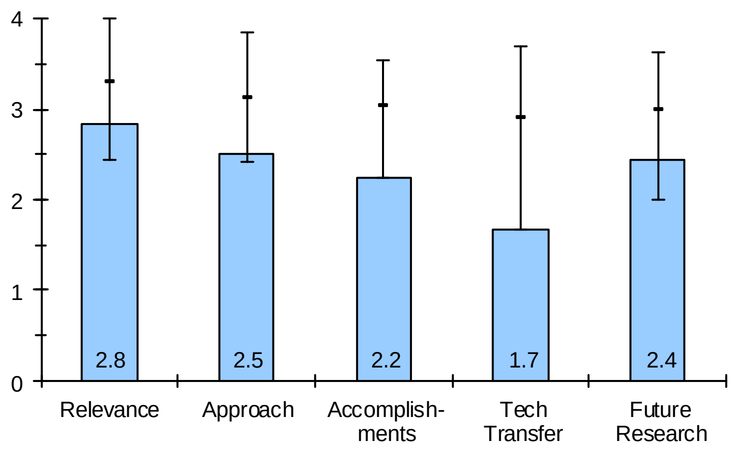
- Project outcomes would be of limited value to research involving alternative technologies.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: PB500, 500 kW Utility-Scale PowerBuoy Project
Dr. Philip R. Hart; Ocean Power Technologies

Overall Project Score: 2.2 (5 Reviews Received)



Brief Summary of Project

The major objective of this project is to create a fully integrated design for the PowerBuoy 500kW (PB500), fabricate/test sub-system assemblies, and to:

- Advance the PB500 design from TRL 4 to TRL 5/6.
- Quantify the operating characteristics of the PB500 design with computer simulations and 3-D design.
- Conduct preliminary and detailed design of the Power-Take-Off (PTO) Device.
- Build prototype Power-Take-Off Device.
- Achieve target operating characteristics:
  - i. Low cost of energy produced.
  - ii. Low cost of installed power capacity.
  - iii. High availability factor and capacity factor.
  - iv. Low operating and maintenance costs.
  - v. Achieve high modularity and manufacturability.

The specific endpoint of this effort will be the full scale 500kW PowerBuoy design.

This project benefits:

- Ocean Power Technologies in allowing the expansion of its technology.
- The renewable energy industry by pushing another form of renewable energy into commercial competition with fossil fuel sources.
- The ocean wave energy community in expanding the acceptance and support of this form of abundant and environmentally friendly power.

Challenges this project addresses:

- Prove that the scaled-up PowerBuoy concept design can be implemented into a manufacturable, cost effective, energy conversion device.
- Prove through sub-system testing and subsequent analysis that the device meets its TRL 5/6 goals and is then ready to proceed directly to a full system demonstration.
- Build a Prototype Power-Take-Off device to verify specified modularity, scalability and performance matrix.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.8** for its relevance to DOE objectives.

- Supports deployment of a potentially commercially-viable MHK technology in the midst of a challenging economic environment.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- Provided a vague description on specifics
- Given the information provided and the project schedule the approach appears to be generally effective.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.2** based on accomplishments.

- Based on the information provided, progress in this area has been good.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **1.7** for technology transfer and collaboration.

- Uncertain as to how they are collaborating with - no mention of industry or academic partners only locations around the world as to where testing occurred.
- Given the proprietary nature of this information and the focus on a specific MHK technology it is difficult to assign this project a higher score.

Question 5: Proposed future research

This project was rated **2.4** for proposed future work.

- NA

Strengths and weaknesses

Strengths

- Supports an emerging industry during a prolonged economic downturn.

Weaknesses

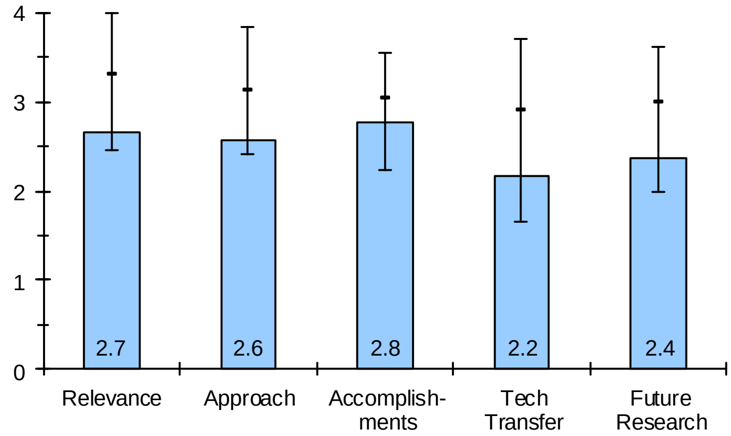
- Specifics of project development were lacking and answers to questions were vague.
- It was very hard to review this project properly as both the presentation and written description was very guarded with regard to work done and results achieved. Is not at all clear what they are doing.
- Technology specific outcomes may be of limited practical value.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Reedsport PB150 Deployment and Ocean Test Project
Dr. Philip R. Hart; Ocean Power Technologies

Overall Project Score: 2.5 (5 Reviews Received)



__Brief Summary of Project__

The overall objective in the Reedsport PB150 Deployment and Ocean Test Project is to assemble and deploy a full scale 150kW PowerBuoy for "relevant ocean testing" in the Oregon Territorial Sea and collect detailed operating characteristics during two (2) years of operation. This data will be used to validate market opportunities for the PB150, which can produce up to 150 kilowatts of power and be economically viable in markets where the fundamental cost of electricity is high and/or targets have been set to install renewable technologies to meet a Renewable Portfolio Standard or related targets. The project will provide performance and reliability data directly applicable to the development of manufacturing methodologies to maximize production and minimize cost for deployment in future buoy farms.

The project will accomplish the following goals:

- Advance the PB150 design from TRL 5/6 to TRL 7/8.
- Deploy a single PB150 and operate the system autonomously on a grid simulated load for two (2) years.
- Quantify operating characteristics of the PB150 and compare to pre-deployment estimates.
- Confirm a levelized cost of energy is achievable in volume production of PB150's.
- Establish O&M costs for mature product.
- Collect environmental information consistent with the Settlement Agreement negotiated with fourteen (14) Federal, State, and Nongovernmental Agency stakeholders for the Project.
- Establish manufacturing methodologies to maximize production and minimize cost for volume production in conjunction with Lockheed Martin Maritime Systems and Sensors (MS2).

Expected outcomes include:

- A database of actual PB150 operating characteristics suitable for:
    - Development of financial projections for a wave park at the Reedsport site.
    - Definition of capital equipment cost (PowerBuoys and infrastructure such as submarine cables and underwater substations) and levelized cost of energy for a mature PB150 design.
    - Definition of the actions required to advance the PB150 product to TRL 9.
    - Demonstration of environmental impact of the PB150 consistent with the Settlement Agreement.
- Initial orders and refined estimates of national and international market potential for the PB150 from 2015 to 2020.
- Transfer knowledge and early production expertise from the PB150 to develop designs, manufacturing methodologies, and marketing plans for large, utility scale, wave power stations.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.7** for its relevance to DOE objectives.

- Limited - OPT appears to looking to increase their bottom line instead of supporting the development of the industry.
- Under current economic conditions this project is of critical importance to the MHK industry.

Question 2: Approach to performing the research and development

This project was rated **2.6** on its approach.

- The five requirement described in the approach appeared to be logical and well thought out.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.8** based on accomplishments.

- Based on the materials presented and my experience with the MHK industry progress to date has been substantial.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.2** for technology transfer and collaboration.

- Lack of collaborators listed.
- Based upon the information provided and my own familiarity with the Oregon Wave Energy Trust, this PI has fair amount of collaboration within the energy industry.
-

Question 5: Proposed future research

This project was rated **2.4** for proposed future work.

- It would appear that this project has made significant progress towards its objectives and has developed a logical work plan.

Strengths and weaknesses

Strengths
- NA

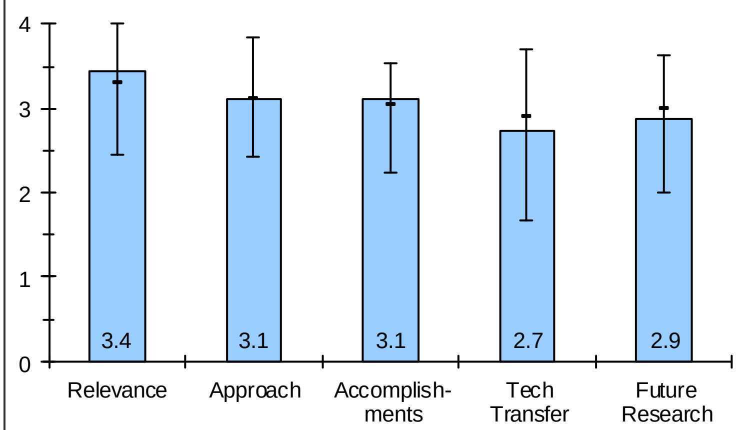
Weaknesses
- Vague with specific details on approach for deployment and environmental studies.
- It was very hard to review this project properly as both the presentation and written description was very guarded with regard to work done and results achieved. Is not at all clear what they are doing.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Marine High-Voltage Power Conditioning and Transmission System with Integrated Energy Storage *Mark Holveck; Princeton Power Systems*

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

The objectives of this project are to:

- Demonstrate integrated operation of the power-routing functions of the power conditioner with the high voltage direct current switching bridge and ultra-capacitor bank.
- Demonstrate (1) three-port operation, (2) conversion efficiency of >97%, and (3) 10 year system design life.
- Prove $.50/Watt materials cost in production.
- Finalize field demonstration plan.

Project Accomplishes

Wave, tidal, and ocean power technologies are nascent markets and technologies with a large potential for growth. The power electronics for these systems are often overlooked. The power electronics for these systems must be capable of operating in a demanding, ocean environment, over an extended period of time, with minimal servicing and maintenance requirements. Furthermore, the power conditioner must better integrate the intermittent power created by most marine hydrokinetic generation systems, by buffering the power using control algorithms and a small energy storage bank. Princeton Power Systems will deliver a product that meets these rigorous demands.

Final Product

Our team will deliver a 50kW Marine Power Conditioner with Storage; demonstrate high conversion efficiency (97.0%), and a compact high-frequency internal transformer to allow direct connection to a 50kV DC line for transmission to shore. The small size, efficiency, and simplification of the system design will significantly reduce the installation cost of ocean power systems while improving transmission efficiency and grid integration.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- A project in full alignment with DOE objectives.
- Storage is an important aspect to consider in renewable energy.
- Not clear if this is truly "storage" or "smoothing."
- Lowering the cost of energy by 2020 is the key goal of the DOE program. They have identified several groups that will benefit, including end users, utilities, rate payers and others.

- Power conditioning and DC switching with the ability to perform energy storage are critical to the development of MHK.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Should identify potential partners to integrate technology into a field testing scenario earlier in the process.
- Combining 3 existing approaches into a single solution appears to be a potentially successful solution.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.1** based on accomplishments.

- Positive to see the project on schedule and on budget.
- They are on schedule and in the final two stages.
- This presentation and the accompanying project summary appear are somewhat lacking in terms of reporting project progress.
- This section of the project summary requires additional information.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.7** for technology transfer and collaboration.

- A good balance of private and academic collaborators.
- Not much info transfer to date that was reported.
- They have identified a market outreach plan to disseminate information.
- According to the presentation and project summary. The integration, collaboration and information transfer from this project is confined to a small number of project partners.
- Interest within the power conditioning sector with respect to MHK technology is expected to be high; I'd recommend that industry outreach be expanded.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- There is a potential technology transfer with offshore wind that should be explored.
- Additional information with regard to project progress is required to improve project scoring in this area.

Strengths and weaknesses

Strengths
- Technology applicable to multiple devices and locations.
- Addresses recognized industry barrier.

Weaknesses

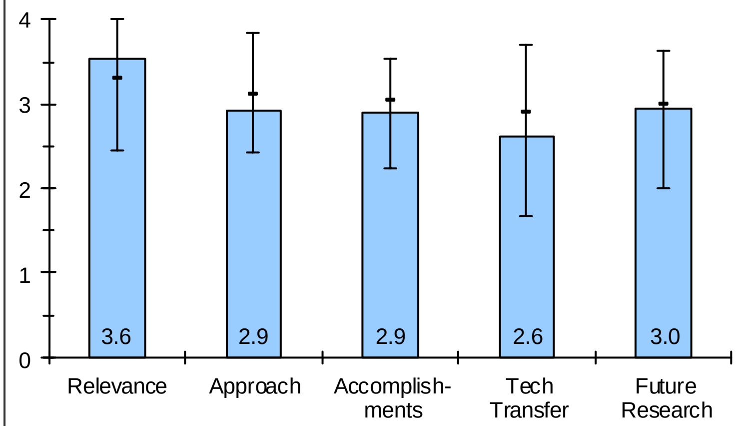
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Wavebob Advanced Wave Energy Conversion Project
Franc Mouwen; Wavebob LLC

Overall Project Score: 2.9 (5 Reviews Received)



<u>Brief Summary of Project</u>

The primary objective of the project is to evaluate system motion, interactions and dynamic responses to better understand the Wave Energy Converter (WEC) power generation in advance of insertion into Advanced Development Model #6 (ADM-6), a commercial-scale demonstration project planned for U.S. waters in 2015. This will be accomplished through complete front-end engineering, integration and laboratory test of key system elements and components. System development and test activities in support of this objective will include:

1. Bench-tests of a novel TRL5 switched reluctance (SR) direct generation power take off (PTO) subsystem.
2. Wave tank tests of an optimized WEC design.
3. Development of an optimized mooring element design in conjunction with (2).

The project retires key risk factors related to replacing the hydraulic-based PTO with a direct generation SR linear generator. This new technology shall be bench tested, WEC shall be optimized for this PTO technology and the mooring element shall be optimized for power absorption and overall body motion. Unique maritime technology expertise resides in U.S. defense and U.S. offshore sector. The U.S. enjoys a significant opportunity to lead both the development and commercialization of wave energy technology, aimed at dominating both domestic and global markets. With this A-WEC project, Wavebob and its U.S. partners play a significant role in progressing towards the commercialization of wave energy.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.6** for its relevance to DOE objectives.

- Assessing new PTO technology looking to replace a hydraulic-based PTO with a switched reluctance direct generation PTO.
- Technology testing in advance of commercial scale demonstration project clearly supports DOE's acceleration goals.
- Provides critical information required for expansion of the MHK industry.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **2.9** on its approach.

- A good outline as to why a certain PTO technology was selected over another.

- The information with regards to the research approach to be used was incomplete and somewhat vague.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.9** based on accomplishments.

- Slow in negotiating contract has created some delay; however, appear on target with go/no go target and budget.
- Tank testing to determine efficiency of the PTO is completed - next step is field deployment of scaled device.
- This project is in early stages; schedule is reasonable.
- The information provided on project accomplishments was incomplete and somewhat vague.
- An expanded discussion regarding the proposed generator design would be suggested.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.6** for technology transfer and collaboration.

- A balance of private industry partners.
- The materials indicate that they plan to disseminate results but at this point specific universities, journals, etc. are not identified. As the project moves forward, they should focus on developing this plan.
- The information provided suggests that an expanded industry outreach campaign by the PI could benefit the project outcomes.

Question 5: Proposed future research

This project was rated **3.0** for proposed future work.

- While increased understanding of system interactions and responses is crucial to successful deployment of MHK technologies, an expanded description of the planned future work is suggested.

Strengths and weaknesses

Strengths

- NA

Weaknesses

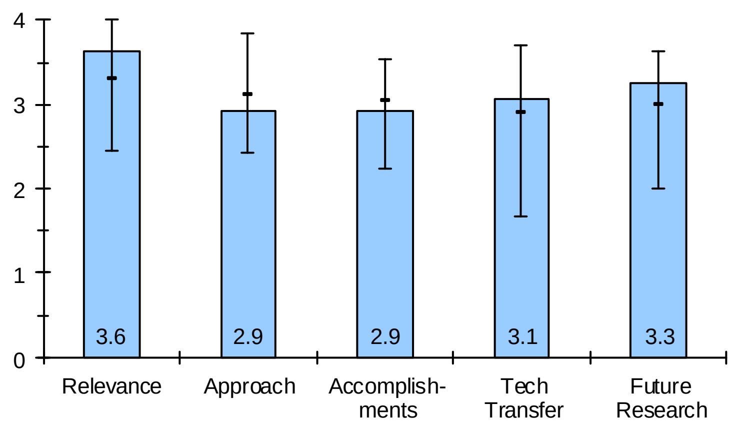
- My comments were based on not a no-so-complete picture as it was presented by Mr. Roger Bagbey and not a WaveBob representative.
- This was hard to review as they were not there to give their presentation.
- It was not clear who the PTO experts are in this project.
- It looked as if this project should focus on PTO only - rather than the whole device.
- Wavebob did not present for review so not clear understanding of some of the challenges etc., hesitant to grade without clear presentation.
- The presenter was not very familiar with the project and was not able to answer questions about it. Therefore, my evaluation is almost entirely based on the written materials.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: WETNZ MultiMode Wave Energy Converter Advancement
Justin Klure and Steven Kopf; Northwest Energy Innovations (NWEI)

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

The objective of this project is to verify multi-mode functionality of the WET-NZ device, through targeted hydrodynamic testing at the wave tank scale and controlled open sea deployment of 1/2 scale (1:2) WET-NZ experimental device. Project summary information is listed below:

- **Year 1 Objective:** Complete wave tank testing and utilize Akaroa Ocean testing to redesign 1:2 WET-NZ device.
- **Year 2 Objective:** Complete detail design, fabricate, and test 1:2 WET-NZ device in Oregon.
- **Final Product:** Verified analysis for TRL 5/6 Status.
- **Who Benefits:** U.S. Department of Energy, WET-NZ, and energy industry.
- **Success:** Advance the industry by demonstrating an innovative technology with a clear path towards commercialization (TRL 7/8 and beyond).
- **Challenges:** Testing and validation of the technology; business strategy for U.S. market.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Strong collaboration between multiple private/public groups.
- An excellent and well planned project in full alignment with DOE objectives.
- Good collaboration.
- In-ocean testing is critical to advancing industry.
- This technology may provide an innovative solution to advancing the MHK sector.
- Initial field tests appear to have been encouraging.

Question 2: Approach to performing the research and development

This project was rated **2.9** on its approach.

- Overall a well-structured project.
- Aggressive permitting time line given that in-tank tests were going on in November and ocean testing is planned for June 2012. Recommend development of critical path permitting strategy and DOE check-ins.
- Both the project presentation and summary provide sketchy somewhat incomplete reporting.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.9** based on accomplishments.

- A good combination of tank testing and in-water deployment at Akaroa.
- Significant design steps completed.
- The PI needs to provide additional information with regards its progress and achievements to date.
- According to the Project Summary the full project budget has been expended, which in light of the project schedule is somewhat confusing.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.1** for technology transfer and collaboration.

- Appreciate the international (NZ) and domestic/academic (e.g., OSU) collaboration.
- Integration between the New Zealand and U.S. research and development communities.
- This area of the presentation and project summary were vague an incomplete.

Question 5: Proposed future research

This project was rated **3.3** for proposed future work.

- The development pathway for the WET technology as contained in the report seems logical although information provided on project progress was incomplete.

Strengths and weaknesses

Strengths

- Innovative MHK technology,

Weaknesses

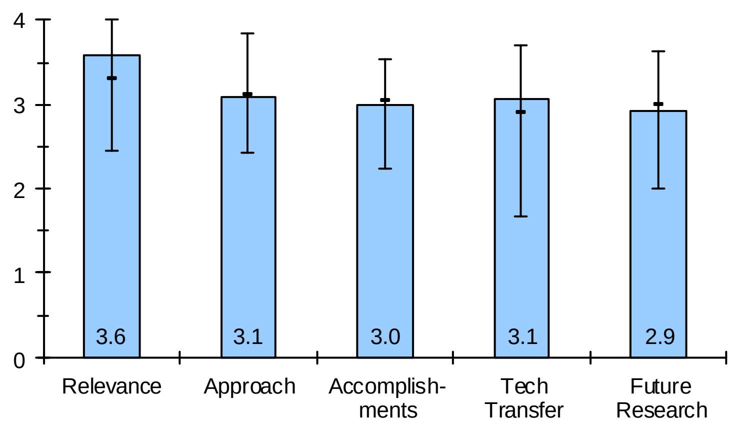
- Questions remain over OSU's NEPA completion and how this project will fit into this review.
- The report and presentation were clearly structured and it was clear the progress that was being made.
- Tied to the OSU NEPA effort which is still on-going.
- It appears that the project budget has been expended.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Advanced Integration of Power Take-Off in Vortex Induced Vibrations Aquatic Clean Energy (VIVACE) *Gus Simiao; Vortex Hydro Energy*

Overall Project Score: 3.0 (5 Reviews Received)



<u>Brief Summary of Project</u>

Vortex Hydro Energy is commercializing a University of Michigan (UM) patented MHK device, the VIVACE converter (Vortex Induced Vibration Aquatic Clean Energy). Unlike water turbines, it does not use propeller blades. Rather, river or ocean currents flow around cylinders causing them to move up and down. This kinetic energy of the cylinder is then converted to electricity. Importantly, the VIVACE converter is simpler in design and more cost effective than a water turbine. Vortex Hydro Energy is unique in that it is the only company using the physical phenomena of vortex induce vibrations and galloping (also known as Flow Induced Motion or FIM) to generate energy from river and ocean currents. Most competitors use some form of propeller-based water turbine.

<u>Project Purpose and Objectives</u>

The present technology readiness level of the VIVACE converter is TRL 4. The objective of this project is to complete DOE TRL 5/6 by the end of the project. VHE has made tremendous progress in developing VIV technology to work effectively over a large range of water current speeds (2 to 8+ knots). The next step is to improve the efficiency of the power takeoff (PTO) system. The objectives of the proposed work pertain to improving the efficiency of the two specific areas of VIVACE's power takeoff system that hold most promise:

1. Increase the conversion efficiency from hydrokinetic energy to cylinder kinetic energy.
2. Increase the conversion efficiency from the cylinder kinetic energy to electric energy generation.
3. Perform open water testing on an improved VIVACE system that will incorporate the improvements obtained from objectives 1 and 2.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.6** for its relevance to DOE objectives.

- An alternative technology (as oppose to propeller blades) that will generate energy from hydraulic flow.
- Generates energy in flows as slow as 2 knots.
- A major accomplishment - deployed device in St. Clair River.
- Excellent alignment and good potential.
- Looking closer at slower current technology is important.
- Innovative MHK technology.
- Addresses conversion of low speed currents.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- A lot of effort going into the assessment of engineering performance but concerned with the lack of considering environmental impacts.
- A reasonably well planned approach.
- Project approach seems well laid out and reasonable.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Based on the project presentation and summary the preliminary reports appear promising.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.1** for technology transfer and collaboration.

- As a university-based design, the team has been active distributing information in publications and at conferences, as well as being highlighted in mass media.
- Not fully clear integrated.
- According to the PI integration efforts as well as public outreach for this project appear to be good.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- Looking to develop the efficiency of the device but appear to not address environmental impacts to the device.
- A novel project that may have great potential **-** however it is too early to say if it will be successful.
- Given the limited information provided, the proposed future research appears appropriate.

Strengths and weaknesses

Strengths
- Looking at an alternative design to propeller generators.
- Have deployed in open water.
- Low velocity technology.
- Innovative approach to extracting energy from relatively low ocean currents.

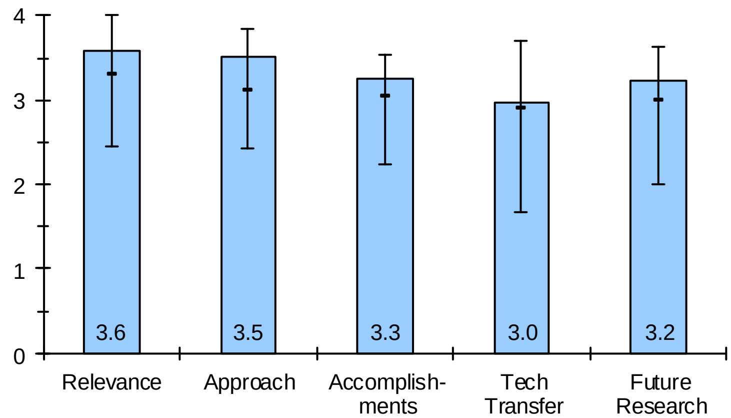
Weaknesses
- Lack knowledge of environmental impacts, in particular the potential impacts to fish passage.
- Because of the unique nature of the project design, final project data may have limited applicability.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: The Water to Wire Project (W2W)
Dr. Edward Lovelace; Free Flow Power

Overall Project Score: 3.3 (5 Reviews Received)



<u>Brief Summary of Project</u>

The project purpose is to evaluate and optimize the performance, environment, and cost factors of FFP hydrokinetic SmarTurbines™ through design analyses and Mississippi River deployments.

Specific objectives are:

- Design, fabrication, and testing of a full-scale prototype turbine (Endpoint: functional generating hardware).
- In-river deployment and testing of the full-scale prototype turbine (Endpoint: test data demonstrating performance, river environment, and resource potential).
- Design and analyses for the commercial scale infrastructure and sites (Endpoint: refined cost and design for complete array systems to provide launch point for next TRL level deployments).

The challenges are that there are no commercially operating hydrokinetic river systems in existence so uncertainty exists about the equipment performance in a relevant environment, commercial cost of capital and O&M for practical systems, and the generation from the available resource that is practically achievable. The project results will provide a pathway and supporting data and demonstration results for FFP and all hydrokinetic developers to address the design and cost challenges associated with turbine siting, installation, and maintenance.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.6** for its relevance to DOE objectives.

- One of few technologies specifically designed for river systems.
- Focusing primarily on river systems.
- In-river commercial project development is key to achieving DOE near term goals.
- In-water deployment of full scale prototype.
- Initial reports appear promising.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **3.5** on its approach.

- Quantitative, laboratory-based fish entrainment studies are applicable to multiple sites.
- Each blade uses different anti fouling paint so also evaluating different paints as well.

- Licensing approach is creative.
- Smart licensing strategy to focus on 5 "lead" projects under ILP and use data from initial studies to inform information needs at other sites. For example fish entrainment studies will be applicable to all sites.
- The technical approach seems very practical and well-reasoned.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Has deployed prototype unit.
- There has been some slippage in the schedule, but accomplishments are good, prototype is in the water, and progress appears to be good.
- Given the immediate generation upon deployment, the projects accomplishments and progress appear to be outstanding.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.0** for technology transfer and collaboration.

- A good balance of private industry members.
- Utilizing USGS labs for testing device.
- Not sure what will be transferred.
- Strong team partners/subcontractors, and FFP has already begun dissemination of results with DOE and labs.
- Given the proprietary nature of this technology, the opportunities for collaboration and technology transfer may initially be somewhat limited.

Question 5: Proposed future research

This project was rated **3.2** for proposed future work.

- Not clear to me future research. Although results, if available, will be useful to broader industry.
- Proposed future research appears to be well reasoned and focused on improving project output.

Strengths and weaknesses

Strengths

- Working with regulatory agencies to identify suitable approaches to assess environmental impacts
- A good solid project, doing good underpinning technology development at large scale.
- It would be interesting to explore if there in tech transfer support.

Weaknesses

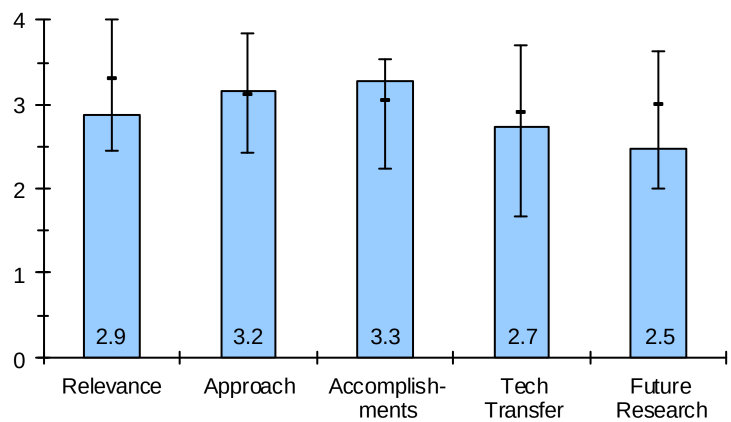
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: WindWaveFloat
Alla Weinstein and Dominique Roddier; Principle Power Inc.

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

The goal of the project is to assess feasibility of integrating wave energy conversion power takeoff (PTO) mechanisms with a floating offshore wind support structure – the WindFloat - in order to a) maximize power output; b) share infrastructure and c) reduce levelized energy cost as compared to the use of the floating support structure only for offshore wind. The integrated device is referred to as the WindWaveFloat ("WWF").

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.9** for its relevance to DOE objectives.

- Very positive - Assessed the potential of combining multiple energy generators in one infrastructure (wave with wind).
- Deep-water and incorporation of more than one technology at offshore site is an important approach being looked at.
- Although it is clear why this project was chosen, given the results (i.e., that the cost of a wave structure is too high and will not be further pursued), I cannot give it a higher ranking because it does not advance the objectives, goals or approaches of the DOE program.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Assessed four different types of PTO to harness wave energy.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Completed tank tests of all four PTOs.
- On schedule and budget.
- Project completed.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.7** for technology transfer and collaboration.

- Teamed with NREL.
- Wave tank testing at University of CA Berkley.
- Integration of more than one device technology.
- BOEM/FERC process for wind/wave integration may be useful in the future for others looking at integrating these technologies.
- The technical approach employed appears very sound.

Question 5: Proposed future research

This project was rated **2.5** for proposed future work.

- A good project exploring hybrid devices.
- Looking at energy storage.
- Seems to be focusing future efforts on non hydrokinetic technologies.
- Principle Power is not proposing additional future research.

Strengths and weaknesses

Strengths

- The integration of wind and wave energy production presents a huge opportunity to increase the efficiency of MHK projects.
- Multiple technologies.

Weaknesses

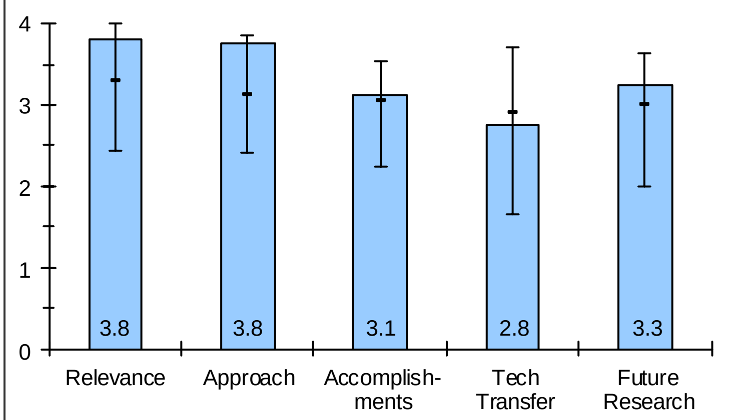
- There was limited number of tests undertaken that I don't believe is fully representative.
- The project appears very expensive for the limited number of tests undertaken.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Aquantis 2.5MW Ocean Current Generation Device
Alex Fleming; Dehlsen Associates, LLC

Overall Project Score: 3.3 (5 Reviews Received)



Brief Summary of Project

The principal objective of the Aquantis Project is the development of technology to harness the vast Gulf Stream energy resource with an innovative breakthrough power generation technology, projected to be cost competitive with thermal power generation in early deployment.

This proposed effort will result in six conclusive products:

1. Experimental Validation of Analytical Tools/Design: Use of Scale Models and Full Scale Component Testing, Subsystem Integration and Global System responses to validate analytical tools and gain confidence in device performance and loads.
2. Cost of Energy Model: Robust model factoring in CAPEX and OPEX. This model will evolve, giving specific design goals for serviceability, maintenance intervals, and reliability.
3. Garner Certification Approvals: via comprehensive plan (DNV, Lloyds).
4. Drawing Package: Full scale manufacturing drawings.
5. Enabling Technology: Development of a direct drive generator
6. Final Report: Design, Trade Studies and Validation via Virtual Prototyping using the latest Computer-Aided Engineering tools, including Solidworks, RANDS, WAMIT, ANSYS, ASDS and Orcaflex, and leveraging a significant experience base in marine renewable energy conversion and the design of offshore structures.

To achieve the aforementioned project objectives, DA has assembled a team of leading recognized ocean industry experts having on average >30 years of experience in their respective disciplines and research labs. The existing

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- An excellent and well planned project in full alignment with DOE objectives.
- Deep current gulf steam technology is relevant to the DOE objectives.
- Development of current technology is directly aligned with DOE's program goals, and near term at-sea deployment as contemplated here is key to the industry's success.

Question 2: Approach to performing the research and development

This project was rated **3.8** on its approach.

- A well-planned approach.
- Impressive project plan and schedule.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.1** based on accomplishments.

- Excellent technical progress to date.
- Still at initial phases of project.
- Project is in early stages. Significant challenges identified so warrants additional attention to keep on track.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- Not fully clear about their approach in this area.
- Results to be communicated at workshops and conferences.
- Numerous partners.
- Project partners include Penn State lab and several others. Need to develop plan to disseminate information beyond the project team.
- Dissemination of the information collected from this project would be extremely valuable within the MHK industry however this area was not clearly addressed in the project presentation or summary.

Question 5: Proposed future research

This project was rated **3.3** for proposed future work.

- Appears to support other future research, however early in project life.

Strengths and weaknesses

Strengths

- A good project by a team that clearly knows what they are doing.
- They are breaking unknown ground and can potentially make a significant impact in this emerging sector.
- Wind technology background on team.

Weaknesses

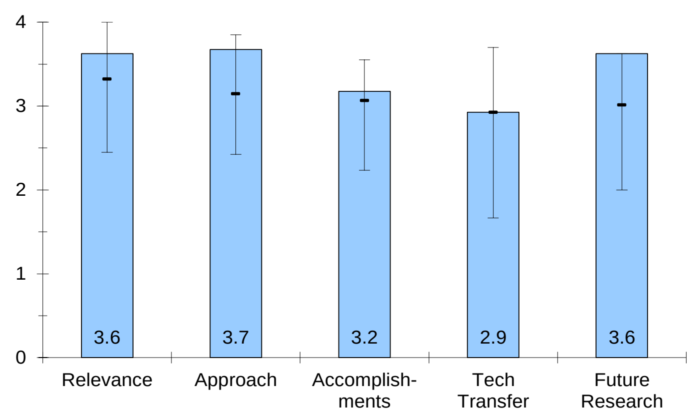
- Potential mooring challenges.
- Research integration.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Aquantis C-Plane Ocean Current Turbine Project
Alex Fleming; Dehlsen Associates, LLC

Overall Project Score: 3.4 (5 Reviews Received)



__Brief Summary of Project__

Aquantis is an in-stream hydrokinetic device that is tethered to the seafloor, with plans for implementation first off the coast of South Florida in the Gulf Stream/Florida Current. Recognizing that offshore platforms often have high costs associated with visiting the commercial site, all aspects of the design require high reliability, and low maintenance to achieve low cost of energy targets. Primary challenges include creating a redundant mooring system for Aquantis, and a reliable, passive means for establishing dynamic and static stability. Additional challenges include: understanding the resource impact on system performance associated with turbulent and unsteady flow, designing a structure that withstands the large hydrodynamic loads, designing a robust system with 20-year life, developing a cost-effective installation and maintenance strategy, determining effective computational and experimental tools, and understanding potential environmental impacts.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **3.6** for its relevance to DOE objectives.

- An excellent and well planned project in full alignment with DOE objectives.
- Moorings are important consideration for this and all marine energy projects.
- Project addresses key issues for current energy -- resource assessment and mooring.
- Project partners are well.

__Question 2: Approach to performing the research and development__

This project was rated **3.7** on its approach.

- A well-planned approach.
- Seems like a sound approach.
- Well planned and organized to fill data gaps.

__Question 3: Technical accomplishments and progress toward project and DOE goals__

This project was rated **3.2** based on accomplishments.

- Excellent technical progress to date.

- On schedule.
- Still in early stages.

<u>Question 4: Research Integration, Collaboration, and Technology Transfer</u>

This project was rated **2.9** for technology transfer and collaboration.

- Not fully clear about their approach in this area.
- FAU involved.
- Need to develop plan to disseminate information.

<u>Question 5: Proposed future research</u>

This project was rated **3.6** for proposed future work.

- Mooring loading.
- Deep-water O&M.
- Well recognized and respected project partners.

<u>Strengths and weaknesses</u>

Strengths

- A good project by a team that clearly knows what they are doing.
- They are breaking unknown ground and can potentially make a significant impact in this emerging sector.
- The project outcomes could provide a valuable tool for resource.

Weaknesses

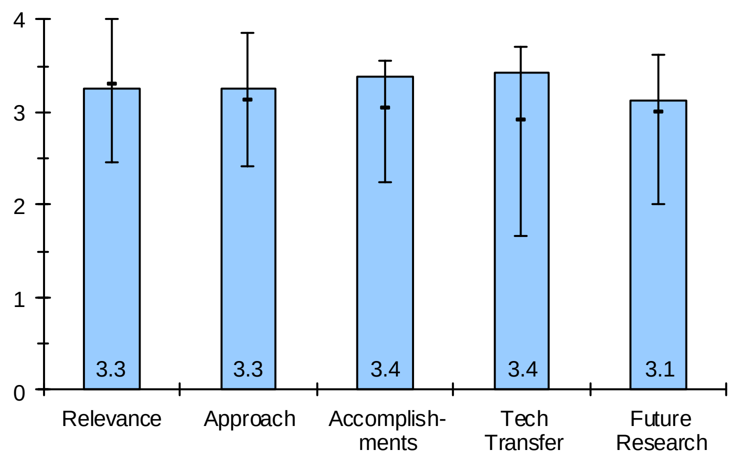
- NA

<u>Specific recommendations for additions or deletions to the work scope</u>

- NA

Project Name: Siting Study Framework and Survey Methodology for Marine and Hydrokinetic Energy Projects in Offshore Southeast Florida
Charles Vinick; Dehlsen Associates, LLC

Overall Project Score: 3.3 (5 Reviews Received)



Brief Summary of Project

The purpose of the project was to investigate areas offshore southeast Florida that appeared most suitable for siting of marine and hydrokinetic energy conversion facilities that may be proposed in the Atlantic Ocean offshore of southeast Florida focusing on those areas offshore of Miami-Dade, Broward and Palm Beach Counties.

The specific objectives of the project included the:

- Development of an acceptable bottom habitat survey methodology and siting study framework in consultation and cooperation with those regulatory and resource management agencies with permitting/review authority for marine and hydrokinetic projects on the OCS, offshore southeast Florida; and
- Identification of general areas offshore southeast Florida that appear most suitable for installing marine and hydrokinetic energy facilities, including subsea electrical transmissions cables to shore, based on the distribution of sensitive bottom habitats identified by existing and supplemental surveys conducted for this project. The geographical area of interest focused on BOEMRE lease blocks off the coasts of Miami-Dade, Broward, and Palm Beach Counties.

The data collected, analyzed, and to be reported through this study is intended to be of value to regulatory agencies, industrial developers, and investors in making early siting assessments and decisions. However, it is important to note that each project developer must evaluate the specific project's potential impacts and minimization/mitigation options and conduct site-specific studies necessary to support their licensing/permitting process, including but not limited to: evaluation of the biological coastal/marine environment and physical environment; performance of site-specific surveys/studies, such as archeological surveys and fishery studies; addressing any use conflict issues; among other possible evaluations and studies that a resource agency may specifically request.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Environmental and physical siting in Gulf Stream is valuable information and needed for any deployment.
- The data collected should inform early siting decisions and therefore should be useful to developers and regulators alike.
- Project partners are well known and respected organizations.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Very sound technical approach.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.4** based on accomplishments.

- Currently working on benthic substrate characterization.
- Identified large area of coral habitat that people will need to avoid.
- Significant progress to date; final analysis and report left.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.4** for technology transfer and collaboration.

- FAU and others involved.
- Project results to be disseminated through FAU web site
- Impressive collaboration with federal agencies (BOEM, NMFS, etc.); all agencies signed off on work plan.
- Data to be shared on FAU and NCRI web sites.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- NA

Strengths and weaknesses

Strengths
- Gathering/organizing useful environmental data.
- Good use of limited funding in what appears to be a well-designed siting study.

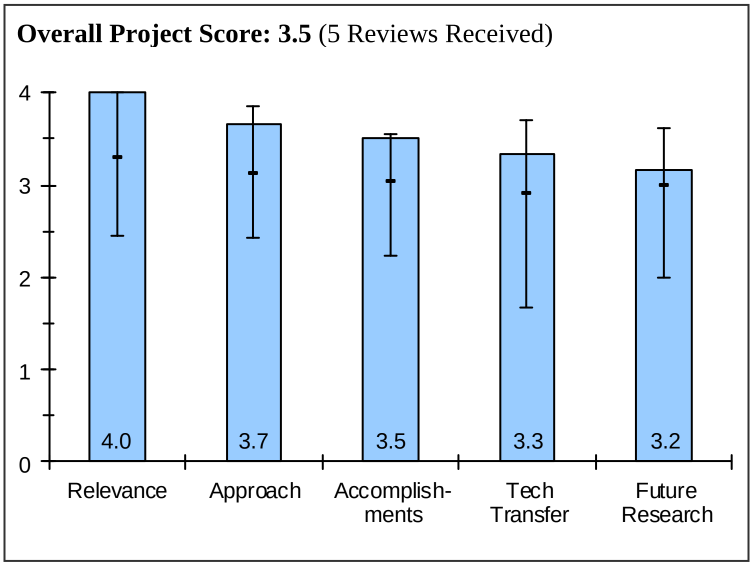
Weaknesses
- Quite a good project but needs more integration with other projects in the program and previous work.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Direct Drive Wave Energy Buoy

Ken Rhinefrank; Columbia Power Technologies, Inc.



Brief Summary of Project

The primary goal of this project is an intermediate-scale (1:7) bay/ocean test of a novel Direct-Drive Rotary Wave Energy Converter (DDR WEC). Knowledge and experience gained from this project is applied to subsequent milestones including design and certification of the commercial-scale system; a land-based test of a commercial-scale generator, with the bearing and seals needed for open-ocean deployment; open-ocean deployment of a commercial-scale DDR WEC in conjunction with a recognized independent testing center. The project seeks to systematically reduce risk following the TRL Approach and according to our pre-commercial Technology Development Plan. The primary commercial opportunity lies with utilities, independent power producers and the US Navy for its island and shore-based facilities. Other possibilities include island and remote shore-based communities as well as data buoys and aquaculture.

This is the first WEC tested in Puget Sound, which is a natural site for protected sea trials for medium scale (1:10 to 1:5) prototypes. The federal, state and local permitting, marine operations surrounding deployment, operation and recovery and acoustic monitoring should all provide an experience base from the local supply chain that will benefit other technology developers. This has been a positive experience for the industry and one that should be publicized to demonstrate the technical and economic benefits that MHK can bring to bear.

The proven success of the TRL approach to managing the evolution from concept through commercial application is unquestioned. It is simply a matter of systematically removing risk with scaled prototypes utilizing the smallest and least expensive scale necessary, in the most controlled environment possible, as early in the process as possible. Wave tanks can only test to a certain size before sea- and open-ocean trials become necessary. But the cost of permitting and marine operations can be prohibitive and are not justified until a baseline level of confidence in the assumptions can be proven. Numerical models validated through physical experimentation and operational experience lead to better assumptions and high confidence of performance at larger scale.

The project has been successful to date in using limited capital efficiently, but public support has been essential to securing the private capital needed to ensure the necessary funding in advance of rapidly increasing needs. This support becomes commensurately more important as the project moves to a commercial-scale test. Once outside the controlled environment of the lab, the project is at the mercy of the environment, which leads to uncertainties that drive cost higher.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **4.0** for its relevance to DOE objectives.

- An excellent and well planned project in full alignment with DOE objectives.
- Ocean testing is critical to closing data gaps and proving commercial viability of WEC technologies in the near term.

Question 2: Approach to performing the research and development

This project was rated **3.7** on its approach.

- A good scaled approach to project development.
- Deploying 1:7 scale is a smart, step-wise approach to development.
- The staged approach to project development was apparently successful.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.5** based on accomplishments.

- Good technical progress being made.
- The performance of the device is not clear.
- It is significant that CPT was able to get a small-scale model permitted in relatively short order. CPT has responded quickly to challenges.
- Significant progress with 7 months of continuous operation.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.3** for technology transfer and collaboration.

- Project information has been shared in several forms and collaboration with labs is ongoing.
- Acoustic and bird/sea life monitoring data could be useful to others but it is unclear whether/how CPT intends to disseminate that specific information.
- Project information has been widely presented and discussed.

Question 5: Proposed future research

This project was rated **3.2** for proposed future work.

- NA

Strengths and weaknesses

Strengths

- Data from this project presents a good real time in-the-field baseline for researchers in the MHK industry.

Weaknesses

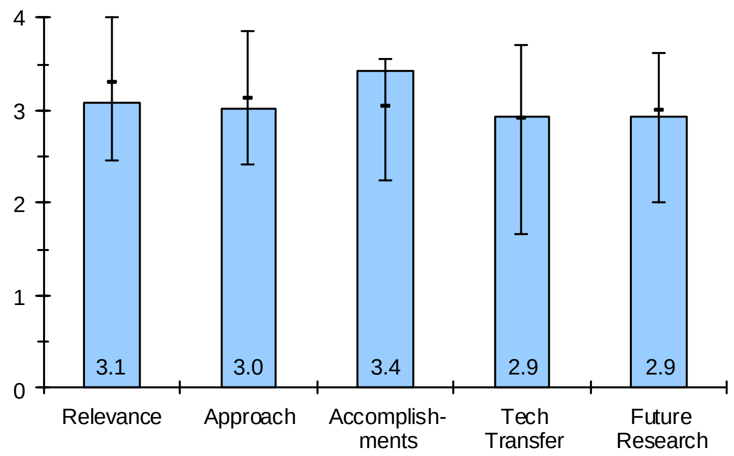
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: An Assessment of Projected Lifecycle Cost For Wave, Tidal, Ocean Current, and In-Stream Hydrokinetic Power in the United States over Time
Mirko Previsic; RE Vision Consulting, LLC

Overall Project Score: 3.1 (5 Reviews Received)



Brief Summary of Project

An accurate understanding of the present and future life-cycle cost for emerging hydrokinetic generation technologies is of critical importance to guide the technology development process, make critical decisions on policy mechanisms that support this sector, and provide input to future capacity planning models. Thus, assessment of projected life-cycle costs is one of the central tools necessary to establish a healthy industry development in the U.S. To date, there is limited cost and economic data available in the public domain and this is the first project that ties the national resource to an economic model. Understanding the long-term potential in terms of extractable resource size and cost is a fundamental building block to drive funding decisions.

The final products will consist of:

1. A report with life-cycle cost and performance profiles for; wave, tidal, river, and ocean current energy conversion technologies. These cost profiles will identify sensitivity to critical cost-drivers such as: plant scale, cumulative deployed capacity, and resource intensity.
2. A report on supply curves for wave, tidal, and ocean current technologies providing an understanding of: (a) at which price-levels will these technologies be adopted in the market place, (b) how much energy can be extracted from the resource at what price point and in which geographic location.

It is important to point out that the primary objective of this effort is to refine cost, performance and economic assessments. The supply curve efforts, while important, are only used at this stage to bring the assessment methodology full-circle.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Relative to project R&D and ocean deployment projects which I believe have the highest priority, projects intended to provide guidance back to DOE, like this project, have lower relevance to the program's overall goals of accelerating the industry.
- In addition, it is not clear that data on industry costs or energy resources were sufficiently developed to supply this research with needed information. Many assumptions had to be made. Perhaps it was premature?

- Uses well respected project partners.
- An excellent and well planned project in full alignment with DOE objectives.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Good approach but lacks discussion on device developer input.
- Not clear to me from presentation how much more information has been created above the previous efforts by EPRI.
- It is not clear that the industry is sufficiently developed to create useful or accurate data for the longer term. In addition, the fact that river resource data were not yet complete led to a decision not to develop a supply curve.
- Given the limited data and need to make many assumptions, it is clear that this will need to be just a preliminary iteration of this work, which will need to be refined as more data are available.
- This approach appears too detailed for the current maturity of the sector.
- It is not clear if innovation and step change break through are used in the costing.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.4** based on accomplishments.

- Seems to be on schedule and budget.
- The project is close to completion and has caught up to be on schedule. Did not undertake river resource supply curve because resource data were not yet available.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.9** for technology transfer and collaboration.

- It wasn't clear as to who ReVision collaborated with during this presentation; it was only in the next presentation by SNL that it was understood.
- Sandia has some integration.
- Use of DOE website to disseminate is good.
- Appears industry cost and energy resource data may not be sufficiently developed to support project.
- The internal integration of this project is not clear.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- More work when riverine data becomes available.
- Revision is engaged in high level assessment that may prove useful for the MHK industry with regards to life cycle costing of the various technologies Revision are right people to be doing this.

Strengths and weaknesses

Strengths

- Efforts will provide utilities with information to understand the potential costs associated with this industry.
- Strong collaborative effort to assemble data on early stage development.
- The project addresses objectives that are extremely.

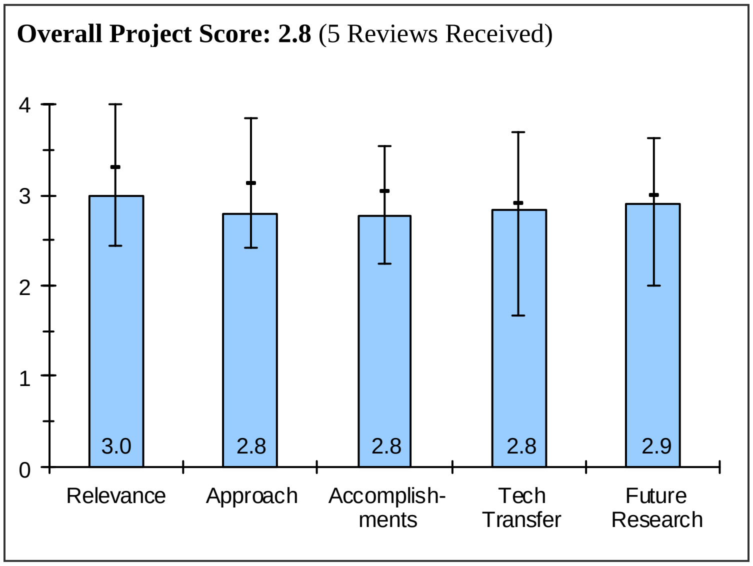
Weaknesses

- Lacks a partnership with device developers.
- Waiting for riverine data. Not sure if there will be dollars remaining in budget.
- Appears that industry cost data and some resource data was not ideal for developing this project. PI suggested that he took a stab with limited resources. Given the limited DOE resources, perhaps this work was premature.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Development of Reference Models and Design Tools (LCOE Models)
Richard Jepsen, Sandia National Labs



<u>Brief Summary of Project</u>

The Reference Models will serve as benchmarks, allowing for determination of existing cost and performance and projection of energy conversion electricity cost for various MHK devices and evaluation of the opportunities for device cost reduction. The Reference Model effort allows DOE to capture and understand both the performance metrics of MHK devices and to ascertain cost drivers. The objectives are establishing baseline cost of energy (COE) and quantifying cost and performance drivers by developing at least three integrated cost and performance reference models by 2011, three more by 2012 and possibly another two to three by 2013. The project will establish baseline COE by 2013 and resource-specific goals by 2014.

Secondary and long-term objectives include:

- Develop and validate tools and techniques for use by the industry.
- Establish benchmark designs and standardized methods by which to evaluate new technologies.
- Establish government sanctioned device assessment methods.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.0** for its relevance to DOE objectives.

- A good approach to "standardize" reference models that can be implemented in different areas of the country; however, there was no detail as to QA/QC or developer input.
- A well planned project in full alignment with DOE objectives.
- This project has a fair purpose - to help DOE prioritize research. However, compared to technology R&D, monitoring and studies, and in-water testing, I must give this project a lower score in terms of relevance to achieving DOE's goals. As we advance, projects like this will undoubtedly be important. At this time, though, we need to prioritize getting projects in the water to advance the industry.
- Based on preliminary data from the PI for this project they appear to be well on their way to developing a key reference model for the MHK industry.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **2.8** on its approach.

- It wasn't clear if device developers were involved with this reference model development.

- This approach appears too detailed for the current maturity of the sector.
- Apparently little or no industry input on assumptions being made as basis for efforts.
- Lots of shifting within the team to meet project goals.
- Should involve industry in early development of assumptions. With unlimited budget, approach of developing something for industry's review might work, but with limited funds DOE should prioritize efficient projects that get early industry input to avoid expending time and effort going down a wrong path.
- Good coverage of the dominant MHK technologies.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.8** based on accomplishments.

- NA

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- An extensive mix of national labs, academic institutes, and private groups BUT lacks significant input from device developers.
- It is not clear how the overall CRM is coordinated.
- Eight different team members opportunity for sharing information.
- There is quite a bit of integration, but it needs to be more carefully managed to direct effort to meet the primary project goals.
- Good information dissemination at industry conferences.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- Preliminary model will give a strong background for in-field testing.
- Are additional reports necessary?
- The researchers may want to consider a coordinated plan for incorporating utility industry input and questions into this project.

Strengths and weaknesses

Strengths

- Unlike the RE Vision project, one of this project's purposes is to identify ways to reduce costs, which is supportive of program goals.

Weaknesses

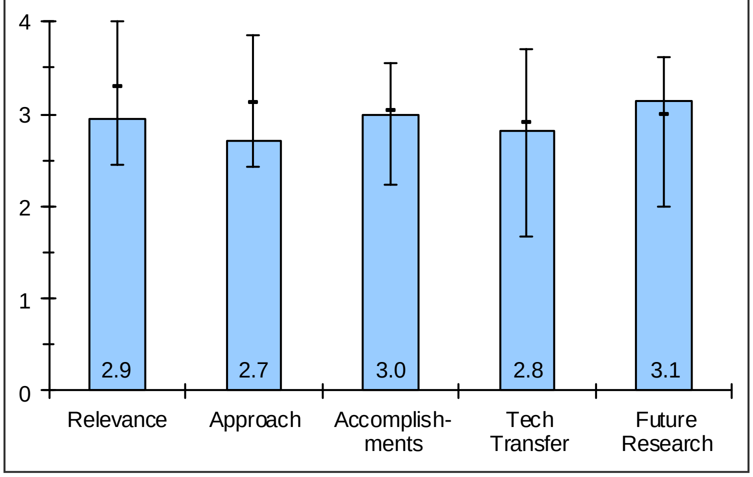
- There is a significant cost associated with this tool, but it appears to be a "road map" on what needs to be assessed - a very large budget for this.
- Little or no industry input.
- Potential for project management challenges
- Challenges described by the PI seem to be internal to the team’s research approach.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: FY09 Lab Call- Supporting Research and Testing for MHK
Robert Thresher, Ph.D., National Renewable Energy Laboratory (NREL)

Overall Project Score: 2.9 (5 Reviews Received)



Brief Summary of Project

The purpose of NREL's Lab Call work is to accelerate marine energy technology development and deployment by providing the industry and researchers essential engineering and design tools, methods, and testing capabilities. This will enable reductions in cost, increases in device energy capture, and a reduction of deployment risk to penetrate the electricity marketplace.

The high level project objectives are to:

- Develop an instrumentation system with flexible architecture for laboratory and field data measurement of wave buoys and current turbines.
- Develop advanced measurement protocols to define machine performance, loading, and function.
- Deploy instrumentation to support in-water research, testing, and evaluation of MHK technologies.
- Develop and disseminate open source computer design tools and simulation codes to predict machine performance, loads, and stability which have been validated by laboratory and field tests (when possible).
- Characterize the hydraulic inflow environment affecting wave and tidal systems; including analysis of wake effects of wave and tidal power systems on downstream hydraulic conditions.
- Understand arrays' interactions on neighboring devices and the environment for both wave buoys and tidal/river current turbines.
- Provide expert support to help the successful establishment of MHK testing centers.
- Assess status of relevant OTEC technologies and materials and develop cost reduction pathways.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.9** for its relevance to DOE objectives.

- Appreciate the objective to assist National Renewable Test Centers.
- A well planned project in full alignment with DOE objectives.
- Relevance but not clearly articulated in presentation.
- This should support acceleration; however, I still am ranking it below projects focused on ocean testing and other R&D and field or empirical environmental testing that will help the first projects get into the water.
- Vary ambitious project with quite a few objectives and purposes.

Question 2: Approach to performing the research and development

This project was rated **2.7** on its approach.

- They have an effective approach in place.
- The overall approach is not clear to me. A number of different tasks within this effort
- Interest was expressed in involving industry but it's not clear they've provided sufficient input into this effort to ensure the end product can be used by them. Need internal collaboration and industry input.
- Not clear those environmental interactions should be evaluated in this context. Tendency to identify all "potential" adverse impacts is not accurate or good for industry acceleration; should leave environmental impact research to those focused on filling data gaps related to specific regulatory standards that are barriers to permitting/approvals.
- The description of the project approach was somewhat vague.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- While the accomplishment were apparently positive overall it was difficult to determine the projects overall progress.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- Overall, a good mix of academic/national labs, but lacks device developer input.
- Uncertain how this project is managed and how it fits into the overall national lab projects.
- It is not clear if there is overlap between this project and CRM project (17).
- This project would benefit from international collaboration.
- Opportunity exists as there are a number of various partners included.
- There are many entities involved, but need clear management of effort.
- Given the number of academic organizations involved as project partners I would have expected more dissemination of the information from this project.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- Glad to see that they are addressing Ocean Thermal Energy technologies.

Strengths and weaknesses

Strengths

- Appreciate the availability on the website for input.
- They have a strong team in place.
- Has had some level of industry input.
- The researchers appear to have addressed the dominant MHK technologies.

Weaknesses

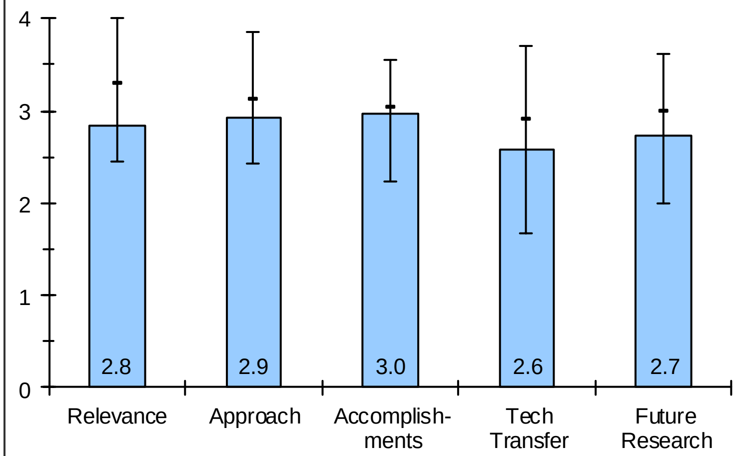
- Very confusing as to who is managing this project and how information is exchanged between partners.
- Potential coordination of team members, 12 partners.
- Conducted workshops but not as much industry participation as they had hoped.
- While "looping back" is important, it is unclear if this work will ever be complete.
- Does disappointing participation by industry in workshops indicate that they don't think this is valuable?
- Needs a coordinated plan for incorporating industry input.

<u>Specific recommendations for additions or deletions to the work scope</u>

- NA

Project Name: FY 09 Lab Call: Research & Assessment for MHK Development
Richard Jepsen; Sandia National Labs

Overall Project Score: 2.8 (5 Reviews Received)



Brief Summary of Project

The purpose of Sandia's Lab Call work is to both accelerate marine energy technology development and to facilitate market acceleration and deployment by assisting industry with the design, manufacture, test, and evaluation of a wide variety of leading MHK concepts and designs as well as developing tools and undertaking research to identify, mitigate and prioritize environmental risks. These efforts will form the foundation for a robust MHK industry by providing key tools and information to increase device efficiency and address environmental issues.

The high level project objectives are to:

- Determine the modification of natural wave propagation due to the presence of wave energy converters (WEC), and then determine the effects of the modified wave fields on nearshore circulation and sediment transport.
- Development of CACTUS code
  - Validation using tow-tank data for axial and cross-flow turbine performance
  - Generation of several test cases and user documentation
  - Public release
- Test axial-flow turbine with innovative blades incorporating Sandia's blunt trailing edges at PSU/ARL 48" water tunnel
- Report describing data collection, verification, validation, and implementation of SNL-EFDC array optimization tool
- Assessment of potential changes to wave, current, and sediment transport patterns due to wave farm installations using Santa Cruz Bight as a test bed
- Develop an outreach plan for SNL-EFDC technology transfer

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.8** for its relevance to DOE objectives.

- A well planned project in full alignment with DOE objectives.
- Relevant but not clearly articulated.
- As compared to technology R&D, monitoring and studies, and in-water testing, I rank this lower in terms of its relevance to achieving DOE's goals. This undoubtedly can be useful as the industry moves forward, but we are desperate to get ocean testing underway and those projects are more closely related to DOE's goals.

- Project purposes and objectives may be somewhat duplicitous of earlier studies that appeared earlier.

Question 2: Approach to performing the research and development

This project was rated **2.9** on its approach.

- They have a well-structured approach.
- Not clear to me exactly what their approach is.
- Eight partners so management and communications are key.
- Good use of existing DOD research with regards to existing marine coatings, composites and anti-fouling agents.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Some data validation.
- Coating assessment and a patent application submitted.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.6** for technology transfer and collaboration.

- Appreciate the solicitation of device developer input.
- It is not clear how this fits with the other lab projects and the cost ref model.
- There is a lack of international collaboration in this project.
- Eight partners in R&D so potential for integration and technology transfer is there, but not clear on how all partners are working together.
- There is quite a bit of integration, but it needs to be more carefully managed to direct effort to meet the primary project goals.
- Need to incorporate more industry inputs if possible.

Question 5: Proposed future research

This project was rated **2.7** for proposed future work.

- Continuing with existing research but not adding any component.
- Results from this effort ties into reference model needs to be coordinated very closely.
- The information on proposed future research was somewhat vague.

Strengths and weaknesses

Strengths

- Includes industry input (both device and coating manufacturers).
- Various challenges to the industry are being looked at.
- Looking at materials and coatings.

Weaknesses

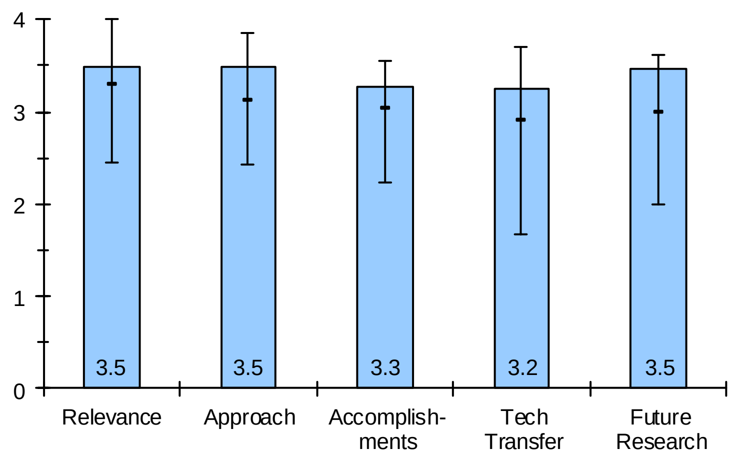
- Models will not significantly advance us past regulatory hurdles; agencies like NMFS require site-specific (or at least ocean tested) data. So this research should be focused on industry needs and questions.
- We should ask ourselves if it would advance DOE's immediate goals better to focus on individual developers to improve performance of their specific technologies to help real projects move forward.
- Improved coordination and integration across the various National Lab PI would result in improve efficiency and decreased duplication of effort.

<u>Specific recommendations for additions or deletions to the work scope</u>

- NA

Project Name: SNMREC Offshore Testing Facility—Small Scale Turbine Testing and Development
Susan H. Skemp; Southeast National Marine Renewable Energy Center at Florida Atlantic University

Overall Project Score: 3.4 (5 Reviews Received)



Brief Summary of Project

The SNMREC is developing the first open-ocean current energy conversion prototype test facility in the U.S. The scope of this project is not yet formally negotiated, but the SNMREC has proposed the items described in this summary. The proposed project will integrate results to date and deploy research equipment to provide testing capability for scaled devices up to the 100kW class. Ongoing efforts are leveraged to further technology development in key areas of greatest need in order to accelerate and improve commercial prototype development. This project will provide TRL 3-5 support for early-stage technology gaps (intelligent sensor systems, reliability and prognostics, rotor instrumentation and modeling, and composite material applications) and will collect device-performance, marine-resource, and environmental-interaction data.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- This test center will provide a much needed facility for device developers to test their products.
- A project in full alignment with DOE objectives.
- Test berths in Gulf Stream.
- Ability to test open-ocean current MHK.
- Excellent planning. Although DOE funding is in the early stages, the project itself is far into conceptual, permitting and planning stages based on state and federal funding.
- A solid research project that would appear to support the MHK industry.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Will allow for devices to be tested; however, didn't describe how data will be relayed back to developers - e.g., plug-in-play approach?
- A well-targeted and focused project
- Good links with industry.
- Securing BOEM lease then deploy in summer 2012.
- Great work with BOEM, NMFS and others.
- Strong well-reasoned approach.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Even with the regulatory uncertainty, it appears that regulatory advancement has taken longer than would have been anticipated.
- Project has not yet started.
- Some regulatory challenges has led to schedule extension
- I support proposed integration of this new project with ongoing research conducted by SNMREC.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.2** for technology transfer and collaboration.

- Very good dissemination of information.
- Good links with regulators.
- Potential for technology transfer and collaboration.

Question 5: Proposed future research

This project was rated **3.5** for proposed future work.

- Strong strategy for BOEM leasing.

Strengths and weaknesses

Strengths

- Can assess multiple levels of technology development.
- This project is geared toward in-water testing which is critical at this time. It should eventually allow various current technologies to be tested here.

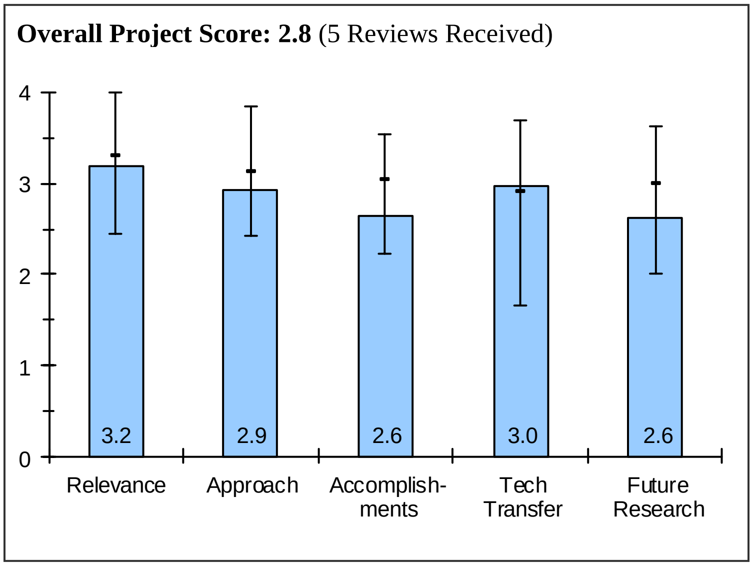
Weaknesses

- Appears there has been regulatory uncertainty that has slowed this project.
- Regulatory uncertainty has slowed the permitting process.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Hawaii National Marine Renewable Energy Center (HINMREC)
Richard Rocheleau, Ph.D.; Hawaii Natural Energy Institute (HNEI), University of Hawaii



Brief Summary of Project

HINMREC was established to facilitate commercialization of Wave Energy Conversion (WEC) devices and to accelerate development and testing of Ocean Thermal Energy Conversion (OTEC) technologies.

WEC developers have indicated that to achieve TRLs 8 and 9 they need a location to perform in-water prototype testing. HINMREC plans to provide access to grid connected berths to test WEC devices under a variety of ocean conditions. To this effect, HINMREC is collaborating with the US Navy to implement a wave-energy-test-site (WETS) in Kaneohe Marine Corps Base Hawaii (MCBH). The concept is to expand existing facilities to provide multiple-berthing for devices in the 100 to 500 kW range. WETS will allow for testing in water depths ranging from 30 m to 70 m.

Electricity generation and desalinated water production has been demonstrated with OTEC experimental plants sized at less than 0.25 MW and economic models indicate that 50 MW and larger plants are required to be cost competitive, indicating that a megawatt sized pilot plant is required as the next step towards commercialization. The development of such pilot plant is hampered by relatively high capital costs, lack of confidence in long-term equipment performance and permitting uncertainty. A HINMREC objective is to support pilot plant design and testing of critical components, like heat exchangers, to reduce technical risk and uncertainty.

In addition, HINMREC is structured to provide engineering, science and policy support to developers by making available: resource assessments; baseline and post-test environmental studies; numerical models for analysis of device performance; and, support of permitting efforts.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.2** for its relevance to DOE objectives.

- Conflicting with OSU's approach to develop a WEC test facility.
- Ideal for OTEC testing.
- Center to facilitate in water testing of wave and OTEC.
- Performing worldwide ocean thermal modeling.
- Ocean testing is so critical to industry advancement now.
- Strong potential with respect to OTEC.
- Good project in alignment with the DOE goals.

Question 2: Approach to performing the research and development

This project was rated **2.9** on its approach.

- While K-Bay appears to be the target location, it does appear to be somewhat of a "shot-gun" approach to determine a suitable site in HI to test WECs.
- Limited discussion on the technical side of their approach.
- Leveraging existing facilities/infrastructure as much as possible. Marine base OTEC heat exchanger at NELHA.
- Looking to leverage the Navy investment in Hawaii.
- Working as well with industry and utilities.
- Appears to be a coordinated approach focused on utilizing Ocean Thermal Energy it's not fully clear what their overall approach or strategy for the center is.
- It is not clear why they researching materials.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.6** based on accomplishments.

- Effort appears to be spread across several areas; need a critical path strategy to achieve project goals?
- Should be commended for recognizing when other facilities are in a better position to perform certain tasks/research.
- Given this projects contracting date there appears to be concerns around its progress.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.0** for technology transfer and collaboration.

- Good mix of stakeholder partnership including device developers (OPT, Oceanlinx), federal (DOD), State, and academic; however, there does not appear to be much involvement with the National Labs
- Positive to see information being disseminated via website and published journals.
- A number of partners. Should allow for increased information transfer.
- Leveraging OPT site.
- Good stakeholder collaboration and academic support with somewhat limited efforts at integration.
- There seem to be no links with the cost reference model.

Question 5: Proposed future research

This project was rated **2.6** for proposed future work.

- Potential for broad assessment of relevant issues.
- Heat exchange testing.
- Looking to do a full scale testing at Navy base, (Kaneohe Bay) leverage DOE funding, University to operate on behalf of DOE.
- Appears to need critical path strategic planning to get final approvals.
- Based on the information provide there appears to be some significant barriers to project completion.

Strengths and weaknesses

Strengths

- A strong group of collaborators involved with this project.
- Provides an ideal site to test OTEC devices.
- Leveraging existing facilities/infrastructure as much as possible. Marine base OTEC heat exchanger at NELHA.
- Looking to leverage the Navy investment.

Weaknesses

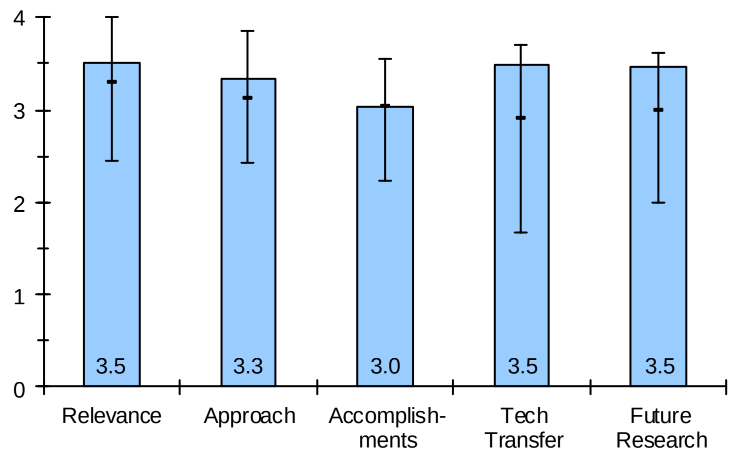
- Appear to be doing similar research as the National Labs but no crossover of information. Is there duplication?
- Both OSU and University of HI are promoting strength as a resource to test WECs - is there collaboration or a sense of competition?
- Not closely coordinated with NREL/Sandia labs efforts yet.
- There seem to be no links with the cost reference model
- I'm not sure why this test site is for both wave and OTEC. I'm not sure what it offers that is not offered at the Oregon center - perhaps this center should focus on OTEC.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Northwest National Marine Renewable Energy Center (OSU/UW)
Robert Paasch; Oregon State University

Overall Project Score: 3.3 (5 Reviews Received)



Brief Summary of Project

NNMREC's mission is to facilitate commercialization of marine energy technology, inform regulatory and policy decisions, and to close key gaps in scientific understanding with a focus on student growth and development. NNMREC's project objectives are to: 1) develop facilities to serve as integrated test center for wave & tidal energy developers; 2) evaluate potential environmental and ecosystem impacts; 3) optimize devices and arrays for deployment; 4) improve forecasting and resource characterization; and 5) increase reliability and survivability of marine energy systems. NNMREC also evaluates the compatibility of marine energy technologies with ocean and coastal environments and coastal users and is a leader in technical, ecological, and human dimensions research for wave and tidal energy projects.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Conflict with University of HI to develop a WEC test center and no cooperation/coordination.
- Advance wave and tidal energy in U.S.
- Looking at environmental and ecosystem impacts.
- Looking at survivability and biofouling.
- Testing facility will be incredibly valuable to industry.
- Demonstrates a strong interdisciplinary and multi-stakeholder approach to furthering MHK research. Excellent project in alignment with the DOE goals.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- A good approach assessing technical, environmental, and social aspects of the project both in Puget Sound and off of OR coast.
- A good balance of academic, industry, and utility participation.
- Working with UW in a collective wave and tidal research effort.
- Has had difficulty with NEPA, which is to be expected (and which was echoed across many projects), but need a critical path strategy to move through permitting process.
- Strong collaborative approach focused on commercialization of MHK.

- Clearly a well-planned and well managed project.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Appear to be on target for deploying in May 2012.
- Meeting most milestones.
- Deployed two wave technologies in OSU facility.
- Delays with environmental review and technical aspects of testing berth.
- Excellent progress from well experienced teams.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.5** for technology transfer and collaboration.

- A good mix of utility, academic, and National Lab collaboration.
- Good potential between team members.
- In addition to partners, OSU/UW is working with OWET and others on coastal community issues.
- Excellent dissemination of their work.

Question 5: Proposed future research

This project was rated **3.5** for proposed future work.

- Non-grid connected test facility to be ready in Newport in 2012.
- Good schedule; keeping on schedule to complete future work and put test center into operation is critical.
- A well-organized forward plan.

Strengths and weaknesses

Strengths

- Proactive on the Standards committee.
- Including the SeaGrant program in the social aspect.
  Graduates are able to work in and support ocean energy industry.
- If successful this project would provide a strong research and development platform.

Weaknesses

- University of Hawaii and OSU appear to be working towards the same cause - is there any collaboration or is it a sense of competition?
- Overlap with University of Hawaii?
- This project would benefit significantly from a grid connected test bed.

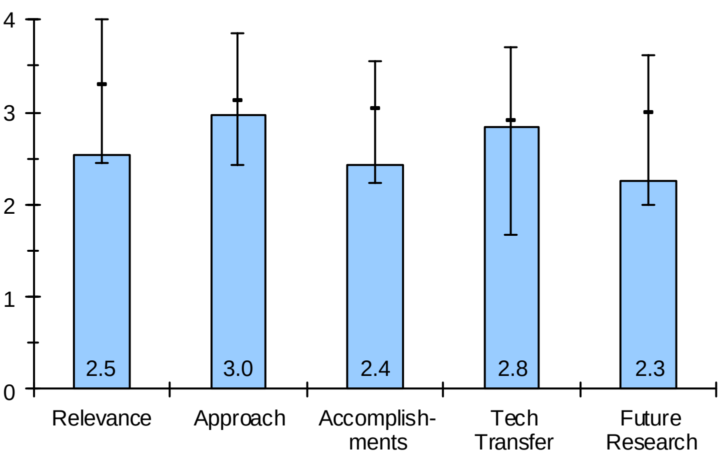
Specific recommendations for additions or deletions to the work scope

- NA

Project Name: The Potential Impacts of OTEC Intakes on Aquatic Organisms at an OTEC Site Currently Under Development (Port Allen, Kauai)

Steve Oney; Alden Research Laboratory, Ocean Engineering and Energy Systems, Inc (OCEES)

Overall Project Score: 2.6 (5 Reviews Received)



Brief Summary of Project

The goal of this project is to evaluate the potential impact of a proposed ocean thermal energy conversion (OTEC) intake (warm water) on aquatic organisms. This evaluation includes: 1) a site-specific assessment of available and feasible warm water intake technologies for minimizing impacts to aquatic organisms, and 2) a field sampling program at the Port Allen, Kauai OTEC site to collect baseline biological data that will help characterize the baseline populations of organisms that could be impacted by a warm water intake at this site.

A key requirement for the licensing of OTEC facilities will be determining the potential impacts of the intakes on aquatic resources. In particular, aquatic organisms may be at risk of impingement and entrainment at the warm water intake structure. Therefore, it will be necessary to determine the potential for OTEC intakes to impact aquatic organisms in the source waterbody and to design intake structures that minimize this risk. The project will generate sound engineering and biological data that will aid regulators (NOAA) and developers (OCEES) in determining the potential impacts of proposed OTEC facility intakes on aquatic organisms in tropical marine environments. In addition, the engineering and biological data generated by this project will make it easier for future OTEC facilities to be designed in a manner that is most beneficial for the environment.

This project is designed to address the barrier of designing and environmentally-friendly warm water intake that is also cost-effective. Without being both, the growth of OTEC in the U.S. will be hindered.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.5** for its relevance to DOE objectives.

- A good approach to determine potential impingement/entrainment impacts of land-based OTEC project; however, location of project is questionable.
- Not clear why they have select a land based site from a permitting perspective?
- Relevant to the development of OTEC plant and industry. However location may be a concern with this project.
- The information gained will not be applicable to offshore projects, which is where the industry is likely to grow.
- This study of intake plumes appears highly relevant to the emergence of the OTEC sector.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Agree with preliminary sampling approach but am concerned with potential impacts ichthyoplankton and the lack of input from NMFS with regards to sample design.
- Desktop initially followed by field sampling.
- Near-shore location may not be best.
- Need to involve NMFS. It is not clear that NMFS screening criteria has been considered.
- Study appears to be well designed.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.4** based on accomplishments.

- Intake analysis and cost estimates for 3 intake designs.
- Delays in other aspects and removal of some biological sampling.
- Delays due to environmental review process. Better planning and advanced consideration of likely environmental hurdles needed.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- Working with NOAA and EPA, however have had delays in project.
- Research results thus far are being disseminated at national conference. But question is whether results will be transferable to other sites. Given likely offshore location of future projects, not clear that this information is critical to OTEC development.

Question 5: Proposed future research

This project was rated **2.3** for proposed future work.

- See concern regarding the limited involvement of NMFS and proposed sampling plan
- Is this a permanent project or demonstration - this leads to a number of concerns with who the federal lead would be.
- Further intake assessments, however not sure right now of ability to achieve this
- Not clear that additional future research will benefit OTEC development given near shore location.
- While this study appears to be solid approach to researching the effects of OTEC intakes on ocean organisms, there may be ways to integrate this research with the prior studies on OTEC effluents plumes.

Strengths and weaknesses

Strengths

- A well run and managed project.
- Working with agencies to determine requirements for intake.
- Investigation of this issue is of high importance to the development of OTEC technologies.

Weaknesses

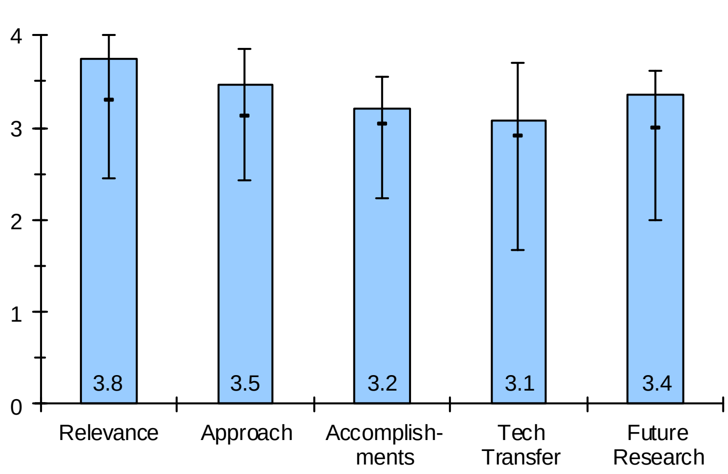
- Significant concerns regarding the lack of input from NMFS to develop field sampling design.
- Need to determine EPA's involvement with permitting (e.g., 316[b]).
- Not clear that there are any links with industry of other OTEC projects Regulatory and siting issues.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Underwater Active Acoustic Monitoring Network for Marine and Hydrokinetic Energy Projects *Dr. Peter J. Stein; Scientific Solutions, Inc. (SSI)*

Overall Project Score: 3.3 (5 Reviews Received)



Brief Summary of Project

The objective of this effort is to develop, integrate, test, and operate a longer-range (order 500 m) active acoustic monitoring (AAM) system for MHK and other offshore renewable energy projects, and specifically for monitoring the region ahead of a tidal turbine. This system will be based on the Swimmer Detection Sonar Network developed by SSI under support from the U.S. Navy. Several SDSN nodes will be deployed and integrated with ORPC's TidGen™ prototype in Cobscook Bay.

The goal at the conclusion of this project is to have a complete acoustic monitoring system design, to have fully demonstrated the system in a prototype deployment that is integrated with an MHK system, and be able to make it generally available to the MHK and offshore renewable power industry through a commercialization effort.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- Technology is applicable to various MHK devices (e.g., wave or tidal).
- Good alignment with DOE goals.
- Is planning ahead with regard to permitting requirements.
- This effort will be helpful in resolving marine species interaction questions and overcoming specific and real regulatory barriers under the ESA and MMPA.
- Good adaptation of existing technology for MHK projects.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- A good non-intrusive technology.
- Not fully clear what the other technology options are?
- Builds on existing knowledge and approach by U.S. Navy.
- Sensible repurposing of an existing technology.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- Some progress has been made but schedule has already slipped; recommend regular check-ins.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.1** for technology transfer and collaboration.

- It what not clear what collaboration and transfer plans they have.
- Excellent use of SSI's US Navy-funded R&D.

Question 5: Proposed future research

This project was rated **3.4** for proposed future work.

- It what not clear what future plans they have.

Strengths and weaknesses

Strengths

- Very applicable to multiple facets of this industry.
- Good re-purposing of DOD technologies for adaptation for MHK.

Weaknesses

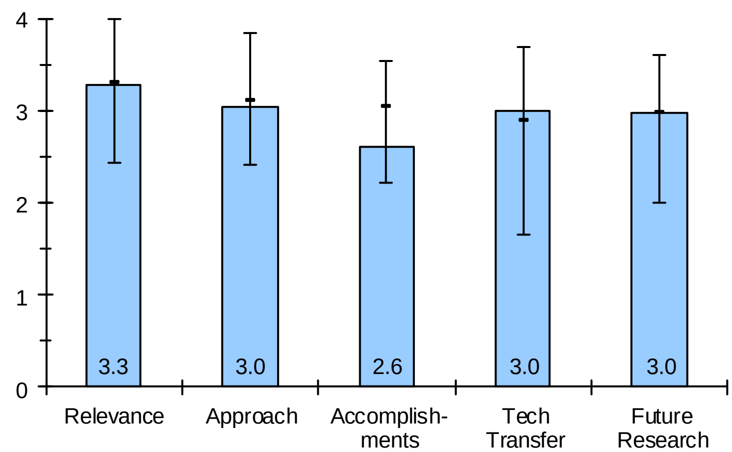
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Active Acoustic Deterrence of Migratory Whales
Justin Klure and Steven Kopf; Pacific Energy Ventures (PEV)

Overall Project Score: 2.9 (5 Reviews Received)



Brief Summary of Project

The Project Objective is to test the effectiveness of an acoustic deterrent mechanism in deflecting migratory gray whales around wave energy structures.

Final Product: Report documenting behavioral response to an acoustic signal which has been designed to encourage whales to slightly adjust their migration route.

Who Benefits: USDOE, project developers, research community, marine spatial planners, project stakeholders, and the aquatic resources – the whale.

Success of this Project: Will advance the industry by demonstrating a mitigation strategy if whale entanglement proves to be a significant potential project effect.

Challenges This Project Addresses: Provides a low-cost, robust method to allow projects to be sited in migration corridors.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Why is this new technology being designed versus redesigning existing technology (such as pingers)? This wasn't made clear.
- A good project in full alignment with the WPP.
- Understanding methods that can be used to deter whales or mammals is important for meeting DOE objective and industry needs.
- Marine mammal acoustic impacts and deterrence studies like this are needed to anticipate and overcome specific and real regulatory hurdles.
- Potentially high visibility issue that is important to the MHK industry.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- A very well planned project.
- Had delay for one year due to equipment issues.

- Approach used may be overly simplistic.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.6** based on accomplishments.

- Due to permit delays, results are still pending.
- Excellent achievements to date Delays in schedule but will deploy January 2011.
- Project has experienced both regulatory permitting and technical challenges. Recommend close monitoring to ensure project moves forward on a revised schedule.
- Few results as of 11/4/11.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.0** for technology transfer and collaboration.

- Inclusion of Dr. Mate/OSU.
- Very good links with regulators.
- This section of the PI's presentation appeared incomplete.

Question 5: Proposed future research

This project was rated **3.0** for proposed future work.

- Not fully clear what the future research will be.
- Monitoring of success of noise and types of noise emissions.
- Good recovery from a technical failure of the 1st test device.

Strengths and weaknesses

Strengths

- A strong academic team member.
- An excellent risk mitigation project for the entire sector.
- Looking at an important issue all marine energy projects will have to deal with.

Weaknesses

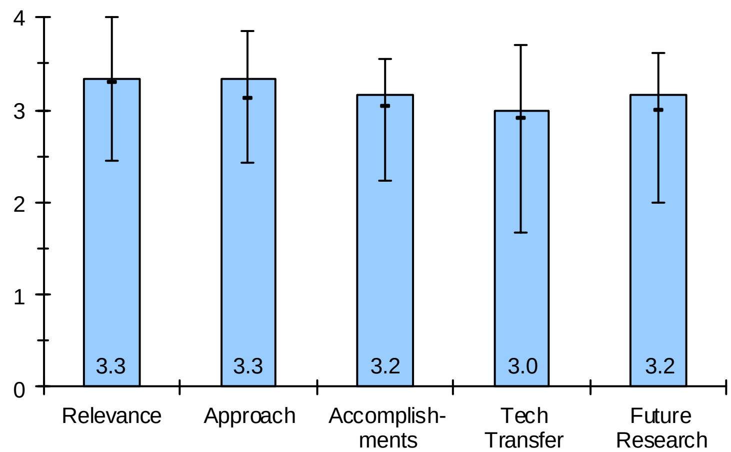
- New methodology, but isn't there a deterrence methods already in place that can be utilized already by the fishing industry (e.g., pingers on gill nets) that can be modified?
- Limited information on why there were permit delays and why an EA was required for the deployment of this single mooring device.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Benchmark Modeling of the Near-field and Far-field Wave Effects of Wave Energy Arrays *Ken Rhinefrank; Columbia Power Technologies*

Overall Project Score: 3.2 (5 Reviews Received)



<u>Brief Summary of Project</u>

This project performs benchmark laboratory experiments and numerical modeling of the near-field and far-field impacts of wave scattering from an array of wave energy devices.

Specific project objectives are to:

a. Carry out laboratory experiments (1:33 scale) on near-field and far-field effects of wave scattering from an array of wave energy converters, lab observations will include both in-situ and remote video data.
b. Analyze in-situ wave and current observations and wave image sequences from 3D video in order to measure constructive/destructive wave interference patterns and 3D motion response of individual devices.
c. Analyze the effect of array configuration on the far-field waves.
d. Analyze device power response (shaft power measurements) in response to wave forcing and its dependence on array design. Shaft power is measured based on a known applied drive shaft damping and the recording of motion capture data to compute speed, torque and power absorbed by each WEC.
e. Develop and test phase-resolving near-shore wave model for simulating near-field wave scattering and far-field waves and wave-driven currents

The expected outcomes of this project are 1) Collection of a benchmark data set for testing numerical models of wave-structure interaction, 2) development of a predictive understanding of the effects of an array of wave energy converters on the wave conditions, and 3) a methodology for estimating the potential for arrays of wave energy converters to change the near-shore current and sediment transport patterns.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.3** for its relevance to DOE objectives.

- Good alignment with WPP objectives.
- This program takes us a step closer to understanding potential effects of WECs on near shore current and sediment transport, which are critical regulatory issues that must be addressed.
- Numeric modeling of MHK array impacts.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- A well planned project.
- Used condensed array for most conservative results.
- Highly theoretical approach in modeling array effects.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- Good results to date.
- Good solid lab data and modeling using the SWAN output.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.0** for technology transfer and collaboration.

- Not clear how the collaboration is being dealt with.
- Coordinating with SANDIA, OWET, etc.
- The PI seems to have close coordination with the MHK industry and researchers.

Question 5: Proposed future research

This project was rated **3.2** for proposed future work.

- Excellent ideas for next stage inquiries: different distances between buoys; effect on sediment transfer.

Strengths and weaknesses

Strengths

- NA

Weaknesses

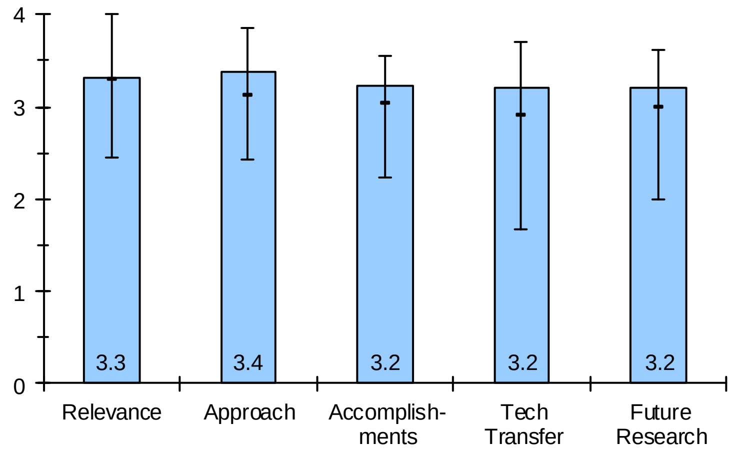
- There is danger that this work overlaps with the Sandia array work.
- Not clear what their future plans are.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Environmental Effects of Sediment Transport Alteration and Impacts on Protected Species *Stephen Barrett; Harris Miller, Miller & Hanson Inc.*

Overall Project Score: 3.3 (5 Reviews Received)



<u>Brief Summary of Project</u>

The major objective of this project is to collect and analyze data on two fundamental areas of the marine environment to advance the conceptual development and permitting of a pilot scale marine hydrokinetic project. Outreach and communication to regulatory agencies and stakeholder interest groups was a central component running throughout the project that contributed to the overall permitting objectives. The work associated with this grant supported the filing of a Draft License Application with the Federal Energy Regulatory Commission (FERC) and provided information for scoping work necessary to file a Final License Application. The Town of Edgartown, holder of the FERC Preliminary Permit for Muskeget Channel, is the primary beneficiary of the project as the work allows for the advancement of the Town's licensing process for the pilot marine hydrokinetic project. The research also provides site specific empirical information on existing benthic habitats and protected species to help guide future environmental impact assessments in those areas. In a broader context, the data collected will provide new information on sediment transport modeling useful for other marine hydrokinetic project applications.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.3** for its relevance to DOE objectives.

- A reasonable link to the WPP objectives.
- Environmental support to permit tidal project.
- Resource characterization.
- Good multi-stakeholder MHK project involving community partners.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **3.4** on its approach.

- Well design approach to gather baseline data.
- A well-planned project.
- The study rationale and approach appeared solid and pragmatic.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- Good results to date Draft License application.
- Resource characterization.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.2** for technology transfer and collaboration.

- A good collaboration between academic and community-based groups.
- Limited knowledge of device selection for this site selection.
- This work could have better links to the cost reference model.
- Potential for integration and collaboration as partners include universities.

Question 5: Proposed future research

This project was rated **3.2** for proposed future work.

- Clear future plans.
- Study appears >95% complete.

Strengths and weaknesses

Strengths

- Study appears to be on-time and under-budget.
- A good results oriented study in advance of possible project deployment.

Weaknesses

- NA

Specific recommendations for additions or deletions to the work scope

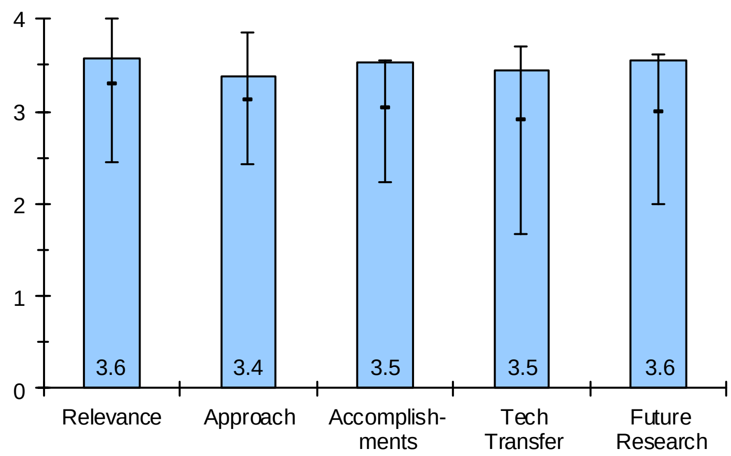
- NA

Project Name: OTEC resource assessment
Matt Ascari; Lockheed Martin Corporation

Brief Summary of Project

Interest in OTEC has a long history, and assessments of its potential have improved over the years. Still, these previous assessments are based on low resolution datasets and limited to the temperature differential between the ocean's surface and 1000 meters depth ($\Delta T1000m$). A thorough understanding of the available ocean thermal resource is necessary to establish effective OTEC and SWAC commercialization approaches and determine the potential impact (in terms of Giga Watts) on the energy market.

Overall Project Score: 3.5 (5 Reviews Received)



The Ocean Thermal Extractable Energy Visualization (OTEEV) project focuses on assessing the Maximum Practicably Extractable Energy (MPEE) from the Ocean Thermal resource. MPEE is defined as being sustainable and technically feasible, given today's state-of-the-art ocean energy technology and foreseeable future improvements. This project will develop a web based , publically accessible GIS mapping tool with overlays to present ocean thermal resource information including feasibility of grid connected OTEC plants, feasibility of energy carrier producing OTEC plants, feasibility of seawater air conditioning, net energy production from an OTEC plant, minimum OTEC plant spacing.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Provides a more definitive assessment of available worldwide resources for OTEC.
- A well planned project in full alignment with DOE objectives.
- Updated assessment modeling will advance industry and is helpful both to industry and policy makers in determining opportunities.
- Provides a deep ocean database for OTEC & SWAC developers.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- Good utility of web-based tool.
- Considered environmental parameters - do not want to exhaust cold water.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.5** based on accomplishments.

- NA

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.5** for technology transfer and collaboration.

- A good blend of private, academic, and national lab balance to the team.
- Good partnerships; hosted by NREL site.

Question 5: Proposed future research

This project was rated **3.6** for proposed future work.

- Potential areas of refinement identified for this model.
- Use same models, refine data as it arrives.
- The study was apparently complete.

Strengths and weaknesses

Strengths
- A distinct are of work with a clear remit and objectives.
- These types of resource data bases are very important to future OTEC developments.

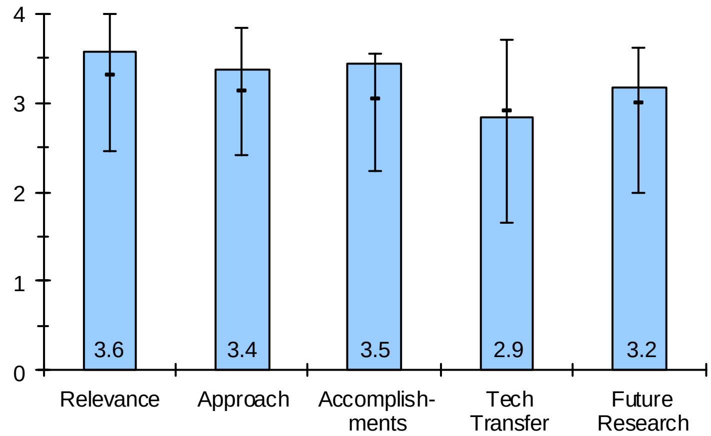
Weaknesses
- Appears expensive for the work they are doing.
- Given the current lack of operational OTEC projects analysis of deep-water resources could be somewhat premature.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Assessment of Energy Production Potential from Ocean Currents along the US Coastline *Dr. Kevin A. Haas; Georgia Institute of Technology*

Overall Project Score: 3.2 (5 Reviews Received)



Brief Summary of Project

The research program will advance the state of the art and market penetration in ocean current energy resource assessment via contributions on numerous topics.

The specific project objectives are as follows:

- Host an ocean currents workshop to assess and revise the project methodology.
- Develop the ocean current energy resource potential database.
- Use data to determine which model worked best for different regions.
- Create joint velocity and direction probability distributions.
- Develop a web based interface and GIS tools for dissemination of the data.
- Display GIS layers of the monthly and yearly mean and the 2% exceedance velocity.
- Provide probability distributions for the velocity and direction.
- Calculate the effective power using a specified number of turbines, efficiencies and dimensions.
- Perform an independent validation of the database.
- Compute the total theoretical available power.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Critical that this information is shared with other web-based resources.
- A well planned project in full alignment with DOE objectives.
- Assessment study of ocean current resources.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Starting with a workshop to get expert input on the model, and then revising the model, was a smart approach.
- The output from discussions with ocean circulation experts may be difficult to quantify and measure.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- NA

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.3** for technology transfer and collaboration.

- Web-based tool is an ideal tool to distribute GIS data.
- No international links.
- Publicly available web page that is user friendly.
- Apparently agreement around accuracy and spatially dense representations of the currents made agreement with industry peers challenging.

Question 5: Proposed future research

This project was rated **3.6** for proposed future work.

- Add additional data to refine in areas of high interest (Gulf Stream); add extraction impacts and determine how projects impact current.
- Beyond documentation of its findings this study appears to be complete.

Strengths and weaknesses

Strengths
- Good value.

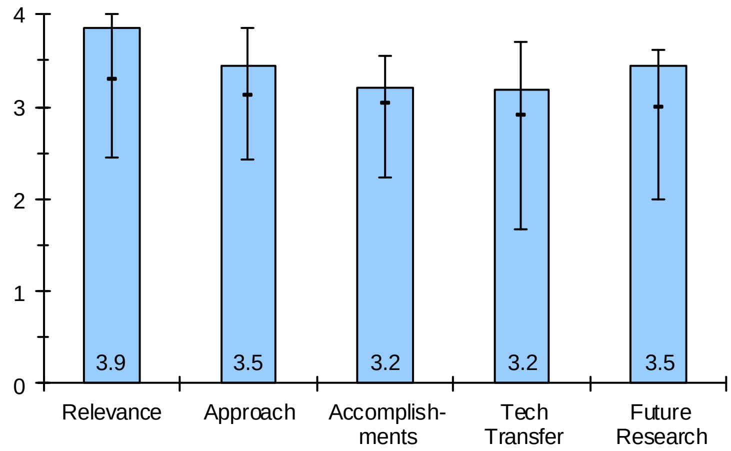
Weaknesses
- The Navy is doing something similar in the next couple of years. Will there be any overlap of information exchange?
- This would benefit significantly from international collaboration.
- Is this redundant with other ocean current assessments? How does this information help inform what FLA is doing?
- According to the PI this project addressed numerous topics employing a number of ocean current specialists which could limit the scientific value of the data.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: A First Assessment of U.S. In-Stream Hydrokinetic Energy Resources Since the 1986 NYU Study *Paul T. Jacobson; Electric Power Research Institute*

Overall Project Score: 3.3 (5 Reviews Received)



Brief Summary of Project

A comprehensive understanding of existing U.S. in-stream hydrokinetic resources is of critical importance to the acceleration of the market for emerging hydrokinetic technology. This project will dramatically improve the state of knowledge of the theoretical hydrokinetic resource and the technically extractable electrical energy from U.S. rivers and man-made channels. The final product will include a geospatial database, verified and validated by a third party, which displays power densities for specific geographic locations.

The expected users of this product include policymakers, project developers, hydrokinetic energy device developers, investors, universities, non-governmental organizations, environmental groups, the Department of Energy, the military, the U.S. Army Corps of Engineers, and the U.S. Geological Survey. The overall goal is to accelerate the process of our nation's serious investigation of whether in-stream hydrokinetic energy resources ought to be added to our national portfolio of energy supply alternatives. In order to make that determination, one of the needs is to assess the U.S. resource. Such an assessment requires analysis and synthesis of site-specific data that is of variable quality over broad geographic areas and was collected to meet other objectives. Furthermore, recovery of hydrokinetic energy is not a simple subtractive process; rather, recovery alters the available resource in complex ways that complicate assessment.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- An excellent and well planned project in full alignment with DOE objectives.
- A very timely update of in-stream MHK resources.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Included device developers in expert workshops; considered how extraction impacts resource.
- Good use of updated modeling tools to conduct a high level assessment of in-stream resource factors.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- Has met technological targets.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.2** for technology transfer and collaboration.

- Good that the device developers were involved in workshops.
- Coordinate with USGS re anomalies.
- EPRI provides a valuable education platform within the utility industry.

Question 5: Proposed future research

This project was rated **3.5** for proposed future work.

- Incorporating socio-economic information will support this database development.
- Address anomalies; more rigorous analysis in areas of high potential.
- The project study appears to be complete.

Strengths and weaknesses

Strengths
- The inclusion of federal agencies (USACE and USGS) in the Expert Workshop.
- Good resource assessment work.
- Unfortunately the PI was unable to collect more granular resource data suitable for potential project sitings.

Weaknesses
- This work really needs to show the "practical resource" to be fully useful.

Specific recommendations for additions or deletions to the work scope

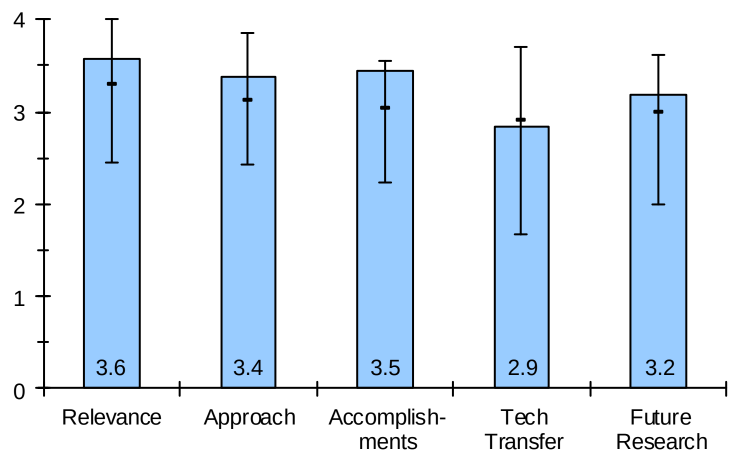
- NA

Project Name: Assessment of the Environmental Effects of Hydrokinetic Turbines on Fish: Desktop and Laboratory Flume Studies *Paul T. Jacobson; Electric Power Research Institute*

Brief Summary of Project

The objective of the project is to determine injury, survival rates and behavioral effects for fish passing through hydrokinetic turbines. Many new technologies are being evaluated both in the lab and the field, mainly for engineering and operational proof-of-concept testing, but some studies have begun to examine environmental impacts. As the number of experimental and permanent field applications increase, so will concerns with the effects of installation and operation on aquatic organisms.

Overall Project Score: 3.3 (5 Reviews Received)



Direct measurement of injury and survival rates in the field is technically challenging. Existing data from conventional hydropower has some applicability, as does theoretical modeling of strike probability and mortality; however, empirical studies of hydrokinetic-fish turbine interactions are also needed. Laboratory flume testing allows for highly controlled evaluations with the ability to closely monitor fish movements and behavior with underwater video systems and advanced radio telemetry techniques, and to recover and examine all fish that have passed through a turbine. Additionally, laboratory evaluations offer the ability to more readily change or examine a variety of test conditions (e.g., approach velocities, turbine operation parameters, and ambient light levels) and to test numerous species and size classes that may be of interest. The results of this project will be of value to policymakers, project and device developers, researchers, resource management agencies, regulators, and the interested public. The results will facilitate permitting and licensing of hydrokinetic projects by reducing uncertainty regarding the potential for adverse fish-hydrokinetic turbine interactions.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Provided a variation of species and age class.
- A well planned project in full alignment with DOE objectives.
- This is critical for many projects in setting expectations with fish agencies; reduces cost and uncertainty.
- As MHK technology is increasingly deployed this has the potential to become a highly visibility issue for the MHK industry.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- Inclusion of experience from the conventional hydrokinetic industry.

- Use of developer's device.
- Good to start with conventional hydro and go from there.
- Should have gotten NMFS and FWS buy in or input.
- The initial approach seems well reasoned and practical.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.5** based on accomplishments.

- NA

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.9** for technology transfer and collaboration.

- More work with NMFS and FWS on methodology needed.
- EPRI is a trusted industry resource.

Question 5: Proposed future research

This project was rated **3.2** for proposed future work.

- Look at different conditions, species.

Strengths and weaknesses

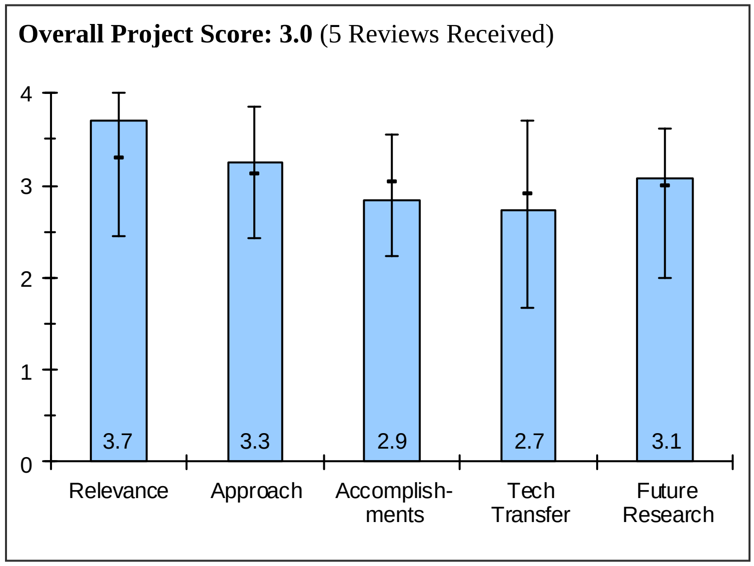
Strengths
- Using knowledge of traditional hydro experience.
- A good, realistic and practical piece of work.
- Good links with the regulators.
- Use of a well-respected Industry research organization for this type of resource interaction study.

Weaknesses
- It is not clear how they deal with scale.
- It is now clear how transferable the results are over a range of different turbines.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: OCGen™ Module Mooring Project
Jarlath McEntee; Ocean Renewable Power Company, LLC



Brief Summary of Project
The objectives of the OCGen™ Module Mooring Project (Project) are: 1) to design a standard mooring system for hydrokinetic devices that will be moored below the surface in reversing tidal environments; that will be environmentally friendly and economical due to the use of simple, standard components; and that can be deployed and recovered with watercraft at the water's surface; 2) to prove the technical and economic viability of this mooring system for fast-water applications; 3) to help resolve a technologically significant barrier to deployment; and 4) to provide the company and others with means to mature pre-commercial tidal electric-generating technology towards near-term commercial viability.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.7** for its relevance to DOE objectives.

- It was not clear as to how this study supports the goals of the Water Program (versus supports the goals of ORPC's own mooring challenges).
- A well planned project in full alignment with DOE objectives.
- Mooring issues are critical to advancing commercialization.
- This research has clear benefits to MHKE developers.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Well focused on mooring which is a critical issue for the sector.
- Good generally effective approach.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.9** based on accomplishments.

- Progress has been limited by permitting and site selection - working in Maine is not effective in winter.

- Good progress to date.
- Environmental reviews have led to delays, but need to keep on track.
- Good progress to date.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.7** for technology transfer and collaboration.

- Limited availability of information - others would need to seek out researchers for this information as oppose to being readily available in the public domain (e.g., via a website).
- They should join the TC114 TS on moorings.
- Virtually all results are technically public (all part of FERC docket), but otherwise not affirmatively disseminated.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- A good forward plan.
- Project timeline appears to be appropriate.

Strengths and weaknesses

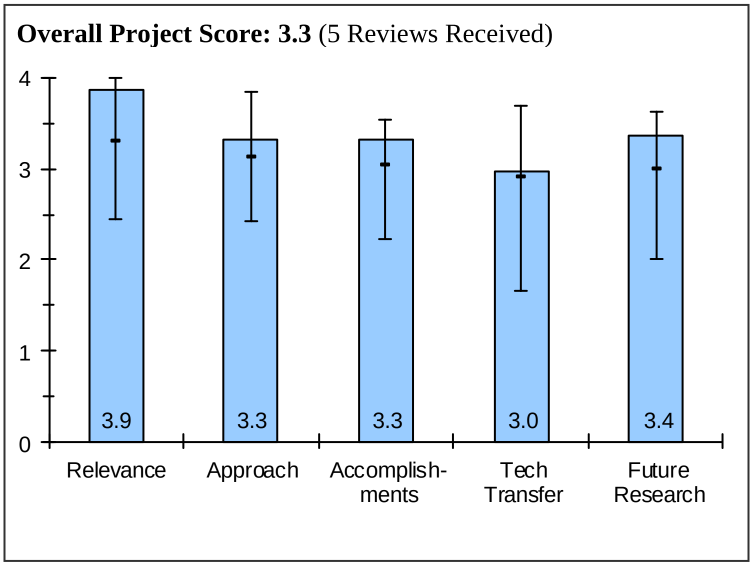
Strengths
- A high level concern for potential project developers.

Weaknesses
- It wasn't clear as to how this study would support the MHK industry as a whole - it would improve ORPC more so.
- There is not clear plan as to how this information would be readily available to the public.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: TidGen™ Power System Commercialization Project
Christopher R. Sauer; Ocean Renewable Power Company, LLC



Brief Summary of Project

The objective of Ocean Renewable Power Company's (ORPC) TidGen™ Power System Commercialization Project is to advance, demonstrate, and accelerate deployment of ORPC's hydrokinetic energy conversion technology, associated power electronics, and interconnection equipment within a replicable full-scale, interconnected array of devices capable of reliably delivering electricity to the domestic power grid. The Project will consist of designing, building, deploying and monitoring a commercial-scale array of five grid-connected TidGen™ devices on the sea floor in Cobscook Bay off Eastport/Lubec, Maine in two phases over three years.

Project benefits will include accelerated distribution of commercial hydrokinetic power systems for reliable and cost-competitive delivery of utility-scale electricity produced from hydrokinetic power systems developed, manufactured, and deployed by a U.S. company in U.S. waters, and successfully marketed and sold in U.S. and worldwide markets. ORPC has validated our Beta TidGen™ Power System, the largest ocean energy device in the U.S, by generating electricity at full design capacity through the full range of tidal current velocities encountered. As next steps, this Project will address the challenges of producing a full-scale, grid-connected, revenue-generating commercial tidal energy system that will reliably deliver electricity to the power grid.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- A strong step forward to moving this industry to a commercial stage.
- A well planned project in full alignment with DOE objectives.
- Need to get commercial projects with power to grid - this is money well spent.
- A grid connected project would be a significant milestone for the MHK Program.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Overall a thorough approach in developing environmental and engineering plans to move this project through the permitting process.

- This is a lot of money to spend on a 1st generation technology when will move to a moored system as in project 48.
- The approach used appears pragmatic and well-engineered.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Getting to final license application process is very significant.
- Timeline to licensing appears aggressive; even though FERC pilot process is supposed to be short, project proponents need to manage this process carefully to stay on track given other agency approvals required.
- Appropriate project milestones appear to have been met.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.0** for technology transfer and collaboration.

- Includes some regional experts when developing plans (biological) but lacks other for engineering.
- This project should link with the sound and sea foundation project.
- Publicly available but no affirmative effort to disseminate.
- Because of IP concerns the research integration from this study is somewhat constrained.

Question 5: Proposed future research

This project was rated **3.4** for proposed future work.

- Proposed timeline seems appropriate.

Strengths and weaknesses

Strengths

- An operational tidal wave project would create a real boost for the MHK industry.

Weaknesses

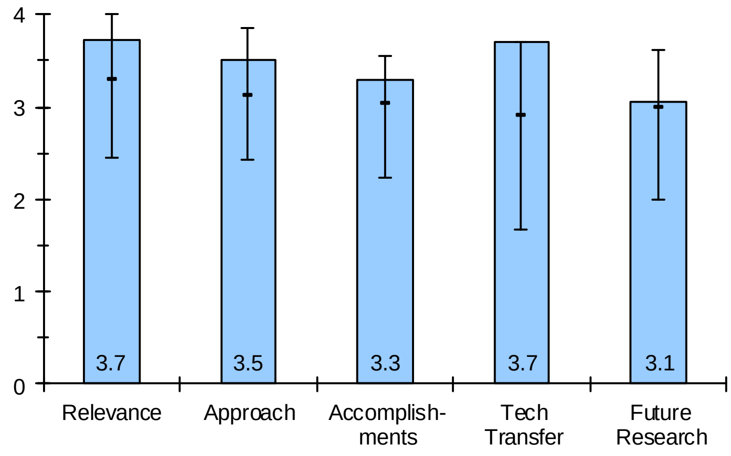
- This project should link with the sound and sea foundation project.
- This is a lot of money to spend on a 1st generation technology when will move to a moored system as in project 48.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Marine Energy Technology Advancement Partnership (METAP)
Karin Sinclair; Clean Energy States Alliance, Inc.

Overall Project Score: 3.4 (5 Reviews Received)



__Brief Summary of Project__

The high-level purpose of this project is to accelerate the overall pace of development and commercialization of marine renewable energy in the United States through the design of a strategic, collaborative approach between the state and federal sectors.

Key objectives of the project included:

- Identifying states or state institutions interested in accelerating the pace of development and deployment for the U.S. MHK industry.
- Coordinating information sharing and discussions of policy objectives between state and federal sectors.
- Developing a coordinated or joint proposed funding mechanism that would allow for federal-state cooperation on projects of joint interest, and plan for state/federal partnership to advance marine energy technology prototype projects.
- Evaluate and document the project as a prototype for how states and DOE/NREL can better align their renewable technology advancement goals and activities.

The final product of the project will be a framework for agreement between DOE and interested states, for collaboration and joint funding of MHK technology development projects. The final report will focus on the effectiveness of the METAP project for encouraging state-federal cooperation in expediting technology deployment, and its applicability to other technologies. Actual usage or implementation of such a framework will be dependent on funding and other policy considerations. States, DOE and the MHK industry would all benefit from such partnerships; if successful they would allow limited DOE and state funds to be jointly leveraged to support a greater number of advanced technology development projects than could have been funded by any individual party. Given the current tight fiscal conditions and limited public dollars, public investments for technologies should be coordinated strategically to make them go farther and create the most learning for the industry.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **3.7** for its relevance to DOE objectives.

- A well planned project in full alignment with DOE objectives.
- A great idea for project - fostering this collaboration is invaluable.
- Development of collaborative approach to meeting state and federal policies.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Appreciate the federal government extending out to the States for input to develop this industry.
- Not fully clear how this engages with work of OREC.
- Project PG CESA is well suited for this type of collaborative research involving multiple agencies.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Project PI appears to have used an effective approach to stakeholder involvement.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.7** for technology transfer and collaboration.

- According to the PI there has been a high level of coordination within the various regulatory organizations.

Question 5: Proposed future research

This project was rated **3.0** for proposed future work.

- Coordinate permitting reviews as well.
- An outstanding approach at outreach to the MHK stakeholder community.

Strengths and weaknesses

Strengths

- Excellent value for money.
- This is win win project.

Weaknesses

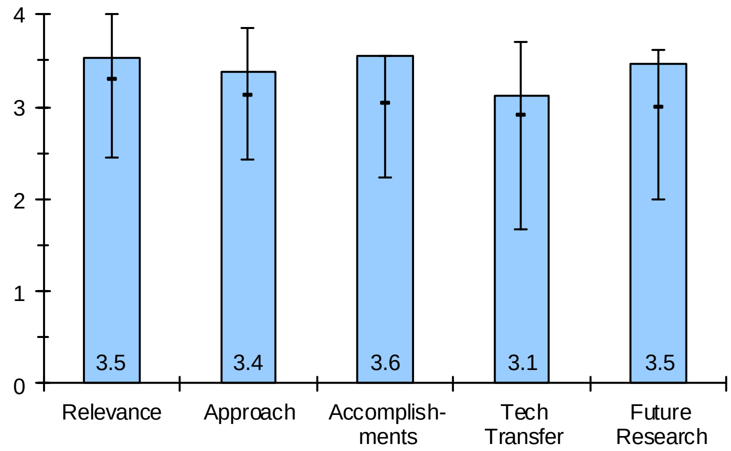
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Assessment of Energy Production Potential from Tidal Streams in the United States
Dr. Kevin A. Haas; Georgia Tech Research Corporation

Overall Project Score: 3.4 (5 Reviews Received)



Brief Summary of Project

Tidal streams are promising renewable energy sources due to their continuous, predictable and spatially-concentrated characteristics. However, the present lack of a full spatial-temporal assessment of tidal currents for the U.S. coastline is a barrier for estimating the national potential and exploitation of this resource effectively and efficiently. This project creates a national database of tidal stream power potential, as well as a Geographical Information System (GIS) tool usable by industry in order to accelerate the market for tidal energy conversion technology.

The original project objectives are as follows:

1. Utilize an advanced ocean circulation numerical model to predict tidal currents.
2. Compute the tidal harmonic constituents for the tidal velocities and water levels.
3. Validate the velocities and water levels predicted by the model with available data.
4. Build a GIS database of the tidal constituents.
5. Develop GIS tools for dissemination of the data.
6. Develop a web based interface for accessing the GIS database and using the GIS tools.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- A well planned project in full alignment with DOE objectives.
- Assessments are critical to showing market potential.
- A resource assessment somewhat similar to other DOE funded studies.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- Good generally effective research approach.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.6** based on accomplishments.

- Project completed - under budget and on time.
- A tracked high usage of the web-based tool.
- Completed.
- Limited study time frame may compromise data collection.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.1** for technology transfer and collaboration.

- There should be some collaboration between this work and the other resource work that is being undertaken.
- Collaborated with NOAA.
- Unclear to the extent which developers were consulted.
- Technology will be made public.
- Technology refinements to be used on ocean current site.
- Integration approach needs additional documentation.

Question 5: Proposed future research

This project was rated **3.5** for proposed future work.

- Refine results and provide more detailed modeling.
- Refinement at high energy sites; detailed measurements; extraction impacts.

Strengths and weaknesses

Strengths

- NA

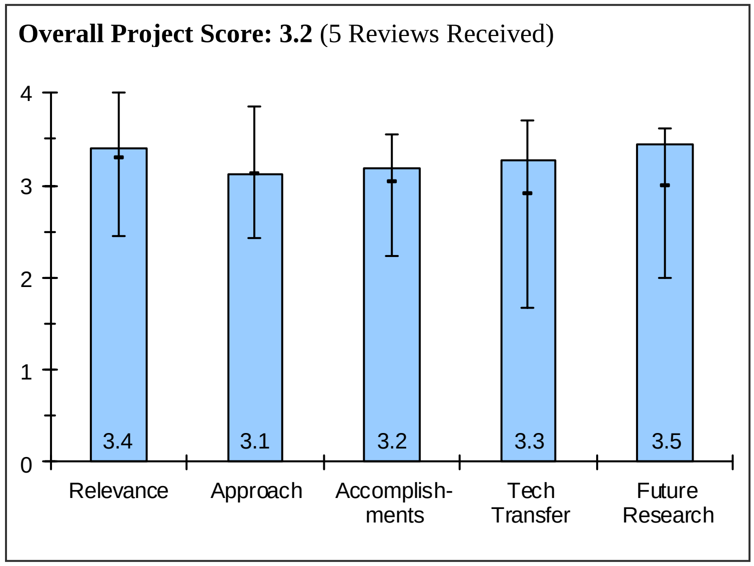
Weaknesses

- It has stopped short of giving a practical resource.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Wave Energy Resource Assessment and GIS Database for the U.S.
Paul T. Jacobson; Electric Power Research Institute



Brief Summary of Project

A comprehensive understanding of U.S. wave resources is of critical importance to accelerate development and commercialization of emerging wave energy technologies. This project estimates the total available and technically recoverable U.S. wave energy resources. Other project deliverables include a geospatial database, verified and validated by a third party, which displays annual and monthly average wave power densities and other sea state parameters for specific geographic coordinates, as well as an accessible data base of hindcast parameters archived at 3-hour intervals over a 51-month hindcast period for a 4-minute resolution grid in U.S. coastal waters. Expected users of this product include policymakers, project developers, wave energy device developers, investors, universities, non-governmental organizations, environmental groups, the Department of Energy, and the military. Policymakers will be able to use the deliverables from this project to characterize the total available and recoverable wave energy resources for the nation and by region and by state. The overall goal is to inform our nation's serious investigation of whether ocean wave energy resources should be added to our national portfolio of energy supply alternatives. Rigorous estimation of available and recoverable wave energy resources required extensive analysis and synthesis of wave hindcasts and measurements that were originally designed to meet other objectives.
synthesis of wave hindcasts and measurements that were originally designed to meet other objectives.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- A well planned project in full alignment with DOE objectives.
- Assessments are critical to showing market potential.
- Wave resource assessment study.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Uncertain why study was assessing 50 m or deeper while the majority of devices are situated in 50 m or shallower.
- This work does not deal well with shallow water.
- Assessed not only the resource but also the recoverable resource for same cost as other assessments.
- The research approach appears somewhat similar to other assessments.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- This work does not deal well with shallow water.
- According to the PI the study employed a method used by other MHK researchers.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.3** for technology transfer and collaboration.

- Publicly available on EPRI and DOE websites.
- Involved NOAA and others.
- Research integration efforts appeared to be good.

Question 5: Proposed future research

This project was rated **3.5** for proposed future work.

- Opportunity to work with multiple government agencies and incorporate data to build a more definitive picture.
- Longer hindcast; shallower water; near field effects of devices on wave propagation.
- According to the PI this research is essentially complete.

Strengths and weaknesses

Strengths

- Incorporated data from NOAA and working with them to develop a longer termed picture.
- Builds on the original EPRI wave study.
- It’s great they give numbers on the recoverable resource.

Weaknesses

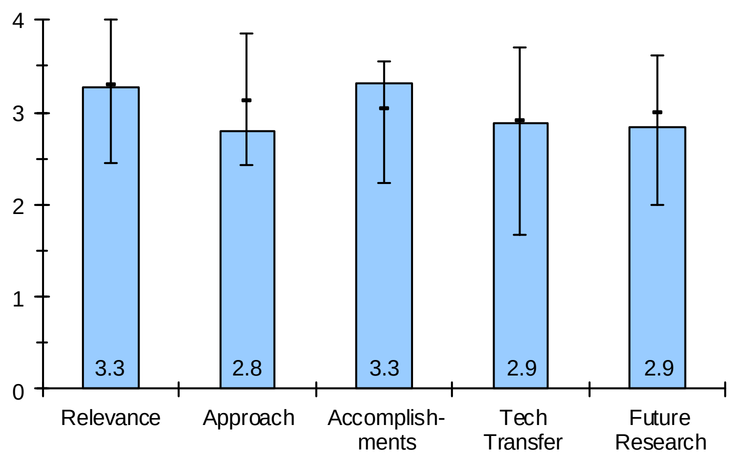
- Assessed 50 m or deeper however devices are typically in 50 m or shallower.
- This work does not deal well with shallow water.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Categorizing and Evaluating the Effects of Stressors (KMS and ERES)
Dr. Andrea Copping; Pacific Northwest National Laboratory (PNNL)

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

PNNL will develop a Knowledge Management System (Tethys) to organize, coordinate and analyze information from many sources, and to assess the value of the information. Tethys will be used in future to evaluate the impacts of multiple and cumulative stressors, and to set priorities for future research and development activities for the national labs, universities, and the DOE Waterpower program. A limited number of datasets will be collected to test the efficacy of the KMS.

PNNL will develop an Environmental Risk Evaluation System (ERES) to help determine the most significant environmental risks facing MHK installations and operations, for different technologies, under differing aquatic conditions. ERES examines planned and existing U.S. MHK projects to understand the interactions that are driving siting and permitting processes.

There is limited information available on the potential environmental effects of MHK development in U.S. waters, creating uncertainty in the siting and permitting of devices in coastal and riverine systems. While some information is available from Europe and elsewhere, U.S. regulators and stakeholders are requiring an enhanced understanding of potential effects before most pilot and commercial deployments and installations will be allowed to move forward. The work of PNNL and project partners will support the MHK industry and regulators by identifying the highest risks to the aquatic environment, making existing information readily available, and identifying key research needs and data gaps. Sharing this knowledge will shorten the time to permitting of early MHK installations and help establish a straightforward and routine permitting pathway in place for commercial array development.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Long-term this is a good approach, but in the early stages of this industry it might be more beneficial to support immediate studies that will get devices in the water and then implement this type of study later.
- A well planned project in full alignment with DOE objectives.
- A better understanding of the risks that are creating regulatory hurdles is key, but there appears to be redundancy between this effort and real in-water projects that have the potential to answer the questions rather than simply highlight them as a top risk.
- Analysis of risk-relevant environmental effects of MHK.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- Uncertain how this study differs from the approach already developed by FERC.
- This work may scare regulators by covering far too many things that may be affected.
- Very concerned about releasing data before experts have weight in on marine mammal encounters.
- The technical approach used and the ability to import data and items from a wide array of sources is outstanding.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- It was not clear who the primary and secondary end users are for this work.
- Need more up front scientific input.
- The beta release in April 2011, as well the high amount of web traffic, indicates significant progress.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.9** for technology transfer and collaboration.

- It was not clear who the primary and secondary end users are for this work.
- High public access and availability on PNNL website as well as webinars arranged through DOE.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- Proposed work plan with Tethys and ERES databases seems appropriate.

Strengths and weaknesses

Strengths
- Will become a predictive model as data becomes more readily available.
- Evaluation of key stressors important to financing of deployment of MHK technologies.

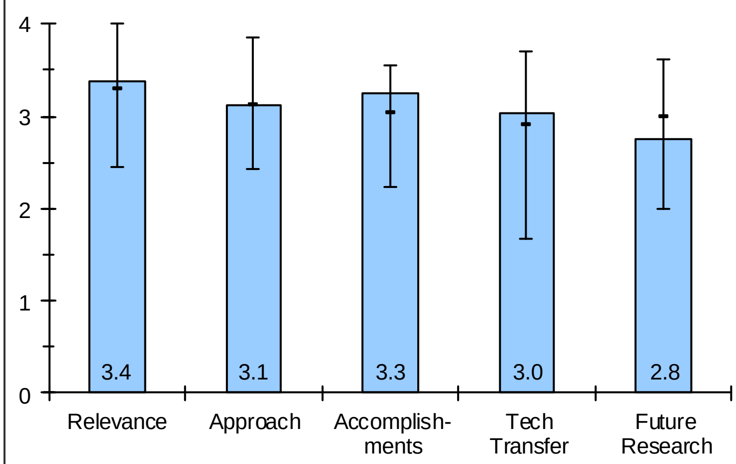
Weaknesses
- FERC has developed a similar process - it is unclear as to how this is different.
- Project appears to back-up conclusions already drawn in other studies previously conducted.
- This work may scare regulators by covering far too many things that may be affected.
- The MHK industry should not be used as an excuse to do research simply because it is interesting
- This is a very expensive project.
- Not clear how this will be used in real projects to advance them.
- Concerned that this will be cited as identifying real risks, when it is simply prioritizing based on information needs.
- Relatively high cost research.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Annex IV: Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal, and Current Energy Systems
Dr. Andrea Copping; Pacific Northwest National Laboratory (PNNL) and Hoyt Battey; U.S. Department of Energy Water Power Program

Overall Project Score: 3.1 (5 Reviews Received)



Brief Summary of Project

A wide range of different ocean energy technologies and devices are currently in development around the world, but the few data that exist on the possible environmental impacts of these technologies are often scarce and expensive to collect and dispersed amongst different countries and developers. These environmental data are a critical component to the permitting and siting of Marine and Hydrokinetic (MHK) projects and are required for the successful advancement of the MHK industry. The purpose of this project is to facilitate the exchange and assessment of ocean energy project information and experience from participating member countries in order to foster a better understanding and accelerate the development of ocean energy technologies. The objectives of this project are to: (1) expand knowledge of environmental effects and monitoring methods; (2) increase accessibility of information; (3) make available proven mitigation strategies; and (4) foster efficient and timely government oversight and public acceptance. The final product of this international collaboration will be a keyword-searchable, publicly available database of monitoring information to be used to evaluate environmental effects, housed within Pacific Northwest National Laboratory's Knowledge Management System, Tethys. The creation of an internationally accessible, comprehensive database on environmental impacts of MHK devices will provide industry members, regulators, researchers, and other stakeholders with an effective tool to assist in the siting, monitoring, and mitigation decisions of MHK projects. Members of the MHK community see the Annex IV database as a tool for developers to communicate with regulators to meet environmental regulations and to facilitate the permitting process.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Incorporating international data sets into the learning.
- A well planned project in full alignment with DOE objectives.
- Searchable database will help advance study, permitting and analysis stages.
- Development of a searchable database of environmental monitoring data to assist in evaluation of MHK projects.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Disagree that database should be limited to information developed in MHK projects only; analogous projects and studies can be very useful in estimating potential noise, EMF and other effects.
- Approach and targeted LCOE are focused and clear.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- According to the PI the project has had to deemphasize a portion of its collection efforts to focus on MHK project specifics.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.0** for technology transfer and collaboration.

- Included an international group to develop this along with US agencies FERC, BOEM, and DOE
- Very good international engagement.
- Good links with regulators.
- Need to be comprehensive; otherwise this will be used to show there is little data and slow commercialization.
- Revisions to data collection efforts have postponed the study and moved out its deadline.

Question 5: Proposed future research

This project was rated **2.8** for proposed future work.

- Look to continue to build this database.
- Not fully clear how this will continue after the annex ends.
- Apparently there have been challenges involved with collection of study data, resulting in delays in completion.

Strengths and weaknesses

Strengths
- Drawing on international experience.
- A good way to leverage existing MHK data to include international information sources.

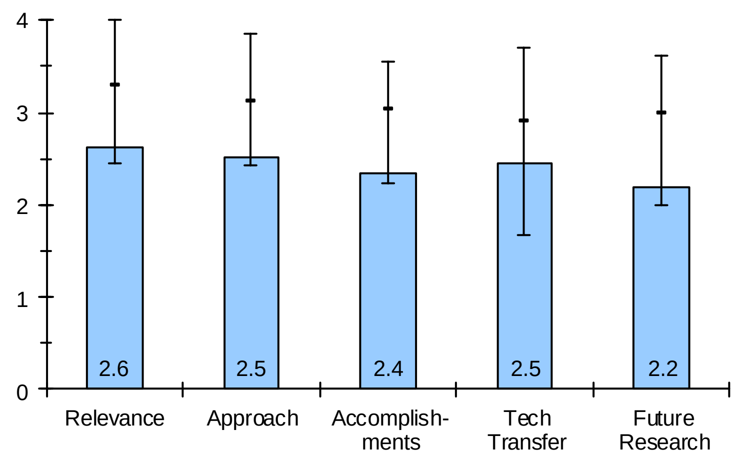
Weaknesses
- There have been a number of MHK environmental monitoring and data collection studies funded by the DOE several of which may have been aggregated into one or two larger research projects.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Categorizing and Evaluating the Effects of Stressors (all Conceptual Model work)
Ihor Hlohowskyj; Argonne National Laboratory (ANL)

Overall Project Score: 2.4 (5 Reviews Received)



Brief Summary of Project

Uncertainty on the part of stakeholders concerning the potential ecological effects of MHK developments has slowed the pace of field deployments of MHK technologies. The objectives of this project are to initiate an environmental risk assessment that that can be used in environmental impact assessments specific to MHK projects. The risk assessment will aid developers in meeting National Environmental Policy Act requirements by addressing the concerns of regulatory and management agencies. The risk analysis will evaluate potential stressors associated with single MHK device deployments, MHK arrays, and the interaction of the MHK device with existing impacts from other non-MHK anthropogenic stressors.

The risk analysis will be summarized in the form of conceptual models (CM) that diagrammatically display MHK stressor-biological receptor linkages and the associated potential impacts. The CMs identify the highest risk impacts that will likely require mitigation and identify data gaps that need to be investigated to reduce uncertainty in the risk and impact analysis. The CM's are part of scientifically-defensible environmental analyses that will address regulatory and permitting concerns, and support developers, regulators and other stakeholders in the approval, siting, design, construction, and operation of MHK projects.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.6** for its relevance to DOE objectives.

- The aim is to support NEPA requirements, but it is difficult to see how this will benefit those writing NEPA documents.
- A well planned project in full alignment with DOE objectives.
- NEPA is clearly a significant hurdle and was mentioned by several presenters as a source of delay. However, I am concerned that this is simply going to chronicle possible risks without resolving the questions raised by those risks, which ultimately is not helpful.
- Collection of NEPA focused risk assessment data.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- It is uncertain as to how this study will aid developers to meet NEPA requirements. Researcher shows a lack of knowledge of NEPA and the regulatory community to design a tool such as this.
- I appreciate the approach of using the EPA assessment format and thus working within the anticipated NEPA framework.
- I am concerned though that there is insufficient data to inform this effort, and that it will result in raising more questions (or seeming to give credibility to questions) without answering them.
- Certainly a cumulative impacts analysis seems very premature.
- The development of a conceptual model for diagramming ecosystem stressors would appear a general effective approach.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.4** based on accomplishments.

- This tool does not add to what is already known and already requested for by regulatory agencies, such as FERC.
- Progress to-date is somewhat unclear awaiting analysis by the PI.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.5** for technology transfer and collaboration.

- This appears to be a study developed by those that have not written by a NEPA document.
- Although this seems a good project is not clear how this links with work at other labs and this is a real concern.
- Integration efforts appear to be good.

Question 5: Proposed future research

This project was rated **2.2** for proposed future work.

- Delay in risk analysis as well as inconclusive monitoring data and the lack of operational MHK projects create some risk concerning project completion.

Strengths and weaknesses

Strengths

- NA

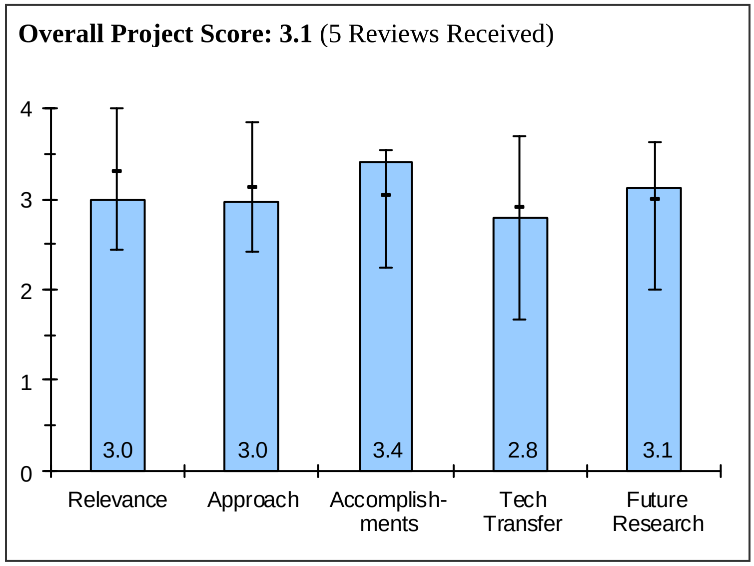
Weaknesses

- This does not appear to support the development of the MHK industry nor support those that would write NEPA documents.
- It appears that this project anticipated that there would be more data available than there clearly is.
- Rather than chronicling risks, DOE should focus on funding efforts to close data gaps, reduce uncertainties, and disprove risks or better quantify them.
- This metadata risk assessment collection study appears to an area of significant interest to the DOE; however aggregation an integration of these large research studies may yield significant economies of scale.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Tools and Methods to Measure and Predict Environmental Impacts
Jesse Roberts; Sandia National Laboratories



Brief Summary of Project

The marine and hydrokinetic (MHK) industry in the United States faces challenges associated with siting, permitting, construction, and operation of pilot- and full-scale facilities that must be addressed to accelerate the environmentally sound deployment of these renewable energy technologies. Little is known about the potential effects of MHK device operation in coastal areas, estuaries, or rivers, or of the cumulative impacts of these devices on aquatic ecosystems over years or decades of operation. This lack of knowledge affects the actions of regulatory agencies, the opinions of stakeholder groups, and the commitment of energy project developers and investors. There is an urgent need for practical, accessible tools and peer-reviewed publications to help industry and regulators evaluate environmental impacts and mitigation measures and to establish best siting and design practices.

The overarching objective of this work is to carry out targeted projects and strategic activities to understand, avoid, and mitigate regulatory and ecological risk associated with deployment of MHK systems. SNL's focus is on the assessment of changes to the physical environment (i.e. currents, waves, sediments, and water quality) potentially incurred through operation of various types of MHK devices and arrays of devices in marine and riverine environments. SNL is also investigating the potential noise spectrum emitted from a representative MHK turbine.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.0** for its relevance to DOE objectives.

- A well planned project in full alignment with DOE objectives.
- This project casts a wide net in an effort to understand and predict flow and noise impacts in ocean, tidal and river systems. While noise and flow impacts will become more and more important as the industry gets to commercial-scale developments, it is not clear that the results of this project will be useful to industry pioneers in getting initial projects in the water, which is critical to achieving DOE's goals.
- Collection of basic risk assessment information needed to advance the MH sector.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- I am concerned that this information is being collected with little reference to the specific regulatory hurdles that real in-water projects are experiencing.
- Like the previous studies conducted by national research labs this appears to be an all-inclusive metadata collection study.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.4** based on accomplishments.

- Research approach appears sound.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- Seek out collaborating with others that are not listed as partners to avoid duplication of research (e.g., with working in Hawaii consult U of HI investigators).
- Although this seems a good project is not clear how this links with work at other labs and this is a real concern.
- Good collaboration with other labs to feed info to them on fish/aquatics.
- SNL's research integration efforts appear to be appropriate.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- Field data collection from operational MHK projects (if successful) would significantly increase the value of this research to the development community.

Strengths and weaknesses

Strengths

- Utilizing experts in relevant industries - e.g., Navy for acoustic modeling.
- Data collection from operational projects.

Weaknesses

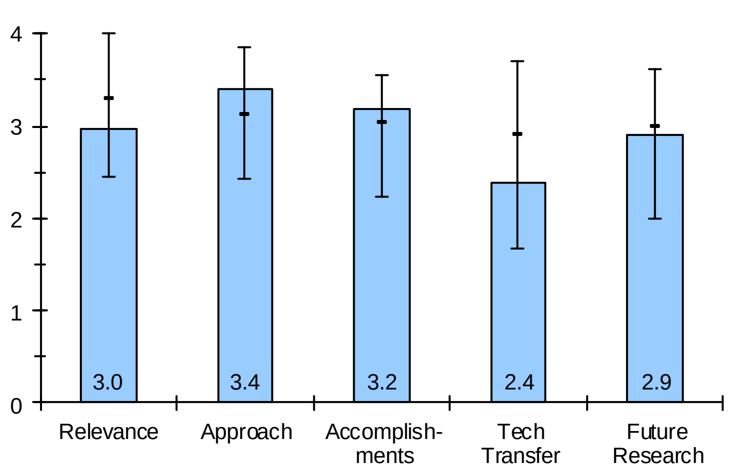
- With limited funds and time, we should focus instead on specific projects and their specific technical and regulatory hurdles.
- One of numerous MHK metadata collection and analysis studies funded by the DOE.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.2 – Effects on Physical Systems *Andrea Copping; Pacific Northwest National Laboratory (PNNL)*

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

To purpose of this project is to accelerate the development of in-stream energy in U.S. coastal waters, accurate assessment of resource characterization and effects of MHK devices on physical systems are needed. While field observation data of MHK devices are sparse, high resolution numerical models for simulating in-stream energy removal and its effects on physical systems become essential. Furthermore, validated models can also provide guidance for device siting and permitting processes, at both pilot and commercial scales. Rich model results at broad spatial and temporal scales will help us reduce the uncertainties in resource characterization and enhance our understanding the level of impacts on marine environments. Numerical modeling of MHK development is an important tool for filling the knowledge gap between observation and theoretical analysis.

The overall objective of this study is to develop an MHK model for the assessment of in-stream resource characterization and effects on physical systems. Specifically, an MHK model will be developed validated in a tidal system, and applied to simulate the effects of deployment of MHK devices on velocity distribution, volume flux and flushing time. Further model application will be conducted to assess the MHK effects on water quality/sediment transport and provide general guidance for device siting.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.0** for its relevance to DOE objectives.

- A well planned project in full alignment with DOE objectives.
- This information should be helpful over the long term, but it does not advance getting projects in the water which should be the top priority for DOE in the near term.
- Another MHK resource assessment and characterization study.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- Research approach appears logical and generally effective.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.2** based on accomplishments.

- According to the presentation progress on this study has been significant.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.4** for technology transfer and collaboration.

- Although this seems a good project is not clear how this links with work at other labs (particularly the SNL array work) and this is a real concern.
- Research integration efforts appear to be somewhat poorly documented and appear to be fair.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- The PI suggests development of data sharing networks along with collaboration efforts with other industry and research organizations.

Strengths and weaknesses

Strengths

- Supplements early-stage MHK data sets for prospective developers.

Weaknesses

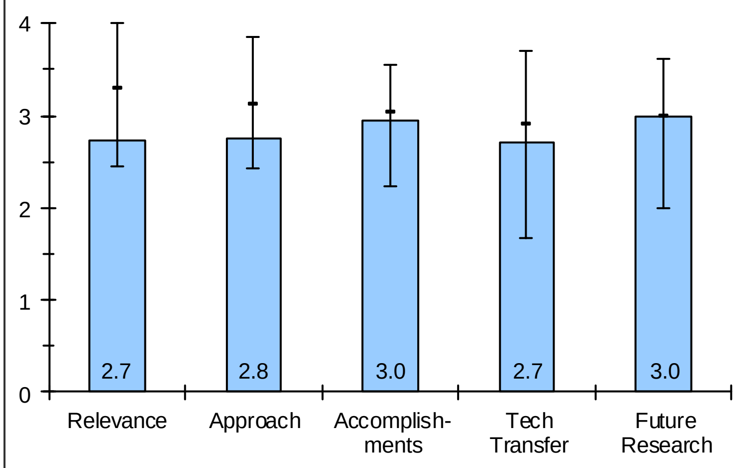
- Uncertain as to how this study feeds into the large National Lab projects run by NREL, SNL, etc.
- Another relatively expensive research project conducted by large national lab which could benefit from aggregation into large comprehensive research projects.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Acoustics, Toxicity, Benthic Habitat Alteration
Dr. Mark Bevelhimer and Dr. Glenn Cada; Oak Ridge National Laboratory

Overall Project Score: 2.9 (5 Reviews Received)



Brief Summary of Project

Knowledge gap: Poor understanding of effects of MHK noise on health and behavior of aquatic organisms. Regulatory agencies require assurance that noise from construction and operation will not adversely affect aquatic animals.

Programmatic goal: Reduce the regulatory costs, time, and potential environmental impacts associated with developing, siting, permitting, and deploying MHK systems.

Project objectives: Determine levels of acoustic output from MHK devices relative to other noise sources and response thresholds of aquatic animals. Develop assessment methods for studying effects of acoustics on a variety of freshwater organisms.

Subtask integration: The results of this task will be incorporated into the risk assessments of Argonne National Laboratory (ANL) and the Pacific Northwest National Laboratory (PNNL).

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.7** for its relevance to DOE objectives.

- Needs to be a more MHK-specific approach.
- Only some of the work is full alignment with the WPP.
- This will be relevant to NEPA and cumulative impacts, but is not needed to get initial projects through the valley of death.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- The acoustic component of this study will be useful for industry.
- There work on toxicity seem to simply be because they have the capability - not because it it's a specific priority of the MHK sector.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- NA

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.7** for technology transfer and collaboration.

- There seems to be duplication with SNL work in this area.
- Appears to be significant overlap with partners.

Question 5: Proposed future research

This project was rated **3.0** for proposed future work.

- NA

Strengths and weaknesses

Strengths

- A significant data gap in the MHK industry is a devices noise signature and its potential effect on the surrounding environment.

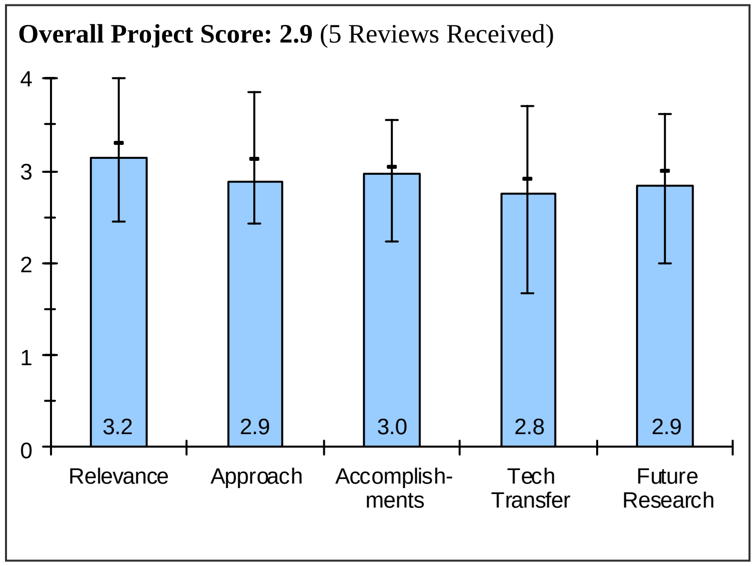
Weaknesses

- Studying effects for the sake of studying. Toxicity has been assessed by other offshore industries (shipping, Navy, oil and gas etc.). This is not MHK-specific.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework - Direct Effects on Aquatic Animals *Dr. Andrea Copping; Pacific Northwest National Laboratory (PNNL)*



Brief Summary of Project

This project examines the direct effects of MHK devices on aquatic organisms, with a focus on effects associated with exposure to electromagnetic fields (EMF) and acoustics/noise. The project team has also conducted a literature review and limited case studies to better understand the potential effects of the physical presence of the devices on marine mammal, fish, and invertebrate communities. Because so little is known about the potential effects of EMF and sound from MHK devices, there is significant regulatory uncertainty that may influence the cost and timelines of emerging MHK projects. To address these concerns, the project team is conducting a series of laboratory experiments with species of ecological, commercial, and recreational value to better understand whether adverse effects are likely, and to propose mitigation if they are observed. By working collaboratively with both industry and regulatory agencies to assess effects and reduce uncertainty, we are addressing this potential barrier to MHK device permitting and operation.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Although this is good work I am not convinced it can't be transferred from other sectors, i.e. offshore wind.
- These experiments are key to closing data gaps and meeting regulatory information standards.
- Part of the basic acoustic research protocols needed to further MHK.

Question 2: Approach to performing the research and development

This project was rated **2.9** on its approach.

- Targeting relevant species.
- Good to see lab soliciting industry input.
- There is a large body of literature on the effects of noise on fish - uncertain what this study would add to this.
- Research approach is somewhat similar to that conducted by other national labs located on the west coast.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Collaborating with NMFS.
- Progress to date has apparently been good.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- Although this seems a good project is not clear how this links with work at other labs and this is a real concern.
- While Oakridge National Labs may not be typically associated with MHK research, integration efforts appear to be good.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- Positive - directing future studies to assess specific species that could potentially be impacted (e.g., lobster or elasmobranchs).
- Future research proposed by the PI appears similar to other ongoing research at other locations.

Strengths and weaknesses

Strengths
- Limited knowledge on effects of EMF to many species - this will help.
- Very thorough - but may be overkill.

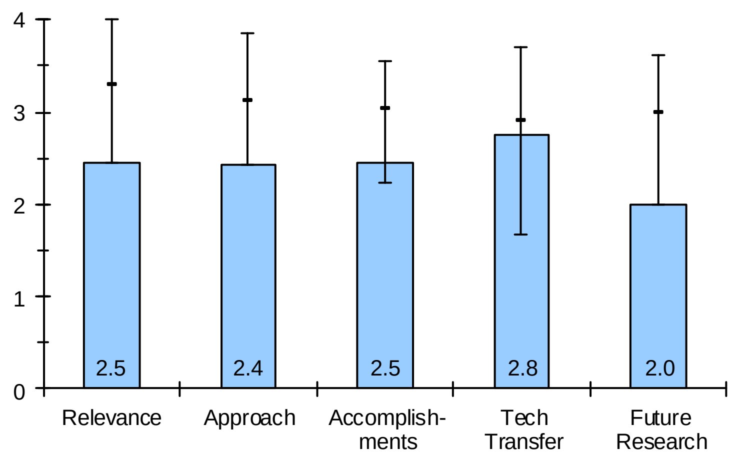
Weaknesses
- Uncertain as to what the acoustic study will add to the already large body of literature on this subject
- Given the benefit to offshore energy more generally, perhaps this should be funded in part through DOE's wind program.
- This research appears very similar to research efforts currently carried out by SNL and PNNL.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Identification, Analysis, and Prediction of Environmental Impacts from Marine and Hydrokinetic Energy Production Using a Risk Informed Framework – Task 2.1.7: Permitting and Planning *Dr. Andrea Copping and Simon Geerlofs; Pacific Northwest National Laboratory (PNNL)*

Overall Project Score: 2.4 (5 Reviews Received)



__Brief Summary of Project__

Objectives for Task 2.1.7 are the following: (1) to work with stakeholders to streamline the MHK regulatory permitting process, (2) to work with stakeholders to gather information on needs and priorities for environmental assessment of MHK development, (3) to communicate research findings and directions to the MHK industry and stakeholders, (4) to engage in spatial planning processes in order to further the development of the MHK industry. Task objectives are met through three subtasks, each representing a distinct area of effort: 2.1.7.1—Regulatory Assistance, 2.1.7.2—Stakeholder Outreach, 2.1.7.3—Coastal and Marine Spatial Planning.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **2.5** for its relevance to DOE objectives.

- Overall, this study does not appear to add anything new to the knowledge base of the regulatory/permitting approach to getting MHK devices into the water.
- A well planned project in full alignment with DOE objectives.
- The presenter acknowledged that the purpose of this effort is to communicate with stakeholders on the process, devices and impacts, and that "nothing new" was learned, i.e., the results were as anticipated. Although the written materials state that the purpose is to find ways to streamline the permitting process, on questioning the presenter stated that this program does not include a streamlining effort, and there will be no concrete recommendations to change any process.
- Research to streamline regulatory permitting processes and environmental assessment of MHK project impacts.

__Question 2: Approach to performing the research and development__

This project was rated **2.4** on its approach.

- Approach appears very similar to other studies being conducted by SNL, ONL and PNNL.

__Question 3: Technical accomplishments and progress toward project and DOE goals__

This project was rated **2.5** based on accomplishments.

- Progress to date has been fair.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.8** for technology transfer and collaboration.

- Positive - Teamed with Pacific Energy Ventures (PEV) to support with this study.
- Integration efforts to-date were speculative and unclear.

Question 5: Proposed future research

This project was rated **2.0** for proposed future work.

- PI indicates that researchers were unable to complete study milestones on time.

Strengths and weaknesses

Strengths

- A great educational tool for the sector.

Weaknesses

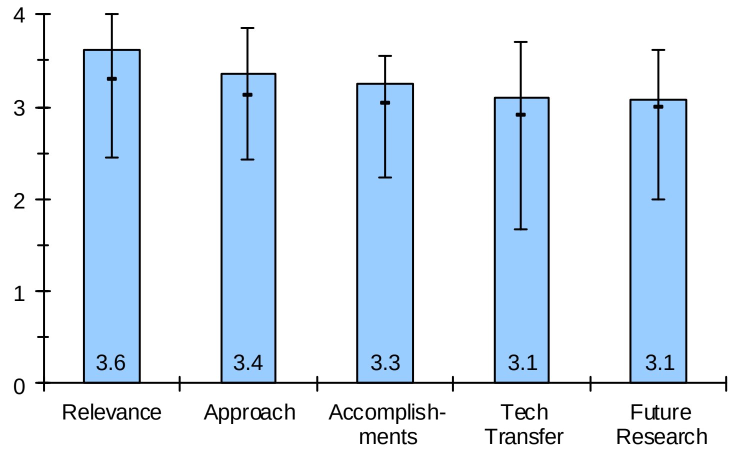
- This project is not adding any new information to the overall permitting/regulatory approach.
- A regulatory/permitting study completed by a National Lab - a group that is not involved in this aspect of the industry.
- It's not clear that PNNL are the best people to run this tool.
- This research study appears very similar to other DOE funded projects.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Abrasion Testing of Critical Components of Hydrokinetic Devices
Monty Worthington; ORPC Alaska, LLC

Overall Project Score: 3.2 (5 Reviews Received)



Brief Summary of Project

ORPC Alaska, LLC (ORPC) will test the performance of core components of our hydrokinetic power systems in a laboratory setting at University of Alaska Anchorage (UAA) that will replicate environmental conditions encountered in Alaskan deployments, with specific focus on understanding wear caused by high suspended sediment concentrations at tidal and river energy sites. The purpose of the project is to perform laboratory testing of various combinations of bearings and seals to determine the wear rate of these components and identify which configuration best resists degradation from suspended sediment abrasion, and the necessary maintenance interval associated with this configuration. Tidal and river sites in Alaska typically have high suspended sediment concentrations, primarily due to predominant glacial influences and the fine particulate silt that glaciers introduce into the water bodies. This sediment has already proven to be a challenge for machinery and vessels in offshore oil and gas and marine service industries that operate in this environment. The data gathered from this study will be used directly by ORPC to inform bearing and seal specifications for Alaskan projects. This Project will therefore benefit development projects in Alaska, as well as other industry-wide hydrokinetic projects in water bodies with high suspended sediment concentrations.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Findings from this study will benefit both ORPC as well as other developers deploying in high silted areas exposed to potential abrasion issues.
- A well planned project in full alignment with DOE objectives.
- Good value project relevant to the entire sector in this area.
- This project is critical to moving forward in tidal and river sites in Alaska, where most of the MHK energy resource is located.
- This project represents basic material science research which the market would not support at the current state of MHK deployment.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- The approach used would appear to be generally effective.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- According to the PI this study has met its proposed timeline.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.1** for technology transfer and collaboration.

- A good mix of private and academic members in the team.
- Sharing results through web site and directly with key industry groups, agencies, and stakeholders. All environmental data and analysis will be made available.
- Research integration efforts by ORPC appear well-reasoned and appropriate.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- NA

Strengths and weaknesses

Strengths

- Seems very good value for money.
- Good value project relevant to the entire sector in this area.
- Prioritized research that directly supports deployment of MHK projects.

Weaknesses

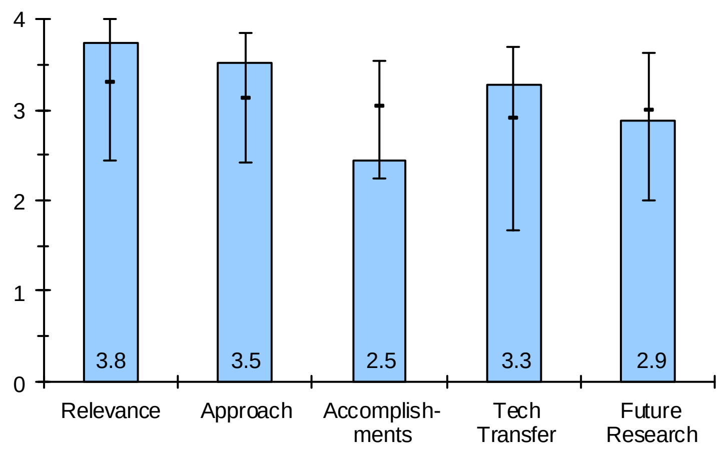
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Acoustic Monitoring of Beluga Whale Interactions with Cook Inlet Tidal Energy Project *Monty Worthington; ORPC Alaska, LLC*

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

The objectives of the Beluga project are: 1) to develop and implement the technology to acoustically detect and locate beluga whales by recording their vocalizations; and 2) to compare this technology and methodology with other passive hydroacoustic technologies, and with visual observation techniques and methodologies, by correlating data from visual and other hydroacoustic monitoring efforts with the hydroacoustic data obtained from this effort. This project will also help establish a best practice for monitoring beluga whale presence in proposed development areas—specifically ORPC's Cook Inlet development areas—and to examine whether there are any effects of habitat alterations on beluga whale distribution, relative abundance, and behavior during turbine installation and operation. Incidental hydroacoustic data collected during this project will also be used to determine the baseline acoustic environment of the study area prior to deployment, and to compare it to the acoustic environment during installation, deployment, and operation of the tidal energy turbines.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- Good value project relevant to the entire sector in this area and the doe WPP.
- Beluga whale interaction/impact issues must be addressed to advance the MHK industry in Cook Inlet, the site of a significant energy resource.
- Given the significant tidal resources in this area this area of research seems appropriate for supporting MHK project development efforts.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Approach appears to be feasible and well designed.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.5** based on accomplishments.

- Concern about remaining budget; recommend monitoring.

- According to the PI the use of DASARs appears unlikely to succeed at this time and other existing detection technologies are being examined.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.3** for technology transfer and collaboration.

- Excellent links with NOAA ad other agencies.
- NMFS not a close partner, but project proponent is in conversations with NMFS and providing regular updates.
- Integration efforts according to the presentation materials appear to be good.

Question 5: Proposed future research

This project was rated **2.9** for proposed future work.

- Significant challenges concerning the completion of this research study have been reported.

Strengths and weaknesses

Strengths

- To deploy in a location such as Cook Inlet, the biggest concern is the presence of ESA-listed marine mammals. The study proposed shows a level of detail and is a proactive approach to address this issue.

Weaknesses

- It wasn't conveyed clearly enough the interaction ORPC has with NOAA from design of studies through to potential mitigation measures if the device is deployed. There is a lot to be learned from Snohomish County PUDs experience in Puget Sound and their work with NOAA on the killer whale issue.
- It was not clear what the actual size of the resource was in the study area - i.e. was the resource large enough to merit this work.
- According to the information provide the PI's face significant technological challenges in completing this research.

Specific recommendations for additions or deletions to the work scope

- NA

4.2 Marine and Hydrokinetic Lower TRL Project Evaluations

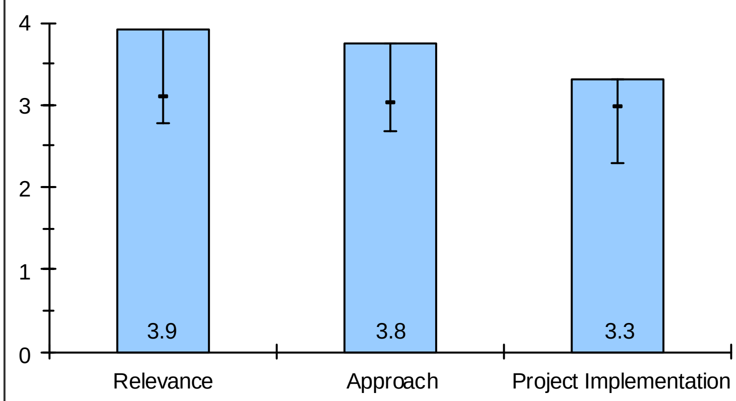
Table 4.3 illustrates the scoring for the MHK Lower Technology Readiness Level (TRL) projects. Individual MHK Lower TRL project scoring summaries and reviewer comments are also included in this section.

Table 4.3 Marine and Hydrokinetic Lower TRL Project Scores

Marine and Hydrokinetic Lower TRL Projects	Relevance to overall DOE objectives	Approach to Performing Research & Development	Project Implementation Pathways	Average Weighted Score
Puget Sound Pilot Tidal Energy Project	3.9	3.8	3.3	**3.7**
Advanced Anchoring Technology	3.5	3.1	3.1	**3.1**
Cycloidal Wave Energy Converter TRL Advancement to Level 4	3.1	2.8	2.8	**2.8**
The Development of Open, Water Lubricated Polycrystalline Diamond Thrust Bearings for use in Marine Hydrokinetic (MHK) Energy Machines	2.8	3.3	3.3	**3.3**
THOR's Power Method for Hydrokinetic Devices	3.1	3.0	3.1	**3.0**
Tidal Energy System for On-shore Power Generation	2.9	2.8	3.0	**2.8**
Development of a wave-actuated power take-off device for electricity generation	3.1	3.0	2.9	**3.0**
Environmentally Benign and Permanent Modifications to Prevent Biofouling on Marine and Hydrokinetic Devices	2.8	2.9	3.0	**3.0**
Protective, Modular Wave Power Generation System	2.8	2.7	2.3	**2.6**
M3 Wave's DMP: Simple, Scalable, and Submerged	3.1	3.2	3.2	**3.2**
Poncelet Kinetics RHK100 Prototype Development Project	3.0	2.8	2.8	**2.8**
River Devices to Recover Energy with Advanced Materials (River DREAM)	3.1	3.1	2.9	**3.1**
Submersible Generator for Hydrokinetics	3.1	2.7	3.0	**2.8**
Active Flow Control on Bidirectional Rotors for Tidal MHK Applications	3.2	3.1	3.0	**3.1**
Remote Monitoring of the Structural Health of Hydrokinetic Composite Turbine Blades	3.4	3.1	3.2	**3.2**
OTEC Cold Water Pipe-Platform Sub-System Dynamic Interaction Validation	3.2	3.3	3.2	**3.2**
Modeling the Physical and Biochemical Influence of Ocean Thermal Energy Conversion (OTEC) Plant Discharges into their Adjacent Waters	3.2	3.2	3.0	**3.2**

Project Name: Puget Sound Pilot Tidal Energy Project
Craig Collar; Public Utility District of Snohomish County No. 1

Overall Project Score: 3.7 (5 Reviews Received)



<u>Brief Summary of Project</u>

The Snohomish County Public Utility District (The District) and its partners propose to deploy two utility-scale turbines in Admiralty Inlet, Puget Sound, WA. This site has been identified as one of the largest tidal hydrokinetic resources in the United States, but is also a sensitive environment within the range of several endangered species and under existing anthropogenic stress. While the project will be connected to the grid and produce a modest amount of energy, the primary purpose of the project is to gather data to better inform the viability of commercial tidal energy generation from technical, economic, social, and environmental standpoints. Lack of data from operating projects is inhibiting commercial development of tidal power in the United States. With respect to technological gaps, until the reliability and maintainability of tidal energy devices is established, the economic competitiveness of tidal energy will be subject to broad uncertainties. Similarly, without project data, environmental risk profiles (e.g., consequences and probability of occurrence) cannot be verified.

By achieving multi-year operation in a sensitive, challenging environment, this project will improve the ability of developers to attract project investment by lowering technical risk and addressing key regulatory concerns.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.9** for its relevance to DOE objectives.

- Good high visibility project.
- Addresses: Functionality, Price, Technology and Performance barriers.
- Getting real projects (demonstration or near commercial) in the water is critical to achieving DOE's goals. Such projects advance the specific technology being supported but also allow for environmental testing and show private investors that the industry is viable.
- An excellent and well planned project in full alignment with DOE objectives.
- A significant project, led by a public utility that will contribute to the environmental and technical understanding of MHK.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **3.8** on its approach.

- Uses an identified resource with a standard technology for this sector.
- Project partners including Snohomish PUD are established and well regarded.
- These studies and monitoring will close specific data gaps that are key to evaluating this project. Data will be site specific but the methodology will be transferable. In addition, information learned will still be very relevant to other MHK projects as the best available data regarding tidal project impacts (or lack thereof).
- Ambitious but well planned.
- Project developer has identified an in-depth and detailed approach to data gathering.
- As a public utility, release of information will likely be transparent and available for others to utilize.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.3** based on project implementation.

- Project partners have done well in adapting to and resolving technical challenges
- Studies and monitoring methodologies are well thought out in coordination with key regulator.
- Not fully clear how this will be implemented.
- The creation of a website for distribution of information.
- Strong collaboration with academic, private, and public utility.
- Well-planned data gathering approach.

Strengths and weaknesses

Strengths

- Snohomish PUD is a well-respected NW utility who lends credibility to the emergence of the MKH industry.
- Project partners have a practical and relatively well conceived project schedule given current industry experience and knowledge in this area.
- Utilizing a more pragmatic can-do approach focused on project completion the PI has been an. effective communicator within both the MHK and the utility industry.
- A strong sign to this emerging industry that a utility is looking to utilize this technology.

Weaknesses

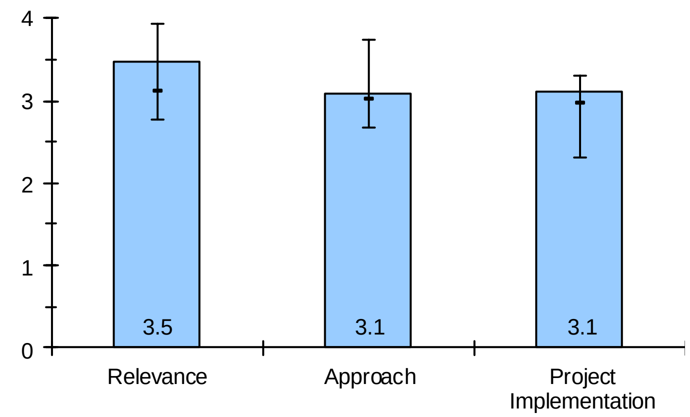
- Go/No go - what are the key factors - concerns over potential impacts to resident killer whale.
- Populations and how mitigation measures may influence the viability of this project.

Specific recommendations for additions or deletions to the work scope

- This project helps demonstrate that the MHK industry is maturing and of potential interest to utility partners.

Project Name: Advanced Anchoring Technology
Dallas Meggitt, P.E.; Fred Arnold, R.G.; Sound & Sea Technology, Inc.

Overall Project Score: 3.1 (5 Reviews Received)



Brief Summary of Project

The purposes and objectives of this project are to:

- Reduce the capital and installation costs of MHK Systems by developing a lower cost and more flexible anchoring technology to a Proof of Concept level (TRL 4).
- Perform critical research and development activities that will significantly decrease the costs of anchoring MHK systems in deep water and in areas with rocky bottoms.
- Expand MHK site selection possibilities leading to a greater number of possible locations and better optimized locations.
- Progress the technology required to remotely attach MHK anchoring systems to the ocean floor in situations where traditional anchoring technologies are impractical. Specifically, develop a remotely controlled grouting procedure suitable for deepwater Grouted Pile Anchor installations.
- Develop a Quality Control and Certification Procedure to validate deep underwater grouted pile anchor installations.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Looking at alternative mooring techniques that will allow MHK developers to deploy in more varied areas that currently accessible.
- Good project in alignment with the DOE goals.
- Understanding anchoring systems and how to improve is relevant to support the industry.
- Development of lower cost/flexible anchoring technology will expand MHK site selection.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Interesting approach to real problem for the sector - too early in the project to fully gauge its success.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.1** based on project implementation.

- Interesting approach to real problem for the sector - too early in the project to fully gauge its success.
- Early in the project.

Strengths and weaknesses

Strengths

- Will allow MHK developers to secure devices in more ideal locations.
- The project addresses an issue of high importance to the MHK industry.
- Research integration efforts were detailed and comprehensive.

Weaknesses

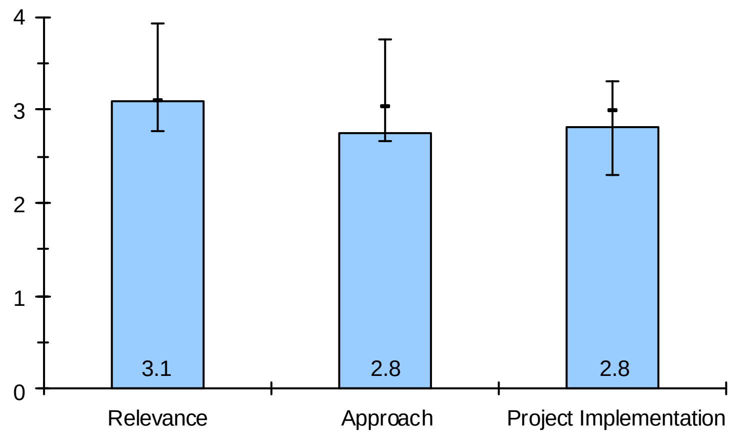
- Ideal for deep mooring; however, mooring near reefs/outcrops would involve consultation with NOAA and incur potential impacts with EFH.

Specific recommendations for additions or deletions to the work scope

- For future work, consider environmental impacts as a factor in developing product; consider ocean testing.

Project Name: Cycloidal Wave Energy Converter TRL Advancement to Level 4
Dr. Stefan G. Siegel, Ph.D.; Atargis Energy Corporation

Overall Project Score: 2.8 (5 Reviews Received)



Brief Summary of Project

This project seeks to advance the Technology Readiness Level (TRL) of the Cycloidal Wave Energy Converter (CycWEC) from TRL 3 to TRL 4. This is achieved by conducting numerical simulations along with constructing and testing of a 1:10 scale model. The CycWEC is a fully submerged lift based wave energy converter design that seeks to address the main shortcomings of other WECs which are high cost of energy due to low efficiency, as well as storm survival without the need for excessively costly structural design. At the start of this program, both numerical simulations as well as small (1:300) scale wave tank tests had shown wave cancellation efficiencies beyond 95% of the incoming wave energy. The goal of the current program is to verify these findings in 1:10 scale tests, which also allow for accurate shaft power measurements.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Potentially a break-through technology for the MHK sector - but little information provided to fully assess.
- Addresses new WEC technology advancing from TRL 3 to TRL4.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- Too little information provided during report and presentation and questioning to properly assess the progress of the project.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.8** based on project implementation.

- Too little information provided during report and presentation and questioning to properly assess the progress of the project.
- Completed first testing.
- Moving forward well after completing first test campaign.

- This project while apparently well designed addresses a mid-level TRL. Given the lack of real time in-the-field MHK projects this type of concept validation may possible be seen as somewhat premature.

Strengths and weaknesses

Strengths

- NA

Weaknesses

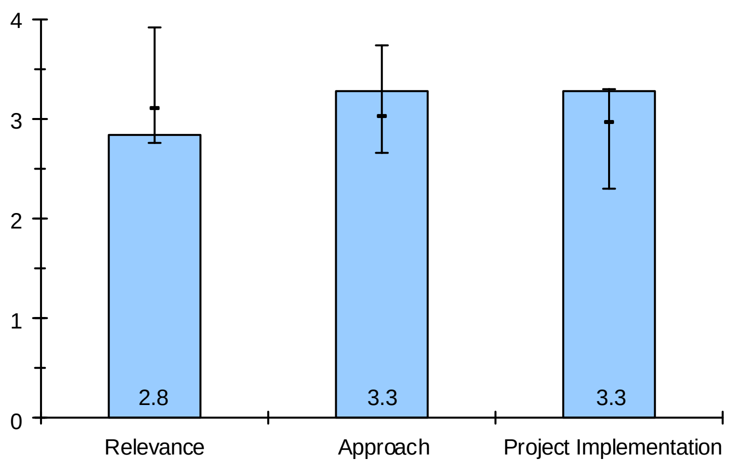
- More information is required to be reported on the project in order to assess quality and progress.

Specific recommendations for additions or deletions to the work scope

- Future work should include ocean testing.

Project Name: The Development of Open, Water Lubricated Polycrystalline Diamond Thrust Bearings for use in Marine Hydrokinetic (MHK) Energy Machines
Craig Cooley; US Synthetic / Bearings

Overall Project Score: 3.3 (5 Reviews Received)



__**Brief Summary of Project**__

The purpose of this project is to evaluate the feasibility of using polycrystalline diamond (PCD) bearings in the moving components of marine hydrokinetic energy producing machines. The motivation for using PCD bearings is to substantially reduce MHK maintenance costs and to protect the marine environment from oil based lubricants. Diamond bearings have the advantage of using the surrounding water as the lubricant and cooling medium. They operate in the open, without requiring seals that can leak and pollute the marine environment. In addition, diamond is resistant to wear giving these bearings the potential for long life and thus low maintenance cost. The end goal of the project will be to demonstrate through laboratory testing and engineering analysis that diamond bearing technology is ready for testing and evaluation in full scale MHK machines. Part of the project will include some initial testing in actual full-scale machines.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__**Question 1: Relevance to overall DOE objectives**__

This project earned a score of **2.8** for its relevance to DOE objectives.

- I'm not sure that bearing are priority for the MHK sector or the DOE program.
- Bearings are integral part of machinery and further understanding of design and materials to be used in marine environments is helpful.
- Oil-based lubricants do not appear to have been identified by key regulators as a critical near-term issue. Once the industry has established demonstration projects and is at the next phase (commercial expansion), this may become a more important hurdle. So, this may advance the program, but in the long-term rather than near-term.
- Good solid materials optimization study of PCD bearings.

__**Question 2: Approach to performing the research and development**__

This project was rated **3.3** on its approach.

- They have not identified a need for this technology in the MHK sector.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.3** based on project implementation.

- They have established the cost requirement for the MHK sector.
- Working on an important aspect of underwater machinery.
- Looking at options is positive task.
- On schedule and budget.
- A relatively low cost materials application research study.

Strengths and weaknesses

Strengths

- Introducing experience from other marine industries to the MHK.
- Could lead to lower O&M costs for certain technologies.

Weaknesses

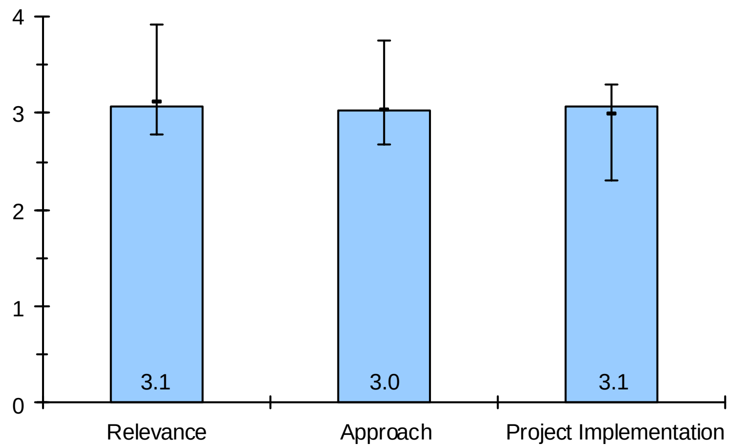
- Concerns regarding costs and the difference between oil and gas industry versus the MHK industry.

Specific recommendations for additions or deletions to the work scope

- Given the use of PCD's for offshore petroleum industry, the project PI's may want to research co-funded PCD projects in the future.

Project Name: THOR's Power Method for Hydrokinetic Devices
Turner Hunt; Turner Hunt Ocean Renewable, LLC

Overall Project Score: 3.0 (5 Reviews Received)



__Brief Summary of Project__

The overall project objective is to demonstrate that THOR's Power Method for Hydrokinetic Devices can provide dramatic increases to the capacity factor, and hence energy output, of hydrokinetic devices. THOR's power method involves changing the depth of the hydrokinetic device by use of variable ballast, variable drag and variable hydrodynamic lift to track the depth at which full rated power is always output from the attached generator. This rated power depth ascends and descends as ocean current speeds change speed from time to time – and the scale model's control system forces compliance with the constant speed, variable depth power mode of operation. Further, inherent system energy losses are introduced to the model via interchangeable parts with the intent of demonstrating that THOR's Power Method provides a compensating means to recover energy losses.

Additional objectives of the testing include the ability to create and maintain an inverse velocity shear gradient in the re-circulating ocean current flume (ROC-Flume), validate the Marine and Hydrokinetic (MHK) scale model operation and control system capabilities, and finally to validate the projected improvements in power production and capacity factor by using THOR's Power Method of operation for MHK devices.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **3.1** for its relevance to DOE objectives.

- In alignment with DOE program.
- A potential method to increase power output for technologies.
- Somewhat theoretical approach do modeling depth factors related to energy output.

__Question 2: Approach to performing the research and development__

This project was rated **3.0** on its approach.

- Too little information provided during report and presentation and questioning to properly assess the progress of the project.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.1** based on project implementation.

- Too little information provided during report and presentation and questioning to properly assess the progress of the project.
- On schedule and on budget.
- While somewhat promising, funding for these types of numerical modeling studies of power output strategies may not address some of the more pressing concerns related to advancing the MHK industry.

Strengths and weaknesses

Strengths

- Own facilities can test different flow conditions.
- Teaming with Virginia Tech.
- Positive results so far.

Weaknesses

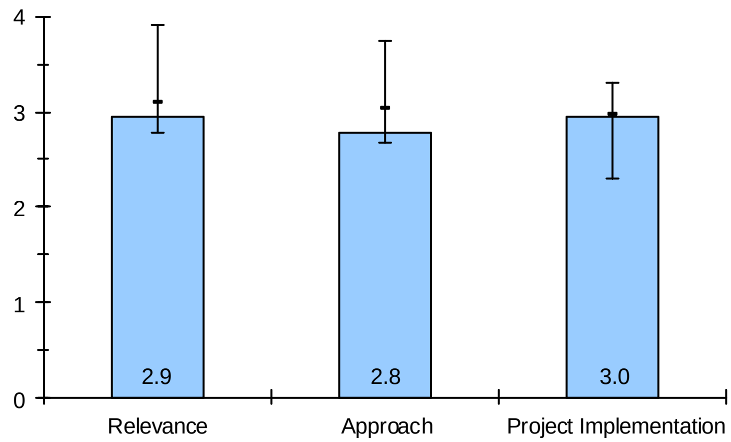
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Tidal Energy System for On-shore Power Generation
Dr. Allan Bruce; Sunlight Photonics Inc.

Overall Project Score: 2.8 (5 Reviews Received)



__Brief Summary of Project__

The project will assess the feasibility of a novel MHK tidal energy system which employs hydraulic energy transfer and operates without submerged electronics or gears. If the technology is found to be feasible, it can provide a more reliable and lower LCOE option for large scale MHK deployments (>10MW). Candidate sites in Maine and the Northwestern USA can contribute significantly to meeting National power needs. The project is designed to eliminate development risk from two standpoints. First, a laboratory demonstration of the key elements of the technology. This includes the design, integration and testing of a TRL4 system using COTS. For expediency and cost-effectiveness, a programmable drive motor is used to simulate a tidal turbine and a computerized data acquisition/control system is used to obtain data corresponding to different tidal conditions. Second, modeling and cost analysis for large scalable systems (>10MW) is conducted, based on COTS and actual site characteristics for the Western passage in Maine. These models include real-world experiences of sub-contractor Atlantis Resources who are leaders in MHK deployments.

The goals of the work are to confirm the viability of the technology and to identify a path for rapid commercialization and deployment which leverages Atlantis's experience base. The deliverables will be a final report including details the design, integration and performance of the TRL4 system.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **2.9** for its relevance to DOE objectives.

- Positive - looking at other ways to utilize tidal power with land-based generation.
- In alignment with DOE program.
- Assessing another means for power takeoff and increase efficiencies.
- Not clear on why go with an onshore hydraulics PTO with all the attendant losses.

__Question 2: Approach to performing the research and development__

This project was rated **2.8** on its approach.

- Not clear what is novel about their approach.
- Little awareness of the needs of the MHK sector.
- This is a relatively unique approach that may require significant R&D investments.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.0** based on project implementation.

- Not clear what is novel about their approach.
- Little awareness of the needs of the MHK sector.
- Budget on track.

Strengths and weaknesses

Strengths

- A strong team made up of private, government, and academic members.

Weaknesses

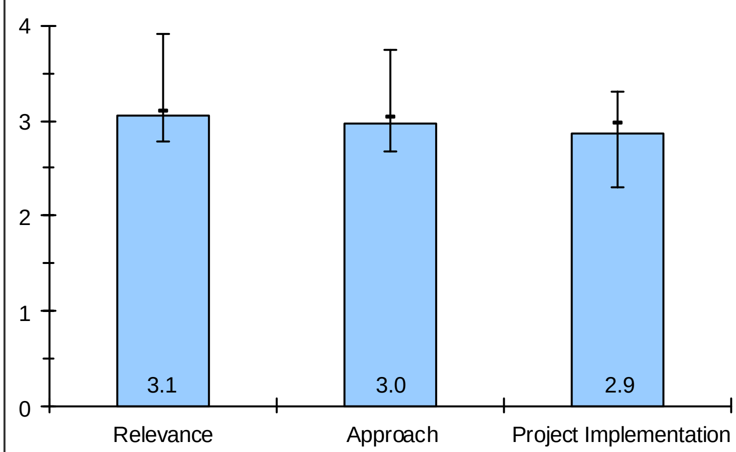
- A lack of discussion of next steps for actual deployment.
- Project addresses a mid-level TRL for a new and relatively untested technology.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Development of a wave-actuated power take-off device for electricity generation
Allan Chertok; Resolute Marine Energy

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

The major objectives of the project are to develop and demonstrate—initially in a laboratory setting—a prototype-scale design for a cost-effective electric power take off (PTO) for wave energy converter (WEC) systems. The PTO design is configured for point absorber devices in general and the Resolute Marine Energy 3D-WEC in particular. The project has completed analyses to determine the requirements for a prototype scale electric PTO for the RME 3D-WEC point absorber WEC including estimation of static bias tension, peak mooring tether displacement, velocity force and power as well as tide range accommodation. Based on these requirements RME is presently detailing the design of a prototype scale electric PTO employing a tether and spool driven rotary permanent magnet generator and helical bias tension spring—both housed in oil-filled, pressure-balanced enclosures to avoid sea water intrusion and to promote lubrication and heat transfer.

The final product of the present program will be a functioning electric PTO which will be tested in a laboratory setting. The PTO will be capable of operation in an ocean environment and RME intends to seek additional financial support to test the PTO in an ocean-deployment with the RME 3D-WEC configuration. Benefactors of this project will ultimately be users of the energy generated. In the near-term PTO-3D-WEC systems could be used in off-grid settings–e.g., to power RO water desalination units, freezers for remote fisheries or hot water in remote cold regions—possibly in WEC-diesel hybrid configurations. In the long-term PTO-3D-WEC systems of larger scale could be integrated with off-shore wind power units, sharing mooring and power transmission capabilities.

While the initial motivation for the project was RME's need for an improved electric PTO solution for its 3D-WEC system the developed electric PTO can be used with other point absorber WEC devices and RME would consider manufacturing and supplying these devices to others.

This project addresses design challenges fundamental to all WEC PTO solutions including

- Prime mover velocity (linear or angular) is very low;
- The PTO must react to very high thrust or torque and a very high generator voltage/speed constant is required;
- Most point absorbers are single-acting and the PTO must provide a restoring force mechanism; and
- Power flow is oscillatory and peak/average power is unfavorable for efficient transmission and grid integration.

The project team recognized that existing linear direct-drive generator solutions are unattractive

- Inefficient material use—only a portion of magnet, copper and steel contribute to reaction thrust;
- Material use is especially inefficient where a wide tide range must be accommodated;

- Inefficient structure—difficult to achieve stiffness required to maintain a small generator air gap;
- Difficult to maintain linear bearing lubrication; and
- Difficult to seal and protect components from sea water corrosion and biofouling.

The project team also recognized that linear restoring force springs are unattractive
- Difficult to protect from the ocean environment; and
- Difficulty in accommodating a wide tide range.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.0** for its relevance to DOE objectives.

- In alignment with DOE program.
- Research by PI presupposes point absorber technologies will be the future of MHK.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Acceptable approach.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.9** based on project implementation.

- Uncertain as to when demonstration project will be available.
- Acceptable implementation.
- Have compensated for investment delays.

Strengths and weaknesses

Strengths
- High value at low cost to DOE.

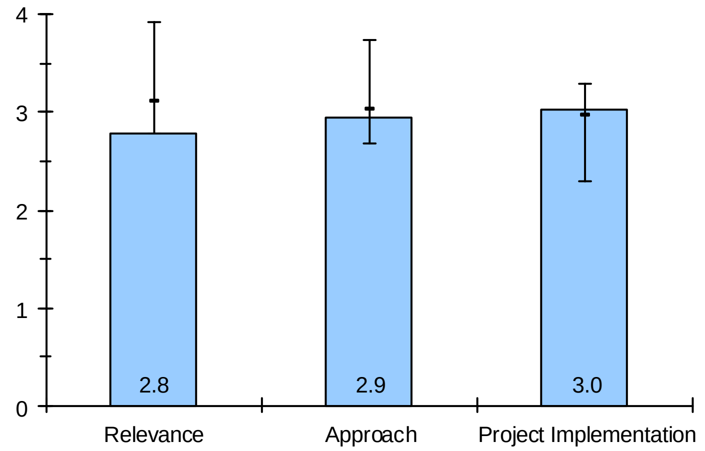
Weaknesses
- NA

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Environmentally Benign and Permanent Modifications to Prevent Biofouling on Marine and Hydrokinetic Devices
Zheng Zhang, PhD; Semprus BioSciences

Overall Project Score: 3.0 (5 Reviews Received)



Brief Summary of Project

This research is to develop environmentally benign and permanent modifications to prevent biofouling on marine and hydrokinetic (MHK) devices. The research is expected to improve the efficiency, maintenance, and environmental impact of current MHK systems by substantially reducing the biofouling with novel permanent modifications. These modifications are expected to outperform currently used nontoxic underwater coatings in biofouling resistance and be ready for the next stage of development with demonstration in MHK systems.

Biological fouling imposes substantial drag and wear with associated efficiency and maintenance penalties (e.g. increased fuel costs) to MHK systems. Most anti-fouling coatings release toxic agents and some of them have been banned because of environmental concerns. Current non-toxic coatings include silicone-based “fouling release” coatings, which release the weakly attached accumulated fouling organisms under applied forces. These coatings are generally designed for moving vessels and are only effective at speeds greater than 30 knots. Most MHK components are required to work in static conditions or in slowly moving tides and coastal waters, where the applicability of the fouling-release class of coatings is limited.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.8** for its relevance to DOE objectives.

- Is there correspondence between Semprus and the National Labs? Concern there is a duplication of efforts.
- Tenuous alignment.
- Looking at environmentally benign means to prevent biofouling.
- Anti-fouling coating toxicity does not appear to be a current regulatory barrier to getting early projects in the water. At a large commercial deployment scale, anti-fouling paint could raise concerns, so this program may be very useful in terms of minimizing cumulative impacts. But this is not critical to achieving near term DOE goals.
- Relatively low cost study of an issue important to the MHK industry.

Question 2: Approach to performing the research and development

This project was rated **2.9** on its approach.

- In do see the why this is a focus of the MHK sector; surely this should be technology transfer from another sector - such as the navy.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.0** based on project implementation.

- On schedule.
- Good solid research on non-toxic bio-compatible anti-fouling coatings.

Strengths and weaknesses

Strengths

- While not a MHK-specific project, this research will benefit the industry.
- I am not convinced the MHK sector needs this project.

Weaknesses

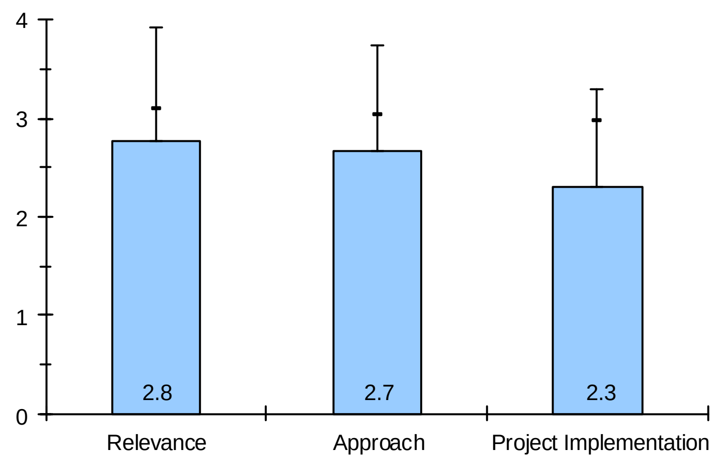
- Appears to be duplication with National Lab project.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Protective, Modular Wave Power Generation System
Jane Vvedensky; Shift Power Solutions

Overall Project Score: 2.6 (5 Reviews Received)



<u>**Brief Summary of Project**</u>

Our goal is to develop and validate a modular generation system that extracts energy from shoreline waves (ocean, inter-coastal and rivers) which can:

- Harvest energy that is destructive to coastal structures such as breakwaters or piers
- Be customized for a variety of installations, has low energy cost, is mass produced and brought to market quickly.
- Be integrated with grids, isolated grids, legacy systems, renewable sources and storage facilities.

This project supports the industry because it can be rapidly commercialized using organic business growth from small installations into large, utility-scale sites. It is unique in that the same technology can be used to deliver power directly to consumers and utilities alike. The earliest beneficiaries of this technology will be coastal inhabitants who live or work in remote locations with high cost of energy or heavily polluting generation. As it develops, our system will become useful to those who manage marine structures (like the Army Corps of Engineers), erosion, sediment migration, piers, oil rigs, and coastal facilities like marinas. Our challenges are to ensure the seaworthiness of our module, its anchoring system, and to cost-effectively deliver consistent power. Our objectives for this phase of the project are to develop a prototype, measure the character of power output in a laboratory environment and optimize the design. This project demonstrates that the program is promoting innovative solutions for the industry.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>**Question 1: Relevance to overall DOE objectives**</u>

This project earned a score of **2.8** for its relevance to DOE objectives.

- Wave energy device to generate for shoreline waves.
- Use of breakwater or pier structures is an area not otherwise represented in the DOE funding portfolio and could prove valuable.
- Apparently a proof-of-concept test for a proposed new technology.

<u>**Question 2: Approach to performing the research and development**</u>

This project was rated **2.7** on its approach.

- NA

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.3** based on project implementation.

- Thus far the main progress is reported as redesigns, and it is not clear whether those redesigns were significant in nature; tank testing will result in useful information.
- Given the relatively narrow focus of this research, project implementation decisions are relatively restricted.

Strengths and weaknesses

Strengths

- NA

Weaknesses

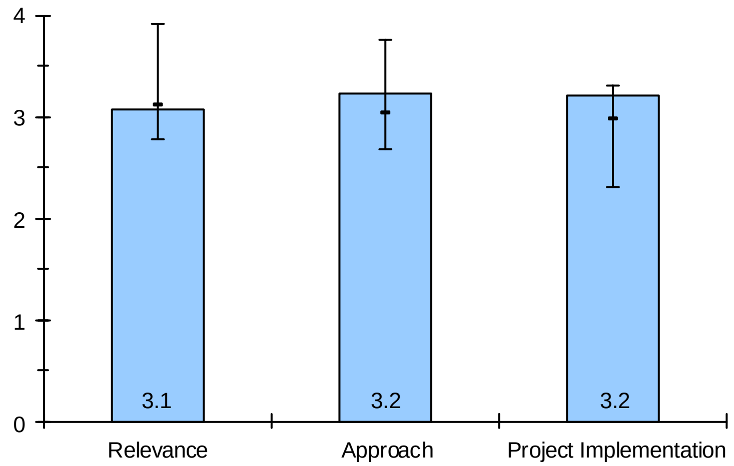
- Concern that cost of permitting is underestimated for a field deployment.
- There was far too little information supplied to fully assess this project.
- The presenter supplied marketing information rather than a project details which was not ideal.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: M3 Wave's DMP: Simple, Scalable, and Submerged
Mike Morrow PE; M3 Wave Energy Systems LLC

Overall Project Score: 3.2 (5 Reviews Received)



<u>Brief Summary of Project</u>

The objective of the proposed work is to advance the DMP Wave Energy Converter from a TRL 2 device to a TRL 3 device. Primary project objectives were to estimate the power output and cost for a full scale device and to confirm that the device can be manufactured, deployed, moored and maintained economically.
Final goal is to derive an estimate of cost per kWh for the technology.

Key challenges addressed during the course of this project:

- Airflow measurement. A novel dual-prandtl tube/dual pressure sensor air velocity measurement system was developed and utilized for much of the scale testing.
- Bag geometry creation. To maintain flexibility while keeping costs low, an off-the-shelf parts bagging system was used from material handling company Uline. The desire to evaluate representative materials was separated from the need to test different geometries. This allowed creation and testing of geometries using simple poly tube bag materials and off-the-shelf thermal sealing equipment, enabling quick-turn manufacturing of geometries. True representative materials were evaluated using optimal geometries determined from the poly bag experiments, reducing the amount of fabrication required with more challenging bag materials.
- Device pre-charge level was far more critical to operation than originally anticipated. The scale device was adapted to include a pressurization port and precision pressure gauges to enable controlling and measuring pre-charge during experiments.
- Telemetry scaling. The prandtl tube/pressure sensor system and associated hardware became nearly impossible to manage in such a small space, so an auxiliary dry box sensor housing was integrated into the device. This presented some challenges to system pre-charge and monitoring since the pressure sensors needed to be isolated from the air column AND vented to atmosphere- all while fully submerged. It is anticipated that larger scale devices will afford enough internal space to negate the need for an extra chamber and more expensive sensors can use internal pressure references. These lessons are already being applied to 1:6 scale models under construction.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.1** for its relevance to DOE objectives.

- In full alignment with DOE objectives.
- Support of technology development from TR2 and TR3.
- Covers an area that is otherwise missing from the portfolio of DOE-funded projects.

- Not clear how they could evaluate LCOE from these type of unique devices without a referencing its approximate efficiency.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Developed their own wave test tank and incorporating knowledge of OSU.
- A well designed set of tank tests.
- Use of tank testing.
- Good to see evaluation of this type of oscillating water column technologies.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.2** based on project implementation.

- Well thought through implementation.
- Impressive planning and schedule, as well as technical approach and progress.

Strengths and weaknesses

Strengths
- Overall a good and novel project.

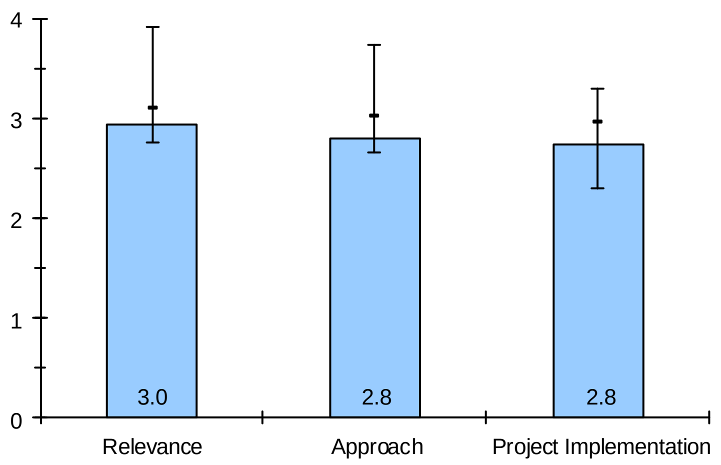
Weaknesses
- While the oscillating water column as an MHK technology may hold some promise, however it wasn't clear if that this particular technology was sufficiently promising to warrant the relatively scarce funding available.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: Poncelet Kinetics RHK100 Prototype Development Project
John R. Hasz; Whitestone Power and Communications

Overall Project Score: 2.8 (5 Reviews Received)



<u>Brief Summary of Project</u>

The primary objective of this project was to develop a hydrokinetic power generation system which would be able to survive in the harshest conditions, be environmentally friendly, simple to build and operate and, most importantly, would provide significant energy cost reduction for rural communities across America and the world. The project will benefit riverine communities which experience high energy costs, unreliable energy production or which have no electrical power generation capacity at all. The belief is that the project will advance the industry by demonstrating that theoretical efficiency of a system is not the most important consideration. The research methodology applied over the course of this project was to develop a system based on the needs and abilities of remote communities rather than trying to conform an intricate and potentially unreliable technology to an underdeveloped infrastructure. This goal was accomplished through the integration of advanced electronics control technology, the introduction of ultra-high performance plastics to the industry, and an engineering approach focused on utility rather than theoretical optimization.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.0** for its relevance to DOE objectives.

- Very versatile - development of a small-scale riverine device that will enable devices to be deployed in remote locations.
- In some alignment with the DOE objectives.
- Looking at high sediment loads and harsh conditions.
- Survivability in harsh ocean environment and ease in manufacturing are important issues that this program seeks to address.
- Focus appears to be on energy production in riverine environments.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **2.8** on its approach.

- Looked at existing technologies and incorporated the potential impacts of the environment into their design.
- It is not clear why they would choose a drag machine - this has displayed not advantages in doing so.
- The approach used was apparently successful in creating a scale model.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.8** based on project implementation.

- They have not displayed a well structures approach.

Strengths and weaknesses

Strengths

- Enable MHK devices to be deployed in remote riverine locations.

Weaknesses

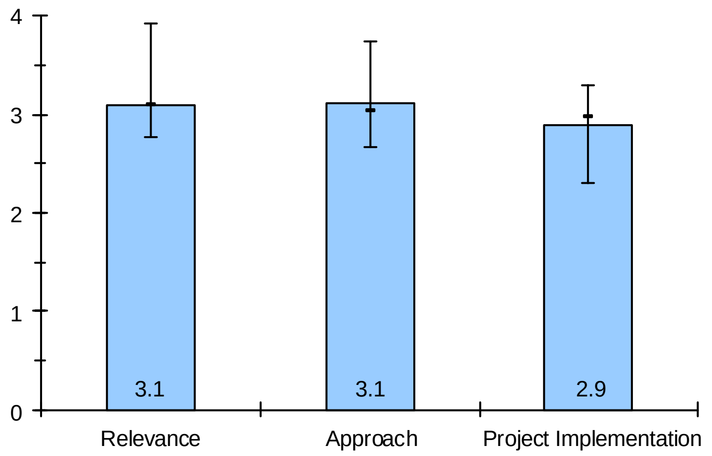
- Learnings from this project may have limited utility in the lower 48 states.

Specific recommendations for additions or deletions to the work scope

- NA

Project Name: River Devices to Recover Energy with Advanced Materials (River DREAM)
Brent Crenshaw; Bayer Material Science

Overall Project Score: 3.1 (5 Reviews Received)



Brief Summary of Project

This project has three research objectives:

1. Oscillator development and design – Characterize galloping behavior, evaluate control surface shape change on oscillator performance and demonstrate shape change with water flow change.
2. Dielectric Energy Generator (DEG) characterization and modeling – Characterize and model the performance of the DEG based on oscillator design
3. Galloping Hydroelectric Energy Extraction Device (GHEED) system modeling and integration – Create numerical models for construction of a system performance model and define operating capabilities for this approach.

Accomplishing these three objectives will result in the creation of a model that can be used to fully define the operating parameters and performance capabilities of a generator based on the GHEED design. This information will be used in the next phase of product development, the creation of an integrated laboratory scale generator to confirm model predictions.

The primary goal of the River DREAM project is the development of an entirely new concept for hydroelectric energy generation. The concept will use a galloping prism to convert water flow into oscillating motion. This motion is converted into electricity via a dielectric elastomer generator (DEG). The galloping mechanism and the DEG are combined to create a system to effectively generate electricity. The purpose in researching this novel generator is to enable the United States to tap into 21,000 megawatts (MS) of existing water resources that have been identified as low head. These resources presently lack a technology to effectively harvest their energy. In addition, this energy generation concept is low profile and largely non-invasive, and is expected to leave rivers useable, aesthetically pleasing, and thus ecologically viable.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Innovative idea with the artificial muscle being applicable to the wave energy development.
- In full alignment with DOE objectives.
- Innovative technology using polymers.
- Somewhat theoretical approach to HKE not clear as how this would be made operational.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- A very well designed approach.
- Based on displacement not velocity.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.9** based on project implementation.

- On track and on schedule.
- A unique approach to realizing MHKE although somewhat unknown within the industry.
- Given the unique nature of this technology determining the appropriate project management pathway seems unclear.

Strengths and weaknesses

Strengths

- Technology appears to be applicable to other MHK devices (e.g., wave).
- An excellent project and very good example of the type of project that merits DOE funding in this TRL level.

Weaknesses

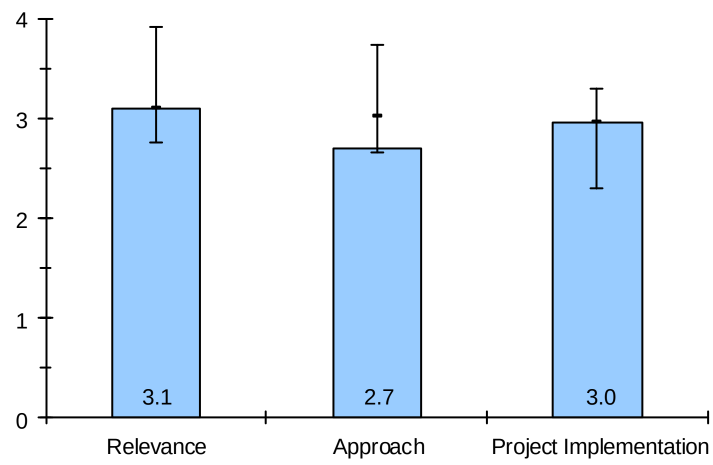
- Extremely theoretical in nature.

Specific recommendations for additions or deletions to the work scope

- Given the limited funding for R&D within MHK this project could be viewed as speculative.

Project Name: Submersible Generator for Hydrokinetics
Robert S. Cinq-Mars; Free Flow Energy, Inc.

Overall Project Score: 2.8 (5 Reviews Received)



__Brief Summary of Project__

The primary objective of this effort is the design of a submersible generator as a discrete and critical subassembly of marine hydrokinetic systems. Unlike earlier designs of MHK systems, in which the generator is integrated into the turbine, this effort takes an approach similar to large industrial and conventional power generation systems in which the generator is designed exclusively for the application and manufactured and applied as a unique system component. The result is a generator optimized for the conditions of marine current energy conversion and which will work with a range of turbine sizes and styles.

The generator was designed to work with two well-known turbines: the vertical axis Gorlov helical turbine (GHT) and a marine version of the horizontal axis FloDesign wind turbine. The project team consists of a partnership of US industrial organizations actively involved in the design, development, manufacture and application of motor/generators; critical components such as laminations, windings, and magnets; and hydrokinetic turbines.

Specific tasks conducted during this project included:

1. Characterize and quantify hydrokinetic resources to reveal the conditions with the greatest probability for use in current energy conversion;
2. Characterize the ambient operating conditions for the same;
3. Design generator to work across turbine platforms.
4. Determine the appropriate generator topology;
5. Electromagnetic circuit design of generator;
6. Mechanical and structural design of generator, component selection, coupling methods and structural requirements.
7. Investigate manufacturability including: tooling, fixturing, machining, component availability and other requirements;
8. Cost analysis; and,
9. Preparation of Deliverables: Final Report and Completed Design.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **3.1** for its relevance to DOE objectives.

- MHK-specific project that can be utilized be various industry members; however, Free Flow does not appear to have solicited industry input on what their needs are.

- Submersible generator.
- Standardized generator design specific to MHK offers significant benefits to the industry.

Question 2: Approach to performing the research and development

This project was rated **2.7** on its approach.

- Lacked discussion with device developers to solicit their needs/wants.
- Reviewed broad spectrum of manufacturers.
- Appears to be a very effective engineering approach.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.0** based on project implementation.

- Completed project.
- Project very close to completion.

Strengths and weaknesses

Strengths
- A good idea that could benefit the MHK industry.
- Standardization of key components may provide significant R&D savings in the early design of MHK technologies.
- Appears to be a well-designed and solid project.

Weaknesses
- Showed significant lack of interaction with device developers.
- It was not clear whether this is a MHK device developer of an electrical generator developer.
- There appeared to be no links to the MHK industry within the project.

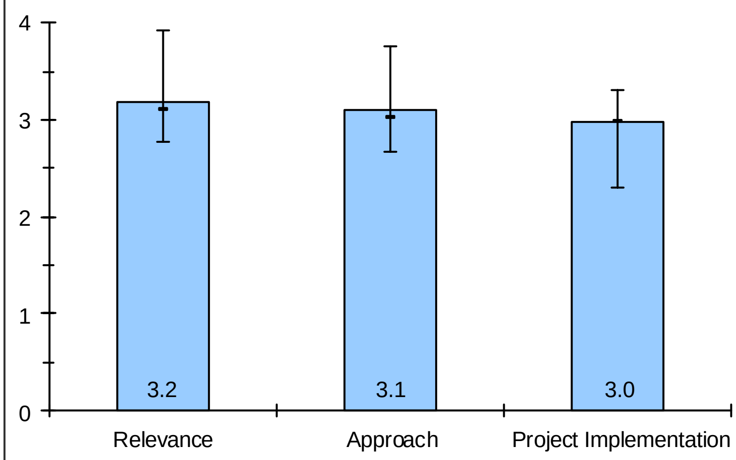
Specific recommendations for additions or deletions to the work scope

- Approach industry to determine their specific needs.

Project Name: Active Flow Control on Bidirectional Rotors for Tidal MHK Applications

C.P. "Case" van Dam; University of California, Davis

Overall Project Score: 3.1 (5 Reviews Received)



Brief Summary of Project

The primary objective is the design of a rotor for bidirectional rotor tidal turbines (BRTT), with improved cost effectiveness via the application of microtabs for active aerodynamic control (AAC). Here, a BRTT is a horizontal axis, axial flow turbine designed for tidal sites with currents running in only two prevailing directions (in 180° opposition to each other). A BRTT rotor can run in both directions, obviating the need for rotor/nacelle yawing or blade pitching. Eliminating these subsystems reduces both capital and operations and maintenance (O&M) costs and improves turbine reliability. However, a bidirectional rotor is inherently less efficient than an optimal, conventional rotor. The application of active aerodynamic control via microtabs recaptures some of the performance shortfall, improving the BRTT's economic viability.

As a TRL 1-3 project, the final product will be a design of a BRTT rotor with active microtabs, ready for further development via laboratory testing in a wind or water tunnel. In the longer term, we intend to advance this project through small scale testing and then ultimately full scale prototype testing. There are multiple potential beneficiaries of this project: (1) BRTT MHK blade, rotor, and turbine manufacturers; (2) the MHK industry in general, as AAC can be applied (although somewhat differently) to any lift-based rotor; and (3) the wind power industry, as AAC research for MHK applications can synergize with existing, ongoing wind power research.

Ultimately, this project will advance the MHK industry by producing a more efficient rotor for MHK BRTTs, thereby lowering their cost of energy (COE). In terms of the wind power industry, we are pursuing "smart" rotor technology advancements, with the same basic goal of cost reduction. As with any energy technology, COE is the primary barrier to adoption. In general, the proper application of AAC can reduce the COE of any MHK turbine with a lift-based rotor.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.2** for its relevance to DOE objectives.

- Will enable turbine developers to improve the efficiency of their devices.
- Horizontal axis turbine capable of generating with flow in two directions with use of microtab.
- Looking to reduce lift to drag coefficient.
- Bi-Directional drive while appealing has still eluded the major wind turbine manufacturers.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Utilizing wind industry experience.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.0** based on project implementation.

- On schedule and budget.

Strengths and weaknesses

Strengths

- A good project with a good team.
- Use of design elements from wind power research.

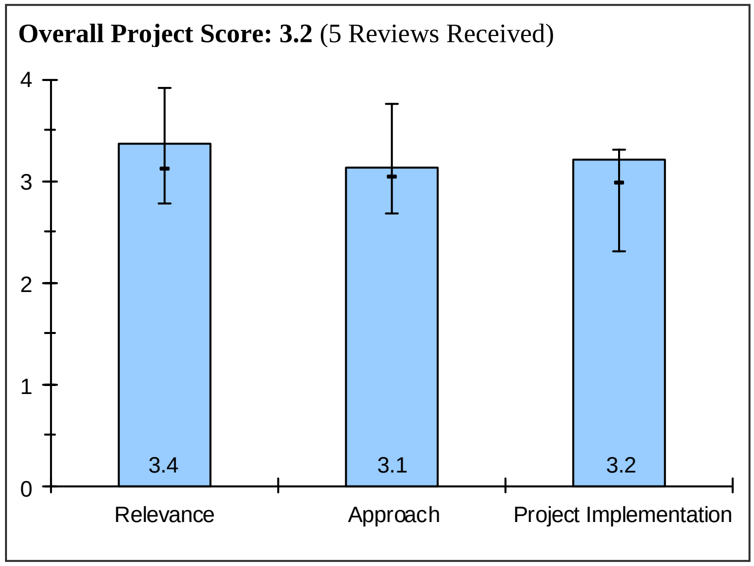
Weaknesses

- Not clear how strong their links to MHK industry are.
- It is not clear what the cost versus performance situation is for their concept.

Specific recommendations for additions or deletions to the work scope

- Agree that industry partners are needed for future research.
- The use of computational models from the wind industry while readily available may not prove applicable to MHK technologies.

Project Name: Remote Monitoring of the Structural Health of Hydrokinetic Composite Turbine Blades *Dr. Joshua Rovey; Missouri University of Science and Technology*



Brief Summary of Project

The proposed project objective is proof-of-concept demonstration of a composite turbine blade that can acquire and transmit data about its structural health. The basic principles for the component have been observed and the essential characteristics and behaviors have been verified. Thus the component concept is currently at TRL 1. The proposed project experimentally demonstrates the critical fabrication and function of the blade and monitoring component, thereby proving the concept and raising the TRL to 3. To achieve TRL 3, this project will: 1) fabricate a prototype composite turbine blade with embedded fiber optic strain gage, 2) demonstrate underwater transmission of strain data during proof-of-concept testing, 3) develop higher fidelity estimates of the component characteristics, 4) assess the viability of commercial off-the-shelf equipment, 5) assess future risks and barriers, 5) revise the component economic potential based on commercial interest and potential market impact, and 6) develop a plan to advance the concept from TRL 3 through 7.

The expected outcome from this project is an assessment of the viability and promise of a composite turbine blade with structural health monitoring capability. Successful demonstration of this technology will lead to accelerated deployment of hydrokinetic systems because longer life composite turbine blades reduce maintenance and a method for monitoring the in-service operation of the turbine blades can alert personnel when maintenance is required. In the future, this component will benefit consumers because savings on operation and maintenance costs will be translated into lower cost of electricity. Further, consumers in remote locations will have access to electricity because a more economical hydrokinetic system is possible.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Enable various turbine developers to utilize this technology.
- Build upon experience from the wind sector.
- Full alignment - The acoustic signal is novel approach than may have applications for sensors in the MHK sector.
- Effort focuses on reducing O&M costs by remote monitoring of turbine blade.
- Reducing O&M costs is very important.
- Interesting use of a blade monitoring and communications.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Have embedded sensors with communication capability.
- Working on how to imbed sensors to blades.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.2** based on project implementation.

- Completed initial tests.
- Has completed initial steps and using dummy fibers.
- Has imbedded sensors into test devices.

Strengths and weaknesses

Strengths

- Will enable turbine developers to reduce O&M costs and measure in real time.
- A good project transferring sensor technology form wind to MHK.
- May provide means to monitor blade condition over time remotely.

Weaknesses

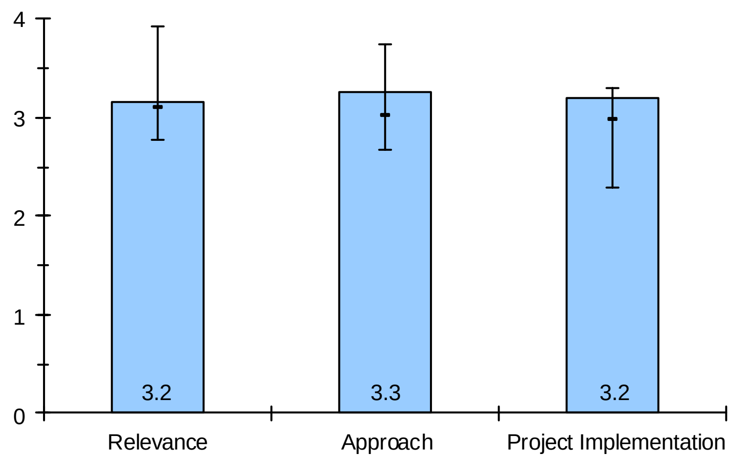
- NA

Specific recommendations for additions or deletions to the work scope

- While remote monitoring of the health of MHK components is attractive, the relatively low TRL for this research project creates a concern regarding the use of limited funds for a study of this type.

Project Name: OTEC Cold Water Pipe-Platform Sub-System Dynamic Interaction Validation
Matthew Ascari; Lockheed Martin Corporation

Overall Project Score: 3.2 (5 Reviews Received)



__Brief Summary of Project__

This project will validate the ability to numerically model the dynamic interaction between a large cold water filled pipe and a floating ocean thermal energy conversion (OTEC) platform excited by meteorological and ocean (metocean) weather conditions using measurements from a scale model tested in an ocean basin test facility.
An OTEC system generates electrical power by running a rankine thermodynamic cycle supported on a moored, floating platform subsystem. Warm surface water evaporates a working fluid. The working fluid gas is expanded through a turbo- generator, producing electricity. The discharged gas is condensed using cold deep sea water accessed through a large cold water pipe (CWP). For power plant capacities of 100 MW, the CWP may be 10 meters in diameter and up to 1,000 meters long. The Pilot Plant CWP will be 4 m in diameter by 1,000 m long. The interaction of this CWP-platform subsystem from combinations of metocean conditions must be understood to design an OTEC system to survive for typical utility life cycles.

The offshore industry uses software modeling tools validated by scale model tests in facilities able to replicate real at-sea metocean conditions to provide the understanding and confidence to proceed to final design and full scale fabrication. However, today's offshore platforms (similar to and usually larger than those needed for OTEC applications) incorporate risers (or pipes) with diameters well under 1 meter. Hence, existing offshore design tools are not validated for OTEC applications where the CWP has mass loading properties of the same magnitude as the rest of the platform. This project will advance the CWP-platform subsystem from TRL 4 Proof of Concept to TRL 5/6 System Integration and Technology Laboratory Demonstration.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

__Question 1: Relevance to overall DOE objectives__

This project earned a score of **3.2** for its relevance to DOE objectives.

- The cold water pipe work is alignment with the WPP.
- Cold water pipe is key part of any OTEC project.
- Software modeling for validation of OTEC applications would appear to have value to developers.

__Question 2: Approach to performing the research and development__

This project was rated **3.3** on its approach.
- Appears to have teamed with an ideal testing facility.

- Doing tank testing.
- Project engineering appeared to be sound.

<u>Question 3: Project implementation pathways toward project and DOE goals</u>

This project was rated **3.2** based on project implementation.

- It is really too early in the project to tell is this project is being well implemented.
- While the total DOE Award Amount was not clear this appears to be a relatively low cost engineering study.

<u>Strengths and weaknesses</u>

Strengths

- NA

Weaknesses

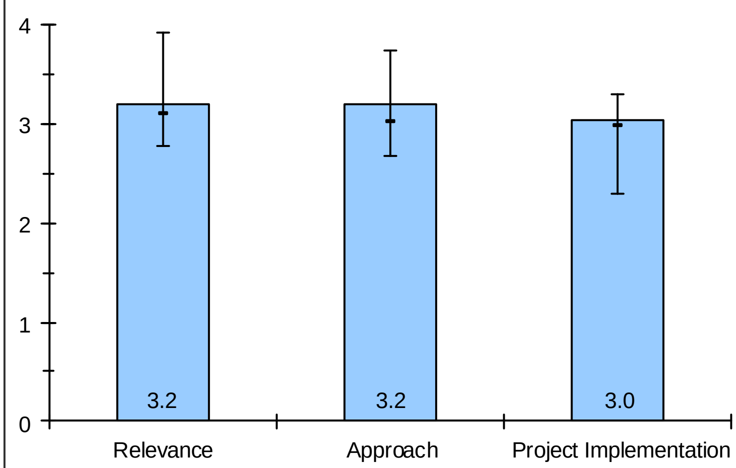
- NA

<u>Specific recommendations for additions or deletions to the work scope</u>

- NA

Project Name: Modeling the Physical and Biochemical Influence of Ocean Thermal Energy Conversion (OTEC) Plant Discharges into their Adjacent Waters
Patrick Grandelli, P.E.; Makai Ocean Engineering*, Inc.*

Overall Project Score: 3.2 (5 Reviews Received)



Brief Summary of Project

OTEC plants use very large flows of warm surface seawater and cold deep seawater to generate baseload renewable power. The deep seawater is oxygen deficient and 20-40 times more nutrient-rich (nitrate and nitrite) than shallow seawater. When mixed, these plumes are slightly denser than the ambient seawater. Makai has already developed a numerical model to simulate the plume mixing physics, nested within the best existing oceanographic circulation model of Hawaiian waters. This project will (1) calibrate the ocean circulation model and (2) upgrade the numerical model to simulate the biochemical response to these OTEC plumes.
The resulting model will answer two critical questions: “What are the predicted environmental impacts of the OTEC discharge plume?” and “How do we adapt the design to mitigate those impacts?”

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.2** for its relevance to DOE objectives.

- Assessing potential eutrophication impacts from the discharge plume.
- Developing a plume model is necessary to predict potential reaction from a nutrient rich plume.
- Very focused attempt at modeling and analysis of OTEC plumes.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Have provided NOAA with biological data.
- Looking to make sure that OTEC doesn’t result in high nitrates from deepwater in photic zone which would lead to a bloom. Looking at picoplankton.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.0** based on project implementation.

- Impending project deadlines may prove to be challenging to completion.

Strengths and weaknesses

Strengths

- Provided NOAA with biological data.
- The impact of OTEC discharge plumes will be of significant interest to regulators.

Weaknesses

- While NOAA has data will they support the development in the regulatory approach?
- An unsatisfactory presentation and summary report. It was not clear what the project had achieved of that it was in line with WPP goal. The presentation did little to add.

Specific recommendations for additions or deletions to the work scope

- NA

5.0 Conventional Hydropower Activities

Conventional hydropower (CH) technologies generate power using a dam or diversion structure to alter the flow of a body of water. Conventional hydropower is a relatively mature technology that currently represents the largest source of renewable power generation in the United States (U.S.). Conventional hydropower contributes significantly to the nation's renewable energy portfolio. The U.S. Department of Energy (DOE) Wind and Water Power Program (referred to as the Water Power Program or the program) works to assess and quantify the current value of the nation's hydroelectric infrastructure, to assess the environmental impacts of hydropower and to develop new methods to minimize or mitigate those impacts, and to increase the value that hydropower confers to the electricity grid through its ability to integrate other variable renewable energy technologies.

The key objectives of the program's CH activities are to: 1) increase the total contribution of conventional hydropower plants to the renewable energy portfolio in the U.S., 2) bring new hydropower technologies that have improved energy and environmental performance characteristics into commercial readiness, and 3) reduce barriers to new development, such as regulatory risks and expense.

The key barriers facing CH activities are:

- Issues with development incentives.
- Expensive and uncertain regulatory process.
- Technology costs remain high in certain sectors.

The technical approaches utilized by the program to address the key barriers facing CH activities are:

- Support immediately-available, low-cost upgrades and feasibility studies to identify additional opportunities.
- Identify resources and address technology/policy needs to maximize medium-long term opportunities.
- Engage regulators and environmental stakeholders to reduce license time and cost.

Below are brief overviews and summaries of the key conventional hydropower activities that are currently being supported by the program.

Summary of Conventional Hydropower Technology Development Activities
The program works to increase the nation's incremental hydroelectric generation, to quantify and maximize conventional hydropower's ancillary benefits to the U.S. electric grid, and to improve the environmental performance of the U.S. hydroelectric infrastructure. Increases in incremental generation can be achieved through efficiency and capacity gains at existing power stations, as well as the placement of power stations at existing non-powered dams and in constructed waterways.

<u>Advanced Turbine Development and Deployment</u>
The program supports the development of more efficient and environmentally friendly hydropower turbines that can compete with traditional designs. This project will produce sufficient engineering data for a new turbine to be designed and constructed for one or more demonstration sites.

<u>Basic and Materials Research</u>
The program funds research and development to identify and test new materials and manufacturing techniques that improve performance and lower costs of conventional hydropower, such as materials or coatings that reduce life-cycle cost of turbine runners, draft tubes, and penstocks, and identification and testing of ways to improve generator efficiency and prevent failures.

Sensors and Controls
The program works to develop, demonstrate, and test new sensors and controls that can improve energy efficiency and environmental performance of conventional hydropower. These activities support industry by reducing capital and operations and maintenance costs, increasing unit availability and plant capacity factors, mitigating risk through enhanced system reliability, and improving the quality (environmental performance attributes as well as ancillary power benefits) and quantity of the energy produced. Areas of focus include water-use optimization, the application of advanced materials and manufacturing methods, and modeling and prediction of water power grid services.

Summary of Conventional Hydropower Market Acceleration Activities
Conventional hydropower contributes significantly to the nation's renewable energy portfolio. The program works to assess and quantify the current value of the nation's hydroelectric infrastructure, to assess the environmental impacts of hydropower and to develop new methods to minimize or mitigate those impacts, and to increase the value that hydropower confers to the electricity grid through its ability to integrate other variable renewable energy technologies.

Environmental Impacts and Mitigation
Although conventional hydro provides numerous societal benefits in addition to renewable energy, sometimes there can also be adverse impacts that must be evaluated. Conventional hydropower can produce adverse environmental impacts on fish populations and migrations, on water quality in reservoirs and downstream from dams, and on river habitats both upstream and downstream from dams. The program works to design, develop, and test new ways of reducing these adverse impacts, which have constrained the development of new incremental hydropower generation and improvements in operational flexibility. Areas of focus include:

- **Fish passage issues –** Research on the passage of fish through and around hydroelectric structures, including development of baseline biological methodologies and data for key species that can be used for improvements in dam infrastructure, such as turbines, fishways, and fish screens that increase fish passage and survival; demonstrations of new technology to determine fishway effectiveness in real-world applications; methods to measure and predict indirect fish mortality and non-lethal injury rates.
- **Instream flow requirements –** Studies to better understand and predict the effects of variable stream flows on fish and wildlife, especially those that occur downstream of hydropower projects; synthesis and integration studies to gather data from experiences across multiple, existing projects.
- **Cumulative impact assessment –** Development and demonstration of new methods to predict the cumulative effects of multiple stresses on the fish and wildlife affected by hydropower projects; methods for comprehensive evaluation of all possible routes of fish passage at dams (e.g., turbine passage, fishways, and spillage), for use in optimizing dam operations.
- **Environmental performance measurement methods –** Development and testing of improved methods for measuring fish passage mortality (direct and indirect) for use in evaluating the performance of advanced turbines.
- **Greenhouse gas emissions from reservoirs –** Development, testing, and demonstration of methods to measure and predict greenhouse gas emissions from reservoirs at hydropower projects.

Asset Management

Existing hydropower facilities in the U.S. show signs of deterioration, including declines in electricity generation, capacity factors, and facility availability, but the data to evaluate these facilities, which include both federal and non-federal assets, are scattered and outdated. Integrated and updated information is needed to understand the causes and potential solutions to the large annual variation of hydropower generation.

Grid Services

Conventional hydropower has the potential to increase the flexibility and stability of the U.S. electric grid and to support the integration of variable renewable resources. The program seeks to maximize this potential value by developing and deploying technologies that increase operational flexibility, including pumped storage, as well as the modification of regional computer models to better assess the potential capacity expansion of pumped storage and facilitate introduction of other variable renewable resources into the market.

Table 5.1 below lists the conventional hydropower projects reviewed during the 2011 Peer Review meeting, including the principal investigator and budget for each project.

Table 5.1 Conventional Hydropower Projects

Project Name	Principal Investigator	FY10 (DOE Funds)	FY11 (DOE Funds)	Total Funding	Duration (Years)
Water-Use Optimization	John Gasper	$2,000,000	$2,000,000	$6,000,000	3.5
(HAP) Hydropower Advancement Project: Audits and Feasibility Studies for Capacity and Efficiency Upgrades	Rajesh Dham and Brennan Smith	$3,285,000	$1,915,000	$5,200,000	2.5
Non-Powered Dams Resource Assessment	Brennan Smith	$589,000	$0	NA	NA
Climate Change Assessment	Mike Sale	$500,000	$0	$500,000	1
Basin Scale Opportunity Assessment	Simon Geerlofs	$500,000	$1,000,000	$1,525,000	2
Quantifying Full Value of Hydro in Transmission Grid	Tom Key	$1,000,000	$900,000	$2,600,000	2
Enviro hurdles- Instream flow	Mark Bevelheimer	$350,000	$350,000	$700,000	3
Conventional Hydropower Lower Technology Readiness Level (TRL) Projects					
SLH Timing Belt Powertrain	Natel Energy	NA	NA	$300,000	1
Laboratory Demonstration of a New American Low-Head Hydropower Turbine	Hydro Green Energy	NA	NA	$300,000	1
W4e Hydropower Turbine Generator system validation	Walker Wellington	NA	$15,000	$116,250	1
Small Hydropower Research and Development Technology Project	Near Space Systems	NA	NA	$300,000	1
Scalable Low-head Axial-type Venturi-flow Energy Scavenger	New Mexico State University	NA	NA	$299,312	1.5
Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site	Weisenberger Mills	NA	NA	$56,000	3
51-Mile Hydroelectric Power Project Demonstration of new methodologies to reduce the LCOE for small, hydropower development	Earth By Design	NA	NA	$1,500,000	3
Proof of Power Project on Potholes East Canal (POP-PEC)	Percheron Power	NA	NA	NA	2
Real World Demonstration of a New American Low-Head Hydropower Unit	Hydro Green Energy	NA	NA	$1,500,000	2
Construction Support for New Slab Creek Power House Project	Sacramento MUD	NA	NA	$1,494,750	3

Project Name	Principal Investigator	FY10 (DOE Funds)	FY11 (DOE Funds)	Total Funding	Duration (Years)
SLH-100 demonstration project at Monroe Drop	Natel Energy	NA	NA	$746,000	2
Geotechnical Investigation and Value Stream Analysis for the Iowa Hill Pumped-Storage Development	Sacramento MUD	NA	NA	$4,961,138	2
Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the U.S.	Argonne National Laboratory	NA	NA	$1,875,000	1.5
Turbine Aeration Physical Modeling and Software Design	University of Minnesota	NA	NA	$600,000	NA
Sensor Fish Re-design to Support Advance Hydropower Development	Pacific Northwest National Laboratory	NA	NA	$299,000	1.5
Deployment and Testing of the Alden Hydropower Fish-Friendly Turbine	EPRI	NA	NA	$1,500,000	3

5.1 Conventional Hydropower Project Evaluations

Table 5.2 below lists the average score per category and the averaged weighted score for each larger conventional hydropower (CH) project that was evaluated by the CH Peer Review Panel. Individual CH project scoring summaries and reviewer comments are also included in this section.

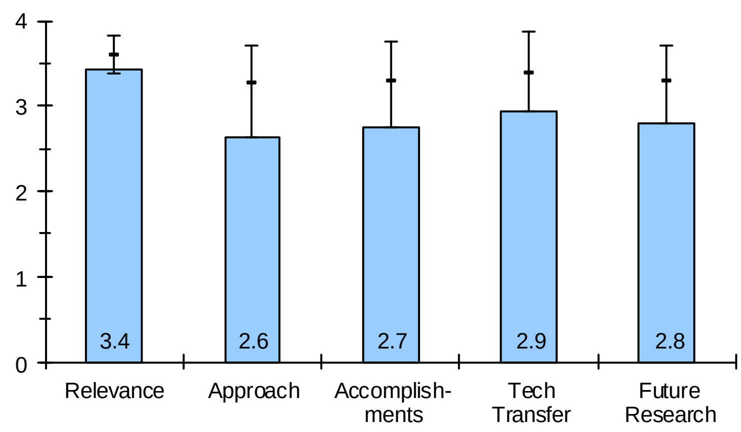
Table 5.2 Larger Conventional Hydropower Project Scores

Conventional Hydropower Projects	Relevance to Overall DOE Objectives	Approach	Technical Accomplishments and Progress	Research Integration, Collaboration, and Technology Transfer	Proposed Future Research	Average Weighted Score
Water-Use Optimization	3.4	2.6	2.7	2.9	2.8	**2.8**
(HAP) Hydropower Advancement Project: Audits and Feasibility Studies for Capacity and Efficiency Upgrades	3.8	3.3	3.3	3.4	3.4	**3.3**
Non-Powered Dams Resource Assessment	3.8	3.5	3.6	3.4	3.4	**3.5**
Climate Change Assessment	3.5	3.7	3.7	3.7	3.7	**3.7**
Basin Scale Opportunity Assessment	3.4	3.2	3.0	3.2	3.1	**3.1**
Quantifying Full Value of Hydro in Transmission Grid	3.8	3.6	3.8	3.9	3.6	**3.7**
Enviro hurdles- Instream flow	3.6	3.2	3.1	3.2	3.1	**3.1**

Project Name: Water Use Optimization: Development and Demonstration of Advanced Forecasting, Power and Environmental Planning and Management Tools and Best Practices

John Gasper, John Hayse, Matt Mahalik, Tom Veselka, Brennan Smith, Mark Wigmosta; Tom Lowry; Argonne National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratory

Overall Project Score: 2.8 (6 Reviews Received)



<u>Brief Summary of Project</u>

Hydropower planners and operators are faced with an increasingly water-constrained operating environment. Complex electricity markets are changing operational paradigms and affecting the value of electricity generated, ancillary services and water. Water quality, habitat protection and restoration requirements, water supply contracts and demands, and changing weather and climate patterns are changing the timing and volumes of available water. As a result, optimizing water use is increasingly important. Existing planning and operational tools are limited in the ability to integrate these conditions into operational efficiency and environmental performance decisions. The objective of this project is hydropower optimization improvement, meaning more energy and grid services from available water, and enhanced environmental benefit from improved hydropower operations and planning. The purpose is to develop and demonstrate an integrated suite of advanced analytical tools (e.g., water forecasting, day-ahead, real-time and seasonal power system models, environmental performance algorithms and hydropower performance metrics) that will allow hydropower planners and operators to better to account for this full spectrum of conditions in power generation and water use decisions.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.4** for its relevance to DOE objectives.

- This project in intended to meet DOE's objective of gaining more energy and grid services from available water as well as more effectively meeting environmental flows. In concept it is possible that providing an integrated set of tools as this project proposes, could meet this objective. However, the components of the project replicate software and services that already exist and are in use in the industry. Therefore, the justification and the plan for development for this project should be based on an identification of problems or deficits with existing tool sets. The project summary states that "Existing planning and operational tools are limited in the ability to integrate these conditions into operational efficiency and environmental performance decisions." This claim is too general to be of use in translating a need into functional requirements and design.
- The stated goal of the project is to develop and demonstrate this set of integrated tools. However, the goal does not include packaging the tools and making them available to the industry. Thus this project

is not consistent with the DOE's research approach of developing decision tools (i.e., tools that can actually be used to meet the objectives).
- Many utilities already have an effective means of forecasting and optimizing operations; the ones that do not have these decision tools probably cannot afford them and/or do not have the technical skills needed in-house to use such tools. The toolset proposed in this project promised to be very expensive and to implement and would require advance skills to use. Thus there is a significant challenge for this project to meet DOE goals.
- Important changes since last year. Software development is on schedule. Good seasonal forecasts. In 2012 will compare with Weather Service forecasting techniques. Ultimately will provide forecasts at locations where Weather Service does not.
- Important aspect of water power.
- Generally supports DOE objective to increase hydropower resources but is a very, very complex project to address a very dynamically constrained situation.
- This is a good project. Significant progress seems to have been made since last year's review.
- Tool sets are usable separately or together. That's good.
- Technical transfer seems a weak point. Lots of good work being done, but it stays in the National Labs with the people working on this project. If someone outside the NL wants to use the work, it requires the NL personnel to make it happen. If there is not transfer, the work to develop a tool is wasted. And I fear that there is a fairly strong probability that the tech transfer will likely not happen. So DOE needs to significantly follow up to make sure the tech transfer takes place.
- Programs of this type take years of continuous development and refinement to be accepted by a broad industry segment.
- The combination of tools that are integrated appears to have potential value for industry.
- As noted in the Applications, the goals in market based environments may be different from independent hydro system operators. A value to market operations would be if the total available hydro resource could be optimized from a probabilistic standpoint. As noted below in Barriers, generators with different owners in a competitive environment may not be willing to coordinate without financial (tariff revenue) incentive.
- This sub-project is very important to the goals and objectives of the overall Water Power Program and specifically to the objectives of the Water-Use Optimization Project.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **2.6** on its approach.

- Among the most serious technical challenges/barriers faced by this project are:
    - The highly detailed data needed to develop, test and calibrate the forecast model; the need to keep the model calibrated as ground conditions change; the intense computational requirements to run such a model. The choice of tools here comes with these challenges/barriers for which there is probably not a remedy.
    - Finding and integrating an optimization solver that is powerful, able to solve the unit commitment problem (e.g., integer programming), multi-objective, fast and flexible enough in implementation to communicate with the software in an integrated way. Further, the optimization must be robust - able to avoid infeasibilities and to manage the problem of alternative optima. These are difficult technical issues that others in the hydropower optimization world have spent years in addressing. It is worrisome that this project has not yet identified a solver much less started to address these implementation challenges.
    - Seasonal optimal analysis must consider hydrologic uncertainty and some metric for hydropower evaluation - forecasted values or value of water in storage - which also have

uncertainties. The stochastic optimization problem has been correctly assessed as being difficult in that it explodes in size with traditional (dynamic) approaches. The optimization scheme presented, which uses a genetic algorithm, results in many alternative solutions. A means for integrating the economic hydropower objective is not apparent, nor is the process of identifying a limited set of possible plans with quantified uncertainties.

  - Environmental flows are already mandated on many rivers, including the Upper Colorado (one of the demonstration areas); on many other rivers stakeholders such as NGOs and Fish and Wildlife Service participate in efforts that result in formal biological opinions. The Index of River Functionality is an interesting concept (greatly improved over the previous metric). In order to be adopted it will need to be submitted for peer review by the environmental research community and tested in various places to compare it with existing metrics.
  - The development of demonstration software is different than development of a software product that is tested and usable by the industry for business processes. The goals of this project have been understandably scaled back to target demonstration and not ready-to-use software. But even so, development of software that is general enough to be used by a range of users, and is reliable, efficient, tested and documented is a formidable challenge.
  - A key milestone is the demonstration of the tools on real systems. One of the systems proposed, the Upper Colorado, already has forecasting, specified operating policies and mandated environmental flows, thus a clear benefit of using the tools cannot be demonstrated there. The difficulty in finding systems or utilities willing to be demonstration sites may reflect the significant effort that would be required by the organization; it may also reflect the lack of concretely identified needs (based on data from specific organizations in the industry). It is a major barrier to the success of the project.

- Technology transfer may be difficult, particularly at the level of hydro-industry operations. The tool box is for optimization of real time operations and therefore is very site specific. An index of River Functionality is generic and may be appropriate for regional analyses when scoping potential options during feasibility studies and basin-scale opportunity assessments. However, the Water-Use Optimization "tool box" is for very detailed site specific analyses where quantitative environmental consequences of various project operations are desired, often on daily or hourly time scales. The environmental aspects must be on the same site specific scale. Time series simulations (seasons and yearly) can compare the potential impacts of alternative hydro operation on environmental resources.
- A relatively expensive undertaking that has had difficulty finding multiple demonstration sites. This raises some concern. The general effectiveness of this toolbox is dependent upon both, the completion of the project including all interfaces, but also the demonstration of widespread use by industry to result in greater conventional hydro power contributions.
- My main fear is that the work will not overcome the non-technical barriers related to making the tools usable and available for use by others.
- Data base used for this needs to be maintained. Will require future funding stream to keep it up to date.
- While the project was proposed as a "proof of concept" project, it will be wasted effort if not made simple enough so external users can use pieces.
- 6 Mill DOE funds invested in this. Wasted if not transferred to outside NL users.
- Multiple owners of hydro facilities in competitive environments may not allow the optimization of hydro operations without a payment (revenue from a tariff).
- Assimilation of complex tools is very slow in the power industry.
- Planning tools would have to be able to simulate the results of the ToolBox if hydro generation is to be chosen as an economical alternative.
- The tool box is for optimization of real time operations and therefore is very site specific. An Index of River Functionality is generic and may be appropriate for regional analyses when scoping out

potentials as in feasibility studies and basin scale opportunity assessments. However, the Water-Use optimization "tool box" is for very detailed site specific analyses where quantitative environmental consequences of project operations are desired, often on daily or hourly time scales, within seasonal and yearly time series analyses.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.7** based on accomplishments.

- The forecasting component appears to be on schedule and has made technical as well as strategic progress in terms of coordination with NWS. Tool integration is main remaining task - this should not be difficult to accomplish in the year remaining.
- The real-time and day-ahead component is behind on listed tasks and also has some technical issues to address regards the solver and representation of units. Also, how are other objectives (other than hydropower and environmental) expressed and how is multi-objective problem formulated? These problems should be solved by now and software integration the outstanding work. However, software integration and the GUI cannot be finalized until these technical issues are resolved - and they are significant. These problems could result in delays to the entire project integration. A plan with timeline and frequent monitoring would be useful to the project team as well as DOE.
- The environmental performance component may be on schedule - not possible to determine from presentation materials. Verification, testing, publication and demonstrations are still to come. Recommend monthly monitoring so all of this can be accomplished in the coming year.
- The seasonal hydrosystems analysis component shows that it has met milestones to date, though does not mention unresolved technical issues. Also, the goals for the coming year are not provided. Due to difficult technical issues and challenge of software integration, a detailed project plan and frequent monitoring would be useful to all.
- The Unit and Plant Efficiency component consists of data provided to the toolbox from the Hydropower Advancement Project. More clarification is needed as to how this data will be integrated with the tools and the timeframe for that integration.
- Good progress toward component goals but attention is needed to linkages among components. Suggest focus on these linkages with a case study where much of the needed information already exists. Pursue possible demo project with USBR ongoing management of the Trinity River in northern California. Their water supply forecasting is critical for establishing water year type and corresponding annual water allocation to restoring the salmon fish population spawning and rearing in the river. The Trinity River has multiple water uses that must be balanced, including reservoir storage and delivery to the Sacramento River basin, hydropower, irrigation, downstream temperature targets, fishery recovery, endangered species, Tribal historical rights, etc.
- Significant progress has been made in the development of the individual tools but the complete end-product will determine the usefulness for the end-user.
- Progress seems to have been significant since last review.
- Sad that the project team is having problems getting demo sites. Could MOU participants be involved to demonstrate? Would also be nice to see some private utilities get involved in demonstrations. Helps make the tool more ready for external users.
- DOE needs to push hard to get the demonstration part going. Use it for 5 rather than 2 projects and then the probability for transfer outside the NL's is higher.
- Will be interesting to watch how the Dissemination of results takes place. Hopefully efforts are made as good as project 72 (Quantifying Full Value of Hydro in Transmission Grid) where multiple seminars to communicate ongoing progress have been made in connection with NHA and HydroVision events among others.

- Use outputs in coordination with RTO or utility power production simulation packages to investigate hydro revenue sensitivity to the scheduling options. An example may be the hydro potential on the Mississippi River for MISO markets integration. Revenue can be from capacity, ancillary services, energy or special capabilities such as being able to black start or assist in the black start of an area. The goal is stated to maximize the power (power is capacity at a specific time, energy is power times time) with the same amount of water. The goal may actually be to maximize the revenue to the generators with the same amount of water if the generator is owned by a company. If the generation is government owned, the goal may be to maximize power or energy production or some other goal.
- Site specific salmon/habitat based fish population simulations involving linked computer models would offer the investigators much insight for linking to watershed runoff, routing, water temperature, habitat population response.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **2.9** for technology transfer and collaboration.

- This project integrates its own components, and also will integrate the HAP project data. There are likely other potential collaborations with environmental efforts as well as market and grid services projects.
- Although there is a plan for demonstrations and publications, a much more aggressive technology transfer effort would be required to convince anyone to use these tools. This may not be possible in the budget and timeframe of the project.
- The coordination of the forecasting component with the NWS is good and a key to future successful use of the tools.
- Coordination among component DOE groups is much improved. Collaboration is identified for incorporating fish population (ORNL), and fish passage (PNNL) in the "tool box". Still need to thoroughly review similar multi-objective decision support efforts and software development by other groups. Great opportunity to build on past efforts. Also, as suggested last year, look into work done by Norway hydro industry and the River System Simulator software developed by the SINTEF NHL Civil and Environmental Engineering group at the Norwegian University of Science and Technology, Trondheim. USGS, Fort Collins Science Center has developed a Decision Support System for the Delaware River, a major water supply for the City of New York.
- Value if transfer to industry users is performed.
- Research integration between NL partners seems quite good.
- Collaboration between NL's seems to be quite good based on material we have been given. I don't sense too much collaboration with Industry.
- Technology Transfer efforts to date are fair at best. Potentially because of the natural evolution of develop, then apply and the project is still in the develop phase. Hopefully TT efforts will be stepped up.
- Integrated together, a score of 3 results, pulled down by dissemination of results, TT.
- The project appears to be well coordinated within the laboratories.
- Two applications, one in a market environment and one in a bi-lateral exchange environment, have the potential to provide good examples.
- Widespread industry acceptance would require long term availability of program support and development.
- A plan to continue beyond the end of the project is not to be expected with the structure of the funding and focus of the research. It would be interesting to see a plan on how to make all the effort and funds expended into a commercial or enduring product for the industry.

- Collaboration is identified for integrating fish populations (ORNL) and fish passage (PNNL). The effort on Index of River Functionality is better focused toward the 67-Basin Scale Opportunity Assessment.

Question 5: Proposed future research

This project was rated **2.8** for proposed future work.

- The project scope has been adjusted since last year to make it more realistic. However, the optimization components and the software integration still face major challenges that may not be possible to overcome within the project timeframe. Further adjustment should be considered with a year left in the project. The demonstration goals may also need to be adjusted.
- Significant progress toward individual component group goals. Need to focus on integration and software linkages in 2012. It is most helpful to develop conceptual linkages among group efforts well before individual group efforts are complete. Have conceptual linkages among group efforts peer reviewed and modify thinking as appropriate. The effort on Index of River Functionality is better focused to Project 67-Basin Scale Opportunity Assessment.
- The rollout of the total package, and its use by the hydro industry at large, is not completely clear. The proposed work is plausible but may have difficulty in actual deployment.
- Next step list presented seems appropriate.
- Get more Demo projects. These are essential to gain more robustness in the tool.
- The basic tools are planned and the development is being completed.
- The time range for the project is too short to expect to see wide industry acceptance. It typically takes at least five years after a program becomes available, before it starts to be accepted by others.
- Suggest that demonstration sites be expanded to one or more USBR projects where salmon fish populations are important aspects of day to day operations. Ex. Trinity River, CA, Klamath River, CA, Yakima River, WA. Also focus on trout populations in the upper Gunnison River. The Colorado Division of Wildlife and Parks has considerable data on the trout populations USGS, Fort Collins has version of the SALMOD model for rainbow and brown trout.

Strengths and weaknesses

Strengths

- An important strength of this project is the vision of an integrated toolbox to increase efficiency of hydroplants and improve environmental performance.
- Another major contribution of this project is the identification of the technical challenges that are inherent in addressing this challenge. Although others have identified these challenges, it is of great value for DOE to understand the issues.
- Overall an excellent development project. The challenge will be in making the products, particularly software support, available to hydro industry and regulated river managers.
- Teamwork and coordination seems to have improved significantly since 2010 peer review recommendations.
- The tool set would help streamline and integrate various uses of Water and allow better utilization balancing competing issues.
- Tool set seems to provide some facts to help with collaboration between water users.
- The greatest strength is the integration of multiple aspects of the hydro problem into a single ToolBox.
- For the money being spent, the project has good potential of producing usable products.

- Great opportunity to advance the state of the instream/environmental flow practice having the excellent expertise and level of detail associated with the other components of the "tool box development." This component must also focus at the same level of detail.

Weaknesses

- The project has undertaken too much - both the development of new tools/approaches to solving these problems and software to implement and integrate the tools.
- The functionality of all the components already exists in many tools that are currently in use or under development. The project was not based on a needs analysis or specifically identified gaps.
- The tools are complex and require significant investment to apply. The tools will not be ready for others to use when the project is completed; applications will have to be developed by the experts who developed the tools.
- The demonstrations will not be able to show an advantage to using these tools, i.e., to show an improvement in operations, because the demo basins already have and use tools. A need for improvement has not been identified.
- Must thoroughly investigate other multi-objective tool development efforts. Understanding and building on and providing significant improvements to past/ongoing decision support efforts will not only facilitate integration efforts but also prompt others to acquire your improved products.
- Incredibly complex program that will likely require much data input, care, and feeding to arrive at solutions that will likely be short-lived in the dynamic environment of hydro operations and power systems. The tools attempt to address some of the variables and uncertainty associated with hydropower and its constraints, but the external influences of demand side uncertainty, temperature forecast uncertainty, and forced outages anywhere on the interconnected generating system, can also have impacts to the hydro dispatch. In some hydro scenarios, the real world usefulness of this product may not be able to offset the effort of the complex input required.
- High investment risk - Final judgment will be based on real-world utilization to arrive at real-world hydro MWh gains using the final completed product. Unfortunately, if the project product is not utilized, for whatever reasons, there will have been a large investment for naught.
- Technology transfer outside of the NL team working on this.
- Dissemination of results.
- Lack of a plan to publish a usable tool set, even if outside the budgeted scope.
- The weakness is that the project appears to be terminal at the end of the present funding. This is within the structure of the funding and should be expected.
- Some of the goals may have to be adjusted to fit in market environments depending on the hydro generation owners.
- The time and resources allocated are not sufficient to achieve wide acceptance in industry.
- Project seems to struggle with and search for a generic environmental index vs. site specific instream analyses.

Specific recommendations for additions or deletions to the work scope

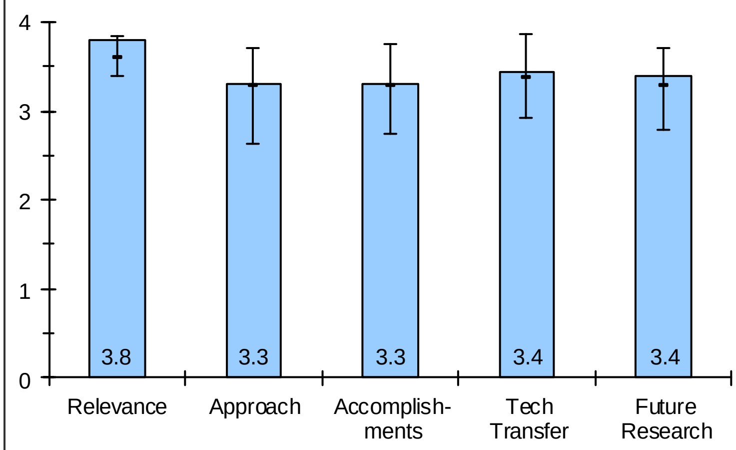
- Since the project scope has been modified such that the anticipated outcome is not a software product that can be readily used by the industry, it would be more productive for the developers of each component to focus on refining their specific tools rather than on the software integration. This would increase the chance of having one outcome of significant value rather than two outcomes of limited value.
- The problem of identifying demonstration basins could be more effectively addressed if the developers of each component could identify one or more basins in which to demonstrate their respective tools instead of looking for basins in which to apply the entire suite of tools. The basins would be chosen with the goal of applying the tools where they can make a difference - they can

improve the way the system is operated and the improvement can be documented and perhaps quantified. This is likely a more tractable approach especially in the timeframe remaining and would have a higher valued result. (The forecast component has already done this).
- Very complex project and coordination is needed.
- Need to look closely at end product to make sure there is alignment.
- Monitor closely to assess progress toward a useful and used product.
- Add a phase to more formally capture the results of the work and publish the tools so the developments and insights gained can be used by others outside the NL's.
- Pursue an investigation in future years of research to see if the ToolBox has the potential of creating value for the power industry.
- Determine the conditions necessary to transfer the ToolBox to a commercial vendor. TVA used to have a generation forecasting program that was used in industry. BPA had power flow, short circuit and dynamic programs that were world class. Both programs were superseded with commercial programs that provide customer support, training and improvement of the programs.
- Examine site specific instream flow analyses being conducted at large water projects elsewhere and adapt on existing demonstration sites. Try to establish partnership with additional water management projects where detailed habitat and fish population data are being collected.

Project Name: Hydropower Advancement Project

Brennan Smith; Oak Ridge National Laboratory

Overall Project Score: 3.3 (6 Reviews Received)



Brief Summary of Project

The expected outcomes of the HAP are (1) estimation of the increased energy production potential across the U.S. hydropower inventory, (2) characterization of barriers to accelerated upgrade of the U.S. hydropower inventory, (3) identification of technology and research needs associated with upgrading existing US hydropower assets, and (4) dissemination of best practices and tools that can assist industry in scoping and justifying upgrades. HAP key concepts include standardized assessments that asset owners/consultants can use to initiate investment and operating policy decisions and aggregated national reporting to enable benchmarking and trending. The HAP will not provide individual ranking or certification of hydropower facilities, as this is an appropriate role for hydropower industry participants and stakeholders.

The HAP will highlight opportunities for improvement of U.S. hydropower value in two categories: (1) equipment and process upgrades that increase the efficiency of generation on an instantaneous and annual average basis, thereby enabling increased energy production from the water passing through turbines and (2) equipment and process upgrades that enable a project to use more of the available water in streams, which will also increase energy production. This distinction between efficiency and utilization is non-trivial in detecting trends in the results of systematic assessments of the U.S. hydropower fleet, and for modeling the effectiveness of federal or commercial RDD&D investments for hydropower improvement.

The potential for increased production and value resulting from efficiency upgrades in the first category is predictable and scalable according to common design features of the hydropower technology. The potential for increased production and value from utilization upgrades in the second category is less predictable and more varied because it depends on site-specific hydrologic and environmental contexts. Improvements in unit reliability and availability contribute to both of these categories—first, by enabling increased flexibility to maintain units at efficient loads, and second, by maximizing the volumetric capacity of the powerhouse. The concept of performance at this stage of the HAP focuses on water use efficiency—how well the facility or individual unit converts potential energy to electrical energy over a long-term averaging period of a year or more, but may also include measures of dispatch flexibility. In most cases, increased utilization resulting from equipment upgrades and process improvements will decrease the levelized cost-of-energy (LCOE) for a facility or fleet of facilities by increasing average annual production relative to the costs of implementation.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- This project will provide data and guidance of best practices that are key to meeting DOE's objectives and could potentially be of great use to other (current and future) research projects.
- Development and dissemination of best practices has potential for significant improvement in efficiency of hydropower plants across the U.S.
- Supports DOE objective to increase hydro generation through upgrades and other sources.
- Project should help provide a more formal method for evaluating upgrade potential of existing hydro sites and quantifying the benefits of upgrades.
- The project provides information to industry that is not readily available today.
- The information from the project may have wider use than just the hydro owners or potential owners. The RTOs or WECC (at least MISO could) determine the proposed value of a potential hydro capacity and energy increase. The hydro projects could be ranked by portfolios of generators that may produce enough value to be economically justified. The Energy Storage report by EPRI with MISO information produces information of this type for CAES and Pumped Storage.
- In areas with Renewable Portfolio Standards, small hydro and in some cases all hydro, qualifies as a renewable resource. Hydro has to compete with other renewable resources (wind) as an RPS resource and not with gas or other primary fuel generation. Policy such as equivalent Production Tax Credit treatment of hydro compared to wind is critical. RPS competition may require a different design than competing as an Ancillary Services resource.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- The approach is well thought out; some technical issues have been identified as well as plans for addressing these. The objective is to identify barriers to increase hydro production. But some important factors are difficult or impossible to include in the analysis including considerations of competing water objectives and risk management especially with respect to licensing. The project understands and acknowledges these limitations, but cannot address them in a meaningful way.
- Scope is to individual hydro-plants. This effort has been interfaced with the Water Use Optimization effort. They are linked and coordinating. Demonstration sites on the McKenzie River, Oregon and adding the Colorado River and collaboration with California Water Resources.
- A shotgun approach to several broad areas of upgrade analysis. One area focuses on understanding why known upgrade opportunities may not always have been pursued.
- NOTE: Duke Energy supported a site visit to help this team understand the upgrade potentials and the philosophies of our company and therefore, why all upgrade opportunities have not been immediately pursued. Applaud this team for getting out into the real world to better understand the constraints and conditions (financial and physical) that may not be so obvious from an academic study or a model at the office.
- Approach is quite good.
- Approaches like this have been used extensively by most Hydro Equipment Designers/Manufacturers to aid their customers in evaluating their existing projects.
- Utilities may feel more ownership if they use a published process themselves to make the evaluations. Therefore results may lead to more modernizations/life extensions.

- Generators may not be willing to share efficiency information in competitive environments. This may hobble the project. The value outlined may be sufficient to overcome the issues. Time will produce an answer or a clearer definition of the barrier.
- "Expensive" compared to what? What is the competition with an RPS and without an RPS? Is the total value of small hydro being addressed?

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Progress to date is significant and mostly on schedule, but Phase III is pending funding and Flaming Gorge Demo Assessment is delayed pending Reclamation approvals. Completion of the assessments will depend on timely solicitations, awards, training and completion, all on a very aggressive timeline. The progress to date does not suggest that DOE needs to maintain regular monitoring.
- Simulating water quality and quantity. Have added ice dynamics to the mix.
- In the early stages with a lot of work to be accomplished.
- Scope has been refined to concentrate and consolidate efforts on highest priority areas.
- Technical accomplishments moving forward nicely.
- Progress seems to be behind schedule in a number of elements.
- The information from HAP may be of interest to Planners in RTOs or other large utilities. The value of hydro to a RTO region could be determined based on the information that is proposed to be collected and processed. The optimization of individual hydro units may not be the best solution for the region as a whole. For example the choice of a turbine type may affect the revenue of a generator and the water used to produce the revenue. The use of a reservoir for regulation may also be changed. Ancillary Services may require half the water through put from the minimum generation to the maximum generation level with half the water and more revenue than if the generator were used for energy production. The generation below the minimum generation output would be priced at the market energy levels. Choosing turbines with lower minimum generation levels may be able to increase revenue from the same water availability. With wind generation the higher revenue periods may be off peak (night, spring, and fall and winter seasons). Adding additional generation capacity and running the generation at lower energy production levels may produce more revenue for a hydro facility than producing energy during the day time peaks.
- The HAP information may be more valuable if it provides input to a resource planning process that can evaluate ancillary service duty and revenue. The PLEXOS power simulation program is becoming commercially viable enough in the last year that it may be able to produce the desired result. How many interactions would be required before a solution settles would be difficult to estimate at this time. NREL is developing PLEXOS capability.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.4** for technology transfer and collaboration.

- This project is inherently strong with respect to integration with other projects. It feeds directly into the Toolbox project, but will also provide data and best practices guidelines that can be used broadly by DOE and other research projects. The HAP includes technology transfer activities and collaboration with industry.
- Interfacing with the Water Use Optimization tool set to provide powerhouse best practices and develop local optimization tools linking with day ahead scheduling. Good progress toward integration as partnership with the Water-Use Optimization Project.

- Good participation and support with industry to help understand the economic real world realities.
- Several demonstrations underway with Industry partners. Good for learning.
- Good collaboration seems to be occurring between team members.
- Dissemination of results moving forward. May be weaker of the comments
- The plans appear to be sufficient. Time will provide an answer.

Question 5: Proposed future research

This project was rated **3.4** for proposed future work.

- Although challenges have been identified, it may be wise to identify decision points and contingency plans, especially given the tight timeframe of the project.
- Technical Expert Review of BPC and Manuals. RFI issue Nov. 2011 to gather feedback on proposed assessment. Stated plan for 2012 is to apply performance and condition assessment to demonstration sites with optimization tool box.
- Those presented seem logical.
- The project addresses its goals well with its assumptions. The assumption set to determine value may be too narrow as indicated with the other comments.

Strengths and weaknesses

Strengths

- This is potentially a high-value project in terms of how it can contribute to the quantification of possible increased hydropower.
- The technical approach is well thought out and the project team understands the issues and limitations of the analysis.
- A solid hands-on, in the field, approach should help this project avoid the type of "think tank" product that so often can yield little value in the real world of hydro producers.
- Provides a process for plant owners to do self-assessment, or to compare proposed assessments by others to methods documented by this project.
- Project may show elements of the process which are lacking in those processes used by Hydro Equipment Designers/Manufacturers.
- The strength of the program is that information that is difficult to obtain is intended to be produced.
- Hopefully, industry will support the program on its strength.

Weaknesses

- There are some complications with getting meaningful assessments.
- Monitoring data is not as available as anticipated.
- Quality of material provided prior to the presentation was less than ideal. Presentation used material not previously distributed. For the budget size of the project, not a lot of detail presented, possibly due to time limitations of this Peer Review cycle. More time for sharing of more details with Peer Review panel would have been good.
- Many of the contractors working on this project seem to have been involved in TVA's Hydro Modernization efforts. Some input by others doing similar modernization and not involved in the TVA HM efforts may add some insights.
- The scope of use of the data may be too restrictive. Until the last few months' evaluation of some of the barriers have not been possible. The project should be evaluated on the state of the art of study capabilities at the time that the scope was written.

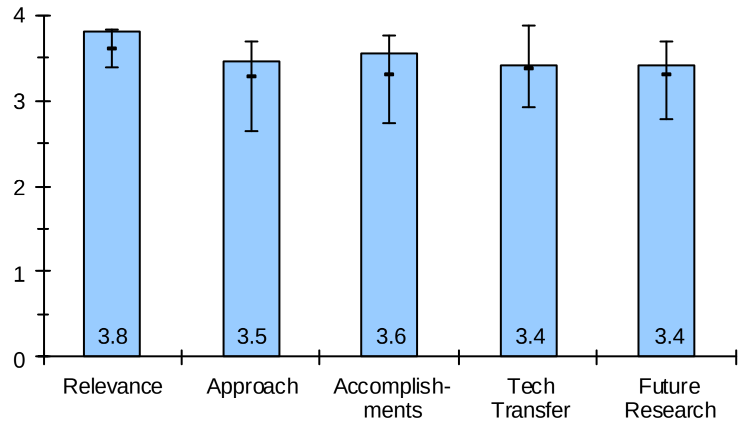
- The project is very ambitious for the time and resources devoted to the project.

Specific recommendations for additions or deletions to the work scope

- Did visit and communicate utilities on why they did something
- Does interface with optimization tools efforts. Seems like a lot of work to still being done. However adjusting scope and reducing cost was a step in right direction.
- Scope looks good as it is.
- For future years, modify the scope to evaluate portfolios of hydro upgrades or additions with respect to market revenue. WECC is investigating an Ancillary Services type arrangement that may provide value for hydro services that the generators are not compensated today.
- Defining the Guiding Principles that the hydro program is expected to provide to each region may be performed by an RTO Board of Directors, a group of state regulators or Governors. Determining the conditions precedent to building hydro may also be enlightening. The RPS factor may justify more hydro than just a capacity and energy study would. Ancillary Services to manage wind may have additional revenue factors because hydro is renewable and can manage wind variability.

Project Name: Non-power Dam Hydropower Resource Assessment
Boualem Hadjerioua; Oak Ridge National Laboratory.

Overall Project Score: 3.5 (6 Reviews Received)



Brief Summary of Project

The overall objective of this effort is to assess the amounts of new hydropower energy resources which can be developed in the U.S. by powering existing non-powered dams. Due to high capital cost, time-consuming procedure, and potential environmental objection, the construction of new hydropower dams is a challenging and high-risk investment. In order to effectively raise the US total hydropower generation to achieve the strategic goal of increasing the usage of renewable energy, this study estimates the amount of potential power that can be produced by developing hydropower facilities at non-powered dams.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- Non-powered dams are an obvious place to look for potential for new capacity and production. This study attempts to quantify that potential.
- This project is in strong alignment with identifying additional sources of conventional hydropower potential.
- Well-conceived, good objective, provides improved database and detailed information, reduces erroneous data.
- Being able to identify hydro facilities that could be developed is a key goal and vital to industry if the sites are to be developed.
- Providing information about a category of a dam or one with certain range of characteristics may be as useful as individual assessments.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- The approach of doing an inventory of NPD, making some assumptions and approximations is realistic.
- Improved accuracy of existing data on dams, corrected location, identified non-power dams, corrected some as already having power. Improved estimates of head and flow at non-power dams.
- Recognizes that not all sites have the head or flow to make them economically feasible and begins to narrow them down to the most promising locations.

- Seems well done, well executed.
- As the project presentation points out the large numbers of dams makes it difficult to perform the study with the budget allowed.
- Data availability may be a barrier.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.6** based on accomplishments.

- The results - that the top 50 NPDs have over 60% of the national potential and that 85% of these are USACE locks and dams with relatively small environmental concern - is an important finding.
- Project is complete.
- Considering over 54,000 non-powered dams have been identified, this process has made good progress to identify the top 100 locations with highest potential.
- Seems well done, well executed.
- The number of dams is huge. Would it be possible to use head and flow to sort dams into ranked categories? The best and worst dams in a category could be evaluated. If the first one fails, the others do not need to be evaluated.
- The value of the storage of the dam is not being evaluated if it exists. Time of day revenue or ancillary service functions could be more important than the total energy.
- Economic development weights given to local construction may have an impact on the hydro being chosen in a competitive environment.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.4** for technology transfer and collaboration.

- The results will be combined with the HAP. Perhaps the results could help identify locations for testing of some of the turbines being researched.
- Close association with COE, USBR, and power authorities.
- Improved coordination between INL and ORNL from 2010 to 2011 following peer review recommendations.
- Seems well done, well executed.
- When database is available to public through NHAAP as indicated in future steps, TT will be good.
- The communication with the data sources seems to be good.
- The communication with the dam owners is vague.

Question 5: Proposed future research

This project was rated **3.4** for proposed future work.

- The project is completed as of November 2011, almost on schedule.
- Project is completed and no future research planned at present.
- Good. Future needs identification.
- Lists of evaluations are not especially useful if they cannot be screened or converted to a simple feasibility evaluation.
- The input data is impressive. The output data will be the test to see if the effort produces usable results.

Strengths and weaknesses

Strengths

- In spite of much uncertainty in a lot of the data, an important finding came out of this research.
- The inventory could be of used to future projects.
- Documented real potential for hydropower at locks and dams.
- Identifies practical locations and helps re-enforce the message that additional hydro is possible.
- Cleans and upgrades quality of the database.
- The strength is the promise of being able to obtain an evaluation of many sites.

Weaknesses

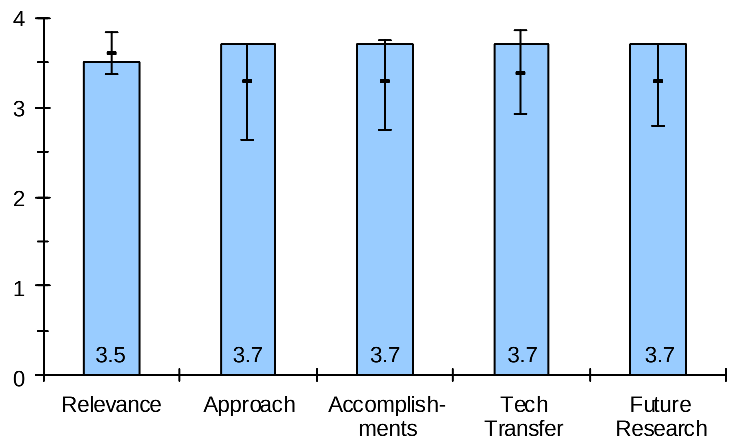
- Existing data bases were found to have errors, especially for small dams, making estimates for power generation on small headwater dams with low levels of confidence.
- Most locations have existed for many years but have not become powered due to the high upfront cost and regulatory uncertainties. The economics of these project sites may still need the support of renewable incentives and/or long term carbon credits to make them financially attractive. Addressing regulatory uncertainties is still a need overall.
- Not clear what the next steps are or how this info will be used.
- Not apparent.
- The weakness is the large amount of analysis that needs to be done on a limited budget.
- The second weakness is the time to communicate with owners has not really been evaluated.

Specific recommendations for additions or deletions to the work scope

- Good to recognize where sites may be located etc.
- Where does it go from here?
- Does make sense to collect in one place as this does.
- Maybe good next step would be to figure out the value of the top projects are in the real world, i.e. review with ISO's.
- Make sure results of the work (database) are available to the public.
- Try a sample of the sites that appear to be best using a simple screening tool. The reason would be to estimate the time and effectiveness of the study process.
- Determine if there are cut off characteristics that may eliminate sites and work.
- Having an early success of justifying some sites may be a better outcome than surveying all sites from an industry perspective. Industry is cautious and moves slowly. They may be satisfied with one or two sites to investigate further.
- For sequential sites on a common river, the evaluation of portfolios of sites including storage capabilities may be able to produce additional value to justify the development of the sites. The Mississippi river is an example that might be used.

Project Name: SECURE Water Act Section 9505 Hydroelectric Power Assessment
Michael J. Sale (subcontractor) and Shih-Chieh Kao; Oak Ridge National Laboratory

Overall Project Score: 3.7 (6 Reviews Received)



Brief Summary of Project

In Section 9505 of the SECURE Water Act of 2009 (P.L. 111-11), Congress directed the Department of Energy (DOE) to prepare a comprehensive assessment examining the effects of climate change on water available for hydropower at federal facilities and on the marketing of power from these federal facilities. This "9505 Assessment" was produced in consultation with the four federal Power Marketing Administrations (PMAs), the U.S. Geological Survey (USGS), the National Oceanographic and Atmospheric Administration (NOAA), and relevant state water resource agencies, as well as with the U.S. Army Corps of Engineers (Corps) and the Bureau of Reclamation (Reclamation). The detailed Assessment Report was completed at the end of FY2011 after extensive peer review. The Report to Congress will be a shorter summary of the full assessment, and it will include recommendations from the PMA Administrators on how they can respond to these effects and risks of climate change. As of September 30, 2011, the Report to Congress was in the DOE concurrence review process.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- This project was mandated by Congress via the Secure Water Act and not specifically designed to meet DOE's objectives. However, it is also of some value to DOE and the hydropower industry.
- Critical component of the Water as Power Program and mandated by Congress.
- Mandated by Congress.
- Good project, needing updates to keep it up to date with assessments every 5 years.
- The object is to produce two reports.
- Two reports appear to have been produced.
- Do not know how to determine if the report conclusions are valid.

Question 2: Approach to performing the research and development

This project was rated **3.7** on its approach.

- The approach is well designed and effective in terms of the climate scenarios, assessment variables and simulations.

- The project team decided to project the climate change scenarios out only 30 years because of the great uncertainties after that time - uncertainties not only in climate but also in the nature of the power grid and power technologies. Most climate change studies project between 60 and 100 years because the greatest projected effects of changing climate are expected to be felt in 30 to 40 years. Projecting out 50-60 years would give valuable information about the potential for climate change alone to affect the hydropower industry. This is useful for example, in case climate change accelerates greatly, or simply to understand how planning studies may be affected. Many investments in hydropower, for example large pumped storage facilities, would expect to have a life beyond 30 years.
- Integrated data base of "best available scientific information" on federal power systems combined DOE's NHAAP with data from 4 federal PMAs, COE, USBR, NOAA and USGS. Assembled three state-of-the-art climate models to project future hydro-relevant climate variables.
- The PI has done a good job of putting this into context. The year -to-year statistical variability of precipitation already should make hedging and backstanding a part of the PMA planning. Clearly, there could be more uncertainty in the future, but it would be very difficult to "bet big" dollars based on this type of study.
- Well done.
- The barriers appear to have been overcome.

<u>Question 3: Technical accomplishments and progress toward project and DOE goals</u>

This project was rated **3.7** based on accomplishments.

- The project was completed within the planned budget and timeframe. This was a very aggressive schedule and was accomplished on a surprisingly small budget - an outstanding accomplishment.
- Met project goals on time (one year) and within budget.
- Used best available information on current thinking.
- Good improvement over past efforts.
- The budgets and desired outputs are clear. The PMAs produce the information that is included in the report.
- Cannot judge whether the processes are valid, but the test will be if congress accepts the report.

<u>Question 4: Research Integration, Collaboration, and Technology Transfer</u>

This project was rated **3.7** for technology transfer and collaboration.

- This project adds to other Resource Assessment activities, is leveraged with the NHAAP and was produced in consultation with the four federal PMAs, the USGS, NOAA, Corps and Reclamation.
- Excellent collaboration by forming an assessment team consisting of representatives of DOE, contractor, the PMAs, COE and USBR.
- Good integration reported.
- Communications appear to have worked. Reports are produced as specified.

<u>Question 5: Proposed future research</u>

This project was rated **3.7** for proposed future work.

- Project is now completed until the next 5-year assessment as required by SECURE Water Act.
- Final report is in internal review and will be delivered to Congress as scheduled. Plans are to update the assessments every 5 years.

- Key is development of better long term modeling to capture effect of greenhouse gas changes in future precipitation patterns.
- The reports were produced. If congress accepts them the program is effective.

Strengths and weaknesses

Strengths

- Accomplished quickly, within budget and provides valuable information to the hydropower industry.
- Collaboration and teamwork among multiple federal agencies. Project summary and presentation was very well done (the best presentation during the review).
- Has authority to bring this to fruition.
- The project used available references and data to paint a fair picture based on these very speculative forecasts.
- Looked ahead 30 years.
- Seemed to use best available information to update the databases.
- The reports were produced on time.
- The information resources used that one might expect to be used were involved.

Weaknesses

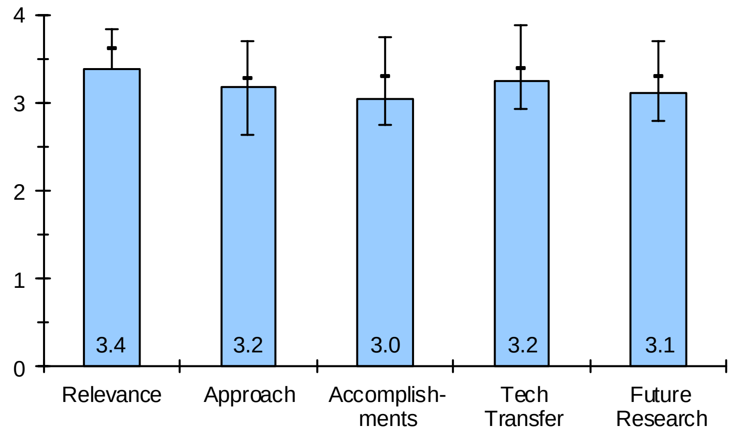
- Climate change projection horizon is not extended far enough into the future.
- The complexity of the subject and the continuing dynamic changes make these forecasts very, very speculative.
- Can we model well effects of greenhouse gas on climate patterns to accurately forecast what is happening?
- Would any model have predicted 2011 weather events one year in advance? Will 2011 events average out to look like the past 20 year average?
- There is no way to test the results. Maybe this is strength of the process as well.

Specific recommendations for additions or deletions to the work scope

- Project is completed now.
- Follow preparing for future assessments recommendations in Next Steps in slide 14.

Project Name: Integrated Basin Scale Opportunity Assessment Initiative
Simon Geerlofs; Pacific Northwest National Laboratory

Overall Project Score: 3.1 (6 Reviews Received)



Brief Summary of Project

The Integrated Basin-Scale Opportunity Assessment Initiative is an action item of the March 24, 2010 Sustainable Hydropower Memorandum of Understanding (MOU) between the U.S. Department of Energy (DOE), U.S. Army Corps of Engineers, and the Bureau of Reclamation. As envisioned in the MOU, an integrated basin-scale opportunity assessment would take a system-scale approach to identifying opportunities and actions to both increase hydropower and enhance environmental conditions within the context of existing water uses in river basins of the United States. Assessments are intended to be collaborative processes that work with stakeholders at the basin scale to identify hydropower and environmental opportunity scenarios. Opportunity scenarios are analyzed, again in collaboration with stakeholders, through modeling and visualization software to assess tradeoffs and system-scale effects. Opportunity assessments are not intended to produce decisional documents or substitute for basin planning processes; assessments are instead intended to provide tools, information, and a forum for catalyzing conversation about scenarios where environmental and hydropower gains can both be realized within a given basin. In fiscal year 2011, DOE's Energy Efficiency and Renewable Energy Water Power Team provided funding to Pacific Northwest National Laboratory, Oak Ridge National Laboratory, and Argonne National Laboratory to develop an assessment approach and toolbox, and carry out an initial pilot opportunity assessment. In February 2011, the Upper Deschutes/Crooked River Basin in central Oregon was selected as the pilot basin. Through establishment of stakeholder working groups, a technical site visit, a series of interviews, a stakeholder workshop, and identification of existing tools and data sets, initial opportunities have been identified and analytical tools selected to explore opportunity scenarios.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- This project supports the DOE objective of reducing barriers to increased hydropower production. In this case the barrier is competing water uses, particularly environmental flows.
- Intent is to provide tools. Information and a forum for catalyzing conversation about scenarios of where environmental and hydro gains may be realized.
- Supports assessment of basin wide opportunities and hydropower development.
- Although stated report will not represent a recommendation for planners and stakeholders, people will use this document to refer to make recommendations.
- This project has a lot of resemblance to a FERC relicensing process: "collaboration is difficult, time-consuming, and expensive". Although this purports to not be basin scale water use planning, these are

inseparable if this initiative is to be effective. It would be extremely valuable to use this approach to review/audit a FERC licensing process to ensure that the water use tradeoffs made economic sense to society.

- Addresses a key issue - how to balance multiple needs related to water use.
- Provides a tool to add some quantification to a touchy feely emotional issue.
- While coordination of government agencies and laboratories is good, the interaction with established procedures is probably upsetting to people doing the processes.
- The pilot provided results, but the feedback from the planners does not appear to be included.
- The initial first case will be very interesting and enlightening.
- The value added needs to have input from the stakeholders affected by the assessment. The identification of incremental opportunities identified above the present planning methods needs to be documented.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- The project technical approach - the development of opportunity assessment approach, i.e., a "system-scale approach to identifying opportunities and actions to both increase hydropower and enhance environmental conditions" - is in the spirit of "shared vision" modeling and stakeholder processes that are recommended by national and global water management experts. Whereas this is not Integrated Water Resources Management (IWRM) as pointed out in the presentation, the system-wide approach and the concept of opportunity scenarios is a central tenant of IWRM. This approach is powerful and important for DOE to understand and embrace.
- The details of the process of identifying and assessing opportunities need to be worked out further. In many cases there are tradeoffs and a method for tradeoff analysis is important. Also needed is an identified process for negotiating compromises to arrive at the opportunity scenarios. Tools have been assembled, but were not described in enough detail to evaluate. There are many such tools in use in various places; the project should put the selected tools in context.
- The project team understands the difficulty of developing a methodology that fits many cases because each case is so different. This speaks to the importance of a generalized tool set for facilitating the process.
- It remains to be seen whether the Opportunity Assessment Toolbox will be adequate to meet the project goals.
- Direct result of the Sustainable Hydropower MOU.
- Similar to FERC relicensing process.
- Providing an assessment that "informs" is not likely to yield actions. "Not here to make recommendations" is precisely what the process is lacking - an objective evaluation of the cost and value of tradeoffs made during the re-licensing process.
- Looks good.
- Key is people interaction - a sometimes difficult thing.
- As reported in the presentation, expectations need to be managed. Expect that until the project has produced outputs for a few years the expectations may not be clearly understood.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- The project appears to be on track in meeting the schedules and goals; completion by the September 2012 target date seems likely.
- New project not yet started.
- Good recognition of the difficulties in the existing process but does not yet address how the process can be made better. "Informing" of opportunities is only the beginning and must lead to more difficult, actionable decisions of water use planning.
- Would have been nice to have seen a preview of the toolbox and more details about it and how it works.
- Process uses existing tool elements assembled into a toolbox.
- Will the tool box be simple enough for use by others? A concern.
- The inclusion of people in the process doing the work seems to be well thought out.
- Inputs from stakeholders affected do not seem to have a place that can be identified.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.2** for technology transfer and collaboration.

- This project by definition is collaborative **-** it is based on the MOU signed by multiple agencies, it involves many stakeholders, and the National Steering Committee includes industry and NGO representatives, and several federal labs partner on the project.
- There is not a technology transfer aspect to this project. It would be useful to teach others the approach, assuming is it successful and useful.
- Raises awareness of the cost and difficulty of collaboration among stakeholders with very diverse views.
- Seems to have been good. 115 people involved.
- The program team members appear to be coordinated. Results are being produced.
- A question remains is whether the program produces identification of additional opportunities beyond the present planning process.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- The future of the project in the coming 10 months has been planned; the work scope for this timeframe seems very ambitious **-** it includes development of software, development of models for scenario modeling, a workshop and conclusion of the case study, presumably with documentation. No decision points or contingency plans have been noted.
- Seems reflected in the Next steps.
- The program appears to be on track to achieving and demonstrating that goals will be met.

Strengths and weaknesses

Strengths

- Involvement of many federal, industry, research and stakeholder constituents.
- System approach to solving problems.

- Can raise awareness of what a relicensing process involves.
- Can forward issues in particular basins that have not had planning efforts yet.
- Good recognition and raising awareness of the difficulties of basin scale water use planning.
- Helps balance many issues frequently seen in License applications which have taken a long time to get sorted out.
- Seems to potentially provide a toolbox and methodology to help shorten the Licensing process.
- Coordination is being executed.
- A pilot case has been executed.

Weaknesses

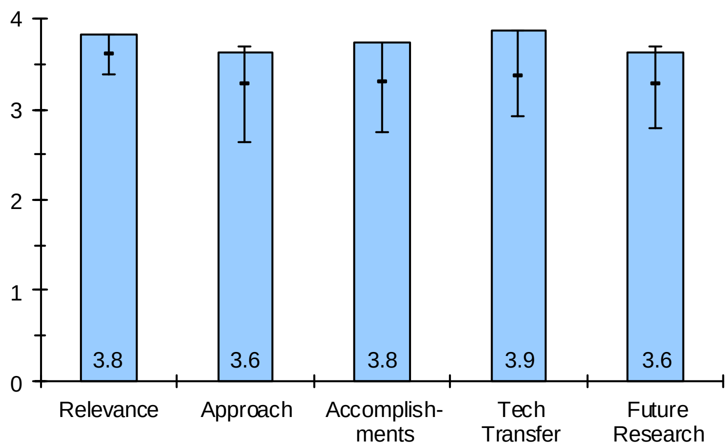
- Stakeholder processes are inherently time-consuming and unpredictable.
- Need more focus on tradeoff analysis which will be a key aspect of identifying opportunity scenarios.
- Not clear what the path forward will be on the results of this effort.
- Not clear what the path forward to use the results will be. Most opportunities are already recognized. What is not recognized in the negotiation process is the tradeoff values associated with various stakeholder requests. Arbitration of these issues is very costly and often lacks good supporting science.
- Project could get lost in the maze of people involved in the collaborations.
- Toolbox may not be usable by others.
- There appears to be no evaluation of whether the program improves the present planning and regulatory processes. It may take some time for people to get used to the program and not react to just having a change.

Specific recommendations for additions or deletions to the work scope

- Stakeholders should interact with the decision support and visualization/tradeoff tools at the third workshop. Perhaps this is intended, but not clear from presentation.
- Make sure methodology and toolbox are well documented and usable by others.
- Clarify how the program is evaluated for improvements to the present planning and regulatory processes.

Project Name: Quantifying the Value of Hydropower in the Electric Grid
Daniel Brooks, Pat March; Electric Power Research Institute

Overall Project Score: 3.7 (6 Reviews Received)



Brief Summary of Project

The objective of this project is to develop and demonstrate an innovative approach for quantifying the maximum benefits available from conventional and pumped-storage hydro-electric plants to electric transmission grids. The results of this project will include three products. These are (1) analysis results from a validated, large scale power and market systems model; (2) a series of scenarios analyses using multiple tools to understand and quantify the benefits of the projects to the transmission systems, including the integration of other renewables; (3) current and projected cost data for alternative pumped-storage and conventional hydropower development options.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- Project focuses on the objective of increasing total contribution of hydropower and reducing barriers, particularly with respect to expense by understanding the potential value of the increase in hydropower.
- Supports DOE objectives to increase hydropower resources.
- The reports should provide a good evaluation of hydro in WECC.
- Other areas can learn from the findings.
- All major areas seem to be covered.

Question 2: Approach to performing the research and development

This project was rated **3.6** on its approach.

- A variety of approaches are applied including case studies, modeling future scenarios, data collection and analysis. Results are reviewed with WECC.
- Important modeling effort to incorporate hydro analyses into electric transmission grids.
- A broad based project that can make a major difference for existing hydro power assets. Several aspects can be immediately used by industry in the exploration and feasibility of hydropower expansion.
- Most project results are user friendly and readily useable to the industry.
- Barriers are not so applicable to this report. The barriers are resources and money to produce the report within budget.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.8** based on accomplishments.

- Much has been accomplished, but the project has suffered some delays as a result of problems with data collection. The project is scheduled to end in February 2012; still running future scenarios to complete report. It is not known if there could be problems and delays. No decision points have been specified.
- Project was given high praise by the industry review committee.
- Multi-faceted project has made contributions in numerous areas.
- The program uses the state of the art study techniques.
- The environment is changing as the study progresses. WECC is investigating methods to handle wind variation.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.9** for technology transfer and collaboration.

- Participants include federal labs, consultants, WECC and many cost share and case study commitments from industry and government. Plan for dissemination of results.
- High degree of collaboration among industry interests. Engaged with 9 hydro plants in 6 regions of U.S. and Canada. Did not get any federal case studies. Data collection an issue. Reached out to pump storage and conventional plant owners with actual data in order to validate the model through engaging utilities.
- Outreach to industry during the project to engage industry and provide status updates has been far superior compared with most projects.
- There appears to be plenty of communication and collaboration. More may delay the project or break the budget.

Question 5: Proposed future research

This project was rated **3.6** for proposed future work.

- Project is ending and most of work has been completed.
- Primarily on schedule with about one month delay thus far.
- A number of excellent investigators from industry, and who have worked closely with industry, have helped to keep the project focused on those elements that are beneficial and can be readily applied.
- There are no other major study areas required.

Strengths and weaknesses

Strengths

- Approaches the issue of valuing hydropower from many angles.
- Participation by many industry, scientific and government entities, including individual agreement with many.
- Project is very organized, with knowledge gaps, approaches, schedules, deliverables documented.
- A strong team of investigators focused on results that can make a difference. Understanding all the values that hydropower brings to system operations, as well as society, is key to the future expansion of hydropower resources for the benefit of all.

- Multiple aspects of the hydro operation are investigated.
- The study list covers the topics of interest.

Weaknesses

- Did not explicitly evaluate ancillary services.
- None seen.

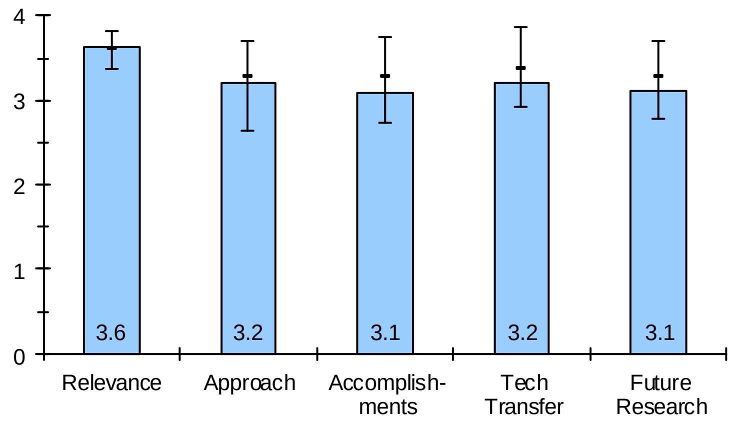
Specific recommendations for additions or deletions to the work scope

- None.
- Finish the report before some major change occurs that invalidates major assumptions.

Project Name: Environmental Hurdles for Conventional Hydropower: Tools and Method Development for Environmental Flows Determination

Dr. Mark Bevelhimer; Oak Ridge National Laboratory

Overall Project Score: 3.1 (6 Reviews Received)



Brief Summary of Project

Objectives: Assess industry needs for addressing environmental flow issues at hydropower projects. [COMPLETED] Develop an analytical approach to characterizing sub-daily flow characteristics to better assess their relationship with stream health and environmental services. Provide information that can be used to support flexible hydropower operations.

Relevance to DOE Program Objectives: Preserving peaking as a viable means of operation prevents loss of hydropower production. Information that supports a positive relationship between hydropower operation and environmental health will assist new development and successful relicensing. Taum Sauk, and Columbia River projects and how the constraints affect provision of grid services.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Sub-daily peaking operations are important to efficient and high-value hydropower, but also potentially problematic to the environment. This project addressed this conflicting use barrier.
- This project can greatly improve communications among hydropower interests and the natural resource interests by dispelling the myth that a simple rule or hydrology statistic can be identified that is applicable across the board. Hydropower projects can be built and operated with minimal impact to downstream aquatic resources but do require detailed analyses. Preserving peaking as an option as opposed to run-of-the-river generation nearly always will justify the expense of detailed analyses necessary to demonstrate that peaking does not necessarily devastate the downstream environmental resources.
- Strong topic with clear industry need. Better economic assessment of the actual incremental environmental benefits of changing toward run of river flow regimes is seriously needed for balanced decision making and overarching environmental policy applied to all power generating sources.
- Good project. Should help provide guidance and quantitative information where only qualitative information exists currently.
- Should help in assessments of tradeoffs.
- Has application.
- There is a need for environmental information to understand the constraints on the hydro operations.

- The area has data that is subject to interpretation that some of the other areas do not, but the large amount of peer review in the meeting process would give one a sense that the results have consensus.
- The budget seems really light for a program of this type.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Combination of database of ecological responses to flow variation, peaking operation flow analysis, tool development and case studies integrates information about sub-daily flow variations from several directions. It is likely that the integration of this information will produce some information/knowledge of value. However, it is uncertain as of yet how this information will be integrated to provide answers to key questions.
- Project presentation seems to indicate that regional/basin-scale analyses can be developed for managing peaking operations with minimal environmental impacts. Such index for formulae approaches have been useful for identifying steady flow releases during season of critical life stages of aquatic species. But, only when these rule based flows are considered to be very conservative in protecting the environmental resource. Run-of-the-river is one such rule. The hydro-operators generally have the choice to accept these rules or conduct more detailed site specific analyses to determine if the rule based flows may be modified (hope is usually lower?).These rule based flow values can be evaluated and adopted for basin-scale use (New England base flow and basin level rules for trout streams in Penn. are examples). These rules can be useful for regional planning analyses.
- Key issues as outlined are on the mark. Allowing and even promoting peaking hydro operations, where it is appropriate, is a huge benefit to system operations and helps to avoid environmental impacts of other peaking generation.
- Difficult project. Project uses tools to help quantify characteristics of flows which may be important to environment, fish.
- Some barriers and areas of needed improvement were listed.
- The rating is on effort, not a percentage of the total barrier list.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.1** based on accomplishments.

- Much is yet to be accomplished. Accomplishments to date seem modest compared to expended budget. This may be due to a change in scope from FY2010 to FY2011. DOE should keep track of the goals and accomplishments.
- Shifting the focus of this project can greatly enhance hydropower/environmental flow considerations and reduce conflict. Consider two classes of problems: 1) basin-scale/regional methods as very different distinct from; 2) site specific methods that provide for the needed flexibility for hydro projects that have unique features, such as hydro peaking, storage, flood control, water quality issues, endangered species, recreational demand downstream and on reservoir pool, and other multiple uses.
- Substantiating the significance of environmental impacts from peaking hydro operations has long been debated and seldom objectively or scientifically analyzed. Survey results reinforce areas that need additional work.
- Peer Review presentation appears to show good technical progress.
- The approach appears to be well thought out and well-reviewed by peers.

Question 4: Research Integration, Collaboration, and Technology Transfer

This project was rated **3.2** for technology transfer and collaboration.

- Will integrate with the Optimization Toolkit; applies NHAAP database in the analysis.
- This project could potentially be of value to the Basin-wide Opportunity Assessment Project.
- Will demonstrate on multiple basins.
- Evidence of good collaboration among scientific staff across Labs.
- Appears to be doing a very good job of publicizing and disseminating the current work and also appears to effectively utilize a lot of previous work.
- Appears to be good.
- The review with peer meetings appears to be a very good effort in communicating.

Question 5: Proposed future research

This project was rated **3.1** for proposed future work.

- Steps beyond 2012 have been identified.
- Much is to be accomplished in the coming year; decision points should be considered.
- One of the biggest barriers to communication re: environmental concerns, is the desire of hydropower proponents to have easily applied rules for environmental flow releases and that the cost of analysis is low. Virtually everything else involved with design, licensing, and operating a hydro plant is data intense. Evidence for detail is illustrated by the other components parts of the Water-Use Optimization "Tool Box"'. A great advance could be offered by this project by making a convincing argument that the simple rule based methods must by their very nature be very conservative for maintenance/protection of the aquatic resource. These conservative rules must provide for seasonal variations. Lack of seasonal variability in minimum flow releases has led to promoting run-of-the-river requirements. Rules for flat line minimum flow releases are no longer acceptable. Where hydro-peaking, pump back storage and other variable operating schemes are to be evaluated, very detailed site specific analyses are necessary to ensure that the aquatic resources is maintained in a healthy condition. By separating approaches for basin-scale and regional planning analyses from site specific hydro-peaking operations much improvement in communication and the state-of-the practice could be accomplished insuring that impacts during critical biological time periods are minimized. Elevating the base flow or curtailing peaking during critical time periods is usually preferable to hydro operators than going to a straight run-of-the river mode. A site specific “effective habitat" analysis is quantifiable and the difference between various peaking and generating flow levels can be readily presented to the stakeholders. This approach can be helpful in overcoming the barrier of insisting that of run-of-the -river is the only alternative. Another important concept to get across is that models must be "validated" by site specific calibration and verification, by comparing model output with field observations. Validation does not result from numerous applications elsewhere but only by field verification at the project site by the model users. For example, application of physical habitat models requires that BOTH the hydraulic sub-models and the biological sub-models MUST be tested and verified on site before model simulations for use in decision-making can be considered valid.
- A very complex issue requiring extensive work to advance beyond current regulatory thinking.
- Good definition.
- For the budget, I think the program was well worth it.
- The value is in the start of the process. There will always be more issues to investigate.

Strengths and weaknesses

Strengths

- Leverages the vast experience of the research team with environmental flows to benefit hydropower.
- The results of this project could potentially be quite useful to the industry.
- Excellent Scientific staff.
- Ambitious project.
- It is extremely important to address the true costs and benefits of tradeoffs involving water used for power generation, irrigation, environmental benefit, water supply, etc. if the objective to add hydro MWh at existing facilities is to be appropriately maximized. Could become useful to regulatory agencies trying to decide on future licensing proceedings.
- Dealing with a difficult issue to quantify what is only qualitatively understood at the moment.
- Will help with reaching consensus on how to get more value out of hydropower.
- It is a start to use scientific methods to provide information to make decisions.

Weaknesses

- Much analysis and conclusions must be done in a very limited timeframe.
- How does it apply to the broader needs.
- Indicates most of budget has been spent. Will they be able to complete effort?
- Not clear how this material can be made generically useful in widespread transferable applications.
- Next steps (beyond this project): lead one to fear that the objectives won't be met until another project is completed.
- Not enough funding.

Specific recommendations for additions or deletions to the work scope

- Focus the peaking methods to site specific analyses in association with the demonstration projects and the Water -Use Optimization tool box efforts. Reserve the rule and formulae based methods to basin-scale and regional efforts. Emphasize the fact that these rules must be conservative for the aquatic resource and that site specific analyses will become necessary if any modifications are requested by hydro operations. Recommend reviewing Moyle, P.B., J.G. Williams, and J.D. Kieman. 2011. Improving environmental flow methods for California Federal Regulatory Commission Relicensing. California Energy Commission. FIER.CRC-500-2011-037. Also, Bencala, K.E., D.B. Hamilton, and J.H. Petersen. 2006. Science for Managing Riverine Ecosystems: Actions for the USGS Identified in the Workshop "Analysis of Flow and Habitat for Instream Aquatic Communities". Open File Report 2006-1256. Documentation re: downstream habitat analyses under alternative peaking hydro regimes will be forwarded to Dr. Bevelheimer.
- Find a way to extend the project to accomplish what is indicated in the next steps (beyond this project).

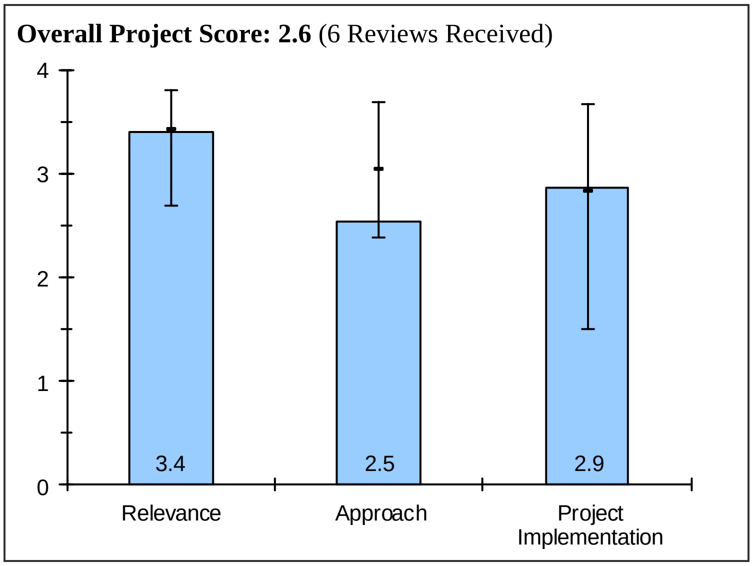
5.2 Conventional Hydropower Lower TRL Project Evaluations

Table 5.3 illustrates the scoring for the CH Lower Technology Readiness Level (TRL) projects. Individual CH Lower TRL project scoring summaries and reviewer comments are also included in this section.

Table 5.3 Conventional Hydropower Lower TRL Project Scores

Conventional Hydropower Lower TRL Projects	Relevance to overall DOE objectives	Approach to Performing Research & Development	Project Implementation Pathways	Average Weighted Score
SLH Timing Belt Powertrain	3.4	2.5	2.9	**2.6**
Laboratory Demonstration of a New American Low-Head Hydropower Turbine	3.6	2.8	2.5	**2.7**
W4e Hydropower Turbine Generator system validation	3.5	3.2	2.8	**3.1**
Small Hydropower Research and Development Technology Project	3.5	2.5	2.6	**2.6**
Scalable Low-head Axial-type Venturi-flow Energy Scavenger	3.5	3.1	2.9	**3.1**
Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site	3.0	2.8	2.7	**2.8**
51-Mile Hydroelectric Power Project Demonstration of new methodologies to reduce the LCOE for small, hydropower development	3.4	3.0	2.8	**3.0**
Harnessing the Hydro-Electric Potential of Engineered Drops in the Columbia Basin Project	3.6	3.3	3.1	**3.2**
Real World Demonstration of a New American Low-Head Hydropower Unit	3.4	3.2	3.0	**3.2**
Construction Support for New Slab Creek Power House Project	3.4	3.3	3.3	**3.3**
SLH-100 demonstration project at Monroe Drop	3.3	2.9	2.8	**2.8**
Geotechnical Investigation and Value Stream Analysis for the Iowa Hill Pumped-Storage Development	3.5	3.1	3.1	**3.1**
Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the U.S.	3.7	3.2	2.4	**3.0**
Turbine Aeration Physical Modeling and Software Design	2.7	2.4	1.5	**2.2**
Sensor Fish Re-design to Support Advance Hydropower Development	3.7	3.7	3.7	**3.7**
Deployment and Testing of the Alden Hydropower Fish-Friendly Turbine	3.8	3.7	3.6	**3.7**

Project Name: Schneider Linear hydroEngine™ Timing Belt Powertrain
Abe Schneider; Natel Energy, Inc.



Brief Summary of Project

Natel Energy, Inc. (Natel) is a renewable energy technology company that is commercializing a novel low-head, low environmental impact hydropower technology called the Schneider Linear hydroEngine™ (SLH). The SLH expands the developable low-head hydropower resource to sites with as little as 1.5 meters (5 feet) of head, while cutting the cost of the water-to-wire package by as much as 50%. Successful demonstration of the SLH's performance and economics in lowhead hydropower settings will enable cost-effective development of the more than 40,000 existing dams in the U.S. that do not produce power, and the thousands of drop structures in irrigation district canals. According to the U.S. Department of Energy, only about 2% of the available low-head hydropower resource in the U.S. has been developed, leaving more than 70 GW of annual mean potential low-head capacity untapped.

Natel is working with the Alden Laboratory in this proposal to develop a new high performance powertrain for the SLH, utilizing Kentucky-based Gates Corporation's "Poly Chain Carbon GT" timing belt – the first-ever carbon-fiber reinforced timing belt.

The project will result in:

- Development of an enabling technology for efficient and low cost small hydropower that can be quickly and efficiently deployed in low head/low flow existing waterways and constructed waterways.
- Creation of advanced SLH powertrain manufacturing methods and production of long-term mechanical performance test data, thus advancing the industry's expertise in engineering, design, installation, and performance evaluation of low-head hydropower technology.
- Reduction of LCOE from low-head and constructed waterway projects built with hydroEngines™ to less than $0.07 per kWh.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- Shows considerable promise for development of 50 and 500 Kw belt/blade units for low cost small hydro.
- Working on low head hydropower.

- Search for a better technology, low head, generating machine is in support of the DOE objectives.
- Stimulates evaluation of a potentially usable technology.
- These machines are too small for utility use. The price would be competitive with retail power at distribution voltages. These machines may be attractive to farm and ranch applications that have irrigation or flowing water on their property or small towns.
- The cost of the interconnection to a distribution system would have to be included. The generators may form a micro grid.
- Reliability with respect to trash and mud may be an issue. Testing will resolve this issue.
- If sold to farmers and ranchers, they would have the mechanical knowledge to keep the generator running. Farmers and ranchers are used to equipment that requires daily supervision and occasional maintenance.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- Plan and schedule seem reasonable.
- Unique type of project technology utilizing belts.
- Device looks to be quite complex with numerous moving components, probable efficiency losses, and fatigue failure locations. Also, likely limited to clear water applications since trash, grit, aquatic weeds, fish issues, and other environmental hurdles could pose numerous problems for the mechanism. Needs input and oversight from a technical review panel to better assess true feasibility.
- Not much detail presented. Hard to make good evaluation.
- Key is to develop design and evaluate it in test to see if it worked. Logical.
- Sales and marketing costs may be high on these generators.
- Customer support may also prove to be difficult. However, farmers and ranchers fix equipment with belts frequently.
- Trash and mud have yet to be evaluated.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.9** based on project implementation.

- Project has just been initiated.
- On schedule testing next week at Alden Labs.
- Ties into another DOE grant.
- Cost - effectiveness of the SLH device remains to be seen but will likely be very challenging, both the initial construction and on a continuing Operating and Maintenance basis. Project appears weak on engineering details and raises technical concerns. If all feasibility issues are resolved, a sustained installed demonstration project would be necessary as true proof of concept.
- Schedule shows redesign and reevaluation step.
- For the scope of the project, the project seems to be well planned to produce a prototype which is all that is required.
- More extensive testing with trash, mud, snakes and moss may be required.

Strengths and weaknesses

Strengths

- Potential to utilize irrigation drops.
- Reasonable design and plan. Novel project should provide for low-head units with minimal environmental impacts.
- Will determine operational efficiencies and able to determine general effects from operating under full load.
- Out-of the box thinking.
- Gets some testing. Will show either it works or it has weaknesses.
- Project related to Project 70.
- Most of the project is in tight control of a few people.
- The key component manufacturing sources appears to be under control.
- There is little requirement for communications other than the developing company.

Weaknesses

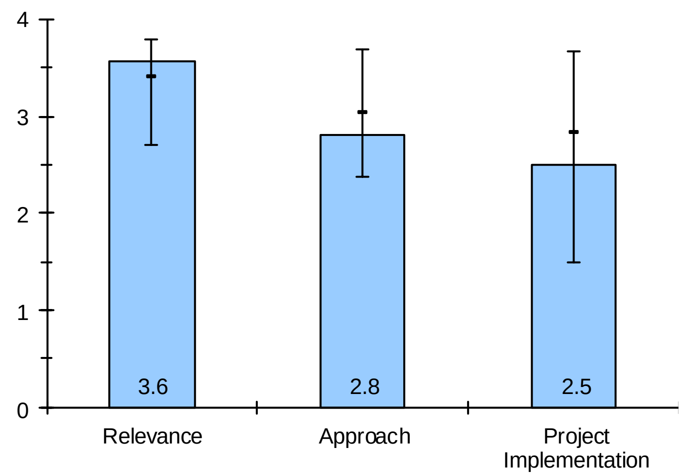
- Appears to be complicated machinery, perhaps would have high maintenance needs.
- Not sure if the technology will be successful.
- Unconventional approach that appears to have weaknesses by traditional engineering analysis.
- The linear hydro engine concept seems to have a lot of potential points of operational reliability.
- Lots of moving parts, lots of points for possible failure.
- May have trash, water quality issues.
- Additional costs on sales, marketing, customer support and electrical distribution systems may change the costs. However, cost depends on the alternative. Running a power line for miles for a few hundred HP of pumps is not low cost either.

Specific recommendations for additions or deletions to the work scope

- Long term follow-up on pilot installation.
- Needs close oversight from DOE or a technical review panel to better assess true feasibility.
- Monitor for tangible progress and evolution of true costs.
- Keep a good eye on this, as its success directly impacts project 70, SLH-100 demonstration project at Monroe Drop.
- Build one and field test it in an irrigation ditch complete with trash, mud, crayfish, snakes, etc. Test it. No one will believe it until they see it operate in the real world.
- If it works, perfect the design and let a farmer or rancher operate it. Further perfect the design.
- Determine if you have a business case.
- The rating is a function of the equipment design and size and should not be used to eliminate the project.
- People who build small wind turbines have similar issues, but they sell some in niche markets.

Project Name: Laboratory Demonstration of a New American Low-Head Hydropower Turbine
Robert Rittase, Mark R. Stover; Hydro Green Energy, LLC, HDR, Mechanical Solutions Inc.

Overall Project Score: 2.7 (6 Reviews Received)



Brief Summary of Project

HGE's design for low-head hydropower turbines will reduce development costs associated with small hydropower projects. Both the civil engineering and licensing costs associated with installing and maintaining typical hydropower projects do not scale down for projects with lower net head and therefore lower potential energy. HGE's system is designed to reduce project LCOE in several ways. It integrates vertically-stackable, belt-driven turbines into a modular design that can be adapted to use any number of power units depending on site conditions. Unlike other projects, this system works within the existing water depth on the tail water side of an impoundment. Because it does not require river damming or riverbed excavation, it may help developers avoid costly licensing and development processes. A project's total costs can also be driven up significantly by the price of foreign-made low-head hydropower turbines that are currently on the market. Off-the-shelf foreign-made turbines do not work in HGE's modular system and can only be integrated into such systems with substantial and costly modifications.

HGE's turbine design requires a progression of engineering and testing efforts to move the design from concept to commercial application. The initial design concept will be the foundation for full scale and scale model turbines, whose performance and design will be evaluated and validated through the work proposed here.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- Much potential for applying low-head concepts from foreign plants to U.S. sites and conditions.
- Search for new low head hydro power technologies supports DOE mission.
- Difficult to evaluate.
- Very little information provided in presentation.
- Don't even have a picture/sketch of the equipment proposed.
- Project does testing and gets performance data. That helps bring the project concept to a more mature point of technology. That is a good next step.
- Description of tests to be done is fuzzy and not at all clear. Cannot evaluate based on this limited information.

- The program addresses a segment of the industry needs. The rating is based on addressing a segment and not all industry needs.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- Lab. demonstration for New American low-head turbine (8'-30' head).Determined that foreign units not applicable in U.S.
- Presentation is missing many details and does not instill confidence in technical feasibility or superiority over other options.
- Cannot evaluate without more information.
- The barriers have been identified.
- The risk is being addressed by a pilot project and testing.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.5** based on project implementation.

- More information is needed.
- Project just starting. May be applicable for COE lock and dam sites.
- Approach appropriately involves significant analytical effort and engineering prior to prototype development and deployment. Modular approach could offer advantages over conventional hydro in limited applications but also could face challenges on cost-effectiveness of initial construction as well as ongoing O&M costs.
- Cannot evaluate without more information.

Strengths and weaknesses

Strengths

- More information is needed.
- Gets some data on the concept.
- Cannot evaluate without more information.
- The development of a concept and taking it to field demonstration is impressive.
- Coordination that is needed between the two parties performing the project appears to be adequate.
- The design and implementation appear to be well planned.

Weaknesses

- Presentation lacks significant explanation or discussion of fundamental energy conversion equations and processes.
- Poor overview of project details.
- Licensing and installation issues cannot be evaluated until a unit is installed successfully.
- The pilot project should answer questions on licensing and installation.

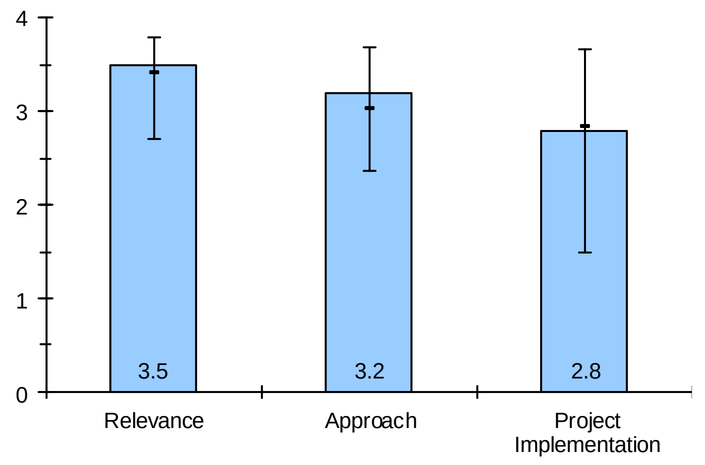
Specific recommendations for additions or deletions to the work scope

- More information is needed
- Monitor for tangible progress and evolution of true costs.

- Provide reviewers with much better description of the project so they can make a better evaluation.
- Finish the project and report the results as well as lessons learned.
- This is a small program and a tight control is required to maintain costs and schedules.

Project Name: W4e Hydropower Turbine Generator System Validation
Henry W Russell; Walker Wellington, LLC

Overall Project Score: 3.1 (6 Reviews Received)



<u>Brief Summary of Project</u>

The funding awarded under DE-FOA-0000486 will allow Walker Wellington LLC to employ and otherwise utilize the testing capabilities of Alden Research Laboratory Inc, Holden, Massachusetts) and the technical expertise of GZA GeoEnvironmental Inc. Norwood, Massachusetts to validate the design predictions/intention for the W4e hydroturbine generator by examining and documenting full-scale prototype turbine performance under actual service conditions. Successful completion of this project will result in published third party validation of the W4e technology which will provide public utilities, consulting engineers and others with independent data and the knowledge and confidence of when and where this technology may be applied. The W4e technology is appropriate for a variety of conduit and traditional hydropower applications.

The shop testing, field testing and modeling to date cannot demonstrate the full range of practical operation and limitations which a research facility such as Alden offers. Alden offers the capability of testing the W4e across a wide range of head and flow conditions.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

<u>Question 1: Relevance to overall DOE objectives</u>

This project earned a score of **3.5** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- Hope is to get 3rd party demonstration to work at variable flows, given a range of heads such as waste water discharges, irrigation channels, storm water conduits. Much potential for use in conduits.
- Low head variable flow applications.
- Example would be water treatment plant effluent.
- Search for new technologies for low head applications supports DOE objectives.
- Gathers performance data through laboratory testing. Helps provide information to judge concept viability.
- The need to test turbine generators is a necessity.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **3.2** on its approach.

- Testing initially at Alden Lab. Protocol described. Will examine the range of head and flow that would be feasible.
- Looking to get 3rd party validation of technology.
- Deploying turbine in pipe at lab.
- Also will establish method to install into a pipeline.
- Determine efficiencies.
- Not a package design. Will be engineered for each site and this may add to cost.
- Appears to be feasible and innovative, but cost-effectiveness remains to be seen.
- Both initial and ongoing O&M. Low cost to DOE to support testing.
- Approach looks good. Uses known performance test code, known facility.
- There appears to be few barriers to implementing this project.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.8** based on project implementation.

- Project is just starting.
- Doing lab testing. Proof of concept.
- Prototype apparently exists and testing is needed.
- Future work beyond the testing not discussed in the presentation.
- The project is straight forward in concept.

Strengths and weaknesses

Strengths

- Design for a wide range of flows and heads. Independent lab testing.
- Uses known test protocol and known test laboratory.
- The project is well defined.
- One would expect the output that is forecast. A test will be performed.
- Communications appear to be sufficient for a test. The number of people involved is reasonable for a project like this.
- The work is well documented as what the plant to test will be.

Weaknesses

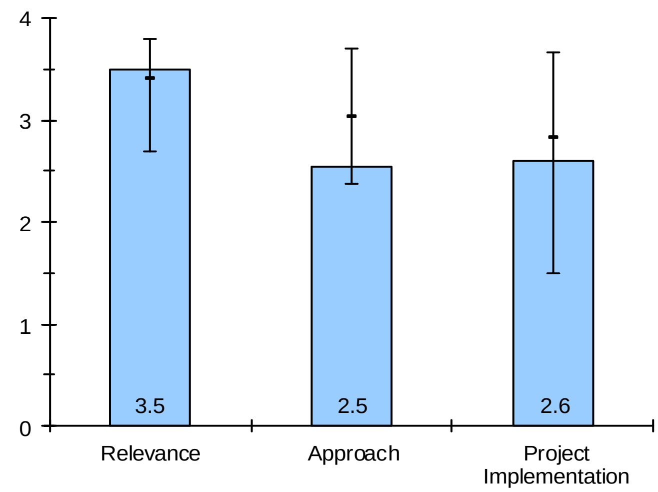
- Machine appears to have lots of parts, appears complicated (therefore potentially expensive), appears to be at risk to debris which is typically in the water of most sites.
- No weakness found.

Specific recommendations for additions or deletions to the work scope

- Monitor for tangible progress and evolution of true costs.
- Have an evaluation of failure modes to assess risk associated with implementation of the concept in an actual site.
- Do it.

Project Name: Small Hydropower Research and Development Technology Project
Callum Sulliva; Near Space Systems, Inc.

Overall Project Score: 2.6 (6 Reviews Received)



Brief Summary of Project

The goal of this research is to investigate and develop the next generation of small hydro turbine generator designs that maximize the energy transfer from flowing water to electrical power generation. This research focuses on the potential technologies that are either in existence or require development in order to introduce the next embodiment of small hydro turbines. Where at all possible, lessons learned from larger turbines will be used to leverage the investigation. The smaller the turbine gets, the greater the loss in the efficiency of the architecture used in the larger units. It is our intent to identify where those losses are occurring, and use new approaches to minimize losses and produce a small hydro turbine generator design that performs with efficiencies similar to those of the largest hydro generators. The expected outcome of the study is a design that will lower the Levelized Cost of Energy LCOE) from small hydro turbines and enable the cost effective use of a myriad of small hydro sources.

The overall purpose of this proposed study is to increase the maximum efficiencies of small hydro turbines through the reduction of friction and the utilization of existing turbulence and water particle motion in pipelines. Efficiencies of turbines that fall outside traditional efficiency curves, especially with very low flows, will be explored as a potential for maximizing the cost effectiveness and utilization of micro and pico hydro projects. New technologies in runner design and electrical generation will be considered, as will the potential for modular and scalable design. The ultimate objective will be to provide a prototypical design for micro and pico hydro generation that is easily adaptable to a wide array of variables, while maintaining higher efficiencies than typically sized current installations. The following factors will be specifically investigated: 1. Friction reduction; 2. Electrical power generators that are driven by the turbine; 3. Impeller design; 4. Materials; 5. Flow control; 6. Application and installation.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- This is an R & D project for new turbine designs and development of a prototype for small hydro with low flow and low head.
- Low head system.
- Search for new micro/pico hydro technologies that could potentially add to hydro resources supports DOE objectives.

- Concept is similar to an old concept by Harza. Uses plastic components - possibly a cost reduction for mass production.
- Uses PMG rim generator - keeping it simple. Wind turbine technology.
- The objective seems to be properly f focused. However, the type of operation assumption for design optimization might not be correct in all cases. This statement is expanded in the Approach section.
- Having a known generation option should be an advantage to many projects.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- R & D with goal to develop new design turbine. Just starting, no progress.
- Modular design.
- Presentation is very short on economics and engineering analysis. Cost effectiveness appears very questionable without supporting information. Claims of transformational success seem premature at best. Not clear on the roles and responsibilities.
- Seems complicated and expensive in first view.
- Lots of small blades. Likely not good for fish.
- Seems like it may have reliability issues.
- Seems like just a design study. No model testing?
- The barriers appear to be in the installation and testing. The barriers are identified.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.6** based on project implementation.

- Project is just starting.
- Project appears to have a concept without further details. Progress toward objectives is limited at this time.
- How is the concept evaluated for future next steps? Not at all clear.
- The performance criteria appear to be to produce the most energy for the lowest cost to maximize revenue. Ancillary services markets pay slightly more than the cost of energy for less energy, but for more flexibility in scheduling. It might be worthwhile to evaluate a turbine design to provide ancillary services (ramping and regulation). The difference may be a turbine design that has a lower minimum output. The increase in the variable range may allow additional turbines to be operated with the same water supply as for fewer turbines operated for maximum energy production. One does not need Ancillary Services markets to require the variable operation. Coal and gas fired generation experience significant increases in the operation and maintenance cost due to thermal fatigue when operated in a variable output mode. DOE-NREL has a project in WECC to calculate the cost of ramping and regulation to fuel fired generation. Once the cost of ramping and regulation from fuel fired generation is known, the mode of use of hydro may be modified to perform ramping and regulation at lower cost.

Strengths and weaknesses

Strengths

- Project has potential for small hydro.
- Out-of-the-box thinking.
- Possible small hydro design using PMG concept and plastic materials.

- The program is well defined as development and testing projects.
- The program appears to be able to be completed without major risk.
- The projects necessary to complete the program appear to have been identified.
- Coordination with groups required to make the project successful have been identified.

Weaknesses

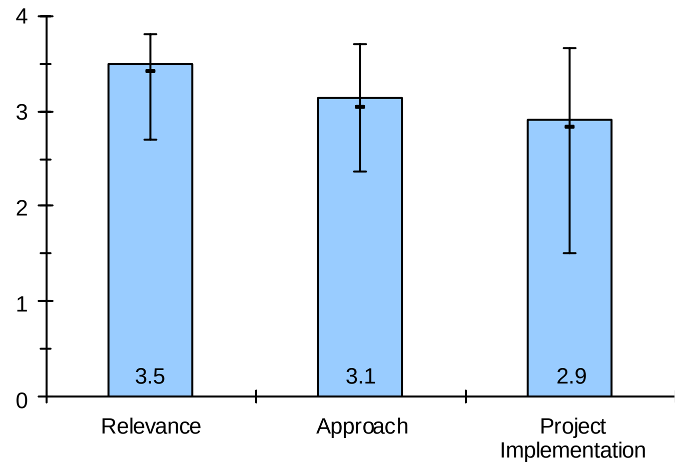
- Economics unclear.
- Short on supporting facts and engineering. Economics are unclear but questionable at this point. Appears suitable only for clear water applications that would not damage turbine mechanism or affect magnetic centering.
- No criteria for evaluation of the results of the work.
- See the discussion in Approach.
- Communication of the results may have proprietary issues.

Specific recommendations for additions or deletions to the work scope

- Have close oversight to see how it progresses.
- Close oversight of the project is recommended to determine if significant progress toward objectives is happening through engineering and cost analysis.
- Monitor for tangible progress and evolution of true costs.
- Quantify how results of the work will be evaluated.

Project Name: Scalable Low-head Axial-type Venturi-flow Energy Scavenger
Nadipuram R. Prasad; New Mexico State University

Overall Project Score: 3.1 (6 Reviews Received)



<u>Brief Summary of Project</u>

<u>Objective 1</u>: To conduct in-depth computational fluid dynamics studies of the venturi-shaped turbine and impeller for an axial-flow hydropower generating system that will show technical feasibility to harvest or scavenge the maximum amount of energy from low-head/low-flow waterways. Study results will enable the selection of generators having appropriate speed/torque characteristics, along with associated power conversion equipment and required instrumentation sensors for data acquisition and measurement of overall turbine-generator performance. Outcome of this feasibility study will provide a basis to design and develop a novel, scalable, low cost, easy to manufacture and assemble, modular and extremely portable, environmentally friendly and a highly efficient technology for harvesting the unused hydroelectric resource potential offered by a natural, renewable energy source.

<u>Objective 2</u>: Based upon the harvester specifications derived from achieving Objective 1, NMSU will fabricate two, 10kW hydropower harvester prototypes for testing and validation. Laboratory experiments and test procedures along with appropriate instrumentation will enable field testing and validation of the prototypes. Modular design of the turbine-generator system will allow quick and efficient deployment of the prototypes in the Elephant Butte Irrigation District (EBID) irrigation canal system. In the system testing and validation phase of development, a fully integrated set of technology components including power electronics to convert generated power into standard 60Hz will be laboratory and field tested for performance.

Technical feasibility will show that substantial amounts of hydropower can be produced to support growing irrigation needs, provide rural electrification for the present and future farming communities, and contribute to a multitude of other micro-grid applications along human made and natural waterways. This will allow novel conceptualizations of micro-grid infrastructures to be explored and developed. Testing the prototypes will provide sufficient basis to improve the net energy harvesting performance, followed by commercialization and widespread use of hydropower generators by independent power producers. While the technology offers a reliable and efficient means to harness energy from a natural renewable resource, a major barrier relates to current Federal regulations for the integration of small-scale hydropower generation into the electric grid.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness and facilitating licensing for add hydro to existing facilities.
- A project with promise for low cost turbines using plastic components.
- Low head axial type venturi flow turbine.
- Search for new low head and low power technologies supports DOE objective of increasing hydropower resources.
- Keeps civil cost low.
- Possible low head micro hydro candidate.
- Modular.
- The program provides demonstration of a concept that appears to have use in some applications.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Scalable low-head axial-type venturi-flow energy scavenger designed for low head applications on existing waterways, canals.
- Utilizes a plastic molding.
- Plastic turbine technologies have been explored previously by major hydro turbine manufacturers and can have significant difficulties. Cost effectiveness will be a challenge.
- Seems complete with design, manufacture, deploy, test steps.
- Small budget for the proposed scope. Is the budget realistic?
- Price of energy may be a barrier depending on the retail rates.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.9** based on project implementation.

- Project is just starting.
- Will determine the engineering parameters based on pilot studies.
- Proposed to be deployed at Leesburg Drop canal.
- 10 kW units.
- Attempting to use plastics to lower costs.
- Relatively small budget with cost share.
- Keep an eye on as it progresses.
- Project appears to be only at the conceptual stage.
- Plan looks logical.
- The approach is straight forward.
- The cost will be determined.

Strengths and weaknesses

Strengths

- Has university research participation.
- Can take advantage of irrigation low head drops.
- Promise for low cost hydro power.
- University supported.
- Micro hydro.
- Some partners with some experience.
- The program is well defined.
- The program would be expected to be completed.
- Communications for a project of this type seem to be planned.
- All required elements for a successful program seem to be in place.

Weaknesses

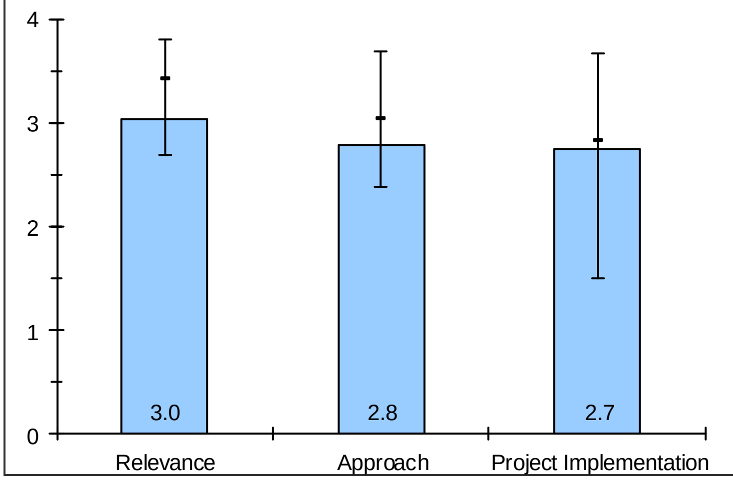
- Maintenance would be a concern.
- Appears most suited to clean water applications since there is not debris removal capability shown with the intake screens. Also, channeled flows that do not allow flows to go around the device (path of least resistance) are desirable and increase the cost of the civil works. Cost effectiveness will remain a challenge.
- Budget seems quite small for the scope.
- The program is part research and is expected to have learning experiences.

Specific recommendations for additions or deletions to the work scope

- Monitor for tangible progress and evolution of true costs.
- How will the unit be tested?

Project Name: Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site *David Brown Kinloch; Weisenberger Mills, Inc.*

Overall Project Score: 2.8 (6 Reviews Received)



Brief Summary of Project

Under Small hydro developers face a limited set a bad choices when choosing a generator for a small low-head hydro site. Direct drive synchronous generators, like the ones used at large hydro sites, are very expensive and complex, requiring voltage regulators and auto-synchronizers. Thus the usual choice instead is an induction generator that has its own problems. Induction generators are higher speed, requiring a speed increaser, usually a gearbox or timing belt drive system. The resulting system is inefficient, loud and the sources of many maintenance problems. The induction generators are also less efficient and have power factor problems that require correction capacitors. In addition, both induction and synchronous generators turn at a fixed speed, to stay synchronized with the power grid. This results in the connected water turbines running off their peak efficiency curve whenever the available head is different than the designed optimum head.

The wind industry has struggled with similar generator problems, made even more acute by rapidly changing wind gusts. To address these problems, the wind industry has developed variable speed Permanent Magnet generators. These generators allow the wind turbine to turn at an optimum speed all the time, depending on the strength of the wind. While hydro developers have been very curious about this new technology, they have been reluctant so far to leave their “tried and true” induction and synchronous generators.

This project will demonstrate the many advantages of a variable speed Permanent Magnet generator for small low-head hydro sites. The Weisenberger Mill (FERC Project No. 9684) offers an ideal site to demonstrate the dramatic improvements to efficiency that Variable Speed Permanent Magnet Generators can offer to small low head sites. This new technology could make thousands of undeveloped small, low-head sites economically feasible and simpler to develop.

The purpose of this project is to not only demonstrate Permanent Magnet generators for small low-head hydro sites, but also disseminate information about this new technology to the hydro industry. If this new technology proves to live up to expectations, this new technology will be used at two larger 2.64 KW new sites that are currently in the licensing process on the Kentucky River (FERC Projects No. 13214 and 13213).

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.0** for its relevance to DOE objectives.

- Does not appear to be generally applicable research.
- Goal is to adapt wind technology (variable speed permanent magnet generator) to small hydro sites. Certainly supports Water Power Program goals. Good concept of documenting efficiency of existing turbine in open flume and then comparing permanent magnet generator to be installed at site.
- Variable speed permanent magnet generator.
- Supports DOE objective of expanding hydro power resources. Appears to involve little R&D.
- Concept evaluates wind generator technology in a hydro installation.
- Has variable speed, but this will bring not much efficiency in the application without a large head variation.
- Very sketchy information provided in the material distributed for Peer Review.
- Permanent magnet generation with four quadrant converters would be a necessity to reduce cost, complexity and improve performance.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- Does not appear to be generally applicable research.
- Good economic evaluation of alternatives for this particular application.
- Verbal presentation of approach seemed straight forward. Install PMG generator in place of existing synchronous hydro generator. Test.
- Presentation material inadequate.
- What we call "agricultural" barriers are the seals, thermal performance and vibration issues that are not foreseen at the time of design may appear.
- The small stuff can bring a project down as fast as the major components.
- Intense quality control is necessary to produce reliable, total low cost solutions.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.7** based on project implementation.

- Project just starting.
- Different type generator applied to a hydroproject.
- Cannot evaluate based on material provided.
- The program appears to be long overdue.

Strengths and weaknesses

Strengths

- Another promising demonstration for low cost power generation at small hydro sites.
- Low cost to DOE.
- Evaluates PMG for hydro service.
- Direct application of existing technology.
- A very obvious solution for small projects.

- The level of coordination seems to be appropriate for a project of this size.
- The necessary projects and demonstrating sites appear to be in place.

Weaknesses

- Not sure how generically transferable it is, or beneficial to industry.
- Weak PowerPoint presentation. Appears focused on a specific site with less focus on transferability to other generic locations.
- Poor presentation material.
- The weaknesses probably will not be discovered until the project is operational.

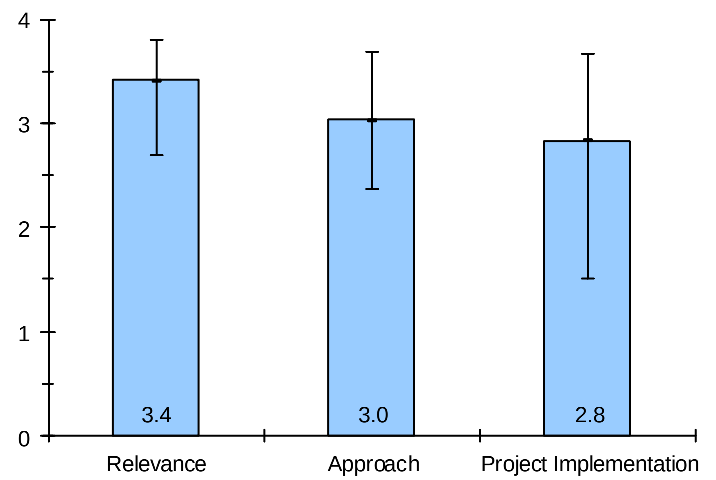
Specific recommendations for additions or deletions to the work scope

- Monitor for tangible progress and evolution of true costs.
- Get testing protocol, audit results, and require report.

Project Name: 51-Mile Hydroelectric Power Project Demonstration of new methodologies to reduce the LCOE for small, hydropower development

J Gordon, Norm Bishop, & Boualem Hadjerioua; Earth by Design, Inc.

Overall Project Score: 3.0 (6 Reviews Received)



Brief Summary of Project

The overall objective of the advanced hydroelectric technology project is to promote cost effective, sustainable small hydropower development through advanced technologies and methodologies. The proposed advanced hydroelectric facility will provide quick and efficient methods for deployment of the new technology, reducing the LCOE to less than $0.07 per kWh. Implementation and success of the proposed innovative hydropower at this site could enable numerous other plants to be developed at similar sites on a variety of other run-of-canal sites. This proposed advanced hydroelectric project in this location would provide a water-to-wire energy generation experience, below the desired $0.07 per kWh, and competitive market data which the DOE needs to advance its strategies for developing low-head hydropower technologies at reduced capital investments. Other developing US electricity markets and LCOE plants could benefit from the lessons learned from this project since there are minimal infrastructure modifications needed to construct the facility at this site. This project will validate the sufficiency of the technology and methodologies being used to reduce capital costs and effectively generate income from low-head projects, nation-wide.

CleanPower's new technology, with its ease of implementation, low capital cost, and long-term, reliable energy production will assist in securing power cost increases, keeping farmers profitable and willing to continue supplying food products at reasonable prices. Cleanpower's technology will be successfully demonstrated as the most cost-effective, technologically sound and most beneficial method of increasing the value of renewable energy and sustaining a long-life, to deliver lower capital and operating costs than traditional hydroelectric facilities.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness and reducing LCOE for small hydropower development.
- Supports small hydropower.
- Supports DOE objective to increase hydropower resources.
- Bow Thruster technology concept applied to hydro power generation.
- Bow Thrusters well developed product.
- Turbine testing seems to have a use.

- Not sure what is being done in the second phase.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Approach is well thought out.
- Testing proprietary Clean Power turbine/generator unit for small hydro applications. Goal is to keep costs under $0.07Kwhr.
- ORNL to assist in developing the testing parameters.
- Incorporates generator and turbine in one unit.
- Appears to have better than normal engineering resources and cost share funding behind the project. Appears to be a feasible pilot site.
- Hard to evaluate with the very limited information given.
- This a more general program than the single applications.
- The broader range of turbine testing is valuable.
- The concept test is vague.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.8** based on project implementation.

- Project is just starting.
- Early in implementation.
- Hard to evaluate with the very limited information given.
- As mentioned in other reviews, the expected use of the turbines might be investigated for cycling duty as well as maximum energy production. The generator revenue may be higher for ancillary service duty than as an energy resource.
- Reservoir scheduling may be an issue to maximize revenue if possible.

Strengths and weaknesses

Strengths

- Significant cost sharing; good test site.
- Pump manufacturer and has pump background.
- Engineering support and project funding are stronger than most other projects. ORNL participation in evaluation stage. Good schedule and cash flow description.
- Verbal statement that this will use bow thruster technology adapted to turbine concept.
- Obvious need for the results produced.
- The turbine testing was defined.

Weaknesses

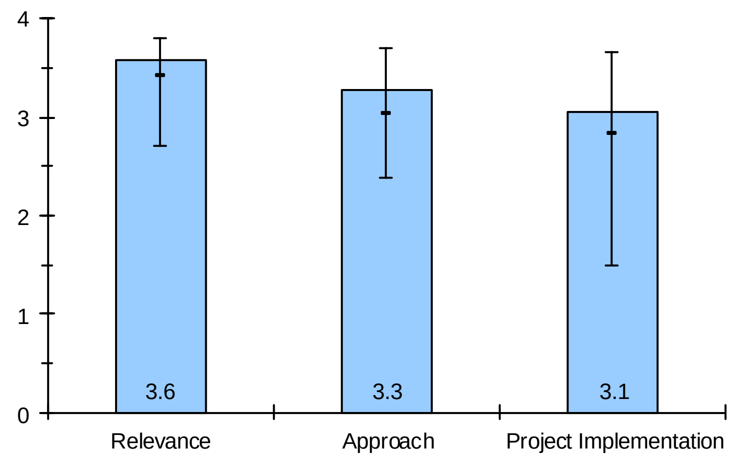
- Presentation provides few technical details.
- Poor material provided for presentation and Peer Review. Cannot evaluate on the limited information.
- Vague descriptions of what is being done.
- The implementation test was not clear.

Specific recommendations for additions or deletions to the work scope

- Pay good attention to test protocol and test report.
- The communication and coordination requirements seem to be adequate for this project, but are a little vague.

Project Name: Proof of Power Project on Potholes East Canal (POP-PEC)
Jerry L. Straalsund; Percheron Power, LLC's

Overall Project Score: 3.2 (6 Reviews Received)



Brief Summary of Project

The objectives of Percheron Power, LLC's (Percheron Power) Project are to design, develop, permit, and operate an innovative low-head hydro-electric generation facility on an existing engineered drop of the Columbia Basin Project irrigation canal system. The hydro-electric generation facility will employ a new type of turbine and technology, called an Archimedes Hydrodynamic Screw (AHS), to harness the existing potential of the engineered drop. The site is located at Station 1973 on the Potholes East Canal, with a design flow of 1800 cfs and average head of 18 feet. The average annual energy production of the POP-PEC Project is estimated to be 7,000 MWh.

Percheron Power has minimized the technical and constructions risks of the project by involving subject-matter experts since the first feasibility phases of the project. Our own team has decades of experience in developing and managing engineering projects. The selection of the POP-PEC site was made carefully with a focus on the lowest potential environmental risk and expected concerns of stakeholders, Tribes, and federal and state agencies.

One of the largest potential barriers to success of the POP-PEC Project and the AHS Technology System in general is gaining the acceptance of Reclamation and the irrigation system operators that the design, construction, and operation of the AHS technology system will not impact the structural integrity or operations of the irrigation system. Percheron Power will mitigate this risk by involving Reclamation, SCBID, and other canal owners and operators in the design of the AHS system for engineered drops at the start of the project and building a consensus around the design process. JUB Engineers has an outstanding civil design reputation in the region and record of success in consensus-building with community and agency stakeholders.

Another area of risk and key success factor for the project is the availability and price of the AHS turbine systems once the POP-PEC Project is approved for construction. The decreasing value of the U.S. dollar in foreign currency markets can escalate the price of imported components. Percheron Power expects to mitigate this risk by qualifying and receiving bids from multiple suppliers of the AHS systems.

The project will demonstrate the ability of the Archimedes Hydrodynamic Screw (AHS) system to overcome several key barriers to the deployment of low head hydropower in the U.S. The system is designed to work reliably and provide power at a competitive cost, with little or no environmental impact. With DOE's support, the POP-PEC project will also demonstrate to Reclamation, SCBID, and other agencies and stakeholders, that hydro-electric generation projects can be implemented in existing conduits and engineered drops with NO negative impact on the structural integrity or operation of existing irrigation system infrastructure. Upon successful demonstration of the AHS system at the POP-PEC site, it is envisioned that development and deployment at other low-head hydro sites in existing canals would be accomplished with an acceptable ROI and with the support of the irrigation system operators and owners.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- Project to demo. Screw Type turbines in Columbia basin. Bringing technology that is applied on over 50 plants abroad.
- Archimedes hydrodynamic screw, proof of concept project.
- Expects 85% efficiency and $69 per mwh.
- Supports DOE objective of increasing low head hydropower.
- Existing turbine concept with 50 plants outside U.S.
- Gets US attention by being applied to U.S. site.
- Appears to be too good to be true.
- Definite stated advantages.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Feasible as has been implemented outside US, thus high chance of success.
- This is a demonstration project on the East Potholes Canal in Columbia basin.
- 700 - 1800 cfs. For use in bypass canal in irrigation canals, 400 kW turbine.
- Get a conduit exemption from FERC.
- Has been installed throughout the world. Up to 50 deployments.
- Interesting approach. Archimedes hydrodynamic screw could find acceptance in some locations where other technologies might not.
- Looks well throughout.
- Barriers to irrigation operators noted. This may take time to resolve.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.1** based on project implementation.

- Good test site.
- Project just in startup.
- To be placed in existing infrastructure.
- A U.S. demonstration site is valuable to demonstrate if this device will be feasible, cost effective, and environmentally/fish compatible.
- As this type of turbine has been previously installed in other sites, looks well thought out.
- Not much information on the testing process or report to be prepared. Pay close attention to the testing. Use accepted test protocols.
- The turbines are low speed. Are gear boxes required?
- Were the generator and gearbox costs included?

Strengths and weaknesses

Strengths

- Should provide for generation in conduits with essentially no environmental impacts.
- Pilot projects exist in Europe.
- Proven deployment internationally. Novel concept may be suitable at numerous low head applications.
- Concept well proven in the 50 installations.
- Simple, low risk program is the greatest strength.
- Lower cost is another strength.
- Easy mechanical design is a further strength. Why has this not been done before?
- Satisfactory communications and coordination for a project of this size.

Weaknesses

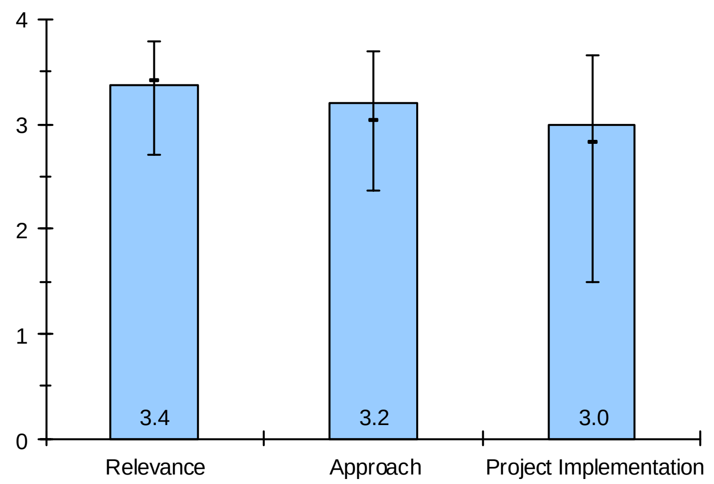
- Testing protocol not identified.
- No generator details or connection costs noted. This may be substantial in remote areas.
- Needs a discussion of the coupling to the generators.

Specific recommendations for additions or deletions to the work scope

- Would be good to get operational data.
- Expand on details of Task 4, Testing and Commissioning.
- A more detailed plan of how to work with the irrigation operators may be in order.

Project Name: Real World Demonstration of a New American Low-Head Hydropower Unit
Timothy Banta, Mark Stover; Hydro Green Energy, LLC, HDR, Mechanical Solutions Inc.,

Overall Project Score: 3.2 (6 Reviews Received)



Brief Summary of Project

HGE's design for low-head hydropower turbines and infrastructure will reduce the civil engineering and licensing costs associated with installing and maintaining small hydropower projects. Because these costs do not scale down proportionally for projects with lower net head, they can pose significant barriers to this type of hydropower generation. HGE's modular, "civil-light" system is designed to reduce the LCOE of these projects on a number of fronts. It integrates vertically-stackable, belt-driven turbines into a modular design that can be adapted to use any number of power units depending on site specifications. Unlike other systems, it works within existing available water depth on the tail water side of an impoundment. As a result, it does not require river damming, standard concrete power houses or riverbed excavation, allowing developers to avoid costly licensing processes. The price of currently available foreign-made low-head hydropower turbines can also drive up project costs. Off-the-shelf foreign-made turbines do not work in modular systems and integrating them requires substantial and costly modifications.

HGE, in partnership with MSI, Inc., and HDR, will fabricate, install, and operate an interchangeable Modular Bulb Turbine™ (MBT), which will be inserted in a Large Frame Module (LFM) and the supporting civil infrastructure designed by HGE at the USACE Braddock Lock & Dam, a low-head hydropower site on the Monongahela River in Braddock, PA, for which HGE is currently engaged in licensing with FERC.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- Supports DOE objective of increasing hydropower resources.
- Evaluates another low head hydro concept with analysis and testing.
- Obvious need to install turbines and verify turbine performance.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Not enough information.

- Good design starting with lab. Testing and moving to actual implementation via FERC licensing and installation of New World turbine at COE Braddock Lock and Dam on Monongahela River.
- Has the involvement and guidance of experienced hydropower consulting firms in the assessment and development of this second generation turbine from Hydro Green Energy.
- Not enough information provided to evaluate.
- Concept seems logical.
- No barriers noted after the license.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.0** based on project implementation.

- Not enough information.
- Two year project that started June 2011. Excellent approach to demo low head hydro at COE facility.
- Upfront CFD and FEM design work should result in a better prototype.
- No testing protocol indicated.
- Well defined project with low risk after licensing.

Strengths and weaknesses

Strengths

- Good combination of project "partners" to advance this project.
- Evaluates a small hydro concept through install and test.
- This is a clearly defined project after licensing.
- The time to completion is short thus the risk is reduced.
- No research is needed, only implementation.
- Communications appears to be adequate for a project this size.
- All projects required appear to be under control after licensing.
- Short lead time reduces risk.

Weaknesses

- Relatively expensive.
- No test protocol, report description.
- None noted.

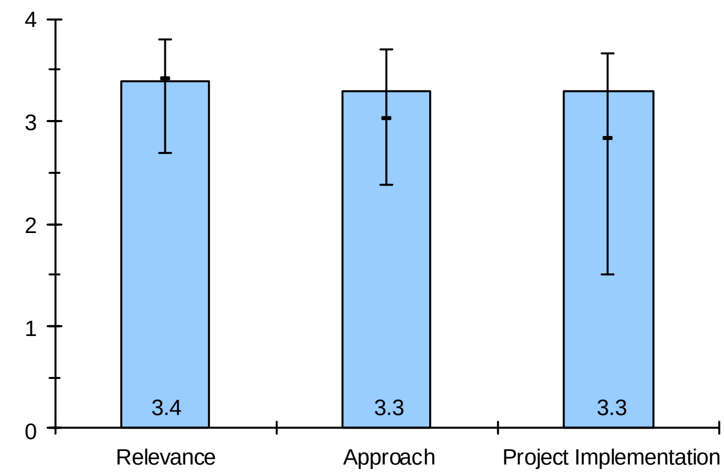
Specific recommendations for additions or deletions to the work scope

- Monitor for tangible progress and expected cost.
- Provide more details to Peer Reviewers.
- None.

Project Name: Construction Support for New Slab Creek Powerhouse Project

Scott Flake; Sacramento Municipal Utility District

Overall Project Score: 3.3 (6 Reviews Received)



Brief Summary of Project

The Sacramento Municipal Utility District is currently in the final stages of relicensing its 688 MW Upper American River Project (UARP). Under the new license, SMUD will begin releasing substantially higher flows from many UARP reservoir dams, including Slab Creek Reservoir and Dam. SMUD has decided to construct a new powerhouse to take advantage of the new release flows from Slab Creek Reservoir. The new 5.0 MW powerhouse will provide approximately 15 GWh of renewable energy for the State of California. Placing a new small powerhouse at or near existing dam structures using a novel approach to siting and innovative turbine technologies is a worthy concept – one that can apply to many similar circumstances to demonstrate the value of small hydro projects in helping to meet sustainable and renewable energy goals.

In the case of the New Slab Creek Powerhouse Project, the siting of the powerhouse is constrained by the dam location. Set in a deeply incised canyon, the concrete arch dam has a spillway where water falls from the crest to the base of the dam. A secondary constraint is the variability of flow releases. A common feature of modern relicensing proceedings is the goal to mimic the natural hydrograph, which generally results in a highly variable range of releases. In the case of Slab Creek Dam, the release requirement of the new license will range from 63 to 415 cfs.

The overall objective of the proposed project is to demonstrate value of the New Slab Creek Powerhouse Project:

- Demonstrate how power tunnels can be used in the construction of small hydro plants to take advantage of minimum flows when placing the plant at the base of the dam is not feasible;
- Demonstrate the value of dual Francis turbines to maximize energy production from highly variable minimum releases from hydroelectric dams;
- Establish a streamlined approach to hydroelectric license amendment process for small hydro projects added to existing hydro facilities; and
- Demonstrate the economically competitive nature of new small hydro projects in comparison to other utility-scale technologies.

The innovative concepts of the New Slab Creek Powerhouse Project should be directly transferable to similar projects in the U.S. Utilities throughout the western U.S. stand to benefit from SMUD’s experience with the New Slab Creek Powerhouse Project. Hundreds of hydroelectric dams will be releasing minimum flows much higher than current levels. Many of these dams will be releasing not only higher flows, but a broad range of flows. These projects must go through a license amendment proceeding similar to that planned for the New Slab Creek Powerhouse Project.
SMUD will develop a Technology Transfer Plan that identifies a list and schedule of technology transfer opportunities. Activities may include presentations at conferences (e.g., NHA annual conference),

workshops, or other public venues. Publishing in trade journals is another avenue of promoting the benefits of the novel and innovative concepts associated with the New Slab Creek Powerhouse Project.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- Supports objective of reducing cost of licensing, but may not be generally applicable.
- Objective is to demonstrate use of power tunnels at existing dams for construction of small plants with highly variable minimum flow requirements.
- Small hydropower project and utilize existing infrastructure (tunnels) at Upper American River project.
- Supports DOE objective of increasing hydropower resources.
- Seems to be a conventional hydro project.
- Goal of streamlined licensing for small hydro is good.
- Civil costs minimized - very site specific here.
- Seems to use conventional equipment but configured to deal with highly variable inflow.
- The program provides demonstration of a concept that appears to have use in some applications.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Novel look at using existing power tunnels.
- This is a collaborative demo via FERC relicensing where variable instream flow releases are required. Will demonstrate how retro fitting to facilitate seasonally varied instream flow releases. This approach can promote compatible environmental and hydro relicensing and run-of-the-river instream flows.
- Utilize existing structures (canals) that transport water for recreational flows as part of an existing licensed facility.
- Will need an amendment to the current license.
- Demonstration project with little classical R&D but could be useful to show how regulatory streamlining could assist in hydropower production.
- Logically presented.
- No real barriers other than permitting were identified.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.3** based on project implementation.

- Project is in initial stage.
- Demonstration project that is clearly feasible.
- Logically presented.
- The approach is straight forward.
- The cost will be determined.

Strengths and weaknesses

Strengths

- Licensing is big cost of many small hydro projects. This project seeks to streamline the process.
- Civil cost is big cost of many small hydro projects. This project seeks to minimize by using existing civil structures as much as possible.
- Application of using two smaller turbines to deal with highly variable flows looks good.
- The program is well defined.
- The program would be expected to be completed.
- Communications for a project of this type seem to be planned.
- All required elements for a successful program seem to be in place.

Weaknesses

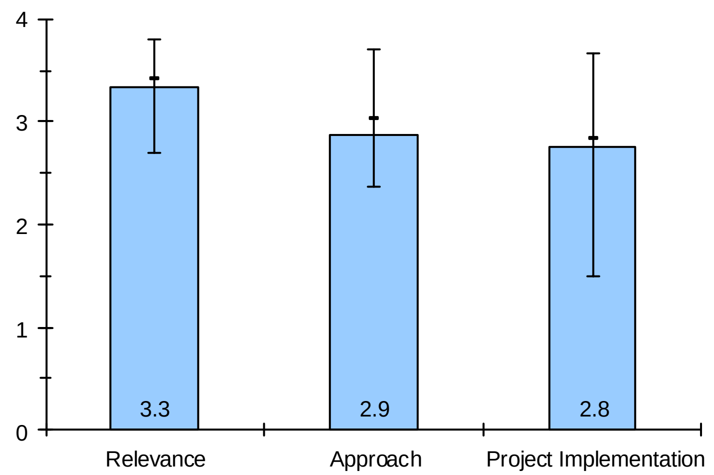
- Demo can greatly facilitate new environmental requirements imposed under relicensing.
- No real new steps in the process. Demonstration focused.
- Project is site specific. Perhaps only license process usable at other projects.
- No weaknesses noted.

Specific recommendations for additions or deletions to the work scope

- Emphasize focus on the regulatory streamlining aspects to maximize transferability.
- Test of equipment to see if it provides objectives at end.

Project Name: SLH-100 Demonstration Project at Monroe Drop
Abe Schneider; Natel Energy, Inc.

Overall Project Score: 2.8 (6 Reviews Received)



Brief Summary of Project

Natel Energy, Inc. (Natel) is a renewable energy technology company that is commercializing a novel low-head, low environmental impact hydropower technology called the Schneider Linear hydroEngine™ (SLH). The SLH expands the developable low-head hydropower resource to sites with as little as 1.5 meters (5 feet) of head, while cutting the cost of the water-to-wire package by as much as 50%. Successful demonstration of the SLH's performance and economics in lowhead hydropower settings will enable cost-effective development of the more than 40,000 existing dams in the U.S. that do not produce power, and the thousands of drop structures in irrigation district canals. According to the U.S. Department of Energy, only about 2% of the available low-head hydropower resource in the U.S. has been developed, leaving more than 70 GW of annual mean potential low-head capacity untapped.

Natel, with support from the North Unit Irrigation District (NUID), is proposing to develop a new, low-head hydropower project at a site, called Monroe Drop, on NUID's Main Canal approximately 12.5 miles south of Madras, OR utilizing one of Natel's SLH100 units.

The installation will demonstrate:

- Commercial performance of the hydroEngine™, which has the potential to reduce the LCOE from low-head and constructed waterway projects to less than $0.07 per kWh.
- Process, challenges and feasibility for irrigation districts to develop similar projects within their canal systems, thus advancing the industry's expertise in siting, engineering, design, installation, and performance evaluation of low-head projects in constructed waterways.
- LCOE for a significant source of new, predictable renewable energy.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Supports objective of bringing new inexpensive hydropower technologies into commercial readiness.
- Noval low-head, low environmental impact hydropower application to existing USBR Irrigation canal.50% cost share.
- Supports DOE objective of increasing hydropower resources.
- Demonstration of a new concept for small hydro.

- The need is hard to understand from a utility perspective, but from an end user, behind the meter, application it may be interesting. The rating is based on an end user perspective.

Question 2: Approach to performing the research and development

This project was rated **2.9** on its approach.

- Installation on canal drop.
- Will install diversion upstream of canal drop. Commercializing Schaffer Linear hydro engine (SLH) operable with as little as 5 ft. of head.
- Deploy in a conduit.
- Interconnection with PacifiCorp.
- SLH appears to be a complex mechanical device with many moving parts exposed to waterborne debris and with potential for multiple maintenance concerns in real world waterways.
- Technical approach and risk management approach seem logical.
- The overhead of permitting will be known after the project is complete. Permitting may be a show stopper for the technology.
- The implementation may not produce a successful business plan. Obtaining behind the meter value for energy would be better.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **2.8** based on project implementation.

- Two year project, design, permitting in fall 2011.
- Seems to be well thought through and logical approach.
- Demonstration site selected. Actual implementation progress in early stages.
- Overcoming barriers may be a challenge with this project. What happens with funding if barriers (no interconnection agreement or no power sales agreement) develop?
- Hydro Engine concept seems to have lots of complication, operational reliability concerns.
- The size of these generators would place them generally in the behind the meter class of generation. Energy value (prices) is higher at retail than wholesale. For most interconnections with utilities, the payment for energy is wholesale. The location picked unfortunately does not seem to have local load. A small town or industry would be required for load. The concept used in the program is practical for a demonstration, but one would probably market the generators differently as mentioned in the related review above.
- Maintenance on small units would probably not be attractive to a utility, but as mentioned in the related review, farmers and ranchers who could arrange being the meter value for the energy and perform most of their own maintenance may find the generators of interest. Areas with irrigation motors or electric heat may be candidates.

Strengths and weaknesses

Strengths

- Can facilitate low head hydro on existing irrigation canals throughout the western U.S.
- Good partners, good site.
- The price performance appears to have merit.
- The generators would appeal to people with an independent nature. The rural areas probably have some of those people. Small towns may be candidate owners.

- The parts and pieces seem to be present for the demonstration.

Weaknesses

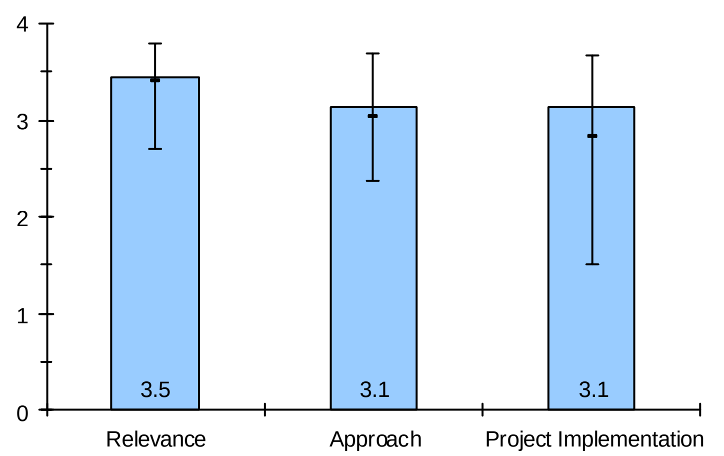
- Device appears to have limited application in real world applications without significant modifications and protections. Existing technologies appear to have far less maintenance difficulties.
- No test planned. Operational data may be qualitative rather than quantitative.
- The size of the generator may limit the applications for utilities, but may make it attractive for electric cooperative or larger users of electric energy in rural areas.
- There are a lot of permits for such a small generator.

Specific recommendations for additions or deletions to the work scope

- Tied into previous project and likely challenges with O&M etc. regards to the timing belt turbine
- Potential overlap with the belt system technology being proven.
- Monitor for tangible progress and evolution of true costs.
- Add performance testing phase with approved test protocols.
- Just finish the project and provide answers, lessons learned and determine if there is path to the future.
- The program probably has more than enough communication and coordination overhead.

Project Name: Geotechnical Investigation and Value Stream Analysis for the Iowa Hill Pumped-storage Project. *Scott Flake; Sacramento Municipal Utility District*

Overall Project Score: 3.1 (6 Reviews Received)



Brief Summary of Project

The Sacramento Municipal Utility District (SMUD) is currently in the final stages of licensing a 400 MW pumped-storage project called the Iowa Hill Pumped-storage Development, or Iowa Hill. The DOE grant will be used to further pre-construction planning for Iowa Hill. The primary barriers to Iowa Hill are economic: construction cost and project value. The uncertainty associated with geological conditions within the mountain where the water conveyance and pumping/generation facilities will be located results in wide range of potential construction costs. Also, while the Iowa Hill project is expected to provide several different value streams to its beneficiaries in the areas of operating flexibility, reliable capacity and environmental advantages, there is a degree of uncertainty with the services that will be provided.

The geotechnical investigation will meet the following objectives:

- Identify geotechnical defects in the subsurface that could result in costly remedial measures.
- Determine depth of the weathered zone, landslides, and toppled rock in construction area.
- Develop detailed information through the powerhouse gallery, tunnels, and shafts on minimum in-situ stresses to inform the degree of steel lining needed.
- Develop detailed information in the main gallery, tunnels, and shafts on geologic structures, contacts, and shears.
- Evaluate extent and impact of water bearing geologic structures.

The value stream modeling component of the grant project will meet the following objectives:

- Determine ancillary service requirements to balance increased variable renewable generation.
- Examine value from pumped storage relative to conventional gas generation for providing on peak energy and ancillary services in the SMUD BA, and, as part of the entire California region.
- Define and quantify the value streams of Iowa Hill relative to conventional gas units with future anticipated higher levels of variable renewable generation.
- Analyze the net benefits of variable speed versus fixed speed for pumped storage technology.

A number of utilities will benefit from the advancement of Iowa Hill. A demonstration of the value of pumped-storage in general and Iowa Hill in particular is highly relevant to the changing energy landscape of the U.S. The days of heavy reliance on fossil fuels to run the U.S. economy are slowly receding. With this change, it will be critical for the nation's utilities to choose wisely which resources to build for dispatchable capacity, given the significant amount of energy that will be derived from variable resource projects. Pumped-storage can provide replacement capacity for gas-fired power plants, which will be reduced in number and/or use.

The means of communicating the success of the DOE grant project for Iowa Hill to the industry at large will be discussed with the DOE during preparation of the final report. The form of technology transfer may include presentations at conferences, workshops, or other public venues. SMUD has already presented SMUD's licensing strategy for Iowa Hill at NHA, HydroVision, and other pumped-storage meetings.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Supports development of pumped storage.
- A real project that is just getting started however.
- Supports DOE objective to increase hydropower resources.
- Looks focused on moving an advanced technology Pumped Storage project toward its building.
- This project would be of interest to many pumped storage sites.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- This may not be general research.
- Demonstration is designed to promote the value of pumped storage as relevant to the changing energy landscape in the U.S.
- Geotechnical issues related to rock coring may become problematic.
- Geotechnical exploration is not R&D in the classical sense but rather a normal part of this type of project and has very little transferability due to site specific geology. Ancillary service valuation process could prove to be more useful and transferable to broader industry as a demonstration of the valuation of hydro pumped storage.
- Appears to contain steps needed to reach objectives.
- Barriers and risks have been identified.
- There are some potential show stoppers in the barriers.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.1** based on project implementation.

- Project is likely to result in a good project outcome.
- New multiple year projecting collaboration with Sacramento Municipal Utility District.
- Early on in the project.
- Looks to be well conceived.
- The process is straight forward.

Strengths and weaknesses

Strengths

- Moves a potential PS project along toward its next decision point (to build or not to build).
- The program has a good chance for success with identified risk factors.

- Their need is identified. Ancillary Services values are being identified.
- All communication and coordination necessary for the single project appears to be covered.
- Collaboration among DOE, SMUD, EPRI, FERC.

Weaknesses

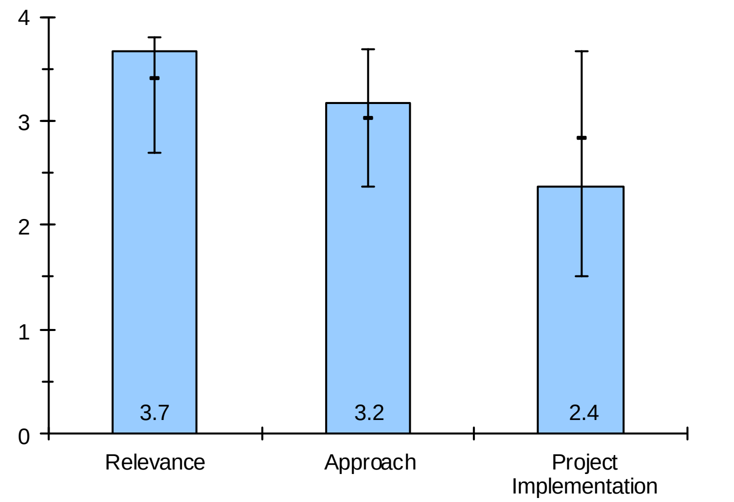
- Not so applicable to other projects.
- None that is evident.

Specific recommendations for additions or deletions to the work scope

- Recuse myself as I worked on competing proposal.
- Emphasize efforts on the value stream analysis and minimize focus on the geotechnical investigation as R&D.
- All projects seem to be identified. Risks may add to the list.

Project Name: Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the U.S. *Vladimir Koritarov; Argonne National Laboratory*

Overall Project Score: 3.0 (6 Reviews Received)



Brief Summary of Project

The main objectives of the project are: (1) to improve the modeling representation of advanced pumped storage hydropower (PSH) and conventional hydro (CH) plants in power system and energy market simulation models; (2) quantify their ability to provide various grid services; (3) quantify the value of these services under different market structures and renewable energy (wind and solar) penetration scenarios; and (4) provide information about the full range of benefits and value of PSH and CH plants.

New models are needed to analyze, quantify, and demonstrate the value of PSH and CH plants in providing various grid services. Although existing models have certain capabilities to represent CH and PSH plants, they typically do not provide levels of granularity required for detailed simulations necessary to capture the full range of technical capabilities, benefits or revenues, and ancillary services provided by these facilities. This project also aims at developing capabilities to simulate and address the value of new technologies, such as variable (or adjustable) speed PSH plants.

The models developed during the project will be made publicly available for integration with other production cost, stability, and power flow packages. Prior to their publishing, the models will be tested and validated using the actual operation data for PSH and CH projects operating within the WECC region or, for technologies that currently do not exist within WECC, using the data from other countries or the manufacturers' design data.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.7** for its relevance to DOE objectives.

- Supports PSH and valuing the benefits.
- Will assist in incorporating hydro in electric market simulations. Objective is to obtain balance across energy sectors.
- Pertinent to DOE water power program.
- Development of new models of advanced pumped storage hydropower and analyze capabilities to provide services to the grid and also to assess this value.
- Supports DOE objective to bring new hydropower technologies and reduce barriers to new development.
- Project complements and improves on other projects underway.

- Project has potential to increase the accuracy of the evaluation of the value of Pumped Storage and Hydro in Grid support applications.
- The program has a potential of producing new and improved models of CH and PSH. The present models do not include technologies such as variable speed pumping. Hydro modeling is very crude in most economic simulation programs.
- How data into the second range will be used should be interesting.

<u>Question 2: Approach to performing the research and development</u>

This project was rated **3.2** on its approach.

- Ambitious but potentially useful development of tools.
- Will provide useful for input to Project 72-Hydro in Transmission Grid. Plan as outlined is through including model testing and validation.
- Analyzing and demonstrating the value of hydro and pumped storage grid services is key to the economic feasibility of increasing future hydropower resources.
- Write up does not mention time steps used in simulation but verbal indicated seconds and seconds to minutes time steps will be enabled in the modeling. This will improve the modeling capability as some of the existing models only deal in minutes to hours and up time steps.
- Having models of advanced PS projects will be good addition. Need to capture the inertia of the water and mechanical systems in the hydro models. Critical in the short duration time steps.
- Barriers were not discussed.

<u>Question 3: Project implementation pathways toward project and DOE goals</u>

This project was rated **2.4** based on project implementation.

- Timeframe seems impossible for software development of this complexity.
- Project has not started yet.
- Project has just been awarded and has not yet been initiated.
- Not yet initiated.
- Not able to see this based on the information provided.
- The approach may not be developed enough to present a process diagram or a project chart. Either would be helpful.

<u>Strengths and weaknesses</u>

Strengths
- A needed area of continued understanding and educational awareness.
- Adds capabilities needed for grid simulation.
- Ambitious goals to provide higher quality modeling for PSH and CH.
- Impressive list of resources involved.
- The list of coordination and communication partners covers the subject area.

Weaknesses

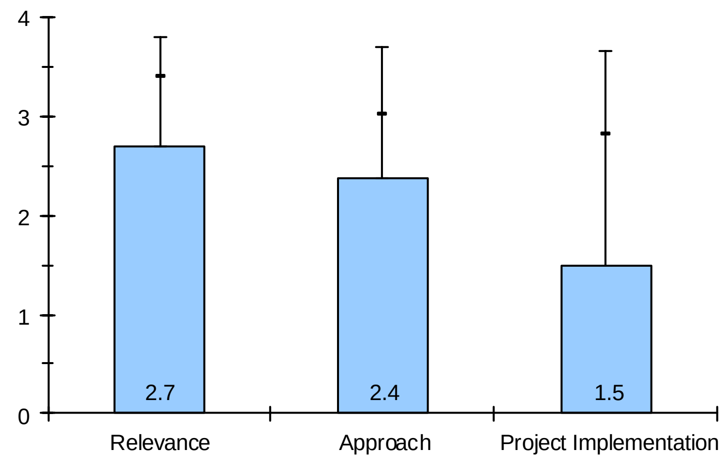
- Complex project with lot of interactions. Big objective with short time duration to complete. Not a weakness, but certainly a flag that this project will need a good eye on its monthly progress.
- Program has not presented the scope and schedule documentation.

Specific recommendations for additions or deletions to the work scope

- Should be integrated with 72-Hydro in Transmission Grids.
- Not sure how to grade since just started, however this is an important topic
- Strong project management and team communications and accountability for project leadership needed for this project to be successful.
- Follow closely.
- Have the project manager task, assign resources and identify milestones for the project.
- The scope of the studies would be helpful. The list of items for the scope may be overly inclusive for the budget.

Project Name: Turbine Aeration Physical Modeling and Software Design

Overall Project Score: 2.2 (6 Reviews Received)



Brief Summary of Project

No summary was provided by the Principal Investigator.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.7** for its relevance to DOE objectives.

- no presentation or information
- If successful this project will greatly minimize environmental impacts at some high head hydro plants.
- Supports DOE objective to bring new technologies that improve environmental performance.
- Contrary to the statement in the purpose, objectives & integration: Turbine runner designers do have the tools (experiments or computational codes) to design effective aeration on a runner blade. So some of the technology exists.
- Algorithms to simulate oxygen transfer process in a hydroturbine do exist to some extent.
- No verbal presentation to Peer Review panel was made. No chance to ask questions.

Question 2: Approach to performing the research and development

This project was rated **2.4** on its approach.

- No two page document was provided. Review was from power point file only.
- Exploring use of CFD for aeration technologies to create an environmental enhancement solution to a known concern.
- Measurement of DO uptake in a closed loop test rig questionable.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **1.5** based on project implementation.

- Project has not started.
- Initiation date is TBD.
- Limited information included in the presentation. Not possible to judge.

Strengths and weaknesses

Strengths

- Team composed of a renowned university hydraulics laboratory working with a major hydro turbine supplier.
- Limited information included in the presentation. Not possible to judge.

Weaknesses

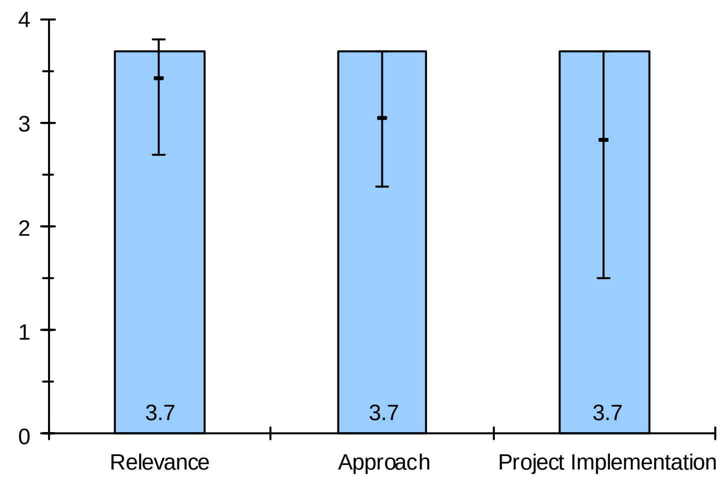
- No presentation or information.
- Would guess that some of this work may already exist within the private competitive information held by other turbine manufacturers.
- Effectiveness of closed loop testing for evaluating DO uptake questionable.

Specific recommendations for additions or deletions to the work scope

- Need more details on plan to be able to comment.

Project Name: Sensor Fish Collaboration
Z. Deng, T. Carlson; U.S. Department of Energy Water Power Program

Overall Project Score: 3.7 (6 Reviews Received)



Brief Summary of Project

Acceleration in development of additional conventional hydropower will require tools and methods to perform laboratory and in-field validation of turbine performance and fish passage claims. The Sensor Fish has proven very valuable in providing information otherwise unobtainable about the physical conditions in the water passages of turbines to assist such assessments. Sensor fish information has been and is currently being used to evaluate turbine design and operating alternatives. In the 2011 EPRI–DOE Conference on Environmentally Enhanced Hydro Turbines, various organization including the Electric Power Research Institute (EPRI), Voith, U.S. Army Corps of Engineers (USACE), and Alden Research Laboratory identified the Sensor Fish as a critical tool for further development of fish-friendly turbines designed to increase hydropower generation, decrease licensing cost, and improve environmental performance. However, widespread use of a Sensor Fish device will require redesign to accommodate use by more diverse users over a wider range of turbine designs and operating environments. If made more accessible and available through commercialization, a redesigned Sensor Fish would be a valuable tool to accelerate conventional hydro development by shortening schedules and decreasing costs for validation of performance claims to regulators. In addition, the data obtained using Sensor Fish have been proven essential in providing feedback to design engineers for performance of turbine designs that reach advanced model or prototyping stages. Development strategies that include the use of measurement utilities such as the Sensor Fish, that expedite engineering evaluation and biological performance claims for turbine designs and installations, will accelerate increased production of power by conventional hydro.

The objectives of the Sensor Fish redesign project are to:

1. Identify the desired range of applications of redesigned Sensor Fish by coordinating with existing and potential users such as U.S. Army Corps of Engineers, Bureau of Reclamation, turbine designers, and large and small hydropower entities.
2. Develop design specification for the new Sensor Fish to address the applications identified from objective 1.
3. Design a Sensor Fish that meets the specifications from objective 2.
4. Build prototypes of the redesigned sensor fish.
5. Perform laboratory and field testing of the new sensor fish.
6. Place the new sensor fish with a vendor capable of manufacturing the Sensor Fish and supporting its use by others.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.7** for its relevance to DOE objectives.

- Supports development of fish-safe turbines.
- Goal is to reduce the size and design of existing sensor fish model to be more fish like in passing through turbines. If successful this design will provide for more efficient testing and defining potential impacts of new turbines on passing fish.
- Supports DOE objective to bring new hydropower technologies that can improve environmental performance.
- Sensor fish is a demonstrated tool for getting data from inside turbine related to effects of turbine on fish. But current design of sensor fish is expensive.
- Reducing cost is key to wider use. More data will improve knowledge and improve designs reducing injury to fish passing through hydro turbines.
- There is an apparent need for the sensor fish. The old design appears to be obsolete.
- This is a slam dunk project.

Question 2: Approach to performing the research and development

This project was rated **3.7** on its approach.

- Approach is well thought out.
- After redevelopment objective is to place with commercial vendor.
- Developing a better understanding of the rapidly changing conditions that fish are exposed to during turbine passage or spill are very important to understanding how to mitigate these exposures and decrease mortality.
- Clear and specific.
- Any barriers have not been identified other than getting the program completed.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.7** based on project implementation.

- Detailed plan looks feasible.
- Project is scheduled to start Jan. 2012 and end Sept. 2013.
- To be initiated in 2012.
- Presentation details sketchy.
- From what I can tell, the process appears to determine the specifications and leads to a design and manufacturing.
- This is a repeat and refinement of a past process.

Strengths and weaknesses

Strengths
- The sensor will be very important for validating turbine performance (mortality) when passing fish.
- Appears to be promising.
- Based on existing technology. Risk is only in finding supplier who will reduce costs.
- There appears to be an immediate need for a new sensor fish.

- There appears to be no arguments about producing a new one that will meet the needs of the users.
- All projects for a successful program appear to have been identified.
- The communication and coordination plans appear to be well planned.

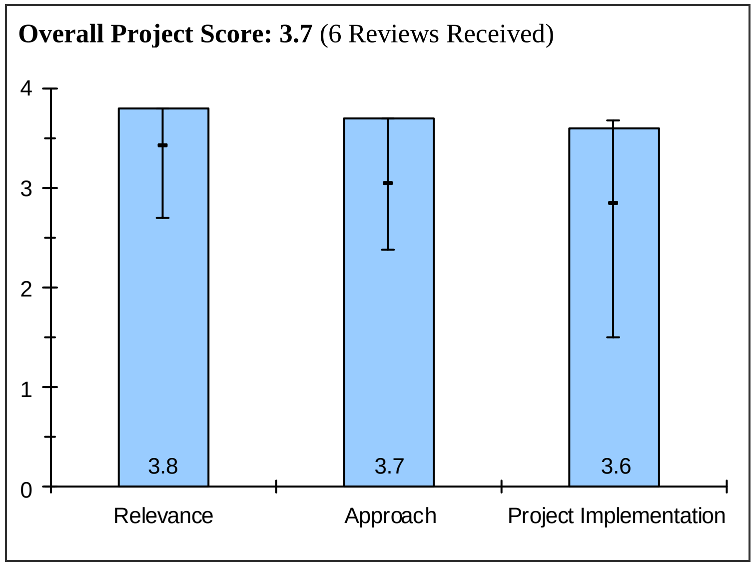
Weaknesses

- None apparent.
- This appears to be a monopoly business. I suppose the industry needs a standard and cannot justify competition.

Specific recommendations for additions or deletions to the work scope

- No changes.

Project Name: Deployment and Testing of the Alden Hydropower Fish-Friendly Turbine
Douglas Dixon; Electric Power Research Institute (EPRI)



Brief Summary of Project

The EPRI Team proposes to support installation and performance (efficiency and fish passage survival) of the Alden "fish-friendly" hydropower turbine (Alden turbine) at Brookfield's School Street Hydroelectric Project (FERC # 2539) on the Mohawk River in Cohoes, NY. Throughout North America and around the world, the primary environmental issue of concern related to hydropower is blockage of fish passage and turbine induced mortality on downstream migrating fish. This issue is best exemplified by long-term concerns over the declining status of native salmon stocks in the Columbia River basin and the possible contribution of hydropower operation to the decline via turbine mortality on downstream migrating juveniles. The proposed project provides an option for mitigating downstream passage impacts. Developed via a public-private industry collaborative over the past 15 years to mitigate hydropower turbine fish passage issues, the Alden turbine is now ready for deployment and testing. The benefit associated with the installation and operation of the Alden turbine is primarily the increase in energy production. The unique benefit of the Alden turbine is that the flows previously required for the operation of the conventional fish bypass now become available for generation, as the Alden turbine would be the primary mechanism for fish passage.

The additional energy production is a source of revenue to the project through the sale of energy to the NYISO. An additional source of revenue is realized through the elimination of the routine operation and maintenance costs associated with the conventional fish bypass system. While the bypass would be maintained for use during maintenance and shut-downs of the Alden turbine, a significant portion of the total annual operation and maintenance costs would be avoided. These avoided costs increase the net revenue of the project. Operation and maintenance costs associated with the Alden turbine are expected to be comparable to those of a conventional design. The business case for the installation of the Alden turbine versus a conventional turbine of equivalent capacity is that once the debt service has been retired, the Alden turbine generates approximately 25% more energy, i.e., revenue, than the conventional design through the recovery of energy in the flows otherwise used for the conventional fish bypass system.

The bullets below are a compilation of comments made by individual panel members during the evaluation of this project. Panel members could make multiple or no comments in each category.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.8** for its relevance to DOE objectives.

- Support fish friendly turbine.
- This involves field application of a full scale Alden Fish-Friendly turbine on the Brookfield plant on the Mohawk River.
- Pertinent to industry.

- Supports DOE objective to bring new hydropower technologies that have improved environmental performance.
- This is another slam dunk program.
- There appears to be a need to finish the design and testing of this turbine that appears to solve many industry problems.

Question 2: Approach to performing the research and development

This project was rated **3.7** on its approach.

- This project moves into the testing phase. Shows great potential.
- Previous Lab testing of 1/3 scale models of the Alden turbine have shown 100% survival of 42,000 fish passed through. One of the best designed, documented and presented projects.
- A new turbine design concept supported by significant engineering research and design work. Very promising.
- No barriers were identified. Just get it done.

Question 3: Project implementation pathways toward project and DOE goals

This project was rated **3.6** based on project implementation.

- This project moves into the testing phase. Shows great potential.
- Not yet started but has great potential.
- Still need to get owner's go ahead for utilization of the project.
- Significant progress beyond conceptual design with a well-documented design plan, schedule, implementation, and test plan.
- The approach is specific to getting the turbine installed and tested. There appears to be no need for an alternative.

Strengths and weaknesses

Strengths

- After several years of development and testing of 1/3 scale models that full scale installation and testing is very important. This project is one of the best research designs of all presented for review and is well documented. The third year is dedicated to biological testing of survival of the turbine as well as the degree of disorientation or injury leading to susceptibility to predation.
- Helps address a key issue in hydropower.
- Strong project team with demonstrated excellent accomplishments to date.
- A unified expression of need. Now how, but when the program is completed is the question.
- The program is well defined to finish.
- It appears that the communications and coordination have been successful and one would not expect problems with finishing the program.
- All projects to complete the program appear to be in place.

Weaknesses

- None noted.

Specific recommendations for additions or deletions to the work scope

- Good project to date.
- Excellent initiative and project.
- None.

6.0 Overall Program Evaluation

As part of the 2011 Water Power Peer Review process, the panel members were asked to evaluate the performance of the U.S. Department of Energy (DOE) Wind and Water Power Program (referred to as the Water Power Program or the program) in the marine and hydrokinetic (MHK) and conventional hydropower (CH) technology areas. This section represents the MHK and CH Peer Review Panels' quantitative and qualitative analysis of the program.

Panel members provided both quantitative and narrative evaluations based on the following criteria:

- Objectives,
- Barriers,
- Approaches,
- Projects, and
- Communication & Collaboration.

Specifically, panel members were asked to evaluate: 1) how well program objectives align with industry needs, 2) if the program identified the critical barriers to sustaining hydropower development and deployment, 3) if current program approaches are appropriately and effectively designed and implemented in order to achieve objectives and overcome technical and non-technical barriers, 4) if the program formed an effectively balanced portfolio of projects that will contribute to achieving its goals and objectives, and 5) the degree and impact that program interaction has on industry, universities, federal agencies, as well as comparable international actors and other stakeholders. Panel members were also asked to comment on the strengths and weakness of the program.

6.1 Marine and Hydrokinetic Evaluation

Below is a summary of the MHK Peer Review Panel's evaluation of the Water Power Program's performance in the MHK technology area. Figure 7.1 shows the quantitative analysis of the Wind and Water Power Program in the MHK technology area.

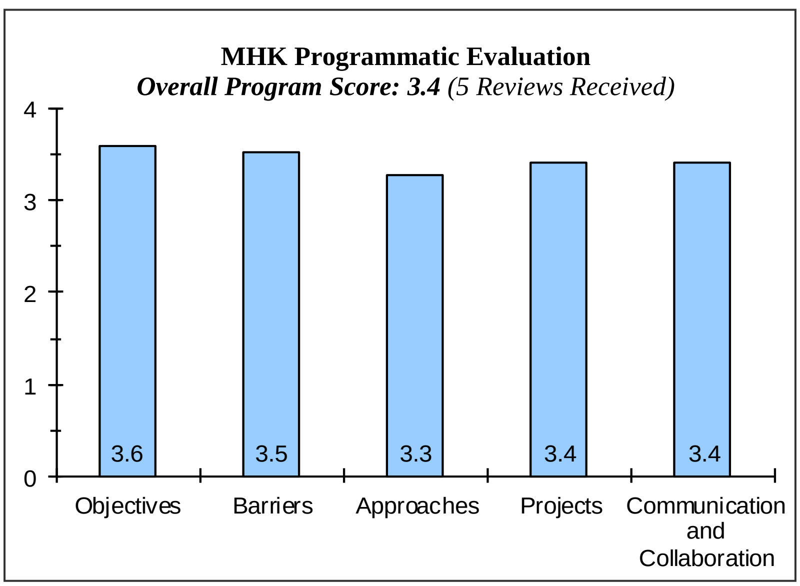


Figure 7.1. Marine and Hydrokinetic Program Area Evaluation Results

Question 1: How well do Program objectives align with industry needs?

- Excellent alignment with industry needs. The TRL funding categories allows the program to be well tailored to the challenges faced by the sector.
- Strong DOE management team in place.
- Does a good job at aligning with the objectives of the program.
- This Program is invaluable if the industry is to progress to a commercial scale.
- The TRL approach provides an effective scale to enable funding at different levels of project development.
- Project funding in the short-term may want to target more specific MHK-directed projects. The current aim is to get devices into the water. Assess potential impacts versus funding projects assessing issues that can be drawn from other marine industries, such as biofouling/toxicity.
- The research projects funded by the DOE to confirm resource availability as well as those investigating environmental impacts were outstanding.
- There was excellent concurrence between the research and the identification of promising MHK technologies.
- The research presented was effective in identification of the key cost drivers involved with the production of MHK energy.
- Confirming resource availability in a manner that provides credible energy and jobs data is critical to obtaining continued funding support within the DOE and in Congress and is an important near-term objective. Over the longer term, this information will also be useful for siting projects.
- With regard to assessing potential environmental impacts, highly favor real-world field testing that is focused very specifically on closing data gaps where existing uncertainties are posing too high a hurdle for industry pioneers. It is not enough to do a long-term noise study - we should be focused on answering how loud WECs will be relative to ambient noise and how that noise will or will not impact Southern Resident killer whales, gray whales, humpback whales, and right whales. We should conduct in-ocean EMF studies that tie analogous studies in other industries to the types of technologies likely to be first in the water. I would discourage the DOE from funding expensive and long-running desk top analyses that do not have in mind a specific regulatory information standard that needs to be met, or that focuses on impacts of large commercial arrays when there are still so many data gaps that are slowing the approval of in-water demonstration projects
- I agree with the objective of identifying technology leaders and targeting R&D investments to reduce key cost drivers.
- Missing from this list of objectives, in my view, is the need to get real projects in the water, ideally grid connected, and monitored to prove the technology and confirm that environmental risks are minor. I am concerned that if we do not get a handful of projects in the water ASAP that enthusiasm for this industry will wither. For that reason, I would say this should be the DOE's number one goal.

Question 2: Has the program identified the critical barriers to sustaining hydropower development and deployment?

- One area that is missing is work with regard to infrastructure (i.e. ports and harbors, grid, supply chain etc.) that would be required for roll out of the MHK sector.
- The approach provides opportunity to address the technical and environmental barriers at different levels of development.
- Continue to increase focus more on the relevant key barriers where little or no work has been performed by others and that could support getting devices in the water quicker.
- A priority is to get devices in the water and assess both the device's efficiency as well as the environmental impact associated with its deployment.

- A lot of funding has gone to national labs to research projects that do not immediately target the identified barriers mentioned above, but instead are either 1) researching long-term tools and strategies or 2) looking at issues that have either been assessed by other industries leaders (e.g., the Navy or offshore oil/gas industry) or issues that are not MHK-specific.
- The DOE research appears to have done an outstanding job of addressing the environmental risk factors pertaining to technology deployment.
- Regulator's uncertainties as well as some basic information on MHK technologies were also well covered by the research presented.
- Given the number of potential MHK technologies available the research programs were well focused on those with highest likelihood for success.
- I believe these are the right barriers. In addition, though, on environmental risks, I would not only say that the existing regulatory process is expensive and/or uncertain, but that agency staff are implementing existing law in a manner that is far more conservative than the law requires. Agency staff is empowered by laws such as the ESA, CWA and MMPA to use their best professional judgment, pulling from the best available science, which in this case may be analogous data in other industries. Too often agency staff is failing to rely on analogous data and their best professional judgment despite the law's edict that they do so. Instead, they are searching for a level of certainty that causes a "chicken or egg" problem. This is avoidable if agency officials send a message to staff to move these projects forward consistent with the "best available data" requirements of these statutes. DOE will have to consider whether and how its program can address this barrier.

Question 3: Are current Program approaches appropriately and effectively designed and implemented in order to achieve objectives and overcome technical and non-technical barriers?

- Excellent alignment with industry needs with the TRL funding categories allows the program to be well tailored to the challenges faced by the sector.
- TRL is good approach.
- On the large project teams, those with 3 or more team members, suggest an increased effort or improved structure on quality control and communications. This was evident on those tasks associated with the reference model which had many team members.
- Find ways to increase industry input.
- The TRL structure creates a very supportive program for development from the initial stages through to a commercial scale.
- Initially there appears redundancies and overlap in some of the research. While this is a large and complicated program, it may be beneficial to implement a third-party review group to oversee that these issues are reduced or map projects to eliminate this issue - in particular, with the National Labs as they received the greatest proportion of funding and appear to have the greatest level of overlap with research.
- There appears to be limited coordination efforts and duplication between the test centers proposed in Hawaii and Oregon. It may be more beneficial for Hawaii to target either one technology or reduce their current level of effort (they are proposing four test sites - it maybe more beneficial to focus on one or two).
- Based upon the research presented to the reviewers, there appeared to be several topic areas, including resource assessments, power take off devices and environmental impact studies among others that may have to be aggregated into one or two larger and potentially more comprehensive investigative projects.
- As mentioned above, I recommend that DOE ensure that environmental impact projects are focused on a specific regulatory information standard that demonstration projects actually have to meet and are having trouble meeting (i.e., "need to know"), rather than on "nice to know"

questions or questions that will be relevant to cumulative impact analyses only once the industry is at the large commercial scale.

- With regard to projects that are being deployed in-water (not in-tank), including testing facilities in Florida, Hawaii and Oregon, these projects are critical to the success of the industry. These types of projects should continue to be supported by DOE. In terms of how these projects are managed, DOE should require project proponents to develop a permitting and approval strategy that provides a reasonable and realistic schedule, identifies critical path issues in advance and how they will be resolved, and involves appropriate experts to execute the plan. NEPA and other regulatory standards were cited over and over as a reason for delay. There should be planning to avoid the delays (or an acknowledgement from the beginning of a much longer time line).
- National Lab work should be more focused on specific questions, enlargement of scope should be discouraged, and funding should come from wind and other DOE funding programs when research will benefit ocean wind. In terms of internal coordination and coordination between labs, it seems that this is not being done sufficiently well. Project proponents were not always sure of the goal of their research. This program has too few funds, and this industry has too little time, to function as a source of eternal work for labs. We do need these labs very much, but we need their work to focus on critical path questions and to be completed in as efficient a manner as possible. Based on the materials, presentations, and our discussions with them during our meeting, it is not clear that is happening. Going forward, I recommend DOE fund discrete, specific projects with clear parameters, goals and end points.

<u>Question 4: Has the program formed an effectively balanced portfolio of projects that will contribute to achieving its goals and objectives?</u>

- Very good balance of projects across the TRL levels.
- Excellent balance between test centers, resource assessments work, and technology development.
- Good mix of projects at different levels of development.
- Increase efforts on projects that are working to get devices in the water with monitoring.
- There is a good balance to the project portfolio; however, at such an early stage in this industry's development it might be more beneficial to target projects that will get devices in the water and assess environmental impacts instead of long-term planning tools. These tools could be developed in the future.
- Because MHK remains in its infancy, the DOE has funded a well-focused and diverse portfolio of research studies designed to help "bootstrap" the Ocean Energy industry.
- As mentioned above, I am very pleased to see so many projects being funded by the DOE that are planned for in-water deployment. These are very important projects and the DOE should continue to support them and projects like them. Technology development is also critical, as are empirical environmental tests that can be used in first generation deployments to close critical data gaps.
- There appears to be a lot of money being spent on projects that will answer questions not yet asked by the regulators (e.g., toxicity of anti-fouling paint, which will not be a serious question until we have large commercial projects in the water, if ever). With limited funds, I urge DOE to continue to focus on getting the first projects in the water, and fully funding the questions that need to be answered in the near term for those projects.

Question 5: What degree and impact does Program interaction have on industry, universities, and federal agencies, as well as comparable international actors and other stakeholders?

- There could be improved communications between the works done at the National Labs.
- On those projects with greater than three team members, suggest an increased effort to assure regular and effective communications between team members and other DOE projects that may depend on results of the recipients' efforts.
- There is a good blend of participation from industry and academic groups; however, it may benefit the growth of this industry if there was more involvement from the regulatory community (e.g., NMFS for marine mammals and ESA species, or EPA and NOAA regarding shore-based OTEC devices).
- Because of confidentiality concerns involving proprietary information from several DOE-funded projects, the DOE may want to investigate the use of an independent panel of researchers designed to provide limited access to information from these studies for qualified research institutions.
- The DOE's leadership and funding are both critical to enabling the communication and collaboration we need to see in this industry. I do see quite a bit of this happening now in the industry. Perhaps it needs to be better organized in some cases, but I'm happy with the impact of the program on industry, universities, agencies, and etc. I would like to see a bigger impact on the industry itself in the near term, as comments above reflect.

Program Strengths

- Very good balance of projects across the TRL levels.
- Excellent balance between test centers resource assessment work and technology development.
- Implementing the TRL structure.
- Overall, there is a wide variation of projects including supporting environmental/resource studies, device developers, and components for increasing power takeoff in devices.
- TRL is an effective structure to support projects in various stages of development.
- The funding protocols are thoughtful and well designed.
- Focus on LCOE is well communicated.
- The program's emphasis on getting real projects in the water, many grid connected, should advance the industry past the "is it real" stage and beyond. In addition, because the DOE has this program, it is in a leadership position and has the ability to bridge gaps with other agencies and send messages within DOE and to Congress about the importance of this industry to our long term national energy goals.

Program Weaknesses

- There appeared to some overkill on the range of environmental work being undertaken by the National Labs. This may unnecessarily scare regulators, by unnecessarily highlighting a very long list of potential issues of the sector.
- There could be improved communications regarding the work done at the National Labs.
- There appears to some work (such as toxicity) being done within some of the National Lab work that is done because the labs have the capability rather than it has been identified by the sector as a priority need.
- Although its primary audience is the DOE I believe that the cost reference model would benefit from a larger focus on industry needs.
- The test centers would all benefit from having a grid connection.
- Some redundancies seem to be apparent.
- Project management/QA/QC/communications on the larger projects could be improved to assure that efforts are performed in a collaborative manner when appropriate.

- Many projects currently funded are not MHK-specific, but are/have been assessed by other offshore industries. Some research is applicable to other offshore energy infrastructure (e.g., offshore wind or offshore oil and gas). These studies need to be reduced or eliminated and funds targeted to more MHK-specific projects.
- Several of the DOE funded research projects may have had substantial overlap with research conducted by other PI's.
- Several of the researchers appeared to have IP concerns which may have limited their willingness to disseminate project data.
- As said above, the program would benefit from refocusing some of its efforts on longer-term or more nebulous inquiries to near-term "need to know" questions and in-water projects.

Recommendations

- Get more industry involvement where it makes sense.
- Grid connections for test centers.
- Having a commercial arm of the test centers that may have different management than at present.
- Increased industry focus for cost reference model.
- Foster increased communication between National Labs.
- Consider an independent project management board for the national work projects.
- Foster increased international collaboration in all projects.
- Ensure all projects that are funded are novel and specific to the MHK sector.
- Is there a communications protocol for award recipients when it comes to making public comments regarding the work they are doing that is funded by DOE dollars? If not, it is suggested that one be created and reviewed with the recipients.
- May want to look at funding more MHK-specific projects that address the immediate needs of the industry.
- Funding may want to be directed towards gathering empirical data that can be presented to regulatory agencies, such as NMFS. For example, acoustic data or potential for marine mammal collision.
- Many environmental-based projects are assessing the negative "what ifs" with very few looking at the positives. There needs to be more of a balance.
- Overall the DOE'S MHK Research Program has provided significant benefits to the Ocean Energy industry and the research community.

6.2 Conventional Hydropower Evaluation

Below is a summary of the Conventional Hydropower (CH) Peer Review Panel's evaluation of the Water Power Program's performance in the conventional hydropower technology area. Figure 7.2 shows the quantitative analysis of the Wind and Water Power Program in the CH technology area.

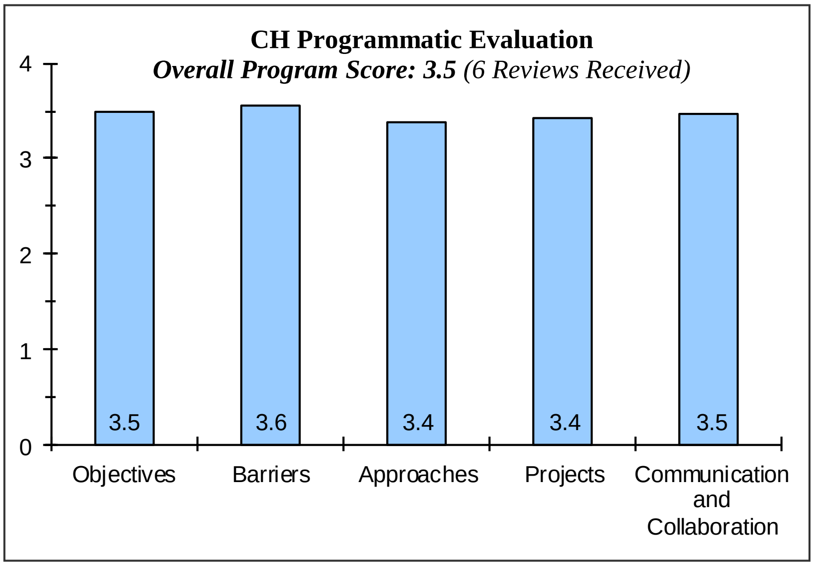


Figure 7.2. Conventional Hydropower Program Area Evaluation Results

<u>Question 1: How well do Program objectives align with industry needs?</u>

- The DOE Water Power Program is an extremely valuable component of industry R&D efforts and to the advancement of responsible renewable energy expansion efforts.
- The program objectives are being met well with the conventional hydro projects in general.
- Some projects are more highly ranked in terms of meeting objectives than others.
- All projects as presented support the DOE Water Power Program. Many are excellent.
- The projects strongly support industry needs with few exceptions.
- The main concern is the methods that hydropower are being valued. Hydro has advantages compared to other generation methods in the ramping, regulation and fast starts areas that have value. Ancillary Service Markets segregate services and pay for them. It may be possible to obtain the same revenue from a hydro facility using 60-70% of the water that the economic methods being used require 100% of the water. Each market tariff is specific. A short paper presenting the market uses for hydro (including revenue) was provided.
- Small hydro has competitive advantages that are not being addressed. Small hydro qualifies as a renewable resource in many states. Renewable Portfolio Standards RFP processes are such that small hydro does not have to compete against gas turbines and other low cost generation options. Small hydro has to compete with wind. The playing field in government support needs to be level for small hydro to compete. Hydro has advantages for capacity, regulation, ramping and fast starting that wind does not. A focus on how to get hydro to compete in the markets should be a focus point.
- Some small hydro is behind the meter from a RTO standpoint. The hydro is connected to voltages lower than 100 kV and does not sell energy to the wholesale market. The value of energy behind the meter is 30-100% higher than on the wholesale side of the meter. There has to be a load that can use all the hydro energy generated by the hydro on the distribution system. Ancillary Services are not applicable on the distribution side of the meter. Specific case studies

of the hydro value behind the meter generation are probably needed. The value of energy behind the meter is very dependent upon the customer taking the energy.
- The "slam-dunk" projects appear to be good candidates for value optimization. Getting the technology installed and operating is the main focus. Obtaining maximum revenue is a business case that DOE probably cannot control. Industry and customers have to control the business case. There should be some cooperative way to get the business case information back into the Hydropower Program so others can learn from successes and lessons learned.
- Length of life is another factor not being evaluated. The present value cash flow of a hydro generator compared to a wind turbine may be worth funding. The present value cash flow of a combustion turbine including cycling costs over the life of a hydro facility may also be worth funding. WECC and NREL are working on identifying the cycling costs of fossil fueled generation. Perhaps the NREL work could feed the Hydropower Program.

Question 2: Has the program identified the critical barriers to sustaining hydropower development and deployment?
- The program has done an admirable job of identifying the impediments to additional responsible hydropower development. The issues around climate change and carbon intensive energy generation make it imperative that the barriers to additional renewable hydro energy are addressed and overcome.
- The identification is right on target.
- Some of the current projects also work on other barriers not listed here, such as environmental issues, which often are not yet well understood, and soft qualitative reasoning is being replaced with more science through the program so competing uses are more fairly weighed.
- As more renewable energy generation comes on line, the market for grid services will grow. But hydro, particularly for storage and grid service takes a long time to get built (5 year license, preparatory work and then 5 years to get it built and commissioned). Renewable energy growth has been quite rapid. The realization that once renewable energy generation passes a certain supply percentage, grid stability issues will become problematic has not yet been recognized in the US. In Europe, this has been recognized and hydro is contributing nicely to grid stability there.
- Yes, in general. Competing uses should include all other uses, not just environmental.
- Barriers of high cost of hydro and high cost of licensing and regulations are important to address.
- Licensing appears to have grown to show stopper levels and time durations for small hydro.

Question 3: Are current Program approaches appropriately and effectively designed and implemented in order to achieve objectives and overcome technical and non-technical barriers?
- The R&D program applies an appropriate mix of traditional engineering and scientific approaches to eliminate existing barriers while also exploring out-of-the-box thinking for selected research and development prototype devices for small and micro hydro power opportunities.
- The program is heading in the right direction.
- Many private utilities have done a lot to incorporate upgrades into their strategy. Many have modernized much of their fleet of hydro units. The Federal Hydropower fleet seems to lag in taking advantage of available technology and services to make better use of their hydro installations. While it was hoped that the MOU would have accelerated the modernization of the federal hydropower fleet, this seems quite slow to materialize.
- Corrections to the programs ongoing efforts related to hydropower value modeling improvements through the FOA's in 2011was good to see.
- A number of operational tools to help maximize generating at existing and new facilities have been available. While not expensive, they are having none the less not been well utilized or accepted as helping.

- I am not convinced yet that the program approach to quantify and monetize hydropower ancillary service is achieving a positive outcome. Vertically integrated utilities who use hydropower value it much higher than analyses will indicate.
- Great work on the regulatory and environmental stakeholder topic. It's soft, touchy-feely and the work is bringing more quantification to it. But it takes a long time but is very important, so keep going.
- Approaches involve inventories and data analysis, developing and testing new products, market and grid analysis, software development to support improved operations and new methods for identifying improved operations, and stakeholder facilitation approaches. This is the right mix of approaches to address all the objectives. DOE could be better served by retaining experts in all relevant fields during the evaluation and oversight of the projects over the range of approaches.
- Near term programs with straight forward plans through results seem to be able to get examples.

Question 4: Has the program formed an effectively balanced portfolio of projects that will contribute to achieving its goals and objectives?

- Some recent projects have shown promise of technological breakthroughs that likely would not have been possible without DOE support.
- A few of the experimental prototype projects will need careful oversight since their proposals are somewhat lacking in traditional scientific analysis and data support.
- The balance feels good. Nice job here!
- Most of the projects are effective and the portfolio is well balanced.
- The projects to get hydro installed appear to be focused with the exception of the economic justification.

Question 5: What degree and impact does Program interaction have on industry, universities, and federal agencies, as well as comparable international actors and other stakeholders?

- The DOE program stimulates interest, education on hydro issues, and private investment on a scale that few other avenues can accomplish.
- In 2011, there is clear evidence that the program has used feedback from the peer review process in 2010 to make subtle changes for the betterment of several projects.
- One of the greatest impediments to hydro advancement and development is dealing with the federal regulatory bureaucracy. An objective DOE "audit" of the federal regulatory process could serve to open some eyes in Washington.
- I sense the collaboration can be better. But it takes both the program and others to make that happen. Note that there are a number of conventional hydro projects where pilot or demonstration sites are needed and there has been reported a degree of difficulty in getting participants to work with the program. This hinders acceptance and also hinders real world input to program projects. There needs to be more push to get more participants in the test case, pilot or demonstration segments of the program.
- Some of the projects are set up to be proof of concept (POC). Large investments are being made. Work is being done mostly inside the National Labs. When the POC projects are completed I have a fear that the resulting technologies will get lost. DOE needs to find a way to capture the technologies generated and make them usable by Industry, Universities, and Agencies outside the National Labs.
- Evidence of much improved communication and coordination across labs. Also seen with industry and federal agencies.
- Many projects show excellent communication and collaboration, but there are some that do not.
- There appears to be adequate communications and coordination for the programs.

Program Strengths

- Program has access to some of the greatest minds in the business with open solicitations.
- Program is performing impressive work in a wide range of areas.
- Excellent talent working on the projects.
- Good mix of projects.
- Projects well focused on the right targets.
- Good representation of all appropriate disciplines. Excellent scientists working in true interdisciplinary fashion.
- The program has a wide range of projects that address almost all, if not all, of the objectives and barriers.
- The program's level of collaboration and participation is impressive. It involves virtually all the federal agencies, many of the utilities and most of the federal labs. Also, many university researchers and EPRI are involved as well as consultants and NGO's.
- The result of most of the projects will be products or information that can used directly to improve hydropower efficiency and acceptance.
- Most of the programs are straight forward to near term results.
- The program is heavy on demonstration projects that are needed to give industry the confidence to proceed with installations.

Program Weaknesses

- Areas to continue to focus on:
    - A couple projects require extensive data input and may have difficulty getting to the point of ultimately achieving the objective of added hydro MWhs.
    - Some projects lack clarity in rolling out to end users and next steps. Measures of success are not always clearly identified and tracked.
- Technologies developed may be lost if not captured in a technology transfer to the industry segment of the projects.
- There needs to be more focus on achieving and communicating quantifiable and meaningful results.
- Still needs more awareness of what is going on in other parts of the world.
- A few of the projects did not begin with adequate demonstration of need and thus may not address the program needs.
- Identifying the values of hydro seems to be the greatest weakness.
- Valuing hydro is not in the normal set of skills held by the researchers leading the programs.

Recommendations

- The DOE Water Power Program is of tremendous value to the power generation industry and society in general. The program provides credibility, objectivity, and stakeholder education that cannot be easily provided by other means. The solutions to future energy demand and global emission impacts will rely on innovative thinking and also critical re-examination of previously held beliefs and misconceptions. The DOE Water Power Program is one of many needed tools to provide solutions to these extremely complex socio-economic- political problems.
- I heartily applaud the DOE efforts and the openness to improvement opportunities provided by the Water Power Peer Review process.
- Technologies developed and databases created in the program need to be made available to and effectively usable by industry, universities, others outside the projects.
- Increase awareness of work being done by others outside the DOE, particularly in other countries, aimed at similar targets of the program. Look in particular at European use of hydro Pumped Storage for grid support.

- Licensing issues seem to be a major cost to many future hydro projects. Good work is being done in the program. Push hard to get processes and firm facts. Continued emphasis on streamlining is important in growing hydro generation.
- For the review process, have all new projects, where work has not yet started, on one day (perhaps the second day) with documentation previously provided to Peer Review Committee and have the scientists appear via visual teleconference only. Have ongoing projects on a different day with the scientists present and devote more time for presentation and interaction with review team.
- Software development tasks (there are 3 or 4 important ones) should be evaluated and guided by someone with software experience in addition to the energy-related oversight provided by DOE.
- DOE should establish a more organized dissemination of results and information so the projects can benefit from each other and the public and industry can get more immediate and direct access to the results.
- The Sandia project evaluated Ancillary Services last time. The next steps need to be taken beyond the report to drive projects by industry to be installed. The Hydro program appears to be identifying the opportunities sufficiently.
- Form an industry team of developers and researchers to formulate a plan to reach the installation goals for hydro. Determine what needs to be done to reach the goal. Perhaps a hydro group with segments by size similar to UVIG for wind and solar should be established that focus on integration of hydro. There is probably an organization that is close to that already due to the maturity of hydro technology. UVIG also has an O&M group that focuses on operational problems. O&M groups probably exist for larger hydro. Small hydro may need one.
- Focus on a doable set of installed projects of different sizes each year. Get the projects done.

7.0 Lessons Learned from the 2011 Water Power Peer Review Meeting Process

The 2011 Water Power Peer Review meeting took place on November 1-4, 2011 at the Hilton Alexandria Mark Center located in Alexandria, Virginia. A Marine and Hydrokinetic Panel (MHK), consisting of four members, and a Conventional Hydropower (CH) Panel, consisting of five members, participated in the 2011 peer review process. One overall chairperson oversaw both panels, bringing the total number of reviewers involved in the 2011 peer review process to ten. Approximately 85 individual projects were evaluated during the 2011 peer review process, representing a DOE investment of over $100 million over the last few years. The following is a list of comments and actionable recommendations aimed at improving the process for future peer review meetings:

- The global objectives of the U.S. Department of Energy Water Power Program (the program) are very good. The main points are on target and the research teams are focused on their objectives.
- Metrics for project performance and success were not clear on some projects.
- Project deliverables should be linked to end-users and use-cases should identify how the products could be used in order to guide the development of the project. An understanding of the end-user in a real-world context should also be maintained, and projects should incorporate processes for bringing end-users into product development.
- The program should communicate to all principal investigators in the spring that there will be a peer review meeting coming up in the fall. This will enable principal investigators to start thinking about the peer review process months in advance.
- The program should provide project information to the peer review panel in a timelier manner to improve the effectiveness of the peer review process, and should ensure consistency of the presentation format by requiring principal investigators to use a template with key project information and results.
- The use of the peer review process by the program is a very commendable approach to continuous improvement, especially the inclusion of both programmatic and technical reviews.
- Improvements in including technical review teams following the 2010 peer review recommendations were clearly observed.
- Reviewers noticed significant improvements in the coordination between projects and reducing overlap areas.
- The program should gather all reviewers in a meeting room 30 minutes prior to the start of the meeting in order to review the scoring process and TRL level of projects. In addition, reviewers should be given several minutes between presentations to complete scoring and notes to allow reviewers to focus on presenters rather than trying to draft and score simultaneously.
- The format of overlapping MHK and CH sessions created time pressure that resulted in a less effective review.
- Project presentations seemed to fall into two classes, new projects and on-going projects. New projects were presented succinctly and with adequate time coverage. On-going projects could have presented more details including lessons learned and benefitted from more time for questions and discussion.
- There were 62 MHK presentations, and there were times when the short presentations got a little daunting. A couple of minutes in between projects would be beneficial for the reviewers.
- Reviewers recommend grouping all projects of similar technologies together and having a representative from the program provide a 3-5 minute overview of that technology area before the presentations commence.
- The program should require principal investigators to start their presentations describing why their project is important as well as its "Relevance to Overall Program Goal."

- The three step process (review before, review at, review after) requires that the materials get turned in on time. It should either be a process where you come in cold and do a lot of work during and after the review, or where reviewers heavily prepare ahead of time and have a lighter week, but it should not be both.
- Reviewers weren't comfortable sitting in the front row with a laptop scoring the projects. A different room design is preferred for next year to ensure confidentiality.

APPENDICES

Appendix A. Meeting Attendee List

Appendix B. Evaluation Form Templates (Marine and Hydrokinetic, Conventional Hydropower, Lower TRL, and Programmatic).

Appendix C. Results of Surveys Submitted by Attendees

Appendix A: Meeting Attendee List

U.S. Department of Energy, Wind and Water Power Program Water Power Peer Review, November 1-4, 2011 Alexandria, Virginia		
Last Name	**First Name**	**Organization**
Ahlgrimm	James	U.S. Department of Energy, Wind and Water Technologies Program
Ascari	Matthew	Lockheed Martin Corporation
Bagbey	Roger	Cardinal Engineering, LLC
Bagley	Tim	The Bagley Group
Baldwin	Kenneth	The University of New Hampshire
Banister	Kevin	Principle Power, Inc.
Barco	Janet	Sandia National Laboratories
Barco-Mugg	Janet	Sandia National Laboratories
Barrett	Stephen	Harris Miller Miller & Hanson Inc.
Batten	Belinda	Oregon State University
Battey	Hoyt	U.S. Department of Energy
Beck	Fred	SRA, International
Bernstein	Bernard	Investment Intermediary
Bevelhimer	Mark	Oak Ridge National Laboratory
Bier	Asmeret	Sandia National Laboratories
Biggs	S. James	Artificial Muscle, Inc.
Blanchard	Whitney	NOAA NOS
Borek	Jessica	Strategic Marketing Innovations
Brazaitis	Alison	DOE Water Power Program
Brown-Saracino	Jocelyn	NewWest/ U.S. Department of Energy
Bruce	Allan	Sunlight Photonics Inc
Calvert	Stan	U.S. Department of Energy
Cinq-Mars	Rob	Free Flow Energy, Inc.
Clark	Charlton	U.S. Department of Energy
Cline	Joel	NOAA, National Weather Service
Coffey	Anna	U.S. Department of Energy
Coleman	Andre	Pacific Northwest National Laboratory
Conzelmann	Guenter	Argonne National Lab
Cooley	Craig	US Synthetic Corporation
Copping	Andrea	Pacific Northwest National Laboratory
Cotrell	Jason	NREL, National Wind Technology Center
Datko	Christopher	THOR Energy Group LLC
Dham	Rajesh	U.S. Department of Energy
Dougherty	P.J.	SMI Inc.
Driscoll	Frederick	NREL, National Wind Technology Center
Eugeni	Ed	SRA International
Fisher	Cameron	Ecology and Environment, Inc.
Fisher	Richard	Voith
Fleming	Alex	Dehlsen Associates, LLC
Frame	Caitlin	U.S. Department of Energy

U.S. Department of Energy, Wind and Water Power Program Water Power Peer Review, November 1-4, 2011 Alexandria, Virginia		
Gasper	John	Argonne National Laboratory
Gay	Paul	SMI/Helios Strategies
Geerlofs	Simon	PNNL
Gill	Carrie	U.S. Department of Energy
Gilman	Patrick	DOE Wind and Water Power Program
Grandelli	Patrick	Makai Ocean Engineering, Inc.
Haas	Kevin	Georgia Tech
Hadjerioua	Boualem	Oak Ridge National Lab
Hart	Chris	U.S. Department of Energy
Hart	Phil	Ocean Power Technologies, Inc.
Hartman	Liz	U.S. Department of Energy, Wind and Power Program
Hayse	John	Argonne National Laboratory
Heavener	Paul	Princeton Power Systems
Heibel	T.J.	BCS
Hess	Matthew	U.S. Department of Energy, Wind and Water Technologies Program
Hinckley	Thor	Portland General Electric
Hoesly	Ryan	SRA, International
Hogan	Timothy	Alden Research Laboratory, Inc.
Holveck	Mark	Princeton Power Systems
Hunt	Turner	THOR Energy Group LLC
Jacobson	Paul	Electric Power Research Institute
Jeffrey	Henry	The University of Edinburgh
Jepsen	Richard	Sandia National Laboratories
Key	Thomas	Electric Power Research Institute
King	Thomas	Oak Ridge National Laboratory
Klure	Justin	Northwest Energy Innovations
Kopf	Steven	Pacific Energy Ventures
Korigsburg	Amy	Energetics
Kunko	Damian	SMI/Helios
Laird	Daniel	Sandia National Laboratories
Lamprecht	Michael	U.S. Department of Transportation, Federal Highway Administration, Office of Planning, Environment, and Realty
Leahey	Jeff	National Hydropower Association
Lewis	Greg	Duke Energy Carolinas, LLC
Li	Ye	NREL
Lindenberg	Steve	U.S. Department of Energy
Lin-Powers	Jessica	National Renewable Energy Laboratory
LiVecchi	Albert	NREL
Lounsberry	Brian	Cardinal Engineering
Lovelace	Edward	Free Flow Power
Lovelace	Edward	Free Flow Power
Lovy	Jerry	UEK
Lowry	Thomas	Sandia National Laboratory

U.S. Department of Energy, Wind and Water Power Program Water Power Peer Review, November 1-4, 2011 Alexandria, Virginia		
Lustig	Jay	Scientific Solutions, Inc
Mahalik	Matthew	Argonne National Laboratory
Mauer	Erik	CN JV (DOE Contractor)
McEntee	Jarlath	Ocean Renewable Power
McLean	Genetta	Ocean Renewable Power
Montagna	Deborah	Ocean Power Technologies, Inc.
Moreno	Alejandro	Public
Morrow	Mike	M3 Wave Energy Systems LLC
Murphy	Michael	HDR Engineering
Musial	Walt	NREL, National Wind Technology Center
Neary	Vincent	Oak Ridge National Laboratory
O'Connor	Patrick	BCS, Inc.
O'Neill	Sean	Ocean Renewable Energy Coalition
O'Neill	Sean	Ocean Renewable Energy Coalition
Oram	Cherise	Stole Rives LLP
Osborn	Dale	Midwest ISO
Ozkan	Deniz	Atlantic Wind Connection
Polagye	Brian	University of Washington (NNMREC)
Previsic	Mirko	RE Vision Consulting
Putnam	Logan	Cardinal Engineering
Quinn	Samantha	CNJV- Contractor to U.S. Department of Energy
Ramsey	Tim	U.S. Department of Energy
Reed	Michael	U.S. Department of Energy
Rhinefrank	Ken	Columbia Power Technologies, INC.
Roberts	Jesse	Sandia National Laboratories
Rocheleau	Andrew	Sea Engineering, Inc.
Rocheleau	RIchard	HNEI, University of Hawaii at Manoa
Rogers	Lindsey	Electric Power Research Institute
Rumker	Joel	THOR Energy Group LLC
Sale	Michael	M.J. Sale & Associates
Shuff	Stephanie	Energetics
Simiao	Gus	Vortex Hydro Energy
Sinclair	Mark	Clean Energy States Alliance
Skemp	Susan	Southeast National Marine Renewable Energy Center, FAU
Smith	Brennan	Oak Ridge National Laboratory
Spray	Michael	New West Technologies
Staby	Bill	Resolute Marine Energy, Inc.
Stalnaker	Clair	USGS
States	Jennifer	Pacific NW National Laboratory
Stein	Peter	Scientific Solutions, Inc.
Thresher	Robert	NREL, National Wind Technology Center
Toman	William	SAIC
Tusing	Richard	DOE Wind and Water Power Program
Vauthier	Denise	Uek Systems

U.S. Department of Energy, Wind and Water Power Program Water Power Peer Review, November 1-4, 2011 Alexandria, Virginia		
Vega	Luis	Hawaii National Marine Renewable Energy Center
Vesecka	Thomas	Argonne National Laboratory
Vinick	Charles	Ecomerit Technologies, Inc
Vitale	Philip	Naval Facilities Engineering Command
Voisin	Nathalie	Pacific Northwest National Laboratory
Weinstein	Alla	Principle Power Inc.
Wigmosta	Mark	PNNL
Wynne	Jason	U.S. Department of Energy/Energetics
Yang	Zhaoqing	Pacific Northwest National Laboratory
Zagona	Edith	University of Colorado

Appendix B. Evaluation Form Templates

The evaluation forms were the only means by which reviewers documented their quantitative and qualitative project evaluations. Separate evaluation forms were used to document reviewer scores and comments regarding: 1) marine and hydrokinetic (MHK) projects, 2) conventional hydropower (CH) projects, 3) lower TRL projects (for both MHK and CH), and 4) an overall evaluation of the program.

The panel was asked to rate marine and hydrokinetic and conventional hydropower projects in the following weighted categories:

1. **Relevance to Overall DOE Objectives:** the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. (Stand Alone Metric)
2. **Approach**: the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. (Weight = 30%)
3. **Technical Accomplishments and Progress:** – degree to which the project has progressed compared to the latest project schedule and goals. (Weight = 30%)
4. **Research Integration, Collaboration, and Technology Transfer:** with industry/universities/other laboratories – the degree to which the project interacts, interfaces, or coordinates with other institutions and projects, and the degree to which projects are disseminating the results of the R&D. (Weight = 20%)
5. **Proposed Future Research:** the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and when sensible, mitigating risk by providing alternate development pathways. (Weight = 20%)

The panel was asked to rate the "Lower TRL" marine and hydrokinetic and conventional hydropower projects in the following weighted categories:

1. **Relevance to Overall DOE Objectives:** the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. (Stand Alone Metric)
2. **Approach**: the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. (Weight = 80%)
3. **Project Implementation:** the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed research or technology, and when sensible, mitigating risk by providing alternate project management pathways. Also, the degree to which projects have achieved any notable accomplishments or encountered setbacks (for those projects which are underway and have completed a significant amount of work). (Weight = 20%)

Additionally, the program evaluation forms were designed to capture input regarding the following criteria:

1. **Objectives:** how well do program objectives align with industry needs?
2. **Barriers:** has the program identified the critical barriers to sustaining hydropower development and deployment?
3. **Approaches:** are current program approaches appropriately and effectively designed and implemented in order to achieve objectives and overcome technical and non-technical barriers?
4. **Projects:** has the program formed an effectively balanced portfolio of projects that will contribute to achieving its goals and objectives?

5. **Communication & Collaboration:** the degree and impact that program interaction has on industry, universities, federal agencies, as well as comparable international actors and other stakeholders.

For project evaluations, numerical scores were based on a four point scale, with the following qualitative descriptors given for the numerical scoring index:

- **4 – Outstanding**. Project is critical to supporting the objectives, goals, and approaches of the program.
- **3 – Good**. Most project aspects support the objectives, goals, and approaches of the program.
- **2 – Fair**. Project partially supports the objectives, goals, and approaches of the program.
- **1 – Poor**. Project provides little support to the objectives, goals, and approaches of the program.

For the program evaluation, numerical scores were based on a four point scale, with the following qualitative descriptors given for the numerical scoring index:

- **4 – Outstanding**. All program objectives fully support industry needs.
- **3 – Good**. Most program objectives support industry needs.
- **2 – Fair**. Some program objectives support industry needs.
- **1 – Poor**. Very few program objectives support industry needs; objectives should be re-evaluated and revised.

Additionally, the evaluation forms were designed to capture reviewer input regarding the strengths and weaknesses for a specific project or the program as a whole.

The following templates represent the MHK and CH project evaluation forms, the Lower TRL project evaluation forms, and program evaluation forms.

2011 U.S. DOE Water Power Peer Review
MHK Project Evaluation Form

Project Name: ____________ **Reviewer:** ____________

Presenter Name: ____________ **Presenter Org:** ____________

Provide specific, concise comments to support your evaluation.

Relevance to overall DOE objectives – the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. Please see attached document for program objectives, goals and approaches. **(Stand Alone Metric)**

- 4 - **Outstanding.** Project is critical to supporting the objectives, goals, and approaches of the Program.
- 3 - **Good.** Most project aspects support the objectives, goals, and approaches of the Program.
- 2 - **Fair.** Project partially supports the objectives, goals, and approaches of the Program.
- 1 - **Poor.** Project provides little support to the objectives, goals, and approaches of the Program.

score

Comments

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1. Approach – the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. **(Weight = 30%)**

- 4 - **Outstanding.** Well designed and technically feasible; continue to move forward with this approach.
- 3 - **Good.** Generally effective.
- 2 - **Fair.** Has significant weaknesses; and requires significant improvement.
- 1 - **Poor.** Not effective to meet objectives; a new approach should be developed.

score

Comments

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2. Technical Accomplishments and Progress – degree to which the project has progressed compared to the latest project schedule and goals. **(Weight = 30%)**

4 - **Outstanding.** Excellent progress; little to no monitoring needed for project completion(once a month or

3 - **Good.** Significant progress made. The project needs regular monitoring (once a month depending on

2 - **Fair.** Modest progress made; regular project monitor needed (two times a month).

1 - **Poor.** Little or no demonstrated progress made. (Project needs to be monitored regularly - once a

score

Comments

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3. Research Integration, Collaboration, and Technology Transfer – with industry/universities/other laboratories – the degree to which the project interacts, interfaces, or coordinates with other institutions and projects, and the degree to which projects are disseminating the results of the R&D. **(Weight = 20%)**

4 - **Outstanding.** Close, appropriate coordination with other institutions; partners are full participants.

3 - **Good.** Some coordination exists; full/needed coordination could be accomplished easily.

2 - **Fair.** A little coordination exists; full/needed coordination would take significant effort.

1 - **Poor.** Most work is done at the sponsoring organization with little outside interaction.

score

Comments

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4. Proposed Future Research – the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and when sensible, mitigating risk by providing alternate development pathways. **(Weight = 20%)**

4 - **Outstanding.** Excellent progress toward objectives; suggests that barrier(s) 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 towards objectives or any barriers.

score

Comments

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Project Strengths

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Project Weaknesses

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Recommendations for Additions/Deletions to Project Scope

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Project Number: ______ **Reviewer**: ______

2011 U.S. DOE Water Power Peer Review
CH Project Evaluation Form

Project Name: ____________ **Reviewer:** ____________

Presenter Name: ____________ **Presenter Org:** ____________

Provide specific, concise comments to support your evaluation.

Relevance to overall DOE objectives – the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. Please see attached document for program objectives, goals and approaches. **(Stand Alone Metric)**

score

4 - **Outstanding.** Project is critical to supporting the objectives, goals, and approaches of the Program.
3 - **Good.** Most project aspects support the objectives, goals, and approaches of the Program.
2 - **Fair.** Project partially supports the objectives, goals, and approaches of the Program.
1 - **Poor.** Project provides little support to the objectives, goals, and approaches of the Program.

Comments

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1. Approach – the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. **(Weight = 30%)**

score

4 - **Outstanding.** Well designed and technically feasible; continue to move forward with this approach.
3 - **Good.** Generally effective.
2 - **Fair.** Has significant weaknesses; and requires significant improvement.
1 - **Poor.** Not effective to meet objectives; a new approach should be developed.

Comments

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2. Technical Accomplishments and Progress – degree to which the project has progressed compared to the latest project schedule and goals. **(Weight = 30%)**

4 - Outstanding. Excellent progress; little to no monitoring needed for project completion(once a month or less).

3 - Good. Significant progress made. The project needs regular monitoring (once a month depending on the project).

2 - Fair. Modest progress made; regular project monitor needed (two times a month).

1 - Poor. Little or no demonstrated progress made. (Project needs to be monitored regularly - once a week or more frequently; OR major course correction needed)

score

Comments

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3. Research Integration, Collaboration, and Technology Transfer – with industry/universities/other laboratories – the degree to which the project interacts, interfaces, or coordinates with other institutions and projects, and the degree to which projects are disseminating the results of the R&D. **(Weight = 20%)**

4 - Outstanding. Close, appropriate coordination with other institutions; partners are full participants.

3 - Good. Some coordination exists; full/needed coordination could be accomplished easily.

2 - Fair. A little coordination exists; full/needed coordination would take significant effort.

1 - Poor. Most work is done at the sponsoring organization with little outside interaction.

score

Comments

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4. Proposed Future Research – the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and when sensible, mitigating risk by providing alternate development pathways. **(Weight = 20%)**

4 - Outstanding. Excellent progress toward objectives; suggests that barrier(s) 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 towards objectives or any barriers.

score

Comments

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Project Strengths

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Project Weaknesses

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Recommendations for Additions/Deletions to Project Scope

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Project Number: **Reviewer:**

2011 U.S. DOE Water Power Peer Review
Lower TRL Project Evaluation Form

Project Name: ____________ **Reviewer:** ____________

Presenter Name: ____________ **Presenter Org:** ____________

Provide specific, concise comments to support your evaluation.

Relevance to overall DOE objectives – the degree to which the project supports the objectives, goals, and approaches of the Water Power Program. Please see attached document for program objectives, goals and approaches. **(Stand Alone Metric)**

score

4 - **Outstanding.** Project is critical to supporting the objectives, goals, and approaches of the Program.
3 - **Good.** Most project aspects support the objectives, goals, and approaches of the Program.
2 - **Fair.** Project partially supports the objectives, goals, and approaches of the Program.
1 - **Poor.** Project provides little support to the objectives, goals, and approaches of the Program.

Comments

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1. Approach – the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers. **(Weight = 80%)**

score

4 - **Outstanding.** Well designed and technically feasible; continue to move forward with this approach.
3 - **Good.** Generally effective.
2 - **Fair.** Has significant weaknesses; and requires significant improvement.
1 - **Poor.** Not effective to meet objectives; a new approach should be developed.

Comments

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2. Project Implementation – the degree to which the project has effectively and logically planned future work by incorporating appropriate decision points, considering barriers to the realization of the proposed research or technology, and when sensible, mitigating risk by providing alternate project management pathways. Also, the degree to which projects have achieved any notable accomplishments or encountered setbacks (for those projects which are underway and have completed a significant amount of work). **(Weight = 20%)**

4 - Outstanding. Excellent planning to achieve progress toward objectives (or excellent progress if significant work has been completed); suggests that any barrier(s) will be overcome.

3 - Good. Significant planning or demonstrated progress toward objectives and overcoming barriers.

2 - Fair. Modest evidence of project management planning or progress; possibly minor setbacks.

1 - Poor. Minimal project management planning or any significant progress towards objectives.

score

3.0

Comments

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Project Strengths

- Will allow MHK developers to secure devices in more ideal locations.
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Project Weaknesses

- Ideal for deep mooring; however, mooring near reefs/outcrops would involve consultation with NOAA and incur potential impacts with EFH.
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Recommendations for Additions/Deletions to Project Scope

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Project Number:

Reviewer:

2011 U.S. DOE Water Power Peer Review
Program Evaluation Form

Program: **U.S. DOE Water Power Program**

Presenter Name: ______________________ **Presenter Org:** **U.S. Department of Energy**

Provide specific, concise comments to support your evaluation.

1. Objectives - how well do Program objectives align with industry needs?

Objectives	• *Increase the total contribution of conventional hydropower plants to the renewable energy portfolio in the U.S.* • *Bring new hydropower technologies that have improved energy and environmental performance characteristics into commercial readiness* • *Reduce barriers to new development, such as regulatory risks and expense*

4 - Outstanding. All Program objectives fully support industry needs.
3 - Good. Most Program objectives support industry needs.
2 - Fair. Some Program objectives support industry needs.
1 - Poor. Very few Program objectives support industry needs; objectives should be re-evaluated and revised.

score

Comments

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2. Barriers - Has the Program identified the critical barriers to sustaining hydropower development and deployment?

Identified Barriers	**Issues with development incentives**	**Expensive and uncertain regulatory process**
	• *Not aligned with resource value and potential*	• *Time-consuming/costly permitting process and associated litigation*
	• *High capital costs and long payback periods*	• *Renewed licenses often reduce generation and operation flexibility*
	• *Lack of markets for grid services*	**Technology costs remain high in certain sectors**
	• *Competing water uses get priority*	• *Small hydropower and pumped storage technologies remain expensive*
	• *Limited policy support*	• *Limited deployment of innovative R&D*

4 - Outstanding. Program has correctly identified all of the critical barriers.
3 - Good. Program has identified most of the critical barriers.
2 - Fair. Program has identified some of the critical barriers.
1 - Poor. Program has not correctly identified the critical barriers; barriers should be re-evaluated and revised.

score

Comments

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3. Approaches - are current Program approaches appropriately and effectively designed and implemented in order to achieve objectives and overcome technical and non-technical barriers?	
Program Approaches	**Support immediately-available, low-cost upgrades and feasibility studies to identify additional opportunities** ● *Deployment support for immediate, lowest-cost opportunities (ARRA)* ● *Feasibility studies to identify and publicize additional low-cost, advanced-technology opportunities; targeted deployment support to catalyze private sector investment* ● *Develop operational tools to maximize generation at existing and new facilities*
	Identify resources and address technology/policy needs to maximize medium-long term opportunities ● *Integrate resource assessments and cost curves with key pumped storage and small hydro technology needs to identify critical COE drivers* ● *Market analysis to accurately quantify and monetize hydropower ancillary services*
	Engage regulators and environmental stakeholders to reduce license time and cost ● *Align energy generation and environmental priorities across river basins to facilitate development* ● *Generate data to more accurately correlate generation and water use with environmental impacts*

4 - Outstanding. Program has implemented appropriate and effective approaches.
3 - Good. Most of the approaches implemented by the Program are appropriate and effective.
2 - Fair. Some of the approaches implemented by the Program are appropriate and effective.
1 - Poor. Approaches are not appropriate or effective; Program should be re-evaluate and revise approaches.

score

Comments

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4. Projects - has the Program formed an effectively balanced portfolio of projects that will contribute to achieving its goals and objectives?

4 - Outstanding. Extremely effective and well-balanced portfolio of projects.
3 - Good. Generally effective and well-balanced portfolio of projects.
2 - Fair. Project portfolio has significant weaknesses and could be improved.
1 - Poor. Poorly balanced project portfolio; unlikely to contribute to achieving goals and objectives.

score

Comments

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5. Communication & Collaboration - degree and impact that Program interaction has on industry, universities, Federal agencies, as well as comparable international actors and other stakeholders.

- **4 - Outstanding.** Close, appropriate coordination with other institutions.
- **3 - Good.** Some coordination exists with other institutions.
- **2 - Fair.** A little coordination exists with other institutions.
- **1 - Poor.** Little to no outside interaction occurs with other institutions.

score

Comments

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Program Strengths

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Program Weaknesses

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Recommendations

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Appendix C. Results of Surveys Submitted by Attendees

Water Power Peer Review Meeting, November 1-3, 2011, Alexandria, VA

DOE Office of Energy Efficiency and Renewable Energy

Questionnaire for Evaluating the Peer Review Process

EERE is committed to continuous improvement in its peer review progress. This questionnaire to evaluate the peer review process is designed to produce post-review information that can be applied to improve the effectiveness of future reviews.

A. DEMOGRAPHIC QUESTIONS

A-1. What was your role in the review?

Peer Reviewer - 0

Presenter of a program activity or project under review (non-program office presenter) = 9
(Note: two of the respondents only completed Part B, instead of Parts B and D)

Presenter of a program activity or project under review (program office staff) = 0

Attendee, neither Reviewer nor Presenter = 5

A-2. What is your affiliation?

Government agency directly sponsoring the program under review = 3

National/government lab, private-sector or university researcher whose project is under review = 8

In an industry directly involved in the program under review = 2

In an industry with interest in the work under review = 1

Government agency with interest in the work = 0

National/government lab, private-sector or university researcher not being reviewed, interest in the work = 0

Other (please specify: e.g., consultant, retired employee, public, etc.) = 0

B. QUESTIONS B-1 THROUGH B-14 FOR ALL ATTENDEES

B-1 Purpose and scope of review were well defined.

1 = 0
2 = 0
3 = 4
4 = 4
5 = 5
NA = 1 (Comment: "Missed Intro")

B-2 The quality, breadth, and depth of the following were sufficient to contribute to a well-considered review:

1. Presentations

   1= 1
   2 = 1
   3 = 3
   4 = 5
   5 = 4

2. Question & Answer periods

   1= 0
   2 = 2
   3 = 3
   4 = 8
   5 = 1

3. Answers provided concerning programmatic questions

   1= 0
   2 = 2
   3 = 3
   4 = 7
   5 = 1
   ? = 1

4. Answers provided concerning technical questions

   1= 1
   2 = 1
   3 = 2
   4 = 8
   5 = 2

B-3 Enough time was allocated for presentations.

1= 1
2 = 4 (Note: 1 respondent who chose #2 commented: "Time was much too short to fully describe the work that was being accomplished")
3 = 1
4 = 6
5 = 2

B-4 Time allowed for the Question & Answer period following the presentations was adequate for a
rigorous exchange.

1= 0
2 = 5 (Note: 1 respondent who chose #2 commented: "Same as above – no dialog was possible")
3 = 3
4 = 5
5 = 1

B-5 The questions asked by reviewers were sufficiently rigorous and detailed.

1= 0
2 = 1
3 = 7 (Note: 1 respondent who chose #3 commented: "The reviewers dug into as many issues as they could given the short time available.")
4 = 5
5 = 1

B-6 What questions should have been asked, but were not?

1. Plenty of technical questions were asked, but there didn't seem to be many programmatic questions.
2. How do you ensure industry participation?
3. Has industry benefitted from your work? If yes, how?
4. Solicit comments regarding DOE target of 0.06$/kwh by 2030 with Maine Renewables.
5. I'm not sure it's really possible, but questions were about details not germaine to the primary goals of whether the project is worthwhile to MHK.
6. For the lower TRL projects, some fundamental practicality questions could have been asked to clarify points made in presentations.
7. How PIs will use/incorporate or learn from other projects in DOE's water portfolio to inform either their own project's deliverables or planning of future work.
8. There was little time, in some cases none, to really present results or communicate the technical implications. The larger impact projects being supported, particularly the device development and deployment projects being done by industry deserve a much more complete review in private so that sensitive issues can be discussed and addressed. It is unclear that any critical issue would, or should, be discussed in this type of open forum.

B-7 There were no problems with:

1. Classification of projects (project groupings)

   1= 0
   2 = 0
   3 = 3
   4 = 5
   5 = 6

2. Quality/Level of the information presented

   1= 0
   2 = 1
   3 = 3
   4 = 6
   5 = 4

3. Proprietary data

   1= 0
   2 = 3
   3 = 1
   4 = 3
   5 = 2
   NA = 2
   No Answer = 1
   Comment = 1: "None Presented"
   Comment = 1: One respondent chose #1-5 and commented, "None was given that I could see;" and then commented, "Interestingly, Dehlsen Associates provided the most information."

B-8 The frequency *(insert the planned frequency of review – e.g., annual, biennial, etc.)* of this kind of formal review process for this program/subprogram is:

About right = 11 (of the 11 responses, 2 people chose "Annual")

Too frequent = 1

Not frequent enough = 0

No Answer = 1
Comment: "Never to yearly to biennial; should depend on the project funding level and importance to the program success! As well as problems/challenges being encountered."

B-9 The review was conducted smoothly.

1= 0
2 = 0
3 = 0
4 = 6

5 = 8

B-10 What was the most useful part of the review process?

1. Consistent format of the presentations.
2. Presentations.
3. Copies of presentations (assuming they will be available upon completion of meeting by November 4).
4. Getting everyone together.
5. Understanding the scope of technologies. Becoming familiar with technology.
6. Ability to obtain an overview of all projects funded by DOE from the PIs.
7. It's a very informative way to quickly understand what the program is up to.
8. Seeing full portfolio of research projects.
9. The Q&A.
10. Finding out the current status of projects.
11. Getting a broad overview of all the projects so that it shows the breadth and depth of activities. Now it is possible to figure out who is doing what and give them a call for further information.
12. Presentations.

B-11 What could have been done better?

1. Reiterate process for submitting questions if time does not allow taking questions from the audience.
2. More rigorous questions and more time for frank discussion. Nobody wants to "rock the boat" and the boat will benefit from rocking.
3. The venue <u>MUST</u> be on the Metro. For out-of-town participants, this location is ridiculous.
4. Add a few open forum periods where presenters can talk about what is not working well on the DOE MHK grant programs.
5. Call-in format not great – folks should be here in person.
6. The problem with any program of this size is that time/project is quite limited in order to fit the review in a manageable time window. Improving exchange with reviewers in the time allowed would be beneficial.
7. There was too much content on the slides for presentation. Some of the content should be placed in a narrative to be submitted with the slides.
8. 10-minute presentations seems just a bit too short to get to the appropriate level of detail. Also, most presentation slides from presenters were very word-heavy and could have been much more clear and readable.
9. I would suggest that this style of review only be used for university and other projects that are intended to be put in the public domain and increase the time allotted according to funding level and importance. Industry projects with IP and sensitive results need to be done on a case-by-case basis.

B-12 Overall, how satisfied are you with the review process?

1= 0
2 = 0
3 = 2 (Note 1 respondent's comments: "Given the time constraints.")
4 = 11

5 = 1

B-13 Would you recommend this review process to others and should it be applied to similar DOE programs?

Yes = 11
No = 2
No Answer = 1 (Included this comment: “Can’t comment on B-13 until I receive reviewer comments.”)

B-14 Please provide comments and recommendations on the overall review process.

1. The number of people needed to make this run smoothly was good (person in charge of presenters, timer, etc.). The frequent breaks were helpful in staying on track (timewise) and focused for the listeners and reviewers. Wireless was available in the MHK (C Room); it was not available in the CH (Walnut) room
2. See B-11 (response #2). Good effort by DOE but could really benefit from more constructive critique.
3. Time allowed for presentation was inadequate for technical discussion. However, it does allow the reviewers to personally see the PIs.
4. The ppt outline could be improved. Suggest an online milestone tracking tool to provide continuity from program launch. Link this review process to the quarterly review process. *This survey Section D, the ppt format, and the reviewer score sheet are not totally aligned. For example, on the survey, Management is a category, but that is not an explicit category on the scoring sheet.
5. Will there be feedback available on PIs?
6. While the opportunity for all projects to hear about all other projects, closed-session reviews might allow reviewers to ask harder questions.
7. Having separate review panels for different categories of projects within TD/MA structure might (1) allow for longer presentations, (2) ensure reviewer expertise aligns with projects, and (3) avoid burn-out for a small panel being “subjected” to all projects.
8. Giving the reviewers an opportunity to communicate big questions to participants ahead of the review (based on the narratives) could help to ensure that participants address reviewer concerns in their presentations.
9. This is a good review of funded projects, but there wasn’t a place for reviewers to comment on what’s <u>not</u> being funded but should be.
10. This review process is important to both the researchers and the program. It needs to be done to provide direct feedback that helps the participants as well as the program. It is an important tool for managing the research and a significant effort is required.

C. QUESTIONS C-1 THROUGH C-12 FOR PEER REVIEWERS ONLY

NOTE: No feedback was received for Section C

C-1 Information about the program/subprogram/projects under review was provided sufficiently prior to the review session.

C-2 Review instructions were provided in a timely manner.

C-3 The information provided in the presentations was adequate for a meaningful review of the projects.

C-4 The evaluation criteria upon which the review was organized were clearly defined and used appropriately.

1. Quality, Productivity, Accomplishments
2. Relevance
3. Management
4. Other:
5. Other:

C-5 Explanation of the questions within the criteria was clear and sufficient.

1. Quality, Productivity, Accomplishments
2. Relevance
3. Management
4. Other:
5. Other:

C-6 The right criteria were used to evaluate the project(s)/program.

1. Quality, Productivity, Accomplishments
2. Relevance
3. Management
4. Other:
5. Other:

C-7 During the review process, reviewers had adequate access to principle investigators, research staff, or requested sources of additional data.

C-8 The number of projects I was expected to review was:

Too many
Too few
About right

C-9 The reviewers in my session had the proper mix and depth of credentials for the purpose of the review.

C-10 There were no problems with the numerical rating schemes used.

C-11 Altogether, the preparatory materials, presentations, and the Question & Answer period provided sufficient depth of review.

C-12 When considering the final reporting of recommendations:

1. Process for developing final reporting was appropriate.
2. Enough time was allocated for reviewers to deliberate before recording review comments.

D. QUESTIONS D-1 THROUGH D-9 FOR PRESENTERS ONLY

D-1 The request to provide a presentation for the review was made sufficiently prior to the deadline for submission.

1= 0
2 = 1
3 = 0
4 = 3
5 = 3

D-2 Instructions for preparing the presentation were sufficient.

1= 0
2 = 0
3 = 2
4 = 2
5 = 3

D-3 The evaluation criteria upon which the review was organized were clearly defined and used appropriately.

Note: 1 respondent made no choice for D-3, #1-3, but made the following comment: "Perhaps I missed communication on this, but the review evaluation criteria is not something I am familiar with."

1. Quality, Productivity, Accomplishments

   1= 0
   2 = 0
   3 = 0
   4 = 4
   5 = 2

2. Relevance

1= 0
2 = 0
3 = 0
4 = 4
5 = 2

3. Management

   1= 0
   2 = 0
   3 = 1
   4 = 3
   5 = 2

4. Other: None

5. Other: None

D-4 Explanation of the questions within the criteria was clear and sufficient.

Note: 1 respondent made no choice for D-4, #1-3, but made the following comment: "See comment on D-3."

1. Quality, Productivity, Accomplishments

   1= 0
   2 = 0
   3 = 0
   4 = 3
   5 = 3

2. Relevance

   1= 0
   2 = 0
   3 = 0
   4 = 3
   5 = 3

3. Management

   1= 0
   2 = 0
   3 = 1
   4 = 3
   5 = 2

4. Other: None

5. Other: None

D-5 The right criteria were used to evaluate the project(s)/program.

Note: 1 respondent made no choice for D-5, #1-3, but made the following comment: "See comment on D-3."

1. Quality, Productivity, Accomplishments

   1= 0
   2 = 0
   3 = 0
   4 = 3
   5 = 3

2. Relevance

   1= 0
   2 = 0
   3 = 0
   4 = 3
   5 = 3

3. Management

   1= 0
   2 = 0
   3 = 1
   4 = 3
   5 = 2

4. Other: None

5. Other: None

D-6 During the review process, reviewers had adequate access to principle investigators, research staff, or requested sources of additional data.

1= 0
2 = 0
3 = 2
4 = 2
5 = 2
NA = 1 (Comment: "No contacts")

D-7 The reviewers in my session had the proper mix and depth of credentials for the purpose of the review.

1= 0
2 = 0
3 = 0
4 = 1
5 = 4
Don't Know Their Credentials = 2

D-8 There were no problems with the numerical rating schemes used.

1= 0
2 = 0
3 = 1
4 = 0
5 = 0
NA = 4 (One comment: "Don't know.")
No Answer = 2

D-9 Altogether, the preparatory materials, presentations, and the Question & Answer period provided sufficient depth of review.

1= 0
2 = 2
3 = 2
4 = 2
5 = 1

Comment: "Could have provided more time for lower TRL projects. However, there will be winners."

Comment: "More Q&A (including offline Q&A might be helpful)."

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