# 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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Idaho National Laboratory

# Idaho National Laboratory



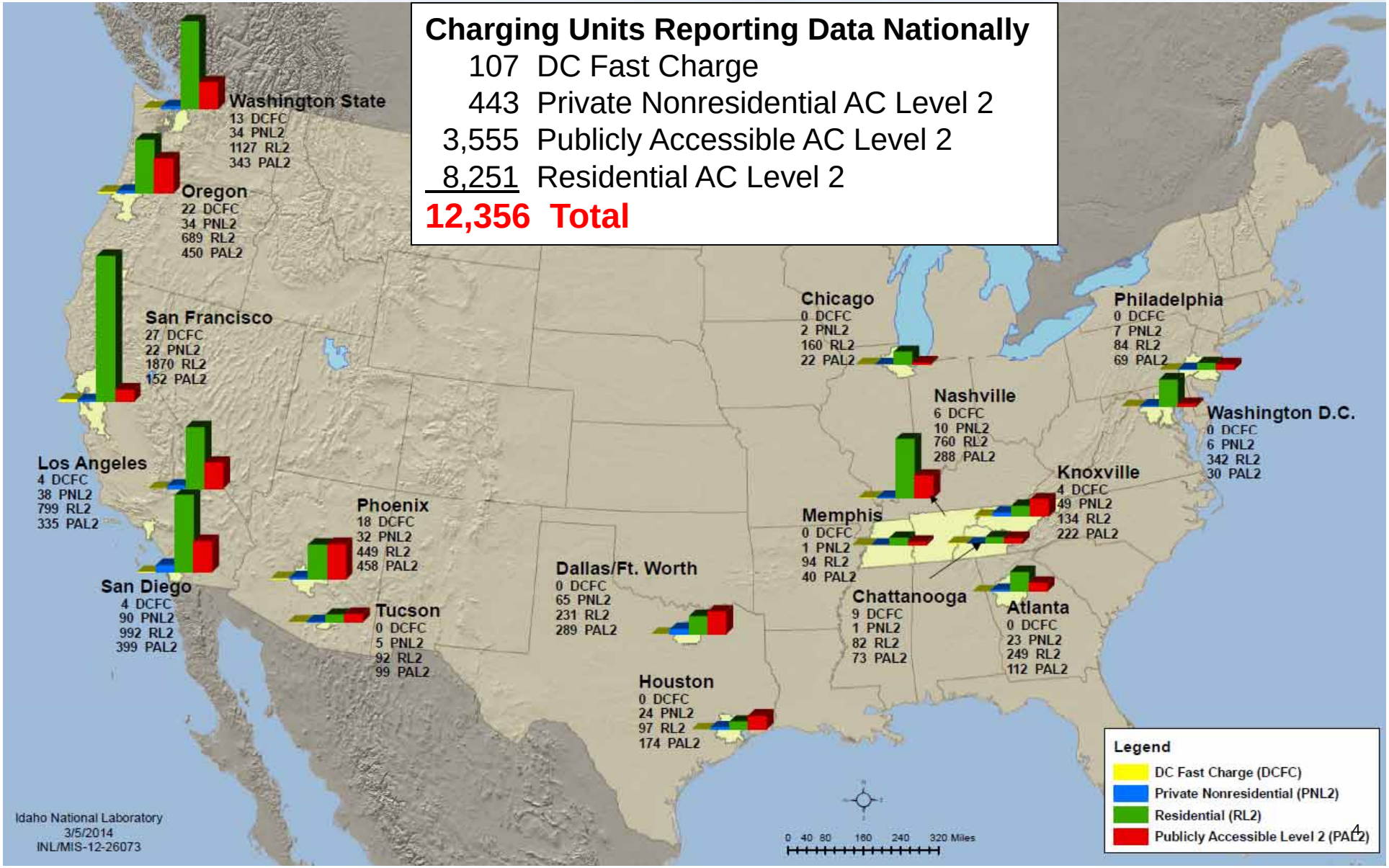




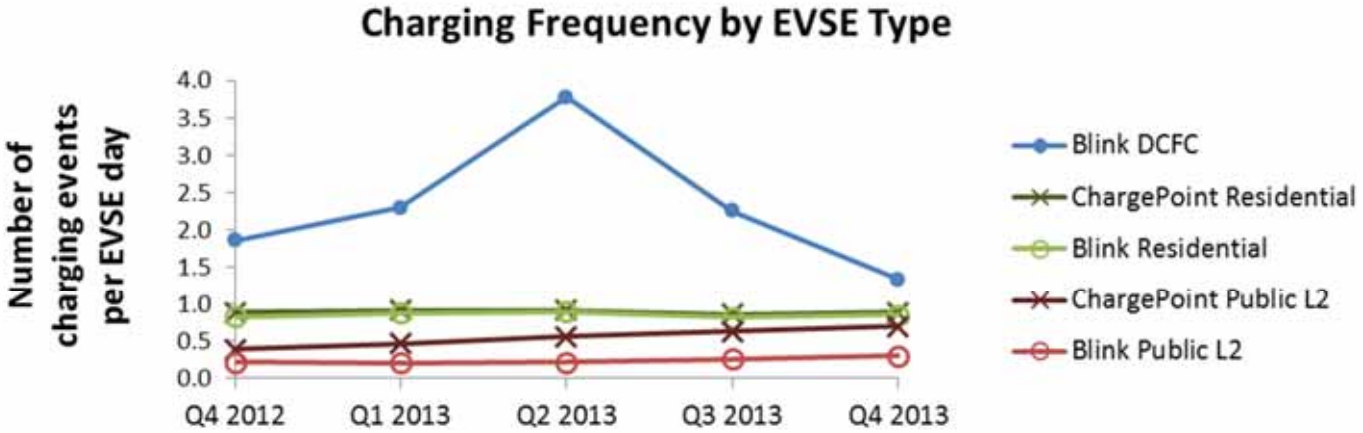
- U.S. Department of Energy (DOE) laboratory
- 890 square mile site with 4,000 staff
- Support DOE's strategic goal:
  - Increase U.S. energy security and reduce the nation's dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Fossil, Biomass, Wind, Geothermal and Hydropower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

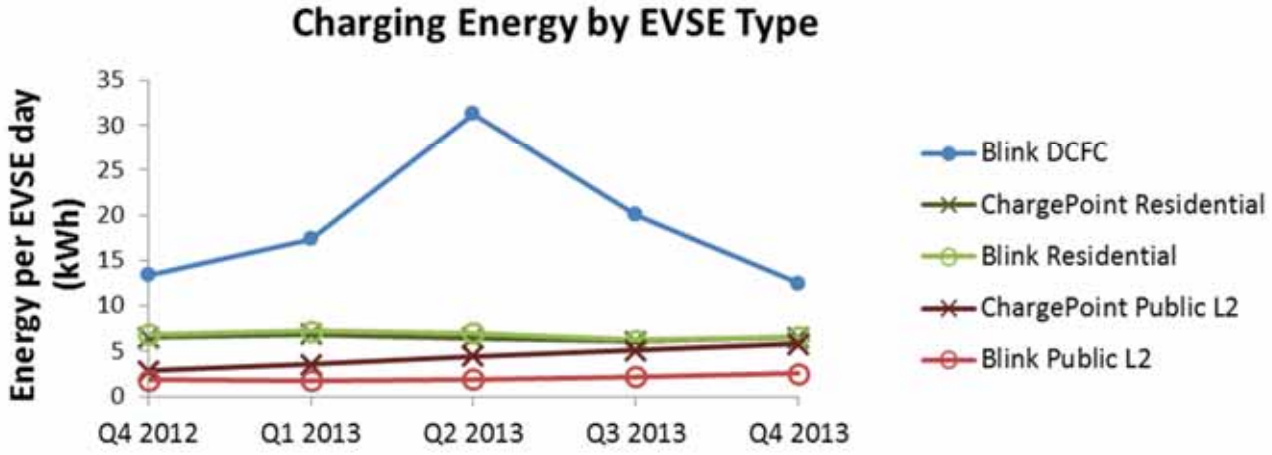
# *DC Fast Charger (DCFC) Use in the EV Project*

# EV Project (Blink) Infrastructure Deployment



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

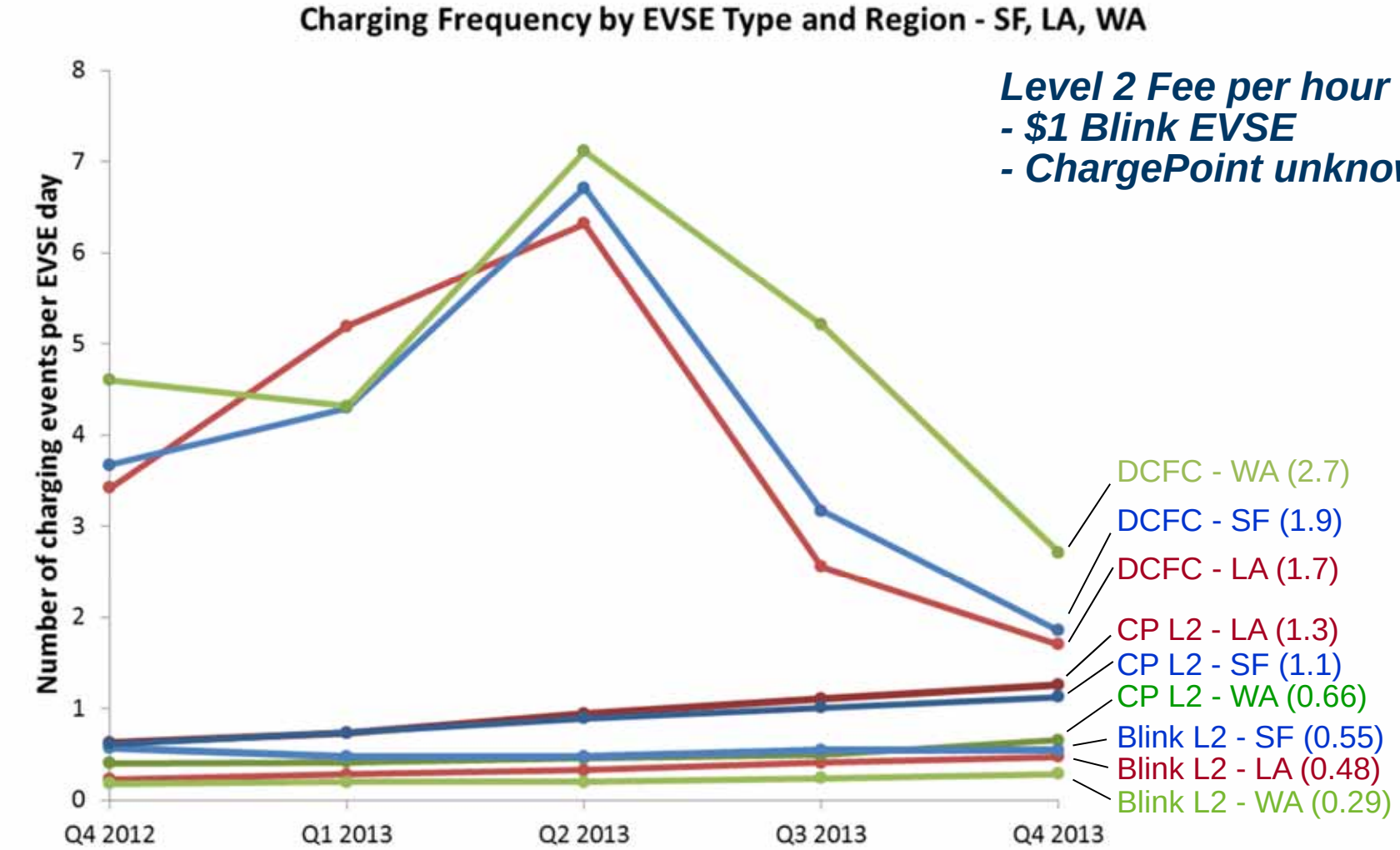




***EVSE = Electric Vehicle Supply Equipment. L2 = SAE's AC Level 2 EVSE (208 – 220 Volts) definition. DCFC = DC Fast Charger***

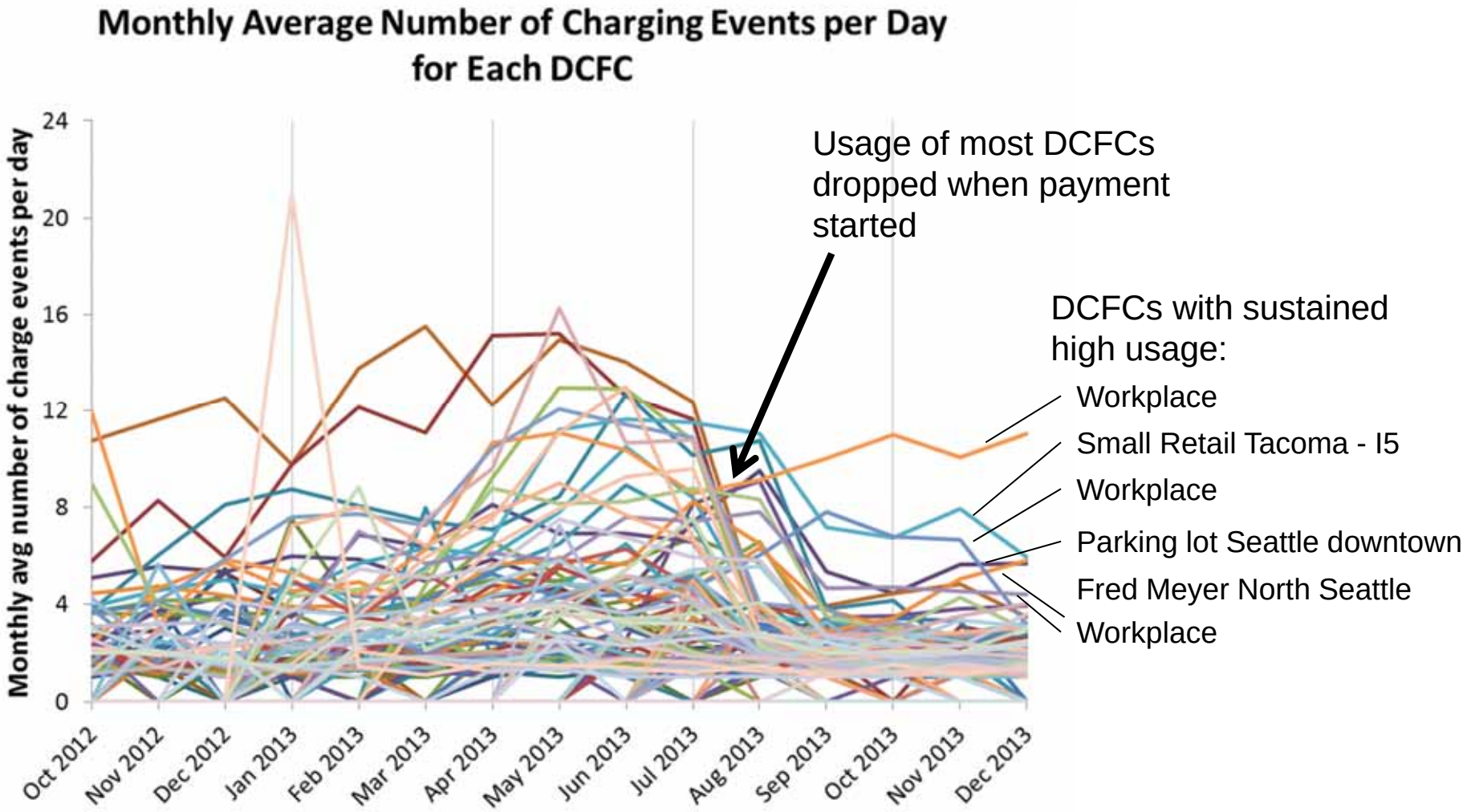
# Blink DC Fast Chargers - Fee Impacts

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

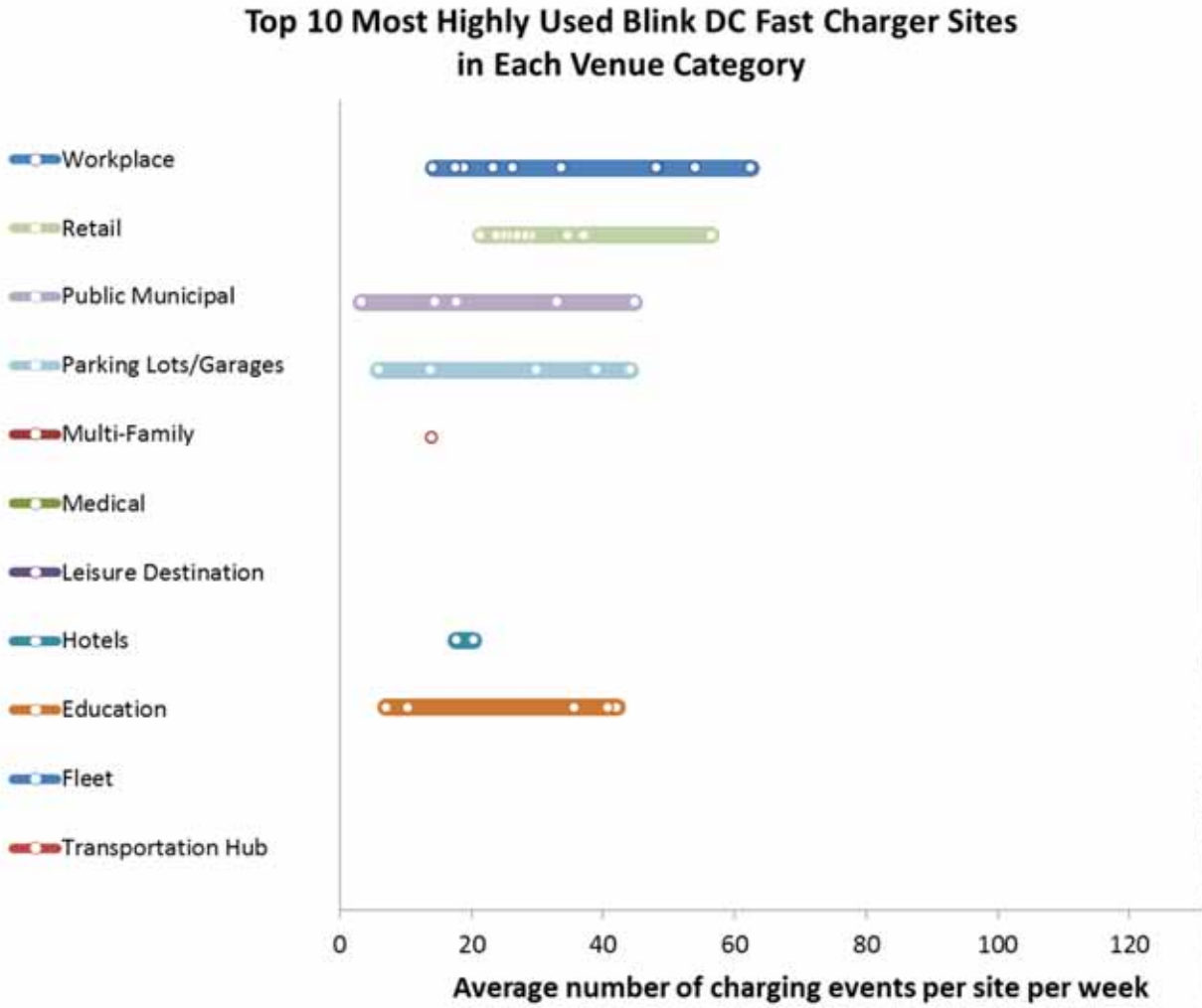
# Average Usage Rate for Public Level 2 EVSE & DC Fast Chargers per Select Regions

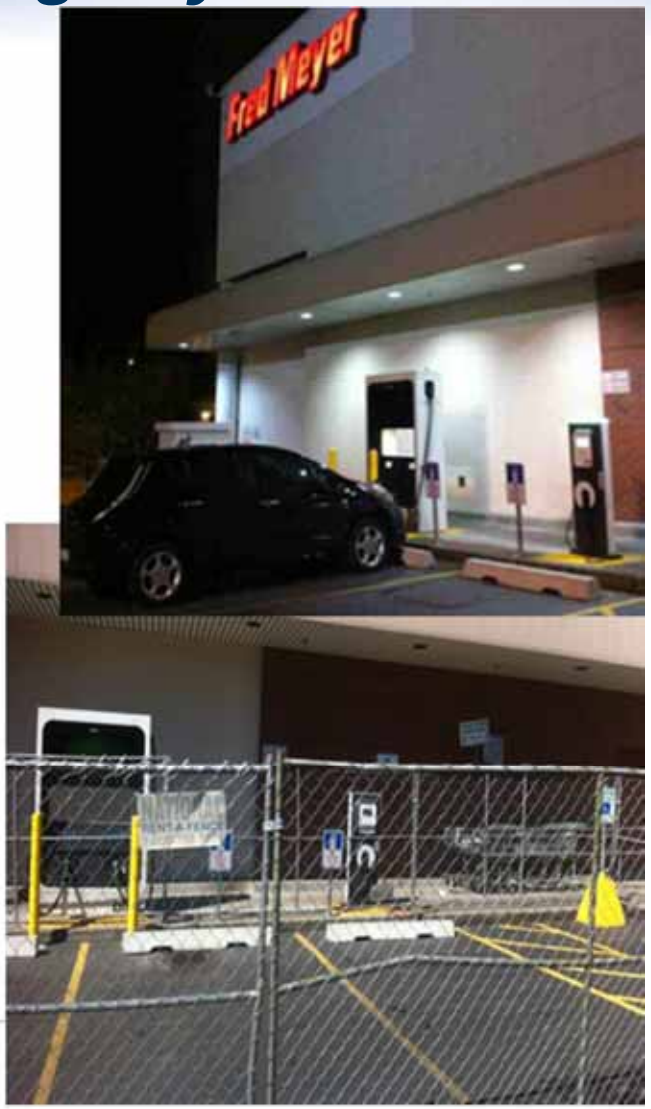


# Usage Frequency of All DC Fast Chargers Nationally

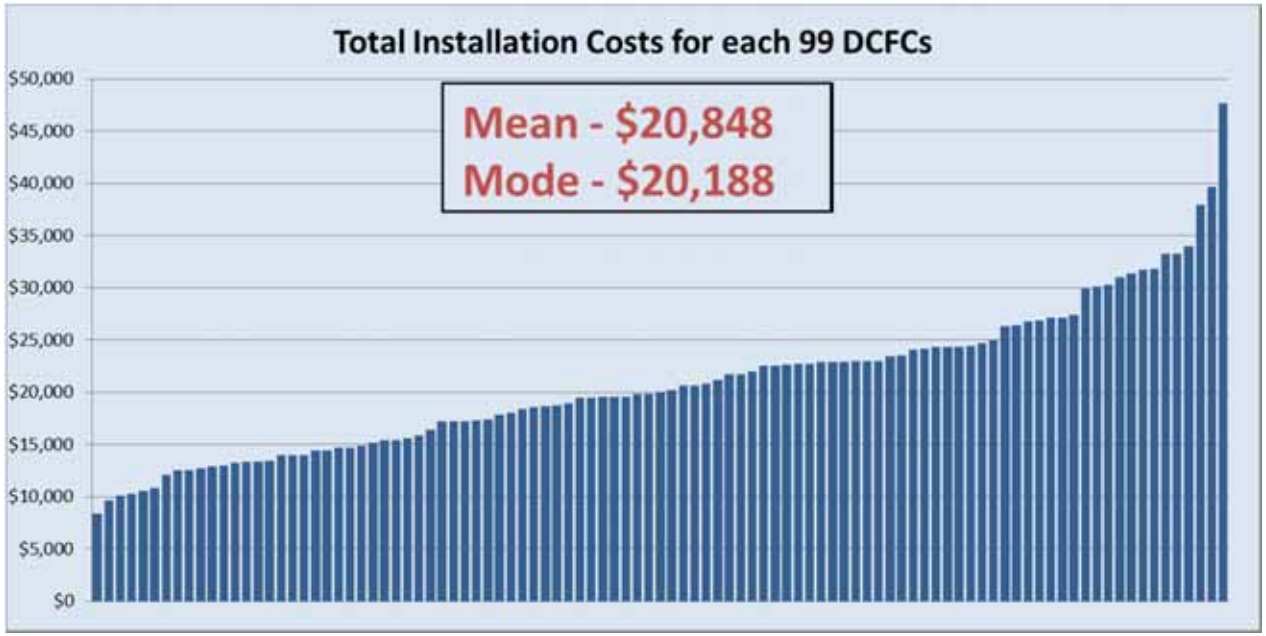


# Public Blink DC Fast Charger Usage by Venue & Site – One DCFC per site



# 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

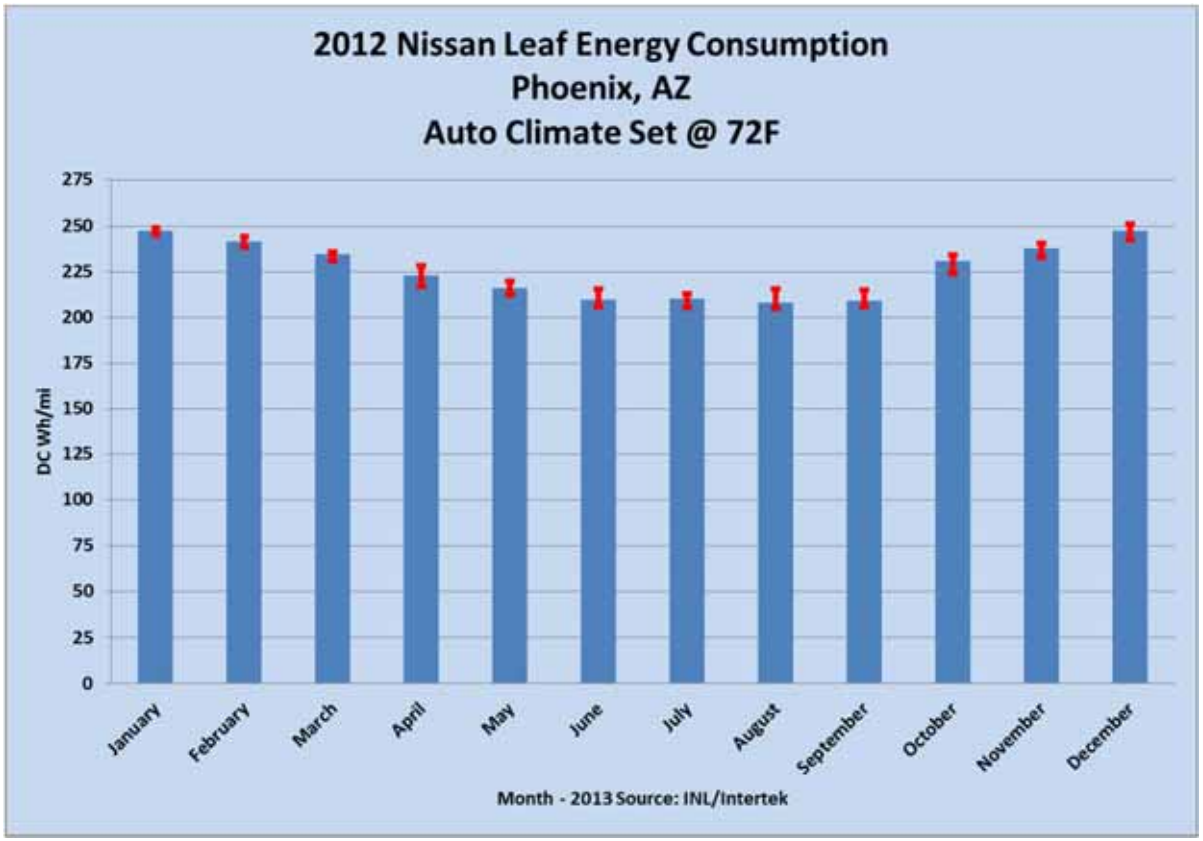
- **Two Goals**
  - **Determine DC Fast Charge (DCFC) impacts versus Level 2 impact**
  - **Compare on-road to laboratory test results**
- **Two on-road Nissan Leafs are exclusively Level 2 (L2) charged**
- **Two on-road Nissan Leafs are exclusively DCFC charged**
- **Identical on-road routes are driven**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

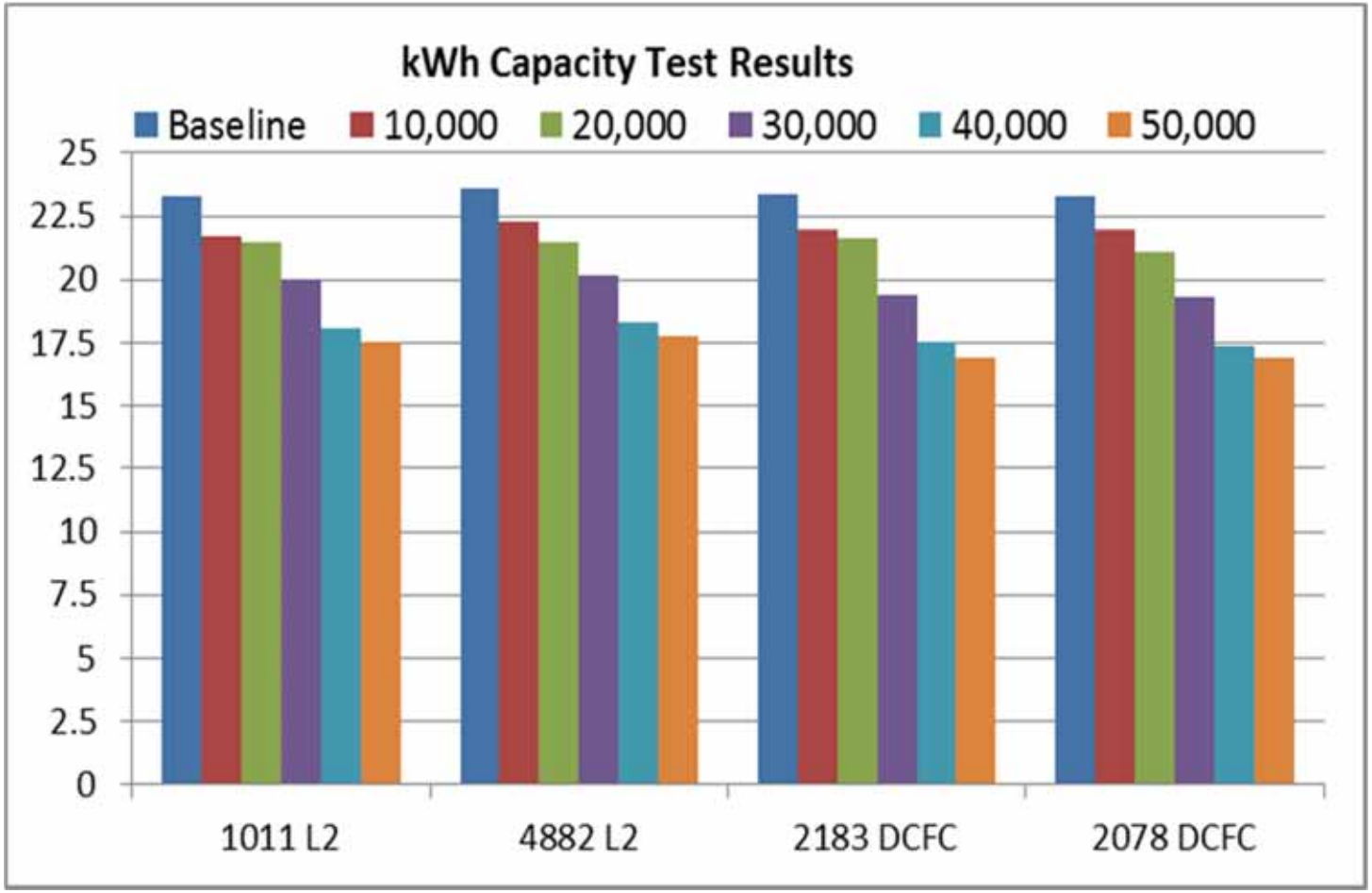
# DC Fast Charging Impact Study on 2012 Leafs

- 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



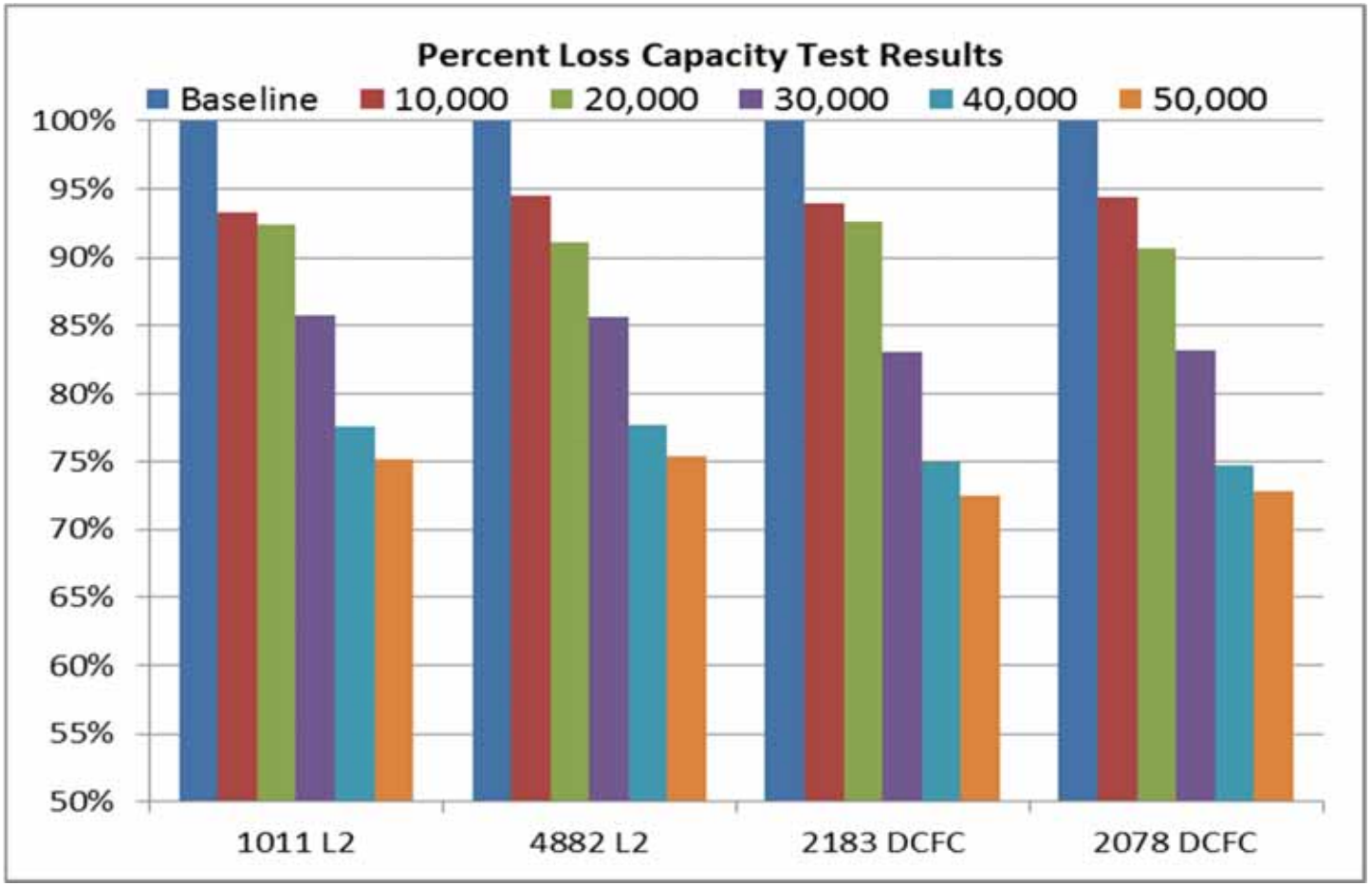

# DC Fast Charging Impact Study on 2012 Leafs

- **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**



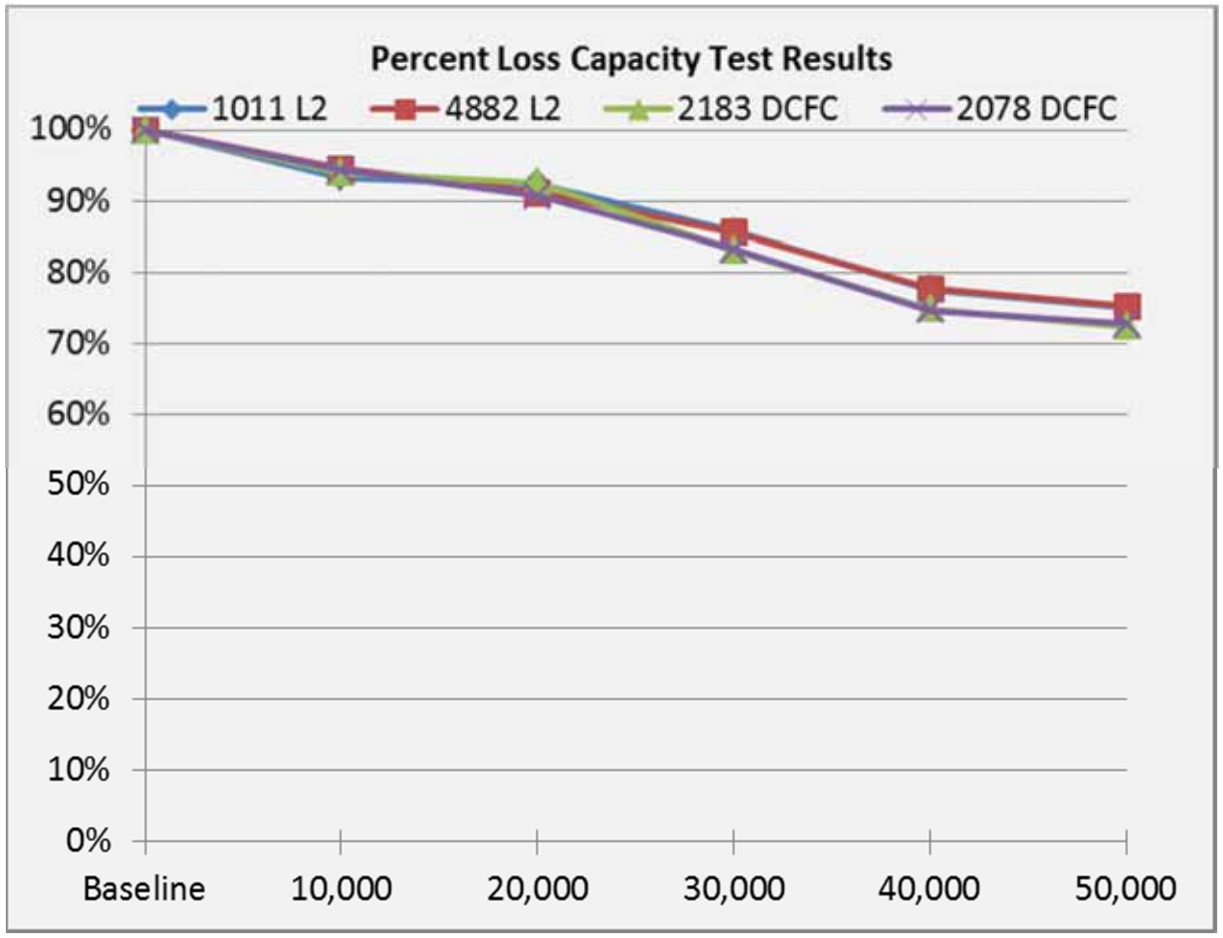
# DC Fast Charging Impact Study on 2012 Leafs

- **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**

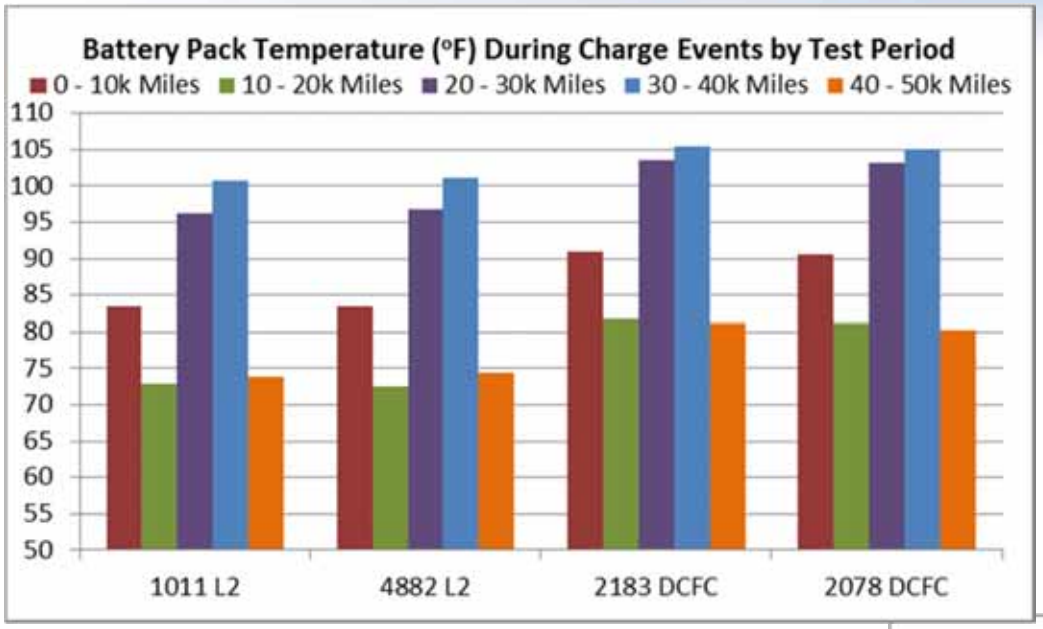


# DC Fast Charging Impact Study on 2012 Leafs

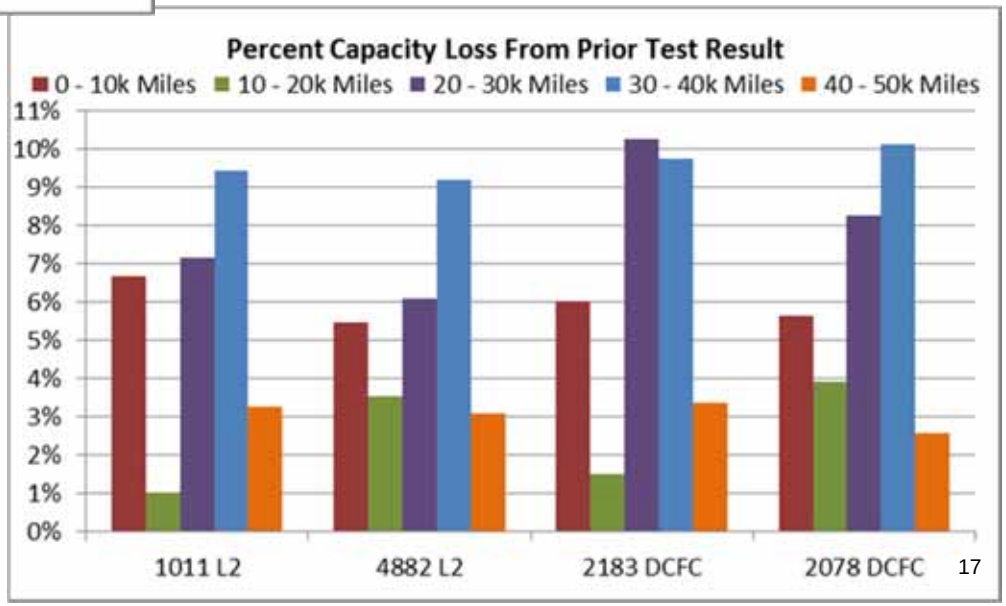
- **Same data as last slide. Each line represents a single vehicle, plotted by capacity SOC for each battery test**



# DC Fast Charging Impact Study on 2012 Leafs

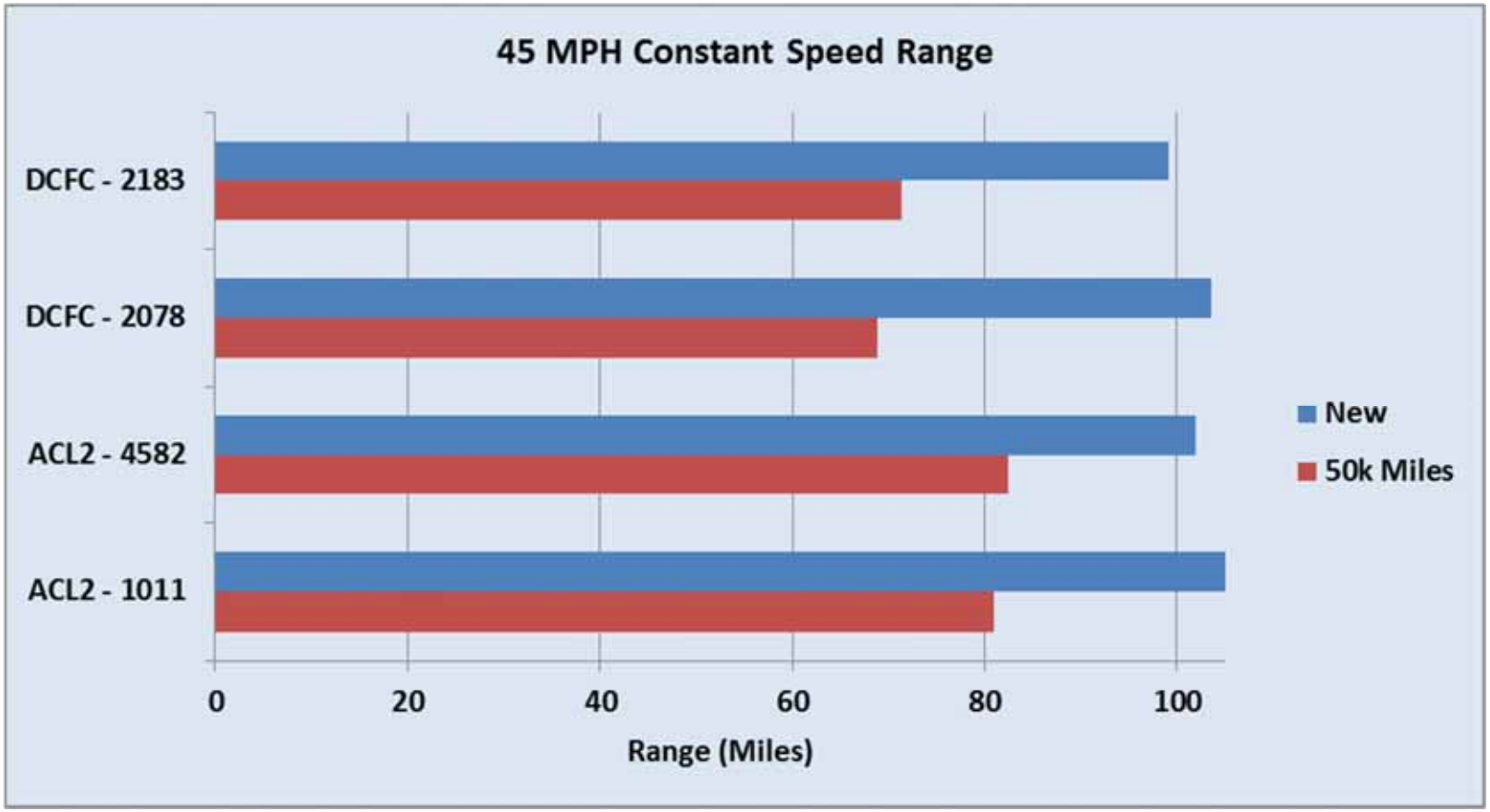



- **Largest decreases in capacity from test before, occurred during high heat charging operation**
- **Phoenix heat likely accelerates all results**



# DC Fast Charging Impact Study on 2012 Leafs

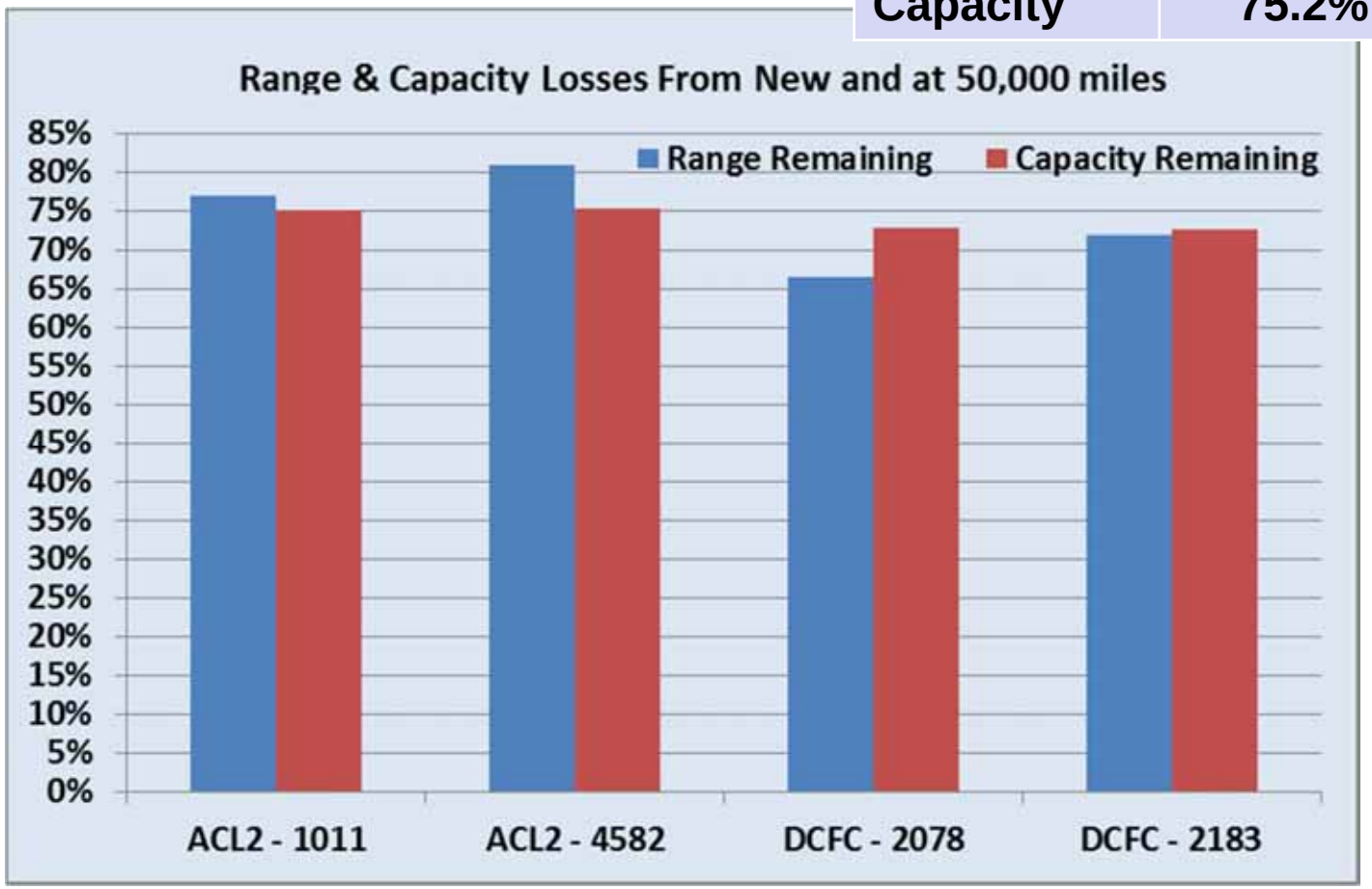
- **Range (miles) at 50,000 miles compared to testing when new**



# 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% | 72.6% |

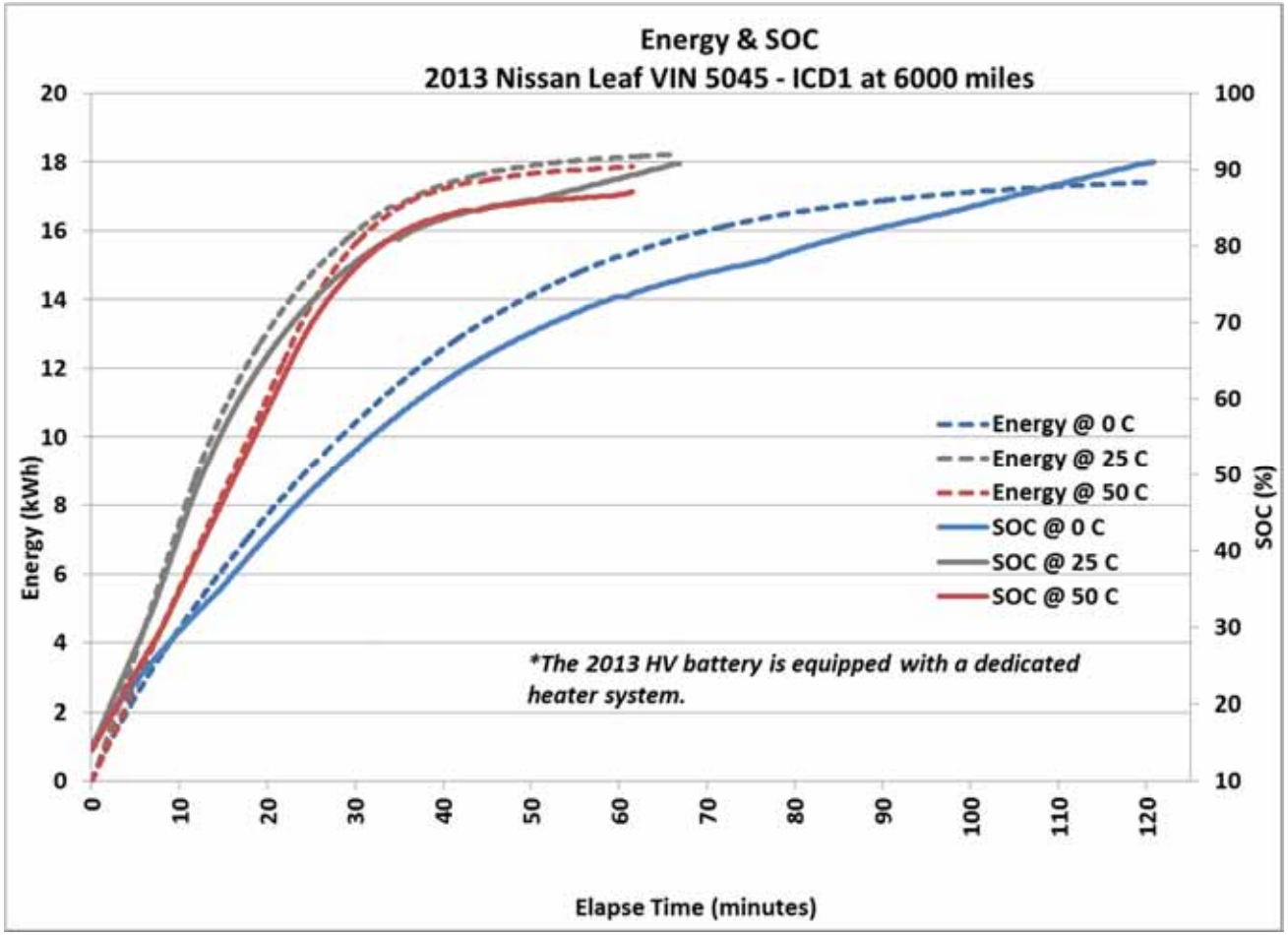


# *DC Fast Charging Acceptance Rates at Various Temperature*

# 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

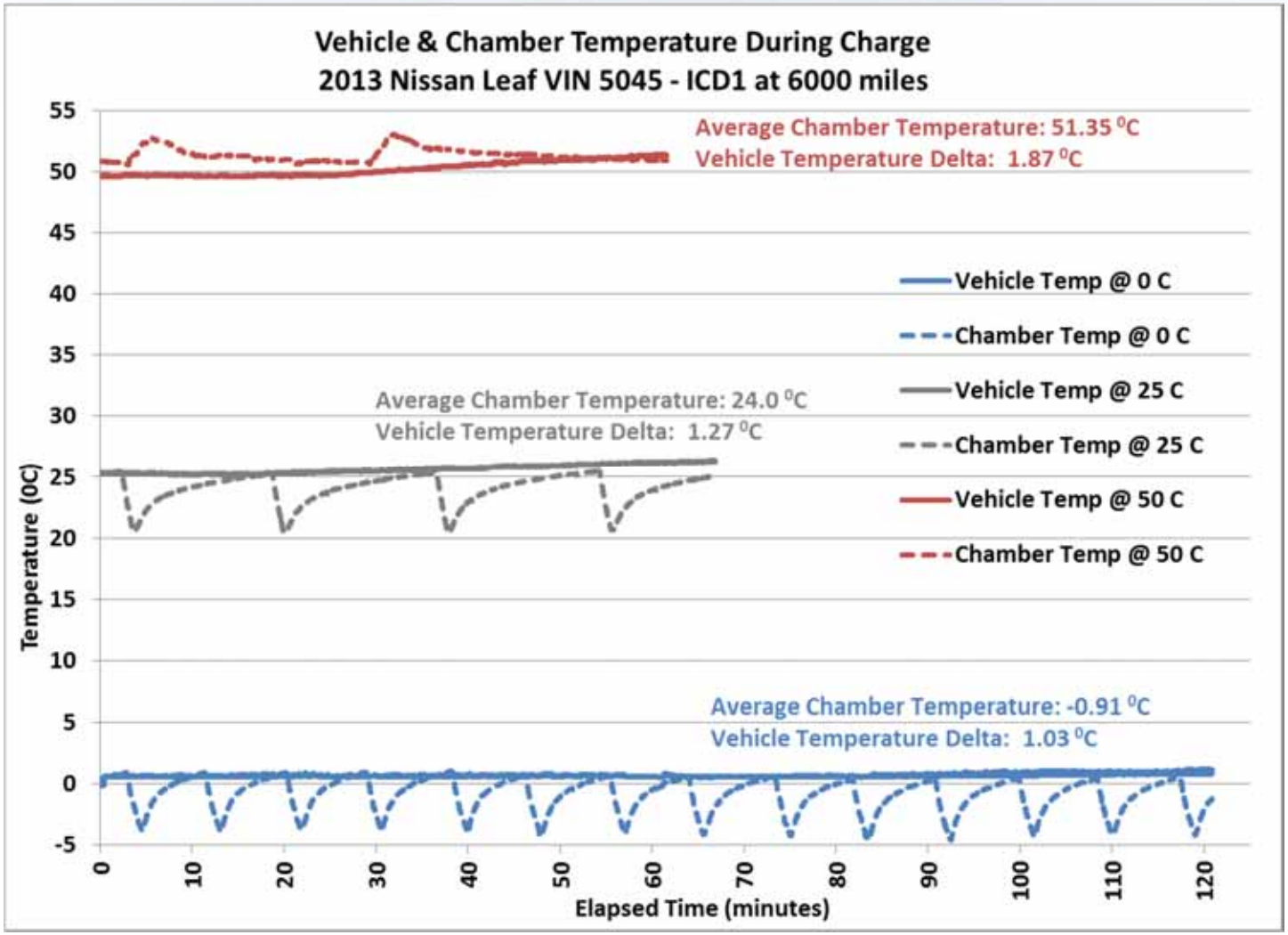



**Preliminary Data Results**

- **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**

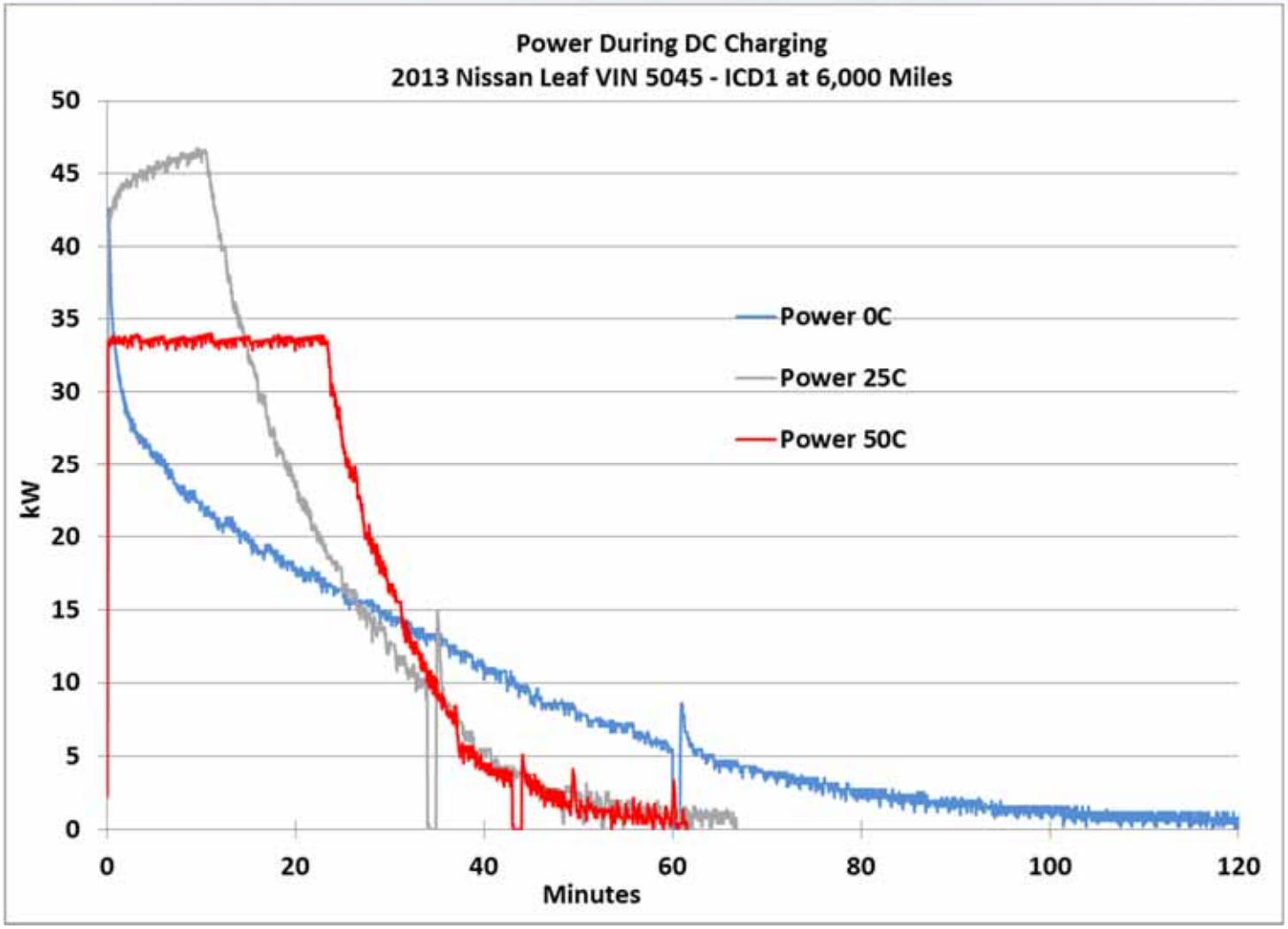
**0 C = 32 F**
**25 C = 77 F**
**50 C = 122 F**

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



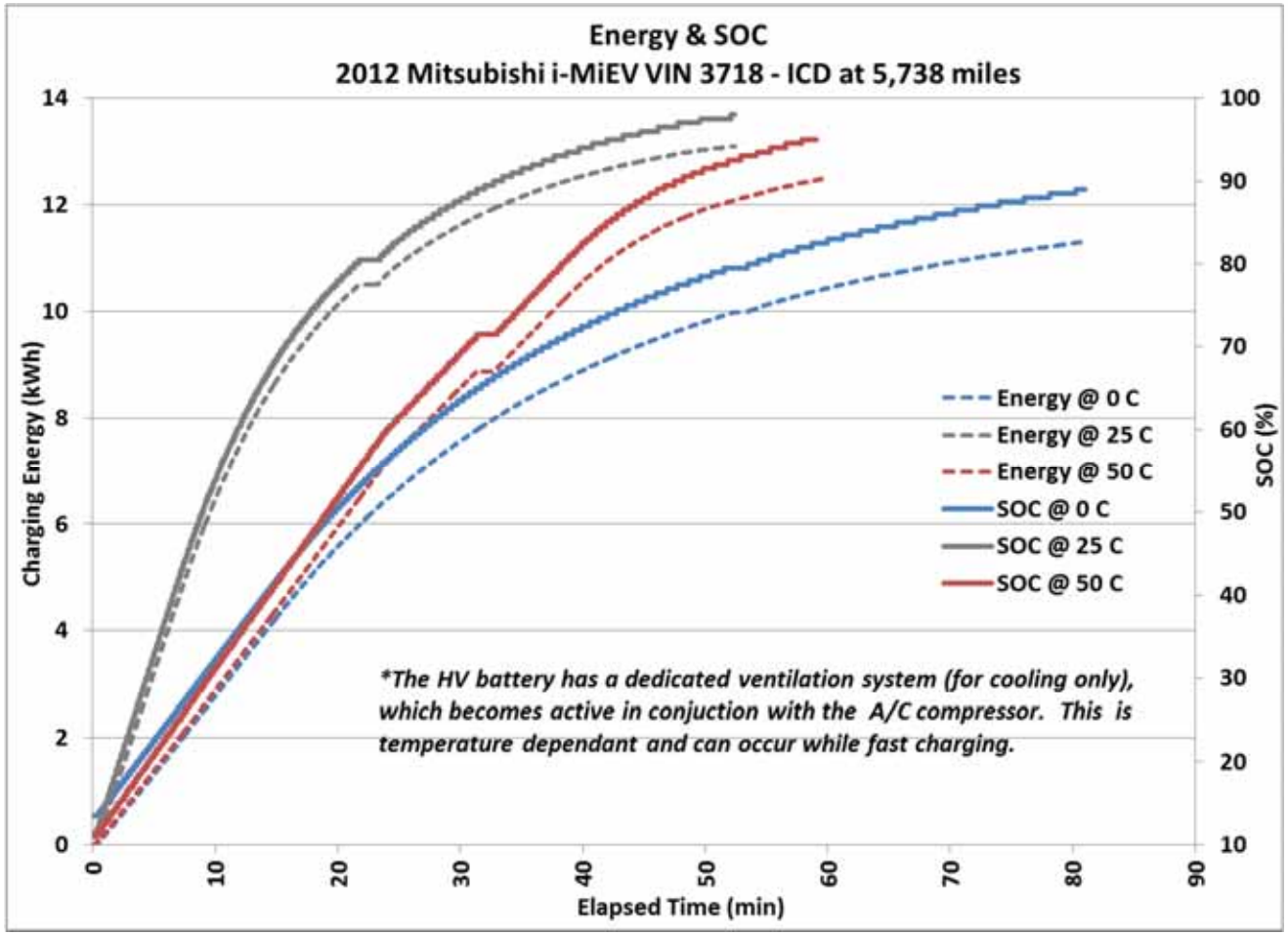

**Preliminary Data Results – Note that the vehicle temperature was measured at the passenger side front seat**

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




**Preliminary Data Results**

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

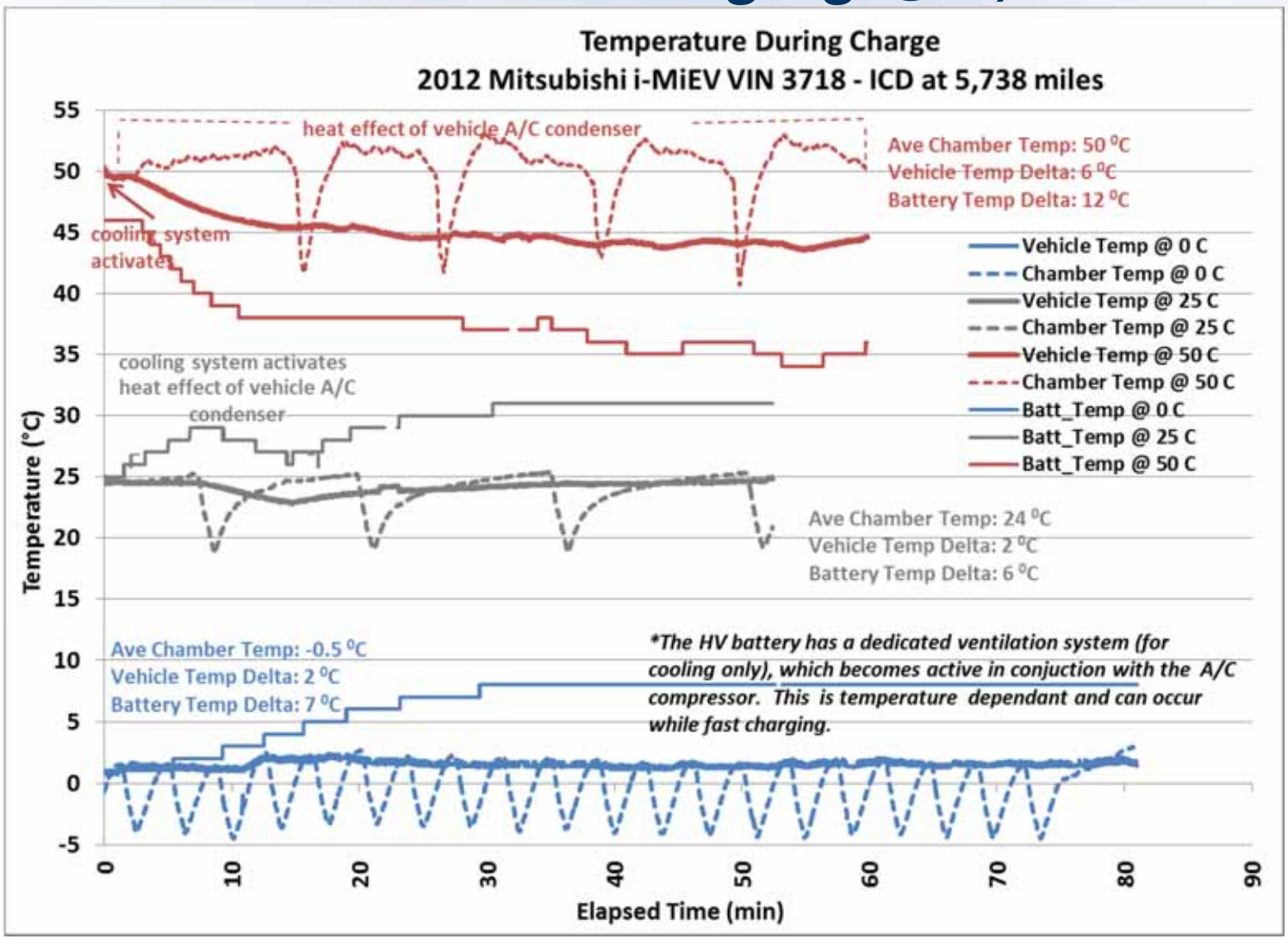



**Preliminary Data Results**

- **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**

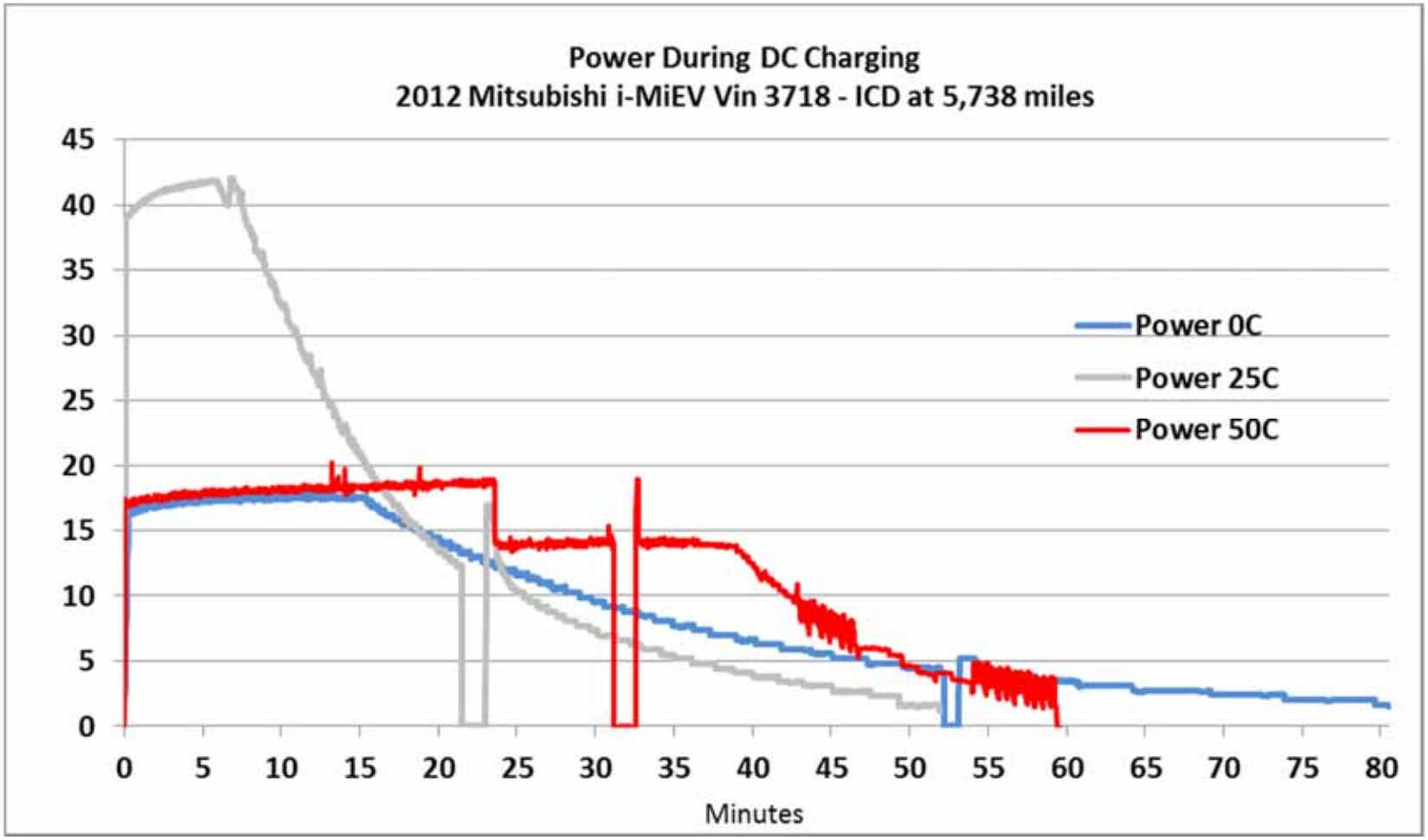
**0 C = 32 F**
**25 C = 77 F**
**50 C = 122 F**

# 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**

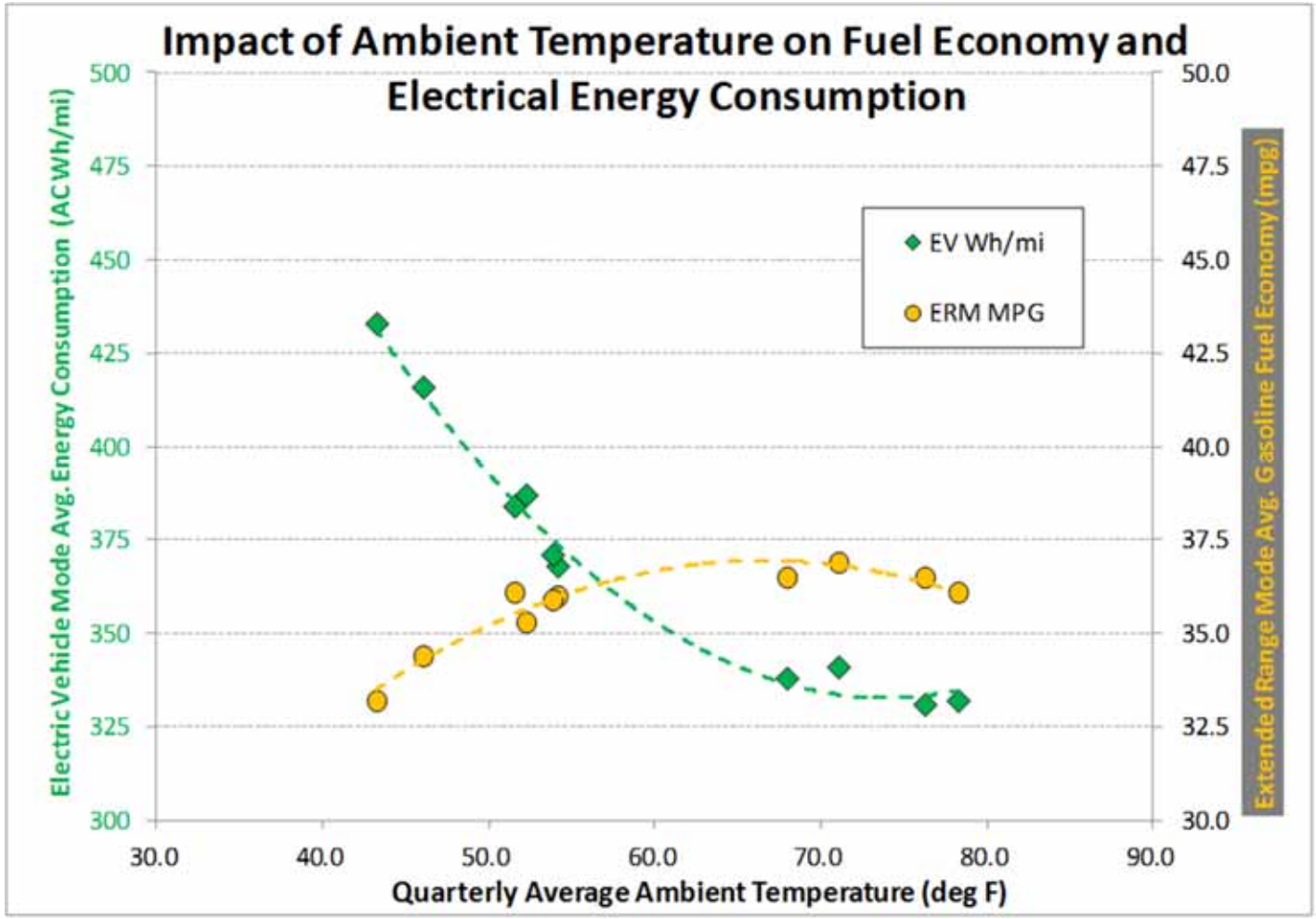
# 2012 iMiEV - DC Fast Charging @ 0, 25 & 50 C




**Preliminary Data Results**

# 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**



# Additional Information

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

**Funding provided by DOE`s Vehicle Technologies Office**