DC Fast Charger Use, Fees, Battery Impacts, and Temperature Impacts on Charge Rates – WA State EV Working Group

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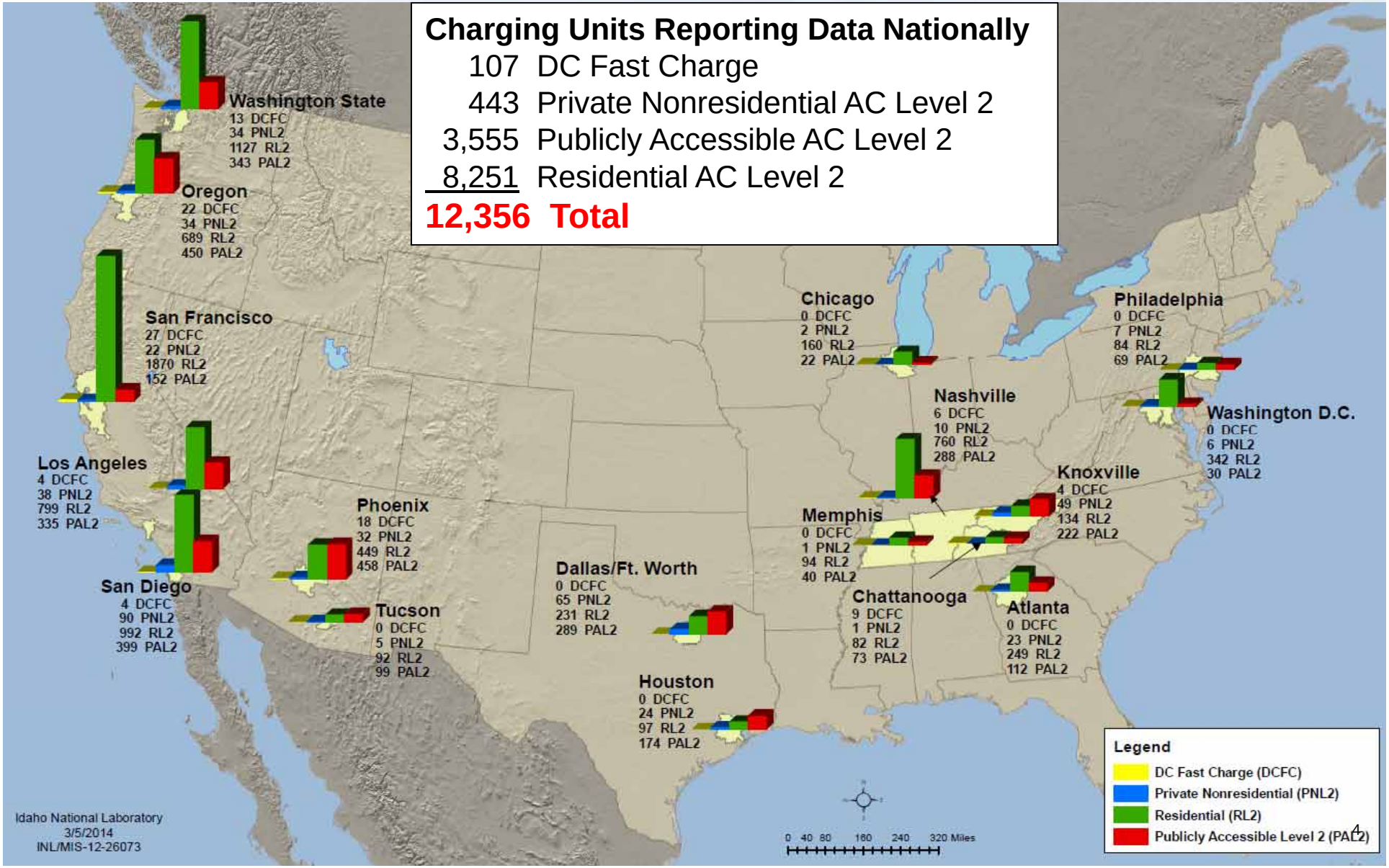
Idaho National Laboratory

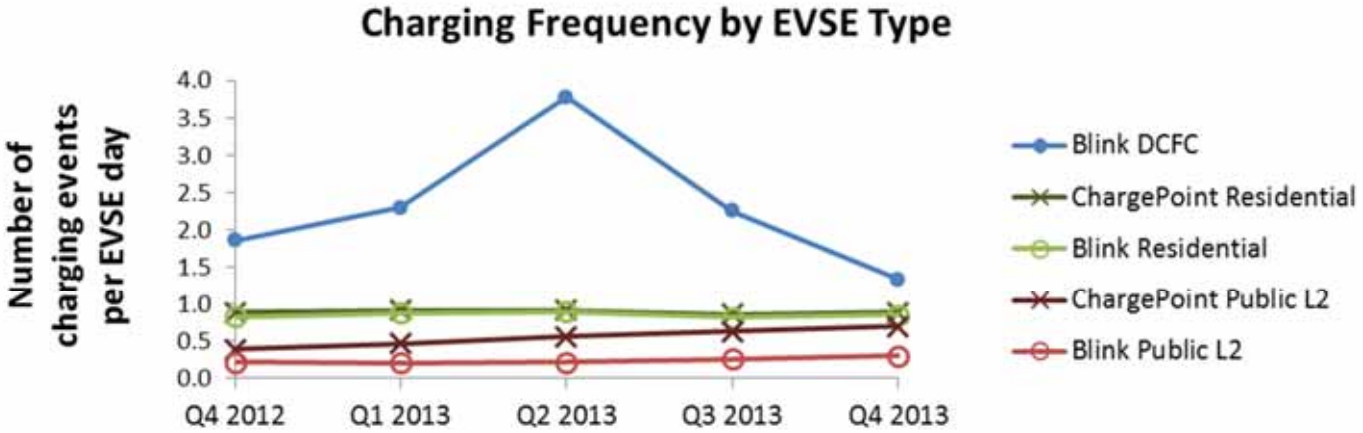
- U.S. Department of Energy (DOE) laboratory
- 890 square mile site with 4,000 staff
- Support DOE's strategic goal:
  - Increase U.S. energy security and reduce the nation's dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Development
  - Homeland Security and Cyber Security

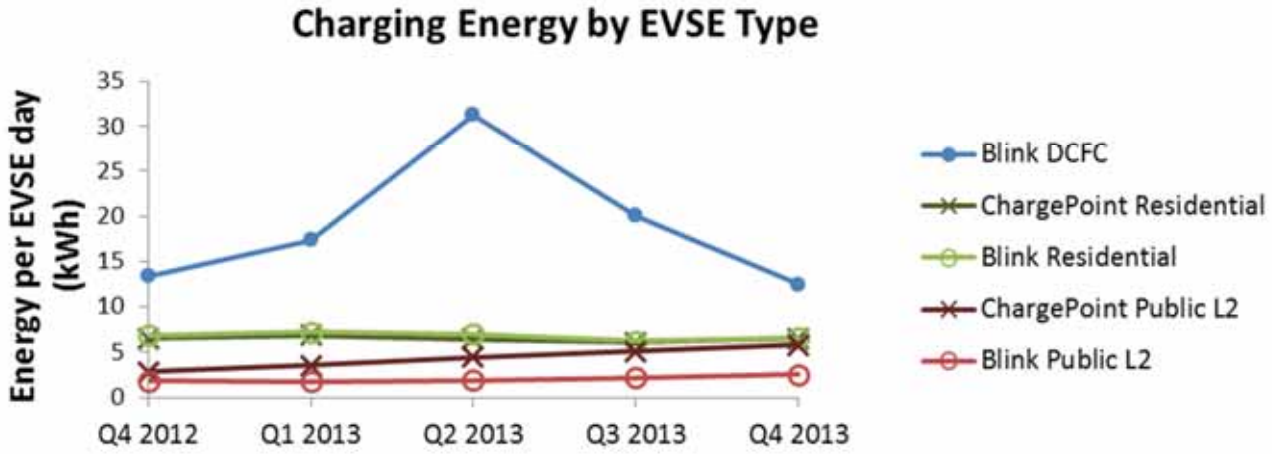
DC Fast Charger (DCFC) Use in the EV Project

EV Project (Blink) Infrastructure Deployment



Usage Frequency of Residential & Public Level 2 EVSE and DC Fast Chargers



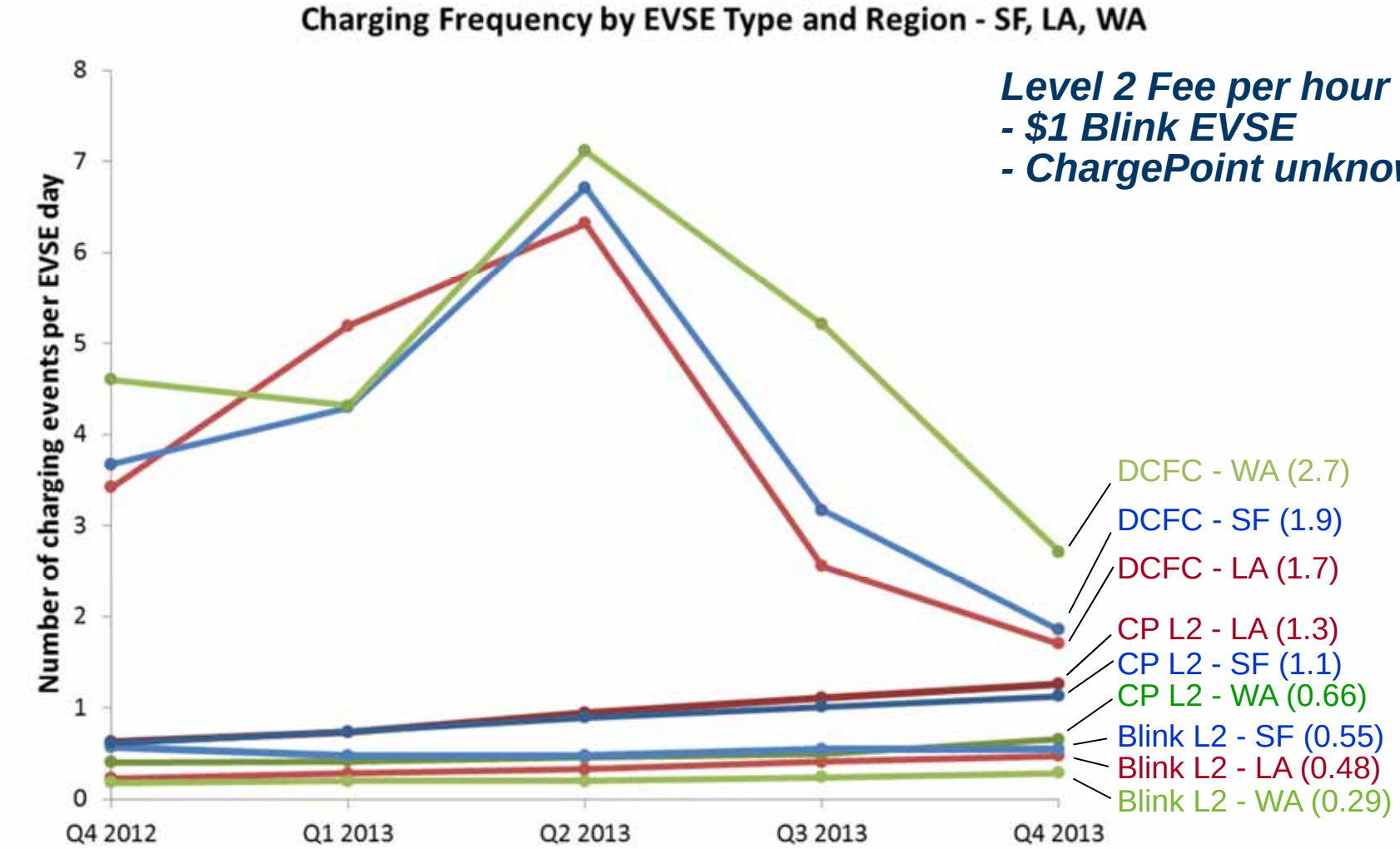


EVSE = Electric Vehicle Supply Equipment. L2 = SAE's AC Level 2 EVSE (208 – 220 Volts) definition. DCFC = DC Fast Charger

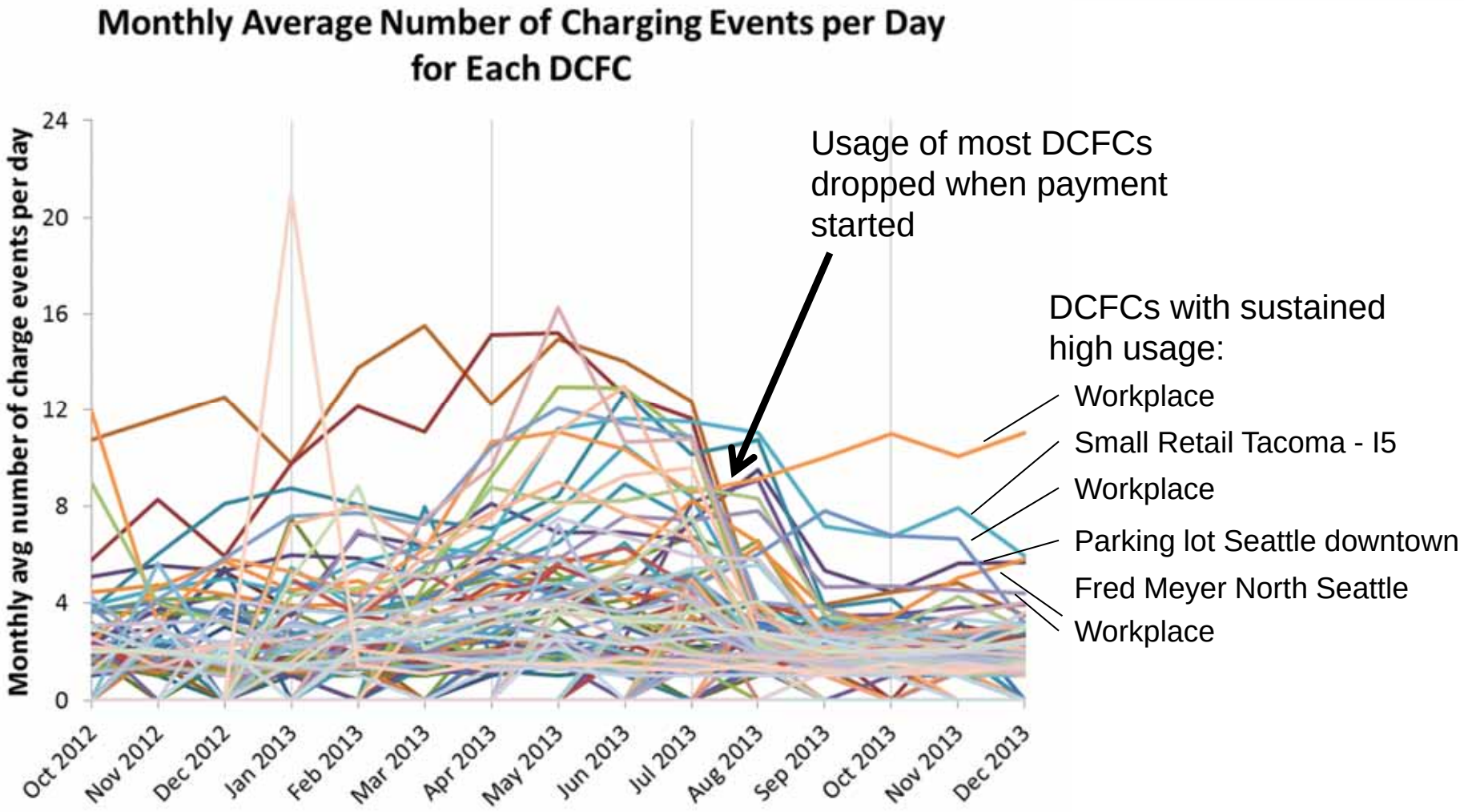
Blink DC Fast Chargers - Fee Impacts

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

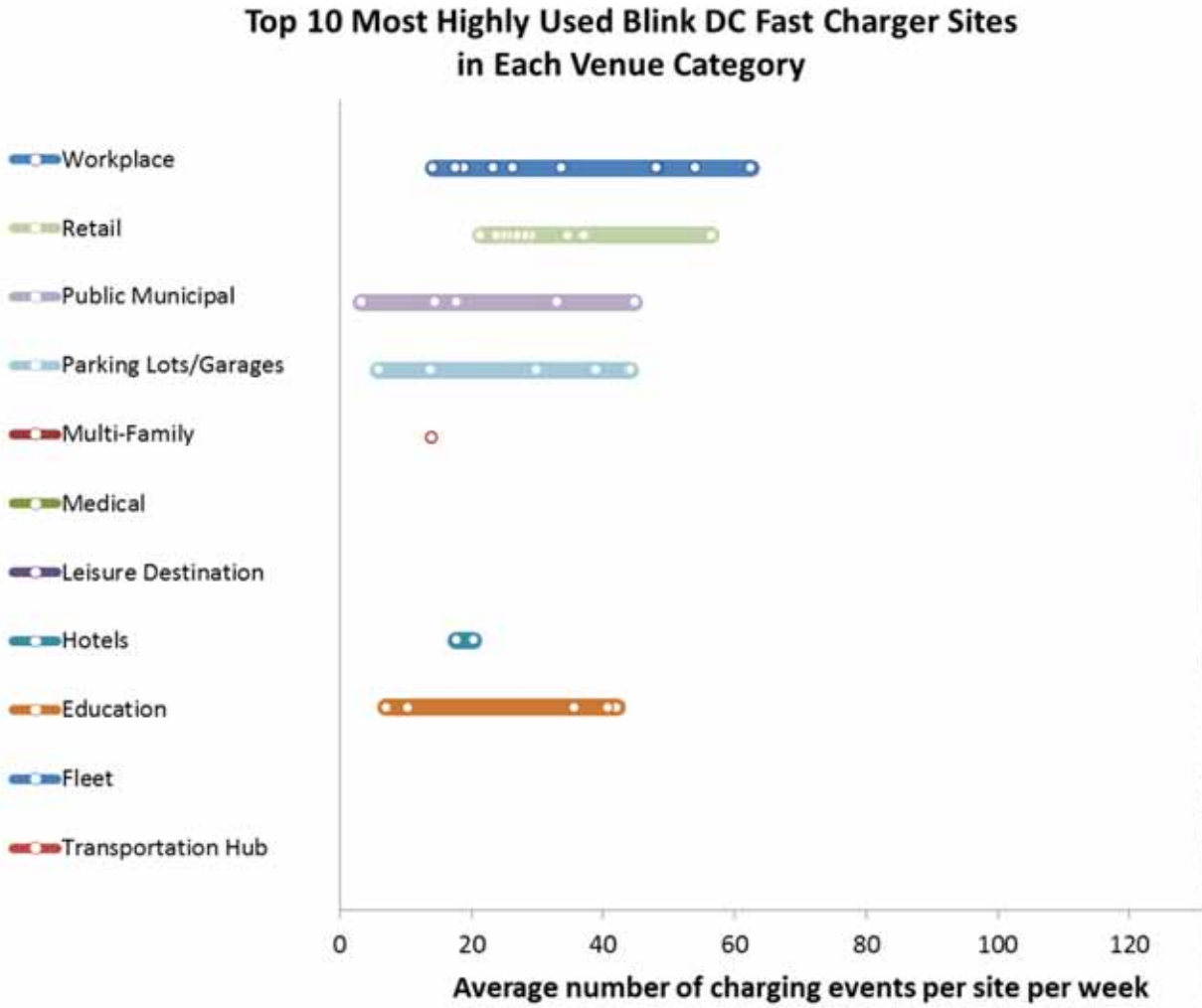
Average Usage Rate for Public Level 2 EVSE & DC Fast Chargers per Select Regions

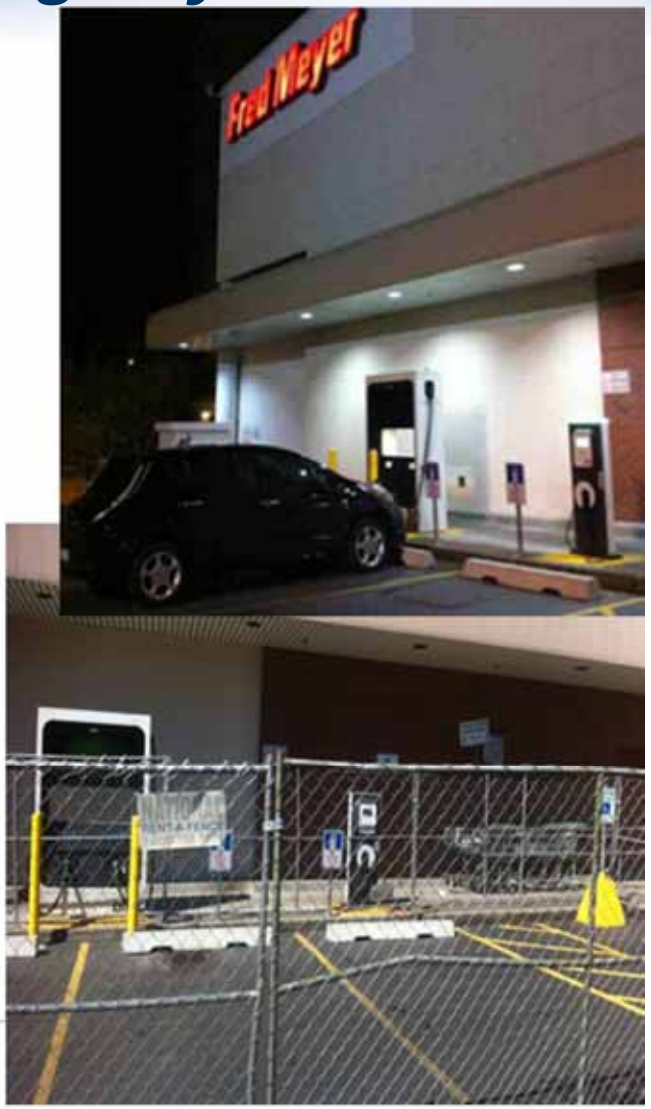


Usage Frequency of All DC Fast Chargers Nationally

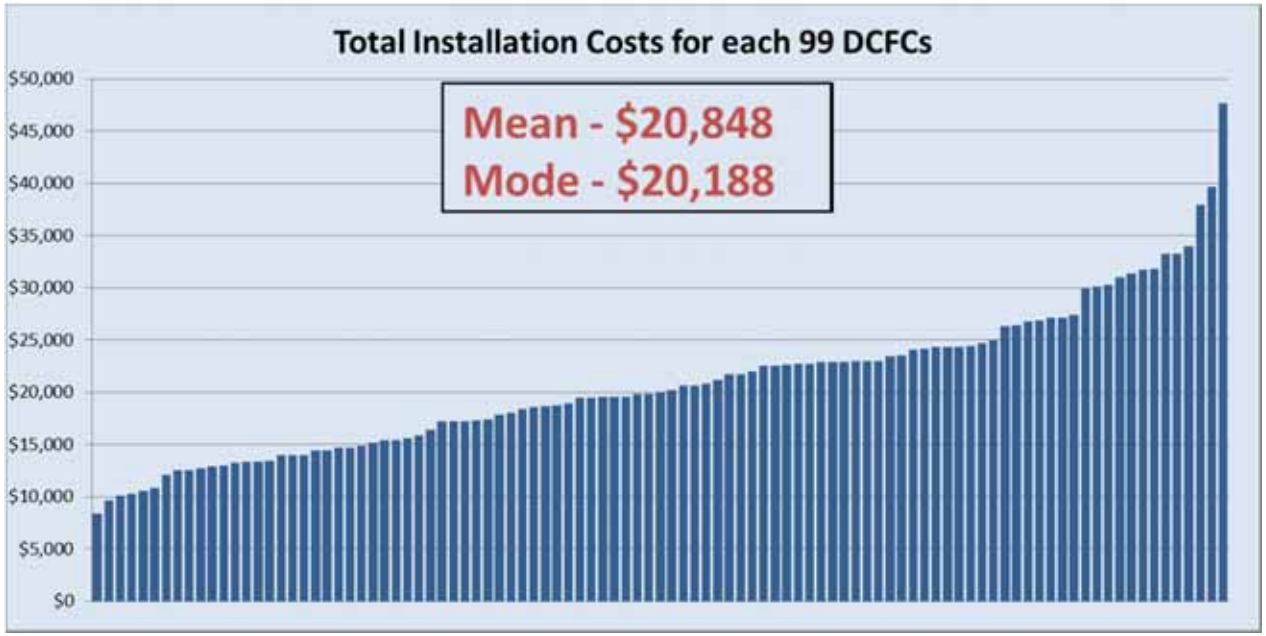


Public Blink DC Fast Charger Usage by Venue & Site – One DCFC per site





DC Fast Charger (DCFC) Infrastructure Installation & Demand Costs



Utility Demand Charges - Nissan Leaf		Cost/mo.
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

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

DC Fast Charging Impact Study on 2012 Leafs

DC Fast Charging Impact Study on 2012 Leafs

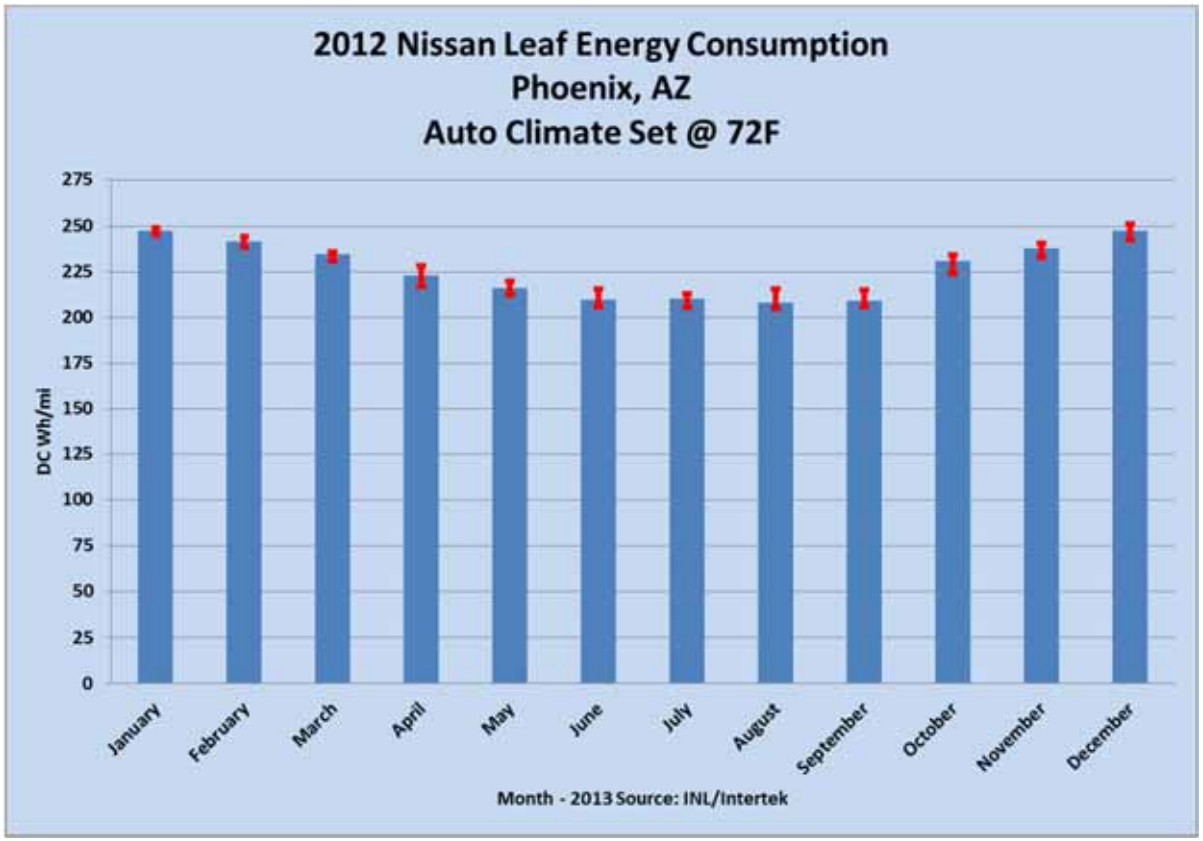
- **Two Goals**
  - **Determine DC Fast Charge (DCFC) impacts versus Level 2 impact**
  - **Compare on-road to laboratory test results**
- **Two on-road Nissan Leafs are exclusively Level 2 (L2) charged**
- **Two on-road Nissan Leafs are exclusively DCFC charged**
- **Identical on-road routes are driven**
- **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**

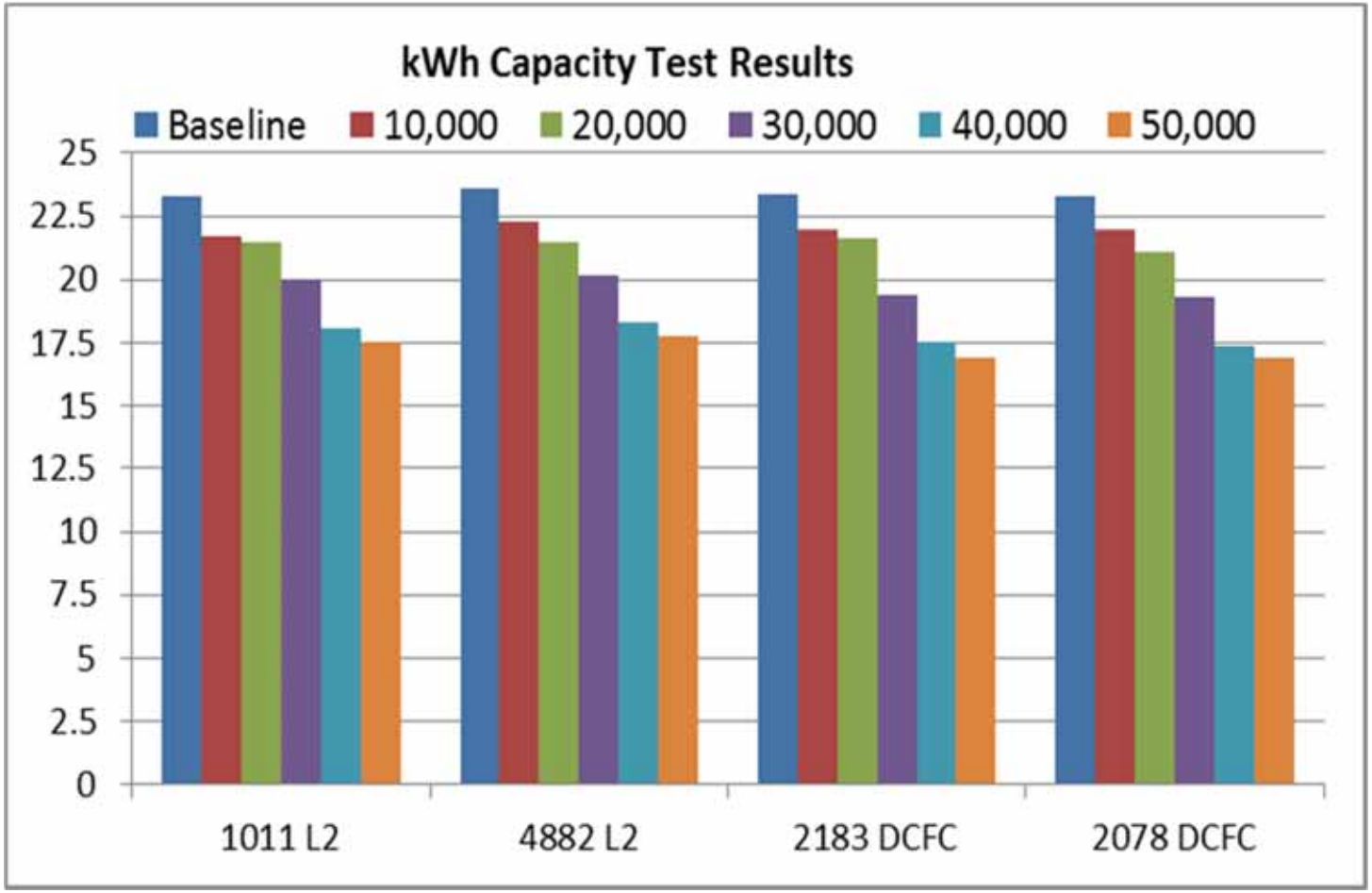
DC Fast Charging Impact Study on 2012 Leafs

- 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



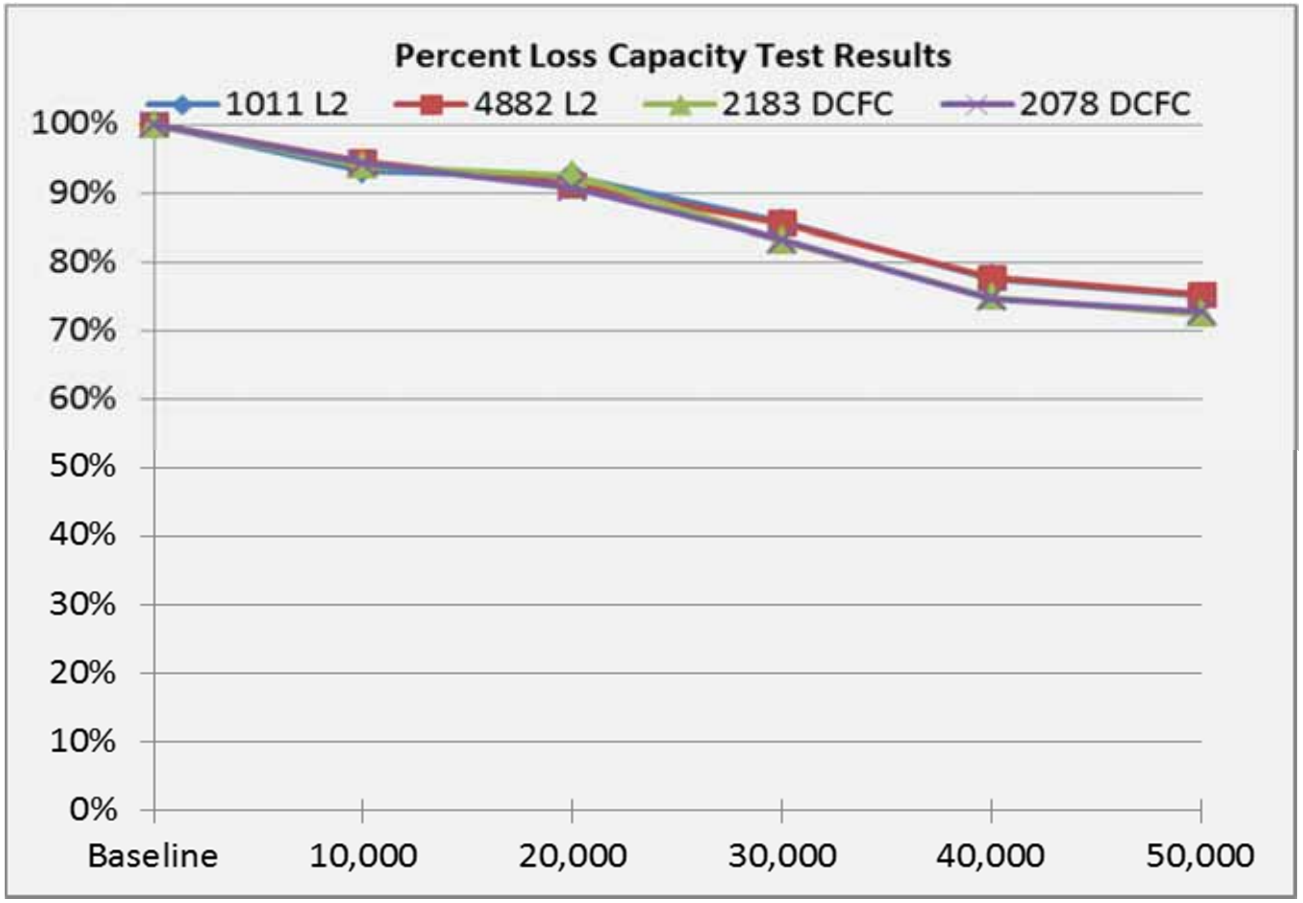
DC Fast Charging Impact Study on 2012 Leafs

- **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**

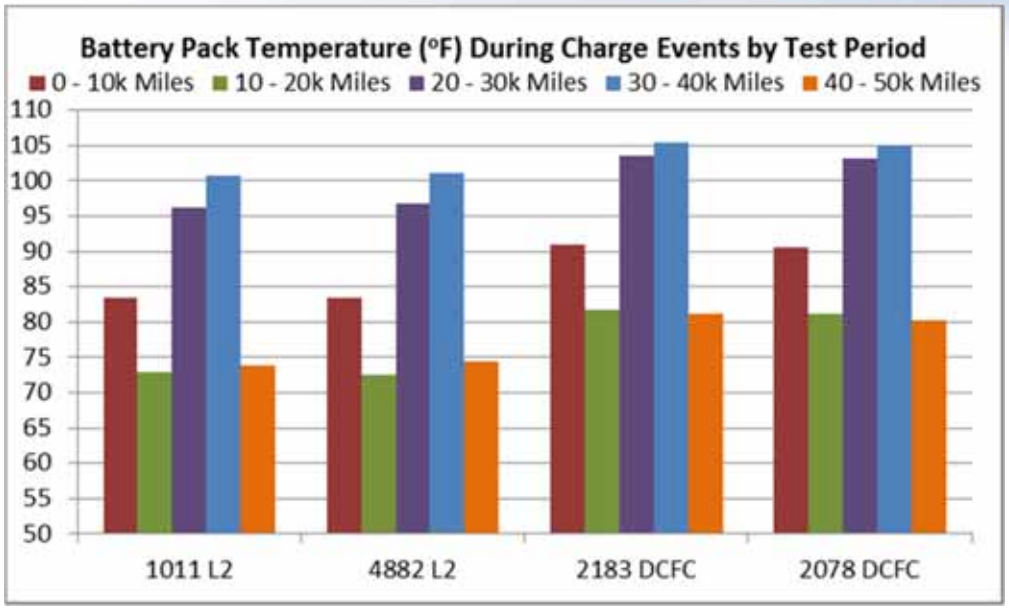


DC Fast Charging Impact Study on 2012 Leafs

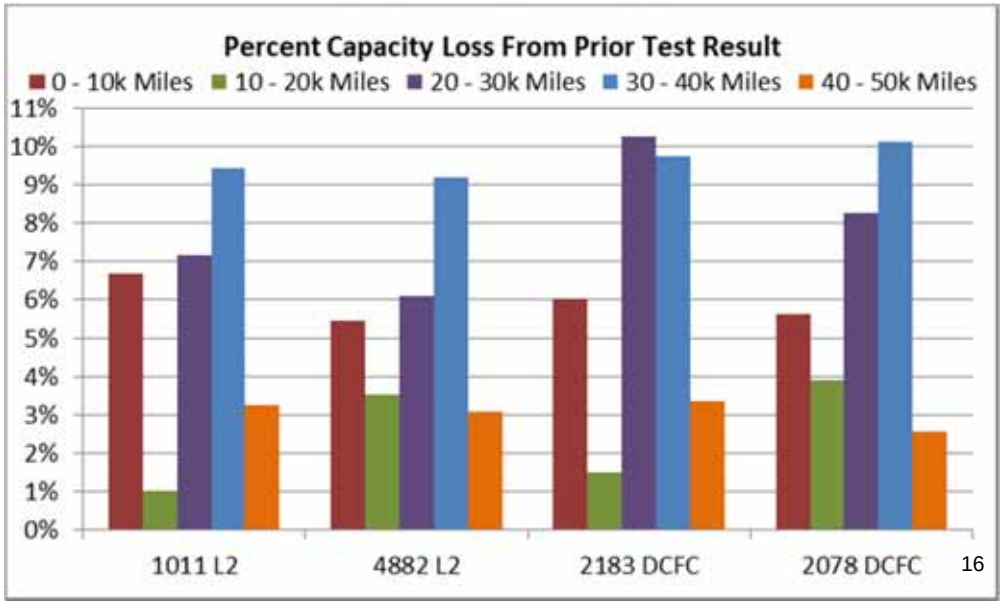
- **Level 2 averaged 75.2% SOC @ 50k miles**
- **DCFC averaged 72.6% SOC @ 50k miles**
- **2.6% capacity difference @ 50k miles, probably not a significant difference**



DC Fast Charging Impact Study on 2012 Leafs

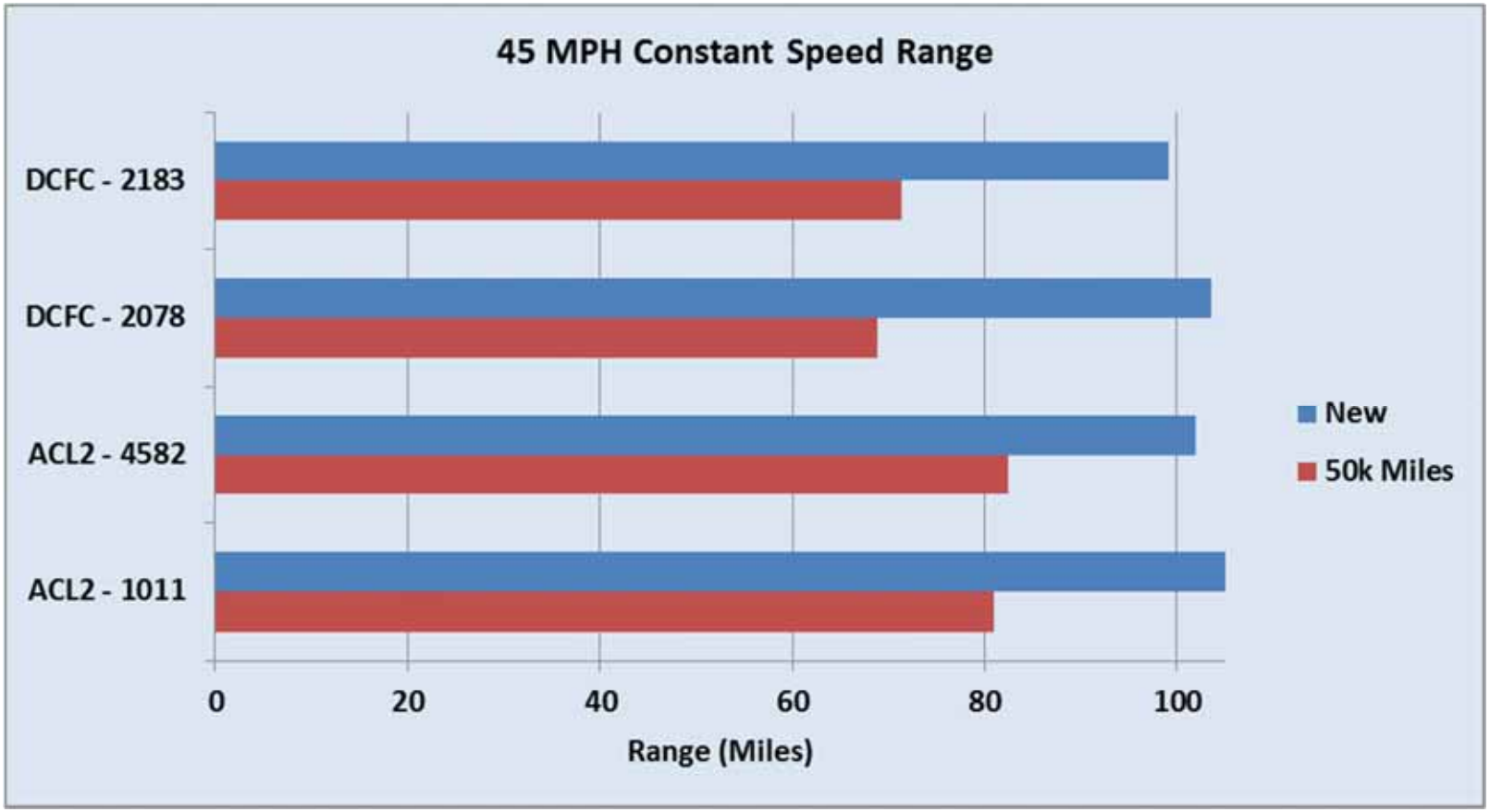


- **Quantify in field & lab settings, impacts on battery performance and life**
- **DCFC 27% & L2 25% capacity losses at 50k miles/vehicle**
- **Phoenix heat likely accelerates results - largest decreases in capacity from test before occurred during high heat charging operation**



DC Fast Charging Impact Study on 2012 Leafs

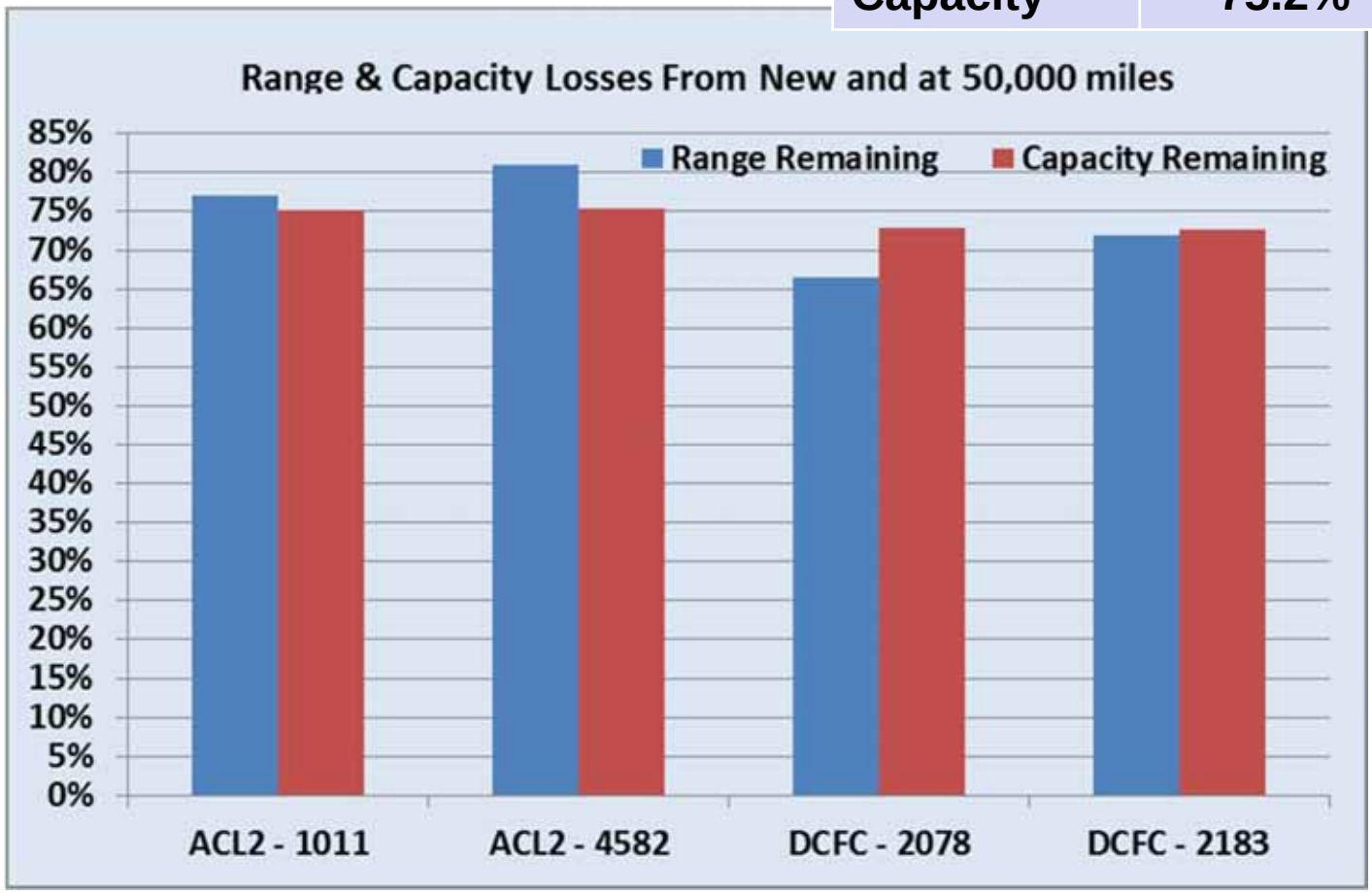
- **Range (miles) at 50,000 miles compared to testing when new**



DC Fast Charging Impact Study on 2012 Leafs

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

	L2 Average	DCFC Average
Range	79.0%	69.3%
Capacity	75.2%	72.7%

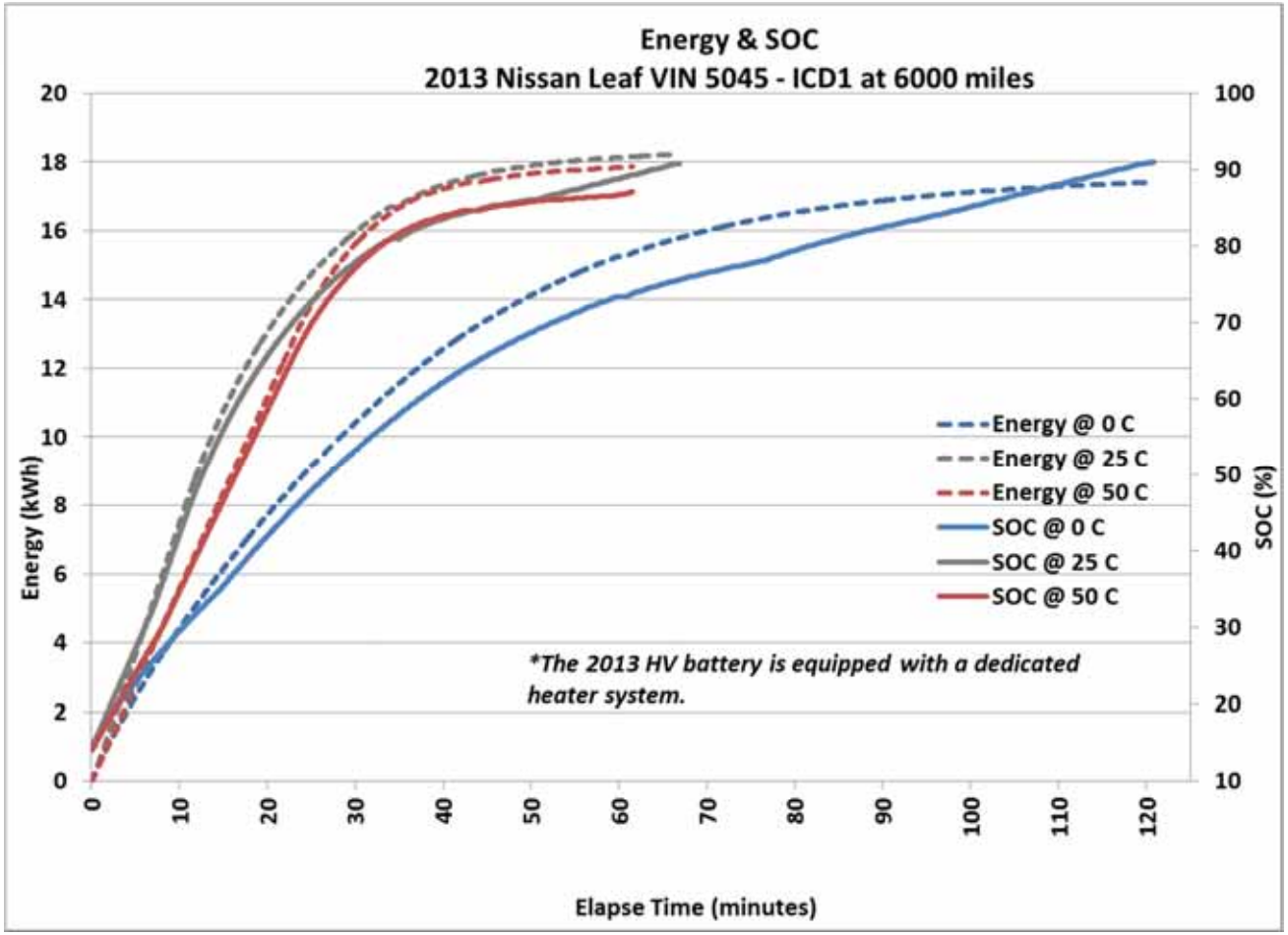


DC Fast Charging Acceptance Rates at Various Temperature

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

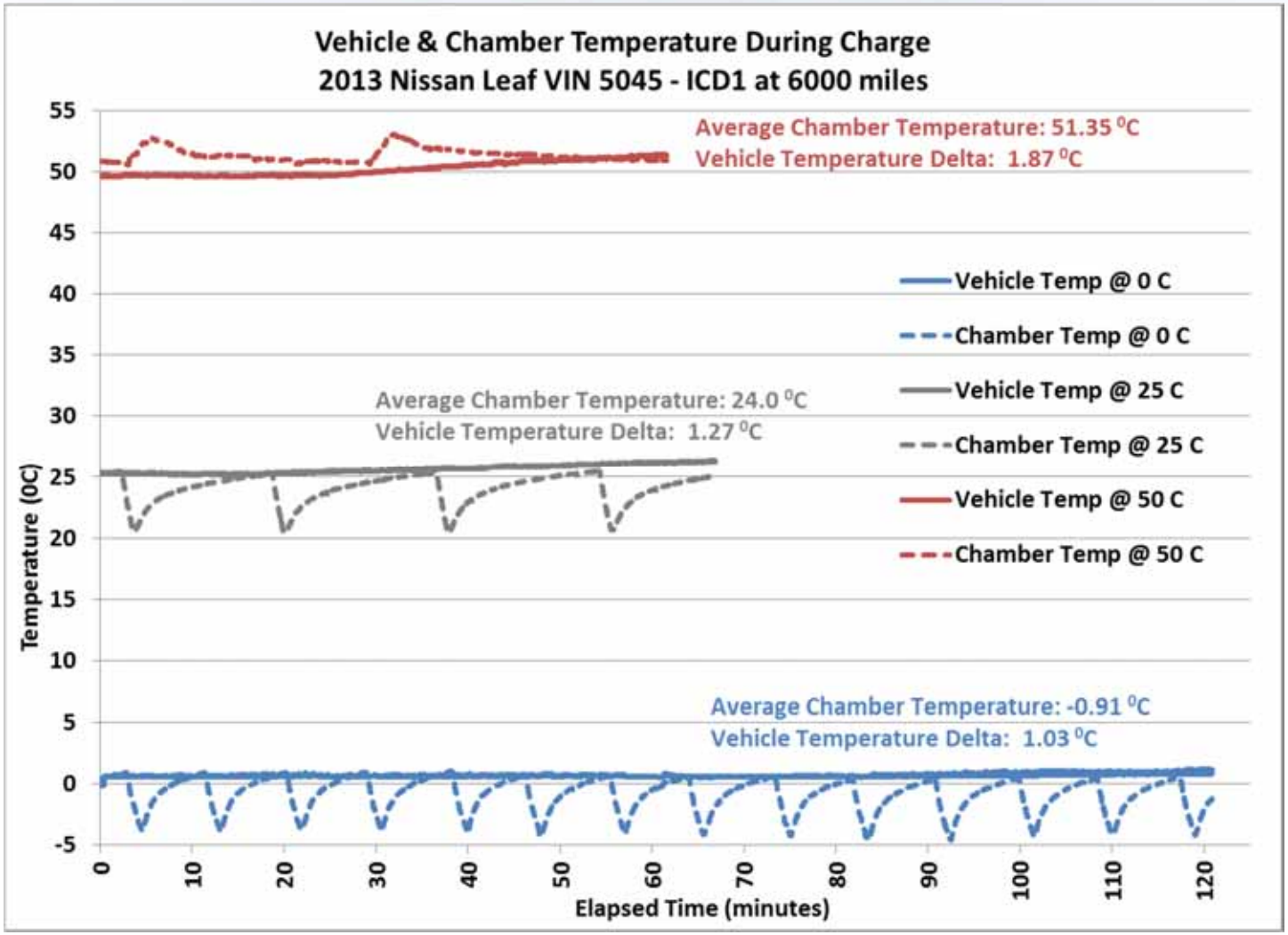


Preliminary Data Results

- **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**

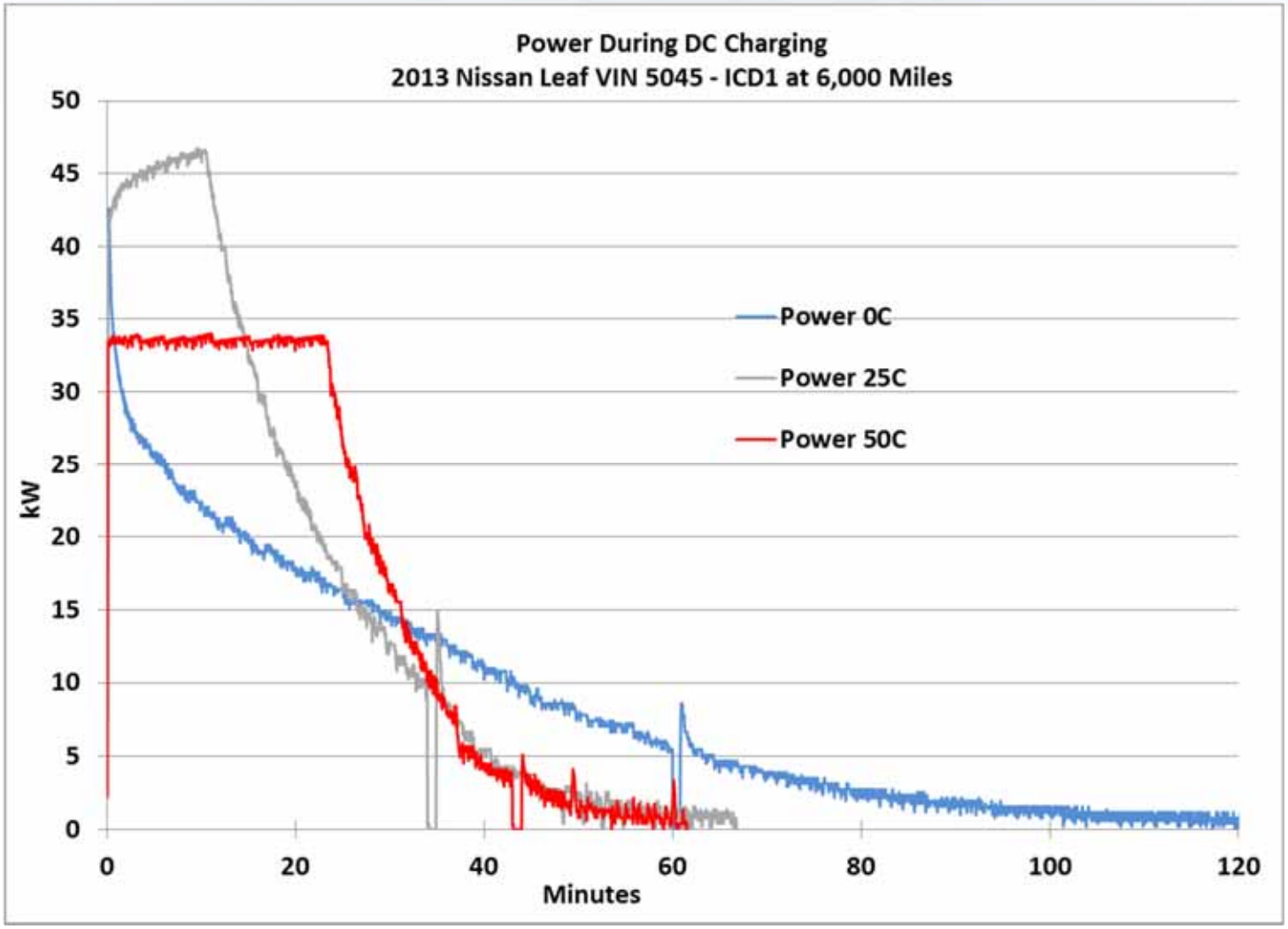
0 C = 32 F
25 C = 77 F
50 C = 122 F

2013 Leaf - DC Fast Charging @ 0, 25 & 50 C



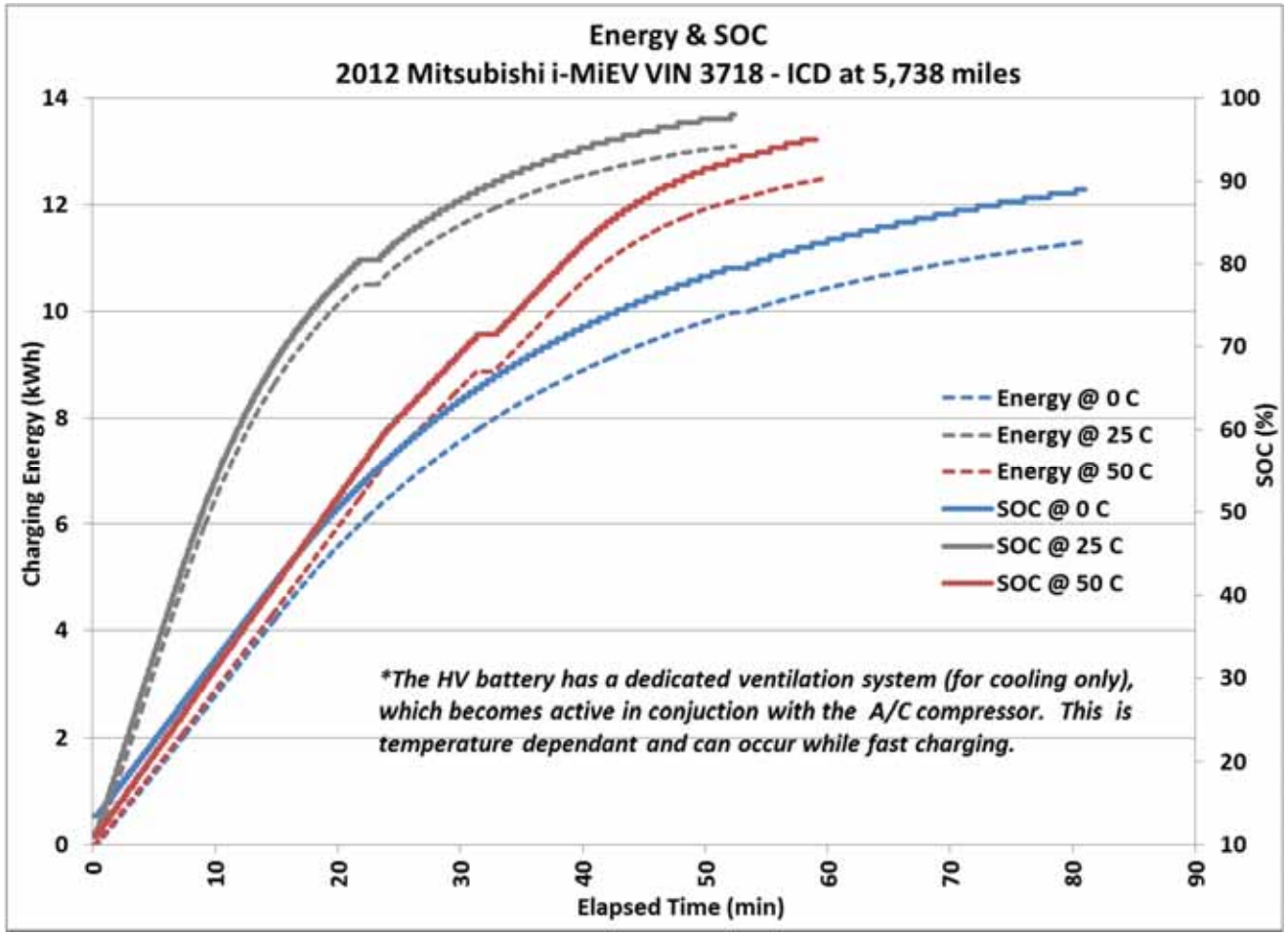
Preliminary Data Results – Note that the vehicle temperature was measured at the passenger side front seat

2013 Leaf - DC Fast Charging @ 0, 25 & 50 C



Preliminary Data Results

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

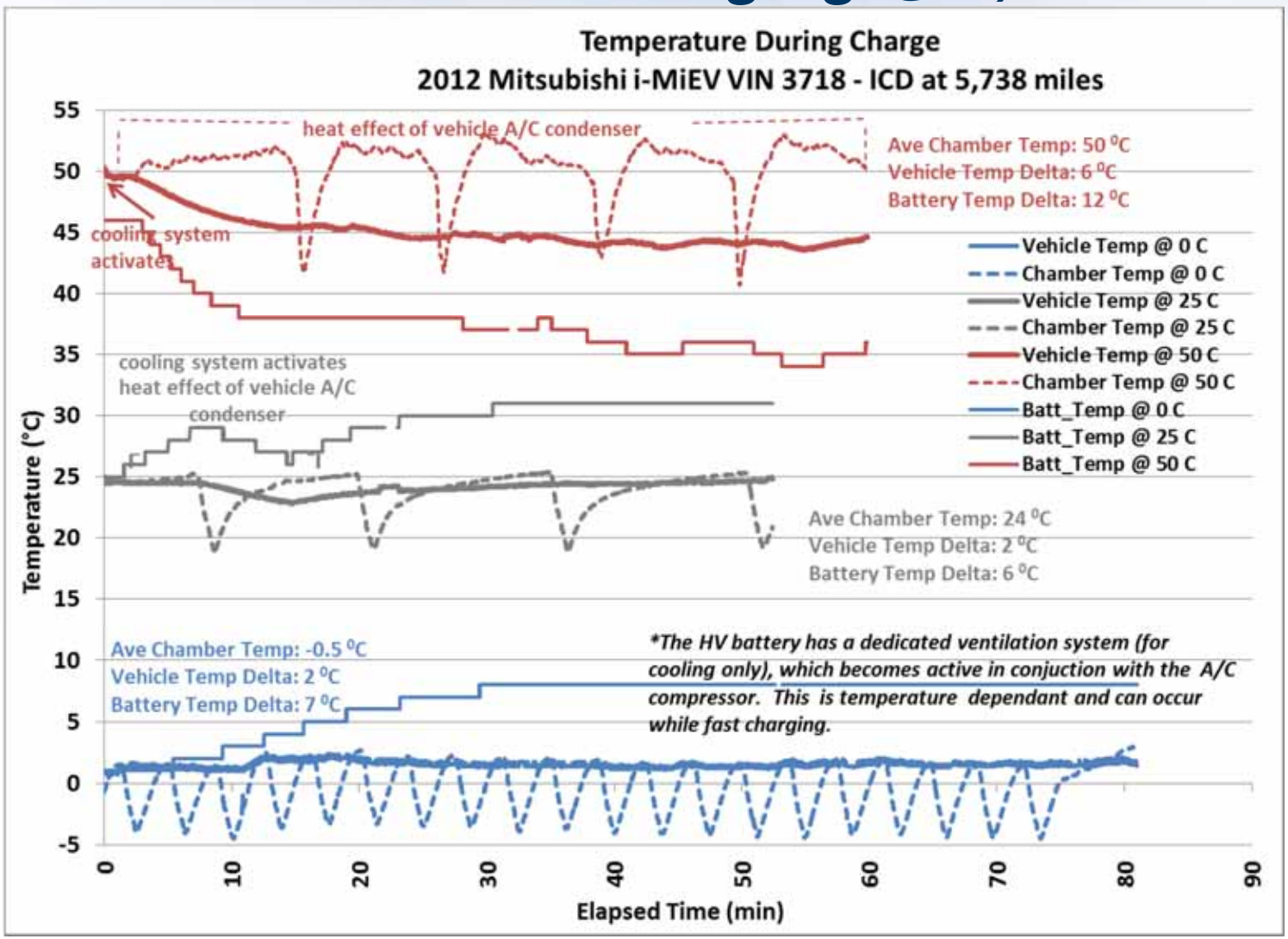


Preliminary Data Results

- **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**

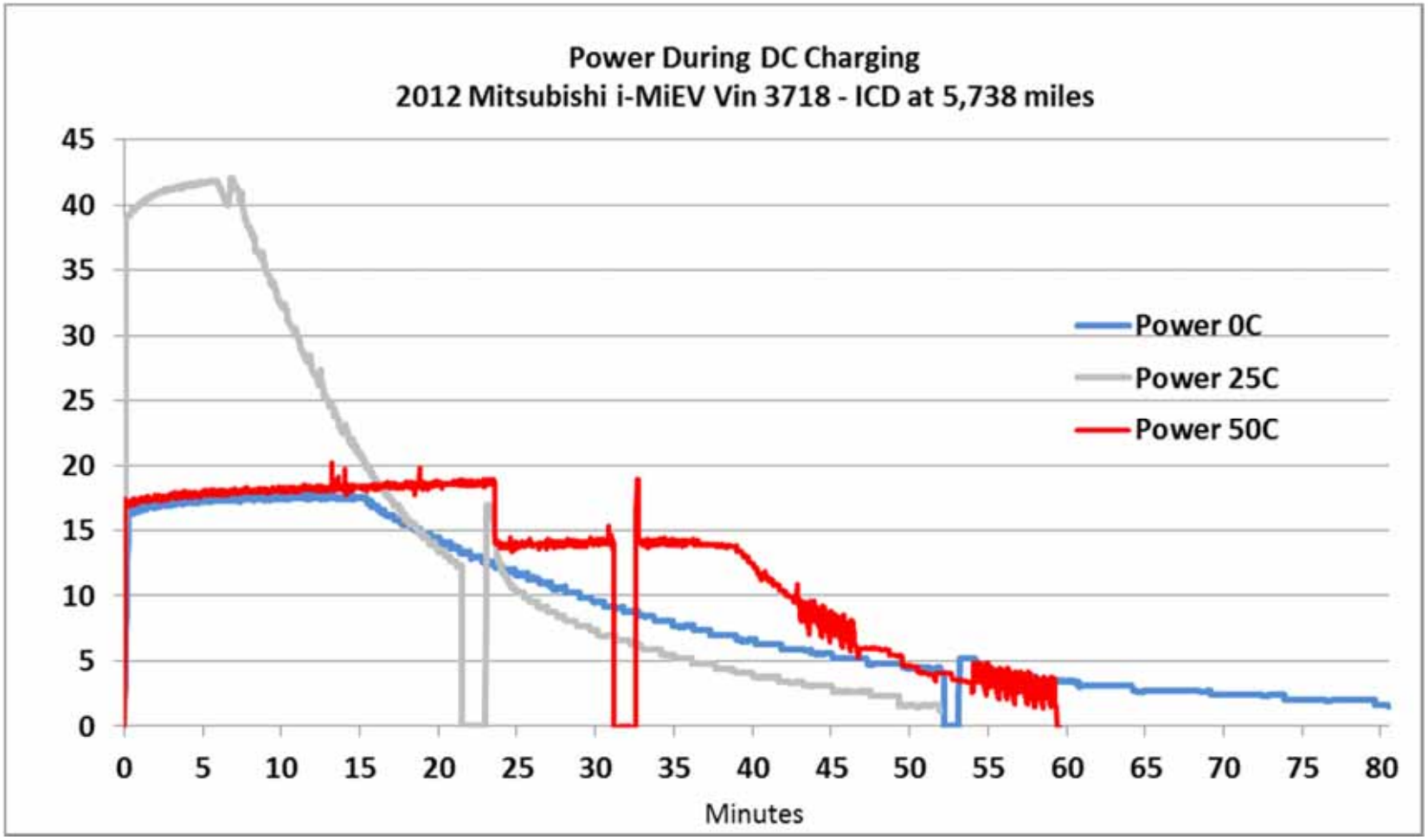
0 C = 32 F
25 C = 77 F
50 C = 122 F

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



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

Additional Information

For publications and general plug-in electric vehicle performance, visit http://avt.inl.gov

Funding provided by DOE`s Vehicle Technologies Office