



# Energy Storage Test Pad

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Sandia  
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# Energy Storage Test Pad (ESTP)

- **Challenge:** Unbiased, third party evaluation is a necessary step to bring new technologies to market
  - The equipment and expertise necessary to perform testing of energy storage systems can be cost prohibitive, especially at the MW level
- **Approach:** Offer third party testing that provides a real picture of how energy storage systems operate
  - This in turn provides confidence to developers, users and adopters of energy storage
- **Goal:** Utilize infrastructure and expertise at Sandia to perform high value testing of energy storage systems
  - Generate reliable data by performing validation testing
  - Research new and advanced testing methodologies
  - Organize and participate in standards activities

# Energy Storage Systems Testing



Testing Validation

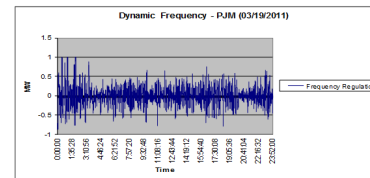
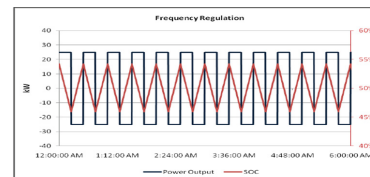


Altairnano  
East Penn  
RedFlow DC  
RedFlow AC  
Boeing Flywheel

Testing Methods



Service Modeling  
Stacked Profiles



Testing Standards



DOE  
IEEE  
IEC



# Testing Validation (systems)

- Energy Storage Test Pad (ESTP)
  - Capabilities (MW and beyond)
- RedFlow System Development Kit (SDK)
  - DC System, preliminary report released in February
  - Temperature testing performed since then
  - Full report pending on completion of R510US testing
- RedFlow R510US
  - AC System, preliminary commissioning and cycling data
- Boeing 3kW 5kWh Flywheel with superconductive bearings
  - Low speed testing complete at Boeing

# Energy Storage Test Pad (ESTP)



- Can test for both power and energy applications including energy time shift, capacity, load following, area regulation, voltage support, T&D deferral, demand charge management, and power quality and reliability.
- Programmatically integrated with Distributed Energy Technologies Lab (DETL)
- Test duration can range from one day to multiple months.
- Scalable from 1 KW to 1 MW, 480 VAC, 3 phase.

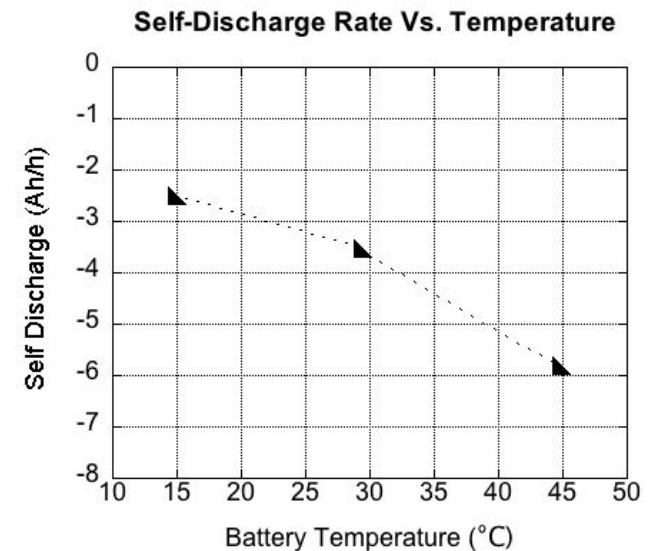
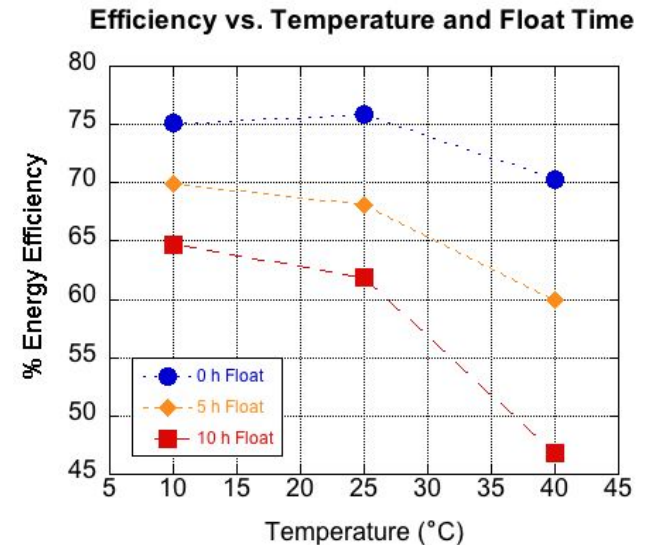


# Testing Validation RedFlow SDK

- Released Initial Test Results Report in February
  - Covered initial characterization
- Progress:
  - Completed temperature testing
  - Will begin telecom service cycling soon



RedFlow SDK Undergoing Temperature Testing

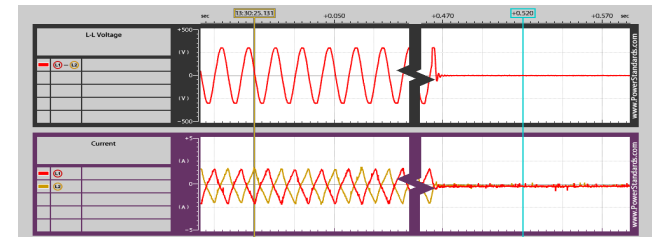


# Testing Validation RedFlow R510US



- Islanding data from real power outage

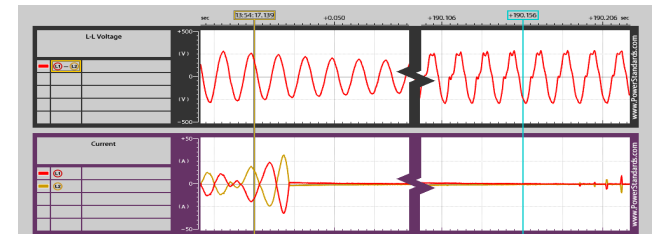
V (t)



I (t)

Breaker Trip Islanding Test

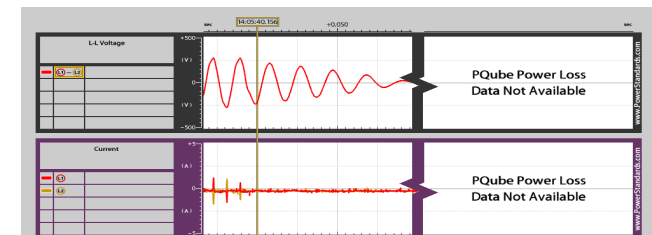
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I (t)

Voltage Sag 1

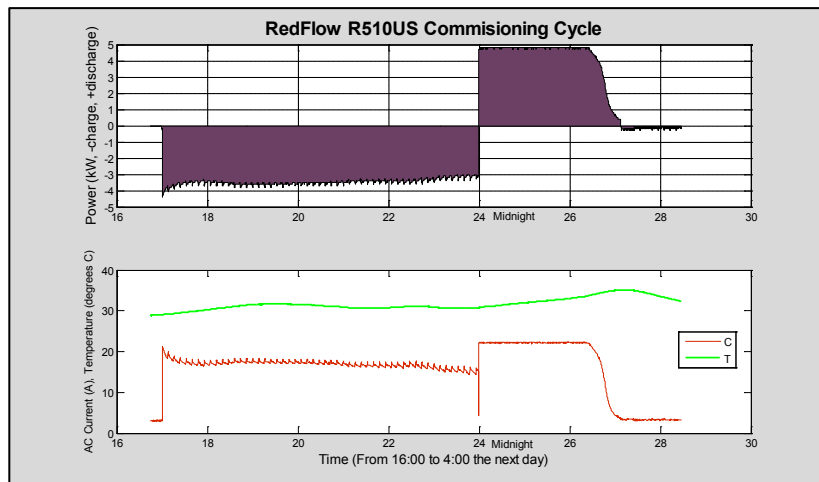
V (t)



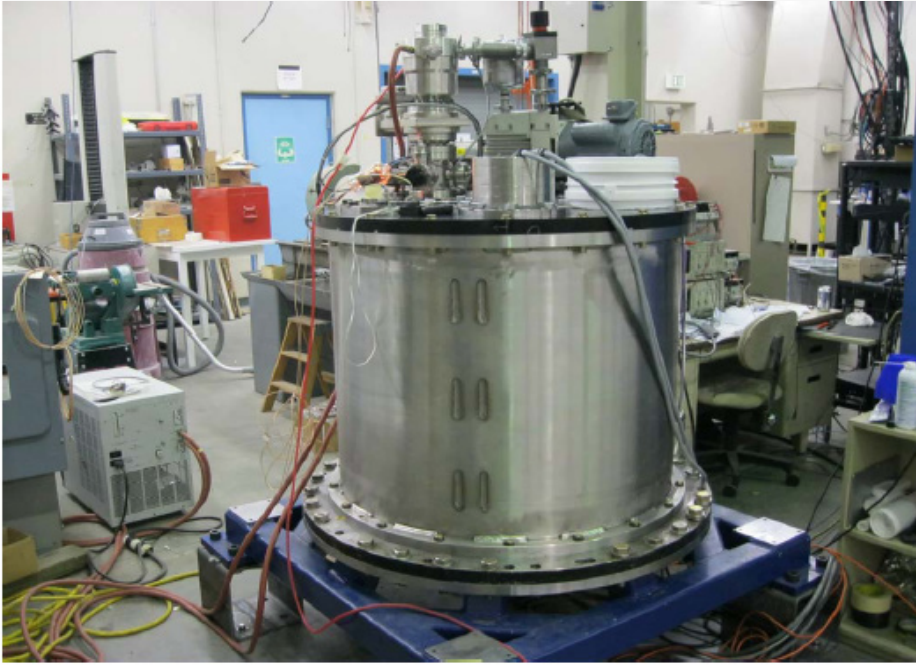
I (t)

Voltage Sag 2

- Cycling



# Testing Validation Flywheel



## Initial Test Plan

- Capacity
- Efficiency
- Self Discharge
- Response Rate

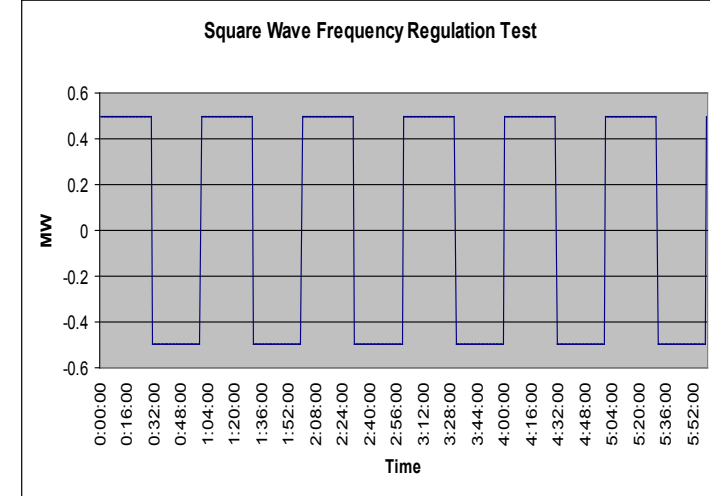
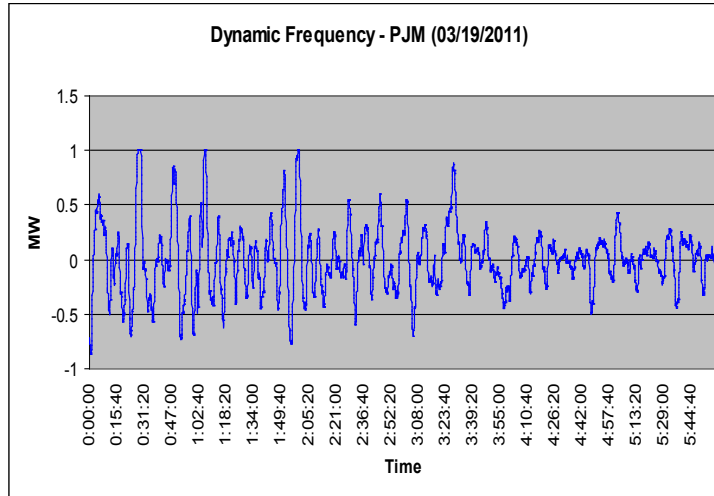
## Long term plan

- Utilize as a research and development asset to test new control schemes and hardware



# Testing Methods

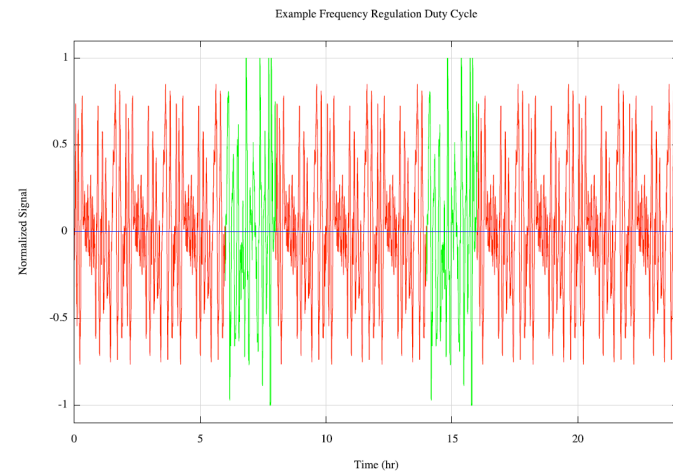
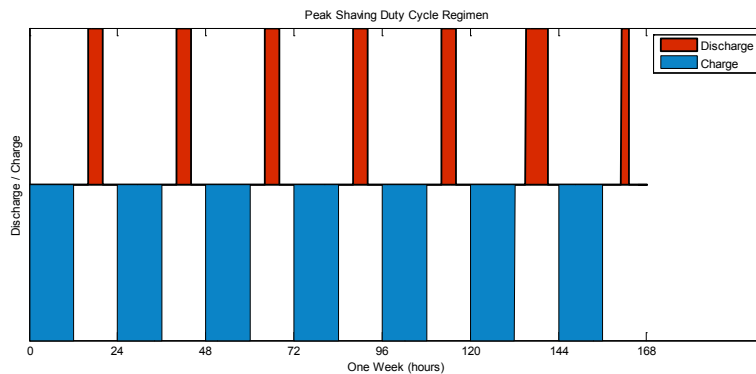
- Application Characterization and Modeling
  - Statistical analysis of day-to-day variations in application requirements.
  - Autoregressive Modeling to Generate Statistically Representative Profiles



- Effect on Cell Life of Stacked Profiles
  - Frequency Regulation & Peak Shaving

# Testing Standards

- DOE Performance Protocol
  - Application Specific Performance



- IEEE P2030.2 Interoperability of Energy Storage
  - Continuing Contributors

# Outreach

- Released a Call for Collaboration
  - Generated interest from many industry partners including: Samsung SDI, Primus Power, Altairnano
- Energy Storage at Forward Operating Bases (Fort Devens)
  - RFI requires validation at ESTP before demonstration
- Collaboration with the Electric Power Research Institute (EPRI)
  - Demonstration project in 2013 to be validated at ESTP
- Ongoing pursuit of collaborators

# Summary/Conclusions

- Validation
  - Report released in February 2012 on the initial test results of the RedFlow DC system
  - RedFlow AC system
  - Boeing System being prepared for shipment to Sandia
- Methodology
  - Frequency regulation model data has been statistically validated
  - Life cycle cell testing with stacked applications has begun at KEMA
- Standards
  - DOE Performance protocol published
  - IEEE activity is ongoing

# Future Tasks

- Continue testing systems
  - RedFlow
  - Boeing
- Continue to refine our testing methodology
  - Completion and publication of stacked waveform and stochastic application testing
- Continue to contribute to energy storage standards
  - IEEE
  - IEC
- Find new collaboration opportunities for testing
  - End Users
  - Manufacturers
  - You!



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