Charging Infrastructure Use Profiles and Installation Costs for 17,000 Units

John Smart, Jim Francfort
Idaho National Laboratory

TRB 2015 Annual Meeting
Session on Plug-in Electric Vehicle Infrastructure and Driver Behavior: Issues and Solutions for Continued Market Growth
Jan 12, 2015
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
  - Renewables and Hybrid Energy Systems
  - Advanced Vehicles, Batteries, Fuels, and Infrastructure
  - Unmanned Aerial Systems and Autonomous Vehicles
  - Cyber Security
INL was 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 through December 2013**

**Charging Units Reporting Data Nationally**
- 107 DC Fast Charge
- 443 Private Nonresidential AC Level 2
- 3,555 Publicly Accessible AC Level 2
- 8,251 Residential AC Level 2
- **12,356 Total**
Infrastructure Deployment in ChargePoint America through December 2013

Charging Units* Reporting Data Nationally

- 39 Not specified
- 264 Private Nonresidential
- 2,508 Publicly Accessible
- 1,836 Residential
- 4,647 Total

* All units are AC Level 2
Dual-port units count as 2 units
What have we learned from data collected from Nissan Leafs and Chevrolet Volts in The EV Project?

4,038 Leafs

A B C
25 31 43

1,867 Volts

A B C
25 29 40

Avg Daily eVMT (on days when driven)
## Nissan Leafs and Chevrolet Volts in The EV Project

**Oct 2012 – Dec 2013**

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**Conclusions:**

- Away-from-home charging infrastructure was consistently effective as an EV range extender... for a small fraction of vehicles
- For both Leaf and Volts, 20% of the vehicles were responsible for 75% of the away-from-home charging
What about the remaining 80% of vehicles?

- It is not clear what role away-from-home charging infrastructure played for the majority of drivers who only used it occasionally or never used it:
  - Psychological benefit as a safety net?
  - Occasional but important range extension?
  - Cool factor?
  - No role at all?

- Away-from-home charging can be public or workplace charging
What do we know about workplace charging?
Workplace Charging Analysis

We observed driving and charging throughout the day of vehicles with access to charging at work.
Where did PEV drivers with access to workplace charging choose to charge?

Nissan Leafs

Overall Charging Frequency by Location (to scale)

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

Percent of Charging Events by Location and Day

Workdays
- Home: 56%
- Work: 42%
- Other: 2%

Non-workdays
- Home: 92%

707 vehicles, Jan 2012 – Dec 2013
Where did PEV drivers with access to workplace charging choose to charge?

Chevrolet Volts

Overall Charging Frequency by Location (to scale)

- Home - 57%
- Work - 39%
- Other - 4%

Percent of Charging Events by Location and Day

- Workdays:
  - Other: 2%
  - Work: 50%
  - Home: 48%
- Non-workdays:
  - Other: 11%
  - Work: 89%

96 vehicles, Jan 2013 – Dec 2013
How has public AC level 2 EVSE and DC fast charger usage changed over time?
Usage Frequency of Public Level 2 EVSE and DC Fast Chargers by Region

Average Charging Frequency over Time by EVSE Type and Region

Average number of charging events per EVSE per day

- Blink DCFC
- ChargePoint Public L2
- Blink Public L2
Usage Frequency of Blink DC Fast Chargers

Average Charging Frequency of Blink DC Fast Chargers over Time by EV Project Region

Blink Network fees instituted Jul – Aug 2013

Average number of charging events per DCFC unit per day

- San Francisco
- Washington
- Oregon
- Los Angeles
- San Diego
- Nashville
- Phoenix

Q4 2012 Q1 2013 Q2 2013 Q3 2013 Q4 2013 Q1 2014 Q2 2014 Q3 2014
Which public charging sites are used most frequently?
Usage of Publicly Accessible Level 2 Sites

Cumulative Distribution of Charging Frequency of Blink and ChargePoint Level 2 Publicly Accessible Sites

9/1/2012 to 1/1/2014  N = 2,498 sites

- 4% of public sites had ≥ 21 events / week
- 8% of public sites had ≥ 14 events / week
- 16% of public sites had ≥ 7 events / week
- 28% of public sites had greater than our arbitrary minimum threshold (> 3 events / week)
Usage of Publicly Accessible Level 2 Sites

Cumulative Distributions of Charging Frequency of Blink and ChargePoint Publicly Accessible Sites

- Blink Free L2 sites (N = 212)
- ChargePoint L2 sites (N = 1159)
- Blink For-cost L2 sites (N = 1127)
- Blink DCFC sites (N = 94)

Blink for-cost L2 sites used less than free L2 sites

Avg number of charging events per site per week

9/1/2012 to 1/1/2014
Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue

Median site usage frequency

Data from 9/1/2012 to 1/1/2014; includes all sites meeting minimum usage threshold
Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue
Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue
Blink & ChargePoint Level 2 Sites – Parking Lots and Garages

- 77.5 Downtown Palo Alto CA
- 73.4 Fifth & Mission Garage, San Francisco CA
- 70.6 Downtown Palo Alto CA
- 60.9 Downtown Redwood City CA
- 58.3 Parking Structure, Irvine CA
- 51.8 Parking Structure, Irvine CA
- 51.4 Parking garage, San Francisco CA
- 50.7 Sutter Stockton Garage, San Francisco CA
Blink & ChargePoint Level 2 Sites – Transportation Hubs

53.0  San Francisco International Airport
39.3  Metrolink park and ride, Anaheim CA
32.3  Metrolink park and ride, Oceanside CA
**Blink & ChargePoint Level 2 Sites – Public / Municipal**

- 76.7 SCAQMD HQ building, Diamond Bar CA
- 52.8 City library, Dublin CA
- 50.0 City library, Redwood City CA
- 39.3 City hall, Huntington Beach CA
- 37.7 Civic center, Campbell CA
- 37.3 City hall, Hermosa Beach CA
- 35.1 SCAQMD HQ building, Diamond Bar CA
- 34.6 City hall, Orange CA
30.3 Rialto Sebastopol Cinemas, Sebastopol CA
**Blink & ChargePoint Level 2 Sites – Retail**

- **50.1** Retail-Small (Becker Surfboards), Hermosa Beach CA
- **49.9** Mall (Bella Terra Shopping Ctr), Huntington Beach CA
- **45.5** Mall (Westfield Galleria Mall), Roseville CA
- **40.7** Mall (The Grove), Los Angeles CA
- **40.3** Mall (The Americana at Brand), Glendale CA
- **32.1** Mall (Stanford Shopping Center), Palo Alto CA
- **30.4** Mall, Beverly Hills CA
Distribution of Usage Frequency of Blink DCFC Sites by Venue

8/1/2013 to 1/1/2014 (after Blink network fees were instituted)
Distribution of Usage Frequency of Blink DCFC Sites by Venue

Average number of charging events per site per week

- Public Municipal
- Parking Lots/Garages
- Workplace
- Hotels
- Education
- Multi-Family
- Retail
Distribution of Usage Frequency of Blink DCFC Sites by Venue

54.4  Tahoma Market on I5, Tacoma WA
42.3  Parking lot downtown Seattle WA
35.0  Fred Meyer, Kirkland WA
30.4  Nissan dealership, Bellevue WA
29.2  Parking garage downtown Seattle WA
23.1  Fred Meyer, Hillsboro OR
22.8  Fred Meyer, Seattle WA
22.6  Mall on I205, Happy Valley OR
22.0  City hall, Hayward CA
20.9  Fred Meyer, Salem OR
EVSE Installation Costs
## Commercial Level 2 EVSE Permitting Costs

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<th>Region</th>
<th>Count of Permits</th>
<th>Average Permit Fee</th>
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<td>$775</td>
</tr>
<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>
Commercial Level 2 EVSE Installation Costs

- Nationally, commercially sited Level 2 EVSE averaged $4,000 for the installation costs. EVSE hardware cost excluded.
- There is much variability by region and by installation:
  - Tennessee and Arizona had average installation costs of $2,000 to $2,500.
- Costs driven by siting requirements:
  - Example: mayor may want EVSE by front door of city hall, but electric service panel is located at the back of the building.
  - Multiple EVSE at one site drive down per-EVSE install cost.
DC Fast Charger (DCFC) Infrastructure Installation & Demand Costs

- DCFC installation costs do not include DCFC hardware costs
- DCFC Demand Charges can have significant negative financial impacts

<table>
<thead>
<tr>
<th>Utility Demand Charges - Nissan Leaf</th>
<th>Cost/mo.</th>
</tr>
</thead>
</table>
| CA
  Glendale Water and Power                               | $ 16.00  |
  Hercules Municipal Utility:                               | $ 377.00 |
  Los Angeles Department of Water and Power                 | $ 700.00 |
  Burbank Water and Power                                   | $1,052.00|
  San Diego Gas and Electric                               | $1,061.00|
  Southern California Edison                               | $1,460.00|
| AZ
  TRICO Electric Cooperative                              | $ 180.00 |
  The Salt River Project                                   | $ 210.50 |
  Arizona Public Service                                   | $ 483.75 |
| OR
  Pacificorp                                                | $ 213.00 |
| WA
  Seattle City Light                                       | $  61.00 |
Recommendations to Support Market Growth

- Promote workplace charging
  - DOE is leading this through the EV Everywhere Workplace Charging Challenge
- Identify public charging hot spots
  - INL is using vehicle and infrastructure data to characterize known hot spots and build predictive tools
- Continue work to understand consumer mindset
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
Smart Boys Like EV Charging Infrastructure

(Now if only Dad would buy them an EV…)

[Image of three boys standing in front of an EV charging station]
BACKUP SLIDES
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**
  - Charge port or cord

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

Blink

• Public AC Level 2 fees started Jul – Aug 2012
  – Varies from $1.00 to $2.00 per hour connected
  – 16% of sites were still free as of Dec 31, 2013 (per local site host discretion)

• DC Fast Charger fees started Jul 2013
  – $5 for Blink member / $8 for non-member per session

ChargePoint

• Vary by site (per local site host discretion)
• Many are free (rumored 70% free / 30% cost)

AeroVironment in WA/OR

• Free prior to Apr 1, 2014
• After Apr 1, 2014 – Monthly subscription fee of $19.99 for unlimited usage or “drive up” fee of $7.50 per session for DCFC and $4 per session for L2