U.S. Department of Energy’s Vehicle Technologies Program -

Fully Charged 2012 International EV Summit – The EV Project Update

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Fully Charged 2012 International EV Summit
Dublin, Ireland
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This presentation does not contain any proprietary or sensitive information
Outline

• Participants, goals and testing experience
• Data processes and data security
• EV Project
  – Description and data parameters
  – Project status
  – Leaf, Volt, and EVSE benchmarking results
  – Bulk of presentation
• Potential grid impacts
• Other electric drive vehicle research activities
• Summary
• Future work
Idaho National Laboratory (INL)

- Eastern Idaho based U.S. Department of Energy (DOE) Federal research laboratory
- 890 square mile site with 4,000 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
  - Energy Critical Infrastructure Protection
  - Homeland Security and Cyber Security
  - Advanced Vehicles and Battery Development
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
AVTA Participants and Goals

- INL manages the Advanced Vehicle Testing Activity’s (AVTA) field testing of advanced technology light-duty vehicles for DOE
  - AVTA is part of DOE’s Vehicle Technologies Program
  - ECOtality provides testing support via DOE’s National Energy Testing Laboratory
- Test partners include electric utilities, Federal, state and local government agencies, private companies, and individual vehicle owners
- The AVTA goal: Petroleum reduction and energy security
  - Confusing people with facts via testing regimes
  - Providing benchmark data to DOE, technology modelers, R&D programs, vehicle manufacturers (via VSATT), and target and goal setters
  - Assist fleet managers, via Clean Cities, FEMP and industry gatherings, in making informed vehicle and infrastructure deployment and operating decisions
Vehicle / Infrastructure Testing Experience

- 48 million test miles accumulated on 8,200 electric drive vehicles representing 114 models
- EV Project: 4,700 Leafs and Volts, 6,200 EVSE (electric vehicle supply equipment)
  - 30.3 million test miles
  - 865,000 charge events, 7,300 MWh
- PHEVs: 14 models, 430 PHEVs, 4 million test miles
- EREV: 1 model, 150 EREV, 900,000 test miles
- HEVs: 21 models, 52 HEVs, 6.2 million test miles
- Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 485,000 test miles
- NEVs: 24 models, 372 NEVs, 200,000 test miles
- BEVs: 47 models, 2,000 BEVs, 5 million test miles
- UEVs: 3 models, 460 UEVs, 1 million test miles
- Other testing includes hydrogen ICE vehicle and infrastructure testing
INL Vehicle/EVSE Data Management Process

Process Affected by Disclosure Agreements

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

INL Vehicle Data Management System

- File server
- SQL Server data warehouse
- Report generator

Data reports

- Individual vehicle reports
- Fleet summary reports
- Reports - Public
- Focused technical analyses and custom reports
- Modeling and simulations
Data Security, Protection and Use

- All vehicle, EVSE, and personal information raw data protected by NDAs (Non Disclosure Agreements)
  - Limitations on how proprietary data can be distributed, stored, and used
  - No raw data can or will be distributed by INL
  - Raw data, in both electronic and printed formats, is not shared with DOE in order to avoid exposure to FOIA
- Vehicle and EVSE data collection would not occur unless the above limitations are strictly adhered by INL
- The AVTA has used data loggers on vehicles and EVSE (electric vehicle supply equipment) since 1993 to benchmark vehicle and charging equipment profiles
EV Project Locations and Goal

- 18 current locations with more being added
- Goal: Build and study mature charging infrastructures and take the lessons learned to support the future streamlined deployment of grid-connected electric drive vehicles
- ECOtality is the EV Project lead, with INL, Nissan and GM/OnStar as significant partners
- EV Project reporting requires INL to blend three distinct data streams based on GPS and time/date stamps, and provide independent reports to DOE, ECOtality, project participants, industry, and the general public
EV Project – EVSE Data Parameters Collected per Charge Event

- Data from ECOtality’s Blink EVSE network
- Unique ID for Charging Event
- Unique ID Identifying the EVSE
- Date/Time Stamp
- Connect and Disconnect Times
- Start and End Charge Times
- Maximum 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 Parameters Collected per Start/Stop Event

- Data is received via telematics providers from Chevrolet Volts and Nissan Leafs
- Vehicle ID
- Event type (key on / key off)
- Odometer
- Battery state of charge
- Date/Time Stamp
- GPS (longitude and latitude)
- Recorded for each key-on and key-off event
EV Project – Vehicle Deployments / Miles

- 4,278 Leafs (6/24) and 428 Volts (4/01) reporting data
- 4,706 vehicles and growing
- 30.3 million total miles
- 105,000 test miles per day
EV Project – EVSE Deployment and Use

- 4,634 Res. EVSE
- 1,623 non-Res EVSE
- 6,257 total EVSE
- 865,000 charge events
- 3,500 charge events per day
- Non-Residential includes DCFC
- Above as of 6/24/12
- Data is continuously back-filled
EV Project – Total Charge Energy (MWh)

- 6,888 MWh residential
- 401 MWh non-residential
- 7,300 MWh total electricity charged
- 26 MWh used for charging per day

- Vehicle efficiency cannot be accurately calculated using total vehicle miles and total energy
- Non-EV Project vehicles sometimes charge at EV Project EVSE
- EV Project vehicles may charge at 110V or other 240V non-EV Project EVSE
EV Project – Overview Report 1st Quarter

- Vehicles and charging infrastructure deployed to date 1\textsuperscript{st} quarter 2012 and data received by INL
- Charging infrastructure
  - 5,432 units installed
  - 665,968 charging events
  - 5,069 AC MWh

- Vehicles
  - 4,066 Leafs
  - 427 Volts
  - 22.6 million miles

- Regional analyses are conducted and reported each quarter as 4 summary reports (93 pages last quarter)
## EV Project – Vehicle Usage Report

### Vehicle Usage – 1st quarter 2012

<table>
<thead>
<tr>
<th></th>
<th>Leafs</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>2,987</td>
<td>317</td>
</tr>
<tr>
<td>Number of Trips</td>
<td>773,602</td>
<td>76,425</td>
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<tr>
<td>Distance (thousands)</td>
<td>5,558 mi</td>
<td>610 mi</td>
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<tr>
<td>Average (Ave) trip distance</td>
<td>7.2 mi</td>
<td>8.0 mi</td>
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<tr>
<td>Ave distance per day</td>
<td>30.2 mi</td>
<td>36.4 mi</td>
</tr>
<tr>
<td>Ave number (#) trips between charging events</td>
<td>3.8</td>
<td>3.0</td>
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<tr>
<td>Ave distance between charging events</td>
<td>27.4 mi</td>
<td>24.1 mi</td>
</tr>
<tr>
<td>Ave # charging events per day</td>
<td>1.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Note that per day data is only for days a vehicle is driven
EV Project – Leaf Usage Report (1st ¼ 2012)

- Battery state-of-charge quarterly trends may indicate greater driver confidence in vehicle range and EVSE availability.

- SOC is also available for Volts.
EV Project – Leaf Usage Report (1st ¼ 2012)

- Regional variations in charge behavior
- Possible rich versus non-rich public charge environment impacts

- Data is also available for Volts
EV Project – Leaf Usage Report (1st ¼ 2012)

- Regional variations in drive profiles
- Need to be compared to ICE vehicle travel patterns (if data available)
• Seasonal variations may not be significant yet, given low number of vehicles and “early adapters” in early quarters
EVSE Infra. Summary Report

- Charging Availability
- National Data
- Range of Percent of Charging Units with a Vehicle Connected vs. Time of Day
  - 1st quarter 2012
  - 3,324 residential and 955 publicly available Level 2 EVSE
  - 10 DC fast chargers
  - 51,476 values calculated just for 1st quarter 2012 infrastructure (Infra.) report
EV Project – EVSE Infra. Summary Report

- Charging Demand
- National Data
- Range of Aggregate Electricity Demand vs. Time of Day (AC MW)
- 1st quarter 2012
- 3,324 residential and 955 publicly available Level 2 EVSE
- 10 DC fast chargers
- Time of day kWh rates are influencing charging start times as measured by AC MW demand
EV Project – EVSE Infra. Summary Report
• Residential Level 2 Weekday EVSE 1st Quarter 2012
• Time of day kWh rates clearly influence charge patterns

San Diego

Washington State

San Francisco

Oregon
EV Project – EVSE Infra. Summary Report

- National Data – 1st quarter 2012
  - Ave time vehicle connected R2 WD: 11.4 hours
  - Ave time vehicle connected R2 WE: 11.8 hours
  - Ave time vehicle drawing power R2 WD: 2.4 hours
  - Ave time vehicle drawing power R2 WE: 2.0 hours
  - Ave energy per charge event R2 WD: 8.7 AC kWh
  - Ave energy per charge event R2 WE: 7.3 AC kWh
  - Ave time vehicle connected P2 WD: 6.3 hours
  - Ave time vehicle connected P2 WE: 4.1 hours
  - Ave time vehicle drawing power P2 WD: 2.1 hours
  - Ave time vehicle drawing power P2 WE: 1.9 hours
  - Ave energy per charge event P2 WD: 7.3 AC kWh
  - Ave energy per charge event P2 WE: 6.6 AC kWh

- Yes, this is an ugly slide

- R: residential, P: public, WD: weekday, WE: weekend, 2: Level 2 EVSE
EV Project – EVSE Infra. Summary Report

- Percent of public EVSE deployed is increasing (22%)
- However, use is increasing at a slower rate (next slide)
EV Project – EVSE Infra. Summary Report

- Percent charge events and AC MWH use by residential and public EVSE each reporting quarter
- Percent public EVSE use (red and blue lines) is clearing increasing as it is deployed in larger numbers
- 9.1% charge events and 8.0% MWh 1st quarter 2012
## U.S. Grid Impacts

- Average daily delta between peak and off peak demand

<table>
<thead>
<tr>
<th>Utility</th>
<th>Delta (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona Public Service Co.</td>
<td>33.7%</td>
</tr>
<tr>
<td>Salt River Project</td>
<td>32.2%</td>
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<tr>
<td>Tucson Electric Power Co.</td>
<td>34.0%</td>
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<tr>
<td>LA Dept of Water &amp; Power</td>
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<tr>
<td>Pacific Gas &amp; Electric Co.</td>
<td>35.2%</td>
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<tr>
<td>San Diego Gas &amp; Electric Co.</td>
<td>39.8%</td>
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<tr>
<td>Portland General Electric Co.</td>
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<tr>
<td>Puget Sound Energy</td>
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<tr>
<td>Seattle City Light</td>
<td>33.0%</td>
</tr>
<tr>
<td>Arizona Public Service Co.</td>
<td>33.7%</td>
</tr>
<tr>
<td>Average above utilities</td>
<td>35.1%</td>
</tr>
</tbody>
</table>
U.S. Grid Impacts

- Average daily delta between peak and off peak demand

![Graph showing percentage max exceeds min daily demand 2010 U.S. Grid Demand]
U.S. Grid Impacts

• Average daily U.S. maximum demand is 45% higher than minimum demand = off-peak has much excess generation
• 2010 total generation was 4,125,060 GWh
• At 2,920 kWh per year (assumes approximate Leaf use)
  – 1% of generation charges 14.1 million Leafs
  – 2% of generation charges 28.3 million Leafs
  – 3% of generation charges 42.4 million Leafs
  – 4% of generation charges 56.5 million Leafs
  – 5% of generation charges 70.6 million Leafs
• Macro grid impacts are of no concern for the immediate future
• Micro grid impacts, if any, will hopefully be identified by the EV Project
Other AVTA Projects for DOE

- Other vehicle data collection activities
  - 150 Chevrolet Volt EREVs
  - 108 Chrysler Ram Pickup PHEVs
  - 21 Ford Escape Prototype PHEVs
  - 20 Quantum PHEV Escape conversions
  - 5 different US Postal Service electric delivery vehicle conversions
  - Field and laboratory fast charge study compares DC fast charging and Level 2 charging impacts on battery life in 6 vehicles
  - Above all equipped with lithium traction batteries
More AVTA Projects for DOE

- Mass impacts on fuel efficiency of HEVs, ICEVs and BEVs
- Conducting testing of “dumb” and “smart” EVSE
- Initiated wireless charging test program
- Benchmarking ChargePoint America project with 2,453 EVSE deployed, 223,000 charge events & 1,500 AC MWH
- Other EVSE providers have started to provide charging data to INL
- Initiated first responders training program with the National Fire Prevention Association and NHTSA
- Battery mule test vehicle provides field testing of traction battery packs at any power and efficiency level
EV Project Summary To Date

• EV Project vehicles connected much longer than needed to recharge - opportunities to shift charging times
• Significant residential Level 2 EV Project charging occurs off-peak with charge-starts occurring at the midnight starts of super off-peak kWh rates
• Significant opportunities to fully understand how the public uses public versus non-public infrastructure
• Revenue models for public charging being introduced – impacts?
• Only about 30% of EV Project data collected to date
• “Normal” research project process requires:
  – Design and execute the project, data collection completed, data analyzed, and finally, reports issued at completion of experiment
• INL/ECOtality needs to completely collect all data before definitively reporting seasonal trends and behaviors
Future EV Project Data Analysis Subjects

• Pricing elasticity – TOU rate influences?
• Regional and seasonal demographics and charging behaviors?
• Density of residential and non-residential EVSE as input to local micro distribution studies – transformer failures?
• Charge control preferences – vehicle, Blink and web based, and scheduled versus random?
• Rich public versus non-rich EVSE charging behaviors?
• Level 2 EVSE versus DCFC behaviors?
• Travel corridor versus convenience charging at stores?
• Length of vehicle ownership and miles per day / week / charge?
• Non-residential subcategories (public and work parking)?
• Etc., etc., etc.?
Acknowledgement

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And this presenter is very grateful for their support

More Information
http://avt.inl.gov

This presentation can be found in the publications section of the above website