ASME Treasure Valley Section - Electric Drive Vehicles and Infrastructure Overview

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November 2010

Presentation Outline

- Idaho National Laboratory (INL) / Advanced Vehicle Testing Activity (AVTA) backgrounds
- Comparison of Internal combustion engine (ICE), hybrid electric (HEV), plug-in hybrid electric (PHEV), and battery electric (BEV) vehicle technologies
- Grid connected vehicle charging infrastructure and charging levels
- INL / AVTA electric drive vehicle testing
- American Recovery and Reinvestment Act (ARRA) – DOE’s Transportation Electrification Demonstrations and Educations Programs
- DOE’s Vehicle Electrification Project Data Collection
- OEM Electric Drive Vehicle Deployment Announcements
- Acknowledgement and AVTA WWW Address (Test Reports / Fact Sheets)
- The northern most Blue Football Field in America
Idaho National Laboratory

- Eastern Idaho based U.S. Department of Energy (DOE) Federal laboratory
- 890 square mile site with 3,600 staff
- Support DOE’s strategic goal:
  - Increase U.S. energy security and reduce the nation’s dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Development
  - Energy Critical Infrastructure Protection

AVTA Description

- Advanced Vehicle Testing Activity (AVTA) is conducted by INL for DOE’s Vehicle Technologies Program
- AVTA tests light-duty vehicles, battery subsystems, and fueling infrastructures that employ / support:
  - 100% Electric and dual-fuel electric drive systems
  - Advanced energy storage systems
  - Some ICE 100% Hydrogen and HCNG blended fuels
  - Advanced control systems (i.e., start/stop HEVs)
- Provide benchmarked vehicle and infrastructure testing results to R&D programs, modelers, OEMs, battery manufacturers, and target/goal setters (DOE)
- Assist early adaptor fleet managers and the general public in making informed vehicle purchase, deployment and operating decisions
- Presentations to industry groups, including via Clean Cities’ sponsored webinars and symposiums
Comparison of Vehicle Technologies

• Conventional vehicle with internal combustion engine (ICE) only
Comparison of Vehicle Technology

- Hybrid Electric Vehicle (HEV) with ICE and electric drive
- Does not plug in to electric grid

Comparison of Vehicle Technology

- Plug-in Hybrid Electric Vehicle (PHEV) with ICE and electric drive
Comparison of Vehicle Technology

- Battery Electric Vehicle (BEV) with electric drive only

Conceptual Comparison of Vehicle Operation

- Hypothetical 15 mile drive cycle
Conceptual Comparison of Vehicle Operation

Conventional vehicle

HEV

PHEV10 (all-electric capable)

BEV (100 mi range)

Grid Connected Vehicle Charging Infrastructure Overview
Vehicle Electrification: Grid Impacts

• In the U.S., current grid capacity could supply electricity for 70% of our vehicles without adding capacity, but assumes:
  – Vehicles would only charge off-peak
  – “Perfect” distribution of electricity
  – No local impacts such as overburdening neighborhood transformers
• EVs and PHEVs will not cause a grid “meltdown” but we clearly need to work fast to reduce vehicle rollout impacts
• Smart charging will be key to lowering costs and minimizing impacts
• Time of day pricing also important
• Administration Goal: 1 Million Plug-in Vehicles by 2015

Build-out of Charging Infrastructure

• Key today: Home Charging
  – Need to get the cost and installation process right. Currently a significant barrier
• Public Charging
  – Expansive if not well utilized
  – Expansive to fully cover full driving patterns
• Ideally need market pull to determine public infrastructure build-out
  – PHEVs may be key to help initiate market pull for public infrastructure
Innovative Approaches

- Battery swapping
  - Requires OEM buy-in
- Fast Charging (becoming less innovative)
- Innovative Financing
- Secondary use of batteries
  - Utility ancillary services
  - Bulk energy storage
  - Present value
- Vehicle to Grid (V2G)

Level 1 Charging Level

- This method allows broad access to change an EV or PHEV by plugging into the most common grounded electrical outlet in the U.S.
- AC energy transfer to onboard charger
- Typical hardware includes portable cord set that must utilize a vehicle connector UL approved for the purpose, a GFCl, and otherwise meet NEC 625 requirements and SAE standards, including the J1772 connector:
  - Separate circuit
  - Standard 120V/15A or 20A
  - Current 12 amps or 16 amps (80% of amp breaker)
  - Power 1.44 kW
- Charge Times (general approximation)
  - Battery EV 14 hours (20 kWh battery) to 39 hours (56 kWh battery)
  - PHEV 3 to 8 hours
  - NEV 9 to 13 hours
Level 2 Charging Level

- Expected to be most common method for residential and commercial charging
- EVSE (electric vehicle supply equipment) for AC energy transfer to onboard charger
- Permanently attached wall box, GFCI, some vehicle communication, UL approved, NEC 625 requirements and SAE standards, including J1772 connector:
  - 240V single phase up to 100A
  - Current up to 80A (80% of amp breaker)
  - Power up to 19.2 kW
  - 3.3 kW or 6.6 kW more typical initially
- Charge Times (general approximation)
  - 20 kWh Battery EV 3 hours (at 6.6 kW) to 56 kWh battery in 8.5 hours (at 6.6k kW)
  - PHEV 3 to 8 hours
  - NEV 9 to 13 hours

Level 3 Charging Level

- This charge level is NOT “FAST Charge” as currently used
- Typically would be 480VAC energy transfer to an onboard charger
- Current up to 400 amps
- Typically 60 kW to 120 kW, but can be up to 200 kW
- HOWEVER, no light-duty original equipment vehicle manufacturer plans to use onboard chargers at these energy levels
Fast Charging

• Expected to be used in an intercity grid pattern or along travel routes between cities in commercial settings
• Off-board charger (high cost, large volume and weight)
• Used for DC energy transfer to vehicle
• Requires most charger-to-vehicle communication and control
• No current U.S. SAE standard connector, however, U.S. fast chargers are using Japanese TEPCO (Tokyo Electric Power Company) connector per CHAdeMO protocol
• Up to 500VDC and 125A. 60 kW likely
• Charge Times are dependant on battery size
  – BEV intent is 50% recharge in 15 minutes and 80% recharge in 30 minutes
  – Charge times dependant on charger / battery relative sizing
  – Generally not used for PHEVs and NEVs due to small relative battery sizes
**AVTA Vehicle Testing Approach**

- Depending on vehicle technology and capabilities, vehicles are tested via:
  - Closed test tracks
  - Dynamometer testing
  - Laboratory testing (batteries)
  - Accelerated testing, using dedicated drivers and other methods to accumulate miles and cycles
  - Fleet testing, uses unstructured vehicle utilization
  - Different testing methods are used to balance testing control/repeatability, sample size, and costs
- Current INL staff has used onboard data loggers to document vehicle and charging operations since 1993
- Publish testing results in relevant ways to accurately
  - Document real-world petroleum reduction potentials
  - Document fuel and infrastructure use
  - Document life-cycle risks and costs

**Testing by Vehicle Technology**

- Plug-in hybrid electric vehicles (PHEVs)
  - 12 models, 259 vehicles, 3 million test miles
- Hybrid electric vehicles (HEVs)
  - 22 models, 56 vehicles, 5+ million test miles
- Neighborhood electric vehicles (NEVs)
  - 23 models, 200,000 test miles
- Hydrogen internal combustion engine (HICE) vehicles
  - 7 models, 500,000 test miles
- Full-size battery electric vehicles (BEVs)
  - 41 EV models, 5+ million test miles
- Urban electric vehicles (UEVs)
  - 3 models, 1 million test miles
- 15 million test miles have been accumulated on 1,600 electric drive vehicles representing 107 different electric drive models
PHEV Testing To Date

- 12 PHEV models tested to date
  - Hymotion Prius (A123 Systems)
  - Hymotion Escape (A123 Systems)
  - Ford E85 Escape (Johnson Controls/Saft)
  - EnergyCS Prius, 2 models (Valance and Altair Nano)
  - Electrovaya Escape (Electrovaya) - done
  - Hybrids Plus Escape, 2 models (Hybrids Plus and K2 Energy Solutions)
  - Hybrids Plus Prius (Hybrids Plus)
  - Manzanita Prius (lead acid and Thunder Sky)
  - Renault Kangoo (Saft NiCad) - done
  (Lithium unless noted)

- Testing focus is on the PHEV technology concept and batteries, and driver and environmental impacts on fuel efficiencies and charging rates, not on individual PHEV conversions

PHEV Testing Partners

- 259 PHEVs in 26 states, Canada and Finland, 3 million miles - AVTA only purchased 2 PHEVs and conducted 12 conversions. Highly leveraged testing activity

- 93 PHEV testing partners include:
  - 38 Electric utilities
  - 10 County governments
  - 4 State governments
  - 10 Canadian government groups
  - 3 Sea ports and military bases
  - 2 PHEV conversion companies
  - 5 Private companies and advocacy organizations

- 3,000+ automated monthly 3-page summary reports have been generated and disseminated to testing partners
Current PHEV Conversion Demonstrations

Most Vehicle Conversions
- Prius & Escapes
- Li-ion Batteries

Vehicle Data Management Process

Process Affected by Disclosure Agreements

INL Vehicle Data Management System

- HICEVs
- HEVs
- PHEVs
- BEVs / EREVs
- EVSE & Chargers

File server
SQL Server data warehouse
Report generator

Data quality reports
Individual vehicle reports
Fleet summary Reports - Public
Focused technical analyses and custom reports
Modeling and simulations
## Vehicle and Infrastructure Data Sources

<table>
<thead>
<tr>
<th>Vehicle time-history data (second-by-second)</th>
<th>HEV: 12 vehicle models, 1 data logger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HICE: 1 vehicle model, 1 data logger</td>
</tr>
<tr>
<td></td>
<td>Conversion PHEVs: 8 vehicle models, 3 data loggers</td>
</tr>
<tr>
<td></td>
<td><strong>Ford</strong> Escape PHEV, Ford wireless logger</td>
</tr>
<tr>
<td></td>
<td><strong>Chrysler</strong> Ram PHEV, Chrysler wireless logger</td>
</tr>
<tr>
<td>Vehicle event data (key-on, key-off)</td>
<td><strong>Nissan</strong> Leaf, Nissan telematics</td>
</tr>
<tr>
<td></td>
<td><strong>Chevrolet</strong> Volt, OnStar telematics</td>
</tr>
<tr>
<td>Charger event and 15 min time-history data</td>
<td><strong>ECOtality</strong> Blink networked level 2 EVSE, DC/fast chargers</td>
</tr>
<tr>
<td></td>
<td><strong>Coulomb</strong> ChargePoint networked level 2 EVSE</td>
</tr>
</tbody>
</table>

### Managing 26 different data models

### PHEV 3-Page Report
- Reports 2 million Hymotion Prius test miles and 211,000 trips
- Report by charge mode:
  - Charge depleting (CD)
  - Charge sustaining (CS)
  - Mixed (CD/CS)
- All trips, 48 mpg, 58 AC Wh/mi & 37 DC Wh/mi
- CD, 60 mpg & 121 DC Wh/mi
- CD/CS, 53 mpg & 46 DC Wh/mi
- CS, 43 mpg
PHEV 3-Page Report

- Report fuel use by highway/city cycles and driver style
- CD city, 58 mpg, 146 DC Wh/mi
- CD highway, 64 mpg, 90 DC Wh/mi
- CS city, 37 mpg
- CS highway, 45 mpg
- Less aggressive driving (0 to 20%) averages ~70 mpg
  - (Aggressiveness = accelerator pedal position)

PHEV 3-Page Report

- Report charging stats, time of day driving, and charging profiles
- Average 1 charging event per day when PHEV driven
- 47 miles between charge events
- 5.1 trips between charge events
- 2.8 hours per charge
- 22.3 hours time plugged in per charge
- 2.7 AC kWh per charge event
PHEV Ambient Temperature MPG Impacts

Engine Operation is a Main Factor for PHEV Fuel Economy Changes
Hymotion Prius PHEVs – CD Trips

- MPG and aggressive driving impacts March ‘08 – May ‘09

MPG & Driver Aggressiveness for 22,700 CD Trips, 151,000 miles (6.7 miles average trip distance)

Data from 150 Hymotion Prius with V2Green and Kvaser loggers

Usable Battery Capacity is Slightly Effected by Temperature

Hymotion Prius Battery Energy Capacity
PHEV Fleet Results from Full Charge Trip Sequences
Hymotion Li-Ion Battery Internal Resistance Change with Temperature

Commercial / Private Fleet Charge Demand

Private Fleet

Commercial Fleet
HEV Testing

- 5 million total HEV testing miles
- 22 HEV models and 56 HEVs tested to date:
  - 6, 2001 Honda Insight – 2, 2007 Toyota Camry
  - 6, 2002 Gen I Toyota Prius – 2, 2008 Nissan Altima
  - 4, 2003 Gen I Honda Civic – 2, 2008 GM 2-mode Tahoe
  - 2, 2004 Chevrolet Silverado – 2, 2010 Ford Fusion
  - 2, 2004 Gen II Toyota Prius – 2, 2010 Toyota Prius
  - 2, 2005 Ford Escape – 2, 2010 Honda Insight
  - 2, 2005 Honda Accord – 2, 2010 Mercedes Benz S400
  - 3, 2006 Lexus RX 400h – 2, Honda CRZ
  - 2, 2006 Toyota Highlander – 3, 2010 Smart Fortwo Pure Coupe
  - 2, 2006 Gen II Honda Civic – 2, 2010 MazDA 3 Hatchback
  - 2, 2007 Saturn Vue – 2, 2010 Volkswagen Gold TDI.

- HEV testing includes beginning and high mileage HEV traction battery testing – HPPC, Static Capacity tests, as well as acceleration and fuel economy tests.

HEV Air Conditioning use MPG Impacts

<table>
<thead>
<tr>
<th>Car Model</th>
<th>Percent MPG Difference (J1634 With &amp; W/O Air)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gen I Insight</td>
<td>-18.6%</td>
</tr>
<tr>
<td>Gen I Prius</td>
<td>-16.0%</td>
</tr>
<tr>
<td>Gen II Civic</td>
<td>-13.9%</td>
</tr>
<tr>
<td>Silverado</td>
<td>-15.1%</td>
</tr>
<tr>
<td>Accord</td>
<td>-16.7%</td>
</tr>
<tr>
<td>Highlander</td>
<td>-16.1%</td>
</tr>
<tr>
<td>RAV4</td>
<td>-22.1%</td>
</tr>
<tr>
<td>Gen II Civic</td>
<td>-21.7%</td>
</tr>
<tr>
<td>Camry</td>
<td>-22.1%</td>
</tr>
<tr>
<td>Vue</td>
<td>-24.4%</td>
</tr>
<tr>
<td>Altima</td>
<td>-24.4%</td>
</tr>
<tr>
<td>Tahoe</td>
<td>-22.1%</td>
</tr>
<tr>
<td>Gen III Prius</td>
<td>-22.1%</td>
</tr>
<tr>
<td>Gen III Insight</td>
<td>-21.8%</td>
</tr>
<tr>
<td>Ford Fusion</td>
<td>-22.1%</td>
</tr>
<tr>
<td>Mercedes S400</td>
<td>-22.1%</td>
</tr>
<tr>
<td>Average</td>
<td>-22.1%</td>
</tr>
</tbody>
</table>
HEV Maintenance Sheets

HEV Fleet Testing
Advanced Vehicle Testing Activity
Maintenance Sheet for 2007 Nissan Altima

2-Page HEV Fleet Testing Fact Sheets
NEV Testing

- CARB requires all NEVs be tested by AVTA to be eligible for incremental funding – 25 models tested to date

**NEV Maximum Speed and Range Test Results**

- Maximum Speed Test (mph) with 170 lbs Payload
- Range Test (miles) - tested at max speed
AVTA NEV Testing – cont’d

American Recovery and Reinvestment Act (ARRA) – DOE’s Transportation Electrification Demonstrations and Educations Programs
American Recovery and Reinvestment Act (ARRA)

• $2 Billion in DOE grants to establish advanced battery, power electronics and motors manufacturing
• $400 Million for Transportation Electrification Demonstration, Infrastructure, and Education
  – 8 Awards totaling over $360M for grid-connected vehicle and infrastructure demonstrations
    • 13,000 vehicles from 9 OEMs and over 22,000 charging stations will be deployed across America
    • Vehicle performance and grid impact data will be gathered and analyzed to support the development of vehicle technologies and grid infrastructure
  – 10 Grants totaling $39M - establish comprehensive educational and outreach programs to educate first responders and emergency personnel for dealing with EV and PHEV accidents
    • Also, public outreach

Transportation Electrification Demonstration Activities

**Electric Transportation Engineering Corporation - AWARD: $114.8M**

• Demonstration of 5,700 Nissan Leaf EVs and 2,600 Chevy Volt EREV
• Deployment of 15,000 Level 2 electric vehicle supply equipment (EVSE) charging Stations (EVSE) and 300 fast chargers, in 16 metropolitan areas
• Full instrumentation of vehicles and infrastructure for comprehensive data-collection and analysis effort

**Chrysler, LLC - AWARD: $48M**

• Development, validation, and deployment of 140 PHEV Dodge Ram pickups
• Deployment of vehicles through 11 partner fleets across a wide range of geographic, climatic, and operating environments
Transportation Electrification Demonstration Activities (cont’d)

South Coast Air Quality Management District - AWARD: $45.4
• Development of a fully integrated production PHEV system for Class 2-5 vehicles (8,501-19,500 lbs GVWR).
• Demonstration of 378 trucks and shuttle buses through network of partner fleets
• SCAQMD based in Diamond Bar, CA; Manufactured in Galesburg, MI, and Elizabethtown, KY

Coulomb Technologies - AWARD: $15M
• Deployment of approximately 4,000 public and private charging stations in up to 9 U.S. Cities
• Locations will be coordinated with OEM deployment of 400 grid connected vehicles

Navistar, Inc. - AWARD: $39.2M
• Develop, validate, deploy 950 advanced Battery Electric delivery trucks (12,100 lbs GVWR) with a 100-mile range
• Manufacturing in Elkhard Co., IN; Deployment in Portland, Chicago, and Sacramento

Cascade Sierra Solutions - AWARD: $22.2M
• Deployment of truck stop electrification infrastructure at 50 sites along major US interstate corridors
• Provide 5,450 rebates of 25% of the cost for truck modification to incorporate idle reduction technologies
Transportation Electrification Demonstration Activities (cont’d)

**General Motors - AWARD: $30.5M**

- Develop, analyze, and demonstrate 125 Chevy Volt EREVs for electric utilities and 500 Volt EREVs to consumers
- Manufacturing in Detroit, MI; Deployment in conjunction with several utility partners

**Smith Electric Vehicle - AWARD: $32M**

- Develop and deploy up to 500 medium-duty electric trucks.
- Manufacturing in Kansas City, MO; Deployment in conjunction with 20 launch partners representing a range of commercial and public sector markets, geographies, and climates

Transportation Electrification Distribution
## Transportation Electrification Education Program

<table>
<thead>
<tr>
<th>Award Recipient</th>
<th>DOE Award</th>
<th>Project Locations</th>
<th>Project Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Virginia University (National Alternative Fuels Training Consortium)</td>
<td>$6.9M</td>
<td>Morgantown, WV State of South Carolina</td>
<td>Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Emergency Responders; General Public; Partnering with: NAFTC Headquarters and members; West Virginia Department of Education; South Carolina Department of Education; Greater New Haven Clean Cities Coalition; Innovation Drive, Inc.; Advanced Vehicle Research Center; Auto Exposures LLC; Big Fish Advertising and Public Relations; MotorWeek; Sabre Engineering; Northeast Utilities</td>
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<tr>
<td>Purdue University</td>
<td>$6.1M</td>
<td>State of Indiana West Lafayette, IN</td>
<td>Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; General Public; Partnering with: University of Notre Dame; Indiana University Purdue University at Indianapolis (IUPUI); Purdue University – Calumet; Indiana University – Northwest; Ivy Tech Community College</td>
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<tr>
<td>Colorado State University</td>
<td>$5M</td>
<td>State of Colorado State of Georgia Fort Collins, CO Boulder, CO Atlanta, GA</td>
<td>Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Emergency Responders; General Public; Partnering with: CSU; Georgia Institute of Technology; Arapahoe Community College; Douglas County School System; Nissan NA; KShare; Ricardo; AM General; Motion Reality, Inc.</td>
</tr>
<tr>
<td>Missouri University of Science &amp; Technology</td>
<td>$5M</td>
<td>Rolla, MO Warrensburg, MO Linn, MO St. Louis, MO Kansas City, MO Lee’s Summit, MO</td>
<td>Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Mechanics; Emergency Responders; General Public; Partnering with: University of Central Missouri; Linn State Technical College; St. Louis Science Center; Smith Electric Vehicles U.S. Corporation (SEV-US); Kokam America Inc.</td>
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<tr>
<td>Wayne State University</td>
<td>$5M</td>
<td>Detroit, MI Warren, MI</td>
<td>Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; Technicians; Emergency Responders; General Public; Partnering with: NextEnergy; Macomb Community College</td>
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<tr>
<td>National Fire Protection Association</td>
<td>$4.4M</td>
<td>Quincy, MA</td>
<td>Educational programs for: Emergency Responders; Partnering with: Fire Protection Research Foundation; Automotive Alliance; NREL</td>
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<td>Michigan Technological University</td>
<td>$2.98M</td>
<td>Houghton, MI (Western Upper Peninsula of MI)</td>
<td>Educational programs for: Graduate, Undergraduate and Secondary Students; Teachers; General Public; Partnering with: Argonne National Laboratory; AVL; GM; Eaton; Hosta; MathWorks; Schweitzer Engineering Laboratories; Woodward</td>
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<td>J. Sargeant Reynolds Community College</td>
<td>$0.72M</td>
<td>Commonwealth of Virginia and Neighboring Mid-Atlantic States</td>
<td>Educational programs for: Secondary Students; Technicians; Partnering with: James Madison University; Virginia Department of Education; Ford; GM; Toyota; Firestone/Bridgestone</td>
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INL Data Collection Activities in Support of DOE’s Vehicle Electrification Project

INL ARRA / TADA Data Collection Support

- INL tasked with data collection, analysis and reporting for five light-duty vehicle and infrastructure deployment projects funded by DOE via ARRA and Technology Acceleration and Demonstration Activity (TADA):
  - EV Project: 8,300 Leaf EVs and Volt EREVs, and 15,300 eTec Level 2 EVSE and fast chargers. All 23,600 pieces of equipment are equipped with data loggers (DLs)
  - 140 Chrysler Ram PHEV Pickups with DLs
  - 125 General Motors EREV Volts with DLs
  - 21 Ford Escape PHEV SUVs with DLs
  - 4,000 Level 2 EVSE deployed by Coulomb with DLs
- Raw data and personal information protected by numerous NDAs (Non Disclosure Agreements) with participant partners
EV Project - Overview

• $230 million total project funded by a US Department of Energy grant ($115 million) via the American Recovery and Reinvestment Act (ARRA)
• Partners cost share match greater than $115 million
• Lead by Electric Transportation Engineering Corporation (eTec) (renamed Ecotality NA)
• Data will be collected by INL via data streams from eTec (charging infrastructure), and Nissan and General Motors/OnStar (vehicles)
• EV Project purpose is to build and study mature electric vehicle charging infrastructure in eight regions – 16 cities
• Product: Take the lessons learned from the deployment of these first 8,300 EVs and the 15,300 charging infrastructure units supporting them, to enable the streamlined deployment of the next 5,000,000 EVs

EV Project Partner Locations
EV Project - Infrastructure Data Collected per Charge Event

- Date/Time Stamp
- Unique ID for Charging Event
- Unique ID Identifying the EVSE – may not change
- Connect and Disconnect Times (plugged in and out)
- Start and End Charge Times
- Max Instantaneous Peak Power
- Average Power
- Total energy (kWh) per charging event
- Rolling 15 Minute Average Peak Power
- And other non-dynamic EVSE information (GPS, ID, type, contact info, etc.)

EV Project - Vehicle Data Collected per each Start / Stop Event

- Vehicle ID
- Date/Time Stamp
- Event type (key on / key off)
- Odometer
- Battery state of charge
- GPS (longitude and latitude)
- Liquid fuel consumption (some vehicles)
- Recorded for each key-on and key-off event
INL Data Management System - Push
(Nissan, GM, Chrysler, Coulomb)

- Vehicle and Charger Data
  - Access restricted by firewall rules
  - EV Project FTPS/SFTP Server

- OEM Data Management Systems
  - OEM pushes using FTPS/SFTP

- Protected Data
  - INL pulls with encrypted transmission
  - INL Protect Enclave - EV Project member access only

- Protected Data
  - EV Project Team
  - INL pulls with encrypted transmission

- Internal data quality reports

- Fleet summary reports - public

INL DMZ Firewall – Public has access to AVT.INL.GOV
INL Protect Enclave - EV Project member access only
INL transmits reports to DOE And OEMs
Reports posted on WWW

INL Data Management System - Pull
(ECotality, Ford, conversion PHEVs, HEVs, HICEs)

- Vehicle and Charger Data
  - Access restricted by firewall rules

- OEM Data Management Systems
  - OEM pushes using FTPS/SFTP

- Protected Data
  - INL pulls with encrypted transmission

- EV Project Team

- Internal data quality reports

- Fleet summary reports - public

INL DMZ Firewall – Public has access to AVT.INL.GOV
INL Protect Enclave - EV Project member access only
INL transmits reports to DOE And OEMs
Reports posted on WWW
EV Project - Reporting

- INL will analyze and report on the charging infrastructure utilization (Level II EVSE units and fast chargers) by the 8,300 Leaf and Volt drivers
- INL will report on driver/vehicle charging patterns, and charging infrastructure utilization patterns
- Many of the 42+ EV Project partners are electric utilities with high interest in demand / smart charging controls, including multitier time-of-day pricing and micro grid analysis
- Reporting targets include: DOE/governments, OEMs, electric utilities, public, etc.
- Specialty analyses will include micro grid and other variable influences

EV Project - Fact Sheet Reporting

- Driving (by reporting period)
  - Number of trips
  - Distance driven (miles)
  - Average number of trips between charging events
  - Average distance between charging events
- Charging Infrastructure
  - EV Project vehicle charging
    - Number of charging events
    - Percent of all charging events
    - Total time plugged in (hours)
    - Percent of all time plugged in
  - Non-EV Project vehicle charging events
    - Number of charging events
    - Percent of all charging events
EV Project Summary

• Provide feedback on infrastructure deployment decisions
• Reporting can not begin until after November/December 2010 start to vehicle and infrastructure roll-outs, and data analyzed
• Successful grid-connected electric drive vehicle deployment is dependent on successful infrastructure deployment
• Future charging infrastructure deployments must be based on real-world travel and charging patterns
• Goal is to replace internal combustion engine vehicles with grid connected, and infrastructure dependant, electric drive vehicles

Original Equipment Manufacturer (OEM)
Electric Drive Vehicle Deployment Announcements
Some OEM EDV Announcements

- The below announcements and dates come from several sources and may change

<table>
<thead>
<tr>
<th>Introduction Year</th>
<th>Manufacturer / Model</th>
<th>Battery Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Nissan / Leaf</td>
<td>BEV</td>
</tr>
<tr>
<td>2010</td>
<td>GM / Volt</td>
<td>EREV</td>
</tr>
<tr>
<td>2011</td>
<td>Coda / Coda</td>
<td>BEV</td>
</tr>
<tr>
<td>2011</td>
<td>Ford / Focus</td>
<td>BEV</td>
</tr>
<tr>
<td>2011</td>
<td>Ford / Transit (Van)</td>
<td>BEV</td>
</tr>
<tr>
<td>2011</td>
<td>BYD / e6</td>
<td>BEV</td>
</tr>
<tr>
<td>2011</td>
<td>Fisker / Karma</td>
<td>BEV</td>
</tr>
<tr>
<td>2011</td>
<td>Mitsubishi / i-MiEV</td>
<td>BEV</td>
</tr>
</tbody>
</table>

BEV – Battery Electric Vehicle
EREV – Extended Range Electric Vehicle
PHEV – Plug-in Hybrid Electric Vehicle
EDV – Electric Drive Vehicle

Some OEM EDV Announcements – con’td

- The below announcements and dates come from several sources and may change

<table>
<thead>
<tr>
<th>Introduction Year</th>
<th>Manufacturer / Model</th>
<th>Battery Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Smart / FORTWO</td>
<td>BEV</td>
</tr>
<tr>
<td>2012</td>
<td>Toyota / IQ-Based</td>
<td>BEV</td>
</tr>
<tr>
<td>2012</td>
<td>Tesla / S</td>
<td>BEV</td>
</tr>
<tr>
<td>2012</td>
<td>Toyota / Prius</td>
<td>PHEV</td>
</tr>
<tr>
<td>2012</td>
<td>Toyota-Tesla / RAV4</td>
<td>BEV</td>
</tr>
<tr>
<td>2012</td>
<td>Chrysler-Fiat / 500</td>
<td>BEV</td>
</tr>
<tr>
<td>2013</td>
<td>BMW / MegaCity</td>
<td>BEV</td>
</tr>
<tr>
<td>2013</td>
<td>Volkswagen / Eup</td>
<td>BEV</td>
</tr>
</tbody>
</table>

There have been another 50+ electric drive vehicle announcements beyond 2010 from Audi to Volvo.
Other INL Data Collection Projects

- Data collection for Ford’s PHEV SUVs and Chrysler Ram Pickups include 25+ onboard parameters, such as charging and driving profiles, and vehicle performance; collected via the CAN and data loggers
- Other OEM vehicles may be added to EV Project
- Five USPS electric long life vehicle (ELLV) conversions
  - ELLVs required five customized onboard data loggers
  - Testing to USPS and AVTA test procedures and cycles
- Development of vehicle-based battery test-bed mule

AVTA Summary – WWW Visitors

[Graph showing INL AVTA WWW Visitors & Gasoline Costs (all formulations, areas, and grades)]
The Other Blue Turf - Barrow, Alaska High School Football – Home of the “Whalers”

Arctic Ocean in the Background (08/01/10)
Acknowledgement and AVTA WWW Address

This work is supported by the U.S. Department of Energy's Vehicle Technologies Program

Additional AVTA Information, Reports, and Fact Sheets @ http://avt.inl.gov