In-Use Performance of Electric Drive Vehicles and Infrastructure: EV Project Results to Date

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Electrifying the Vehicle Market in the Southeast
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University of Tennessee, Knoxville
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This presentation does not contain any proprietary or sensitive information
Outline

• Advanced Vehicle Testing at INL
• Data Collection Methods
• EV Project Description
• EV Project Results to Date - Overall
• EV Project Results to Date - Tennessee
• Summary
• Where to find this presentation
Idaho National Laboratory

- U.S. Department of Energy (DOE) laboratory
- 890 square mile site – 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
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Development
  - Homeland Security and Cyber Security
AVTA Participants

- DOE’s Advanced Vehicle Testing Activity (AVTA), part of the Vehicle Technologies Program (VTP) conducts field-, test track-, and laboratory-based testing of light-duty vehicle systems and subsystems
  - Idaho National Laboratory provides technical direction and oversight of the AVTA for VTP
  - ECOtality provides testing support via a competitively bid NETL (National Energy Testing Laboratory) contract
- For the EV Project, ECOtality is the project lead and INL provides data collection, analysis and dissemination support
- Test partners include electric utilities, Federal, state and local government agencies, private companies, and individual vehicle owners
INL Vehicle/EVSE Data Management Process

Process Driven by Disclosure Agreements

INL Vehicle Data Management System

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 simulation input

HICEVs
HEVs
PHEVs
BEVs & EREVs
EVSE & Chargers

Data elements:
- Parameters range check
- Lame data check
- Missing/empty parameter check
- Conservation of energy check
- SOC continuity
- Transfer completion

Trips Fuel Economy (mpg)
MPG vs. Trip Aggressiveness (Percent of trip above the 40% accelerator pedal position)
CD trips
CD/CS trips
CS trips
Log. (CD trips)
Log. (CD/CS trips)

Avg Hourly Vehicle Charging Demand
Time of Day
600-659
700-759
800-859
900-959
1000-1059
1100-1159
1200-1259
1300-1359
1400-1459
1500-1559
1600-1659
1700-1759
1800-1859
1900-1959
2000-2059
2100-2159
2200-2259
2300-2359
000 - 059
100-159
200-259
300-359
400-459
500-559

Mon AM - Tues AM
Tue AM - Wed AM
Wed AM - Thu AM
Thu AM - Fri AM
Fri AM - Sat AM
Sat AM - Sun AM
Sun AM - Mon AM

Modeling and simulation input

Focused technical analyses and custom reports

Data quality reports

Individual vehicle reports

Fleet summary Reports - Public

Data elements:
- Parameters range check
- Lame data check
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INL Vehicle Data Management System

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EV Project

- Goal: Build and study mature charging infrastructures and take the lessons learned to support the future streamlined deployment of grid-connected electric drive vehicles

- Vehicle data is collected every trip via telematics providers from Volts and Leafs
- 8,715 Vehicles (6,329 Leafs, 1,255 Volts, 330 Smart EVs)
- 1 Million miles of data every 5.8 days
- EVSE Data is collected for each project charger as well
EV Project in the Southeast - Vehicles

• Nissan Leafs and Chevrolet Volts Reporting Data
  – Project-to-date through December 2012
# Nissan Leaf Data – 4th Quarter 2012

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Chattanooga</th>
<th>Knoxville</th>
<th>Memphis</th>
<th>Nashville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg trip distance (mi)</td>
<td>6.9</td>
<td>6.8</td>
<td>8</td>
<td>5.4</td>
<td>7.3</td>
</tr>
<tr>
<td>Avg distance traveled per day when vehicle was driven (mi)</td>
<td>29.2</td>
<td>29.8</td>
<td>33.4</td>
<td>26.5</td>
<td>32.2</td>
</tr>
<tr>
<td>Avg number of trips between charging events</td>
<td>3.8</td>
<td>3.7</td>
<td>3.4</td>
<td>4.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Avg distance traveled between charging events (mi)</td>
<td>26.3</td>
<td>25.1</td>
<td>27.7</td>
<td>23.4</td>
<td>26.6</td>
</tr>
<tr>
<td>Avg number charging events per day when vehicle was driven (mi)</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
<td>1.2</td>
</tr>
</tbody>
</table>
# Chevrolet Volt Data – 4th Quarter 2012

<table>
<thead>
<tr>
<th></th>
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<th>Memphis</th>
<th>Nashville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Fuel Economy (mpg)</td>
<td>126</td>
<td>119</td>
<td>112</td>
<td>117</td>
</tr>
<tr>
<td>Overall electrical energy</td>
<td>229</td>
<td>227</td>
<td>216</td>
<td>215</td>
</tr>
<tr>
<td>consumption (AC Wh/mi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg trip distance (mi)</td>
<td>8.1</td>
<td>8.1</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Avg distance traveled per day</td>
<td>40.5</td>
<td>43.1</td>
<td>38</td>
<td>45.1</td>
</tr>
<tr>
<td>when vehicle was driven (mi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg number of trips between</td>
<td>3.5</td>
<td>3.5</td>
<td>3.9</td>
<td>3.5</td>
</tr>
<tr>
<td>charging events</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg distance traveled between</td>
<td>28.2</td>
<td>28.5</td>
<td>27.6</td>
<td>31.9</td>
</tr>
<tr>
<td>charging events (mi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg number of charging events per</td>
<td>1.4</td>
<td>1.5</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>day when vehicle was driven</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Frequency of Charging by Charging Location

**EV Project Nissan Leaf**

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</tr>
</thead>
<tbody>
<tr>
<td>Home location</td>
<td>76%</td>
<td>81%</td>
<td>68%</td>
<td>84%</td>
<td>75%</td>
</tr>
<tr>
<td>Away-from-home location</td>
<td>18%</td>
<td>3%</td>
<td>24%</td>
<td>12%</td>
<td>18%</td>
</tr>
<tr>
<td>Unknown location</td>
<td>5%</td>
<td>16%</td>
<td>8%</td>
<td>4%</td>
<td>8%</td>
</tr>
</tbody>
</table>

**EV Project Chevrolet Volt**

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<th>Nashville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home location</td>
<td>81%</td>
<td>66%</td>
<td>72%</td>
<td>81%</td>
</tr>
<tr>
<td>Away-from-home location</td>
<td>13%</td>
<td>18%</td>
<td>7%</td>
<td>15%</td>
</tr>
<tr>
<td>Unknown location</td>
<td>6%</td>
<td>16%</td>
<td>21%</td>
<td>4%</td>
</tr>
</tbody>
</table>
Vehicle State-of-Charge at Start, End of Charge

Battery State of Charge (SOC) at the Start of Charging Events

Battery State of Charge (SOC) at the End of Charging Events

Charging Event Starting SOC (%)

Charging Event Ending SOC (%)

Home location
Away-from-home location
Charging Availability and Demand – All Regions

• All EVSE

Charging Availability: Range of Percent of Charging Units with a Vehicle Connected versus Time of Day³

Charging Demand: Range of Aggregate Electricity Demand versus Time of Day⁴
Demand – Nashville, TN vs San Diego, CA

- Nashville, TN. All EVSE

Charging Demand: Range of Aggregate Electricity Demand versus Time of Day

- San Diego, CA. All EVSE – Effect of TOU Electricity Rates

Charging Demand: Range of Aggregate Electricity Demand versus Time of Day
Public EVSE – Nashville, TN and San Diego, CA

- Nashville, TN - Publicly Available Level 2 EVSE

Charging Availability: Range of Percent of Charging Units with a Vehicle Connected versus Time of Day³

- San Diego, CA – Public Level 2 EVSE – Supporting Car2Go Car Sharing

Charging Availability: Range of Percent of Charging Units with a Vehicle Connected versus Time of Day³
Observations on Charging

• Residential L2 Charging
  – On average, vehicle plugged in much longer than drawing power (about 5:1)
  – Some variation weekend to weekday, but averages are similar

• Public L2 Charging
  – Vehicles plugged in ‘on standby’ less than residential
  – More differences between weekend and weekday

• DC Fast Charging
  – Units average 1.9 events per day, each
  – Average DCFast charge connection time: about 20 minutes, drawing power the whole time
  – 7.2 kWh average energy consumed per DC fast charge
Summary/Discussion

• Utilities with TOU rates seem to drive consumer behavior, charging off-peak

• Significant opportunities exist for ‘smart’ shifting of vehicles charging at home, based on the long plug-in times, and short time drawing power

• EV Project data still being collected – much more analysis will follow completion of data collection.

• DC Fast Charge events have significant demand impacts.

• INL has many other projects studying vehicle technologies and infrastructure – much information available on the AVTA website…
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 is posted in the publications section of the above website, alphabetically as “Electrifying the Vehicle Market in the Southeast: EV Project Results to Date”