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

DOT/FHA – DOE’s EV Project Update

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Idaho National Laboratory

Federal Highway Administration EV Forum
Washington, D.C.
April 16, 2013

This presentation does not contain any proprietary or sensitive information
Presentation Outline

• INL and Vehicle Technology Experience and General Data Collection Methods
• EV Project results to date (majority of presentation)
• Corridor charging (briefly)
• Other Testing Activities (briefly)
• Summary
• Where you can find this presentation
Idaho National Laboratory

- U.S. Department of Energy (DOE) 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
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
AVTA Goals

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

- Provide benchmark data to DOE, National Laboratories (ANL, NREL, ORNL, PNNL), Federal Agencies (DOD, DOI, DOT, EPA, USPS), technology modelers, R&D programs, vehicle manufacturers (via USCAR’s VSATT, EESTT, GITT), 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

- 93 million test miles accumulated on 12,200 electric drive vehicles representing 119 models. 1 million miles / week
- EV Project: 8,715 Leafs, Volts and Smart EVs, 11,208 EVSE and DC Fast Chargers (DCFC), 74 million test miles
- ChargePoint: 3,908 EVSE reporting 761,000 charge events
- PHEVs: 15 models, 434 PHEVs, 4 million test miles
- EREV: 2 models, 156 EREV, 2 million test miles
- HEVs: 24 models, 58 HEVs, 6.4 million test miles
- Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 608,000 test miles
- NEVs: 24 models, 372 NEVs, 200,000 test miles
- BEVs: 48 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
Data Collection and Security History

- 1993 state-of-art 386 PCs and floppy drives that were mailed via the USPS from 300 PEVs. Initial PEV database
- 1994 hand-held, optical readers connected to laptops, read ABB meters on vehicles and EVSE
- 2007 started data collection via the www for 44 PEVs when data could be uploaded from thumb drives
- 2008 started data collection with integrated vehicle data loggers and cellular from 200 PEVs in 28 states
- Twenty year history of data security and NDAs protecting and limiting the distribution of PII and raw data
INL Vehicle/EVSE Data Management Process

Process Driven by Disclosure Agreements

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

INL Vehicle Data Management System

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

File server
SQL Server data warehouse
Report generator

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

Trip Fuel Economy (mpg)
Avg Hourly Vehicle Charging Demand

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

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8

Time of Day

600-65
700-75
800-85
900-95
1000-105
1100-115
1200-125
1300-135
1400-145
1500-155
1600-165
1700-175
1800-185
1900-195
2000-205
2100-215
2200-225
2300-235
000 - 05
100-15
200-25
300-35
400-45
500-55

Modeling and simulation input
Today - Data Collection, Security & 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 the INL
EV Project Goal, Locations, Participants, and Reporting

- **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
- 40 different EV Project reports are generated quarterly for the general public, DOE, ECOtality, project participants, industry, regulatory organizations, as well as per special requests
EV Project – 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.)
EV Project – Vehicle Data Parameters Collected per Key On/Off Events

- 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
EV Project Overview Report 4th Quarter 2012

- San Francisco has 17% of all EVSE and 30% of all Leafs.
- Washington DC has 16% and Texas has 18% of all Volts.

![Bar Chart: Number of Leafs, Volts & EVSE Reporting Data 4th Quarter 2012]
EV Project Data Complexity

- The EV Project has 44 Databases (DB)
  - Nissan Leaf & GM/OnStar Volt
  - ECotality Blink, Aerovironment & EPRI EVSE
  - Admin (look up tables, territories, zips codes, QA parameters, etc.)
    - Each of the above six DBs has three versions (process, stage & production) = 18 DBs
  - Four GIS DBs for the Leafs, Volts, Blink EVSEs, and Base (streets, utility service territory areas, etc.)
  - Above 22 (18 + 4) DBs exist on two systems = 44 DBs

- Hundreds of algorithms and thousands of lines of code are required to generate 56,000 data parameters for populating 132 pages of public quarterly reports
- INL must blend multiple data streams, from multiple sources, all on different delivery schedules
- This is no flat file. This is NOT a simple Excel Spreadsheet task
EV Project Vehicles / Miles, 3/17/13

- 8,715 vehicles reporting data
  - 6,329 Leafs. 73%
  - 1,255 Volts. 24%
  - 330 Smart EVs. 4%
- 73.8 million total miles
  - Leafs 81%
  - Volts 18%
  - Smart EVs 2%
- 173,000 test miles per day = 1 million miles every 5.8 days
EV Project EVSE Deployed / Use, 3/17/13

- 11,208 total EVSE
  - 8,083 (72%) Residential EVSE
  - 3,049 (27%) non-residential EVSE
  - 76 (1%) DCFC

- 2.2 million charge events
  - 2,025,000 (91%) Residential EVSE
  - 173,000 (8%) non-residential EVSE
  - 20,000 (1%) DCFC
18,559 AC MWh total electricity charged
- 17,042 MWh (92%) residential
- 1,370 MWh (7%) non-residential
- 147 MWh (1%) DCFC

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 – National Data

4rd 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>3,762</td>
<td>1,021</td>
</tr>
<tr>
<td>Number of Trips</td>
<td>969,853</td>
<td>369,118</td>
</tr>
<tr>
<td>Distance (million miles)</td>
<td>6.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Average (Ave) trip distance</td>
<td>6.9 mi</td>
<td>8.1 mi</td>
</tr>
<tr>
<td>Ave distance per day</td>
<td>29.2 mi</td>
<td>40.5 mi</td>
</tr>
<tr>
<td>Ave number (#) trips between charging events</td>
<td>3.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Ave distance between charging events</td>
<td>26.3 mi</td>
<td>28.2 mi</td>
</tr>
<tr>
<td>Ave # charging events per day</td>
<td>1.1</td>
<td>1.4</td>
</tr>
</tbody>
</table>

* Note that per day data is only for days a vehicle is driven
EV Project – *Leaf* Operations Trends

- Slight decreases in average miles per day and average miles per charge

| Number of Leafs reporting each quarter with matched EVSE data |
|-------------------|--------------|-------------|-------------|--------------|-------------|-------------|-------------|
| 35                | 956          | 2,394       | 2,645       | 2,987        | 2,911       | 3,200       | 3,762       |
EV Project – Leaf Charging Location Trends

- 13.4% increase in home charging and 36% decrease in non-home charging as a revenue model is introduced
  - HOWEVER, one data point does not make a trend.....

Nissan Leaf Driver Charging Behavior

<table>
<thead>
<tr>
<th>Percent home charging</th>
<th>Percent away from home charging</th>
<th>Percent unknown locations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of Leafs reporting each quarter with matched EVSE data

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Number of Leafs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 2011</td>
<td>35</td>
</tr>
<tr>
<td>2nd 2011</td>
<td>956</td>
</tr>
<tr>
<td>3rd 2011</td>
<td>2,394</td>
</tr>
<tr>
<td>4th 2011</td>
<td>2,645</td>
</tr>
<tr>
<td>1st 2012</td>
<td>2,987</td>
</tr>
<tr>
<td>2nd 2012</td>
<td>2,911</td>
</tr>
<tr>
<td>3rd 2012</td>
<td>3,200</td>
</tr>
<tr>
<td>4th 2012</td>
<td>3,762</td>
</tr>
</tbody>
</table>
EV Project – Volt Operations Trends

- Mostly upwards trends in miles per day and miles per charge reversed last quarter

### Chevy Volt Driver Operations Behavior

- **Avg Trip Distance - Miles**
- **Avg Miles per day**
- **Ave Trips Between Charges**
- **Ave Miles per Charge**
- **Ave # Charges per Day**

### Number of Volts reporting each quarter with matched EVSE data

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Number of Volts</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>
<tr>
<td>4th 2012</td>
<td>1021</td>
</tr>
</tbody>
</table>
EV Project – Volt Charging Location Trends

- 4% increase in home charging and 7% decrease in non-home charging as a revenue model is introduced

- AGAIN, one data point does not make a trend.....

Chevy Volt Driver Charging Behavior

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

Number of Volts reporting each quarter with matched EVSE data

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th 2011</td>
<td>45</td>
</tr>
<tr>
<td>1st 2012</td>
<td>317</td>
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<td>3rd 2012</td>
<td>809</td>
</tr>
<tr>
<td>4th 2012</td>
<td>1021</td>
</tr>
</tbody>
</table>
EV Project – Residential EVSE L2 Use Trends

- Slight increases in times vehicles connected and drawing power, and increase in AC KWh transferred per charge event

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave Hrs Vehicle Connt R2 WD</td>
<td>10.0</td>
<td>12.5</td>
<td>15.0</td>
<td>17.5</td>
<td>10.0</td>
<td>12.5</td>
<td>15.0</td>
<td>17.5</td>
</tr>
<tr>
<td>Ave Hrs Vehicle Connt R2 WE</td>
<td>9.5</td>
<td>11.5</td>
<td>14.0</td>
<td>16.5</td>
<td>9.5</td>
<td>11.5</td>
<td>14.0</td>
<td>16.5</td>
</tr>
<tr>
<td>Ave Hrs Vehicle Draw KW R2 WD</td>
<td>7.5</td>
<td>9.5</td>
<td>12.0</td>
<td>14.5</td>
<td>7.5</td>
<td>9.5</td>
<td>12.0</td>
<td>14.5</td>
</tr>
<tr>
<td>Ave Hrs Vehicle Draw KW R2 WE</td>
<td>6.0</td>
<td>7.5</td>
<td>9.0</td>
<td>11.0</td>
<td>6.0</td>
<td>7.5</td>
<td>9.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Ave AC KWh/charge Event R2 WD</td>
<td>2.5</td>
<td>3.5</td>
<td>4.5</td>
<td>5.5</td>
<td>2.5</td>
<td>3.5</td>
<td>4.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Ave AC KWh/charge Event R2 WE</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Number of Residential EVSE Level reporting each quarter

<table>
<thead>
<tr>
<th></th>
<th>3rd 2011</th>
<th>2704</th>
<th>3rd 2012</th>
<th>3338</th>
<th>4th 2012</th>
<th>4819</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 2011</td>
<td>35</td>
<td>955</td>
<td>2nd 2011</td>
<td>2413</td>
<td>4th 2012</td>
<td>4020</td>
</tr>
</tbody>
</table>

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

- Increases in kWh per charge, time energy is drawn and time connected

### Non-Residential EVSE Infrastructure Use Trends

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave Hrs Vehicle Connt P2 WD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave Hrs Vehicle Connt P2 WE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave Hrs Vehicle Draw KW P2 WD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave Hrs Vehicle Draw KW P2 WE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave AC KWh/charge Event P2 WD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave AC KWh/charge Event P2 WE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Number of Public EVSE Level reporting each quarter

<table>
<thead>
<tr>
<th></th>
<th>170</th>
<th>438</th>
<th>955</th>
<th>1483</th>
<th>1818</th>
<th>1988</th>
</tr>
</thead>
</table>

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

- Percent of public L2 EVSE deployed was about 30% of all L2 EVSE 4th quarter 2012

- As measured by kWh use and number of charge events, revenue model may be decreasing known public L2 EVSE use
### EV Project Public L2 EVSE Usage 4th ¼ 2012

- Public charging contribution of Car Sharing Fleet is significant in San Diego

<table>
<thead>
<tr>
<th>All territories</th>
<th>Car sharing fleet</th>
<th>Nissan Leaf</th>
<th>Chevrolet Volt</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles Charged</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of charging events</td>
<td>25%</td>
<td>21%</td>
<td>5%</td>
<td>49%</td>
</tr>
<tr>
<td>Percent of kWh consumed</td>
<td>38%</td>
<td>17%</td>
<td>3%</td>
<td>41%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>San Diego</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles Charged</td>
</tr>
<tr>
<td>Percent of charging events</td>
</tr>
<tr>
<td>Percent of kWh consumed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oregon (Car2Go in Portland)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles Charged</td>
</tr>
<tr>
<td>Percent of charging events</td>
</tr>
<tr>
<td>Percent of kWh consumed</td>
</tr>
</tbody>
</table>
EV Project – EVSE Infra. Summary Report

- National Residential and Public Level 2 Weekday EVSE 4th Quarter 2012

- Residential and public connect time and energy use are fairly opposite profiles. Note different scales

National Residential Connect Time

National Public Connect Time

National Residential Demand

National Public Demand
EV Project – EVSE Infra. Summary Report

• Residential Level 2 Weekday EVSE 4th Quarter 2012
• San Diego and San Francisco, with residential L2 TOU rates, are similar to national and other regional EVSE connect profiles
EV Project – EVSE Infra. Summary Report

- Residential Level 2 Weekday EVSE 4rd Quarter 2012
- TOU kWh rates in San Diego and San Francisco clearly impact when vehicle charging start times are set
<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave hours V connected R2 WD</td>
<td>12.1 hours</td>
</tr>
<tr>
<td>Ave hours V connected R2 WE</td>
<td>12.2 hours</td>
</tr>
<tr>
<td>Ave hours V drawing power R2 WD</td>
<td>2.4 hours</td>
</tr>
<tr>
<td>Ave hours V drawing power R2 WE</td>
<td>2.1 hours</td>
</tr>
<tr>
<td>Ave AC kWh/charge event R2 WD</td>
<td>8.6 AC kWh</td>
</tr>
<tr>
<td>Ave AC kWh/charge event R2 WE</td>
<td>7.4 AC kWh</td>
</tr>
<tr>
<td>Ave hours V connected P2 WD</td>
<td>5.9 hours</td>
</tr>
<tr>
<td>Ave hours V connected P2 WE</td>
<td>4.1 hours</td>
</tr>
<tr>
<td>Ave hours V drawing power P2 WD</td>
<td>2.5 hours</td>
</tr>
<tr>
<td>Ave hours V drawing power P2 WE</td>
<td>2.5 hours</td>
</tr>
<tr>
<td>Ave AC kWh/charge event P2 WD</td>
<td>8.4 AC kWh</td>
</tr>
<tr>
<td>Ave AC kWh/charge event P2 WE</td>
<td>6.4 AC kWh</td>
</tr>
</tbody>
</table>

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

- DC Fast Chargers Weekday 4\textsuperscript{th} Quarter 2012
- 54 DCFC, 6,089 charge events and 58 AC MWh

- 1.9 average charge events per day per DCFC
- Leafs 43% charge events and 45% energy
- Unknowns are other charge events and energy
- 19.3 minutes average time connected
- 19.3 minutes average time drawing energy
- 7.2 kWh average energy consumed per charge
L2 Access Fees Structure

• **4th Quarter** is first widespread implementation of simple and low cost access fees

• **Blink member**
  – Affiliate credit card with free Blink RFID “In Card”
  – Level 2 access fee of $1.00 per hour of connect time

• **Guest - No Blink RFID “In Card” required**
  – Guest Code using quick reservation code or website
  – Level 2 access fee of $2.00 per hour of connect time

• **Future pricing**
  – Pricing to reflect regional electricity rates
  – Cover electricity costs in all cases
DC Fast Charge (DCFC) Fees Structure

- Encourage DCFC use with initial free charging
- Implement DCFC access fees by region in 1st Quarter 2013 with beta testing currently underway
- Initial fee structure simple and low cost
  - Accommodate varying vehicle charge rates
  - Accommodate select limitation of charging output power
- Blink member
  - $25 per month unlimited use or $5.00 per session
- Guest
  - $8.00 per session
Residential Permit Costs / Issues

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

<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>
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<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 Installation Costs

- **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 Francisco</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 can are significant**
  - Load studies
  - Zoning reviews
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>
</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>
</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>
</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 DC Fast Charger Installation Costs / Issues

- Current installations range from $6,090 to $48,000 (70+).
- Average installation cost to date is about $22,600.
- 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.
Commercial DC Fast Charger 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
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 electric utility service territories

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

- Especially in California, recurring Nissan Leaf 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 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>
</tr>
<tr>
<td>Southern California Edison</td>
<td>$1,460.00</td>
</tr>
<tr>
<td>AZ TRICO Electric Cooperative</td>
<td>$180.00</td>
</tr>
<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 Pacificorp</td>
<td>$213.00</td>
</tr>
<tr>
<td>WA Seattle City Light</td>
<td>$61.00</td>
</tr>
</tbody>
</table>
Corridor Charging – 1st Look 4th Quarter 2012

- Ten Level 2 EVSE and two DCFCs in CA, WA and OR travel corridors outside of major cities
- 55 distinct vehicle owners charged 92 times at Level 2 EVSE for an average of 1.6 hours and 4.1 kWh
- 64 distinct vehicles owners charged 151 times at DCFCs for an average of 19 minutes and 7.9 kWh
- Two locations had one DCFC and one Level 2 EVSE. One immediate I-5 access and one on state highway
  - I-5 DCFC had 2 times the charging events as state highway DCFC
  - DCFC 5 times energy used as Level 2 at ¾ connect time
  - DCFC 2.5 times number charges as Level 2
  - Some vehicles may not be DCFC capable
  - Very small sample

![Bar chart showing comparison between Level 2 EVSE and DC fast chargers in terms of number of charging events, energy consumed, and time connected.](chart.png)
ChargePoint results to date
ChargePoint America ARRA Project

- Conducted by Coulomb
- Project to Dec. 2012
- 3,908 EVSE installed and reporting data
  - 1,763 Residential
  - 193 Private / commercial
  - 1,940 Public
  - 12 unknown
- 760,995 charge events
- 5,359 AC MWh
ChargePoint America ARRA Project

- Oct - Dec 2012 data
- 3,541 units
- Percent time vehicle connected
  - Residential 47%
  - Private/com 24%
  - Public 9%
- Percent time drawing power
  - Residential 9%
  - Private/com 5%
  - Public 4%
- EVSE data only

- Public is open access. Commercial are limited access
- Public and commercial reflect at work charging
- Residential reflects end of day return-to-home charging
- Note difference in scales
Other Testing Activities

Summary

Where you can find this presentation
Additional Testing

- Initiated field and lab DC Fast Charge and Level 2 charging study of impacts on battery life in 6 Nissan Leafs – At 20k miles each vehicle similar minimal capacity fade
- INL, with DOE, DOT and NFPA support, conducting PEV traction battery fire demonstration and suppression project
- INL initiated ~500 New York EVSE data collection with NYSERDA, NYPA, Port Authority of NY/NJ, and Energetics
- 30 EVSE and 10 vehicle conductive interoperability testing conducted with SAE
- Initiated data collection project for six Nissan Leafs in New York City taxi fleet. Data from 6 Level 2 EVSE & 3 DCFCs, vehicles and NYC Taxi & Limousine Commission
- Initiated wireless charging test program – first two systems this month
- Cyber security testing of smart EVSE and thus the Smart Grid
Summary

- 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 charges starting at midnight. TOU rates indicate consumers are price sensitive
- Revenue models for public charging are currently being introduced – long term impacts?
- Only about 60% of EV Project data collected to date
- DCFC charge events have significant demand impacts and this creates electric utility policy decisions
- Tested 13 EVSE and DC Fast Charges to date
- How, where, when we measure EVSE and vehicle system charging efficiencies results in significantly different results
- First independent testing of wireless systems will validate SAE testing procedures
- If I only had another 20 minutes I could have 100 slides…
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 “DOT/FHA – DOE’s EV Project Update”