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

INL Update: The EV Project and Other Light-Duty Electric Drive Vehicle and Infrastructure Activities @ VSATT 2012

Jim Francfort / Barney Carlson

VSATT – ORNL, Knoxville, TN
November 7, 2012

This presentation does not contain any proprietary or sensitive information
Outline

• Participants
• Goals
• Testing experience
• Data processes and data security
• EV Project
  – Description and data parameters and project status
  – Leaf, Volt, and EVSE benchmarking results including demand and DCFC peak issues
  – Lessons learned, summary and future
• Other ARRA and TADA data collection activities
• DC Fast Charge battery impacts
• EVSE, DC FC and wireless activities
• Vehicle Mass impacts on fuel use
• Battery mule status
• Other
AVTA Participants

• INL is responsible to DOE for the light-duty vehicle portion of the Advanced Vehicle Testing Activity (AVTA)
• ECOtality provides testing support to the AVTA via a competitively bid contract through NETL (National Energy Testing Laboratory)
• Test partners include electric utilities, Federal, state and local government agencies, private companies, infrastructure and vehicle manufacturers
• Leverage DOE funding within DOE, other Federal Fleets, and with all external partners
AVTA Goals

• The AVTA goals
  – Petroleum reduction and energy security
  – Benchmark technologies that are developed via DOE research investments

• The AVTA focuses on:
  – Real world field, test track, and laboratory testing of grid connected, electric drive vehicles and subsystems
  – Advanced energy storage systems
  – Charging infrastructure performance and use

• Confuse people with facts via structured benchmark testing

• Provide benchmark data to National Laboratories, Federal Agencies (DOD, DOI, DOT, EPA, USPS), technology modelers, fleet managers, and vehicle manufacturers to support informed vehicle and infrastructure deployment and operating decisions
Vehicle / Infrastructure Testing Experience

- 66 million test miles accumulated on 9,600 electric drive vehicles representing 110+ models, and 11,000+ EVSE
- Currently, 17,500 vehicles and EVSE provide 125,000 miles and 5,200 charging events of data to INL daily
- EV Project: 6,150 Leafs, Volts and Smart EVs, 7,971 EVSE (electric vehicle supply equipment), 48 million test miles

- PHEVs: 14 models, 430 PHEVs, 4 million test miles
- EREVs: 1 model, 150 EREVs, 900,000 test miles
- HEVs: 21 models, 52 HEVs, 6.2 million test miles
- Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 509,000 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 Driven by Disclosure Agreements

- File server
- SQL Server data warehouse
- Report generator

**HICEVs**

**HEVs**

**PHEVs**

**BEVs & EREV**

**EVSE & Chargers**

- Data quality reports
- Individual vehicle reports
- Fleet summary reports - Public
- Focused technical analyses and custom reports
- Modeling and simulation input

**Models**

- Parameters range check
- Lame data check
- Missing/empty parameter check
- Conservation of energy check
- SOC continuity

**Data Quality Reports**

**Vehicle Reports**

**Fleet Reports**

**Focused Technical Analyses and Custom Reports**

**Modeling and Simulation Input**
Data Collection, Security and Protection

- Includes EV Project and non-EV Project Activities
- All vehicle, EVSE, and personal raw data is legally protected by NDAs (Non Disclosure Agreements) or CRADAs (Cooperative Research and Development Agreements)
  - Limitations on how proprietary and personally identifiable information can be stored and distributed
  - Raw data, in both electronic and printed formats, is not shared with DOE to avoid exposure to FOIA requests
  - Vehicle and EVSE data collection would not occur unless testing partners trusted INL would strictly adhere to legally binding NDAs and CRADAs
  - Raw data cannot be legally distributed by INL
- Current AVTA staff have used data loggers on vehicles and EVSE since 1993 to benchmark vehicle and charging equipment profiles
EV Project - Introduction

- ECOtality North America is the EV Project lead, with INL collecting data from the other participants
- Nissan and OnStar/GM are the prime partners, with more than 30 other partners such as electric utilities and air resource boards and state agencies
- For the EV Project, 7,500+ vehicle owners / infrastructure hosts have signed up to be testing partners
- Project objectives
  - Develop mature charge infrastructure “laboratories”
  - Collect and analyze data characterizing vehicle and infrastructure utilization
  - Demonstrate measures to minimize impacts of charging on the grid
  - Conduct trials of payment systems
  - Develop a sustainable business model for non-residential charging infrastructure
  - Document and disseminate the results of the EV Project
EV Project Deployment Objectives

- **8,000 Residential EVSE** for 8,000 plug-in electric vehicles (Nissan Leaf, Chevrolet Volt & Smart EV)
- **5,000 Non-residential EVSE** (workplace, commercial, public, and street side)
- **200 DC Fast Chargers** (publicly accessible)
- Deploying in ten states plus the District of Columbia

![EV Project Map](image)
EV Project – EVSE Data Parameters, Collected per Charge Event

- Data from ECOtality’s Blink EVSE network
- 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
- Date/Time Stamp
- Unique ID for Charging Event
- Unique ID Identifying the EVSE
- And other non-dynamic EVSE information (GPS, ID, type, contact info, etc.)
EV Project – Vehicle Data Parameters Collected per Key-On and Key-Off Event

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

- 6,150 vehicles reporting data and growing
- 4,798 Leafs, 300 Smart EVs, and 1,052 Volts reporting

- 48 million total miles
- 125,000 test miles per day
- Data is continuously back-filled
EV Project – EVSE Deployment and Use

- 7,971 total EVSE reporting
  - 5,676 Residential EVSE
  - 2,295 non-Residential EVSE, includes DCFC
- 1.3 million charge events
- 3,600 charge events per day
- Data is continuously back-filled
**EV Project – Total Charge Energy (MWh)**

- **11,000 MWh total electricity charged**
  - 10,000 MWh residential
  - 800 MWh non-residential

- **32 MWh used for charging per day**

- Data is continuously back-filled

- 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 3rd Quarter 2012

• Vehicles and charging infrastructure deployed data @ INL
  • Vehicles
    – 46.7 million miles total
    – 6,071 total vehicles
    – 4,719 Leafs
    – 1,052 Volts
    – 300 Smart EVs
  • Charging infrastructure
    – 7,799 units installed
    – 1,237,703 charging events
    – 10,316 AC MWh
  • Regional analyses reported each quarter

![Number of Leafs, Volts & EVSE Reporting Data](chart.png)
### EV Project Vehicle Usage Reports

**3rd quarter 2012 Data Only**

<table>
<thead>
<tr>
<th></th>
<th>Leafs</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>3,200</td>
<td>809</td>
</tr>
<tr>
<td>Number of Trips</td>
<td>813,430</td>
<td>286,682</td>
</tr>
<tr>
<td>Distance (million miles)</td>
<td>5.84</td>
<td>2.39</td>
</tr>
<tr>
<td>Average (Ave) trip distance</td>
<td>7.2 mi</td>
<td>8.3 mi</td>
</tr>
<tr>
<td>Ave distance per day</td>
<td>30.0 mi</td>
<td>41.2 mi</td>
</tr>
<tr>
<td>Ave number (#) trips between charging events</td>
<td>3.9</td>
<td>3.5</td>
</tr>
<tr>
<td>Ave distance between charging events</td>
<td>27.9 mi</td>
<td>29.3 mi</td>
</tr>
<tr>
<td>Ave # charging events per day</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Overall mpg</td>
<td>136 mpg</td>
<td></td>
</tr>
<tr>
<td>Overall AC Wh/mi</td>
<td>222</td>
<td></td>
</tr>
</tbody>
</table>

* Note that per day data is only for days a vehicle is driven
• Leaf battery SOC before and after charge events by home and non-home locations – national data
EV Project – Volt Usage Report (3rd 2012)

- Volt battery SOC before and after charge events by home and non-home locations – national data
EV Project – Leaf Operations Trends

Nissan Leaf Driver Operations Behavior

<table>
<thead>
<tr>
<th>Average Trip Distance - Miles</th>
<th>Avg Miles per Day</th>
<th>Ave Trips Between Charges</th>
<th>Ave Miles per Charge</th>
<th>Ave # Charges per Day</th>
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</thead>
<tbody>
<tr>
<td>35</td>
<td>956</td>
<td>2,394</td>
<td>2645</td>
<td>2987</td>
</tr>
<tr>
<td>32.5</td>
<td>22.5</td>
<td>12.5</td>
<td>15</td>
<td>17.5</td>
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<tr>
<td>30</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td>35</td>
<td>22.5</td>
<td>12.5</td>
<td>15</td>
<td>17.5</td>
</tr>
<tr>
<td>32.5</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>12.5</td>
</tr>
<tr>
<td>Avg</td>
<td>25</td>
<td>Ave</td>
<td>15</td>
<td>Ave</td>
</tr>
</tbody>
</table>

Number of Leafs reporting each quarter

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>35</td>
<td>956</td>
<td>2,394</td>
<td>2645</td>
<td>2987</td>
<td>2911</td>
<td>3200</td>
</tr>
</tbody>
</table>
EV Project – Leaf Charging Location Trends

Nissan Leaf Driver Charging Behavior

- Percent home charging
- Percent away from home charging
- Percent unknown locations

Number of Leafs reporting each quarter

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>35</td>
<td>956</td>
<td>2,394</td>
<td>2,645</td>
<td>2,987</td>
<td>2,911</td>
<td>3,200</td>
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</tbody>
</table>
EV Project – Volt Operations Trends

Number of Volts reporting each quarter

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>45</td>
<td>317</td>
<td>408</td>
<td>809</td>
</tr>
</tbody>
</table>
EV Project – Volt Charging Location Trends

Chevy Volt Driver Charging Behavior

- Yellow: Percent home charging
- Orange: Percent away from home charging
- Blue: Percent unknown locations

Number of Volts reporting each quarter

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Volts Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th 2011</td>
<td>45</td>
</tr>
<tr>
<td>1st 2012</td>
<td>317</td>
</tr>
<tr>
<td>2nd 2012</td>
<td>408</td>
</tr>
<tr>
<td>3rd 2012</td>
<td>809</td>
</tr>
</tbody>
</table>
Graphs document when EVSE have a vehicle connected during the 3rd quarter 2012.

National Data, all EVSE.

Range of Percent of EVSE and DC Fast Chargers with a Vehicle Connected vs. Time of Day.
EV Project – EVSE Infra. Summary Report

- Charging demand in AC MW during the 3rd quarter 2012
- National data, all EVSE
- Time of day kWh rates are influencing charging start times as measured by AC MW demand
- Range of Aggregate Electricity Demand vs. Time of Day (AC MW)
EV Project – EVSE Infra. Summary Report

- Residential Level 2 Weekday EVSE 3rd Quarter 2012
- Regional time of day EVSE has a vehicle connected

San Diego

Oregon

San Francisco

Washington State
EV Project – EVSE Infra. Summary Report

- Residential Level 2 Weekday EVSE 3\textsuperscript{rd} Quarter 2012
- Time of day kWh rates clearly influence charge patterns

San Diego

Oregon

San Francisco

Washington State
EV Project – Residential EVSE L2 Use Trends

Residential EVSE Infrastructure Use Trends

- Ave Hrs Vehicle Connt R2 WD
- Ave Hrs Vehicle Connt R2 WE
- Ave Hrs Vehicle Draw KW R2 WD
- Ave Hrs Vehicle Draw KW R2 WE
- Ave AC KWh/charge Event R2 WD
- Ave AC KWh/charge Event R2 WE

Number of Residential EVSE Level reporting each quarter

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>955</td>
<td>2413</td>
<td>2704</td>
<td>3324</td>
<td>3338</td>
<td>4020</td>
<td></td>
</tr>
</tbody>
</table>

Residential EVSE Level 2 = R2, Weekend = WE, Weekday = WD
EV Project – Public EVSE L2 Use Trends

Non-Residential EVSE Infrastructure Use Trends

Number of Public EVSE Level reporting each quarter

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>170</td>
<td>438</td>
<td>955</td>
<td>1483</td>
<td>1818</td>
<td></td>
</tr>
</tbody>
</table>

Public EVSE Level 2 = P2, Weekend = WE, Weekday = WD
EV Project – EVSE Infra. Summary Report

- Percent of public EVSE deployed is increasing, now representing 31% of all EVSE
EV Project – EVSE Infra. Summary Report

- Percent charge events and AC MWH use by residential and public EVSE
- Public EVSE use (red & blue lines) is increasing with 13.5% charge events and 12.80% MWh 3rd quarter 2012

Percentage AC MWH & Charge Events - Public and Residential

- Yellow: Percent Res AC MWH
- Blue: Percent Pub AC MWH
- Green: Percent Res Charge Events
- Red: Percent Pub Charge Events
DC Fast Charging impacts on Demand

- Northwest Electric Utility Service Area

<table>
<thead>
<tr>
<th></th>
<th>Residential Level 2</th>
<th>Non Residential Level 2</th>
<th>DC Fast Charger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number units</td>
<td>135</td>
<td>66</td>
<td>3</td>
</tr>
<tr>
<td>Number charge events</td>
<td>7996</td>
<td>1214</td>
<td>157</td>
</tr>
<tr>
<td>% time vehicle connected</td>
<td>35%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>% time vehicle drawing power</td>
<td>6%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>% of charging events</td>
<td>85%</td>
<td>13%</td>
<td>2%</td>
</tr>
<tr>
<td>% KWh consumed</td>
<td>86%</td>
<td>12%</td>
<td>2%</td>
</tr>
</tbody>
</table>
DC Fast Charging impacts on Demand (MW)

- Northwest electric utility service area, 204 units

**Weekend Vehicle Connect**

- 70% of EVSE
- IQR: max, min, median
- Time of Day: 6:00, 12:00, 18:00, 0:00

**Weekday Vehicle Connect**

- 10% - 30% of EVSE
- IQR: max, min, median
- Time of Day: 6:00, 12:00, 18:00, 0:00

**Weekend Demand**

- IQR: max, min, median
- Time of Day: 6:00, 12:00, 18:00, 0:00

**Weekday Demand**

- IQR: max, min, median
- Time of Day: 6:00, 12:00, 18:00, 0:00
EV Project Data and Reporting

- EV Project reporting requires INL to blend three distinct data streams from ECOtality, Nissan and OnStar/GM
- Additional data streams from Daimler and a couple of EVSE manufacturers
- INL and ECOtality, with DOE concurrence, identified the type of reports that would be publicly released and all of the EV Project partners agreed (or relented)
- More than 80 EV Project reports are generated every reporting quarter
- More than 130 one time and special request reports have been generated
- 22 additional technical papers, lessons learned, and infrastructure planning reports published
- 56 presentations given by INL staff
EV Project Reporting

- [http://avt.inel.gov/evproject.shtml](http://avt.inel.gov/evproject.shtml)
- Public quarterly reports: 100 pages and 56,000 data values calculated for 4 public reports
EV Project Reporting

• Exploring visualization reporting methods via GIS

← EVSE Residential EVSE Phoenix

↓ Leaf “home” locations

← EVSE Public EVSE Phoenix
EV Project Lessons Learned – Currently Available

• http://www.theevproject.com/documents.php
• Reports available include
  – DC Fast Charge-Demand Charge Reduction (May 2012)
  – The EV Micro-Climate Planning Process (May 2012)
  – Signage (April 2012)
  – Greenhouse Gas (GHG) Avoidance and Fuel Cost Reduction (June 2012)
  – First Responder Training (March 2011)
  – Accessibility at Public EV Charging Locations (October 2011)
  – Battery Electric Vehicle Driving and Charging Behavior Observed Early in The EV Project (April 2012)
EV Project Lessons Learned - Coming

  - Need for Commercial Charging
  - Pricing of Commercial Charging
  - Residential Installation Process
  - Commercial Installation Process
  - EV Energy Metering
  - Permitting Cost (Residential & Commercial)
Residential Lessons Learned

- Permit timeliness has not been a problem
- Majority are over-the-counter
- Permit fees vary significantly - $7.50 to $500.00, mean $112.14

<table>
<thead>
<tr>
<th>Region</th>
<th>Count of Permits</th>
<th>Average Permit Fee</th>
<th>Minimum Permit Fee</th>
<th>Maximum Permit Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>66</td>
<td>$96.11</td>
<td>$26.25</td>
<td>$280.80</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>109</td>
<td>$83.99</td>
<td>$45.70</td>
<td>$218.76</td>
</tr>
<tr>
<td>San Diego</td>
<td>496</td>
<td>$213.30</td>
<td>$12.00</td>
<td>$409.23</td>
</tr>
<tr>
<td>San Francisco</td>
<td>401</td>
<td>$147.57</td>
<td>$29.00</td>
<td>$500.00</td>
</tr>
<tr>
<td>Tennessee</td>
<td>322</td>
<td>$47.15</td>
<td>$7.50</td>
<td>$108.00</td>
</tr>
<tr>
<td>Oregon</td>
<td>316</td>
<td>$40.98</td>
<td>$12.84</td>
<td>$355.04</td>
</tr>
<tr>
<td>Washington</td>
<td>497</td>
<td>$78.27</td>
<td>$27.70</td>
<td>$317.25</td>
</tr>
</tbody>
</table>
Residential Lessons Learned

- **Average residential installation cost ~$1,375**
- **Individual installations vary widely**
- **Some user bias to lower costs**

<table>
<thead>
<tr>
<th>Marlets In Ascending Order Of Residential Installation Cost</th>
<th>Number of Installations</th>
<th>Average Installation Cost</th>
<th>Variation From Project Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tennessee (entire State)</td>
<td>542</td>
<td>$1,113.07</td>
<td>-19.0%</td>
</tr>
<tr>
<td>Arizona (Phoenix &amp; Tucson)</td>
<td>357</td>
<td>$1,148.88</td>
<td>-16.4%</td>
</tr>
<tr>
<td>Washington DC</td>
<td>3</td>
<td>$1,197.44</td>
<td>-12.9%</td>
</tr>
<tr>
<td>Oregon (Portland, Eugene, Coralvls &amp; Salem)</td>
<td>465</td>
<td>$1,229.06</td>
<td>-10.6%</td>
</tr>
<tr>
<td>Washington (Seattle &amp; Olympia)</td>
<td>730</td>
<td>$1,289.56</td>
<td>-6.2%</td>
</tr>
<tr>
<td>Maryland</td>
<td>39</td>
<td>$1,311.75</td>
<td>-4.5%</td>
</tr>
<tr>
<td>Washington</td>
<td>80</td>
<td>$1,321.36</td>
<td>-3.8%</td>
</tr>
<tr>
<td>Virginia</td>
<td>38</td>
<td>$1,341.01</td>
<td>-2.4%</td>
</tr>
<tr>
<td>San Fransisco</td>
<td>1254</td>
<td>$1,386.13</td>
<td>0.9%</td>
</tr>
<tr>
<td>Texas (metro Houston &amp; Dallas)</td>
<td>128</td>
<td>$1,422.77</td>
<td>3.5%</td>
</tr>
<tr>
<td>San Diego</td>
<td>726</td>
<td>$1,593.91</td>
<td>16.0%</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>415</td>
<td>$1,791.64</td>
<td>30.6%</td>
</tr>
</tbody>
</table>
Commercial Lessons Learned

• ADA significantly drives cost
  – Accessible charger
  – Van accessible parking
  – Accessible electric and passage routes to facility

• Permit fees and delays are significant for ADA
  – Load studies
  – Zoning reviews
Commercial Lessons Learned

- Commercial permits range $14 to $821

<table>
<thead>
<tr>
<th>Region</th>
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<th>Average Permit Fee</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>72</td>
<td>$228</td>
<td>$35</td>
<td>$542</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>17</td>
<td>$195</td>
<td>$67</td>
<td>$650</td>
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<tr>
<td>San Diego</td>
<td>17</td>
<td>$361</td>
<td>$44</td>
<td>$821</td>
</tr>
<tr>
<td>Texas</td>
<td>47</td>
<td>$150</td>
<td>$37</td>
<td>$775</td>
</tr>
<tr>
<td>Tennessee</td>
<td>159</td>
<td>$71</td>
<td>$19</td>
<td>$216</td>
</tr>
<tr>
<td>Oregon</td>
<td>102</td>
<td>$112</td>
<td>$14</td>
<td>$291</td>
</tr>
<tr>
<td>Washington</td>
<td>33</td>
<td>$189</td>
<td>$57</td>
<td>$590</td>
</tr>
</tbody>
</table>
Commercial Lessons Learned

- **Demand and energy costs are significant for some utilities**
  - 25¢/kWh
  - $25/kW
- **Some utilities offer commercial rates without demand charges**
- **Others incorporate 20 kW to 50 kW demand thresholds**
- **Nissan Leaf is demand charge free in some service territories**

<table>
<thead>
<tr>
<th>No Demand Charges - Nissan Leaf</th>
</tr>
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<tbody>
<tr>
<td>CA</td>
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<tr>
<td></td>
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<tr>
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<tr>
<td>AZ</td>
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<td>OR</td>
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<td>TN</td>
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</table>
Commercial Lessons Learned

- **Recurring Nissan Leaf DC fast charge demand charges are significant in many (California) utility service territories**

<table>
<thead>
<tr>
<th>Utility Demand Charges - Nissan Leaf</th>
<th>Cost/mo.</th>
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</thead>
<tbody>
<tr>
<td>Glendale Water and Power</td>
<td>$ 16.00</td>
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<tr>
<td>Hercules Municipal Utility:</td>
<td>$ 377.00</td>
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<tr>
<td>Los Angeles Department of Water and Power</td>
<td>$ 700.00</td>
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<tr>
<td>Burbank Water and Power</td>
<td>$ 1,052.00</td>
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<tr>
<td>San Diego Gas and Electric</td>
<td>$ 1,061.00</td>
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<tr>
<td>Southern California Edison</td>
<td>$ 1,460.00</td>
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<tr>
<td>TRICO Electric Cooperative</td>
<td>$ 180.00</td>
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<tr>
<td>The Salt River Project</td>
<td>$ 210.50</td>
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<tr>
<td>Arizona Public Service</td>
<td>$ 483.75</td>
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<tr>
<td>Pacificorp</td>
<td>$ 213.00</td>
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<tr>
<td>Seattle City Light</td>
<td>$ 61.00</td>
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</tbody>
</table>
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 public 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.?
Non-public fleet drivers operating 150 Volts
- May ‘11 to June ‘12
  - 1.2 million total miles
- All trips, 70.0 mpg, 174 AC Wh/mi
- EV mode, 352 AC Wh/mi. 49.5% miles
- Extended range mode, 35.4 mpg

April to June 2012
- 371,000 miles
- EV mode, 341 AC Wh/mi. 49.9% miles
### Chevrolet Volt DOE ARRA Project

- **Non-public fleet drivers**
- **150 Volts (May ‘11 – June ’12)**
  - Average charging events per month: **17**
  - Average # charging events per vehicle day: **1.3**
  - Average miles per charging event: **43 miles**
  - Average trips between charging events: **3.4**
  - Average time connected per event: **3.2 hours**
  - Average energy per charge event: **7.2 AC kWh**
  - Average charging energy per vehicle month: **125 AC kWh**
  - Average trip distance city driving: **7.3 miles**
  - Average trip distance highway driving: **44.0 miles**
  - Percent of miles in EREV (electric) mode: **49.5%**
Ford Escape Adv. Research Vehicle

- **21 Ford Escape PHEVs**
- **Fleet drivers**
- **Nov 09 to Sept ‘12**
- **567,000 test miles**
- **All trips, 38 mpg, 101 AC & 69 DC Wh/mi**
- **Charge Depleting (CD), 52 mpg & 163 DC Wh/mi. 29% of all miles**
- **Charge Sustaining (CS), 32 mpg. 28% of all miles**
- **Charging = 63% overall increase in mpg when comparing CD to CS trips**


Since these vehicles are flex-fuel capable, some driving events are conducted with E-85, which may decrease fuel economy results.

*The Ford Escape Advanced Research Fleet was designed as a demonstration of customer duty cycles related to plug-in electric vehicles. The vehicles used in this demonstration have not been optimized to provide the maximum potential fuel economy.*
Ford Escape Adv. Research Vehicle

- Ambient temperature and increased engine off-times impact mpg
- Charging = 60% increase in city mpg and 81% increase in highway mpg (compare CD to CS)
- City - 36% CD and 23% CS miles engine off
- Highway - 11% CD and 4% CS miles engine off
Chrysler Ram PHEV Project

- **109 Ram PHEVs**
- **Fleet drivers**
- **July 2011 to May 2012**
- **815,000 test miles**
- **All trips, 19 mpg, 100 AC & 69 DC Wh/mi. 44 DC Wh/mi captured by regenerative braking**
- **CD, 23 mpg & 210 DC Wh/mi**
- **CS, 17 mpg**
- **Charging = 35% overall increase in mpg when comparing CD to CS trips**
Chrysler Ram PHEV Pickups

- Rams in fleet applications
- Vehicle driving 16% time engine stopped
- Vehicle stopped 23% time engine stopped
- 64.1 miles per charge event
- 7.0 trips per charge event
- 0.89 charge events per vehicle day
- 2.4 average hours per charge event
- 6.4 AC kWh average energy / charge

![Diagram showing effect of driving aggressiveness on fuel economy]
ChargePoint America ARRA Project

- Conducted by Coulomb
- Project to June 2012
- 3,085 EVSE installed and reporting data
- 1,298 Residential
- 216 Private/commercial
- 1,566 Public
- 5 unknown
- 367,000 charge events
- 2,500 AC MWh
ChargePoint America ARRA Project

- April – June 2012 data
- 2,715 units
- Percent time vehicle connected
  - Residential 45%
  - Private/com 22%
  - Public 7%
- Percent time drawing power
  - Residential 9%
  - Private/com 4%
  - Public 3%
- EVSE data only
DC Fast Charge Impacts on Battery Life

- Quantify DC Fast Charge impacts via independent testing that compares AC Level 2 and DC fast charging
- Operate onroad two Nissan Leafs exclusively Level 2 charged and two Leafs exclusively DC Fast Charged on identical routes with same drivers and identical vehicles
- Laboratory cycle one Leaf at Level 2 and one at DC Fast Charge. Very controlled testing
- Compare battery capacity, resistance and other battery health indicator tests
- Periodic battery tests over 30,000 miles each, for one year, ending ~4th quarter FY2013. Publish results
EVSE, DCFC and Wireless Charging Activities

- Benchmarked ten Level 2 EVSE for efficiency and standby power – 99.3 to 99.8% efficient
- Per NDAs, cyber security, EMF and efficiency test five low cost, smart Level 2 EVSE in support of DOE OE’s FOA
- Developing with SAE Level 2 EVSE-to-PEV inter-operative capabilities demonstration with multiple units
- Completed first DCFC (Fast Charge) performance testing
- Developing with SAE a DCFC-to-PEV inter-operative capabilities demonstration with multiple units
- Per NDAs, cyber security, EMF and efficiency testing on manufacturer-developed wireless changing systems
- Based on lessons learned, conduct same testing on two wireless charging systems developed via an EERE FOA
Vehicle Mass and Fuel Efficiency Impacts

- With ANL / ECOtality, multiple test weights tested for each of three vehicles (Leaf, Fusion ICE and HEV) – 250 lb incremental increases and decreases from stock weight
- Coastdown testing determines the impact of mass change on vehicle road load and drag forces
- Vehicle road load is calculated from change in speed (while coasting) and the mass of the vehicle
- Road load coefficients determined from coastdown testing are used to configure the chassis dynamometer
- Chassis dynamometer testing uses standardized drive cycles to determine the impact of mass change on vehicle fuel economy and energy consumption (MPG and Wh/mi)
Energy Storage Testing – Battery Mule

• Test DOE funded advanced energy storage systems (ESSs) in on-road operations. Quantify capabilities, limitations, and performance fade over the life of the ESS

• Only DOE project to perform onroad vehicle-system level testing of ESSs

• Enerdel battery mimics the Leaf battery demands to benchmark changes in calculated discharge, capacity fade, resistance, discharge power capability, charge resistance and charge power capability

• Toshiba is the next test battery
Additional Activities

• Conducting first responders training program with the National Fire Prevention Association and DOT / NHTSA
  – NFPA, OEMs and INL identify full size vehicle battery packs, procure and define demonstration “events”
  – OEMs are donating batteries and batteries will be ignited in NFPA fire suppression test mule

• DOD and Federal Fleets support with FEMP cost share
  – DOD studies electric infrastructure and PEV deployment
  – Lewis McCord, Jacksonville / Mayport, and Pendleton
  – 800 vehicles with data loggers, DOD, NPS, Veterans, etc.

Above source: Jalopnik, October 30, 2012
http://updates.jalopnik.com/post/34669789863/more-than-a-dozen-fisker-karma-hybrids-caught-fire-and
Acknowledgement

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

More Information
http://avt.inl.gov

This presentation will be posted in the publications section of the above website under “VSATT – November 2012 Update INL Activities”

INL/MIS-12-27607