Idaho National Laboratory Testing of Advanced Technology Vehicles

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www.inl.gov

Idaho National Laboratory

Project ID: VSS021
INL/MIS-15-34935

Overview

Timeline

-Vehicle lab and field evaluation is an annually funded activity, providing data from the constantly evolving state-of-the art vehicle technologies

Barriers

-High risk to develop and purchase plug-in electric vehicles (PEV) and charging infrastructure

-PEV infrastructure requirements and impacts are not yet understood

-Development of codes and standards for products and testing is required

Budget

Project Funding

-FY 2014 1.05 M

-FY 2015 1.80 M

Partners

-Intertek Testing Services NA

-NETL, ANL, ORNL

-GM, Ford, OnStar, FCA, Nissan, Honda, Toyota, NYC TLC, NYSERDA

-Idaho National Laboratory - Lead

Relevance/Objectives

AVTA's objective is to support DOE's goal of petroleum reduction and energy security by:

- Performing low-cost testing and demonstrations of advanced technology vehicles and fueling infrastructure to:
  - Identify the real-world potential of the technology for petroleum displacement
  - Verify return on investment of DOE-funded technology development
  - Evaluate fast tracked technologies to look at technologies ability to meet intended purpose
- Providing results and lessons learned to a broad range of stakeholders, including:
  - DOE modelers and target setters to improve model validity
  - R&D organizations to reduce risk of product development decisions
  - Electric utilities, policy makers, and government agencies to guide their infrastructure requirements planning and impact assessment
  - Standards development organizations to support the development of codes and standards
  - Fleet managers and private consumers to assist them in making vehicle and infrastructure purchase, deployment, and operating decisions that minimize the overall cost of ownership

FY14 & FY15 Milestones

- All past milestones met, upcoming milestones on-track
  - More on these in *accomplishments* slides

	FY 2014				FY 2015			
Milestone	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Post advanced vehicle testing reports and fact sheets on AVTA website, report status quarterly	✓	✓	✓	✓				
Generation of at least 15 reports, fact sheets, presentations, lessons learned and other reports that document the ongoing evaluations and analysis					✓	✓		
Complete the introduction of an additional 100 PEVs into the AVTA testing analysis fleet and generation of at least one report per vehicle set								

Approach/Strategy

- AVTA testing procedures are established for each new technology based on:
  - Existing standard test procedures
  - Recommendations from fleet managers and subject matter experts from industry and other national laboratories
- AVTA test procedures are published and strictly followed to reduce testing uncertainties
- Depending on technology and capabilities, vehicles and EVSE are tested via:
  - Laboratory bench testers (battery packs, EVSE)
  - Closed test tracks and dynamometers
  - On-road captive fleet testing
  - Vehicle and infrastructure demonstrations by independent fleets and private consumers
- Different test methods are used to balance testing control / repeatability, depending on sample size, and costs
- All testing results and information is technology and manufacturer neutral – no special interest bias

Approach/Strategy continued

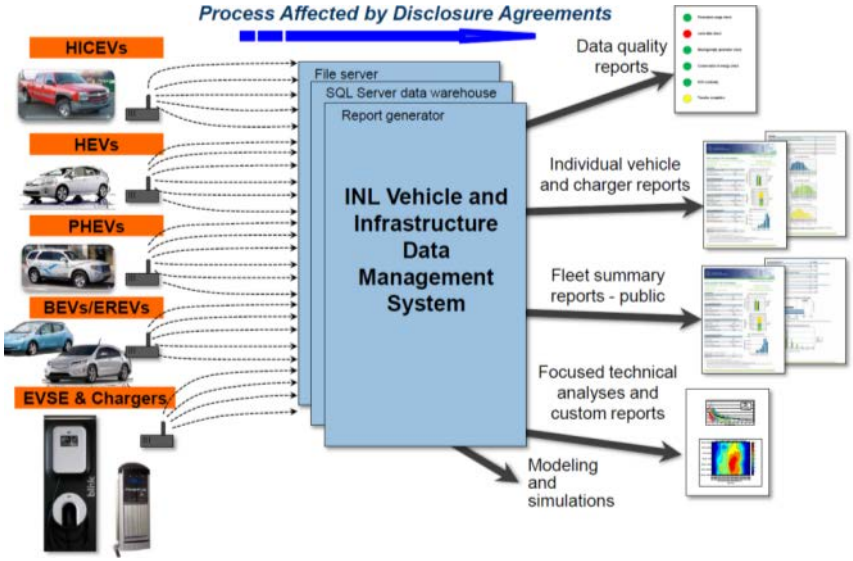
- Vehicle testing results are published to document:
  - Real-world vehicle fuel economy and electricity consumption as a result of driver behavior and external conditions
  - Traction battery pack capacity reduction as a result of vehicle use and conditions
  - Vehicle life-cycle costs
- EVSE testing results are published to document efficiency of charging infrastructure technologies as a result of power level and product design
- Vehicle and infrastructure demonstration results are published to document
  - Vehicle fuel economy and electricity consumption as a result of driving and charging behavior
  - Infrastructure use and electricity demand

Approach/Strategy continued

- Testing and demonstration results are presented in numerous ways, including:
  - To auto and electric utility industry representatives via DOE technical team meetings (VSATT, GITT, EESTT, MTT)
  - Direct meetings with auto OEMs, federal/state/local agencies, NGOs and universities
  - Conferences, Clean Cities webinars, and other public venues
  - Via the EERE VTO and INL AVTA websites
- Publication of testing and demonstration results addresses barriers by
  - Lowering or avoiding cost by improving the product development process and helping end consumers make wise purchase, deployment, and operating decisions
  - Verifying results of DOE-funded technology development to prevent waste and drive future decisions
  - Helping infrastructure planners define infrastructure deployment requirements
  - Providing input to codes and standards development and validation process

Approach/Strategy continued

- AVTA is conducted primarily by INL and Intertek Testing Services North America, with dynamometer testing by ANL
- Testing activities, from individual EVSE tests to large-scale vehicle and infrastructure demonstrations, are made possible by contributions from a multitude of partners – hundreds of organizations and thousands of individual participants to date
- Test methods, quality and efficiency of data collection, and cost of testing have been continuously improving since 1993



Vehicle Testing Accomplishments

Data from 91 AVTE Vehicles Collected This Year

Purchase Vehicle (4 of each model typical)

Baseline Traction Battery Testing

Install On-Board Data Logger (all cars)

4,000 Miles for Break-In

Track Performance and Coast Down Testing (one each model)

Dynamometer Testing (one each model)

Data Collection During Fleet Operation (all cars)

Traction Batteries or Components — 3 Interim Tests

End-of-test Component and Performance Evaluation

EV end-of-test: 36,000 Miles
PHEV end-of-test: 160,000 Miles
HEV, ICE end-of-test: 195,000 Miles

Vehicle Testing Accomplishments

- 5 HEV Models: 4 models continue, 1 begins AVTE fleet testing

Vehicle	Baseline track and dyno testing	Battery Test	Fleet mileage accumulation	Vehicle sample size	Miles target (per vehicle)
2013 Chevrolet Malibu Eco (BAS mild HEV)	Complete	3/5 Tests Complete	61% Complete	4	195,000
2013 Honda Civic Hybrid	Complete	3/5 Tests Complete	55% Complete	4	195,000
2013 Ford C-Max Hybrid	Complete	2/5 Tests Complete	42% Complete	4	195,000
2014 Volkswagen Jetta Hybrid	Complete	2/5 Tests Complete	22% Complete	4	195,000
2015 Honda Accord Hybrid	Scheduled	1/5 Tests Complete	0% Complete	4	195,000

Photos of new models introduced to project

Vehicle Testing Accomplishments

- 5 PHEV Models: 5 Models continue AVTE fleet testing

Vehicle	Baseline track and dyno testing	Battery Test	Fleet mileage accumulation	Vehicle sample size	Miles target (per vehicle)
2011 Chevrolet Volt	Complete	4/5 Tests Complete	57% Complete	2	160,000
2013 Chevrolet Volt	Complete	3/5 Tests Complete	56% Complete	4	160,000
2013 Toyota Prius Plug-In	Complete	3/5 Tests Complete	62% Complete	4	160,000
2013 Ford C-Max Energi	Complete	3/5 Tests Complete	36% Complete	4	160,000
2013 Ford Fusion Energi	Complete	2/5 Tests Complete	32% Complete	4	160,000

Vehicle Testing Accomplishments

- 10 BEV Models: 1 completes, 4 continuing, 5 begin AVTE fleet testing

Vehicle	Baseline track and dyno testing	Battery Test	Fleet mileage accumulation	Vehicle sample size	Miles target (per vehicle)
2011 Nissan Leaf	Complete	5/5 Tests Complete	100% Complete	2	36,000
2012 Mitsubishi i	Complete	2/5 Tests Complete	39% Complete	2	36,000
2013 Nissan Leaf	Complete	2/5 Tests Complete	38% Complete	4	36,000
2013 Ford Focus EV	Complete	2/5 Tests Complete	28% Complete	4	36,000
2014 Smart ED	Complete	2/5 Tests Completed	15% Complete	4	36,000
2014 BMW i3	Scheduled	1/5 Tests Complete	6% Complete	4	36,000
2014 BMW i3 Range Extender	Scheduled	1/5 Tests Complete	9% Complete	4	36,000
2015 Kia Soul EV	Scheduled	1/5 Tests Complete	1% Complete	4	36,000
2015 Chevrolet Spark EV	Scheduled	1/5 Tests Complete	1% Complete	4	36,000
2015 Volkswagen eGolf	Scheduled	0/5 Tests Complete	0% Complete	4	36,000




Photos of new models introduced to project

Vehicle Testing Accomplishments

- 4 ICE Models: 2 continue, 2 begin AVTE fleet testing

Vehicle	Baseline track and dyno testing	Component Test	Fleet mileage accumulation	Vehicle sample size	Miles target (per vehicle)
2012 Honda Civic CNG	Complete	3/5 Tests Complete	40% Complete	4	195,000
2013 Volkswagen Jetta TDI	Complete	NA	43% Complete	4	195,000
2014 Chevrolet Cruze Turbo Diesel	Complete	NA	9% Complete	4	195,000
2014 Mazda 3 (ultracapacitor)	Complete	1/5 Tests Complete	9% Complete	4	195,000

Photos of new models introduced to project

Vehicle Testing Accomplishments

Reports and facts sheets published quarterly for each vehicle:

- Battery/component testing reports detailing battery or appropriate system degradation
- Summary fact sheets with vehicle features and operating costs
- Maintenance sheets detailing maintenance and repair costs
- Vehicle Operation Summary detailing data logged electronically

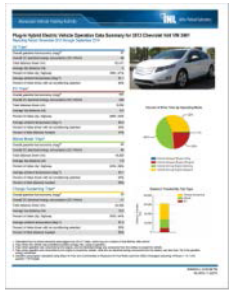
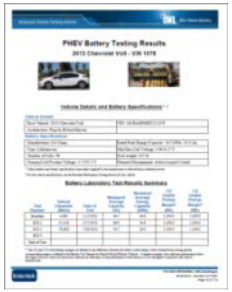
Reports and facts sheets published quarterly for each model

- Fuel consumption and mileage accumulation update fact sheets

Reports published once after track and dynamometer testing:

- Baseline Performance Testing Summary report



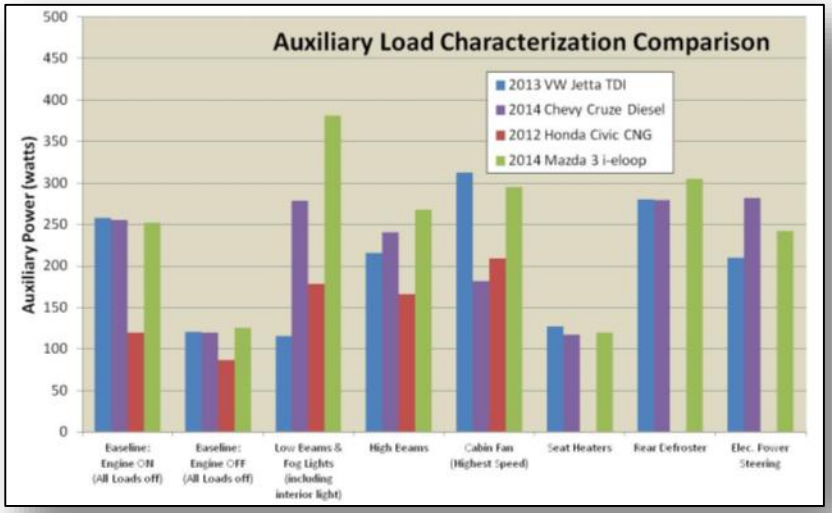




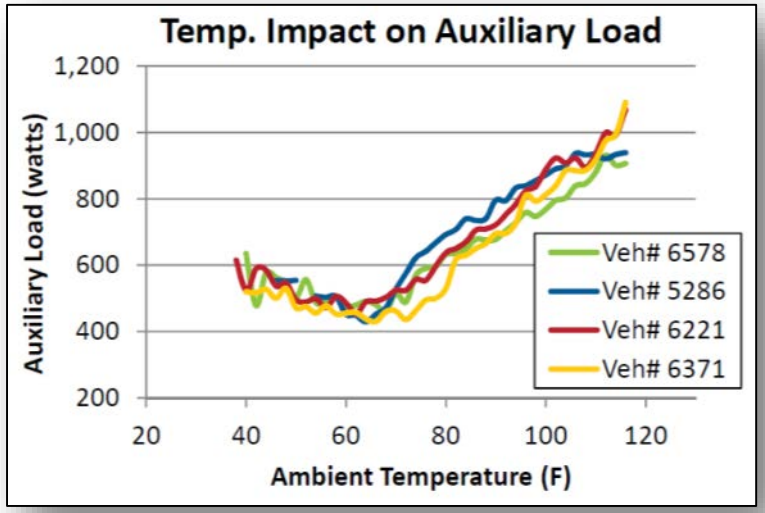
All reports and fact sheets available at http://avt.inl.gov

Vehicle Testing Accomplishments

Quantifying Vehicle Usage Parameters based on Existing Data

- Collaborate with Labs, U.S. OEMs via VSATT team
- 12V accessory load study
  - Characterize accessory usage on-road for non-hybridized ICE vehicles
  - Assess idle times, system level loads, seasonal variation, etc

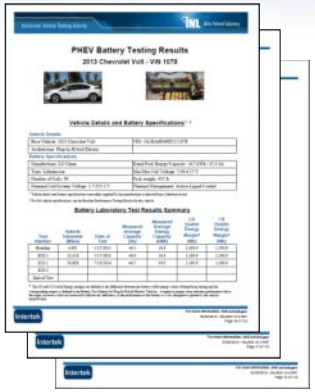




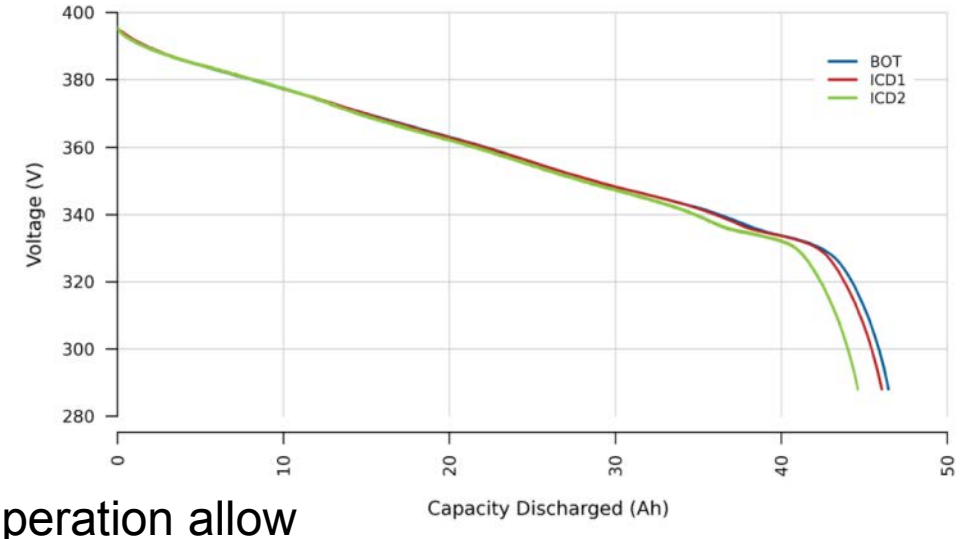
Separate project for FY-15, detailed fully in VSS168

Battery Testing Accomplishments

Traction battery capacity testing at beginning, 3 interim points and completion of fleet mileage accumulation



- Battery testing results-to-date published for 5 new models, updated for 10 existing models:
  - (4) 2013 Chevrolet Malibu Eco
  - (4) 2013 Chevrolet Volt
  - (4) 2013 Toyota Prius Plug-In
  - (3) 2013 Ford C-Max Energi
  - (4) 2013 Ford C-Max Hybrid
  - (2) 2012 Mitsubishi i
  - (4) 2013 Nissan Leaf
  - (4) 2013 Ford Focus EV
  - (4) 2013 Honda Civic Hybrid
  - (4) 2013/2014 VW Jetta Hybrid
  - (4) 2014 Smart Electric Drive Coupe
  - (8) 2014 BMW i3
  - (4) 2014 Kia Soul EV
  - (4) 2014 Chevrolet Spark EV
  - (4) 2015 Honda Accord Hybrid

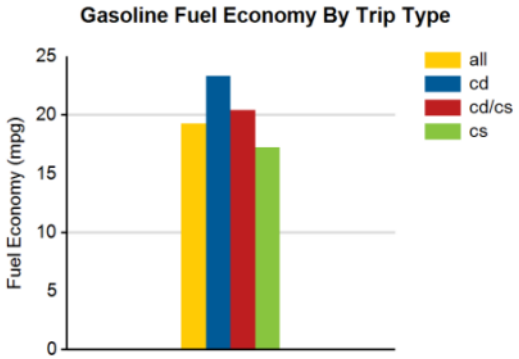


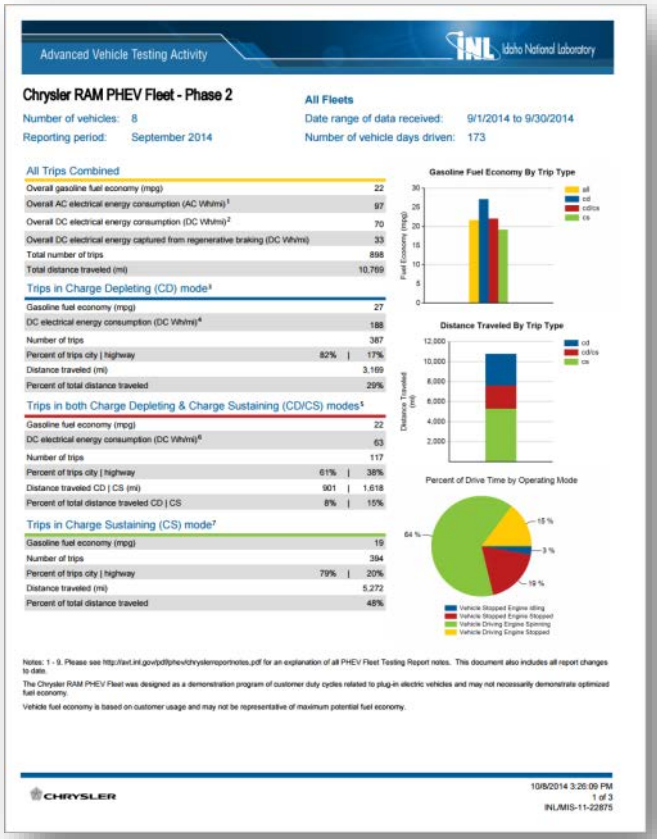
- Five battery test points through operation allow linkages between battery changes and operating conditions, vehicle usage
- Leverages vehicle testing program's fleet mileage accumulation

Vehicle Demonstration Accomplishments

Chrysler Ram PHEV Demo Reporting Completed 9/2014

- Monthly and summary results-to-date INL reports posted on AVT website





- Phase 1 data reporting – *previous years*
  - July 2011 – September 2012
  - 111 Vehicles/1,039,138 Miles
- Phase 2 data reporting
  - November 2013 – September 2014
  - 23 Vehicles/250,478 Miles

Vehicle Demonstration Accomplishments

NYC EV Taxi Pilot

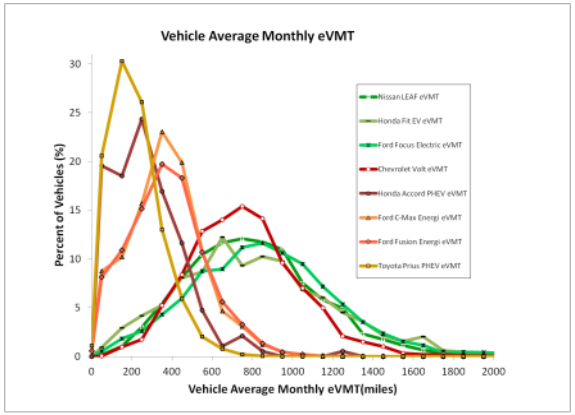
- INL Data collection from
  - Nissan
    - Vehicle driving and charging data from MY2012 Nissan Leaf Taxis
    - 40,000 Miles of Taxi Operation in NYC
  - New York City Taxi & Limousine Commission (NYC TLC)
    - Taxi meter data
- INL merges, analyzes data, provides monthly reporting to Nissan, NYC Taxi and Limousine Commission
- Public report summarizing operation and analysis is currently underway with NYC TLC and Nissan.

Photo Credit: Nissan North America

Vehicle Data Analysis Accomplishments

Electric Vehicle Miles Traveled (eVMT) On-road Results and Analysis

- Analyze real world customer data from eight vehicle models to determine the Electric Vehicle Miles Traveled (eVMT)
- Data analysis of 21,000+ vehicles, 150+ Million miles



- Findings presented to:
  - Automotive OEMs
  - U.S. DOE
  - California Air Resources Board
  - Universities / Academia
  - Reporting publically posted on AVTA website

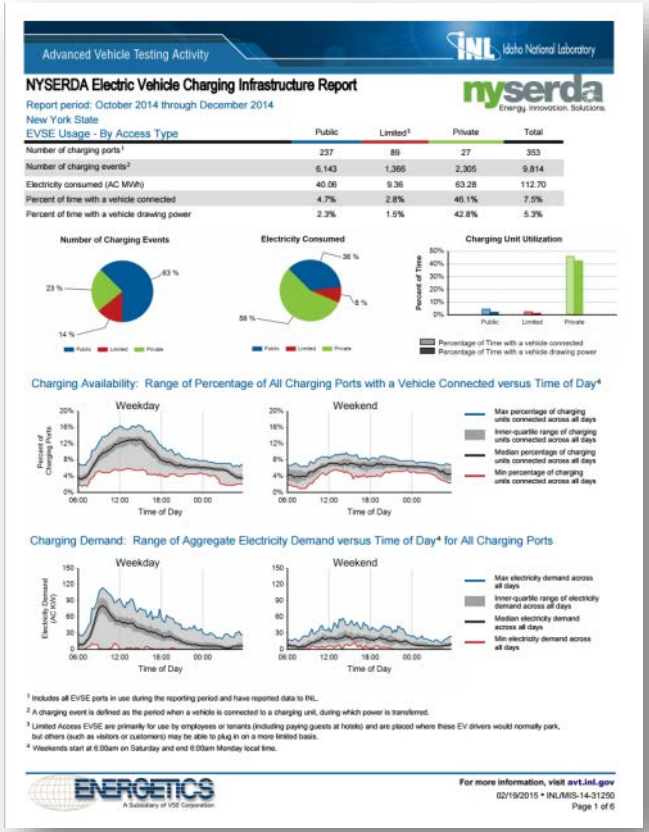
- Analysis results used by California Air Resources Board for consideration of amendments to the Zero Emissions Vehicles (ZEV) credit regulations for the mid-term review in 2016 or before

Project detailed fully in VSS171

Infrastructure Demonstration Accomplishments

NYSERDA EVSE Demonstration Program

- INL collecting data from EVSE deployed in New York State
- Reporting developed in conjunction with NYSERDA and Energetics
- Quarterly reports published publically
  - 5 Quarterly 6-page reports to-date
- Diverse EVSE and attributes
  - 6+ EVSE Mfg.
  - 4+ Data providers
  - Data split by
    - Location
    - Access Type
    - Venue
    - Land use type
    - Fee vs Free
  - Includes some medium duty charging


Advanced Vehicle Testing Activity

NYSERDA Electric Vehicle Charging Infrastructure Report

Report period: October 2014 through December 2014

New York State

EVSE Usage - By Access Type	Public	Limited[3]	Private	Total
Number of charging ports[1]	237	89	27	353
Number of charging events[2]	6,143	1,366	2,305	9,814
Electricity consumed (AC MWh)	40.06	9.36	63.28	112.70
Percent of time with a vehicle connected	4.7%	2.8%	46.1%	7.5%
Percent of time with a vehicle drawing power	2.3%	1.5%	42.8%	5.3%

Number of Charging Events

Electricity Consumed

Charging Unit Utilization

Charging Availability: Range of Percentage of All Charging Ports with a Vehicle Connected versus Time of Day[4]

Weekday

Weekend

Time of Day

Charging Demand: Range of Aggregate Electricity Demand versus Time of Day[4] for All Charging Ports

Weekday

Weekend

Time of Day

[1] Includes all EVSE ports in use during the reporting period and have reported data to INL.

[2] A charging event is defined as the period when a vehicle is connected to a charging unit, during which power is transferred.

[3] Limited Access EVSE are primarily for use by employees or tenants (including paying guests at hotels) and are placed where these EV drivers would normally park, but others (such as visitors or customers) may be able to plug in on a more limited basis.

[4] Weekends start at 6:00am on Saturday and end 6:00am Monday local time.

ENERGETICS

For more information, visit avt.inl.gov

02/19/2015 • INL/MIS-14-31250

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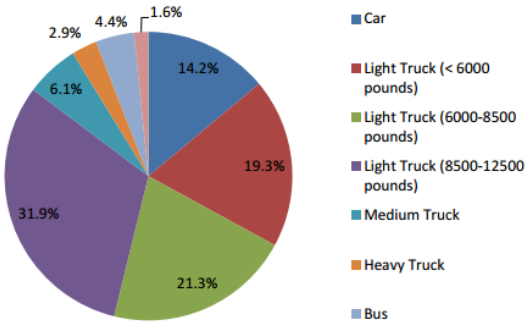
Federal Fleet Outreach Accomplishments

FEMP fleet PEV suitability project

- Collected usage data from conventional vehicles in federal fleets
- Reporting results of analysis as it applies for each fleet's mission
  - Completed and published reports for:
    - Sleeping Bear Dunes National Lakeshore
    - Caribout Targhee National Forest
    - Nasa White Sands Test Facility



- Purpose is to reduce fleets' risks with advanced vehicle and infrastructure purchase, deployment, and operating decisions

Address Previous Year Review Comments

Previous Year's Reviewer Comment	Response
While the output of this project is very valuable, there much more that can be done with the existing and future data to show driving behavior and component response. Given the right set of tools that exists, more analysis should be ongoing. (paraphrased, multiple reviewers)	The project is always gaining more test vehicles, and the completion of tool development to handle the data flow will allow more resources to focus on more in-depth analysis on behavior-response.
More national lab collaboration would be useful	The existing and expanding partnerships and exchange of data with other national labs will allow their tools to leverage more value from the existing and future data collected.
More OEM collaboration should be pursued	We have increased our outreach with OEMs and have had very positive responses through several projects. INL's data security measures and track record should inspire confidence and we hope will allow the OEM partnerships to expand.

Partnerships / Collaborations

- OEMs including Ford, GM, Chrysler, Toyota, Honda, Nissan
  - VSATT, eVMT, USABC, Vehicle Demonstrations
- National Labs – ANL, ORNL, NREL, NETL
  - VSATT, AVTA, exchange of data supporting projects
- Standards organizations – SAE, NIST
  - AVTA data input to separate standards support activities
- Federal, State agencies - EPA, CARB, NYSERDA, WashDOT, ODOT
  - Energy Star, eVMT, EVSE demonstration analysis & reporting
- Universities – CSU, UC Davis
  - Co-investigation, internships
- Industry – Intertek, Electric Utilities
  - Conduct of AVTE contract, EPRI Infrastructure Working Council

Remaining Challenges and Barriers

- Vehicle technologies and market constantly evolving
- Charging infrastructure technologies advancing, changing i.e. wireless
- Standards evolving to meet technology needs, i.e. fast charging
- Vehicle interaction with grid has many uncertainties
  - Incentives, stability, services, trade-offs
- Impacts from DOE investments in R&D are difficult to ascertain

- Each of these challenges are opportunities for testing, evaluation, and demonstration projects to provide key input for modeling, developers, and decision makers

Proposed Future Work

- Increased and enhanced collection and exchange of test data with national labs to support modeling and analysis – ANL, NREL, ORNL, LBNL – for a range of possible DOE VTO projects
  - Autonomie modeling and complimentary tools
  - Consumer guidance apps for AFV purchasing decisions
  - Power electronics system analysis
  - Autonomous vehicle studies
- Demonstration project for DC fast charging with onboard energy storage
- Enhancing battery and component testing reporting to examine on-road cycling with respect to component degradation
- Support new fuels and engine co-optimization efforts via on-road demonstration and data collection
- Examine DC fast charging station and vehicle interoperability

Summary

- AVTA performs low-cost testing and demonstrations for a broad range of advanced technology vehicles and fueling infrastructure to
  - Identify the real-world potential of the technology for petroleum displacement in a wide array of usage scenarios
  - Verify return on investment of DOE-funded technology development
- Results and lessons learned are provided to a broad range of stakeholders and partners to:
  - Reduce risk of development, deployment, and ownership decisions
  - Guide infrastructure requirements planning and impact assessment
  - Support the development of codes and standards
- To date, results clearly show *how the vehicles are used* matters to petroleum displacement
  - Increasing data exchange and analysis will increase impact of testing
- Therefore, AVTA will continue to emphasize technology evaluation across a wide range of usage patterns and customer applications