PEV INFRASTRUCTURE DEPLOYMENT COSTS AND DRIVERS’ CHARGING PREFERENCES IN THE EV PROJECT

John Smart, Idaho National Laboratory

SAE 2014 Hybrid and Electric Vehicle Technologies Symposium
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La Jolla, CA
Idaho National Laboratory

U.S. Department of Energy (DOE) federal 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
- Fossil, Biomass, Wind, Geothermal and Hydropower Energy
- Advanced Vehicles and Battery Development
- Homeland Security and Cyber Security
The EV Project

Purpose is to build mature EV charging infrastructure in 17 US regions and study:

- Infrastructure deployment process
- Customer driving and charging behavior
- Impact on electric grid

12,000+ AC level 2 charging units, 100+ DC fast chargers

8,000+ Electric drive vehicles

INL data collection Jan 2011 – Dec 2013

Project partners

(Collect logos of project partners)
Infrastructure Deployment in The EV Project

Blink Charging Units Reporting Data in The EV Project through September 2013

Total
107 DCFC
474 PNL2
3,511 PAL2
8,250 RL2

Legend
- DC Fast Charge (DCFC)
- Private Nonresidential (PNL2)
- Residential (RL2)
- Publicly Accessible Level 2 (PAL2)
Vehicle Enrollment in The EV Project

Nissan Leafs and Chevrolet Volts Reporting Data in The EV Project through September 2013

Total
5,778 Leafs
2,021 Volts
416 Smart Electric Drives
Conventional wisdom
People spend most of their time at home and work, so most charging will be done there.
This presentation
Provides some insights from these infrastructure demos on actual charging behavior

How much are vehicles charged at home vs. away from home?
How does Volt charging influence EV driving range?
What do we know about workplace charging?
How often are residential, public level 2, and DC fast charging units being used?
What are their installation costs?
How far are Leafs traveling from home?
Actual vehicle charging locations between Jul 2013 – Sep 2013 in The EV Project

Based on 256,288 charging events from 4,036 Leafs and 179,681 charging events from 1,812 Volts in Q3 2013
Additional 15,099 Leaf and 11,579 Volt charging events occurred at unknown locations
Away-from-home Charging Frequency for Volts in The EV Project

Charging data from 1,405 Volts in 18 regions from Oct 2012 – May 2013

Percent of Charges Away From Home

Percent of Vehicles (green bars)

Cumulative Percent of Vehicles (yellow curve)
### Effect of Away-from-home Charging for Volts in The EV Project

Charging data from 1,405 Volts in 18 regions from Oct 2012 – May 2013

<table>
<thead>
<tr>
<th>% of Charging Away from Home:</th>
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<td>Vehicles (% of total)</td>
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<tr>
<td>Home Charges Per Day</td>
<td>1.2</td>
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<td>Away-from-home Charges Per Day</td>
<td>--</td>
</tr>
<tr>
<td>Home SOC Increase Per Charge</td>
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<td>Average Miles Per Day Driven</td>
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This group supplemented home charging with a little away-from-home charging

This group drove a little more each day

Additional charging provided energy for more EV miles per day
Effect of Away-from-home Charging for Volts in The EV Project

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<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
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<td>--</td>
<td>0.1</td>
<td>0.8</td>
</tr>
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<td>60.5</td>
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Compared to vehicles with no away-from home charging…

This group supplemented home charging with a lot of away-from-home charging

This group drove a lot more each day

Additional charging provided energy for many more EV miles per day (53% increase)
### Effect of Away-from-home Charging for Volts in The EV Project

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Compared to vehicles with no away-from home charging…

This group supplemented away-from-home charging with some home charging (*workplace charging?*)

This group drove a little more each day

Additional charging provided energy for a little more EV miles per day
## Workplace Charging Case Studies

Worksites identified where EV Project participant vehicles have parked and charged a significant number of times (excluding fleet vehicles)

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of work sites</th>
<th>Charging locations per site</th>
<th>Types of companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knoxville, TN</td>
<td>2</td>
<td>1, 4</td>
<td>Offices, manufacturing plants, and R&amp;D facilities of companies in computer, telecom, pharmaceutical, biotech, automotive, aerospace, and other industries</td>
</tr>
<tr>
<td>Nashville, TN</td>
<td>6</td>
<td>1 - 6</td>
<td></td>
</tr>
<tr>
<td>Portland, OR</td>
<td>2</td>
<td>1, 4</td>
<td></td>
</tr>
<tr>
<td>Phoenix, AZ</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>11</td>
<td>1 - 15</td>
<td></td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>51</td>
<td>1 - 10</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Workplace Charging Case Studies – Commuting Distance

Distributions of Average One-way Commuting Distance

- Leaf (N = 313)
- Volt (N = 10)

Leaf Cumulative Distribution of Average One-way Commuting Distance

- 86% of EV Project Leafs parking at worksites identified average 30 miles or less between home and work
Workplace Charging Examples in San Diego
Public Level 2 Charging Examples in San Diego

Balboa Park Air & Space Museum (plugshare.com)

San Diego State University

West Mission Valley Mall – Macy’s
Usage of AC Level 2 EVSE and DC Fast Chargers

Q3 2013 EVSE Usage Frequency and Duration by EVSE Type and Region

Number of charging events / EVSE day vs Average time connected per charging event (hr)

- Public L2
- Resid
- Priv nonresid
- DCFC
Usage of AC Level 2 EVSE and DC Fast Chargers

Q3 2013 Residential EVSE Usage Frequency and Duration

Percent of residential charging events by vehicle make and territory:

<table>
<thead>
<tr>
<th>Territory</th>
<th>Leaf</th>
<th>Volt</th>
<th>Plot Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>100%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Nashville</td>
<td>88%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Tucson</td>
<td>81%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>Washington State</td>
<td>76%</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>Chattanooga</td>
<td>74%</td>
<td>26%</td>
<td></td>
</tr>
<tr>
<td>Oregon</td>
<td>68%</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td>Knoxville</td>
<td>66%</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>San Diego</td>
<td>64%</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>Atlanta</td>
<td>63%</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>Phoenix</td>
<td>53%</td>
<td>47%</td>
<td></td>
</tr>
<tr>
<td>Memphis</td>
<td>52%</td>
<td>48%</td>
<td></td>
</tr>
<tr>
<td>Los Angeles</td>
<td>39%</td>
<td>61%</td>
<td></td>
</tr>
<tr>
<td>Philadelphia</td>
<td>28%</td>
<td>72%</td>
<td></td>
</tr>
<tr>
<td>Chicago</td>
<td>14%</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>11%</td>
<td>89%</td>
<td></td>
</tr>
<tr>
<td>Dallas/Ft. Worth</td>
<td>8%</td>
<td>92%</td>
<td></td>
</tr>
<tr>
<td>Houston</td>
<td>6%</td>
<td>94%</td>
<td></td>
</tr>
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Usage of AC Level 2 EVSE and DC Fast Chargers

Q3 2013 EVSE Usage Frequency and Duration
by EVSE Type and Region

Number of charging events / EVSE day

Average time connected per charging event (hr)

- Public L2
- Resid
- Priv nonresid
- DCFC
Usage of AC Level 2 EVSE and DC Fast Chargers

Q3 2013 Public Level 2 EVSE Usage Frequency and Duration

Number of charging events / EVSE day

Average time connected per charging event (hr)

Residential Level 2 EVSE Installation and Permitting Cost (Preliminary)

N = 4,466 units installed before May 2013
Installation cost does not include cost of EVSE
• Costs are influence by project design
  - participant selection criteria
  - subsidy limit

• High costs driven by need to upgrade entire residential electrical service (worst case ex: $8,429) or other requests, such as:
  - Not installing near the service panel
  - Desire to site away from the house and concrete must be cut

• Low costs driven by things like an existing 240 V outlet in the garage
Commercial Level 2 EVSE Installation and Permitting Cost (Preliminary)

- Commercially sited level 2 EVSE averaged between $3,500 and $4,500 for the installation cost through May 2013 (excluding hardware)

- There is much variability by region and by installation
  - Tennessee and Arizona had lowest average installation costs of $2,000 to $2,500
  - Multiple Level 2 units at one location drive down the per EVSE average installation cost

- Costs are significantly driven by poor site requests
  - Example: mayor may want EVSE by front door of city hall, but electric service is located at back of building
Costs above do not include:

- Hardware
- Host commitment for the parking and ground space
- Electric utility cost to evaluate/upgrade service, if necessary
- All the lower-cost sites are targeted first, so final costs may be higher
Where is the best place to put public charging stations?

San Diego area away-from-home parking locations for Volts that average > 35 mi per day (excluding parking locations of single vehicles)
Leaf Travel Extents in the San Diego Area

Mar 2011

Van Nuys
Hollywood
Los Angeles
Long Beach
Santa Ana
San Diego

Project

DC Fast Chargers
Public Level 2
Parking locations of Nissan Leafs based in San Diego Region

INL
Idaho National Laboratory
2/3/2014
INL/MIS-13-30487
Publications coming soon:

- Q4 2013 reports
- White papers on
  - Leaf L2 vs. DCFC usage
  - public charging venues
  - workplace charging case studies
  - EVSE installation costs
- and more

For all EV Project publications, visit

[avt.inl.gov/evproject.shtml](http://avt.inl.gov/evproject.shtml)

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