VSATT: INL's Vehicle Systems Related FY-15 Research Activities

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VSATT Meeting and Project Kickoff Deep Dive
NREL, Golden, Colorado

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INL/MIS-14-33352

Idaho National Laboratory

INL / AVTA (Advanced Vehicle Testing Activity) Objectives and Experience

Objectives

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

- **Perform low-cost (to DOE) testing and demonstrations of advanced technology vehicles and fueling infrastructure to:**
  - **Identify real-world potential of technologies to displace petroleum**
  - **Verify return on investment of DOE-funded technology development, primarily on:**
    - **Plug-in electric whole-vehicle technologies**
    - **Advanced energy storage (i.e., batteries) technologies and chemistries**
    - **Fueling system technologies (conductive and wireless grid-connected electric drive vehicle fueling infrastructure)**
    - **Advanced climate control, power electronic, and other ancillary and accessory systems technologies**
    - **Advanced internal combustion engines (CNG/Turbocharged Direct Injection Diesel)**

Objectives – cont'd

- Provide results and lessons learned to a broad range of stakeholders, including:
  - Original equipment manufacturers (OEMs)
  - DOE modelers and target setters to improve model validity
  - R&D organizations to support product development decisions
  - Electric utilities, policy makers, regulatory, and government agencies to guide their infrastructure requirements planning and impact assessments
  - Standards development organizations to support the development of codes and standards
  - Fleet managers and private consumers to assist them in making vehicle and infrastructure deployment decisions that minimize the overall cost of ownership
- The objectives are accomplished via benchmarking partnerships in ways that leverage DOE funding to the fullest amount possible
- INL either performs the benchmarking internally or is technically responsible to DOE for the direction, execution, analysis and reporting of subcontracted NETL and INL projects

Vehicle / Infrastructure Testing Experience

- **Since 1994, INL staff have benchmarked PEVs in field operations (via data loggers), closed test tracks and dynamometers**
- **INL has accumulated 232 million PEV miles from 27,400 electric drive vehicles and 17,000 charging units**
  - **EV Project: 8,228 Leafs, Volts and Smarts, 12,363 EVSE and DCFC, reporting 4.2 million charge events, 124 million test miles. At one point, 1 million test miles every 5 days**
  - **Ford, GM, Toyota and Honda requested INL support identifying 87 million electric vehicle miles traveled (eVMT) out of 158 million total travel miles by 21,627 PEVs. This analysis used 109 million new PEV miles of data from 15,721 new PEVs, EREVs and BEVs as well as EV Project Volt and Leaf data**

Vehicle / Infrastructure Testing Experience: Cont'd

- Charge Point: 4,253 EVSE reporting 1.5 million charges
- PHEVs: 15 models, 434 PHEVs, 4 million test miles
- EREVs: 2 model, 156 EREVs, 2.3 million test miles
- HEVs: 24 models, 58 HEVs, 6.4 million test miles
- Stop/start hybrid vehicles: 3 models, 7 MHVs, 608,000 test miles
- NEVs: 24 models, 372 NEVs, 200,000 test miles
- BEVs: 48 models, 2,000 BEVs, 5 million test miles
- UEVs: 3 models, 460 UEVs, 1 million test miles

- Other testing: hydrogen ICE vehicle and fueling infrastructure testing

• Vehicles providing data may be purchased by DOE, INL, commercial and government fleets, and the general public

Vehicle Technologies Office – On-Going Research Activities

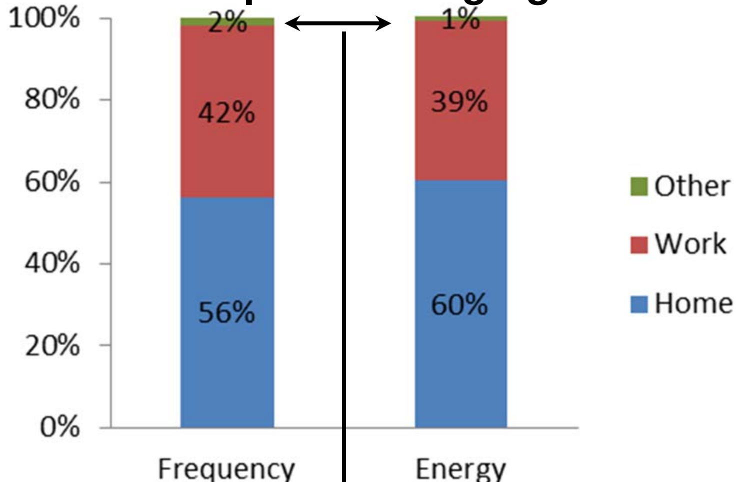
ARRA EV Project & ChargePoint Project

- **124 million miles of data, 6 million charge events from:**
  - **8,228 Leafs, Volts and Smart EVs – bought by the public**
  - **16,600 Residential and public Level 2 EVSE (electric vehicle supply equipment) and DC Fast Chargers**
  - **NDAs with OnStar, Nissan, Daimler, Ecotality and Aerovironment, and 10,000 use agreements**

- **Charging behaviors and charge location preferences**
  - **Time of Use rates – incentive behavior**
  - **99% Home and work place charging**
- **Driving behaviors**
- **Multiplicity of organizations use the 150+ documents**
  - **Many OEMs**
  - **CARB, CEC, NAS, DOT, IEA, DOT, EPRI, Pew Foundation, universities, states and regional groups, interstate travel corridor planners, many electric utilities**
  - **Clean Cities, EV Everywhere Grand Challenge and WorkPlace Charging Challenge**

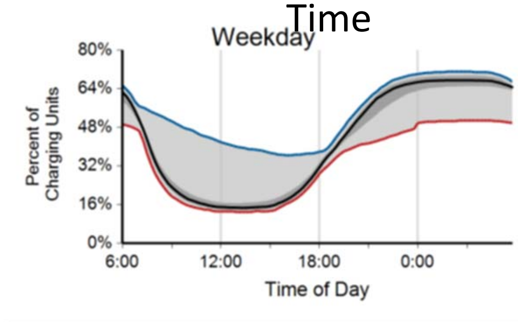
EV Project

707 Leafs with Access to Workplace Charging

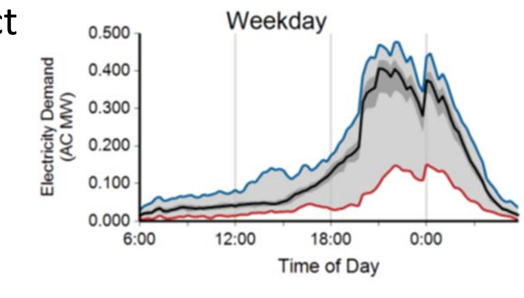


In aggregate, workplace vehicle drivers had little use for public infrastructure on days when they went to work

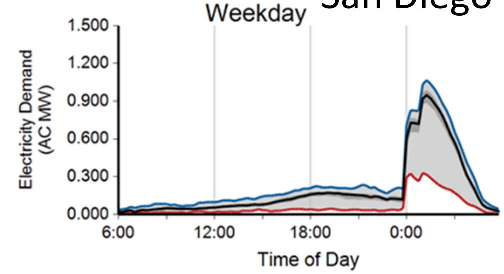
National Residential Connect Time



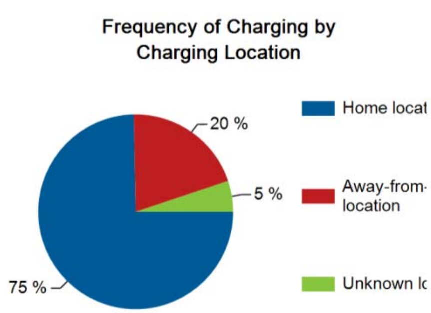
Los Angeles



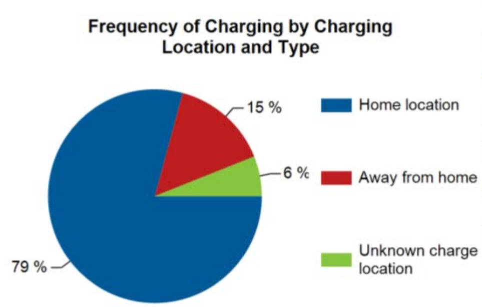
San Diego

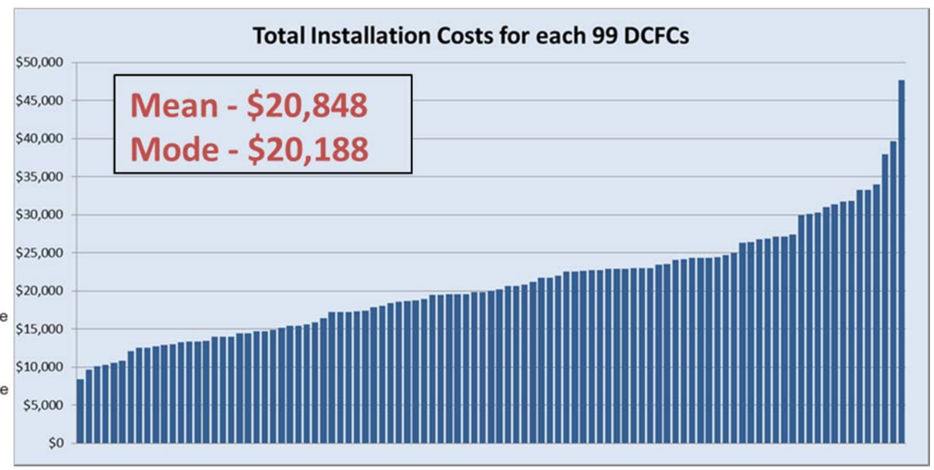


Leafs



Volts





Upcoming EV Project White Papers

Infrastructure Issues

1. **What makes an L2 commercial site highly utilized - correlation between utilization and three location based factors**
2. **What makes an L2 public site highly utilized - correlation between utilization and three location based factors**
3. **What makes a DCFC site highly utilized - correlation between utilization and three location based factors**
4. **What makes an L2 commercial site highly utilized - correlation between utilization and three host based factors**
5. **What makes an L2 public site highly utilized - correlation between utilization and three host based factors**
6. **What makes a DCFC site highly utilized - correlation between utilization and three host based factors**

User Issues

7. **What makes an L2 commercial site highly utilized - analyze correlation between utilization and three user based factors**
8. **What makes an L2 public site highly utilized - analyze correlation between utilization and three user based factors**

Upcoming EV Project White Papers

User Issues – cont'd

9. **What makes a DCFC site highly utilized - analyze correlation between utilization and three user based factors**
10. **Top mileage accumulators - characterize use patterns, demographics and geographic of top 50 highest mileage accumulators**
11. **Top residential charging users - characterize use patterns of top 50 users that never (or rarely) charge away from home**
12. **Top commercial/public charging users - characterize use patterns of top 50 users of commercial/public charging (by percent of their total charging)**
13. **Top DCFC users - characterize use patterns of top 50 users of DCFC (by percent of their total charging)**

Cost Issues

14. **What was the cost to add separate utility submeters at the time of EVSE installation**
15. **What is the impact of utility demand charges on a Level 2 host**
16. **What is the impact of utility demand charges on a DCFC host**
17. **What were the implementation challenges associated with workplace charging installation**
18. **What were the cost drivers for workplace charging installations**

Upcoming EV Project White Papers

Cost Issues – cont'd

19. How do non-residential charging infrastructure installation costs vary by geographic location
20. What were the cost drivers for residential charging installations
21. How do residential charging infrastructure installation costs vary by geographic location
22. What were the cost drivers for DCFC installations
23. How do DCFC infrastructure installation costs vary by geographic location
24. What are the business models currently employed for commercial charging
25. What are the business models currently employed for workplace charging and what is the impact of free workplace charging
26. What are the business models currently employed for DCFC
27. How many Low Carbon Fuel Standard credits have been generated by the EV Project and how many gallons of gasoline have been saved in California
28. What are revenue streams and intangible benefits a charging site host can expect to gain from the installation of EVSE units

Grid Impact Issues

29. Characterize the demand and energy characteristics of L2 commercial EVSE

Upcoming EV Project White Papers

Grid Impact Issues – cont'd

30. Characterize the demand and energy characteristics of L2 public EVSE
31. Characterize the demand and energy characteristics of DCFC
32. Characterize the demand and energy characteristics of residential EVSE
33. Characterize clustering of L2 commercial EVSE
34. Characterize clustering of L2 public EVSE
35. Characterize clustering of DCFC
36. Characterize clustering of residential EVSE
37. Characterize global controllable demand from L2 commercial EVSE
38. Characterize global controllable demand from DCFC
39. Characterize global controllable demand from residential EVSE
40. Characterize energy storage required to reduce peak Level 2 commercial charging demand
41. Characterize energy storage required to reduce peak Level 2 public charging demand
42. Characterize energy storage required to reduce peak DCFC charging demand
43. Characterize energy storage required to reduce peak L2 public/commercial charging demand

Upcoming EV Project White Papers

Grid Impact Issues – cont'd

44. **Characterize impact of 6.6kW residential charging**
45. **Characterize impact of 6.6kW Level 2 commercial charging**
46. **Characterize impact of 6.6kW Level 2 public charging**
47. **Characterize the capability of L1 residential charging to satisfy Volt charging needs**
48. **Characterize the capability of L1 residential charging to satisfy Leaf charging needs**
49. **SDG&E Project description and lessons learned - TOU rates**
50. **What was the impact of the car sharing on Publically Available charging infrastructure in San Diego**
51. **What were 'best practices' for residential infrastructure permitting**
52. **What were 'best practices' for public infrastructure permitting**
53. **What practices were used for non-residential charger locating (way-finding)**
54. **What were practices were used for workplace charging use allocation**

Planning Issues

55. **How does the location of public and commercial infrastructure actually deployed correlate with EV Project Micro-Climate planning locations**
56. **How does the use of public and commercial infrastructure actually deployed correlate with EV Project Micro-Climate planning locations**

Upcoming EV Project White Papers

Planning Issues – cont'd

57. What percent of total charging energy is dispensed at Level 2 vs. DCFC
58. What percent of total charging energy is dispensed at residential vs. workplace vs. commercial vs. public venues
59. What practices were used for parking/charging enforcement issues

First FY-15 EV Project White Papers

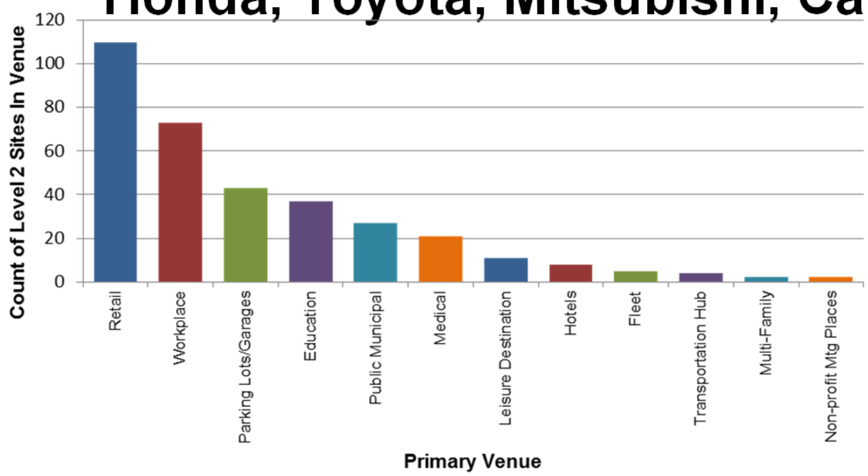
- **What were the cost drivers for workplace charging installations**
- **What were the cost drivers for publicly accessible charging installations**
- **What were the cost drivers for DCFC installations**
- **How do residential charging infrastructure installation costs vary by geographic location**
- **How do publicly accessible infrastructure installation costs vary by geographic location**
- **Characterize clustering of residential EVSE & grid impacts**
- **Characterize global controllable demand from residential EVSE "smart grid"**
- **How does the location of public and commercial infrastructure actually deployed correlate with EV Project Micro-Climate planning locations**

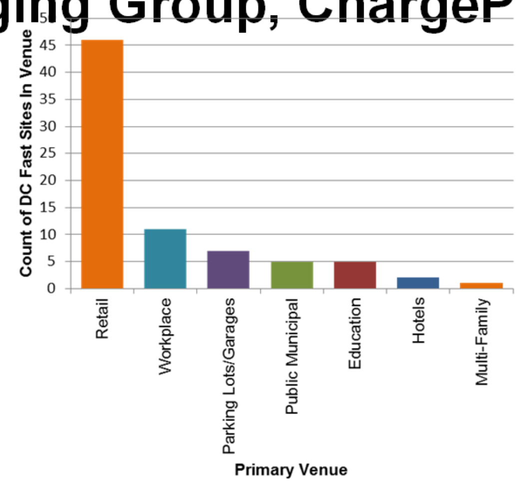
First FY-15 EV Project White Papers: cont'd

- **What percent of total charging energy is dispensed at residential vs. workplace vs. commercial vs. public venues vs. DCFC locations**
- **What makes a DCFC site highly utilized - correlation between utilization and three location based factors**
- **Top commercial/public charging users - characterize use patterns of top 50 users of commercial/public charging (by percent of their total charging)**

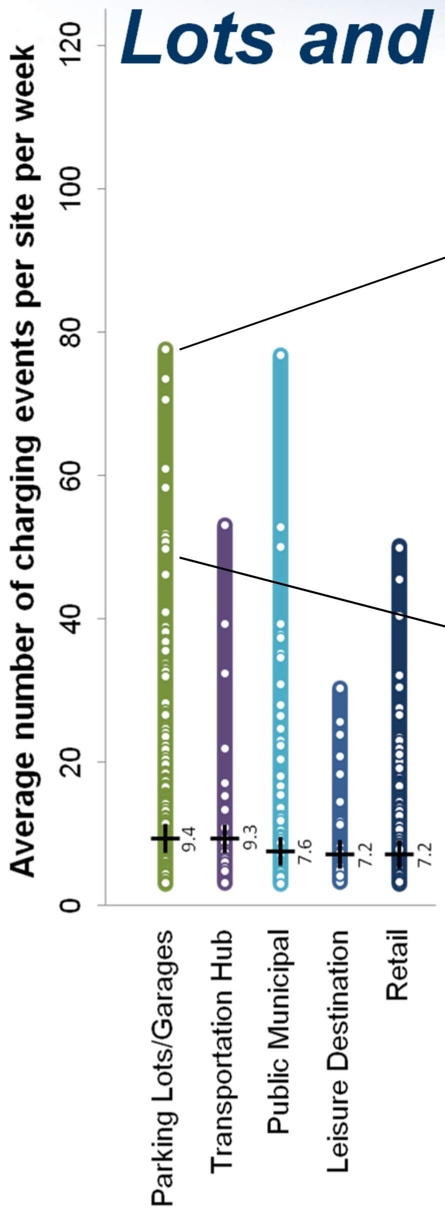
Charging Infrastructure Venue Analysis

- **Defining EVSE data set venues – leverage data from multiple projects to create a comprehensive understanding of charge venue utilization**
- **EV Project, ChargePoint, Aerovironment, DTE Energy, NYSERDA, both Levels 1 and 2 EVSE, and DC Fast Charge (DCFC)**
- **Producing whitepapers for each venue: detailed description on usage, specific case studies, and detailed geographic distribution**
- **Key Stakeholders:**
  - **Venue presentations to NAS Committee on Overcoming EV Deployment Barriers, CARB/CEC, Multiple SAE conferences**
  - **Special reports or presented to: Ford, GM, Chrysler, Nissan, Honda, Toyota, Mitsubishi, Car Charging Group, ChargePoint**



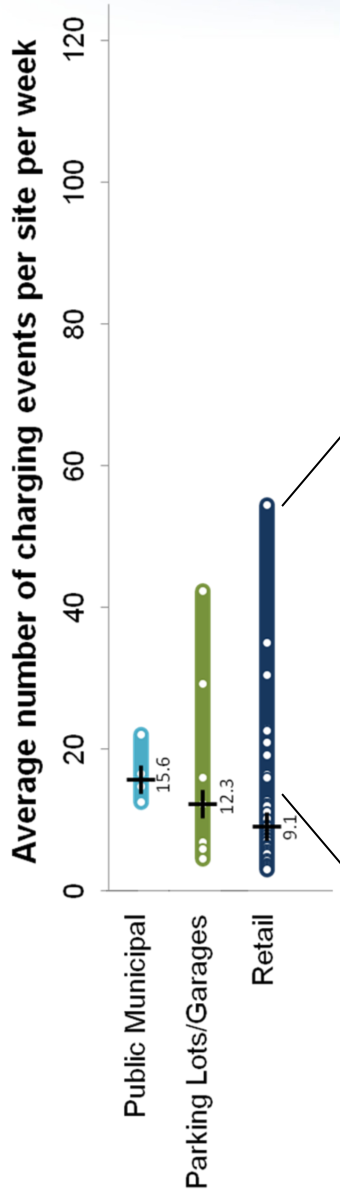


Blink & ChargePoint Level 2 Sites – Parking Lots and Garages



77.5	Downtown Palo Alto
73.4	Fifth & Mission Garage, San Francisco
70.6	Downtown Palo Alto
60.9	Downtown Redwood City
58.3	Parking Structure, Irvine CA
51.8	Parking Structure, Irvine CA
51.4	Parking garage, San Francisco CA
50.7	Sutter Stockton Garage, San Francisco CA

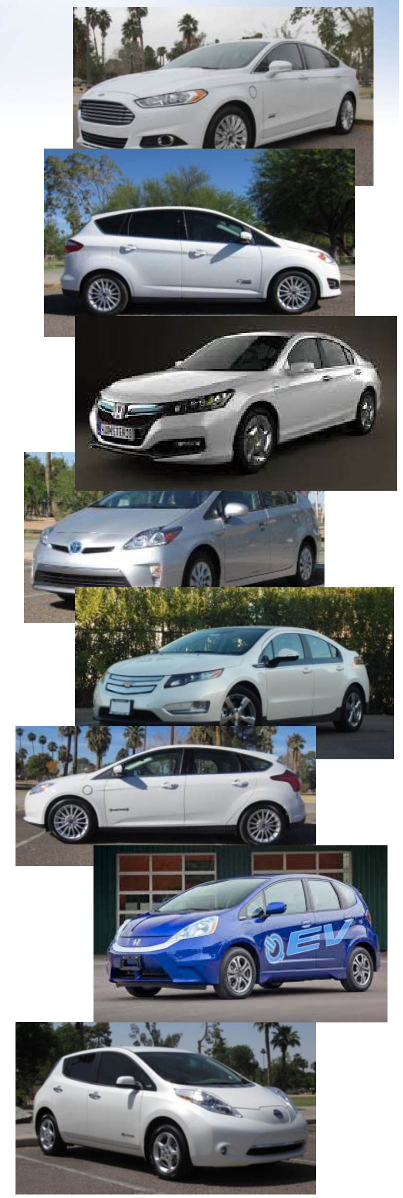
Blink DCFC Sites – Retail



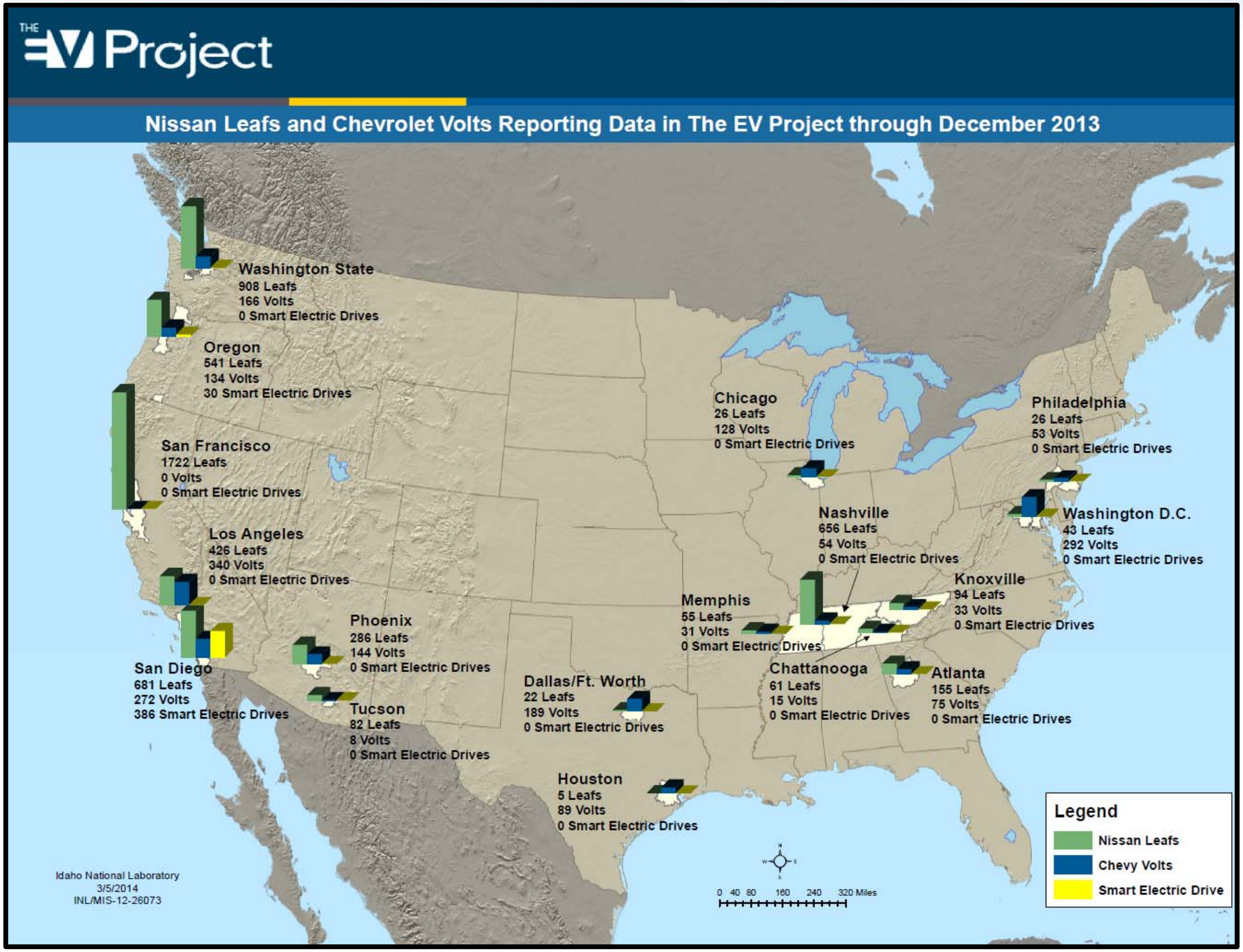
54.4	Tahoma Market on I5, Tacoma WA
35.0	Fred Meyer, Kirkland WA
30.4	Nissan dealership, Bellevue WA
23.1	Fred Meyer, Hillsboro OR
22.8	Fred Meyer, Seattle WA
22.6	Mall on I205, Happy Valley OR
20.9	Fred Meyer, Salem OR
19.1	Fred Meyer, Portland OR
16.5	Nissan dealership, Santa Rosa CA
16.4	Shopping center near I5, Wilsonville OR
16.0	United Markets (grocery store), San Rafael CA
12.7	Nissan dealership, Petaluma CA

eVMT – First Phase

- **Calculated electric vehicle miles traveled (eVMT) for plug-in hybrid electric vehicles**
  - **Ford Fusion Energi, Ford C-Max Energi, Honda Accord PHEV, Toyota Prius PHEV, Chevrolet Volt**
- **Calculated total vehicle miles traveled (VMT) for all electric vehicles (which is equal to eVMT since all the miles are electric)**
  - **Ford Focus Electric, Honda Fit EV, Nissan Leaf**
- **Data is from actual customer, on-road vehicle operation**
  - **158,468,000 miles from 21,600 vehicles**
  - **Across the U.S. (i.e. widely varying regions and climates)**
- **Multiple methods to calculate eVMT were compared**
- **Project collaboration amongst several groups**
  - **INL, Honda North America, Ford Motor Company, Toyota Motor Engineering & Manufacturing NA, General Motors (NDAs signed), Nissan North America**

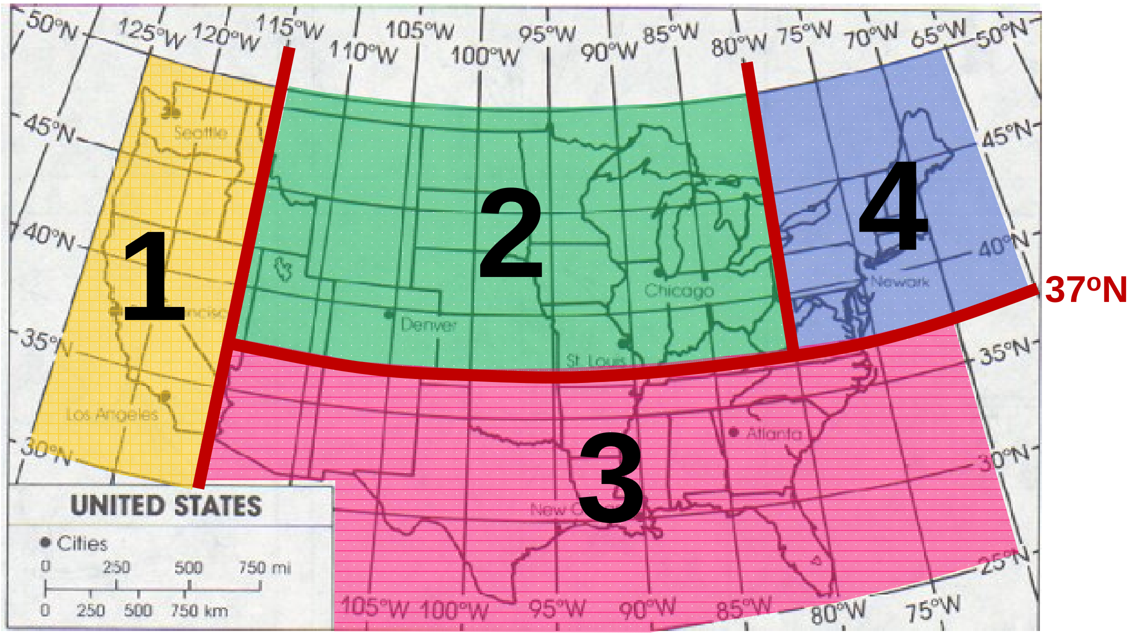


Nissan Leafs & Chevy Volts Regional Distribution



Ford C-Max Energi, Fusion Energi, and Focus Electric Regional Distribution

# of distinct Vehicles ever Driven in the Region	**Region 1**	**Region 2**	**Region 3**	**Region 4**
Ford C-Max Energi	2500	2024	1890	1556
Ford Fusion Energi	2885	1571	2189	1393
Ford Focus Electric	1337	289	313	328



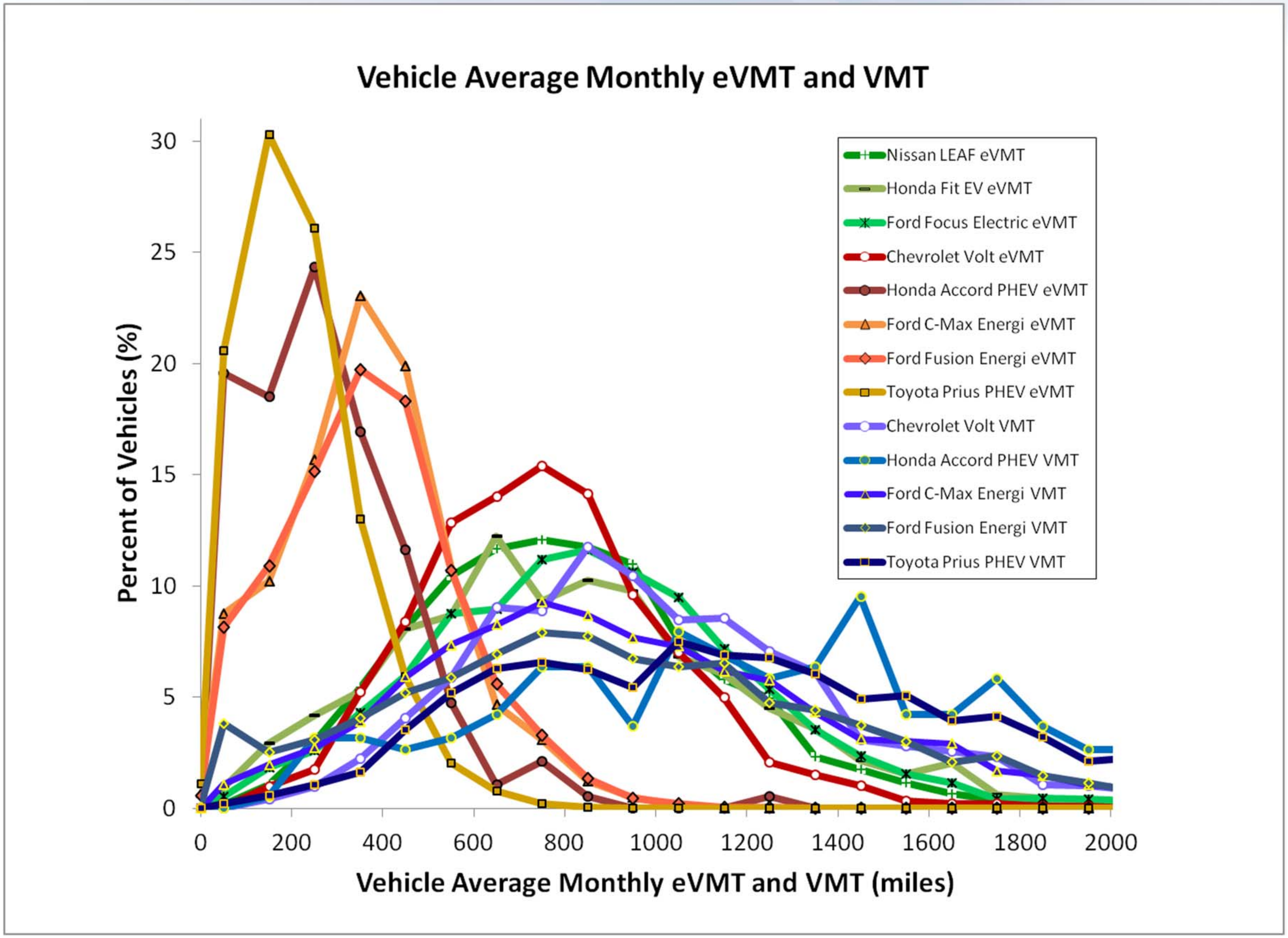
eVMT Analysis Results

	Nissan LEAF *	Chevrolet Volt *	Ford Focus Electric	Ford C-Max Energi	Ford Fusion Energi	Honda Fit EV	Honda Accord PHEV	Toyota Prius PHEV
Number of Vehicles	4,039	1,867	2,193	5,368	5,803	645	189	1,523
Number of Vehicle Months	35,294	20,545	12,622	38,096	32,022	6,090	1,437	15,676
Total Vehicle Miles Traveled *VMT* (miles)	28,520,792	20,950,967	10,043,000	39,376,000	33,098,000	4,912,920	1,794,494	19,772,530
Total Calculated Electric Vehicle Miles Traveled *eVMT* (miles)	28,520,792	15,599,508	10,043,000	12,918,000	11,572,000	4,912,920	399,412	3,224,981
Avg. Monthly VMT	808.1	1,019.8	795.7	1,033.6	1,033.6	806.7	1,248.8	1,261.3
Avg. Monthly eVMT	808.1	759.3	795.7	339.1	361.4	806.7	278	207.0
estimated Annual VMT	9,697	12,238	9,548	12,403	12,403	9,680	14,986	15,136
estimated Annual eVMT	9,697	9,112	9,548	4,069	4,337	9,680	3,336	2,484
Data Format Description	Key-On / Key-Off	Key-On / Key-Off	Enhanced Key-On / Key-Off			Trip Summary		Trip Summary
Geographic Characterization	CA, OR, WA, AZ, TX, TN, GA, D.C., PA, IL	CA, OR, WA, AZ, TX, TN, GA, D.C., PA, IL	Nationwide			CA, OR, NJ, MD, CT, MA, RI, NY	CA, NY	ZEV States and other states

* http://avt.inel.gov/pdf/EVProj/eVMTMay2014.pdf

Minimally Charged Vehicles are <u>Not Excluded</u> from analysis.
These data include 14% of Accord PHEVs that achieve between 0-50 monthly eVMT

eVMT and VMT



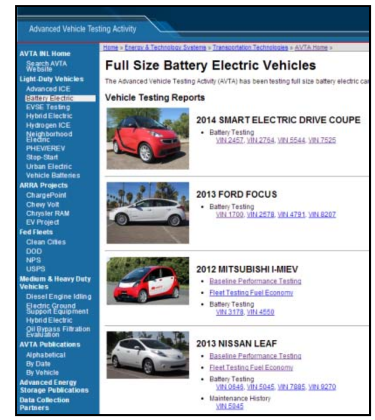
Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.

eVMT Summary

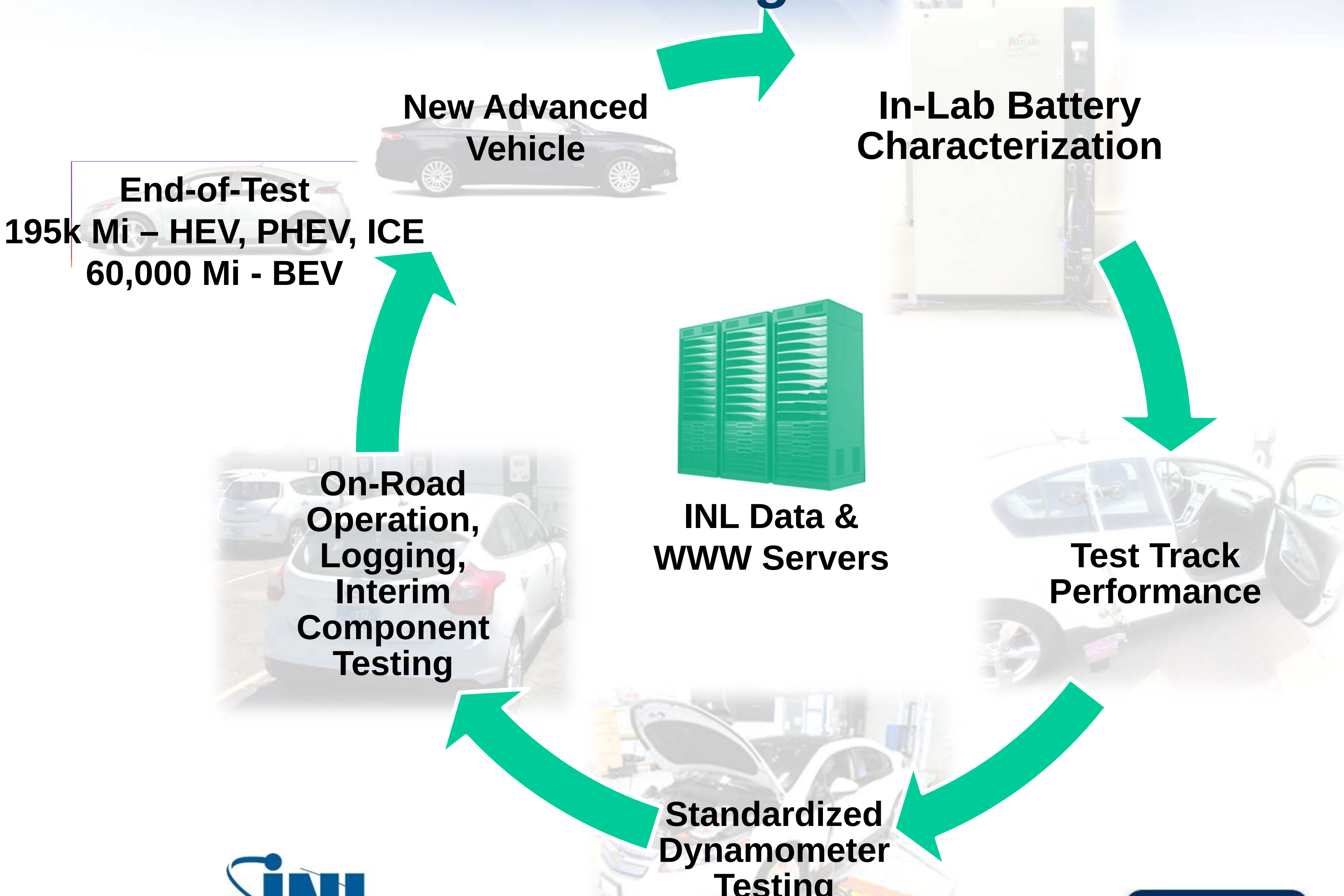
- On-road data from customer operation was analyzed
  - 158,468,000 miles from 21,600 vehicles
  - eVMT analysis
    - Annual eVMT ranged from
      - BEV: 9,548 to 9,697 mi
      - PHEV / E-REV: 2,484 to 9,112 mi
- Data from all vehicle models were from varying regions and climates
- Multiple eVMT calculation methods were compared
  - eVMT calculation methods only differed by <2.5%
- Second Phase
  - Additional vehicle miles
  - More regional and seasonal analysis

Advanced Vehicle Testing – Owned Vehicles

- **77 (FY-15) Advanced Vehicles currently in testing**
  - **Battery electric, battery electric-plus, extended range electric, plug-in hybrid electric, hybrid electric vehicles**
- **Reports published via the AVTA & DOE websites, & industry meetings & symposiums**
  - **Baseline Performance testing**
  - **Battery Characterization & Interim testing**
  - **Fleet Operation and Performance testing**
  - **Maintenance requirements**
  - **Fuel and Electricity Consumption**
  - **Overview Vehicle Fact Sheet**
- **Multiple stages of full vehicle and component testing with industry, lab partners…**
  - **Leverages funding from fleet operators for fuel, insurance, drivers**
- **Supports fleets' and the public's maintenance, life-cycle costs, vehicle durability, and battery life decisions**



Advanced Vehicle Testing Process



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Advanced Vehicle Testing – Owned Vehicles

Example of PHEV fact sheet information

- **Mpg & DC Wh/mi**
- **Total & trip distances**
- **Ambient temperatures**
- **Air conditioning use**
- **By trip mode**
  - **All trips**
  - **EV trips**
  - **Mixed mode trips**
  - **Charge sustaining trips**
- **AVTA installed data loggers**

Advanced Vehicle Testing Activity — INL Idaho National Laboratory

Plug-In Hybrid Electric Vehicle Operation Data Summary for 2013 Ford C-Max Energi VIN 3817

Reporting Period: January 2014 through August 2014

All Trips[1]

Overall gasoline fuel economy (mpg)[5]	46
Overall DC electrical energy consumption (DC Wh/mi)	46
Total distance driven (mi)	12,939
Average trip distance (mi)	11
Percent of miles city | highway	57% | 43%
Average ambient temperature (deg F)	91.6
Percent of miles driven with air conditioning selected	88%

EV Trips[2]

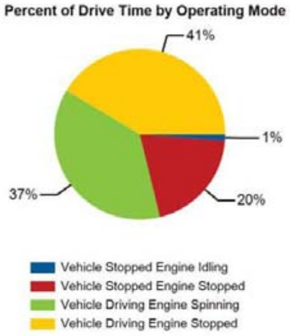
Overall gasoline fuel economy (mpg)[5]	N/A
Overall DC electrical energy consumption (DC Wh/mi)	288
Total distance driven (mi)	575
Average trip distance (mi)	3.0
Percent of miles city | highway	100% | 0%
Average ambient temperature (deg F)	78.1
Percent of miles driven with air conditioning selected	63%
Percent of total distance traveled	4%

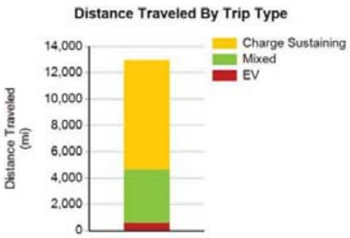
Mixed-Mode Trips[3]

Overall gasoline fuel economy (mpg)[5]	66
Overall DC electrical energy consumption (DC Wh/mi)	123
Total distance driven (mi)	4,041
Average trip distance (mi)	8.7
Percent of miles city | highway	73% | 27%
Average ambient temperature (deg F)	88.5
Percent of miles driven with air conditioning selected	79%
Percent of total distance traveled	31%

Charge Sustaining Trips[4]

Overall gasoline fuel economy (mpg)[5]	38
Overall DC electrical energy consumption (DC Wh/mi)	-8
Total distance driven (mi)	8,323
Average trip distance (mi)	14.5
Percent of miles city | highway	46% | 54%
Average ambient temperature (deg F)	95.3
Percent of miles driven with air conditioning selected	94%
Percent of total distance traveled	64%





1. Calculated from on-board electronic data logged over 12,939 miles, which may be a subset of total lifetime miles driven.
2. Trips where the vehicle was propelled by battery energy only, using no gasoline.
3. Trips where gasoline was consumed by the engine, and net electrical energy was consumed from the battery to propel the vehicle.
4. Trips where gasoline was consumed by the engine to propel the vehicle, while the net electrical energy consumed from the battery was less than 1% of the gasoline energy consumed.
5. Gasoline consumption calculated using Mass Air Flow and Commanded or Measured Air-Fuel Ratio read from OBD2 messages assuming AFR_{stoich} = 14.7 and $\rho_{gasoline}$ = 2819 g/gal.

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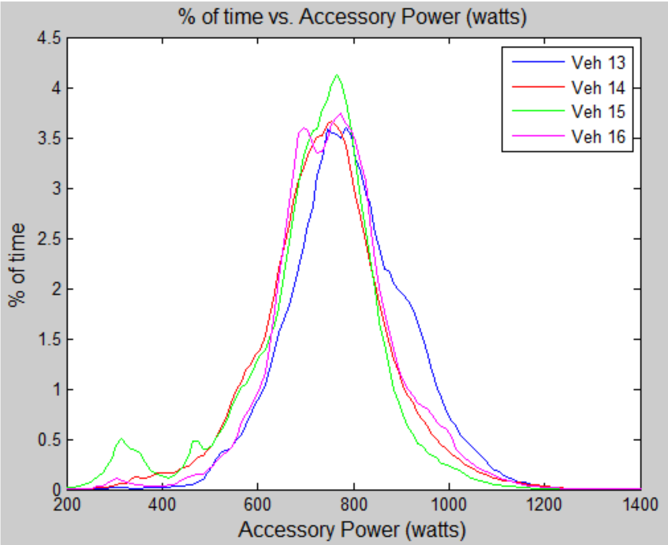
Characterization of On-Road 12V Accessory Power

Per Chrysler's, GM's, and Ford's request

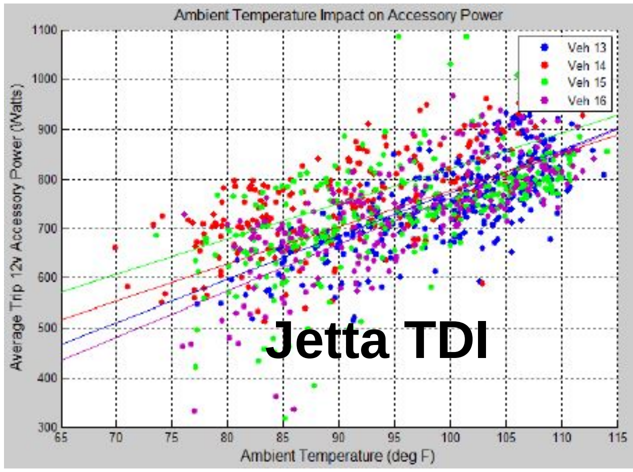
- **INL is collecting and analyzing accessory load data on non-electrified vehicles to support OEM knowledge of off-cycle fuel requirements**
- **Vehicles operated on-road in Phoenix and Houston areas over 80,000 mi/year/vehicle**
  - **Volkswagen Jetta TDI (4 vehicles)**
  - **Honda Civic CNG (4 vehicles)**
- **Preliminary Results**
  - **Average accessory load = 738 watts**
  - **Factors that impact accessory load**
    - **Ambient temperature = increase in A/C utilization (multiple fans)**
    - **Time of Day = night operation loads increase ~ 150W from lights**



Accessory Power Summary

- Jetta TDI Date range: May 13, 2014 through July 17, 2014
- Civic CNG Date range: June 28, 2014 through July 25, 2014
- Data will continue to be collected and analyzed over the next ~2 years as part of the AVTA

- Fleet average Accessory Power (Qty:4 VW Jetta TDI vehicles)
  – 740 Watts
- Fleet average Accessory Power (Qty:3 Honda Civic CNG vehicles)
  – 329 Watts



- Measurable impact on accessory load power:
  – Ambient Temperature
    - Jetta TDI: Approx. 7.5 Watts / degF
  – Time of day
    - Lighting for night driving
      – Approx. 150 Watt increase for night driving
  – Ambient Temperature tracks with Time of Day

DC Fast Charging Impact Study on 2012 Leafs

- Two Goals
  - Determine DC Fast Charge (DCFC) impacts versus Level 2 impact
  - Compare on-road to laboratory test results

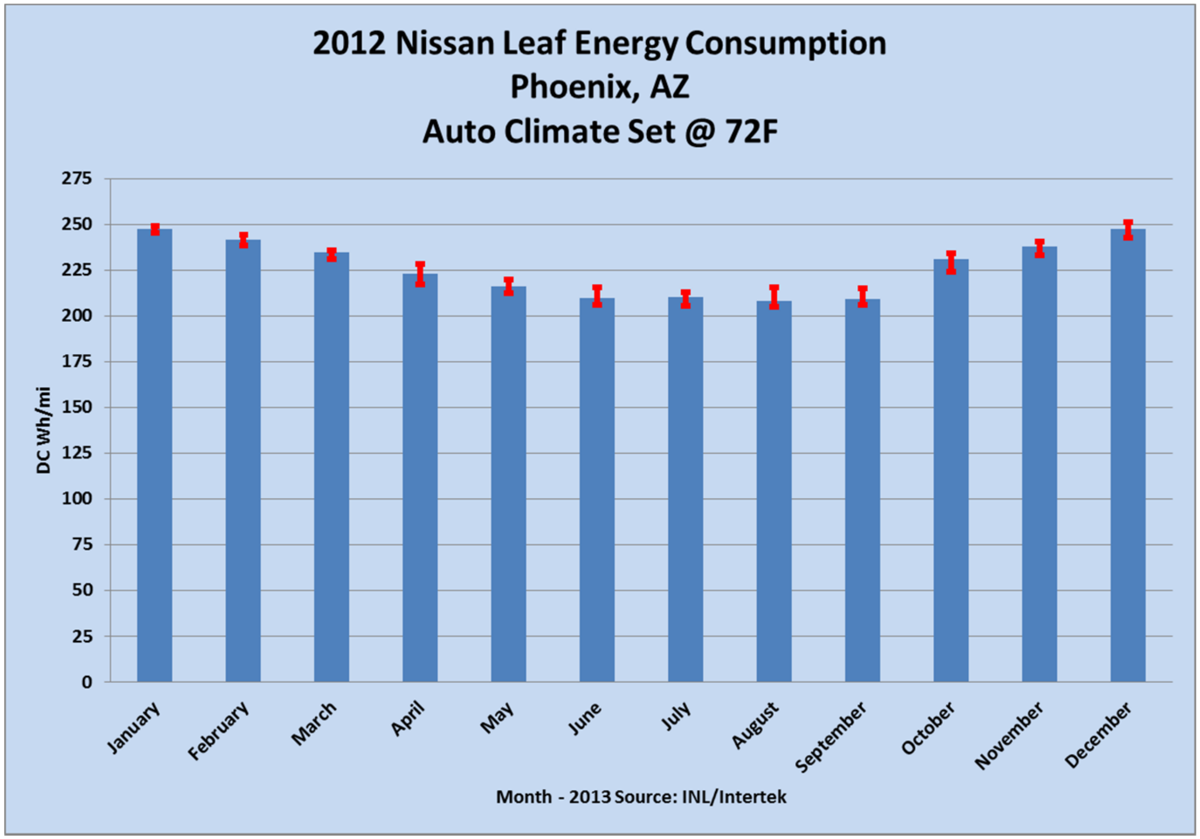
- Two on-road Nissan Leafs are exclusively Level 2 (L2) charged
- Two on-road Nissan Leafs are exclusively DCFC charged
- Identical on-road routes are driven
- Drivers' miles are balanced – all drive the four vehicles equally

- Each Leaf battery was tested when new (Base case)
- Each on-road battery is retested at 10,000-mile increments
- Battery temperature is tracked during normal charging operations
- 50,000 miles completed, going to 70,000 miles per on-road Leaf
- 24 battery tests completed on the on-road Leaf batteries

- Lab testing of two additional batteries (only preliminary results) @ 4,000 mile increments

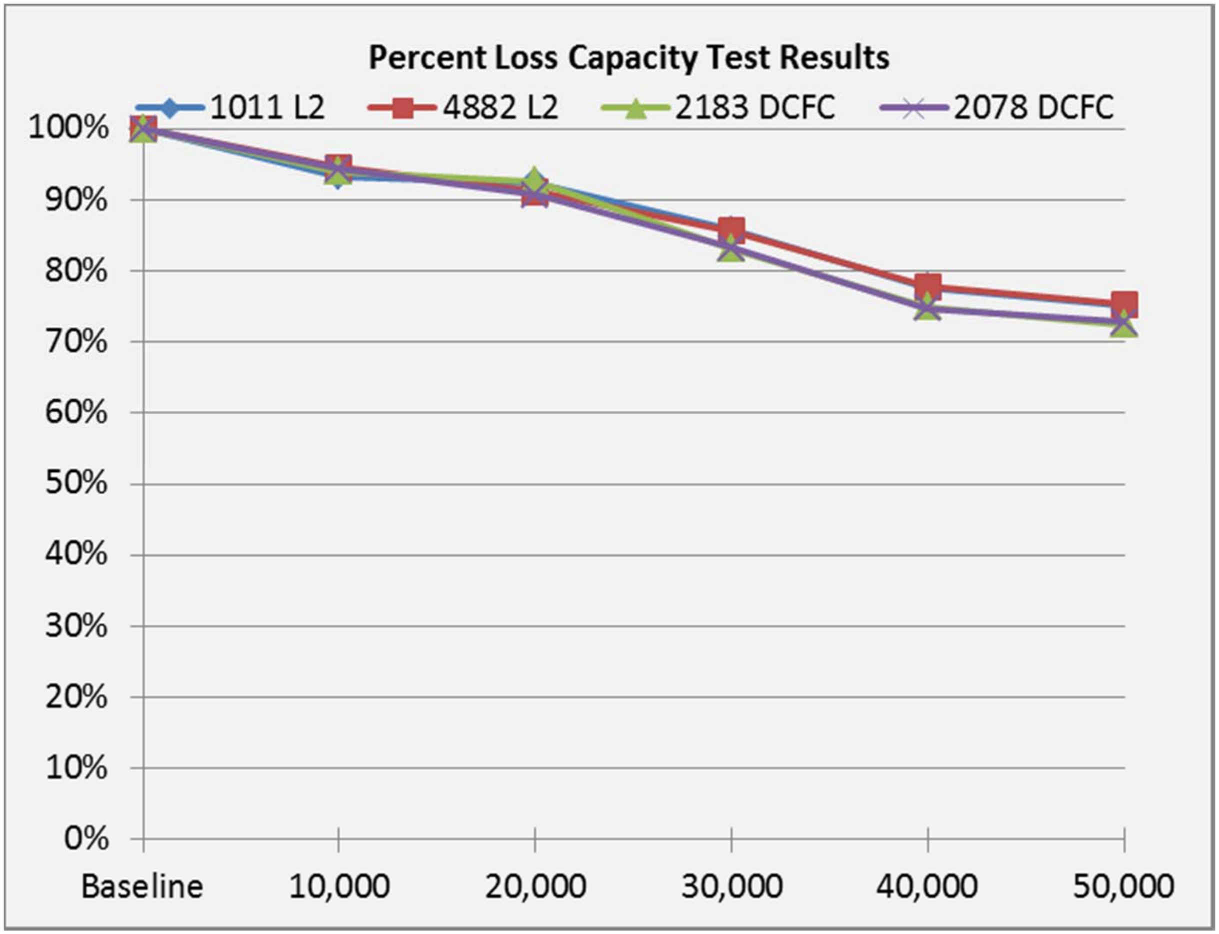
DC Fast Charging Impact Study on 2012 Leafs

- All Leafs were the same color – avoid unequal solar loading
- Note very tight monthly efficiency results across all four Leafs during Level 2 and DCFC operations (red min & max bars)
- Leafs' climate control is set at 72ºF year round
- Note seasonal efficiency impacts from heating and air conditioning
  - 39.8 DC kWh/mi delta for min vs. max month
  - Max month 19% higher than min month

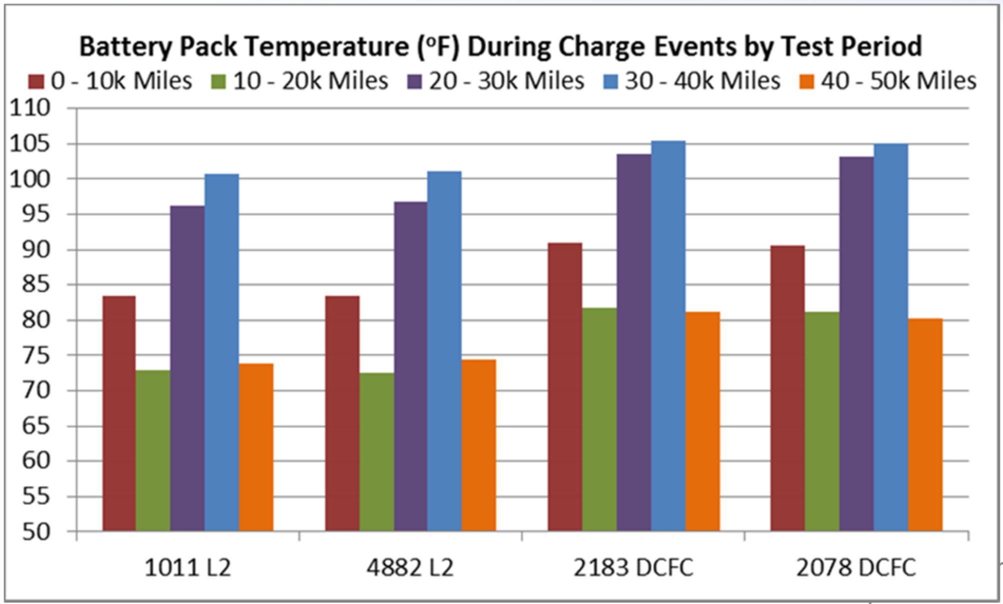


DC Fast Charging Impact Study on 2012 Leafs

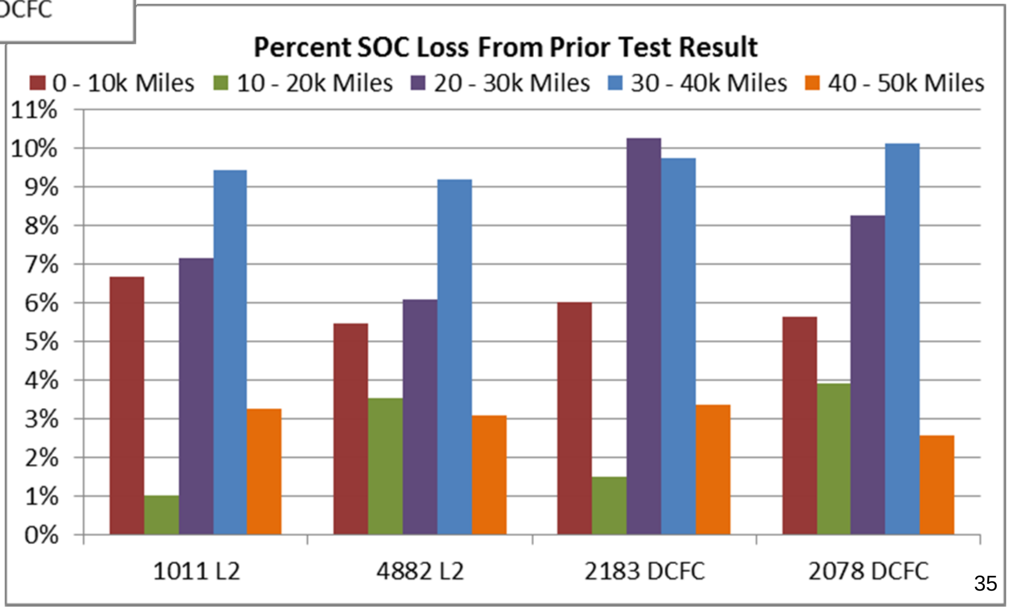
- **Each line represents a single vehicle, plotted by capacity loss for each 10,000-mile battery test**



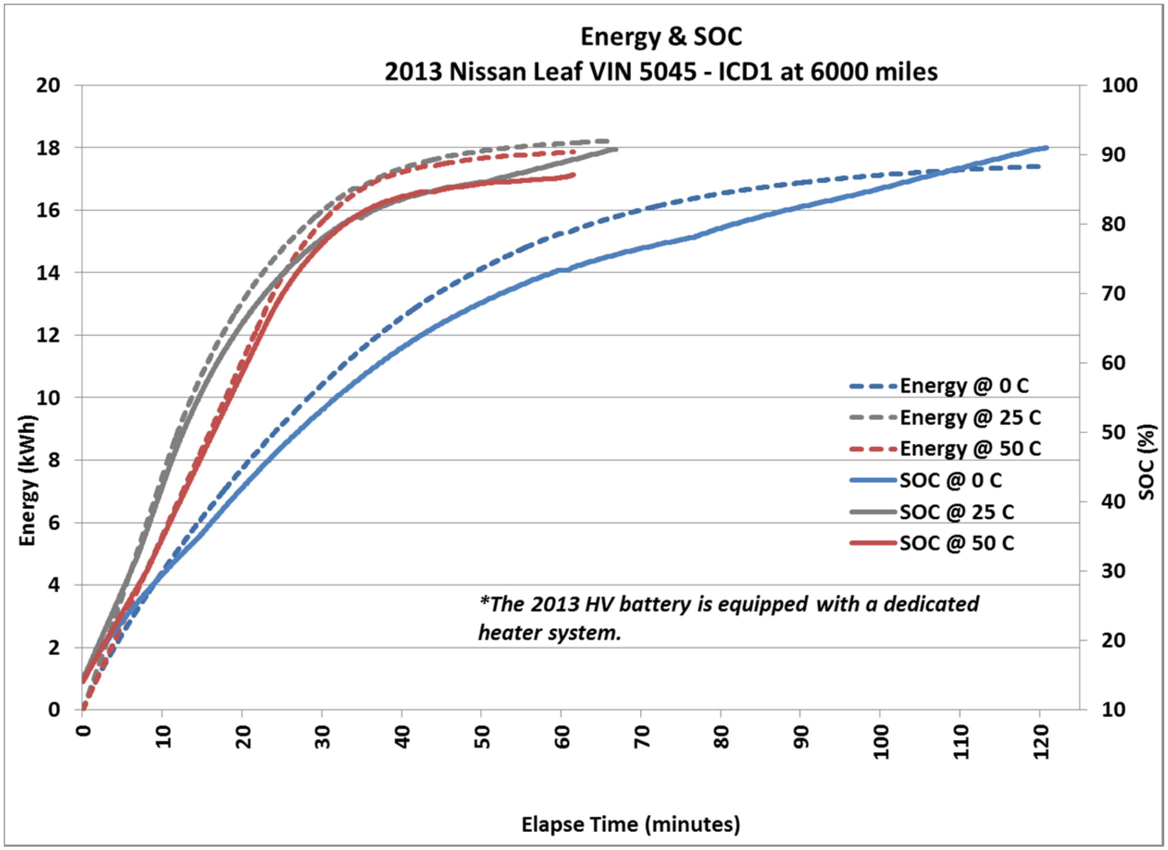
DC Fast Charging Impact Study on 2012 Leafs



- **Quantify impact on battery capacity, vehicle range via field & lab testing**
- **DCFC 27% & L2 25% capacity losses at 50k miles/vehicle**
- **Phoenix heat results in highest decreases in capacity from test before during high-heat charging operations**



DC Fast Charging @ 0, 25 & 50 C Impacts – 2013 Nissan Leaf



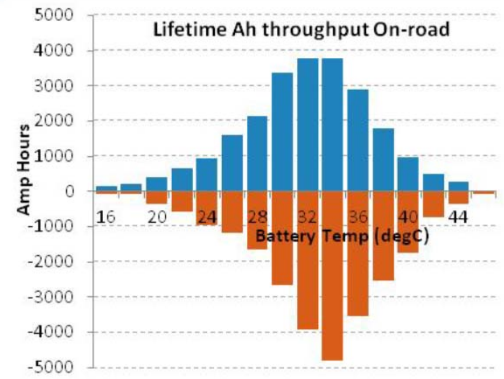
- **After 30 minutes:**
  - **50 C: 77% SOC**
  - **25 C: 77% SOC**
  - **0 C: 53% SOC**
- **At charge end:**
  - **50 C: 87% SOC at 62 minutes**
  - **25 C: 91% SOC at 67 minutes**
  - **0 C: 91% SOC at 121 minutes**
- **Total kWh:**
- **50 C: 17.9 kwh**
- **25 C: 18.2 kWh**
- **0 C: 17.4 kWh**

Preliminary Data Results

- **Additional vehicle battery and charging infrastructure cold and hot weather charging performance will be incorporated into the AVTA benchmarking**

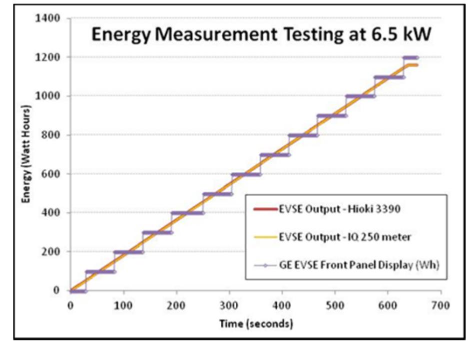
Electric Drive and Advanced Battery and Components Testbed (EDAB)

- **Provide an on-road and dynamometer capable platform for testing Energy Storage Systems (ESS)**
- **Operating modes include all-electric and blended plug-in hybrid electric vehicles**
- **Capture data from ESS performance, capacity fade, and operating condition data during on-road operations**
- **Capture data from motor and power electronic during on-road operation**
- **Detailed data collected during real world driving and charging**
- **Objective is on-road operation and laboratory testing of ESS's to capture performance and capacity fade characteristics**
- **EnerDel pack completed, Toshiba battery entered testing**



Smart Grid EVSE Cyber Security & other Testing

- **Eaton, Sermons, Delta, and GE smart EVSE were developed via an Office of Electricity FOA. Blink EVSE loaned by Blink**
- **Cyber Security testing was completed for the two of five EVSE delivered**
  - **Identified severity and cause of vulnerabilities**
    - **Hardwired connections**
    - **Wireless communication**
    - **Invasive investigation internal to EVSE**
    - **Firmware and back-office vulnerability testing**
  - **Report to EVSE manufacturers**
- **Two EVSE tests completed, results published**
  - **Power Consumption while not charging**
  - **Average efficiency while charging**
  - **Evaluation of EVSE internal energy meter**



Test Condition	Average EVSE Efficiency (Output Power/Input Power)
50 watts	71.9%
1.1 kW	97.8%
3.3 kW	98.7%
6.5 kW	98.5%

Miscellaneous Ongoing Benchmarking

- **Nissan Leaf NYC**
  - **A small fleet of Nissan Leafs are branded and used as taxi cabs**
  - **Per HQ direction, INL defined the team and defined a test plan**
  - **INL collects data from Nissan and the New York City Taxi and Limousine Commission**
  - **Reports on vehicle use and charging metrics**
  - **Supports NYC decision process to introduce electric taxis**
- **NYSERDA car charging infrastructure demonstration**
  - **Approximately 400 EVSE from multiple vendors in NY State**
  - **INL collects charging data from several vendors and reports on use partners – supports NYSERDA decisions about future EVSE sittings**
  - **Teamed with Energetics**

Supporting SAE J2954 via Test Data and Results

- **Objective is to support the SAE J2954 Wireless Charging standards committee by providing test results and test procedure feedback and refinement**
- **INL conducted independent testing using *draft* J2954 test procedures for:**
  - **System Efficiency and EM-field across a range of misalignment, coil gap, and output power**
    - **Off-board vehicle (open-air)**
    - **On-board vehicle (300 meters?)**
  - **Debris tolerance and response**
  - **Mock floor-pan characterization**
- **Considering FCC required testing on-board the vehicle at 300 meters**
- **INL is the only DOE lab to publish wireless charging benchmarking results**

PEV/EVSE Interoperability Project: Introduction

- **Objective is to identify PEV/EVSE interoperability issues, not to publicly state whose equipment did what**
- **In the Interoperability project, staff are helping to evaluate the SAE J2953 standard on the interoperability of PEVs and EVSE to ensure industry compatibility**
- **Participants from leading PEV and EVSE manufacturers have supplied products that are being tested in pairs. Feedback is being provided to industry on project findings**
- **The project includes an evaluation of the Argonne National Labs Interoperability software**
- **Intertek personnel have become members of the SAE J2953 committee, and report project findings to help shape the J2953 standard**

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Interoperability Project: Project Participants

	EVSE Participants
1	Eaton Marina
2	Clipper Creek CS-100
3	Clipper Creek LCS-25
4	GE
5	Siemens
6	Schneider Electric
7	ChargePoint
8	Merit Charge LLC
9	AddEnergie CoRe+
10	AddEnergie Smart Two
11	Aerovironment
12	Bosch
13	EVSE LLC (A division of Control Module Inc.)

	Vehicle Participants
1	Mitsubishi i-MiEV
2,3	Toyota Prius Plug-In, RAV4 EV
4	Nissan Leaf
5	Kia Soul EV
6,7	Ford C-MAX Energi, Focus EV
8	VW eGolf
9	BMW i3
10	Chevrolet Volt
11,12	Honda Fit EV, Accord PHEV
13	Fiat 500e
14,15	Smart Fortwo ED (B-Class EV?)

Interoperability Project: Status

- Testing is complete on:
  - Mitsubishi i-MiEV
  - Toyota Prius Plug-In
  - Toyota RAV4 EV
  - Nissan Leaf
  - Ford C-MAX Energi
  - Ford Focus EV
  - VW eGolf
  - BMW i3
  - Chevrolet Volt (Will finish October 17th)

- Test results have been disseminated down to the Nissan Leaf
- Intertek personnel are updating SAE J2953 committee members on interim project findings at monthly meetings

Interoperability Project: Interim Findings

- **One EV failed during testing. The cause is unknown. The vehicle was recalled by the OEM and has been re-scheduled for the open slot at the end of December (Dec 22-Jan 9)**
- **PEV-EVSE pairs have been able to charge vehicles, but there have been failures according to J2953 criteria—therefore, most PEV-EVSE pairs have received "soft passes" rather than full passes**
- **The Mechanical test that is part of Tier 1 of J2953 is too arbitrary and dependent upon the individual test personnel**

New AVTA Vehicle Benchmarking FY15

- 4 - 2015 Mazda 6 i-Eloop
- 4 - 2015 Honda Accord PHEV
- 4 - 2015 BMW i3 EV
- 4 - 2015 BMW i3 EV with Range Extender
- 4 - 2015 Kia Soul EV
- 4 - 2015 Mercedes B-Class EV
- 4 - 2015 Chevrolet Spark EV
- 4 - 2015 Volkswagen e-Golf EV
- 4 - 2015 Chevrolet Cruze Diesel
- 4 - 2015 Chevrolet Impala CNG
- 4 - 2015 Ford E-350 Propane Conversion by Roush
- Start/stop Ram pickup, CNG & Gasoline, Advanced Pb pack
- XL Hybrids – NDA data collection from initial 140 delivery vans with the HEV conversion kit, via the XL Hybrids telematics systems
- Via Motors – initially 140 to 150 vans and pickups with the PHEV conversion kit, via an EPRI telematics system

Additional Information

For publications and general plug-in electric vehicle performance, visit

http://avt.inl.gov