GMLC: Secondary Use Energy Storage

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Supported by the DOE Office of Electricity:
– Dr. Imre Gyuk, Energy Storage Program Manager
The vision of DOE’s Grid Modernization Initiative (GMI) is:

- A future grid that will solve the challenges of seamlessly integrating conventional and renewable sources, storage, and central and distributed generation.
- The future grid as a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy.
- A future grid that will deliver resilient, reliable, flexible, secure, sustainable, and affordable electricity to consumers where they want it, when they want it, how they want it.
Project Objectives

• General Project Objectives:
  – Broadening the customer base with a low cost energy storage solution.
  – Integrated energy system to increase value of storage.
  – Overcoming secondary-use energy storage challenges.

• Three year Project

• Current Project Deliverable:
  – Initial Prototype with Testing Plan
Why Secondary Use?

What do we do with vehicle batteries once the vehicle is retired?

Where to next?

Reuse?

Repurpose?

Recycle?
Approach

Goal: Prototype system to identify potential challenges with final system design

September 2016

Design Architected

1st Prototype Constructed

September 2017

Test Plan Ready
Power Conditioning System Design

- Previous year:
  - Use cases included energy arbitrage, demand charge, and resiliency
  - Sized according to use cases
  - Published Conference Paper

- CAD was used to layout and design power conditioning system based on previous year schematics

- Designed to match the battery system in form factor.
• Schedule was constructed and testing of hardware is performed on each stage of construction.

• Preliminary non-battery testing of functions completed
Battery System Construction

• Built by partner Spiers New Technologies

• Composed of Graded Nissan Leaf Batteries

• Emergency systems integrated

• System tested at SNT before delivery with basic self protection and control systems.
Failure Mode Effects Analysis (FMEA)

- In-depth study of all possible failure modes for the system was completed
- Asked three major questions:
  - What can go wrong?
  - How does the system automatically respond to this failure?
  - What happens if the system fails to properly respond to the failure?
- Rated results on a “likelihood vs. risk” square to ensure that overall risk stayed low and safe
Preliminary Test-Plan Development

• Split into four parts:
  – Low power functionality testing (relays, communications)
  – High power battery-less testing (Open loop to load bank, push to grid, etc)
  – High power testing with battery (full functionality testing at full rated power levels)
  – Use Case Testing – leveraging existing PNNL/Sandia reports
Battery Functionality Testing

• Inverter connected to battery and Load Bank for testing
• Able to test open-loop and off-grid discharge from DC to AC
• Completed testing of “off-grid” functionality.
• Issue detected on battery system that resulted in inoperable system.
• Began root-cause analysis to determine failure of systems.
Root-Cause Analysis

- Once mid-pack fuse was installed, no way to de-energize control circuitry
- Control circuitry predicted to use 4-7 W while idle
- Actually consumed 40-50 W
- Battery voltage dropped to non-operational levels
  - DC must meet or exceed minimum level to prevent uncontrolled charging of battery
- Analog circuitry would not allow for charging from DC supply
Battery Prototype v. 1.5

• Battery redesigned to allow controls to power down
• Include contactors with status feedback
• Container redesigned to better handle thermal cycling by including an HVAC for temperature control.
• Controls are able to be bypassed to allow for DC charging of battery
• Currently undergoing testing at SNT
Next Steps

• Begin testing of power conditioning system
• Development of final version of system
• Design and Plan commissioning of system
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