ADVANCED VEHICLE TESTING & EVALUATION

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OVERVIEW

TIMELINE

Project Start: October 1, 2011
Project End: September 30, 2018
Percent Complete: 55%

BARRIERS

Risk Aversion from OEMs
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
FY15 Funding: $ 4,180,120
FY16 Funding: $ 2,500,000

PARTNERS

Idaho National Laboratory
Argonne National Laboratory
National Renewable Energy Laboratory
National Energy Technology Laboratory
EZ Messenger
Specialized Delivery Services

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 and report generation are milestones for AVTE
- Data generation on all vehicles for storage in the INL vehicle database
- FY 2015 Vehicle Testing and Reports
  - 8 baseline performance testing reports generated
  - Component testing on 78 vehicles
  - 1 Hz data capture of CAN signals on 93 vehicles
- FY 2016 Vehicle Testing and Reports
  - 5 baseline testing reports generated and 2 planned
  - Component testing on 20 vehicles with 60 planned
  - 1 Hz data capture of CAN signals on 95 vehicles as of March 2016
- Over 6.8 million miles recorded during fleet testing as of February 2016
- Quarterly and annual reports summarizing overall vehicle testing

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 is determined and then procedures are created to obtain baseline performance of that component, which are typically energy storage systems
- Energy storage system procedures are updated to reflect USABC methods with technical agreement from INL
- Interim Component Durability test procedures continue baseline component testing through End-of-Test for a total of five component tests over the life of the vehicle

Approach/Strategy

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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 at fleet to obtain mileage targets along with climate diversity
  - 2011 Volts in Colorado, 2012 Honda Civic CNGs in Oklahoma, 2013 Chevrolet Malibus in California, 2014 Chevrolet Cruze Turbo Diesels in Texas
  - Availability of EVSE units for overnight charging limits fleet locations for BEVs and PHEVs

Approach/Strategy

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FLEET TESTING

- Fleets record fuel, charging, and maintenance history for each vehicle
  - Data collated and collected for Intertek 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 of 15,000 miles/year
    - Fleet testing has revealed four early failures of battery packs across multiple models
    - Two hybrid transmission failures on the same vehicle make and model have also been revealed at close to 100,000 miles on a 2013 model vehicle
- 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

2015-2016 VEHICLE BASELINE TESTING

- Baseline testing completed including component, proving ground, and ANL APRF fuel economy testing
  - 2013 RAM 1500 with start/stop and CNG conversion
  - 2014 BMW i3 / i3 with Range Extender
  - 2014 smart fortwo ED
  - 2014 Tesla Model S 85 kWh
  - 2015 Honda Accord Hybrid
  - 2015 Volkswagen e-Golf
  - 2015 Kia Soul EV
  - 2015 Chevrolet Spark EV
  - 2015 Mercedes B-Class Electric
  - 2015 Chevrolet Impala CNG Bi-Fuel

Technical Accomplishments

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2015-2016 DC FAST CHARGING AT TEMPERATURE

- Assessments of DCFC charge time and performance were conducted on all DCFC-capable vehicles at 0, 25, and 50 °C utilizing a vehicle temperature chamber
  - 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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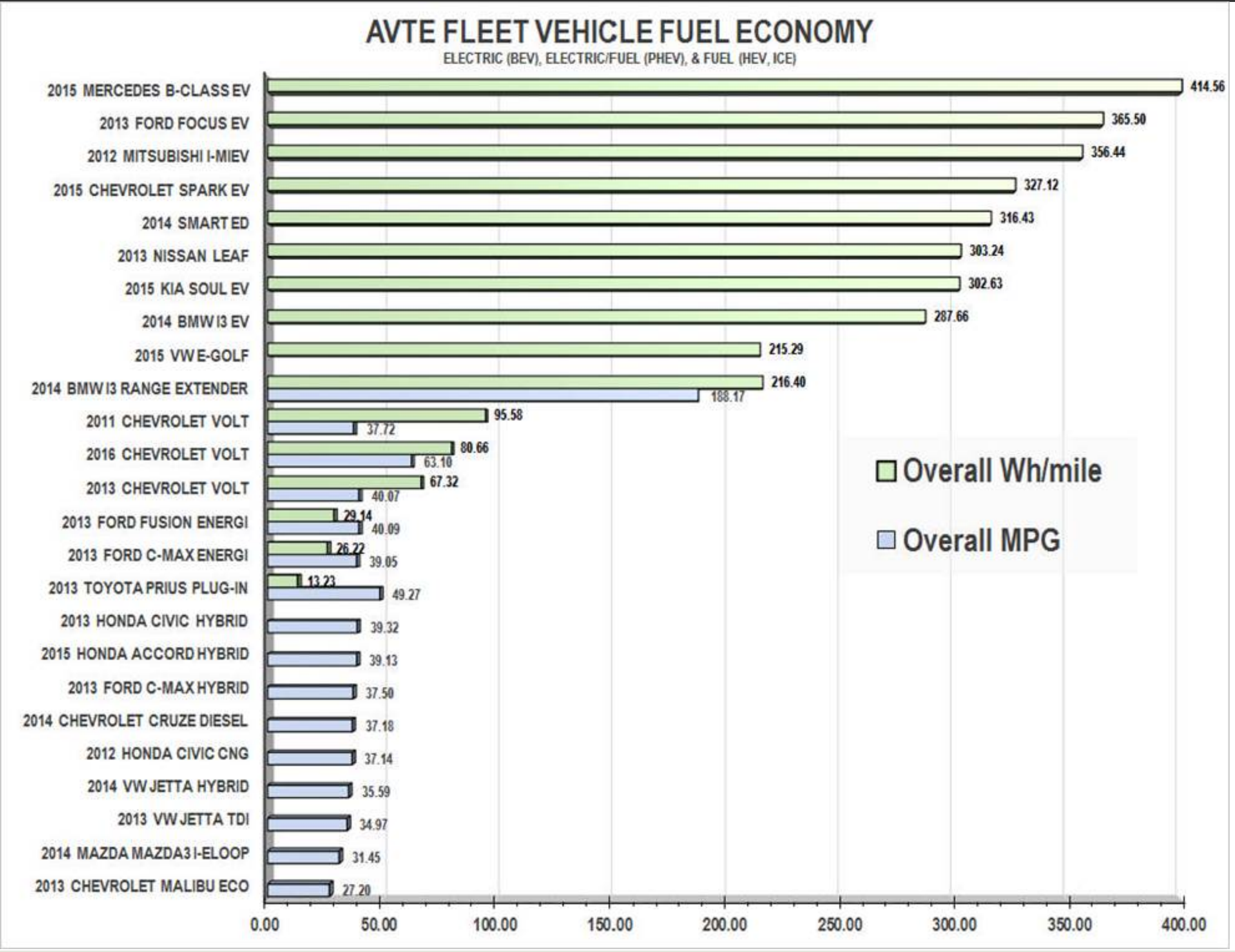
2015-2016 FLEET TEST VEHICLES

- Overall fuel economy for vehicles in fleet use with accelerated mileage targets through February 2016
- 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 APRF
  - Interoperability standards and test development
- DOE National Renewable Energy Laboratory
  - Access to medium and heavy-duty fleets with advanced technologies that reduce petroleum consumption

Collaboration

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INDUSTRY PARTNERS

- EZ Messenger and Specialized Delivery Services
  - Two document delivery companies co-located in Phoenix with multiple fleet locations throughout the United States
  - 24 shared Level 2 EVSE units
  - DCFC available with CHAdeMO
  - DCFC with 12 kWh of onboard energy storage, CHAdeMO, and SAE Combo connectors

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REMAINING CHALLENGES AND BARRIERS

- **Risk aversion** from OEMs
  - OEM implementation of advanced technology vehicles that reduce petroleum consumption typically have a slow introduction to market
  - OEMs are not actively participating in initial AVTE vehicle data collection and component testing
  - Future collaboration with OEMs may encourage a partnership with National Laboratories to introduce advanced technologies on OEM-provided vehicles tested within AVTE
- **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

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REMAINING CHALLENGES AND BARRIERS

- Fueling **Infrastructure**
  - Advanced technology vehicles often have inherent limitations in their fueling infrastructure
    - CHAdeMO and SAE Combo Connector public fast charging locations are slowly increasing
    - Vehicles charging with Level 2 EVSE at fleets are rotated through the available units, which are limited due to site power availability
    - CNG fueling stations and onboard vehicle tank size limit useable range of vehicles
    - Hydrogen fueling station availability and uptime for future fuel cell vehicles limit fueling locations to certain regions and times

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PROPOSED FUTURE WORK

- Continue current vehicles in fleet test for a minimum of three years and their respective mileage requirements
  - Vehicles under test from 2012-2013 are reaching their mileage goals and will be completing component and track testing as part of their End-of-Test procedures
- Advanced technology vehicles planned through 2016 include the Toyota Mirai fuel cell vehicle and OEM-provided vehicles
- Determine vehicle battery pack performance by vehicle type with correlation to on-road cycles and how this may impact the secondary-use battery market
- Conduct a storage-assisted DCFC vehicle recharging demonstration project at the Phoenix partner fleet location

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PROPOSED FUTURE WORK

- Determine OEM involvement and collaboration possibilities for future vehicles of interest to the DOE
- Continue to automate test reporting and add additional vehicle CAN information where needed to assist in fidelity of fleet data at INL
- Analyze charge-depleting range estimation of fleet vehicles and their change over the life of the vehicle
- Determine vehicle interoperability with publically available DCFC stations
- Evaluate light-duty vehicle effects from platooning with adaptive cruise control at a range of speeds and distances to determine fuel economy savings for future autonomous vehicles
- Develop test procedures for new technologies, testing methods, and vehicle types, such as fuel cell vehicles
- Engage a partner medium-duty fleet through NREL to study fuel economy improvements of their advanced vehicle technology implementation

2015 AMR Response to Reviewer Comments

- *[There is] questionable representativeness of the partner fleet operating profiles relative to typical operation of the vehicles in the hands of consumers (admittedly an inherent limitation of deploying them into applications that will quickly accumulate a lot of operating miles); narrow climate representativeness - most of the vehicles seemed to be deployed in Phoenix, which represents a climate on one end of the spectrum.*
  - In order to quickly gather lifecycle data on vehicles, they have to be placed in fleets where they can gain mileage quickly. After 3-4 years, vehicle information may not be as relevant if a new model is introduced. Attempting to record average consumer data does not give the control of having fleet drivers provide fuel, charge, and maintenance information, and their mileage accumulation will most likely be at a lesser rate. There are also liability concerns with monitoring individual consumers that are addressed in agreements between Intertek and the fleets. Efforts continue to expand testing in varied climates, with locations already in Texas, Oklahoma, and Colorado, and recent expansion to cities in California. Coordination of personnel is required to conduct component testing remotely or the vehicle is shipped back to Phoenix and then back to the fleet location.
- *Minimal baseline vehicle data collection and accessibility, data collection and reporting on baseline vehicles (representative of comparable conventional counterparts to the tested vehicles and/or of the best-selling vehicles on the market) would be one way to control for the potential representativeness issues of the drive cycles and climates in the selected fleets, and would provide valuable on-road data in its own right for those vehicles currently dominating the light-duty market*
  - Baseline vehicle data has to be balanced against the research into the advanced vehicle technology of interest. An attempt was made by including both the Ford C-Max Energi (PHEV) versus the C-Max Hybrid counterpart for inclusion into AVTE testing. Further detail was added from the Ford Fusion Energi (PHEV) to compare against the C-Max Energi with the same powertrain. Adding baseline vehicles for comparison is cost intensive and will not produce the results that can be found from high impact advanced vehicle technologies that reduce petroleum consumption.

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SUMMARY

- As of March 2016, over 95 vehicles representing 26 models are 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 6.8 million vehicle miles recorded during AVTE fleet testing
- Expanded current fleet partner locations to include varied climates
- Completed DC fast charging at temperature testing on all capable vehicles in fleet test
- Continue to utilize Intertek office in California to plan for coordination of fuel-cell vehicle testing
- Continue to generate test results and reports posted to the INL AVTA website after review from INL technical staff
- Begin outreach to OEMs for participation in AVTE to evaluate new advanced vehicle technologies

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