Electric Vehicle Charging Infrastructure Usage Observed in Large-scale Charging Infrastructure Demonstrations

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Grid Interaction Tech Team meeting
Mar 26, 2014
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 Testing
  - Homeland Security and Cyber Security
INL is a primary partner in two national electric vehicle (EV) charging infrastructure demonstrations

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:

ChargePoint America

- Deploy 4,700+ residential and public AC level 2 charging units in 11 US regions
- Study customer usage of residential and public infrastructure
- INL data collection May 2011 – Dec 2013
Infrastructure Deployment in The EV Project

Total
107   DC Fast Charge
474   Private Nonresidential
3,511 Publicly Accessible Level 2
8,250 Residential
Infrastructure Deployment in ChargePoint America (all units are AC level 2)

ChargePoint America Charging Units By Type - Through September 2013

Total
33 Not Specified
238 Private Commercial
2,148 Public
1,834 Residential

Legend
- Not Specified
- Commercial
- Residential
- Public
Outline

Questions to answer

• What are the key differences in charging station use between regions?
• Which stations are used most frequently, and which least frequently?
• How are drivers using public and workplace charging stations?
**Measures of “Goodness”**

There are numerous ways to assess how “good” public charging sites are:

- Charging frequency: number of charge events per day or week
- Charging time: hours connected
- Charging energy: kWh consumed / EV miles provided
- Parking time: time spent in parking space / in store
- Charging site host may want electric vehicle supply equipment (EVSE) for other reasons, such as image or cool factor
- etc.
### Terminology

- **Charging site**
- **Charge port or cord**

**Dual-port**
- DC fast charge
- EVSE unit or charging station

**Single-port**
- AC Level 2
- EVSE unit or charging station

**Dual-port AC Level 2**
- EVSE unit or charging station

**Dual-port AC Level 2 EVSE**
- Unit or charging station

**Charge port or cord**
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers

Charging Frequency by EVSE Type

Charging Energy by EVSE Type
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers

Charging Frequency by EVSE Type

- Blink DCFC
- ChargePoint Residential
- Blink Residential
- ChargePoint Public L2
- Blink Public L2
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers

Charging Frequency by EVSE Type

Roll-out of Blink DCFC usage fees during Q3
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers

Charging Frequency by EVSE Type and Region

Number of charging events per EVSE day

- Blink DCFC
- ChargePoint Public L2
- Blink Public L2

Q4 2012, Q1 2013, Q2 2013, Q3 2013, Q4 2013
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers

Charging Frequency by EVSE Type and Region - SF, LA, WA
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers

Charging Frequency by EVSE Type and Region - SF, LA, WA

- **DCFC - WA (2.7)**
- **DCFC - SF (1.9)**
- **DCFC - LA (1.7)**
- **CP L2 - LA (1.3)**
- **CP L2 - SF (1.1)**
- **CP L2 - WA (0.66)**
- **Blink L2 - SF (0.55)**
- **Blink L2 - LA (0.48)**
- **Blink L2 - WA (0.29)**
Blink Charging Unit Usage

Q4 2013 EVSE Usage Frequency and Duration by EVSE Type and Region

Contour lines represent percent of time with charging unit connected to a vehicle:
- Public L2
- Resid
- Priv nonresid
- DCFC

Number of charging events / EVSE day vs. Average time connected per charging event (hr)
### Distribution of Blink & ChargePoint Public Level 2 EVSE Usage Frequency by Region and Metropolitan Area in 2013

<table>
<thead>
<tr>
<th>Region</th>
<th>Nsites</th>
<th>Avg number of charging events per week (excluding first 4 weeks in service)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-west</td>
<td>186</td>
<td>≥70</td>
</tr>
<tr>
<td>California</td>
<td>216</td>
<td>≥70</td>
</tr>
<tr>
<td>Southwest</td>
<td>311</td>
<td>≥70</td>
</tr>
<tr>
<td>South</td>
<td>243</td>
<td>≥70</td>
</tr>
<tr>
<td>East Coast</td>
<td>126</td>
<td>≥70</td>
</tr>
<tr>
<td>Midwest</td>
<td>105</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>176</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>116</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>208</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>79</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>91</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>114</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>≥70</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>≥70</td>
</tr>
</tbody>
</table>
### Top 20 Most Frequently Used Public Level 2 Charging Sites

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<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Date Range</strong></td>
<td>1/1/2013 – 1/1/2014</td>
</tr>
<tr>
<td><strong>Total Charging Events per Site</strong></td>
<td>2500 - 6300</td>
</tr>
<tr>
<td><strong>Average Number of Charging Events per Week per Site</strong></td>
<td>60 -120</td>
</tr>
</tbody>
</table>
| **Sites by State**       | • 19 in California  
                          | • 1 in Tennessee    |
| **Venues of the Top 20** | • Parking Garage (8) 
                          | • Business Office (5) 
                          | • Public / Municipal (3) 
                          | • Mall (2)            
                          | • University (1)      
                          | • Manufacturing plant (1) |
Multiple Cases at Same Public Charging Site

- Public charging venue is not always clear indicator of how the charging units will be used
- Example: EVSE in public parking garage in urban center may serve multiple types of customers
  - Workplace parking / charging
    - Expected to park/charge for ~4 to 16 hrs
  - Restaurant or retail customer parking / charging
    - Expected to park/charge for 0.5 to 2+ hrs
  - Car sharing fleet vehicles
    - Expected to park/charge for 0.5 to 100+ hrs
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
# Top 20 Most Frequently Used Public DC Fast Charging Sites

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range Of Use</strong></td>
<td>1/1/2013 – 1/1/2014</td>
</tr>
<tr>
<td><strong>Total Charging Events per Site</strong></td>
<td>1400 - 3000</td>
</tr>
<tr>
<td><strong>Average Number of Charging Events per Week per Site</strong></td>
<td>23 - 52</td>
</tr>
<tr>
<td><strong>Sites by State</strong></td>
<td>• 11 in California&lt;br&gt;• 7 in Washington&lt;br&gt;• 2 in Oregon</td>
</tr>
<tr>
<td><strong>Venues of the top 20</strong></td>
<td>• Retail / Mall (6)&lt;br&gt;• Business Office (5)&lt;br&gt;• University (3)&lt;br&gt;• Public / Municipal (2)&lt;br&gt;• Auto Dealership (2)&lt;br&gt;• Recreation / Museum (1)&lt;br&gt;• Multi-Family (1)</td>
</tr>
</tbody>
</table>
47% of fast charges were performed on round-trip outings of 60 miles or less.
Charging Site Location Considerations

- EVSE installations with respect to Americans with Disabilities Act (ADA) requirements are not consistent

  “Charger is between 2 handicap spaces. To charge and not get ticketed you need to park behind the charger in any of 3 spaces closest to the elevator / entrance in non EV dedicated spots. Good Luck.”

  – Comment from plugshare.com user

- Parking lot or garage may have
  - limited hours of operation
  - parking fees
  - restricted access
Charging Site Location Considerations

• Parking spaces in front of charging units may not always be accessible
  – Construction
  – Non-electric vehicle in parking spot ("you’ve been ICE’d")
  – Electric vehicles in parking spots but not charging

Fred Meyer in Seattle, WA

Photos from plugshare.com
Charging Site Location Considerations

• Charging unit maintenance and reliability is a big factor

“Both sides [of the DC fast charger] and level 2 not working. Had no electrics left. AAA couldn't send out the EV rescue truck because according to them they didn't have a tech trained to use it on hand. I ended up towing my car home. Not a good night.”
– Comment from plugshare.com user
Workplace Charging Examples
**Workplace Charging Case Studies**

Workplace charging sites identified in two ways:

- Work sites where ChargePoint and Blink EVSE are installed
- Work sites where EV Project vehicles have charged
- Cross-referenced with AFDC database EVSE locations and descriptions
Workplace Charging Case Studies – Analysis of Workplace EVSE Data

Are drivers monopolizing workplace EVSE or do they move their vehicles during the day?

- 5 work sites with numerous ChargePoint or Blink level 2 EVSE were selected

Distribution of Number of Distinct Users per EVSE Day

<table>
<thead>
<tr>
<th>Worksite</th>
<th>Number of EVSE at work site</th>
<th>Number of distinct users per EVSE day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worksite A</td>
<td>10</td>
<td>0, 1, 2, 3</td>
</tr>
<tr>
<td>Worksite B</td>
<td>5</td>
<td>4, 5, 6, 7</td>
</tr>
<tr>
<td>Worksite C</td>
<td>4</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Worksite D</td>
<td>6</td>
<td>5, 6, 7</td>
</tr>
<tr>
<td>Worksite E</td>
<td>7</td>
<td>3, 4, 5, 6</td>
</tr>
</tbody>
</table>
Workplace Charging Case Studies

Summary of workplace charging work sites identified using vehicle data

- 277 work sites with known EV charging for 140 companies
- Located in 11 metropolitan areas across the United States
- Wide variation between sites with respect to:
  - Size (from individual office buildings with small parking lots to large corporate complexes with multiple parking lots and garages)
  - Type and amount of charging equipment,
  - Number and make/model of vehicles that could potentially charge
  - Access (some sites are open to the general public; others are for employees only)
  - Cost (some sites exact fees for charging; others offer free charging)
Workplace Charging Case Studies – Commuting Distance

- Data from 313 Leafs which frequently parked at work sites with EV charging during Q2 2013

86% of EV Project Leafs parking at worksites identified average 30 miles or less between home and work
Workplace Charging Case Studies – Charging Location Preference

- Home
- Work
- Other
Charging Location Preference – Nissan Leaf

- 2012 – 2013 study period
- 707 EV Project Nissan Leafs frequently parked at worksites where PEVs are known to have charged
- 200,000+ total charging events
- How often did these drivers charge at home, work, and other locations?
- How does this compare to the location preference of the overall set EV Project Nissan Leaf drivers?

- Full paper entitled “Where do Nissan Leaf drivers in The EV Project charge when they have the opportunity to charge at work?” is available at avt.inl.gov/evproject.shtml under “Lessons Learned White Papers”
“Workplace vehicles” charged away from home more than twice as much as the overall project group. Most of that away-from-home charging was at work.
Charging Location Preference – Nissan Leaf

Group of Nissan Leafs with Access to Workplace Charging
2012 – 2013

Days When Vehicles Were
Parked at Work

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>56%</td>
</tr>
<tr>
<td>Work</td>
<td>42%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
</tr>
</tbody>
</table>

Days When Vehicles Were
Not Parked at Work

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>92%</td>
</tr>
<tr>
<td>Other</td>
<td>8%</td>
</tr>
</tbody>
</table>

In aggregate, workplace vehicle drivers had little use for public infrastructure on days when they went to work.
Charging Location Preference – Nissan Leaf

Group of Nissan Leafs with Access to Workplace Charging, 2012 – 2013

Overall Charging Frequency by Location (to scale)

Home - 65%
Work - 32%
Other - 3%

Careful!
How important is this 3% to individual drivers’ mobility needs?

How does cost to use workplace charging influence this behavior?
Conclusion

Questions to answer

• What are the key differences in charging station use between regions?
  – San Francisco, Los Angeles, Washington State lead the country in public EVSE use
  – San Diego public Level 2 use high because of Car2Go fleet charging

• Which stations are used most frequently, and which least frequently?
  – For level 2, parking garages and business office lots
  – For DCFC, retail/mall and business office lots
  – Resist urge to rush to conclusions on infrequently used sites

• How are drivers using the stations?
  – Multiple users per EVSE per day at workplaces
  – Multiple use cases for same charging site
  – Those with access to workplace charging use it
  – Cost matters by some measures, but more analysis needed

• Factors that complicate public charging
  – ADA considerations
  – Parking spots can be “ICE’d”, blocked by construction, etc.
  – Parking lot/garage may have hours of operation, parking fees which impact usage of charging units
Additional Information

Publications coming soon:

• White papers on
  • Leaf L2 vs. DCFC usage
  • public charging venues
  • More from workplace charging case studies
  • EVSE installation costs

• and more

• For all EV Project and ChargePoint America publications, visit

  avt.inl.gov/evproject.shtml
  avt.inl.gov/chargepoint.shtml

INL’s funding for this work comes from DOE’s Vehicle Technologies Office
Additionally, the number of public charging sites nationwide includes:

- **Blink**: 1,793
- **ChargePoint**: 1,302

**Blink usage fees**

- Public Level 2 fees started Jul – Aug 2012
  - Varies from $1.00 to $2.00 / hr
  - 16% of sites are still free (per local site host discretion)
- DC Fast Charger (DCFC) fees started Jun – Aug 2013
  - $5 for Blink member / $8 for non-member per session

**ChargePoint usage fees**

- Vary by site (per local site host discretion)
- Many are free