Life Cycle Testing and Evaluation of Energy Storage Devices

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Sandia National Laboratories

Exceptional service in the national interest

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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SNL Energy Storage System Analysis Laboratory

Mission:

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

Problem:

- Current testing methods are inconsistent and the results confusing
- Potential storage customers, i.e. utilities, without experience in storage, are reluctant consumers.

Approach:

Develop advances through:

- exploration of test protocols, through direct research and standards activities
- high precision testing

Provide ongoing:

- expertise in testing programs to customers
- verification of specific technologies

SNL Energy Storage System Analysis Laboratory

Sandia National Laboratories

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

Testing Capabilities Include:

Expertise to design test plans to fit technologies and their potential applications

Cell, Battery and Module Testing

- 14 channels from 36 V, 25 A to 72 V, 1000 A for battery to module-scale tests
- Over 125 channels; 0 V to 10 V, 3 A to 100+ A for cell tests
- Potentiostat/galvanostats for spectral impedance
- Multimeters, shunts and power supply for high precision testing
- Temperature chambers
- IR camera

Energy Storage Test Pad (ESTP)

72 V 1000 A Bitrode (2 Channels)

System Testing

- Scalable from 5 KW to 1 MW, 480 VAC, 3 phase
- 1 MW/1 MVAR load bank for either parallel microgrid, or series UPS operations
- Subcycle metering in feeder breakers for system identification and transient analysis

Standards Activities

Sandia National Laboratories

DOE Performance Protocol

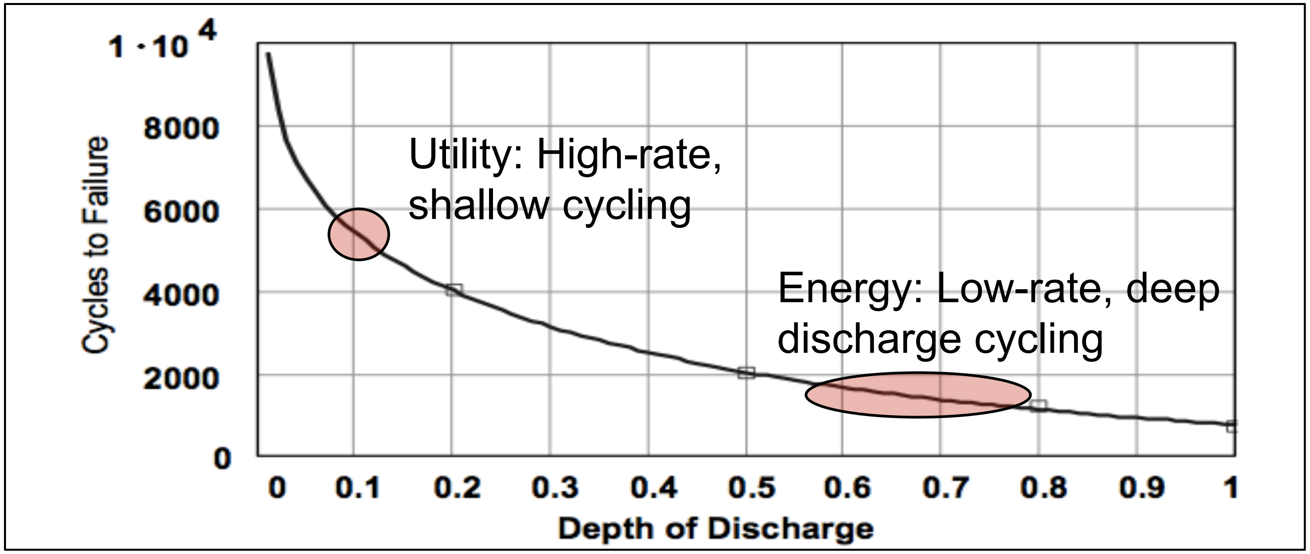
- Working closely with PNNL, and have input from utility and manufacturing side

IEC

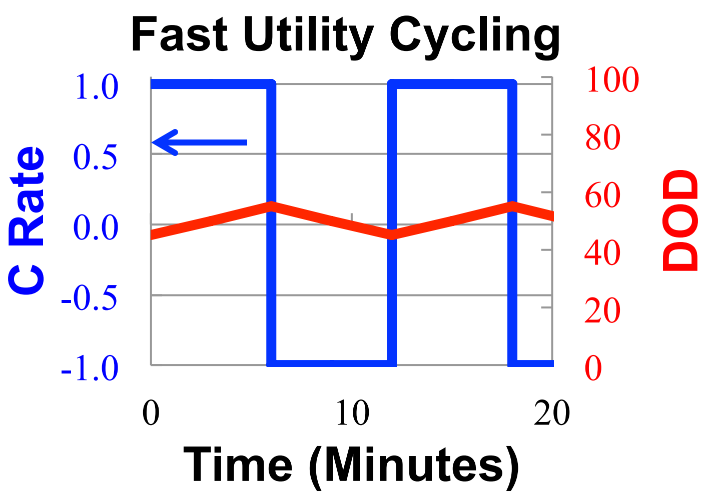
- CENELEC Workshop Agreement for Flow Batteries
- International Standard IEC 61427-2 Secondary Cells and batteries for renewable energy storage – Part 2: On-grid applications

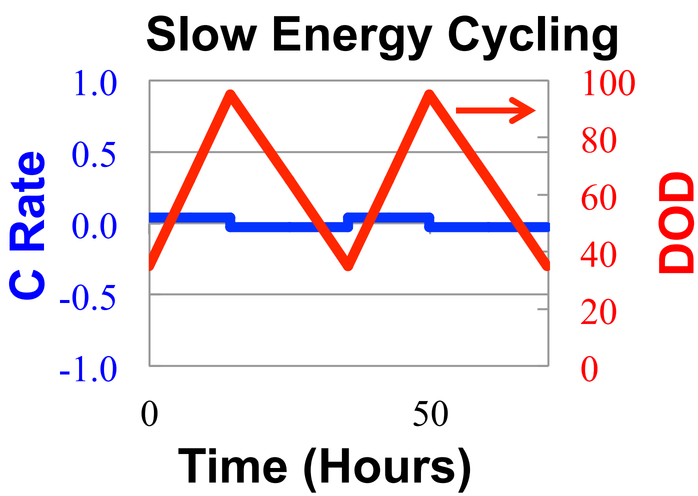
Last Peer Review saw repeated calls for standard language and testing, with definitions. In response standards development has been a large priority in the past year

Cycling protocols employed in testing



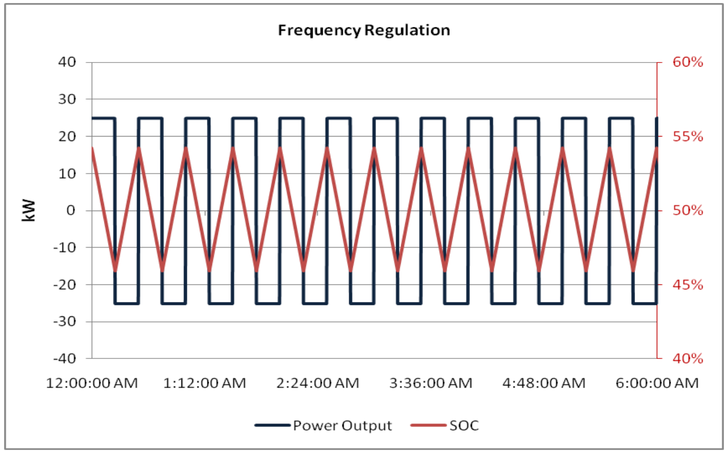
VRLA Life cycle data *S. Drouilhet, B.L. Johnson, 1997 NREL*



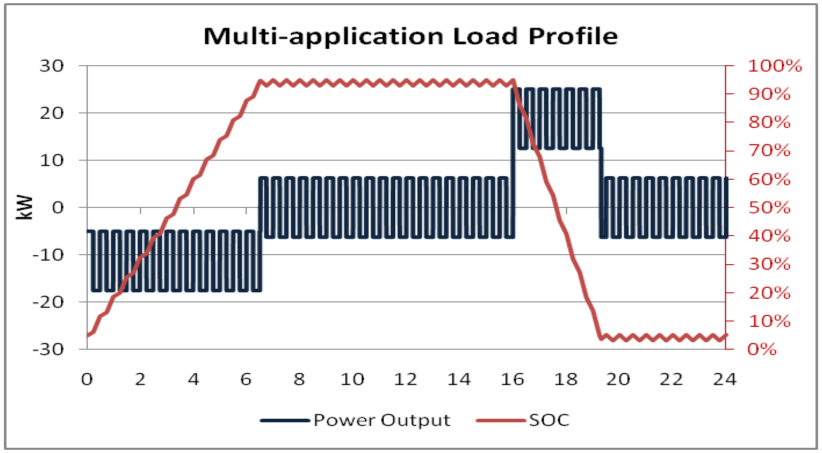


Waveform Testing

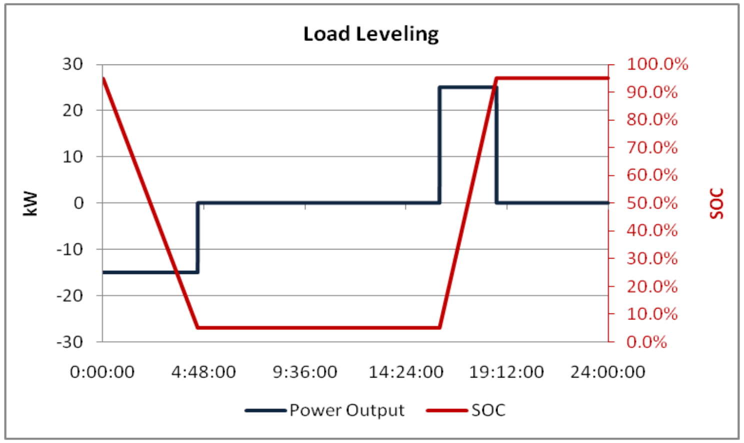
State of the Art: Frequency Regulation



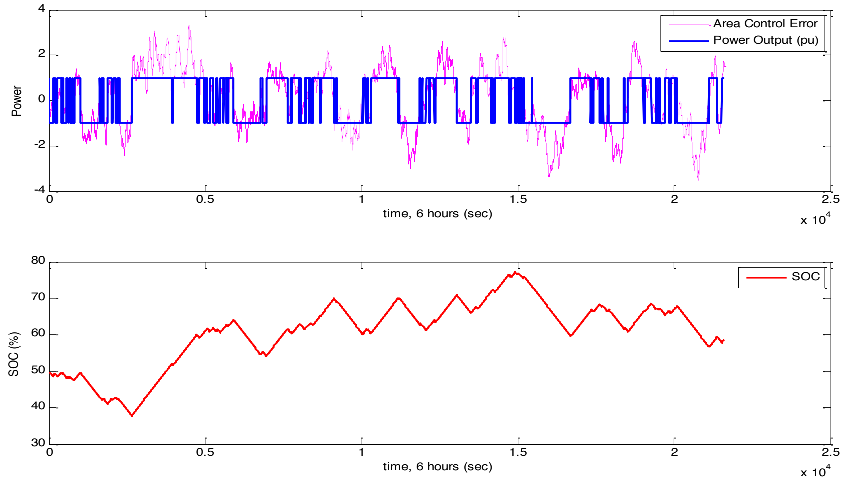
Stacked Applications: Working with KEMA



State of the Art: Load Leveling



Stochastic Application Modeling:



Future Projects

CUNY: Ni-Zn Flow battery modules August 2013

AllCell: Test Program under consideration

Encell: Testing anticipated February 2012

Altairnano: Generation II 13 Ah cells; Generation III 14 Ah

LiFe Batt: Cost share agreement for testing new generation

3rd party testing open to researchers and manufacturers in FY 2013

Summary of completed testing activities

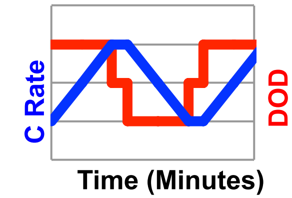
East Penn

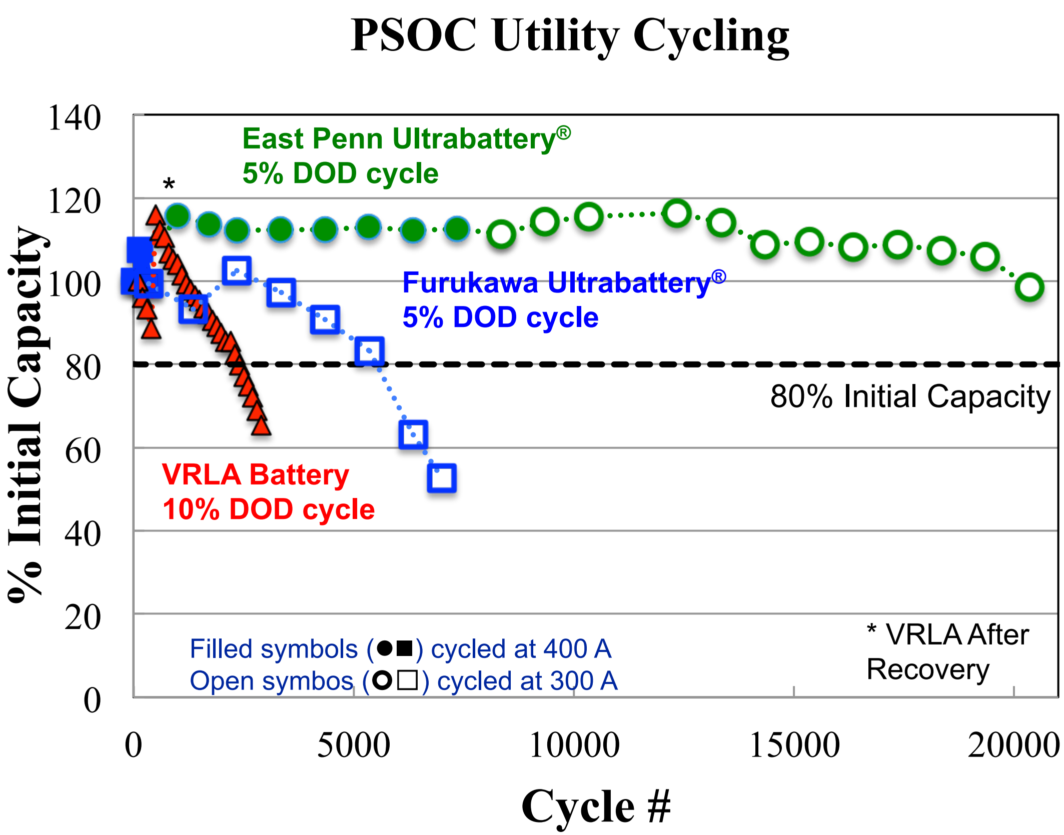
Furukawa

East Penn Ultrabattery® Module
20,347 5% PSOC utility cycles
422 Days and 229 PV deep discharge cycles

FurukawaUltrabattery® Module
7,012 5% PSOC utility cycles
498 Days and 280 PV deep discharge cycles

Ultrabattery® performs much longer than VRLA

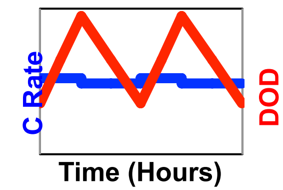


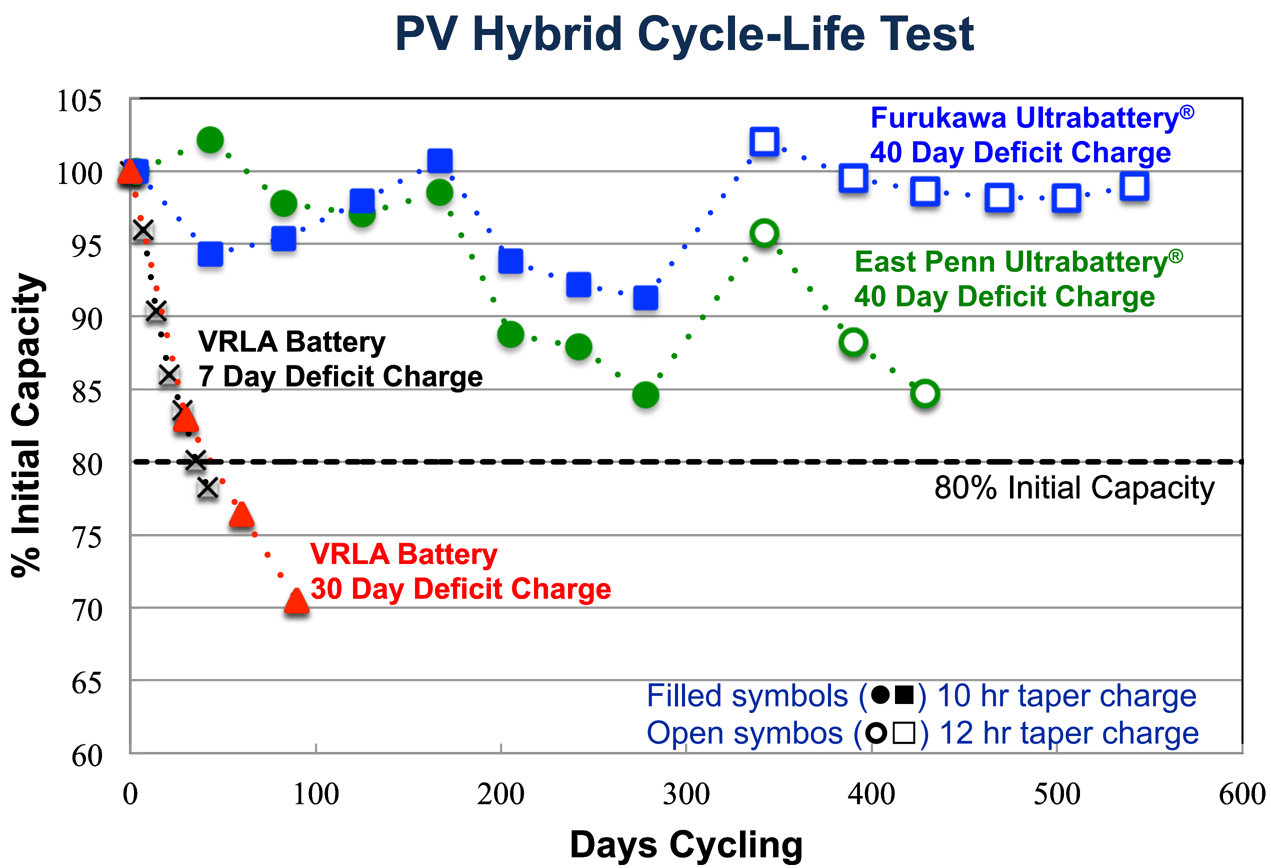


Furukawa Ultrabattery® operated at elevated temperatures, likely leading to thermally activated degradation.

East Penn Ultrabattery® ran for more than 20,000 cycles without recovering the battery

Ultrabatteries® also perform much longer in energy applications than VRLA





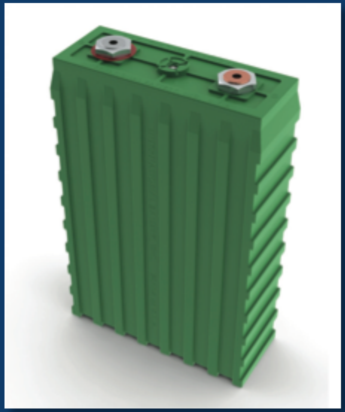
Even at 40 day deficit charge, Ultrabatteries® have performance far surpassing traditional VRLA batteries even with as low as a 7 day deficit charge (without recovery by taper charge).

Ongoing testing activities

Cell Level Testing

East Penn Advanced Battery Cells
(D. Enos 10:50 AM Thur.)

Altairnano Lithium-titanate oxide cells
40,000 10% PSOC



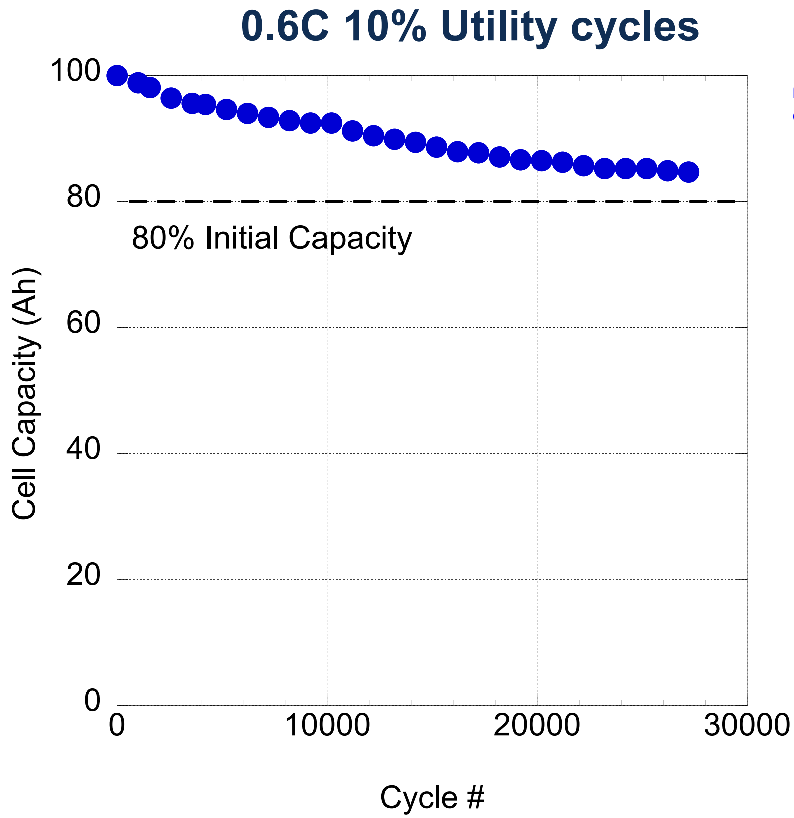
International Battery $Li\text{-}FePO_4$ Cells
20,000+ 10% PSOC

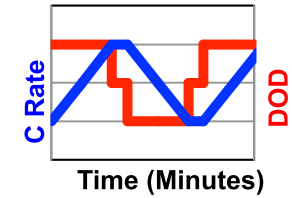
Module Level Testing

RedFlow 10kWh Zn-Br flow battery module and system
(D. Rose)

International battery cell at 27K+ cycles

International battery Li-ion $FePO_4$ large format prismatic 160 Ah cells





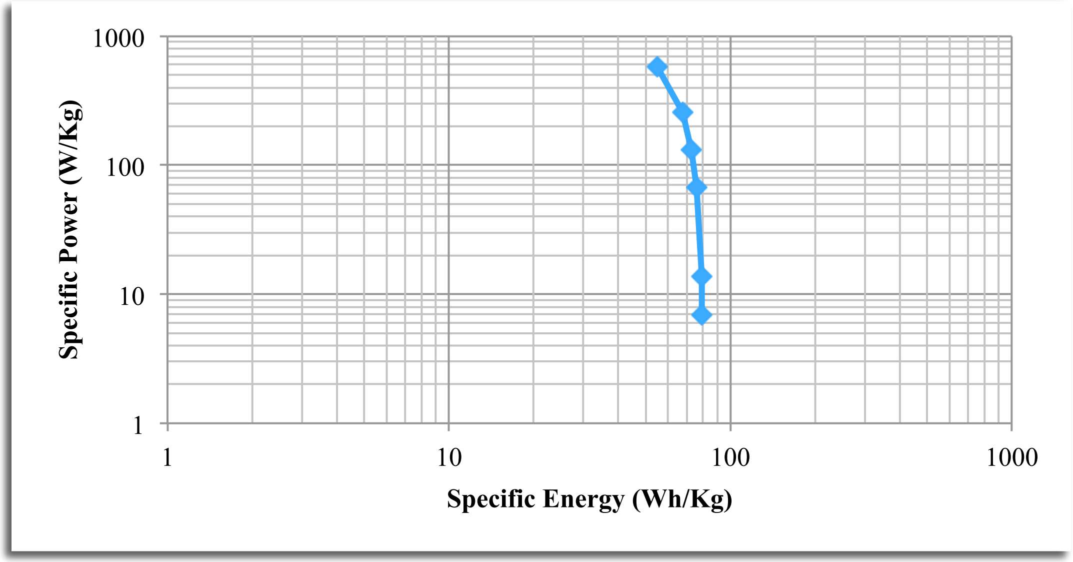
0.6C Utility PSOC cycle
10% SOC cycles at 100 A

15% capacity loss after 27,000+ cycles

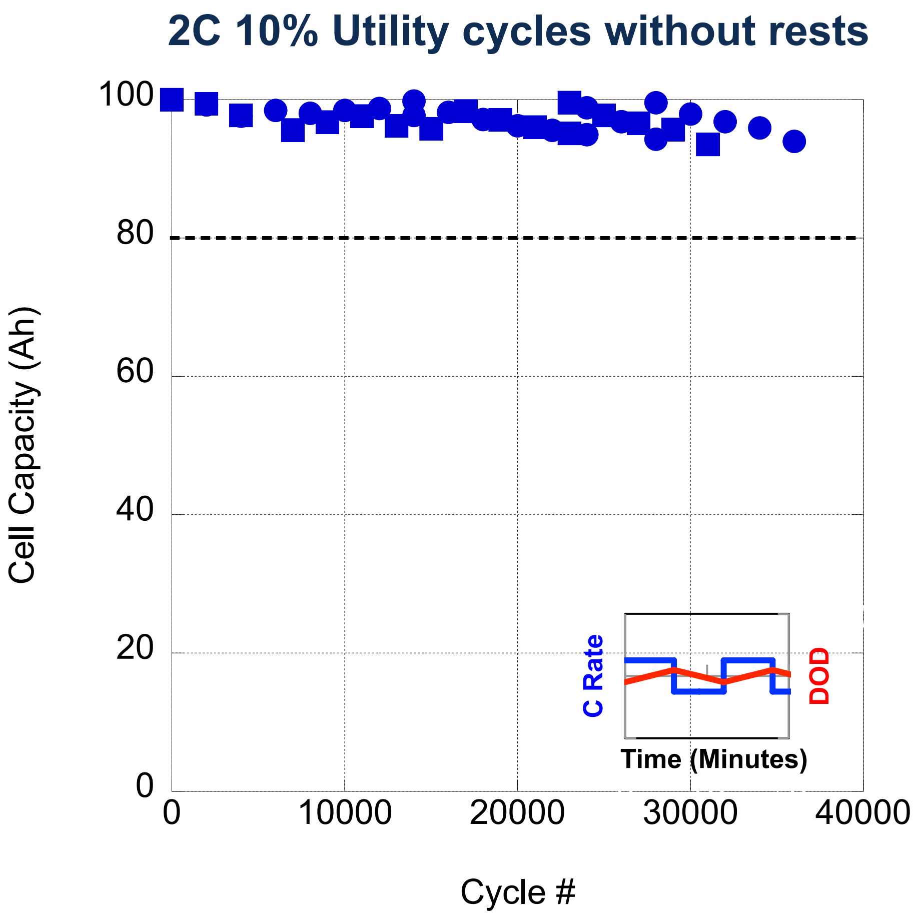
Altairnano Characterization

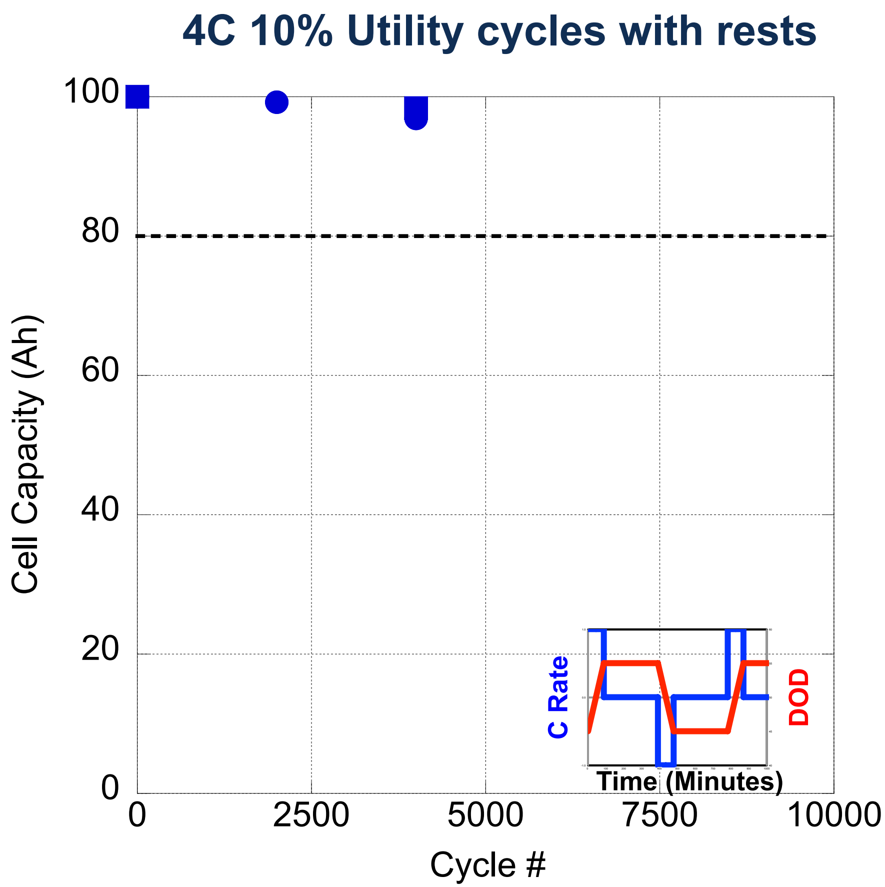
	Average	Standard Deviation
Capacity (Ah)	12.58	0.06
Voc (V)	2.531	0.006
R (μΩ)	2642	147
Mass (kg)	0.367	0.001
3 Month Self Discharge	4.825%	0.025%

Lithium-titanate oxide cells



Altairnano Cycle-Life





94% of initial capacity after 36K 10% PSOC utility 2C cycles without rests

97.6% of initial capacity after 4,000 10% PSOC utility 4C cycles

Summary/conclusions to date

- Current advanced batteries are completing over 10,000 10% cycles with little loss in capacity, currently at over 40,000 cycles for Altairnano.
- Anticipate longer testing to reach EOL so we are exploring testing paths. More aggressive tests, and varied protocols including stacked testing under investigation.
- Participation in standards activities is becoming a priority; as we heard at last Peer Review a recurring call for standard language and testing.

Contact Information:

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