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

GITT 2013 (6/19/13) - EV Project and Charging Infrastructure Update

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USDRIVE Grid Interaction Tech Team
USCAR, Southfield, Michigan
June 19, 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)
  – Vehicle and Level 2 use
  – DCFC use (DC Fast Charger)
  – Some infrastructure lessons learned, including costs
• ChargePoint results to date
• Conductive Charging Infrastructure Testing
• Wireless Charging Infrastructure Testing
• Other Testing Activities and Where you can find this presentation
Vehicle and Charging Technology
Experience and General Data Collection Methods
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

• The Advanced Vehicle Testing Activity (AVTA) is the U.S. Department of Energy, Vehicle Technologies Office (VTO) singular field, tract, and laboratory based source for testing light-duty whole vehicle systems and subsystems
  – Idaho National Laboratory manages 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

- 103.5 million test miles accumulated on 11,500 electric drive vehicles and 16,000+ EVSE and DCFC
- EV Project: 7,991 Leafs, Volts and Smart EVs, 11,959 EVSE and DC Fast Chargers (DCFC), 84 million test miles
- Charge Point: 4,217 EVSE reporting 997,000 charge events
- PHEVs: 15 models, 434 PHEVs, 4 million test miles
- EREV: 2 model, 156 EREV, 2.3 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
INL Vehicle/EVSE Data Management Process

Process Driven by Disclosure Agreements

File server
SQL Server data warehouse
Report generator

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

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

Data quality reports

Trip Fuel Economy (mpg)

CD trips
CD/CS trips
CS trips
Log. (CD trips)
Log. (CD/CS trips)

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

Time of Day

0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

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 results to date – Vehicle and Level 2 use
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
- 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 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
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 120 pages of public quarterly reports
- INL must blend multiple data streams, from multiple sources, all on different delivery schedules
- This is not a flat file, spreadsheet experience and this is NOT a simple task
EV Project Vehicles / Miles, 5/26/13

- 7,991 vehicles reporting data
  - 5,646 Leafs. 71%
  - 1,992 Volts. 25%
  - 353 Smart EVs. 4%
- 84.0 million total miles
  - Leafs 78%
  - Volts 20%
  - Smart EVs 2%
- 197,000 test miles per day = 1 million miles every 6 days
• 11,959 total EVSE
  – 8,516 (71%) Residential EVSE
  – 3,363 (28%) non-residential EVSE
  – 80 (0.7%) DCFC
• 2.7 million charge events
  – 2,443,000 (91%) Residential EVSE
  – 216,000 (8%) non-residential EVSE
  – 36,000 (1.4%) DCFC
EV Project Charge Energy (MWh), 5/26/13

- 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 Weekly Charge Events 5/19/13

- Note 5.4 to 1 weekly Residential EVSE use rate versus 1.4 to 1 weekly Commercial EVSE use rate (last 5 weeks)

Weekly Charge Events and Total L2 EVSE Reporting Data Thru 5/19/13

Carefully Note The Axis Each Line is Plotted ON
### EV Project – National Data

**1st 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>4,240</td>
<td>1,766</td>
</tr>
<tr>
<td>Number of Trips</td>
<td>1,075,000</td>
<td>526,000</td>
</tr>
<tr>
<td>Distance (million miles)</td>
<td>7.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Average (Ave) trip distance</td>
<td>7.0 mi</td>
<td>8.2 mi</td>
</tr>
<tr>
<td>Ave distance per day</td>
<td>28.9 mi</td>
<td>39.4 mi</td>
</tr>
<tr>
<td>Ave number (#) trips between charging events</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Ave distance between charging events</td>
<td>25.9 mi</td>
<td>27.9 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

- Quarterly slight overall decreases in average miles per day and miles per charge

Nissan Leaf Driver Operations Behavior

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>
<tr>
<td>1st 2013</td>
<td>4,240</td>
</tr>
</tbody>
</table>
EV Project – Leaf Charging Location Trends

- Revenue model impacts in 2012 4th quarter appears short term. General increase in Level 2 public charging

Nissan Leaf Driver Charging Behavior

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>
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<tr>
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<tr>
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</tr>
<tr>
<td>4th 2012</td>
<td>3,762</td>
</tr>
<tr>
<td>1st 2013</td>
<td>4,240</td>
</tr>
</tbody>
</table>
EV Project – Volt Operations Trends
- No consistent overall trends per quarter

Chevy Volt Driver Operations Behavior

Number of Volts reporting each quarter with matched EVSE data

<table>
<thead>
<tr>
<th>Quarter</th>
<th>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>
<tr>
<td>1st 2013</td>
<td>1766</td>
</tr>
</tbody>
</table>
EV Project – Volt Charging Location Trends

- No significant overall Level 2 trends per quarter

![Chevy Volt Driver Charging Behavior Chart](chart)

<table>
<thead>
<tr>
<th>Number of Volts reporting each quarter with matched EVSE data</th>
</tr>
</thead>
<tbody>
<tr>
<td>----------</td>
</tr>
<tr>
<td>45</td>
</tr>
</tbody>
</table>
EV Project – *Residential EVSE L2 Use Trends*

- Increases in hours vehicles connected and drawing power, and increase in AC KWh transferred per charge event for residential Level 2

### Residential EVSE Infrastructure Use Trends

#### Number of Residential EVSE Level 2 reporting each quarter

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<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>4819</td>
<td>6031</td>
<td></td>
</tr>
</tbody>
</table>

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

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

![Graph showing use trends of non-residential EVSE infrastructure](image)

<table>
<thead>
<tr>
<th></th>
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<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>1988</td>
<td>2288</td>
<td></td>
</tr>
</tbody>
</table>

Does not include Private Nonresidential Level 2 EVSE

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

- Residential L2 EVSE reporting in 1st quarter 2013 is 70% of all charge infrastructure – 8,580 total units

- Per quarterly report, as measured by kWh use and number of charge events, 88% of charging events occur at residential L2 EVSE
## EV Project Public L2 EVSE Usage 1st ¼ 2013

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

### All territories

<table>
<thead>
<tr>
<th>Vehicles Charged</th>
<th>Car sharing fleet</th>
<th>Nissan Leaf</th>
<th>Chevrolet Volt</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of charging events</td>
<td>9%</td>
<td>20%</td>
<td>5%</td>
<td>66%</td>
</tr>
<tr>
<td>Percent of kWh consumed</td>
<td>14%</td>
<td>18%</td>
<td>4%</td>
<td>64%</td>
</tr>
</tbody>
</table>

### San Diego

<table>
<thead>
<tr>
<th>Vehicles Charged</th>
<th>323 Car2Go fleet</th>
<th>Nissan Leaf</th>
<th>Chevrolet Volt</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of charging events</td>
<td>31%</td>
<td>18%</td>
<td>6%</td>
<td>45%</td>
</tr>
<tr>
<td>Percent of kWh consumed</td>
<td>43%</td>
<td>14%</td>
<td>4%</td>
<td>39%</td>
</tr>
</tbody>
</table>

### Oregon (Car2Go in Portland)

<table>
<thead>
<tr>
<th>Vehicles Charged</th>
<th>30 Car2Go fleet</th>
<th>Nissan Leaf</th>
<th>Chevrolet Volt</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of charging events</td>
<td>1%</td>
<td>29%</td>
<td>4%</td>
<td>66%</td>
</tr>
<tr>
<td>Percent of kWh consumed</td>
<td>12%</td>
<td>29%</td>
<td>4%</td>
<td>65%</td>
</tr>
</tbody>
</table>
EV Project – EVSE Infra. Summary Report

- National Residential and Public Level 2 Weekday EVSE 1st Quarter 2013
- Residential and public connect time and energy use are fairly opposite profiles. Note different scales

![National Residential Connect Time](image1)

![National Public Connect Time](image2)

![National Residential Demand](image3)

![National Public Demand](image4)
EV Project – EVSE Infra. Summary Report

• Residential Level 2 Weekday EVSE 1st Quarter 2013
• San Diego and San Francisco, with residential L2 TOU rates, are similar to national and other regional EVSE connect profiles

San Diego

Los Angeles

San Francisco

Washington State
• Residential Level 2 Weekday EVSE 1\textsuperscript{st} Quarter 2013
• TOU kWh rates in San Diego and San Francisco clearly impact when vehicle charging start times are set
EV Project results to date – DCFC use
EV Project – EVSE Infra. Summary Report

- DC Fast Chargers Weekday 1\textsuperscript{st} Quarter 2013
- 72 DCFC, 13,500 charge events and 102 AC MWh

- 2.3 average charge events per day per DCFC
- Leafs 40% charge events and 40% energy used
- Unknowns are Non EV Project vehicles
- 21.3 minutes average time connected
- 21.3 minutes average time drawing energy
- 7.6 kWh average energy consumed per charge
EV Project – DCFC Preliminary Data Analysis

• Growth in the number of DCFC by market over the past three reporting quarters

• Total DCFC by Quarter
  - 3rd: 39
  - 4th: 54
  - 1st: 72
EV Project – DCFC Preliminary Data Analysis

- DCFC energy consumed over the past three reporting quarters
EV Project – DCFC Preliminary Data Analysis

- Growth in the number of DCFC charging events by market over the past three reporting quarters.
EV Project – DCFC Preliminary Data Analysis

- Average number of charging events per day per DCFC over the past three reporting quarters
EV Project – DCFC Preliminary Data Analysis

- 2013 regional week by week numbers of DCFC charge events (note numbers for final week are not complete)
EV Project – DCFC Preliminary Data Analysis

- 2013 regional week by week total hours connected to DCFC (note numbers for final week are not complete)
EV Project – DCFC Preliminary Data Analysis

• 2013 regional week by week total energy delivered by DCFC (note numbers for final week are not complete)
EV Project – DCFC Preliminary Data Analysis

- Distribution of time vehicle connected per DCFC charge event for all regions (Note: no charge events have occurred where connect time is greater than 60 minutes)
EV Project – DCFC Preliminary Data Analysis

• Distribution of energy delivered per DCFC event time for all regions (Note: No charge event delivered more than 18 kWh)
EV Project – DCFC Preliminary Data Analysis

- Number of charge events per publicly accessible Level 2 EVSE versus per DCFC in the 1st Quarter 2013
- Nationally, 17 events per public L2 and 188 per DCFC
EV Project results to date – Costs and Some Lessons Learned
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>
<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 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, Corvallis &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>
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
Commercial Lessons Learned

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

- Permit fees and delays can be significant
  - Load studies
  - Zoning reviews
Commercial Level 2 Permits Cost

- Commercial permits range $14 to $821

<table>
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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>
</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>
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 hardware or permitting costs
- 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 sitting requests
  - Example: mayor may want EVSE by front door of city hall, but electric service is located at back of building
- These numbers are very preliminary
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 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

• 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>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</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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<td></td>
</tr>
</tbody>
</table>
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 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>
DC Fast Charge (DCFC) Fees Structure

- Encourage DCFC use with initial free charging
- Implement DCFC access fees by region in 2nd 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
EV Project Lessons Learned Reports

- First responder training
- Accessibility at public EV charging locations
- Signage
- Impact of EV Project charging on the electric grid
- EV Project DC Fast Charge - Demand Charge Reduction
- Electric Vehicle Public Charging – Time vs. Energy
- EVSE programming for charging
  - 63% not, 21% vehicle, 15% EVSE and 2% both scheduled
- Vehicle utilization first look
  - Charge events per week by venues
- Dissemination Plan
Charge Point results to date
Charge Point
America ARRA Project

- Conducted by Coulomb
- Project to March 2013
- **4,217 EVSE installed and reporting data**
  - 1,829 Residential
  - 237 Private / commercial
  - 2,121 Public
  - 30 unknown
- **997,249 charge events**
- **7,119 AC MWh**

---

### ChargePoint America Vehicle Charging Infrastructure Summary Report

**Project Status to Date through: June 2012**

<table>
<thead>
<tr>
<th>Charging Unit - By State</th>
<th>Residential</th>
<th>Private Commercial</th>
<th>Public</th>
<th>Not Specified</th>
<th>Charging Units Installed to Date</th>
<th>Number of Charging Events Performed</th>
<th>Electricity Consumed (AC MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>791</td>
<td>36</td>
<td>518</td>
<td>3</td>
<td>1,351</td>
<td>213,758</td>
<td>1,487.7</td>
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<tr>
<td>Connecticut</td>
<td>11</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>2,569</td>
<td>15.1</td>
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<tr>
<td>District of Columbia</td>
<td>-</td>
<td>16</td>
<td>15</td>
<td>-</td>
<td>32</td>
<td>718</td>
<td>5.4</td>
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<tr>
<td>Florida</td>
<td>40</td>
<td>10</td>
<td>218</td>
<td>2</td>
<td>260</td>
<td>9,323</td>
<td>55.2</td>
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<tr>
<td>Maryland</td>
<td>18</td>
<td>7</td>
<td>34</td>
<td>-</td>
<td>74</td>
<td>4,046</td>
<td>27.6</td>
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<tr>
<td>Massachusetts</td>
<td>23</td>
<td>7</td>
<td>74</td>
<td>-</td>
<td>104</td>
<td>4,133</td>
<td>35.5</td>
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<tr>
<td>Michigan</td>
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<td>172</td>
<td>-</td>
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<td>407.1</td>
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<tr>
<td>New Jersey</td>
<td>51</td>
<td>2</td>
<td>17</td>
<td>-</td>
<td>70</td>
<td>15,397</td>
<td>95.7</td>
</tr>
<tr>
<td>New York</td>
<td>23</td>
<td>88</td>
<td>162</td>
<td>-</td>
<td>213</td>
<td>17,401</td>
<td>139.6</td>
</tr>
<tr>
<td>Texas</td>
<td>51</td>
<td>9</td>
<td>227</td>
<td>-</td>
<td>287</td>
<td>17,759</td>
<td>114.4</td>
</tr>
<tr>
<td>Virginia</td>
<td>23</td>
<td>17</td>
<td>43</td>
<td>-</td>
<td>63</td>
<td>10,061</td>
<td>65.0</td>
</tr>
<tr>
<td>Washington</td>
<td>12</td>
<td>7</td>
<td>123</td>
<td>-</td>
<td>142</td>
<td>8,133</td>
<td>50.0</td>
</tr>
</tbody>
</table>

**Total** 1,298 216 1,666 6 3,085 365,664 2,508.7

---

*Includes all charging units that were in use by the end of the reporting period

* A charging event is defined as the period when a vehicle is connected to a charging unit, during which period some power is transferred
Charge Point America ARRA Project  
• January – March 2013 data for 3,668 EVSE

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Private Commercial</th>
<th>Public</th>
<th>Not Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>% EVSE</td>
<td>45%</td>
<td>4%</td>
<td>50%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>% Charge Events</td>
<td>63%</td>
<td>3%</td>
<td>34%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>% AC MWh</td>
<td>62%</td>
<td>3%</td>
<td>34%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>% time with vehicle connected</td>
<td>48%</td>
<td>26%</td>
<td>10%</td>
<td>29%</td>
</tr>
<tr>
<td>% time with energy transferred</td>
<td>9%</td>
<td>5%</td>
<td>4%</td>
<td>4%</td>
</tr>
</tbody>
</table>
• 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
Conductive Charging Infrastructure Testing
EVSE Testing

- AC energy consumption at rest and during Volt Charging benchmarked
- Steady state charge efficiency benchmarked

- Most EVSE consume 13 W or less at rest
- Watt use tied to features
- Most EVSE under 30 W during charge
- Most EVSE 99+% efficient during steady state charge of a Volt
- Three new EVSE for testing received

See [http://avt.inel.gov/evse.shtml](http://avt.inel.gov/evse.shtml) for individual testing fact sheets
Hasetec DC Fast Charging Nissan Leaf

- 53.1 AC kW peak grid power
- 47.1 DC kW peak charge power to Leaf energy storage system (ESS)
- 15.0 Grid AC kWh and 13.3 DC kWh delivered to Leaf ESS
- 88.7% Overall charge efficiency (480VAC to ESS DC)
Wireless Charging Infrastructure Testing
INL Wireless Interoperability Test Bed

• First two wireless systems received from Evatran
• Shared formal test plan with other DOE labs
• Started NDAs with two OEMs for testing vehicles / wireless charge systems
• Discussing testing with another OEM
• Supporting SAE J2954 committee and UL with refinement of testing procedures
• Identified suitable INL runway for 300 meter testing of wireless systems to FCC standard
• Along with other DOE labs, much time spend on SAE wireless committee conference calls
• Structured testing of first wireless system scheduled for this week
INL Wireless Charging Bench Testing

- Grid Power 480 & 240 VAC
- Hioki Power Meter 3390
- Chroma AC Load
- Chroma DC Load
- Narda EM Field Meter (EHP-200)
- Polycarbonate Primary Coil Support
- Multi-Axis Positioning System
- Custom LabVIEW Host and Data Acquisition
- Fiberglass Unistrut Secondary Coil Support
- Secondary Coil Support
Other Testing Activities

and

Where you can find this presentation
Additional Infrastructure Work

- Initiated I-5 corridor DCFC study
- Six Leaf DCFC and L2 charging study on battery life
  - Two vehicles driven on road and L2 charged
  - Two driven identical routes DCFC charged
  - One L2 and one DCFC in battery lab
  - At 20k miles each Leaf similar minimal capacity fade
- INL conducted with NFPA and US DOT, traction battery fire first responder suppression burns – reviewing report
- INL initiated ~400 New York EVSE data collection with NYSERDA, NYPA, Port Authority of NY/NJ, and Energetics
- 30 EVSE and 10 vehicle conductive interoperability testing with SAE scheduled for late summer
- INL will receive data from six NYC Nissan Leaf taxis, six Level 2 EVSE, three DCFCs, and Taxi & Limo Commission
- Conducting TOU rate study for DOE Office of Electricity
- If I only had another 30 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 will be posted in the publications section of the above website, alphabetically as “GITT 2013 (6/19/13) - EV Project and Charging Infrastructure Update”

INL/MIS-13-29455