Argonne NATIONAL LABORATORY

Advanced Powertrain Research Facility Vehicle Test Cell Thermal Upgrade

2010 DOE Hydrogen Program and Vehicle Technologies Merit Review
Washington, DC June 9, 2010

Glenn Keller
Argonne National Laboratory
Vehicle Systems Testing and Analysis

Sponsored by Lee Slezak
DOE/EERE Vehicle Technologies Program

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Project ID: VSS030

OVERVIEW

Upgrade the Advanced Powertrain Research Facility to comply with EPA 5-cycle test requiring an expanded temperature range of 20-95 °F with solar load

Timeline

Start - February 2010

Est. Comp. - April 2011

10% complete

Barriers

Evaluate performance targets in a systems context inclusive of thermal conditions, e.g.; batteries, motors, drivetrain

Budget

Total project funding

DOE - $5M

Partners

ANL Lead

AEI/Flad/Jacobs design

General Contractor – TBD

June 2010

Relevance

Addition of cold and hot temperature vehicle systems test capability will address these Key Strategic Goals:

- Validate, *in a systems context*, performance targets for battery packs, drivetrain components, control strategies and accessory loads.
- Quantify with precision the cold and hot environmental impacts on energy consumption and operation of PHEVs and EVs.
- Verify the fuel consumption during air conditioning and defrost/heater operation.
- Benchmark and evaluate component and vehicle system efficiencies at temperature.
- Generate cold and hot operational characteristics and data to be integrated into the Modeling and Simulation tool, AUTONOMIE.
- Expand the laboratory and field evaluations of advanced vehicle demonstration fleets.
- Evaluate and promote the market readiness of grid-connected vehicle technologies by 2015.

Objective – Testing and Facility Requirements

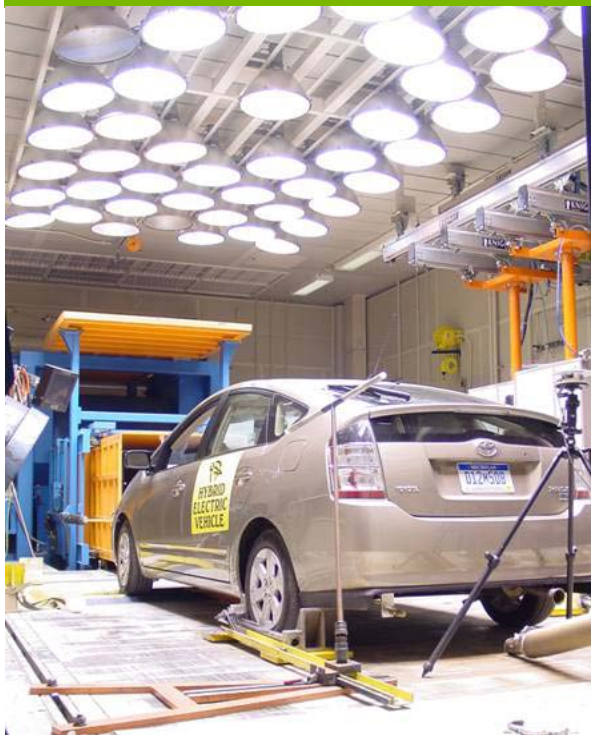
- ANL designated lead DOE laboratory for vehicle systems research utilizing a chassis dynamometer in the APRF.
  - Existing test cell conditions are limited to ambient and hot temp. testing.
  - This construction project will enable compliance with the EPA 5-cycle certification test procedure by modifying the test cell to obtain emissions and fuel consumption measurements at temperatures of 20 °F and 95 °F with solar loading.
- DOE $5M capital and equipment funds will yield:
  - Addition of HVAC refrigeration skid for +20 °F control
  - Enhanced humidity control - desiccant dehumidifier skid
  - Insulated test cell walls, doors and windows
  - Installation of a solar array to reproduce the sun's radiation load
  - Utilization of a precision vehicle speed-coupled blower
  - Modification of building structure for mezzanine-level location of new mechanical equipment & supporting electrical infrastructure

Objective - Enable Validation of Performance Targets and Benchmark

- Study hot and cold effects on powertrain and their influence on vehicle-level control:
  - Battery pack systems performance
  - Thermal management investigations
  - Powertrain component and system efficiencies
- Investigate accessory use and power consumption with impact for EV or PHEV energy consumption or range.
  - A/C systems performance (incl. passenger comfort)
  - Defroster and cabin heater systems
  - Ancillary power loads for vehicle features
- Evaluate vehicle-level control solutions to mitigate temperature-related impacts on energy consumption.

Major EPA Test Specifications:

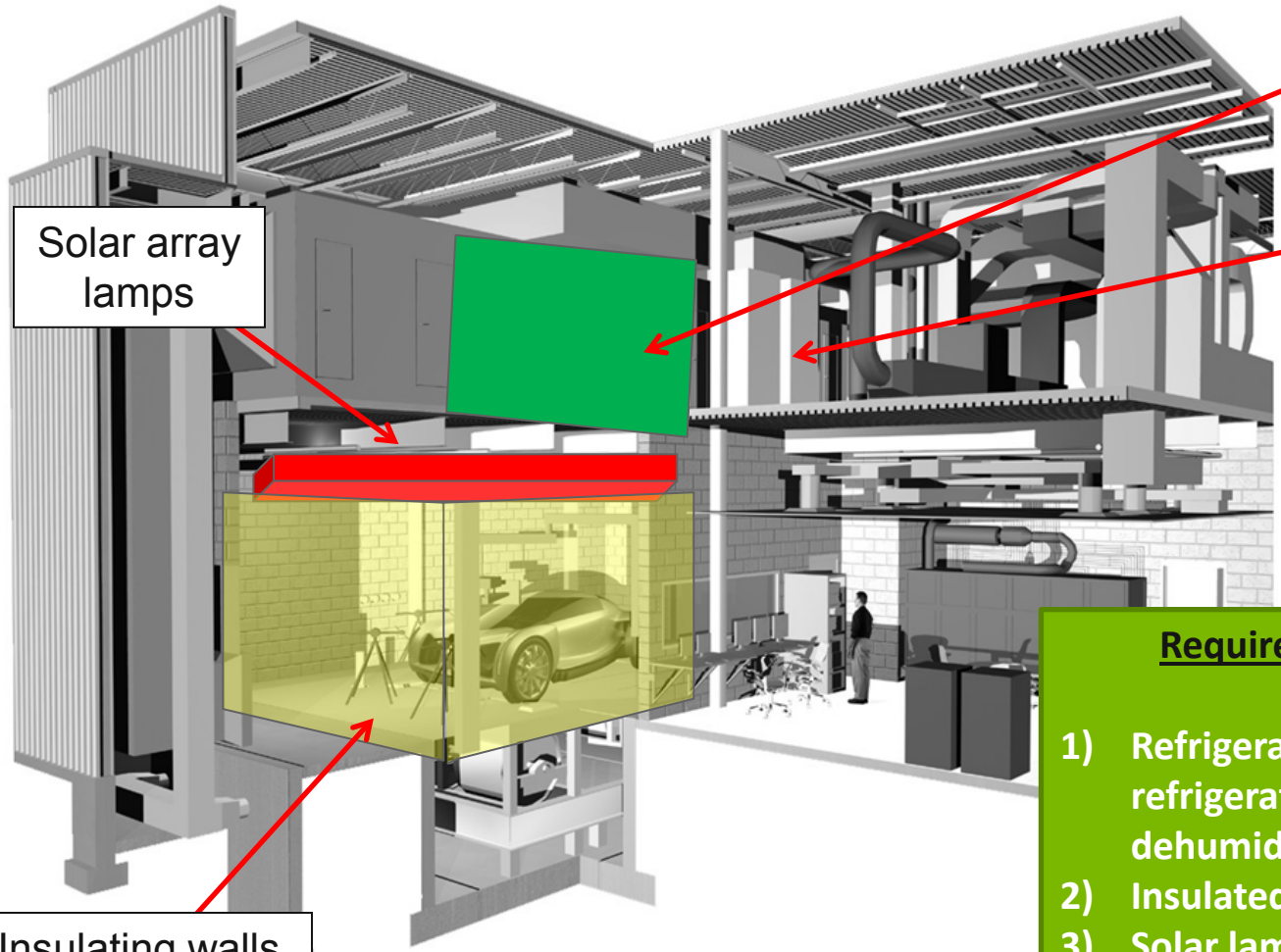
- +20 °F (Cold CO test)
- +95 °F (Hot SC03 test)
- Solar Load (Hot SC03 test)
- Proportional Air Flow Control (Hot SC03 test)



Approach

- Design objective based on compliance to EPA 5-cycle testing protocol for light duty vehicle testing:
  - Energy consumption measurement during Cold CO test conditions and Hot SC03 test with solar load, maximum A/C operation and vehicle speed-matched air flow
- Design to utilize existing test cell configuration and dimensions to reduce cost and downtime
  - Utilize 2wd chassis dynamometer facility during construction
- Mechanical upgrades will utilize a modular design approach to accomplish performance criteria
- Retained original mechanical design firm and architects – Affiliated Engineers Inc. and Flad Architects for design continuity
- Retained Jacobs Engineering for design oversight

Approach for Vehicle Test Facility Thermal Upgrade



Vacant location for chiller coil upgrade

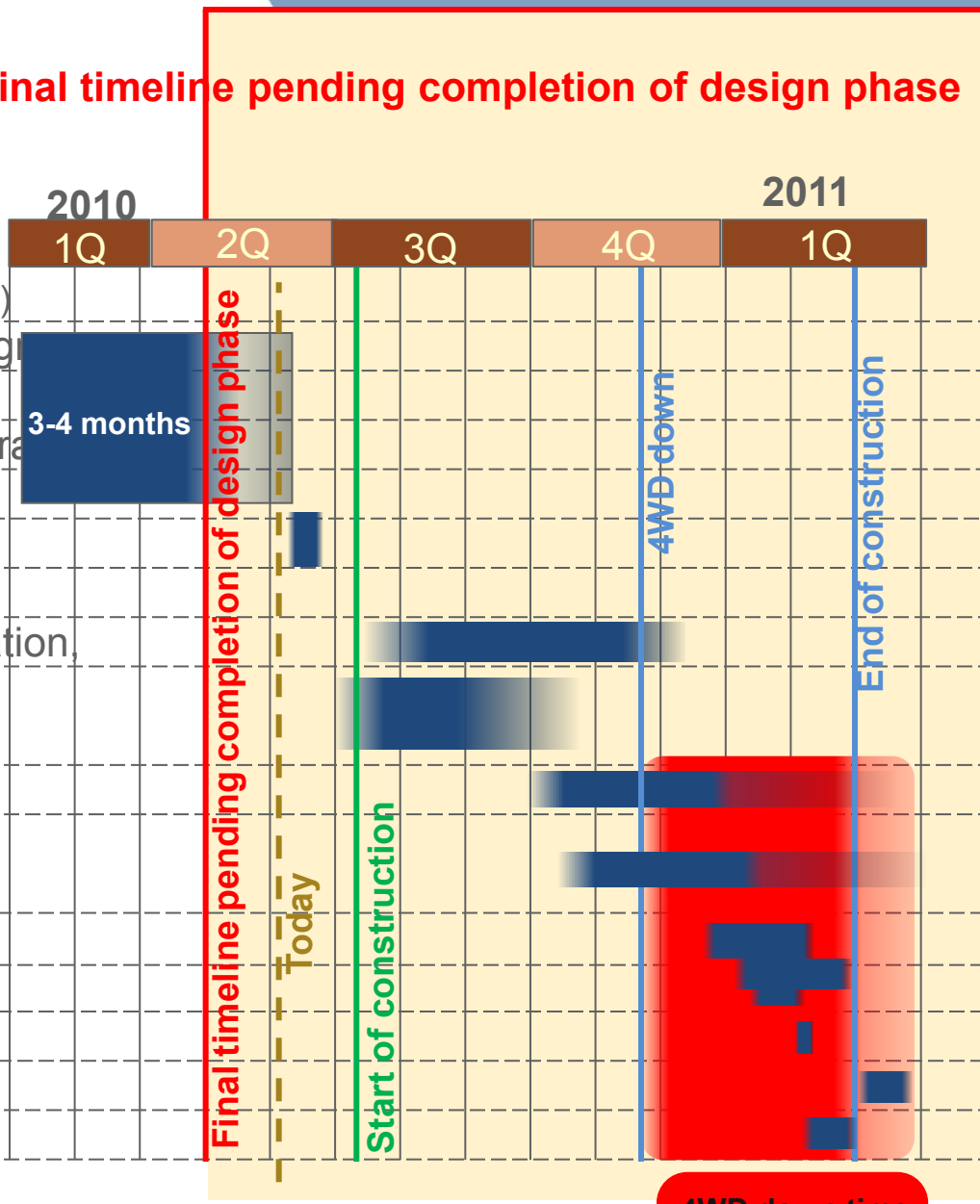
Larger HVAC refrigeration unit & humidity control

Required Test Cell Upgrades

1) **Refrigeration coils in HVAC unit , refrigeration & desiccant dehumidifier skids in mezzanine**
2) **Insulated – walls, doors, ceiling**
3) **Solar lamp array**
4) **Proportional Air Flow Control**

Accomplishments -- Construction Milestones

1. Design contract approval (AEI/Flad & Jacobs)
2. Prepare mechanical and architectural desig
   - Mechanical & electrical systems
   - Equipment bay expansion and structura
   - Airflow controls design consulting
3. General Contractor RFP solicitation
4. Material and equipment purchase
5. Begin outdoor construction: install foundation, concrete, steel, etc.
6. Test cell upgrade
   - Install refrigeration mechanicals and air flow ducting
   - Install Solar array
   - Install electrical and controls
   - System and operation verification
   - Instrumentation check for hot & cold
7. Commission test cell



4WD down time
All vehicle testing will be done on the 2WD dyno

Accomplishments -- Project Status to Date

2/5/2010	Contract Approved to AEI/Flad and to Jacobs Engineering
2/11/2010	Benchmark of GM and Chrysler facilities by ANL/AEI
3/11/2010	Design kick-off meeting ANL/AEI/Flad and Jacobs
3/15/2010	Receipt of DOE funding directive
3/18/2010	Vendor visit for blower dimension discussion
4/1/2010	Second design review meeting with AEI/Flad
May 2010	Delivery of final facility design package from contractor
June 2010	RFP from ANL distributed
June 2010	General Contractor selected

Collaboration Plans with Other Labs

- The thermal upgrade to the 4WD vehicle test facility will generate additional data to support systems performance evaluations at Argonne for the AVTA program in our partnership with Idaho National Lab
  - ANL's upgraded capabilities constitute the only DOE test facility that can benchmark the performance of advanced technologies at a component, system and vehicle level for controlled cold and hot temperatures.
  - The additional systems performance validation provided will enhance DOE's AVTA program
- Other opportunities for collaboration:
  - Evaluate battery pack and associated systems for EDAB project with INL
  - Perform accessory load energy consumption impact studies with NREL
  - Assist in engine control and emission strategy research with ORNL

Proposed Future Activities

- This facility will serve as a systems-based test bed for benchmarking the performance of vehicle battery packs, driveline components, control strategies and accessory load under a range of temperature conditions and duty cycles.
- This facility will contribute to Argonne's ongoing benchmarking and validation of energy consumption and emissions performance from advanced technologies.
- The enhanced capabilities of this test facility will serve to provide data and operational characteristics which will allow implementation of additional features into AUTONOMIE for cold and hot ambient conditions.

Summary

This project to upgrade Argonne's 4WD vehicle test cell temperature range from cold (20 °F) to hot (95 °F) will be a significant capability expansion for the DOE's Vehicle Simulation and Testing Program.

This new capability will serve to:

- **Evaluate, *in a systems context*, performance targets for battery packs, drivetrain components, control strategies and accessory loads**
- **Obtain measurements of the cold/hot environmental impacts on energy consumption and operation of PHEVs and EVs**
- **Design efforts began in February 2010 with projected completion in April 2011 at a budgeted cost of $5M**