



Energy Storage Test Facility (ESTF)

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David Rose, Michael Montoya and Summer Ferreira
Sandia National Laboratories



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Energy Storage Test Facility

Motivation

- **Unbiased, third party evaluation is a helpful step to bring new technologies to market**
- **Thorough independent testing can provide data for evaluating business cases and comparing technologies.**
- **The equipment needed to perform systems tests at the Megawatt (MW) level can be prohibitively expensive**

Some Barriers to Energy Storage Proliferation

- **There is some uncertainty in the business cases for energy storage**
- **Companies see risk in designing and building energy storage systems so the markets for them are hindered**
- **New technologies are held back from their potential applications**



SNL Energy Storage System Analysis Laboratory

Providing reliable, independent, third party testing and verification of advanced energy technologies for cell to MW systems

- Testing capabilities for supercapacitors, primary and secondary storage from cells to MW systems.
- Testing programs are designed to evaluate and validate battery performance.

Testing capabilities include:

Cell Testing

- 100 cell and battery testing channels:
 - 72 V 1000 A Bitrode (2 Channels)
 - 60 V 200 A Arbin (2 Channels)
 - 36 V 100 A Bitrode (3 Channels)
 - 36 V 25 A Bitrode (5 Channels)
 - 10 V 10 A Arbin (48 Channels)



72 V 1000 A Bitrode (2 Parallel Channels)

System Testing

- New Energy Storage Test Pad (ESTP) expands testing capabilities to include megawatt (MW) scale energy storage. This versatile facility is capable of testing in several configurations for many different applications.
- Temperature chambers for thermal control



Energy Storage Test Pad (ESTP) (April 2010)



Energy Storage Test Pad (ESTP)



- Commissioned in April 2011
- Expands testing capabilities to include megawatt (MW) energy storage
- Testing at ESTP will increase industry confidence in large scale energy storage systems



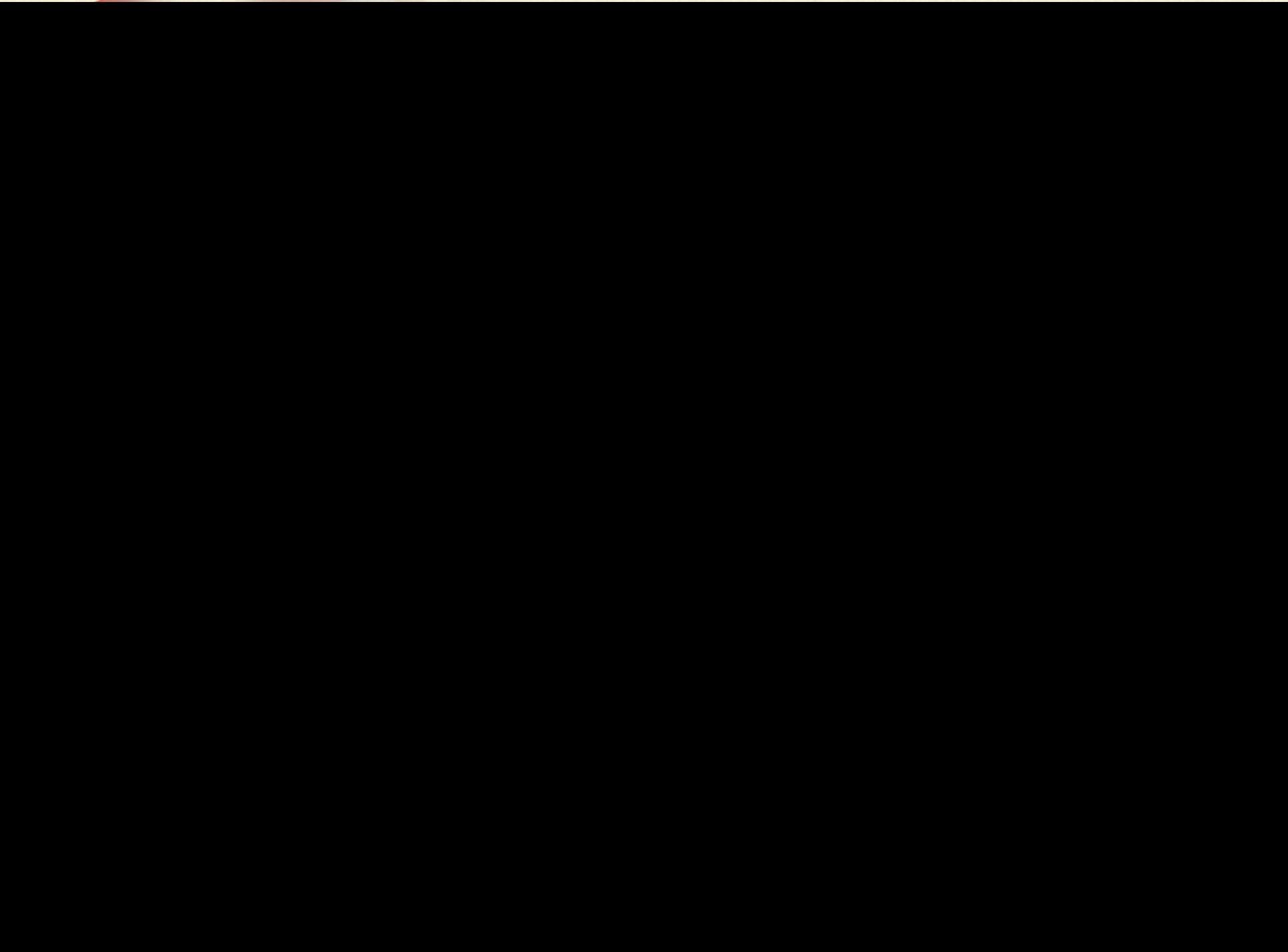
ESTP



750 KVA Uninterruptable Power Supply (UPS) Under Test

- Validates and Demonstrates High Power Testing Equipment
- Helps Streamline Future Testing Activities

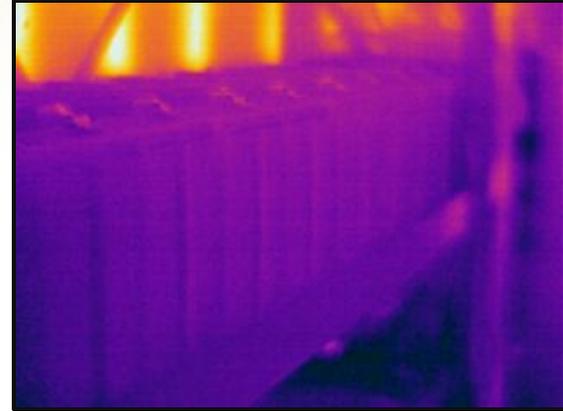




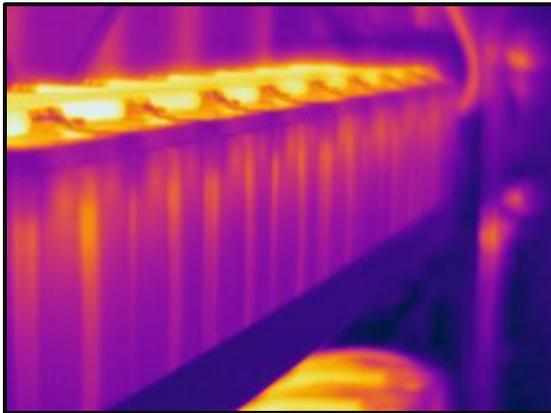
Thermal Imaging



Battery Banks



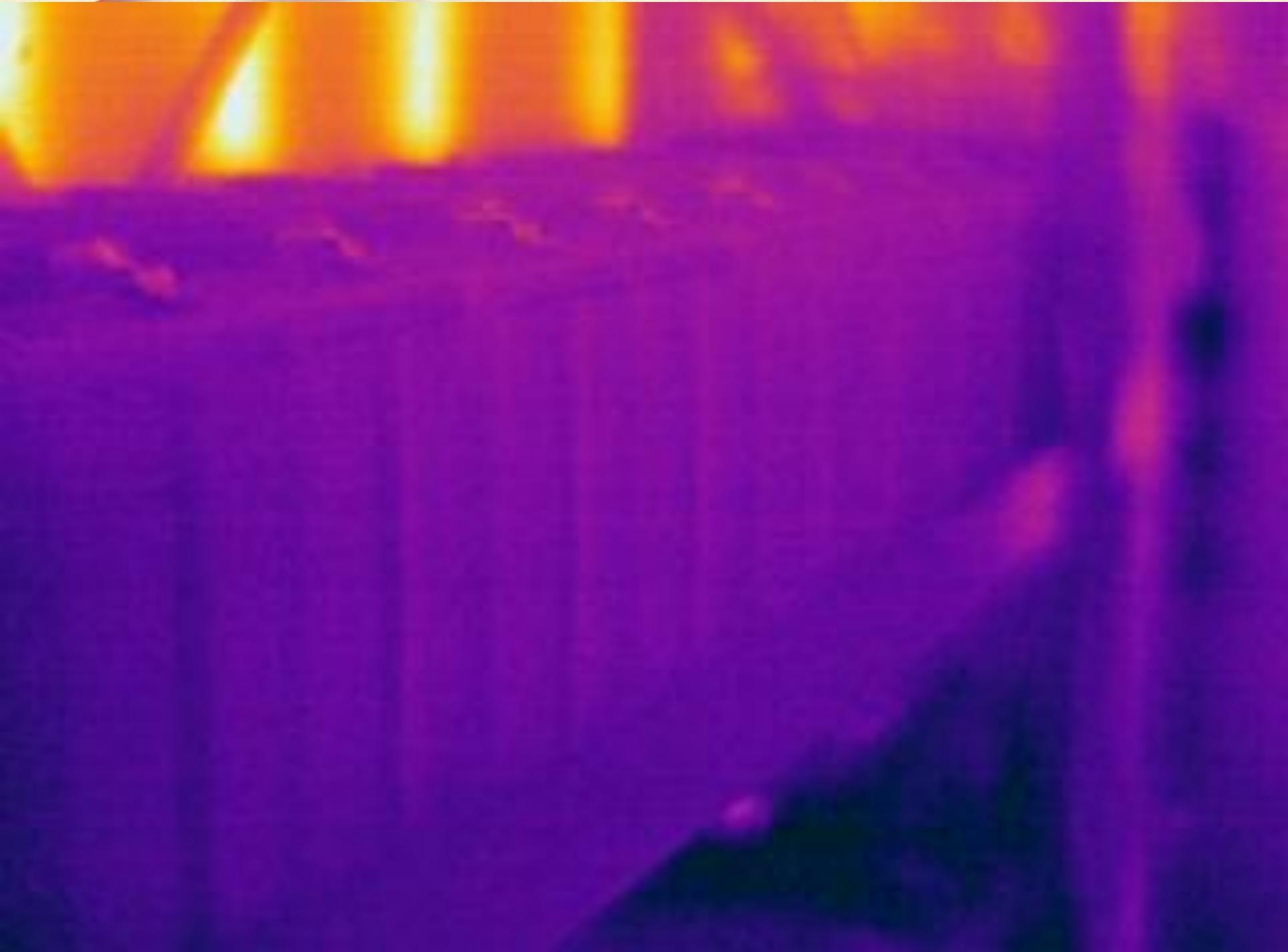
Baseline



Discharge



Charge



Operational Capabilities of the ESTP

The ESTP is a modular, dynamic testing facility. It can be reconfigured to test different characteristics of an energy storage system.

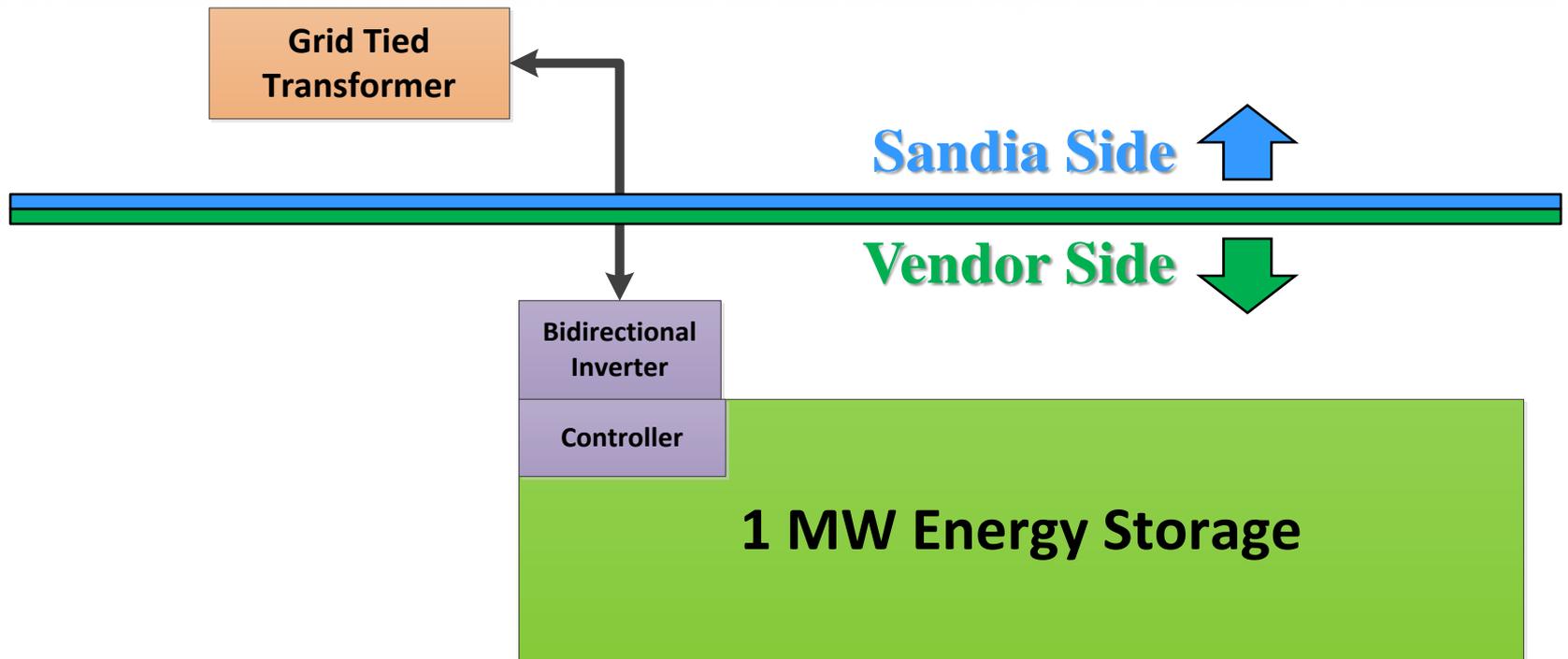
Three main configurations:

- 1. Frequency Regulation and Energy Shifting Applications**
- 2. Islanded Load Following & Power Quality Applications**
- 3. Grid Tied Reactive Power Support Applications**



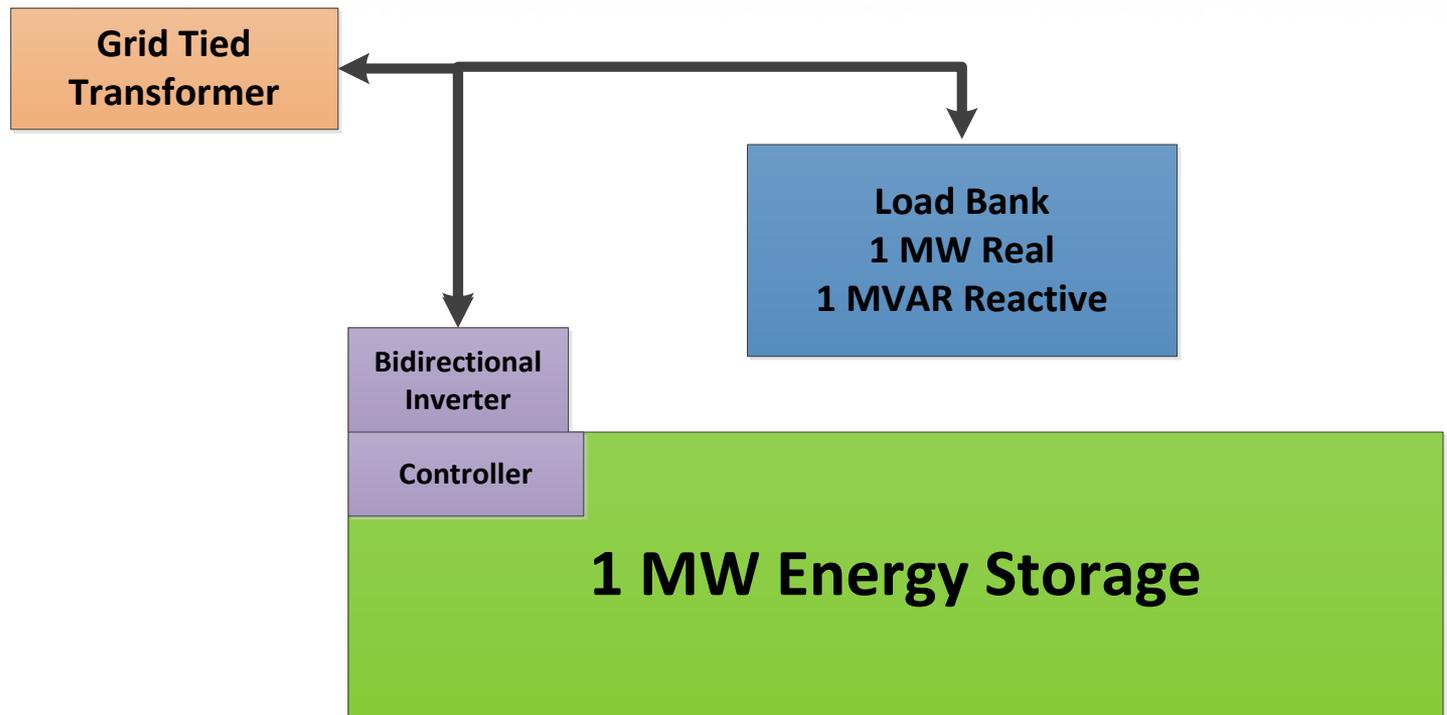
Configuration One

Testing: Frequency Regulation and Energy Shifting Applications



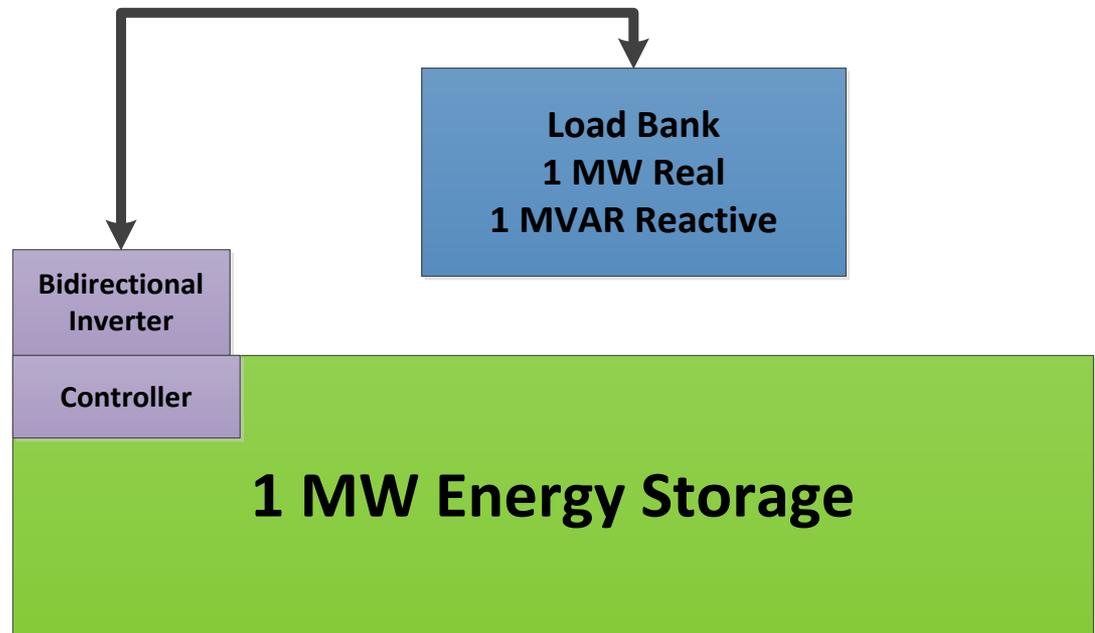
Configuration Two

Testing: Grid Tied Reactive Power Support Applications



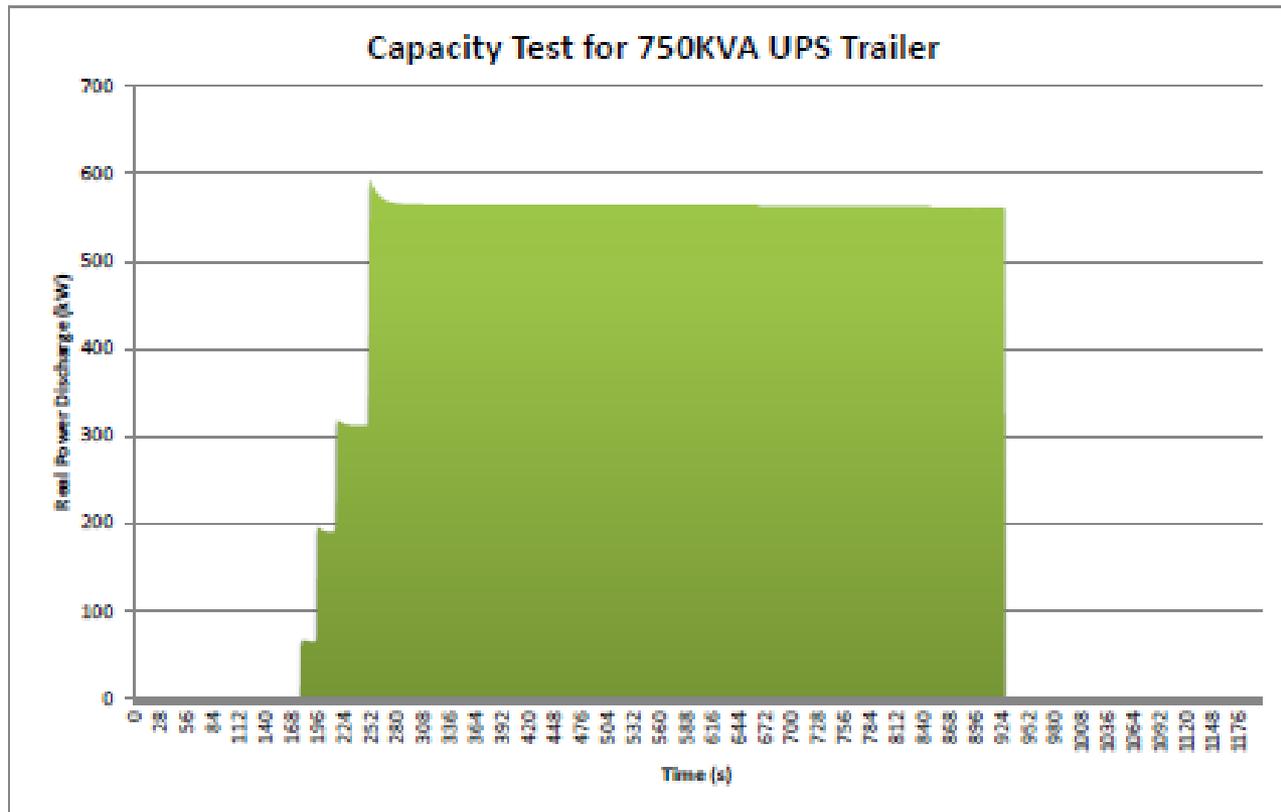
Configuration Three

Testing: Islanded Load Following & Power Quality Applications





Capacity Test for 750KVA UPS Trailer



Total Energy (kWh)	110.1698
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Duration of full load discharge (s)	674
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Mean Power (kW)	330.2288
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Duration of test (s)	747
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Mode Power (kW)	363.73
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Peek Power (kW)	393.73
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RedFlow Testing

System Development Kit (SDK)

- 5kW, 10kWh Flow Battery
- Zinc-Bromine Chemistry
- To be tested in two phases
 - Phase 1: Characterization
 - Phase 2: Applications



RedFlow SDK



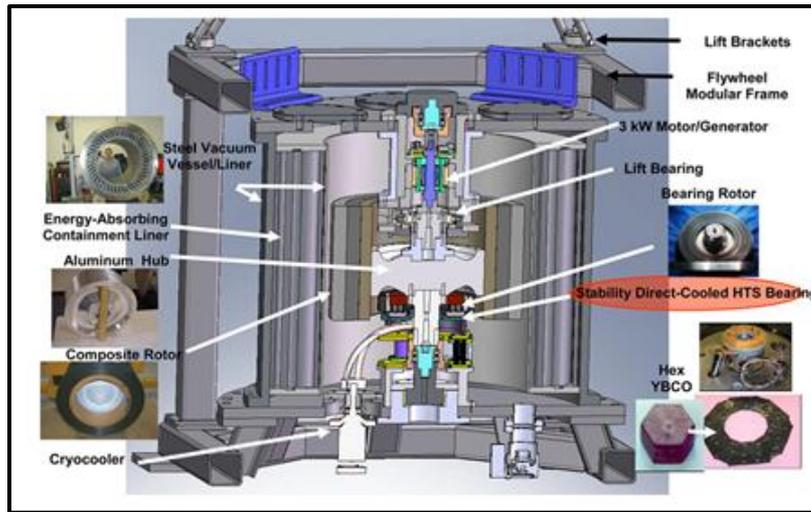
Summary of Present Systems Testing

- **The ESTP is commissioned and ready to test MW level energy storage systems in a variety of applications**
- **The RedFlow system has arrived at SNL and will begin testing shortly**



Future Work

- Support Third Party and Collaborative Testing of Energy Storage Systems
 - Boeing Flywheel (in negotiations for May 2012)
- Automate Control and Telemetry of the Megawatt Loadbank at the ESTP with a Process Logic Controller (PLC)
- Advancement of Sandia energy storage testing methodologies

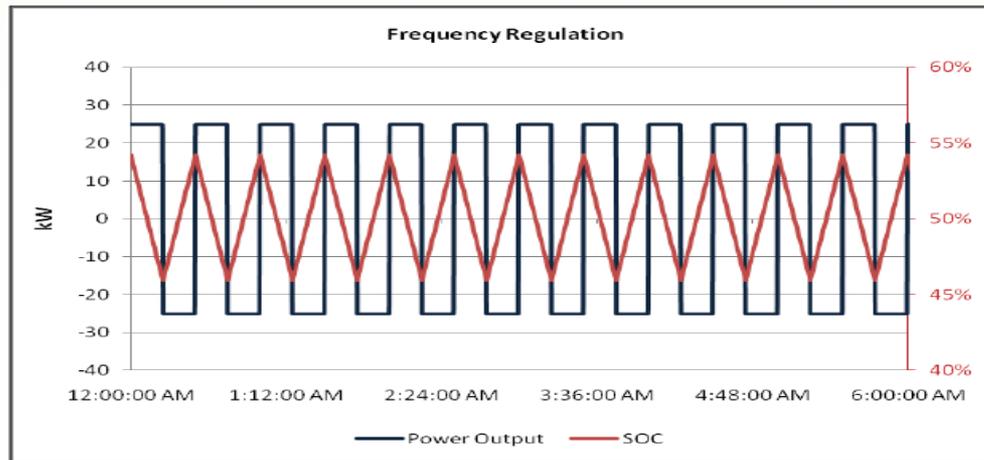


Boeing Flywheel

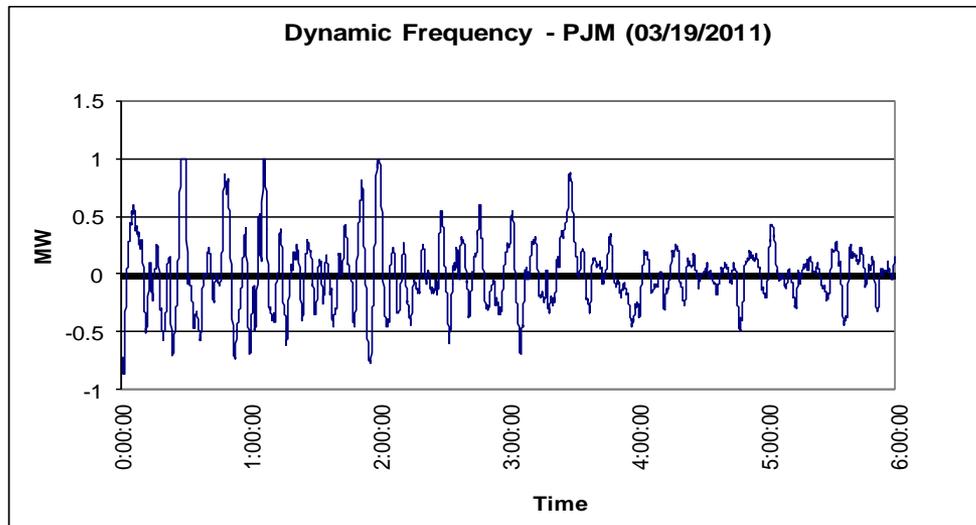


Loadbank at ESTP

Advanced Testing Methodologies



Picture by KEMA



<http://www.pjm.com/markets-and-operations/ancillary-services/mkt-based-regulation.aspx>

ES meant for frequency regulation are tested using a very simplistic charge discharge profiles.

When ES is used for frequency regulation they see a complex, stochastic profile



Advanced Testing Methodologies

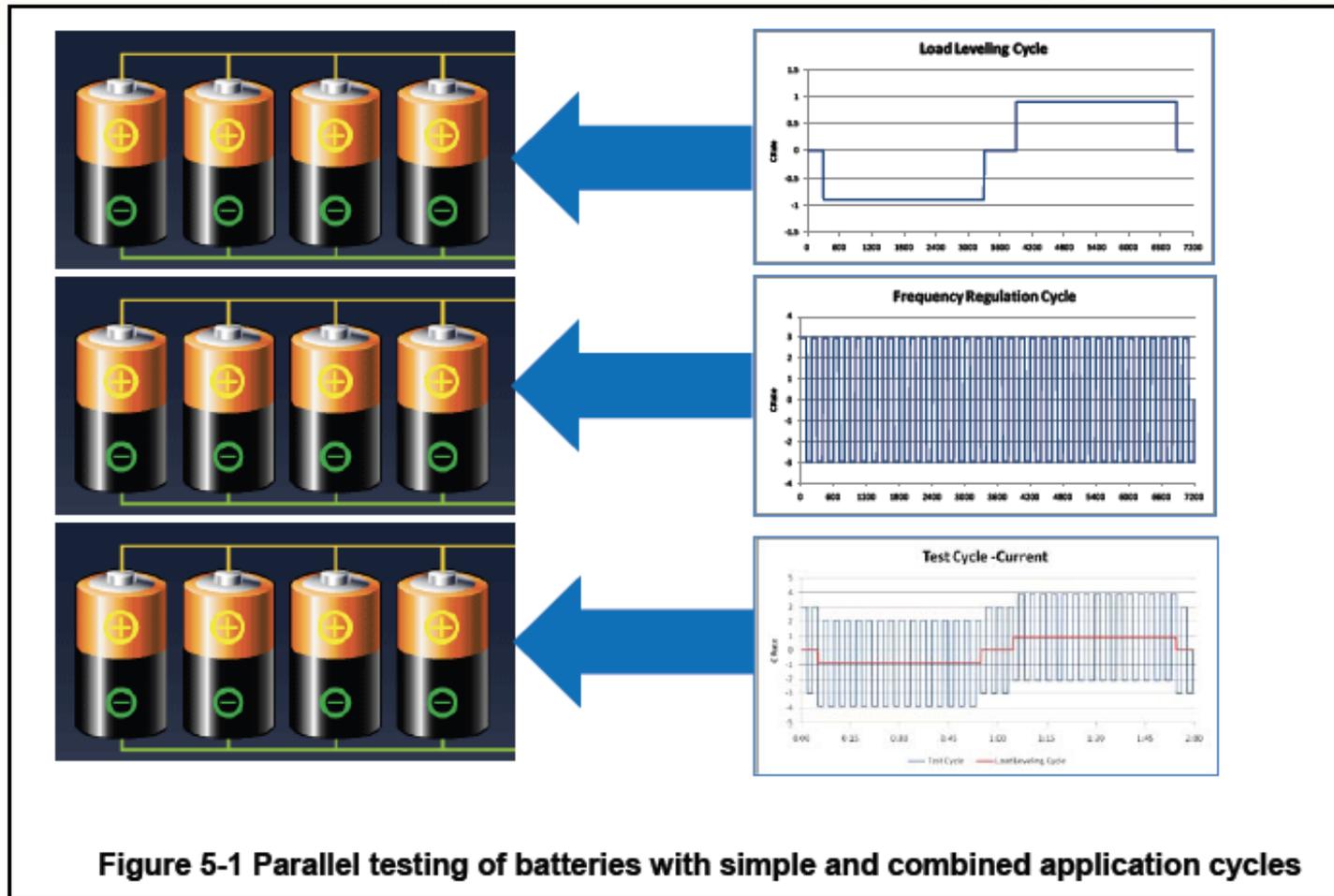


Figure 5-1 Parallel testing of batteries with simple and combined application cycles



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Contact Information

Summer Ferreira

srferre@sandia.gov

David Rose

dmrose@sandia.gov

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