

# Performance and Reliability Analysis of Energy Storage Devices

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**Mission:** *Develop and implement analytics to assess the performance and life of energy storage technologies to advance the adoption of stationary storage solutions.*

## SNL Energy Storage System Analysis Laboratory

**Problem:**

- Life of storage technologies uncertain yet critical to validating economics
- Potential storage customers, i.e. utilities, without experience in storage, are reluctant consumers.

**Approach:**

- Make advances through test protocol, using direct research, standards activities and analysis projects with commercial manufacturers
- High precision testing spun off as an ARPA-E grant recipient in 2013

Consulting available as well as:

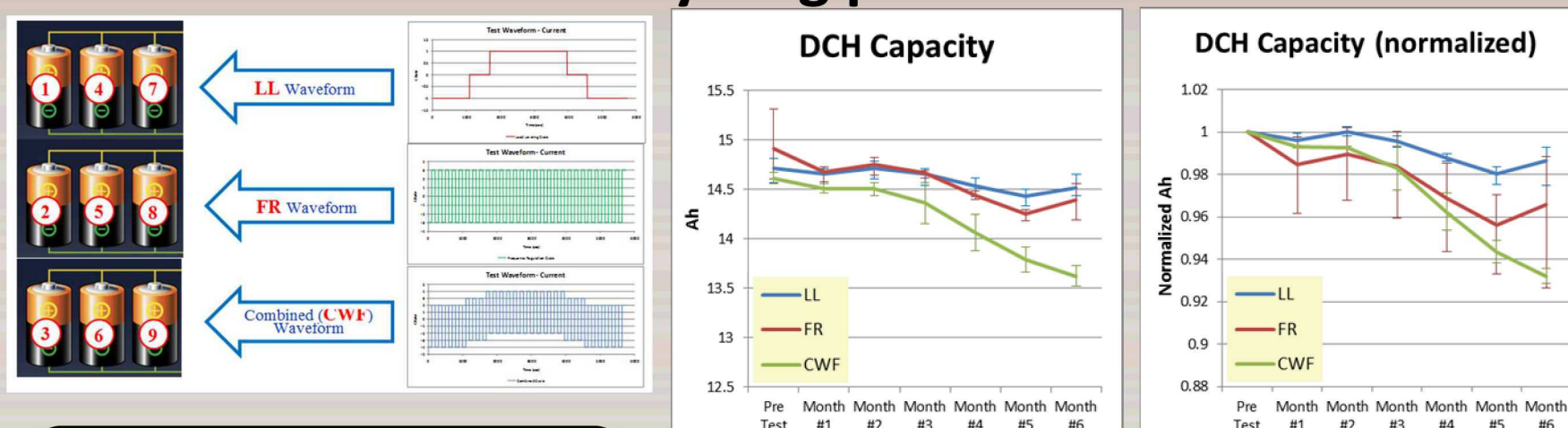
- OE supported testing
- CRADA opportunities
- WFO arrangements



72 V 1000 A Bitrode (2 Channels)

Combining experimental development and use of protocols in the lab, and a long history of collaborative research into commercial technologies we deepen understanding of laboratory results and their correlation to field performance to inform community, and standards development.

## Employing storage devices for multiple uses: Results of stacked cycling profiles



Researching stacked applications in response to interest in the community for combined use cases of single assets for improved value and more flexible systems.

Summarized Results to Date  
Capacity under CWF = (capacity under LL waveform) x (capacity under FR waveform)  
Analysis is ongoing  
Plans to apply the profile to other battery chemistries

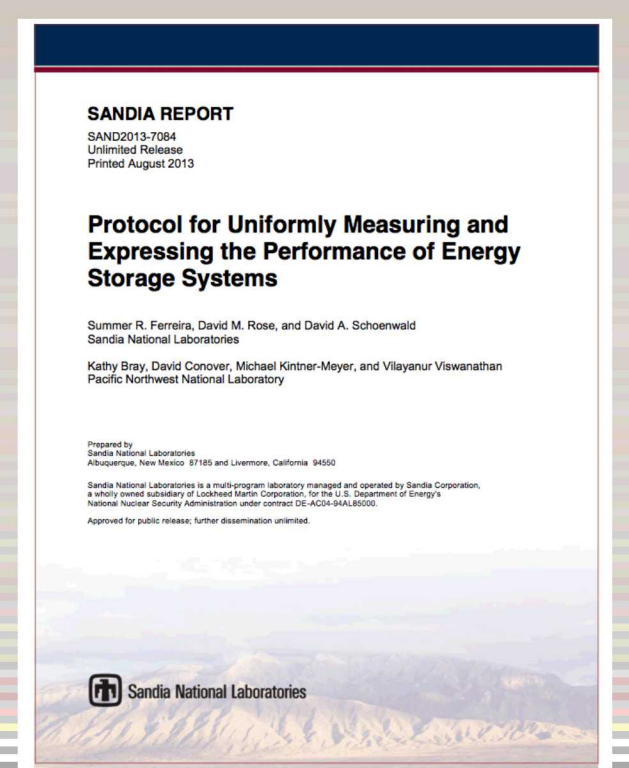
## Participation in Standards Activities

### DOE Performance Protocol

- Included broad input from utility and manufacturing side.
- Initial testing and comments are welcome on previous drafts
- Activities this year on PV smoothing

Eg. ESIC WG2 / IEC 61427-2

Requests from storage customers for a better understanding of technologies and capabilities DOE has invested in supporting protocol development with industry involvement

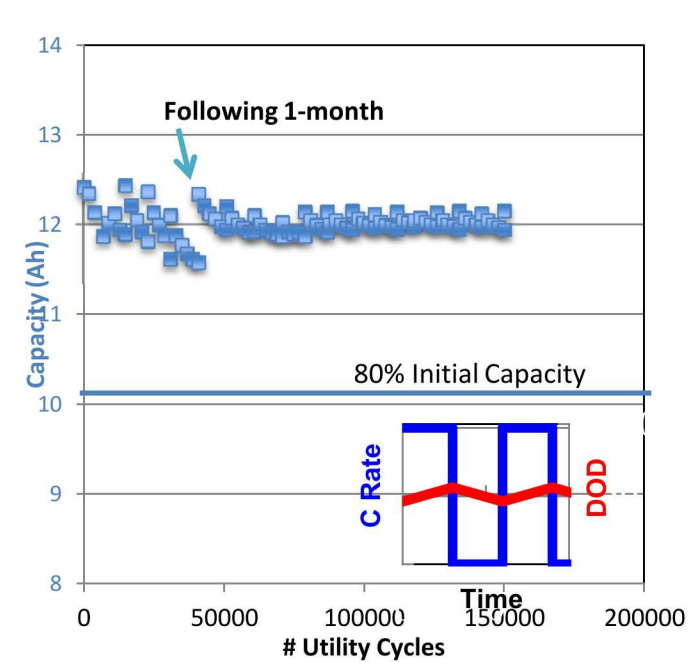


[http://www.sandia.gov/ess/pubs\\_tech.html](http://www.sandia.gov/ess/pubs_tech.html)

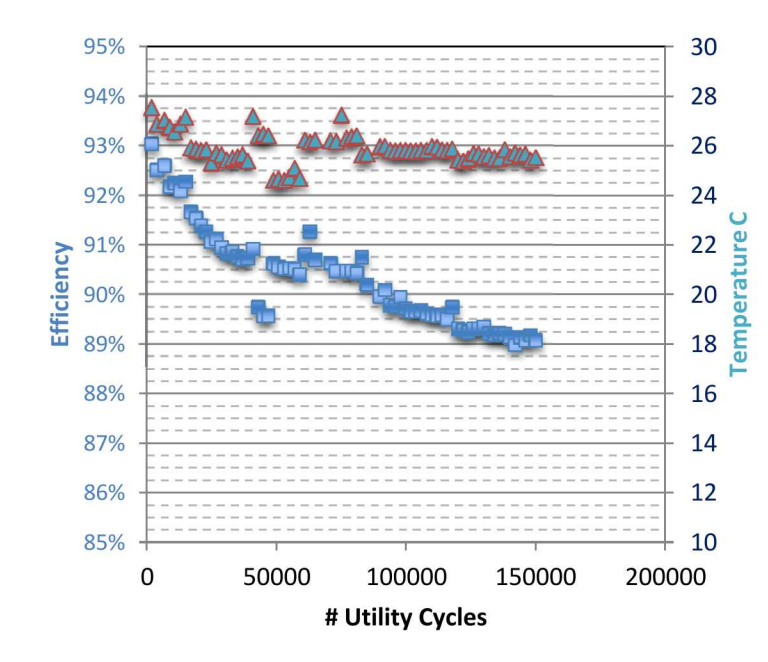
# Performance and Cycle Life Analysis:

## Focus on Cell to Pack analysis: eg. 11 Ah Altairnano Lifecycle analysis in the lab

2C 10% Utility cycles without rests



Efficiency and Temperature during Cycling



- Lithium titanate pouch cell design
- 2% capacity loss
- 5% energy efficiency drop after 150K+ cycles

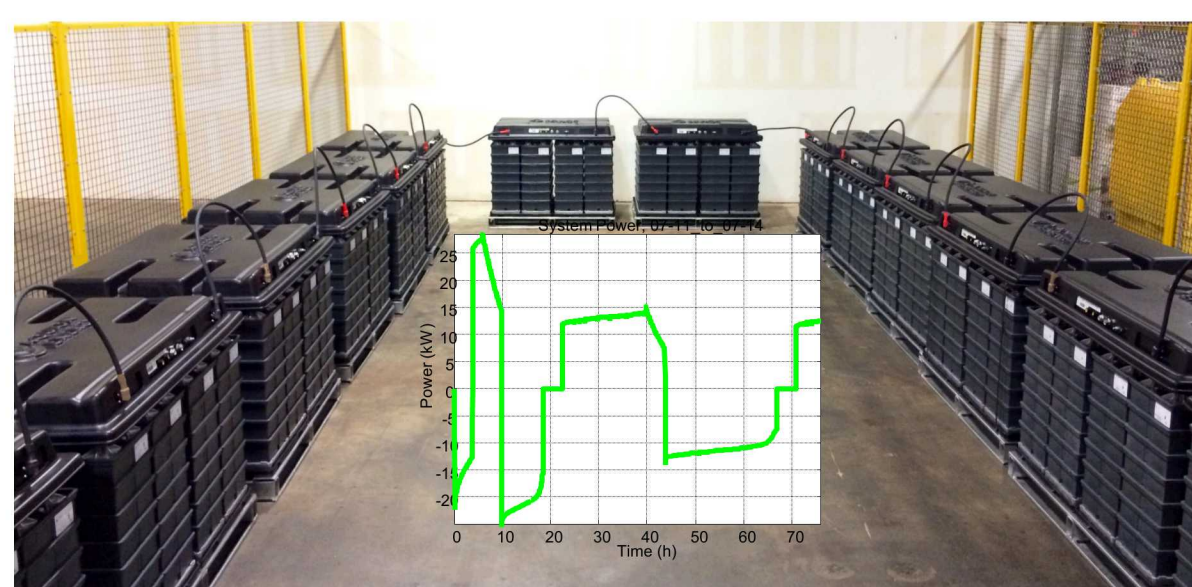
Longevity and reliability of cell chemistries identified through dedicated lab capabilities can inform resource allocation at the larger scale, especially in established markets such as Li-ion

## Pack, string and systems analysis integrated

Aquion single stack Cycling at Sandia



Aquion 11 modules of 12 stack test Cycling at Aquion

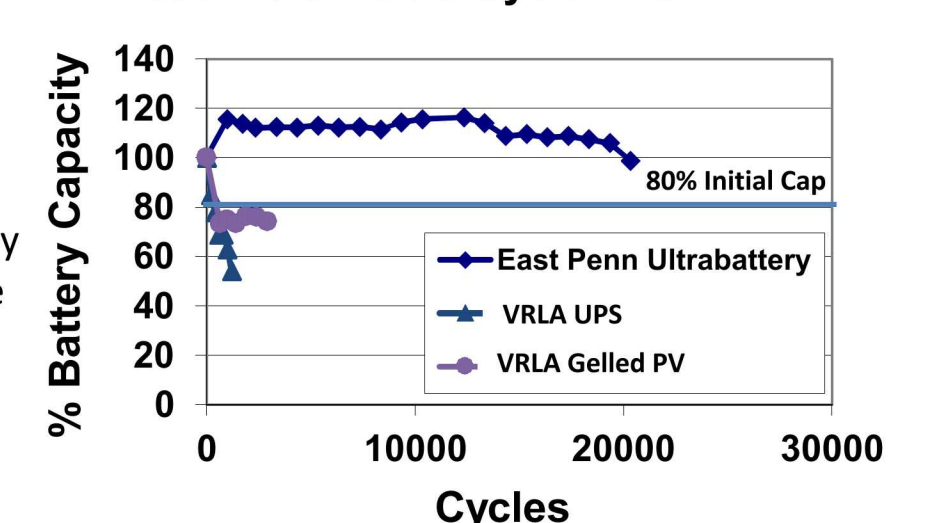


Long term cycling of Aquion begun at Sandia while Aquion designs and tests larger scale systems at their headquarters. Data shared-cycling data can inform design of limits for long term longevity of systems and can inform DOE OE of possible use-cases.

## Compatibility of Lab and Field Data

- Dramatically longer life in Ultrabattery Pb-acid compared to more traditional Pb-acid batteries (1000Ah Ultrabattery PSOC Cycled at 0.5C)
- Demonstration of the technology through the PNM Prosperity site 0.5 MW/0.35 MWh power smoothing Ultrabattery
- Smoothing battery had an average output of 1.6 MWh/month from Aug-12 through Jul-13.

### Lead-Acid PSOC Cycle Life



- After a two years of operation in the field we can now compare the laboratory data for power cycling to the demonstration power cycling for this design



Figure 1: PNM Prosperity energy-storage project.

Through a comprehensive analysis program from the cell to pack to system to field demonstration level we can coordinate knowledge, increase understanding, and inform protocol development and future work

## Effective DOE/Industry collaborative R&D test programs

### Office of Electricity support

- Evaluated Alpha design of an Encell rechargeable nickel alkaline battery
- DOE engages with early-stage companies to identify promising technologies
- Through DOE funded analysis and WFO customer funded projects provide a value added for iterating design and improving-helping bring new options to market
- First round of analysis informed design changes for beta unit
- Use performance tests in conjunction with capabilities including numerous in-situ and ex-situ analysis techniques to provide comprehensive analysis
- More than a test house; the analysis labs at Sandia provide consulting, performance and reliability tests, and materials analysis, in addition to abuse lab capabilities.
- Improved designs have been resubmitted for further DOE supported analysis, testifying to the value industry places in these capabilities.



Experience gained from testing and analysis is fed back into design of protocols

Report available at: [http://www.sandia.gov/ess/pubs\\_tech.html](http://www.sandia.gov/ess/pubs_tech.html) SAND2014-17462

## Energy Storage Systems Analysis Lab Integrated Analysis

Cell Analysis- Lab analysis of performance and reliability



### Battery Analysis



### Pack Analysis



System Analysis- Energy storage test pad performance and remote validation



Demonstration projects – collaborative development and monitoring



## FY14 Accomplishments

### Milestones Reached

- Multiple Services Poster Presented at ESA 2014
- Aquion stack undergoing cyclife analysis at Sandia
- Altairnano cells passed 150,000 PSOC cycles
- SAND Report released for Encell battery technology

### Impacts

- The next generation of test protocols for energy storage systems will provide better information, at lower cost, than what is now available.
- Data collected and disseminated breaks down the barriers to energy storage acceptance by boosting confidence of customers and regulators
- Effective collaborations lead to improved design, and contribute to an understanding of the viability of given technologies in stationary storage use cases.
- We are changing how the industry looks at the safety, reliability, and performance of energy storage systems

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