ADVANCED VEHICLE TESTING & EVALUATION

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2017 DOE Hydrogen and Fuel Cells Program and Vehicle Technologies Office Annual Merit Review and Peer Evaluation Meeting

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GI029

OVERVIEW

TIMELINE

Project Start: October 1, 2011
Project End: September 30, 2018
Percent Complete: 58%

BARRIERS

Cost of Obtaining Vehicle Data
Fueling **Infrastructure**

BUDGET: 80/20

Total Project: $ 33,088,218
DOE Share: $ 26,400,000
Cost Share: $ 6,688,218
FY16 Funding: $ 2,500,000
FY17 Anticipated
Funding: $ 1,525,000

PARTNERS

Idaho National Laboratory
Argonne National Laboratory
National Energy Technology Laboratory
EZ Messenger

Relevance

OBJECTIVES

- Test and evaluate advanced vehicle technologies intended to advance vehicle efficiency and reduce the consumption of petroleum
- Report on vehicle and infrastructure testing & analysis in cooperation with INL for inclusion on the AVTA website
- Provide benchmark data and performance trends for advanced technology vehicles and their fueling infrastructure
- Provide vehicle operation, lifecycle fuel economy, and maintenance cost data for advanced technology vehicles placed in fleets for the INL vehicle database
- Provide advanced technology vehicle component testing performance through the lifecycle of the vehicle

Relevance

MILESTONES

- Vehicle testing completion and report generation are milestones for AVTE
  - Data generation on all vehicles are stored in the INL vehicle database
- FY 2016 Vehicle Testing and Reports
  - 8 baseline testing reports generated
  - Component testing completed on 42 vehicles
  - 1 Hz data capture of CAN signals on 83 vehicles as of Sept. 30, 2016
- FY 2017 Vehicle Testing and Reports
  - 2 baseline testing reports generated
  - Component testing completed on 28 vehicles as of March 31, 2017
  - 1 Hz data capture of CAN signals on 69 vehicles as of March 31, 2017
- Over 9.1 million miles recorded during fleet testing from start of AVTE as of March 31, 2017
- Quarterly and annual reports summarizing overall vehicle testing progress to date

Approach/Strategy

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PROCEDURE/DOCUMENTATION DEVELOPMENT

- Vehicle technology specifications define key vehicle and performance parameters identified for analysis and monitoring
- Each vehicle is different, creating new challenges to obtain monitored parameters during vehicle testing
- The advanced technology component of interest is determined between DOE, INL, ANL, and Intertek, and then procedures are created to obtain baseline performance of that component, typically energy storage systems
- Energy storage system test procedures are updated to reflect USABC methods with technical agreement from INL
- Interim Component Durability test procedures continue after baseline component testing through End-of-Test for a total of five component tests over the life of the vehicle showing trends for component performance

Approach/Strategy

FLEET TESTING

- High-impact light-duty vehicles are selected by a joint group of DOE, INL, ANL, and Intertek for acquisition or loan from another group
- Production vehicles are allocated to fleets for three years and a minimum of 36,000 miles for BEVs, 160,000 miles for PHEVs, and 195,000 miles for HEVs/ICE vehicles
- Loaned vehicles are placed into an accelerated reliability schedule with set routes and drivers depending on the available timeframe
- Each vehicle is equipped with an on-board data logger with automatic data uploading via Wi-Fi at base fleet locations
  - Monitor and record vehicle CAN messages at a 1 Hz rate, including energy storage system parameters
  - Additionally record 12 V accessory loads on vehicles without high voltage energy storage systems
- Vehicle location matched to fleet availability to obtain mileage targets along with climate diversity
  - 2012 Honda Civic CNGs in Oklahoma and 2014 Chevrolet Cruze Turbo Diesels in Texas
  - Availability of EVSE units for charging limits fleet locations for BEVs and PHEVs to Phoenix

Approach/Strategy

FLEET TESTING

- Fleets record fuel, charging, and maintenance history for each vehicle
  - Data is provided to Intertek for review, providing a full history on each vehicle in test
  - The rapid mileage accumulation of the fleet gives insight into common maintenance issues that would not have been identified in a consumer fleet at 15,000 miles/year
    - Fleet testing has revealed four early failures of battery packs across multiple models
    - Three of the same make & model BEV test vehicles exhibited reduced range from fast charging at higher ambient temperatures as they approached 24,000 miles
- Interim Component Durability testing occurs three times between baseline and end-of-life testing, resulting in five total component tests
  - Battery capacity and performance testing for BEVs, PHEVs, and HEVs
  - Compression testing for CNG-fueled vehicles
  - Fast charging at various temperatures for BEVs with DCFC capability

Approach/Strategy

BASELINE TESTING

- Baseline vehicle performance is conducted on vehicles after they have obtained 4,000 break-in miles during fleet testing
- The following vehicle tests are conducted at the base curb weight plus 332 lb distributed in a similar front/rear loading on one vehicle of each make and model:
  - Acceleration
  - Maximum speed at one mile
  - Braking
  - Deceleration in drive in multiple regen modes
  - Charge-depleting electric range (where applicable)
  - Vehicle coastdown testing to obtain coastdown coefficients for fuel economy testing at the ANL APRF

- End-of-Test performance testing is conducted on one vehicle for comparison to baseline track testing

Technical Accomplishments

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FY 2016-2017 VEHICLE BASELINE TESTING

- Vehicle testing includes component, proving ground, and/or ANL APRF fuel economy testing on these vehicles over the past year:
  - 2012 Honda Civic CNG
  - 2012 Mitsubishi i-MiEV
  - 2013 Chevrolet Malibu Hybrid
  - 2013 Chevrolet Volt
  - 2013 Ford C-MAX Energi
  - 2013 Ford Focus EV
  - 2013 Ford Fusion Energi
  - 2013 Honda Civic Hybrid
  - 2013 Nissan Leaf
  - 2013 Toyota Prius PHEV
  - 2014 BMW i3 EV
  - 2014 BMW i3 EV with Range Extender
  - 2014 Mazda Mazda3 i-ELOOP
  - 2014 smart fortwo ED
  - 2015 Chevrolet Impala CNG Bi-Fuel
  - 2015 Chevrolet Spark EV
  - 2015 Honda Accord Hybrid
  - 2015 Kia Soul EV
  - 2015 Mercedes B-Class Electric
  - 2015 Volkswagen e-Golf
  - 2016 Chevrolet Volt

Technical Accomplishments

FY2016-2017 DC FAST CHARGING AT TEMPERATURE

- Assessments of DCFC charge time and performance were conducted on capable vehicles at 0, 25, and 50 °C utilizing a vehicle temperature chamber three times over the vehicle life
- Vehicles tested include:
  - 2012 Mitsubishi i-MiEV
  - 2013 Nissan Leaf
  - 2014 BMW i3
  - 2015 Chevrolet Spark EV
  - 2015 Volkswagen e-Golf
  - 2015 Kia Soul EV

Technical Accomplishments

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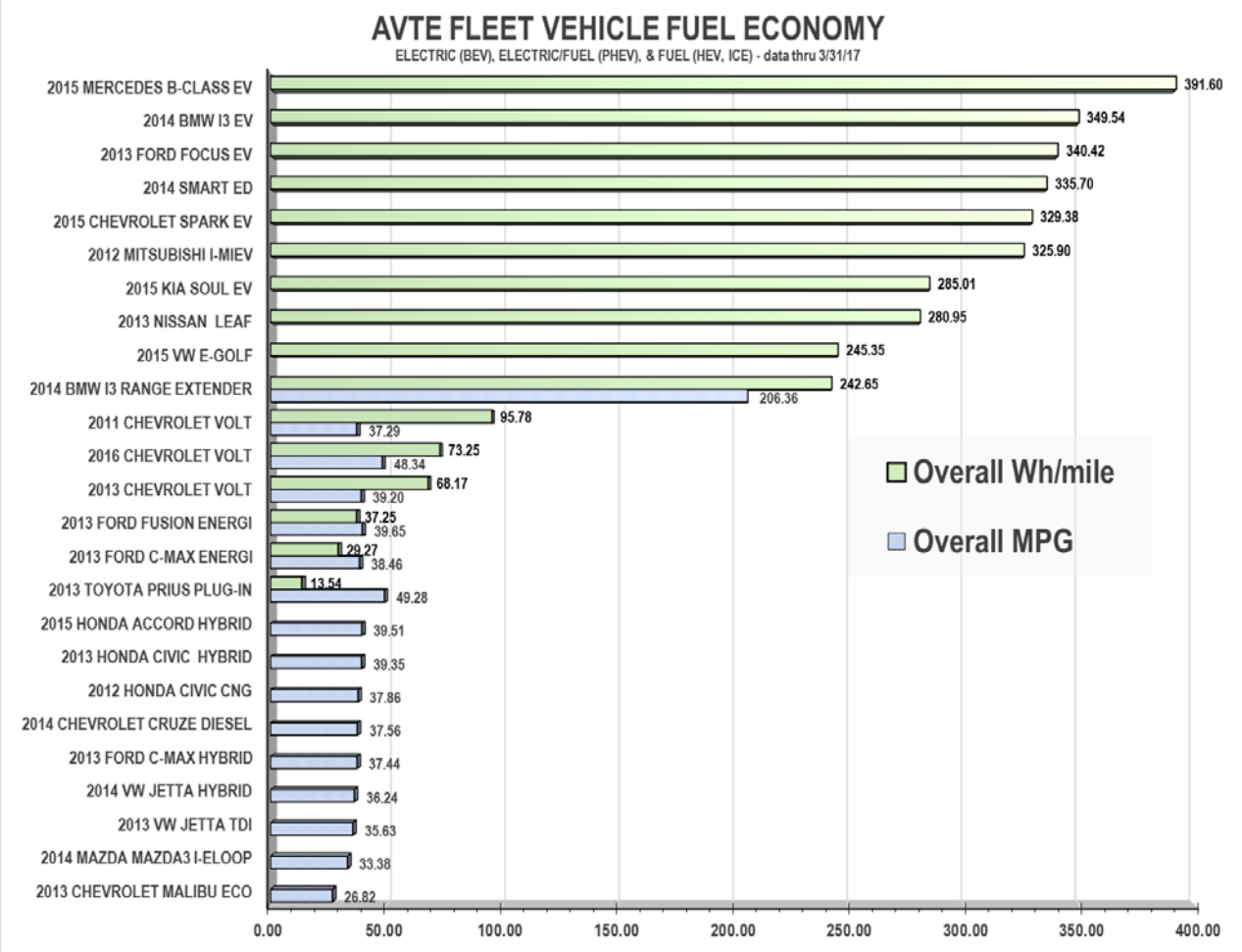
FY 2016-2017 FLEET TEST VEHICLES

- Overall fuel economy for vehicles in fleet use with accelerated mileage targets through March 2017
- Note that PHEVs have both MPG and Wh/mile combined



Collaboration

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NATIONAL LABORATORIES

- DOE Idaho National Laboratory
  - Procedure development and refinement
  - Data analysis and warehousing of vehicle data
  - Reporting and publishing of collated vehicle data
  - Overall technical direction for AVTE
- DOE Argonne National Laboratory
  - Fuel economy testing via the Advanced Powertrain Research Facility utilized in baseline testing reports
  - Continuous improvement in data monitoring of vehicles
  - Interoperability standards and test development

Collaboration

INDUSTRY PARTNERS

- EZ Messenger
  - Document delivery company co-located in Phoenix with multiple fleet locations throughout the United States
  - 24 Level 2 EVSE units on site
  - DCFC with CHAdeMO
  - DCFC with 12 kWh of onboard energy storage, CHAdeMO, and SAE Combo connectors

REMAINING CHALLENGES AND BARRIERS

- **Cost** of Obtaining Vehicle Data
  - Vehicle purchases to obtain advanced technology vehicles limits testing to a few readily-available, high-impact technologies
  - OEM collaboration with donor vehicles could broaden the exposure to petroleum reduction technologies for stakeholders and partners
- Fueling **Infrastructure**
  - Advanced technology vehicles often have inherent limitations in their fueling infrastructure which leads to slow adoption of the technology
    - CHAdeMO and SAE Combo Connector public fast charging locations are steadily increasing for BEVs
    - Vehicles charging with Level 2 EVSE at fleet location are rotated through available units, which are limited due to site power availability
    - CNG fueling stations and onboard vehicle tank size limit usable range of these vehicles

FUTURE WORK

- Transitioning AVTE to Electric Drive, Grid, and Charging R&D
  - High Power Fast Charging (100-350 kW)
    - Investigate future high power fast charging vehicles as they become available, such as the Hyundai Ioniq, and future production and prototype vehicles from OEMs
    - Study thermal cooling required for battery packs, the onboard charger, and power electronics utilizing temperature chamber and Phoenix summer conditions
  - Storage Assisted Recharging of Vehicles (StAR)
    - Conduct further testing with AVTE vehicle fleet studying grid impacts, charging profiles and demand charge savings models
  - Wireless Charging under SAE J2954 standard
    - Intertek can conduct interoperability between OEMs and wireless EVSE manufacturers
  - Accessory Loads on Grid
    - Characterize vehicle accessory loads on the grid due to vehicle battery and cabin pre-conditioning utilizing real-world fleet and vehicle temperature chamber environments
  - Vehicle-to-Grid (V2G)
    - Simulate impact of increased battery cycles from V2G operation
  - Note that any proposed future work is subject to change based on funding levels

2016 AMR Response to Reviewer Comments

- *The reviewer thought that the approach is good. However, questioned if the technical barrier is really "risk aversion from OEMs." The main barrier the reviewer saw was public resistance/reluctance to buying advanced technology vehicles. This is where the program has value, by demonstrating long-term benefits of these vehicles*
  - This technical barrier was removed due to not yet having an opportunity to obtain vehicles from OEMs, but it is planned in the future to be able to continue to offer a diverse set of advanced vehicle technologies that can be demonstrated in real-world use while documenting their performance and durability. From our research into vehicle and component issues discovered during testing, the public does follow the progress of the advanced vehicle testing activities when it is concerning their vehicle of interest. Overall, the main intention of the project is to benefit DOE stakeholders and provide robust data to assist in the simulation of future technologies.
- *The reviewer found that the project was generally excellent, but possible reliance on future participation by OEMs seems questionable. OEMs would need to be convinced of more specific benefits. Also, the study loses some aura of independence if OEMs are providing vehicles.*
  - OEM participation in the project in the future may become a collaborative effort, where there is mutual benefit to the OEM and the DOE for participation of a vehicle and/or component in the project. The project has been performed independently to date, which allows the DOE to set the timelines and data required from each vehicle. In the future, as OEMs are incorporated, the process for testing will be shortenend and modified to suit both participants. The advanced vehicle technologies of an OEM could be demonstrated through this project to show the benefits to a wider audience and enhance future collaboration projects.

SUMMARY

- As of March 2017, 105 vehicles representing 27 models have been placed in test fleets employing five different advanced technologies and various implementation strategies to reduce petroleum consumption in multiple locations in the U.S.
- Over 9.1 million vehicle miles recorded during AVTE fleet testing to date
- Completed DC fast charging at temperature testing on all capable vehicles in fleet test
- Continue to generate test results and reports posted to the INL AVTA website
- Transitioning utilization of AVTE vehicles to benefit research in Electric Drive, Grid, and Charging R&D focus areas

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