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

John Smart, Sera White

NAS Committee on Overcoming Barriers to EV Deployment open-session meeting

Feb 25, 2014

Irvine, 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:

ChargePoint America

- Deploy 4,600+ 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)

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

• Quantitative results
• Qualitative observations
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
- …
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

Number of charging events per EVSE day

- Blink DCFC
- ChargePoint Residential
- Blink Residential
- 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

Roll-out of Blink DCFC usage fees during Q3

Charging Frequency by EVSE Type

Number of charging events per EVSE day

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

Charging Frequency by EVSE Type and Region

- Blink DCFC
- ChargePoint Public L2
- Blink Public L2
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

Average time connected per charging event (hr)
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
- DCFC

Number of charging events / EVSE day

Average time connected per charging event (hr)
Blink Residential EVSE Usage

Q4 2013 Residential EVSE Usage Frequency and Duration

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

Leaf Volt Plot Color

- 90 - 100% 0 - 10%
- 80 - 90% 10 - 20%
- 70 - 80% 20 - 30%
- 60 - 70% 30 - 40%
- 50 - 60% 40 - 50%
- 40 - 50% 50 - 60%
- 30 - 40% 60 - 70%
- 20 - 30% 70 - 80%
- 10 - 20% 80 - 90%
- 0 - 10% 90 - 100%
Blink Charging Unit Usage

Q4 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
- DCFC
Blink Public Level 2 EVSE Usage

Q4 2013 Public Level 2 EVSE Usage Frequency and Duration

Number of charging events / EVSE day

Average time connected per charging event (hr)

San Francisco
San Diego
Atlanta
Los Angeles
Washington State
Chicago
Nashville
Washington, DC
Phoenix
Memphis
Knoxville
Philadelphia
Chattanooga
Tucson
Houston
Blink Public Level 2 EVSE Usage

Q4 2013 Public Level 2 EVSE Usage Frequency and Duration

Atlanta events / EVSE day in each quarter in 2013
Blink Charging Unit Usage

Q4 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
- DCFC

1% 5% 10% 20% 40% 60%
Blink DC Fast Charger Usage

Q4 2013 DCFC Usage Frequency and Duration

Number of charging events / EVSE day

Average time connected per charging event (min)

Washington State
San Francisco
Los Angeles
Oregon
San Diego
Phoenix
Nashville
Knoxville
Chattanooga

5%
1%
Distribution of Blink & ChargePoint Public Level 2 EVSE Usage Frequency by Region and Metropolitan Area in 2013

Avg number of charging events per week (excluding first 4 weeks in service)

N_{sites} = 186 216 311 243 126 105 176 116 52 36 44 208 108 14 79 32 91 108 114 31 120 9
# Top 20 Most Frequently Used Public Level 2 Charging Sites

<table>
<thead>
<tr>
<th>Date Range</th>
<th>1/1/2013 – 1/1/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Charging Events per Site</td>
<td>2500 - 6300</td>
</tr>
<tr>
<td>Average Number of Charging Events per Week per Site</td>
<td>60 - 120</td>
</tr>
<tr>
<td>Sites by State</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 19 in California</td>
</tr>
<tr>
<td></td>
<td>• 1 in Tennessee</td>
</tr>
<tr>
<td>Venues of the Top 20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Parking Garage (8)</td>
</tr>
<tr>
<td></td>
<td>• Business Office (5)</td>
</tr>
<tr>
<td></td>
<td>• Public / Municipal (3)</td>
</tr>
<tr>
<td></td>
<td>• Mall (2)</td>
</tr>
<tr>
<td></td>
<td>• University (1)</td>
</tr>
<tr>
<td></td>
<td>• Manufacturing plant (1)</td>
</tr>
</tbody>
</table>
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
    - 4 to 16 hrs
  - Restaurant or retail customer parking / charging
    - 0.5 to 2+ hrs
  - Car sharing fleet vehicles
    - 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>
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</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><em>11 in California</em></td>
</tr>
<tr>
<td></td>
<td><em>7 in Washington</em></td>
</tr>
<tr>
<td></td>
<td><em>2 in Oregon</em></td>
</tr>
<tr>
<td><strong>Venues of the top 20</strong></td>
<td><em>Business Office</em> (5)</td>
</tr>
<tr>
<td></td>
<td><em>Retail / Mall</em> (6)</td>
</tr>
<tr>
<td></td>
<td><em>University</em> (3)</td>
</tr>
<tr>
<td></td>
<td><em>Public / Municipal</em> (2)</td>
</tr>
<tr>
<td></td>
<td><em>Auto Dealership</em> (2)</td>
</tr>
<tr>
<td></td>
<td><em>Recreation / Museum</em> (1)</td>
</tr>
<tr>
<td></td>
<td><em>Multi-Family</em> (1)</td>
</tr>
</tbody>
</table>
47% of fast charges were performed on round-trip outings of 60 miles or less.
Vehicles had 30% or lower SOC at the start of 42% of fast charges.
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
Comments on Cost of DC Fast Charging

• “One of the DC fast chargers is now open and responsive. When I swiped card, it indicated a charge of $5 would be levied, and since my car was nearly fully charged, I opted not to charge. The other DC fast charger and the Level 2 charger are still inaccessible.” – Comment from plugshare.com user

• “Did a quick charge on blink card, worked great. Was out if charge, so quickly charging up for $5 was OK.” – Comment from plugshare.com user

• “The quick charger here is awesome! I can go into the Fred Meyer and have lunch and have my car fully charged by the time I'm done. This makes having an EV more practical as I had to commute to Redmond from Everett with an already low charge. Definitely worth $5” – Comment from Plugshare.com user
EVSE User Turnover at Work Sites

Distribution of Number of Distinct Users per EVSE Day at 5 Worksites with Level 2 EVSE

<table>
<thead>
<tr>
<th>Worksite</th>
<th>Number of EVSE at work site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worksite A</td>
<td>10</td>
</tr>
<tr>
<td>Worksite B</td>
<td>5</td>
</tr>
<tr>
<td>Worksite C</td>
<td>4</td>
</tr>
<tr>
<td>Worksite D</td>
<td>6</td>
</tr>
<tr>
<td>Worksite E</td>
<td>7</td>
</tr>
</tbody>
</table>
Conclusion

Questions to answer

• What are the key differences in charging station use between regions?
  – San Francisco and Los Angeles areas lead the country in use
  – San Diego use high because of Car2Go Car Sharing vehicle charging
  – Atlanta stands out for increasing trend

• Which stations are used most frequently, and which least frequently?
  – Most frequently used sites identified
  – Workplace charging is popular for level 2 charging, as expected
  – Cannot rush to judgment on infrequently used sites

• How are drivers using the stations?
  – Multiple users per day at workplaces
  – Cost matters, but hard to say how much at this point
  – Multiple use cases for same charging site

• 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:
• 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

INL’s funding for this work comes from DOE’s Vehicle Technologies Office
**Additional Context**

Number of public charging sites nationwide

- 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