DC Fast Charger Use, Fees, Battery Impacts and Temperature Impacts on Charge Rates - EV Roadmap 7

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EV Roadmap 7 – Portland, Oregon
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This presentation does not contain any proprietary, confidential, or otherwise restricted information
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 Vehicle and Battery Testing
  - Homeland Security and Cyber Security
DC Fast Charger (DCFC) Use in the EV Project
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**
Usage Frequency of Residential & Public Level 2 EVSE and DC Fast Chargers

**Charging Frequency by EVSE Type**

**Charging Energy by EVSE Type**

*EVSE = Electric Vehicle Supply Equipment. L2 = SAE’s AC Level 2 EVSE (208 – 220 Volts) definition. DCFC = DC Fast Charger*
**Blink DC Fast Chargers - Fee Impacts**

**DCFC Fee per Session**
- $5 Blink members
- $8 non-Blink members

Roll-out of Blink DCFC usage fees during Q3

Charging Frequency by EVSE Type

- Blink DCFC
- ChargePoint Public L2
- Blink Public L2
Average Usage Rate for Public Level 2 EVSE & DC Fast Chargers per Select Regions

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

Level 2 Fee per hour
- $1 Blink EVSE
- ChargePoint unknown

<table>
<thead>
<tr>
<th>Type</th>
<th>Region</th>
<th>Usage Rate</th>
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<tbody>
<tr>
<td>CP L2</td>
<td>SF</td>
<td>1.1</td>
</tr>
<tr>
<td>CP L2</td>
<td>WA</td>
<td>0.66</td>
</tr>
<tr>
<td>CP L2</td>
<td>LA</td>
<td>1.3</td>
</tr>
<tr>
<td>DCFC</td>
<td>WA</td>
<td>2.7</td>
</tr>
<tr>
<td>DCFC</td>
<td>SF</td>
<td>1.9</td>
</tr>
<tr>
<td>DCFC</td>
<td>LA</td>
<td>1.7</td>
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<tr>
<td>Blink L2</td>
<td>SF</td>
<td>0.55</td>
</tr>
<tr>
<td>Blink L2</td>
<td>WA</td>
<td>0.29</td>
</tr>
<tr>
<td>Blink L2</td>
<td>LA</td>
<td>0.48</td>
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</table>
Usage Frequency of All DC Fast Chargers Nationally

Monthly Average Number of Charging Events per Day
for Each DCFC

Usage of most DCFCs dropped when payment started

DCFCs with sustained high usage:
- Workplace
- Small Retail Tacoma - I5
- Workplace
- Parking lot Seattle downtown
- Fred Meyer North Seattle
- Workplace
Public Blink DC Fast Charger Usage by Venue & Site – One DCFC per site

Top 10 Most Highly Used Blink DC Fast Charger Sites in Each Venue Category

- Workplace
- Retail
- Public Municipal
- Parking Lots/Garages
- Multi-Family
- Medical
- Leisure Destination
- Hotels
- Education
- Fleet
- Transportation Hub

Average number of charging events per site per week
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>
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</thead>
<tbody>
<tr>
<td>CA: Glendale Water and Power</td>
<td>$16.00</td>
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<tr>
<td>Hercules Municipal Utility</td>
<td>$377.00</td>
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<td>Los Angeles Department of Water and Power</td>
<td>$700.00</td>
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<tr>
<td>Burbank Water and Power</td>
<td>$1,052.00</td>
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<td>San Diego Gas and Electric</td>
<td>$1,061.00</td>
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<tr>
<td>Southern California Edison</td>
<td>$1,460.00</td>
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<tr>
<td>AZ: TRICO Electric Cooperative</td>
<td>$180.00</td>
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<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>

Total Installation Costs for each 99 DCFCs

Mean - $20,848
Mode - $20,188
DC Fast Charging Impact Study on 2012 Leafs
DC Fast Charging Impact Study on 2012 Leafs

- **Two Goals**
  - Determine DC Fast Charge (DCFC) impacts versus Level 2 impact
  - Compare on-road to laboratory test results
- Two on-road Nissan Leafs are exclusively Level 2 (L2) charged
- Two on-road Nissan Leafs are exclusively DCFC charged
- Identical on-road routes are driven
- Drivers’ miles are balanced – all drive the four vehicles equally

- Each Leaf battery was tested when new (Base case)
- Each on-road battery is retested at 10,000-mile increments
- Battery temperature is tracked during normal charging operations
- 50,000 miles completed, going to 70,000 miles per on-road Leaf
- 24 battery tests completed on the on-road Leaf batteries

- Lab testing of two additional batteries (only preliminary results) @ 4,000 mile increments
DC Fast Charging Impact Study on 2012 Leafs

- All Leafs were the same color – avoid unequal solar loading
- Note very tight monthly efficiency results across all four Leafs during Level 2 and DCFC operations (red min & max bars)
- Leafs’ climate control is set at 72°F year round
- Note seasonal efficiency impacts from heating and air conditioning
  - 39.8 DC kWh/mi delta for min vs. max month
  - Max month 19% higher than min month
DC Fast Charging Impact Study on 2012 Leafs

- 0.6 kWh average capacity difference @ 50k miles between Level 2 and DCFC Leafs, probably not a significant difference
- Level 2 averaged 5.8 kWh loss @ 50k miles
- DCFC averaged 6.4 kWh @ 50k miles
DC Fast Charging Impact Study on 2012 Leafs

- Level 2 averaged 75.2% SOC @ 50k miles
- DCFC averaged 72.6% SOC @ 50k miles
- 2.6% capacity difference @ 50k miles, probably not a significant difference
DC Fast Charging Impact Study on 2012 Leafs

- Same data as last slide. Each line represents a single vehicle, plotted by capacity SOC for each battery test.
DC Fast Charging Impact Study on 2012 Leafs

- Largest decreases in capacity from test before, occurred during high heat charging operation
- Phoenix heat likely accelerates all results
DC Fast Charging Impact Study on 2012 Leafs

- Range (miles) at 50,000 miles compared to testing when new

![45 MPH Constant Speed Range](chart.png)
DC Fast Charging Impact Study on 2012 Leafs

- Percentage Range and Capacity at 50,000 miles compared to testing when new

<table>
<thead>
<tr>
<th></th>
<th>L2 Average</th>
<th>DCFC Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>79.0%</td>
<td>69.3%</td>
</tr>
<tr>
<td>Capacity</td>
<td>75.2%</td>
<td>72.6%</td>
</tr>
</tbody>
</table>
DC Fast Charging Acceptance Rates at Various Temperature
DC Fast Charging Acceptance Rates at Various Temperatures

- Objective is to develop a formal testing regime to examine battery charge acceptance rates at various ambient temperatures during DC Fast Charging
  - The results should be considered preliminary as the tests were undertaken to identify needed test procedures
  - 2013 Nissan Leaf at 6,000 miles was used
  - 2012 Mitsubishi i-MiEV at 5,700 miles was used
  - Vehicles temperature soaked for minimum of 12 hours
  - Used Intertek’s soak chamber in Phoenix

- Identified additional instrumentation needed in additional proper test regime steps
2013 Leaf - DC Fast Charging @ 0, 25 & 50 C

• After 30 minutes:
  • 50 C: 77% SOC
  • 25 C: 77% SOC
  • 0 C: 53% SOC

• At charge end:
  • 50 C: 87% SOC at 62 minutes
  • 25 C: 91% SOC at 67 minutes
  • 0 C: 91% SOC at 121 minutes

• Total kWh:
  • 50 C: 17.9 kWh
  • 25 C: 18.2 kWh
  • 0 C: 17.4 kWh

0 C = 32 F
25 C = 77 F
50 C = 122 F

Preliminary Data Results
Preliminary Data Results – Note that the vehicle temperature was measured at the passenger side front seat.
2013 Leaf - DC Fast Charging @ 0, 25 & 50 °C

Power During DC Charging
2013 Nissan Leaf VIN 5045 - ICD1 at 6,000 Miles

Preliminary Data Results
2012 iMiEV - DC Fast Charging @ 0, 25 & 50 C

- After 30 minutes:
  - 50 C: 69% SOC
  - 25 C: 88% SOC
  - 0 C: 64% SOC

- At charge end:
  - 50 C: 95% SOC at 59 minutes
  - 25 C: 98% SOC at 67 minutes
  - 0 C: 89% SOC at 81 minutes

- Total kWh:
  - 50 C: 12.5 kWh
  - 25 C: 13.1 kWh
  - 0 C: 11.5 kWh

0 C = 32 F
25 C = 77 F
50 C = 122 F

Preliminary Data Results

*The HV battery has a dedicated ventilation system (for cooling only), which becomes active in conjunction with the A/C compressor. This is temperature dependant and can occur while fast charging.*
Preliminary Data Results – Note that the vehicle temperature was measured at the passenger side front seat
2012 iMiEV - DC Fast Charging @ 0, 25 & 50 C

Preliminary Data Results

Power During DC Charging
2012 Mitsubishi i-MiEV Vin 3718 - ICD at 5,738 miles

- Power 0C
- Power 25C
- Power 50C

Minutes

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

Preliminary Data Results
Ambient Temps Impacts on Volt Fuel Efficiency

- Impact of Quarterly Average Ambient Temperature on Fuel Economy in Extended Range Mode and Electrical Energy Consumption in Electric Vehicle Mode
For publications and general plug-in electric vehicle performance, visit http://avt.inl.gov

Funding provided by DOE`s Vehicle Technologies Office