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

Results from The EV Project: PEV Infrastructure Deployment Costs and Driver’s Charging Preferences

Jim Francfort
Richard “Barney” Carlson (presenter)
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EV Project Goal, Locations, Participants, and Reporting

- 50%/50% DOE ARRA and ECOtality North America funded
- 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 Onstar/GM as the prime partners, with more than 40 other partners such as electric utilities and government groups
- Required 11,000 data agreements to be signed
EVSE Data Parameters Collected per Charge Event

- Data from ECOtality’s Blink & other EVSE networks
- 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.)
Vehicle Data Parameters Collected per Start /Stop 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

- Additional data is received monthly from Car2go for the Smart EVs
Data Collection, Security and Protection

- All vehicle, EVSE, and PII 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 in order to avoid exposure to FOIA
  - Vehicle and EVSE data collection would not occur unless testing partners trust INL would strictly adhere to NDAs and CRADAs
  - Raw data cannot be legally distributed by INL
## EV Project – Summary of National Data

### 2nd quarter 2013 Data Only

<table>
<thead>
<tr>
<th></th>
<th>Leafs</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>4,261</td>
<td>1,895</td>
</tr>
<tr>
<td>Number of Trips</td>
<td>1,135,000</td>
<td>676,000</td>
</tr>
<tr>
<td>Distance (million miles)</td>
<td>8.04</td>
<td>5.75</td>
</tr>
<tr>
<td>Average (Ave) trip distance</td>
<td>7.1 mi</td>
<td>8.3 mi</td>
</tr>
<tr>
<td>Ave distance per day</td>
<td>29.5 mi</td>
<td>41.0 mi</td>
</tr>
<tr>
<td>Ave number (#) trips between charging events</td>
<td>3.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Ave distance between charging events</td>
<td>26.7 mi</td>
<td>27.6 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
PEV Driver’s Charging Preferences
• 74% of charging at Home
• 26% of charging away from home or unknown
EV Project – Volt Driver’s Charging Behavior

- 80% of charging at Home
- 20% of charging away from home or unknown

Chevy Volt Driver Charging Behavior

- Percent home charging
- Percent away from home charging
- Percent unknown locations
EV Project – Leaf & Volt Charging
2nd quarter 2013 Data Only

Leads

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

- Home location
- Away-from-home location

Volts

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

- Home location
- Away from home

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

- Home location
- Away-from-home location
EV Project – Residential EVSE Use

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
EV Project – Non Residential L2 EVSE Use

Non-Residential EVSE Infrastructure Use Trends

- Ave Hrs Vehicle Connt P2 WD/Charge
- Ave Hrs Vehicle Connt P2 WE/Charge
- Ave Hrs Vehicle Draw KW P2 WD/charge
- Ave Hrs Vehicle Draw KW P2 WE/charge
- Ave AC KWh/charge Event P2 WD/charge
- Ave AC KWh/charge Event P2 WE/charge

Chart showing trends from 3rd 2011 to 2nd 2013.
EV Project – DCFC Use

DC Fast Charge Infrastructure Use Trends

- Ave Mins Vehicle Connt DCFC WD
- Ave Mins Vehicle Connt DCFC WE
- Ave Mins Vehicle Draw KW DCFC WD
- Ave Mins Vehicle Draw KW DCFC WE
- Ave AC KWh/charge Event DCFC WD
- Ave AC KWh/charge Event DCFC WE

4th 2012 | 1st 2013 | 2nd 2013
EV Project – Infrastructure use

• Per unit use, 2nd quarter 2013 reports

• Residential L2 EVSE are typically utilized < 1 charge per day

• Public L2 EVSE are typically utilized <0.5 charges per day

• DCFC are utilized from <0.5 to >6 charges per day
EV Project

- Per unit use, 2nd quarter 2013 reports
- DCFC use per unit compared to residential and public access Level 2 EVSE

![Individual Unit DCFC Charge Events to EVSE Ratio - April-June 2013](chart.png)
Residential vs. Public Use Rates

- Ratio of 5.4 : 1 weekly Residential EVSE use versus weekly Public Level 2 EVSE use (last 5 weeks)
Charge Infrastructure Installation Costs
DCFC Installation Costs / Issues

- Current installations range from $8,500 to $48,000 (99 units)
- Average installation cost to date is about $21,000
- Host has obvious commitment for the parking and ground space - not included in above costs
- Above does not include any costs that electric utility may have incurred in evaluating or upgrading service

- These are the preliminary costs to date. When all 200 DC Fast Chargers are installed, installation costs may be different
  - All the best (lower-cost) sites are installed first, so final costs may be higher
  - Lessons learned may help lower future costs and site selections, so final costs may be lower
DCFC Installation Costs

- **Total installation costs (99 units)**
- **Includes everything EV Project has funded per DCFC installation except DCFC charging unit**

<table>
<thead>
<tr>
<th>Number per Region</th>
<th>National - 99</th>
<th>AZ - 17</th>
<th>WA - 12</th>
<th>CA - 37</th>
<th>OR - 15</th>
<th>TN - 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>$8,440</td>
<td>$8,440</td>
<td>$18,368</td>
<td>$10,538</td>
<td>$12,868</td>
<td>$14,419</td>
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<tr>
<td>Mean</td>
<td>$20,848</td>
<td>$15,948</td>
<td>$24,001</td>
<td>$21,449</td>
<td>$19,584</td>
<td>$23,271</td>
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<tr>
<td>Maximum</td>
<td>$47,708</td>
<td>$33,990</td>
<td>$33,246</td>
<td>$47,708</td>
<td>$26,766</td>
<td>$31,414</td>
</tr>
</tbody>
</table>
DCFC Installation Costs / Issues

- Items of concern associated with installation that drive costs
  - Power upgrades needed for site
  - Impact on local transformer
  - Ground surface material and cost to “put back” (e.g. concrete, asphalt, landscaping)
  - Other underground services that may affect method of trenching power to DCFC
  - Gatekeeper or decision-maker for the property is not always apparent
  - Magnitude of operating costs and revenue opportunities are still largely unknown
  - Time associated with permissions
    - Permits, load studies, and pre-, post-, and interim inspections
**DCFC Commercial Lessons Learned**

- Especially in California, DC fast charge demand charges are significant in many utility service territories.

<table>
<thead>
<tr>
<th>Utility Demand Charges - Nissan Leaf</th>
<th>Cost/mo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td></td>
</tr>
<tr>
<td>Glendale Water and Power</td>
<td>$16.00</td>
</tr>
<tr>
<td>Hercules Municipal Utility:</td>
<td>$377.00</td>
</tr>
<tr>
<td>Los Angeles Department of Water and Power</td>
<td>$700.00</td>
</tr>
<tr>
<td>Burbank Water and Power</td>
<td>$1,052.00</td>
</tr>
<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>AZ</td>
<td></td>
</tr>
<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>
</tr>
<tr>
<td>Arizona Public Service</td>
<td>$483.75</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Pacificorp</td>
<td>$213.00</td>
</tr>
<tr>
<td>WA</td>
<td></td>
</tr>
<tr>
<td>Seattle City Light</td>
<td>$61.00</td>
</tr>
</tbody>
</table>
### Commercial Level 2 Permits Cost

- **Commercial permits range $14 to $821**

<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>
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</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>
</tr>
<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>
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<tr>
<td>Tennessee</td>
<td>159</td>
<td>$71</td>
<td>$19</td>
<td>$216</td>
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<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>
Commerical Level 2 Installation Costs

• Nationally, commercially sited Level 2 EVSE average between $3,500 and $4,500 for the installation cost
  – Does not include EVSE hardware
• There is much variability by region and by installation
  – Multiple Level 2 units at one location drive down the per EVSE average installation cost
  – Tennessee and Arizona have average installation costs of $2,000 to $2,500
• 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
Residential Level 2 EVSE Installation Costs

- Max - $8,429
- Mean $1,414
- Min $250
- Medium $1,265

- Count 4,466
- Total installation costs, does not include EVSE hardware
Residential Level 2 Installation Costs

• High costs driven by need to upgrade entire residential electrical service - $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
• Does not include EVSE hardware
Residential Level 2 EVSE Installation Costs

- Regional results for 4,466 units
- Permit versus other installation costs. No EVSE costs
Two examples of Utilization at sites with multiple EVSE
Each EVSE had significant usage in the quarter

All 7 EVSE simultaneously connected to a vehicle for 2 hrs per weekday, on average
EV Project vehicles at “Worksite A”

Parking events by vehicle in Q2 2013

- Many vehicles parked only a few times (perhaps visitors?)
- Some frequent-parking PEVs rarely or never charged
- Drivers may have multiple parking events each day
Level 2 EVSE utilization at “Worksite B”

Each EVSE had significant usage in the quarter.

All 10 EVSE connected to a vehicle for 1 hr per weekday on average.
EV Project vehicles at “Worksite B”

Parking events by vehicle in Q2 2013

- Many vehicles parked only a few times – visitors?
- Frequent-parking PEVs charged *nearly every time* they parked
- Non-employee vehicles may be using DCFC as public charger

Overall
- 24 (13%) Parking events w/o charging
- 113 (61%) Level 2 charges
- 48 (26%) DCFC charges
Summary

- Residential Level2 EVSE are the primary choice for charging by PEV owners
  - 75% to 80% of charging is at residence (home)

- DCFC installation costs range from $8,500 to $48,000
  - Average DCFC installation cost: $21,000

- Commercial L2 EVSE installation cost average between $3,500 and $4,500
  - Multiple EVSE per site reduces the cost per EVSE

- Residential L2 EVSE installation costs: $8,429 to $250
  - Average DCFC installation cost: $1,414
Acknowledgement

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

http://avt.inl.gov