Review of FY-2015 GITT Related Activities at INL: August 2014

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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

Vehicle / Infrastructure Testing Experience

- 144 million test miles accumulated on 11,700 electric drive vehicles and 16,600 charging units, not including a new analysis project:
  - Data for 16,190 additional PEVs being received by INL
- Since 1994, INL staff have benchmarked PEVs in field operations via data loggers & data bases
  - EV Project: 8,228 Leafs, Volts and Smarts, 12,363 EVSE and DCFC, reporting 4.2 million charge events, 124 million test miles. At one point, 1 million test miles every 5 days
  - Charge Point: 4,253 EVSE reporting 1.5 million charges
  - PHEVs: 15 models, 434 PHEVs, 4 million test miles
  - EREVs: 2 model, 156 EREVs, 2.3 million test miles
  - HEVs: 24 models, 58 HEVs, 6.4 million test miles
  - Stop/start hybrid vehicles: 3 models, 7 MHVs, 608,000 test miles
  - NEVs: 24 models, 372 NEVs, 200,000 test miles
  - BEVs: 48 models, 2,000 BEVs, 5 million test miles
  - UEVs: 3 models, 460 UEVs, 1 million test miles
  - Other testing: hydrogen ICE vehicle and infrastructure testing

GITT Related Projects

- **I-5 Travel corridor study of DCFC (DC Fast Chargers) and Level 2 use**
  - **DCFC & Level 2 data from EV Project, ChargePoint and Aeronvironment blended and driver behaviors analyzed**
  - **This and other analysis required venue standardization across all projects. This has been completed**
  - **I-5 data has been loaded and analysis started. Initial results should be available shortly**
  - **Requested by U.S., Washington, and Oregon DOTs, and various additional stakeholders**
- **Smart and less than optimally smart (Dumb) EVSE Testing**
  - **Completed test of GE Smart EVSE with VTO funds. This is one of four Smart EVSE developed via DOE-OE FOA**
  - **Testing includes cyber security testing of all four EVSE, with reports only going to manufacturer**
  - **Blink EVSE previously cyber security tested**
  - **A filtered final report for all five EVSE will be public**

GITT Related Projects

- **OEM PEV electric Vehicle Miles Traveled (eVMT) analysis**
  - **Ford, GM, Toyota and Honda requested INL support identifying eVMTs for PHEVs, EREVs and BEVs**
    - **Total vehicle miles traveled (VMT)**
    - **eVMT per vehicle month**
    - **eVMT for each vehicle**
  - **Most of the data for the 16,190 PEVs have been received by INL**
    - **Ford: 14,000 Fusion & C-Max PHEVs, & Focus BEVs**
    - **Honda: 190 Accord PHEVs & 500 Fit BEVs**
    - **Toyota: 1,500 Prius PHEVs (waiting on NDA)**
  - **In addition to the existing INL's EV Project data sets for this study**
    - **GM: 1,867 Volt EREVs**
    - **Nissan: 4,039 Leaf BEVs**
  - **22,000 total vehicles from across the U.S.A. in the eVMT study**

GITT Related Projects

- **EV Project (ARRA)**
  - **John Smart will detail**
  - **Car Charging plans on providing data to INL through Dec. 2015**
- **SAE Interoperability Studies**
  - **Approximately 30 Level 2 EVSE and 10 vehicles**
    - **Conducted at Intertek for SAE**
    - **Feedback results to SAE for their sharing with manufacturers**
    - **Identifies non-interoperabilities for SAE J1772 compliant vehicles and EVSE**
    - **INL has technical over-site. Conducted as part of the Advanced Vehicle Testing Activity**
  - **Second study will use DCFC**
    - **Charge port protocol questions will have to be resolved**

GITT Related Projects

- **DC Fast Charging with Distributed Energy Storage in California**
  - **55 DCFC with distributed energy storage**
  - **55 additional DCFC with no storage**
  - **INL will blend PEV and DCFC data**
  - **Preliminary approvals completed and NDAs being signed**
  - **INL analysis support requested by vehicle and charger industries**
- **NYSERDA - EVSE**
  - **Data collection from approximately 500 EVSE in NY State is ongoing. EVSE reports generated for NYSERDA. Multiplicity of EVSE providers. NYSERDA requested INL support**
- **DOD PHEV V2G Project**
  - **Downsized from 375 vehicles to 75. Large percentage are supposed to be Via Motors PHEVs. This project appears to continue to have technology and funding limitations**
  - **FY15 start**
  - **INL analysis of final data set requested by DOD**

GITT Related Projects: Facebook Workplace Charging

- Study of the usage of workplace charging stations at Facebook's office campus in Menlo Park, CA from May 1 to August 15 (2013)
- Charging stations included
  - 12 ChargePoint EVSE units capable of AC Level 1 and AC Level 2 charging rates (J1772 & NEMA ports)
  - 10 Blink AC Level 2 EVSE (electric vehicle supply equipment) units (J1772 port)
  - 1 Blink DC fast charger (two CHAdeMO ports)
  - Part of The EV Project & ChargePoint America project
- The EVSE were installed over time as the number of employees owning PEVs and the demand for workplace charging increased

Facebook Workplace Charging Summary

- **Drivers overwhelmingly preferred AC Level 2 charging over AC Level 1 charging**
- **When drivers arrived at these units and both Level 1 and Level 2 options were available, they chose to use the Level 2 cord 98% of time**
- **With only a few exceptions, the Level 1 outlet was only used if the Level 2 cord was already connected to another vehicle**
- **The AC Level 2 charging units were the most heavily utilized, accounting for 83% of the charging events**
- **The AC Level 2 charging units were used heavily during the work day, averaging 8.7 hours connected per cord per work day**

Facebook Workplace Charging Summary

- **Drivers tended to stay connected to Level 2 cords for around 4 hours or around 9 hours – either half a work day or an entire work day**
- **Most of the time, vehicles fully charged their batteries in less than 5 hours**
- **The DC fast charger (DCFC) was typically used between 2 and 6 times per work day for 24 minutes or less per charging event**
- **11% of the time when a DC fast charge event ended and another event began on the same work day, a vehicle was already connected to the second DC fast charger cord prior to the end of the first vehicle's charging event**

Other Grid Impact Activities

- **Chrysler RAM PHEV Demonstration (ARRA)**
  - **Second "stage" of data collection. Continuing data transfer to INL. Project may extend into 2015**
    - **Number of charging events at Level 1- 654 & Level 2 – 2,312**
    - **Charging energy (AC kWh) consumed at Level 1 – 2,757 & Level 2 - 12,613**
    - **Percent of total charging energy from L 1- 18% & L 2 - 82%**
    - **Average time to charge from 20% to 100% SOC Level 1 – 11.53 hours & Level 2 - 2.17 hours**
- **NYC Nissan Leaf taxi fleet**
  - **Small fleet of Leafs in NYC taxi fleets**
  - **Uses DCFC and Level 2**
  - **Extended into 2015**
  - **Nissan EV200 data collection a possiblity**

Other Grid Impact Activities

- **Via Motors PHEVs - 4X4 pickup and van conversions**
  - **ARRA project with EPRI, Via & SCAQMD. CARB certification anticipated soon week**
  - **Approximately 350 PHEVs, shipping started**
  - **EPRI data logger system will be used via Smart Phone**
  - **Examine grid use and petroleum reduction**
- **Echo Automotive PHEV Retrofit**
  - **Add 9 kWh Li-ion battery to ICE pickups and Vans**
  - **Echo telematics system will send data for analysis to INL**
  - **Examine grid use and petroleum reduction benefits of retrofit ICE vans**

GITT Related Projects: Codes and Standards

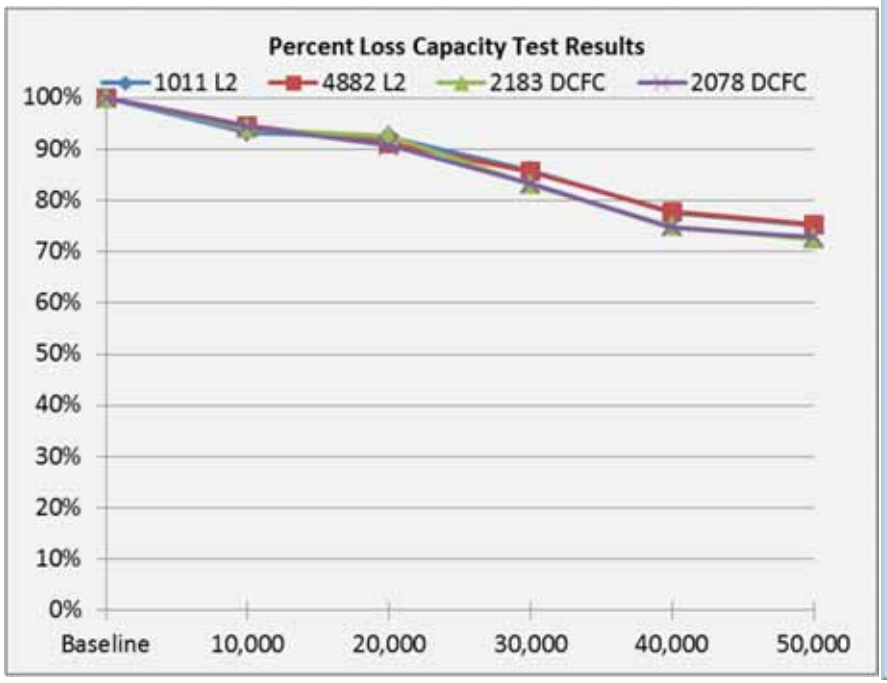
- J2954 Wireless Charging Standards
  - Active participation in J2954 and contribution based on testing experience, including debris testing
  - INL published only independent test results for a wireless charging system (Evatran)
  - INL is actively searching “affordable” additional test subjects
- J2954 Wireless Charging FCC Standards
  - Considering FCC testing at INL or Intertek Michigan facility to support SAE requirements driven by FCC requirements
  - Possibly demonstrate zero signal at 10 meters and zero signal at 300 metes in outdoor test environment
- Barney Carlson can expand

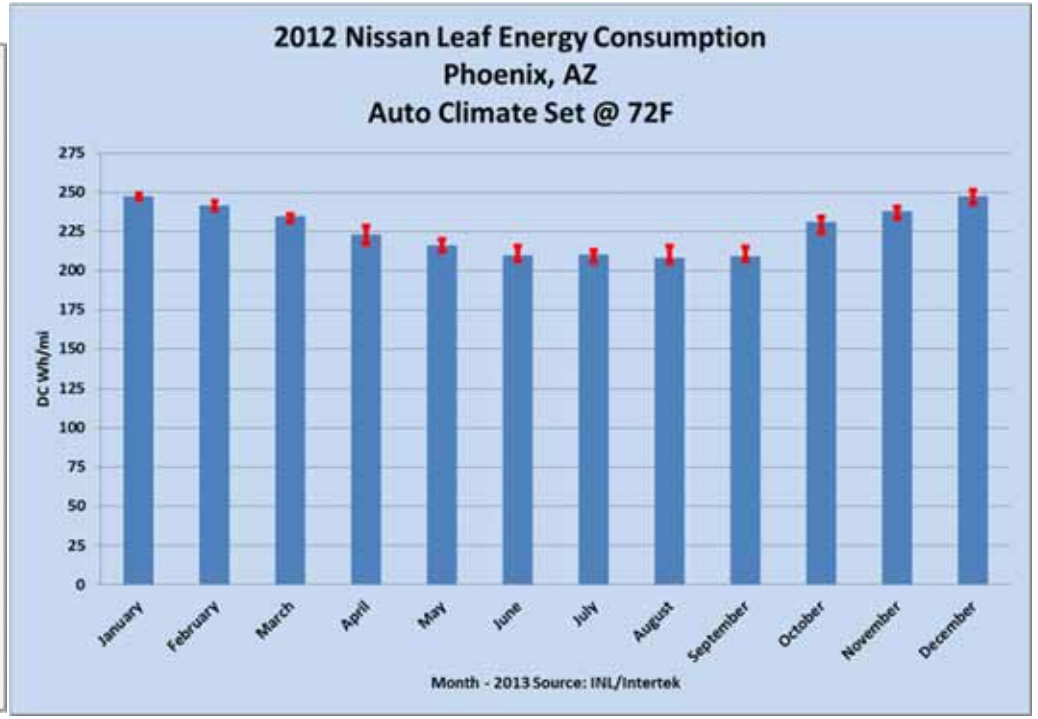
GITT Related Projects: Codes and Standards

- **SAE J2894 Power Quality**
  - **Tasked with developing requirements and test procedures to ensure EVSE do not cause power quality, nor are impacted by them. Based on INL test experience**
  - **Don Scoffield will detail**
- **NIST Fueling And Submetering Committee**
  - **Participation on the National Institute of Standards and Technology led U.S. National Work Group on Measuring Systems for Electric Vehicle Fueling and Submetering**
  - **Don Scoffield will detail**

Other Grid Impact Activities

- **DC Fast Charging – onroad and lab testing of six Nissan Leafs**
  - **50,000 miles accumulated on two Level 2 and two DCFC Nissan leafs. Six battery tests performed per vehicle to date. Track testing identifies range loss**
  - **Two batteries in INL lab testing. 1 each Level and DCFC**
  - **39.8 DC kWh/mi delta for min vs. max month. Max month 19% higher than min month**





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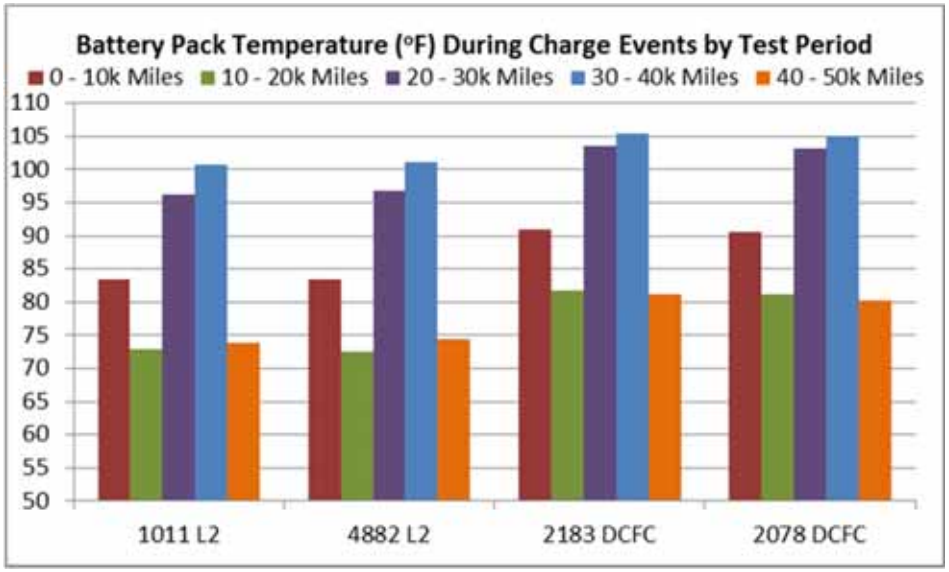
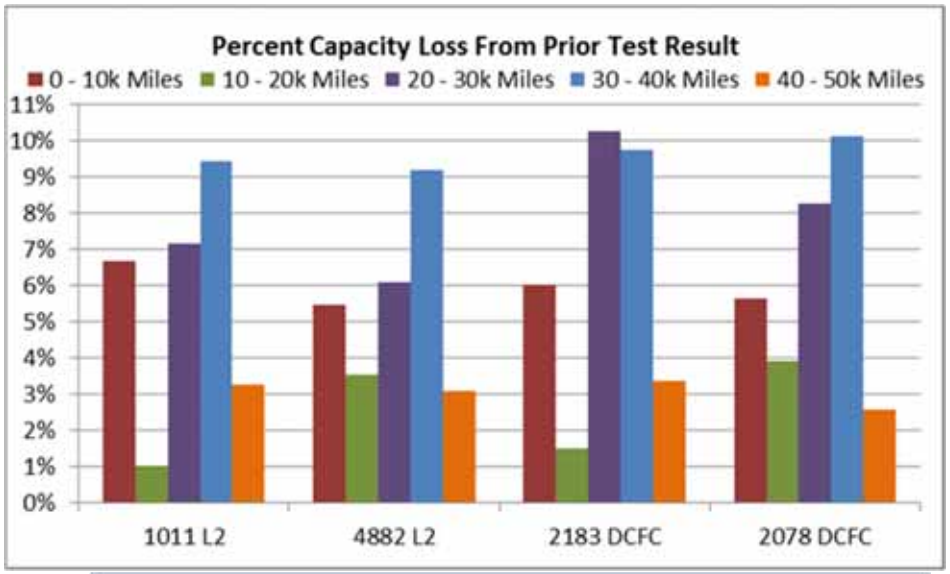
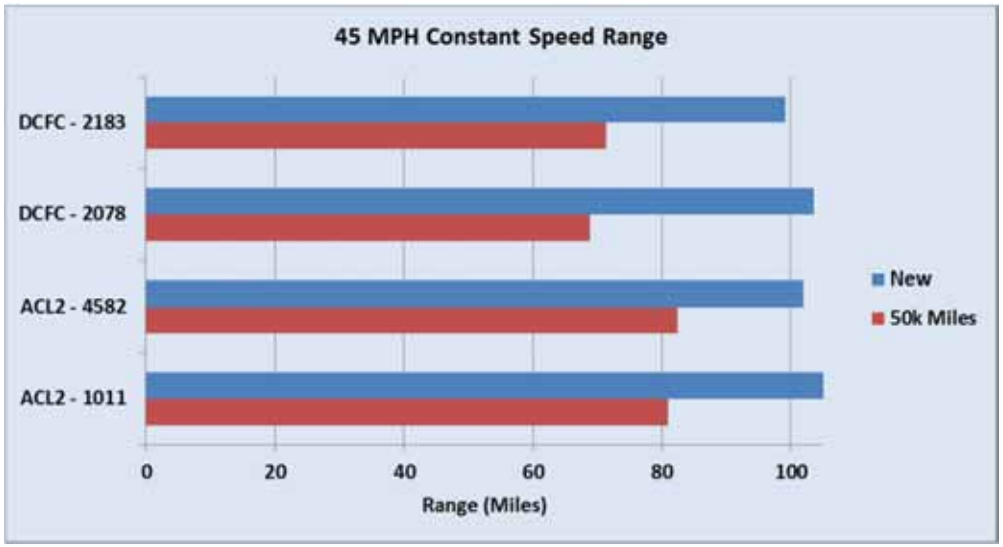
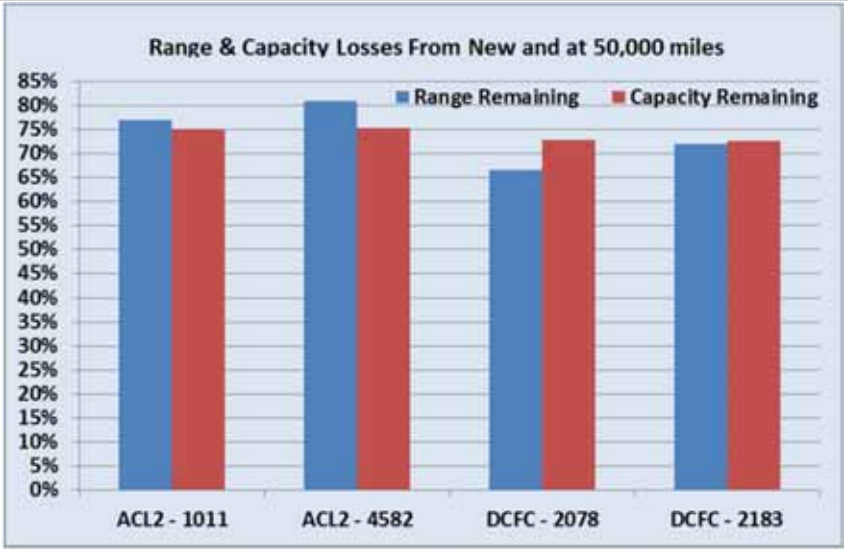






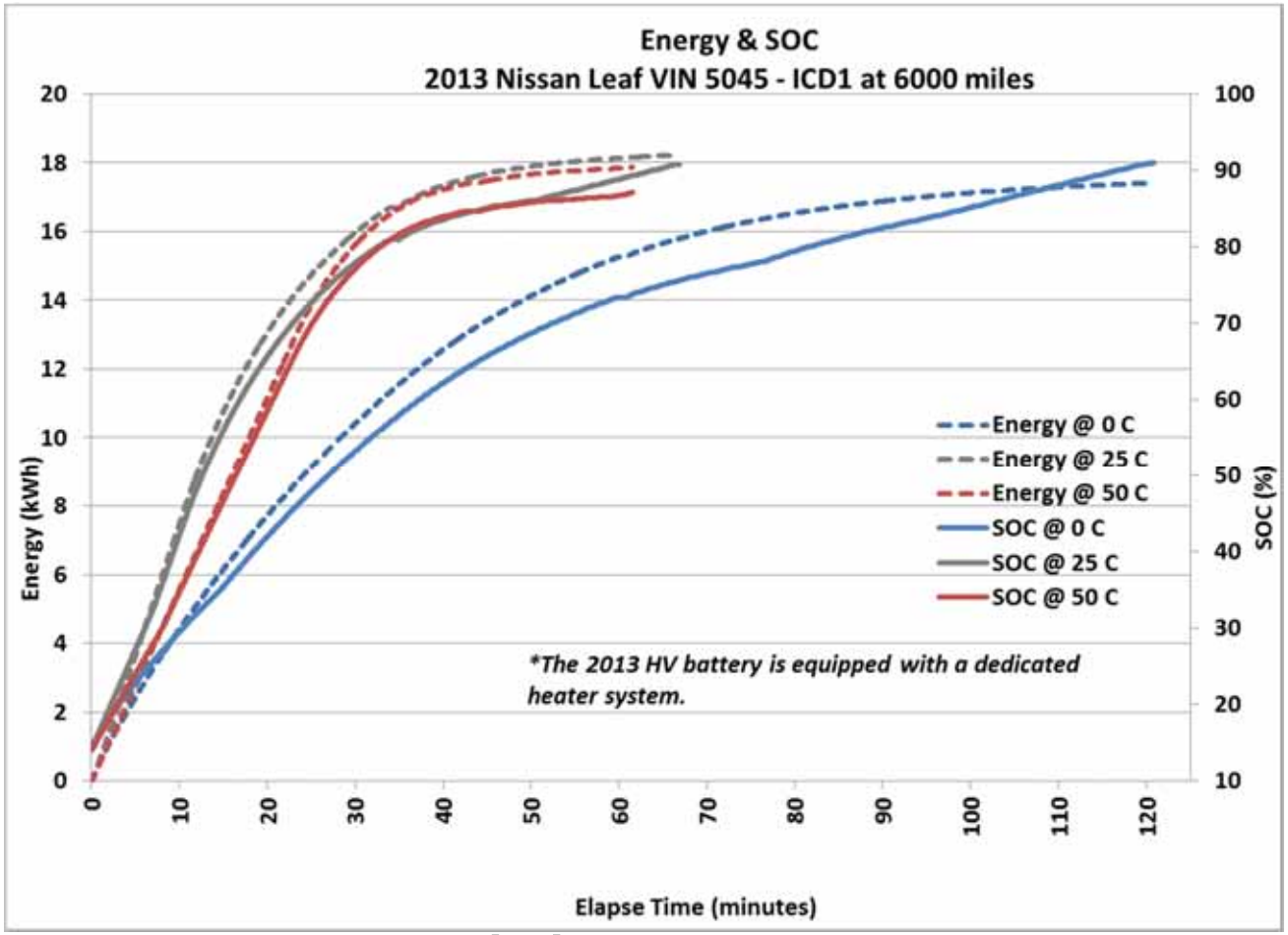


Other Grid Impact Activities

- **DCFC Acceptance Rates at Various Temperatures**
  - Objective is to quantify temperature impacts on grid use
  - Develop formal testing regime to examine battery charge acceptance rates at various ambient temperatures during DCFC and Level 2 charging
    - Results are 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
  - Identified additional instrumentation needed and proper test regime

DCFC Acceptance Rates at Various Temperatures

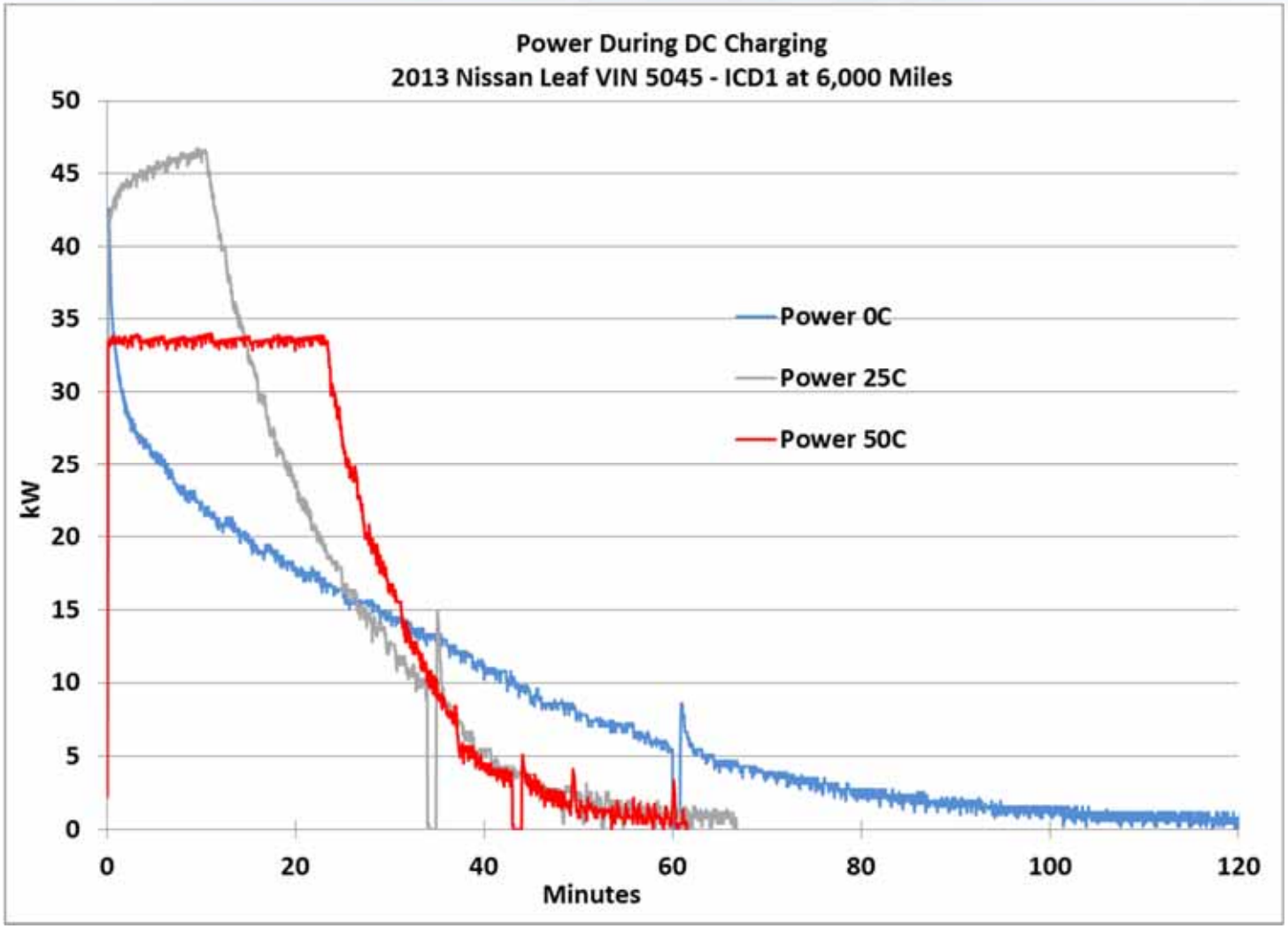
- **2013 Leaf - DC Fast Charging @ 0, 25 & 50 C**



- **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**

Preliminary Data Results

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



Preliminary Data Results DC kW

Autonomous and Connected Vehicles Analysis

- **Autonomous and Connected Vehicles Work Proposed**
  - **Paper studies identify the potential positives and negatives that come with the use of greater connectivity and autonomous technologies**
    - **Impacts on onboard energy storage requirements**
    - **Likely need to increase vehicle accessory power**
    - **Weight penalties or possible weight reductions**
    - **Fuel economy impacts based on the INL managed vehicle mass reduction project**
    - **What codes and standards must be revised or introduced**
    - **Can INL drive data can be used to characterize current drive patterns and energy charging needs**
    - **Cyber security analysis to identify potential security issues and vulnerabilities to vehicles and grid connections**
    - **What types of test programs and testing methodologies will be needed to quantify fuel use benefits or penalties**

Additional Information

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

Funding provided by DOE`s Vehicle Technologies Office