Reliability Performance Testing of kW Scale Modules at PNNL

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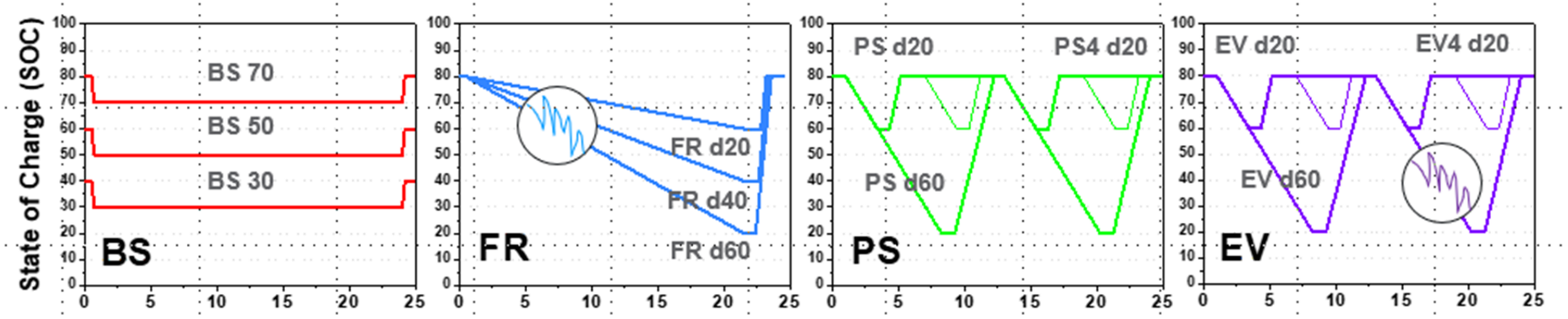
PNNL is operated by Battelle for the U.S. Department of Energy

Battery Reliability Laboratory at PNNL

Objectives

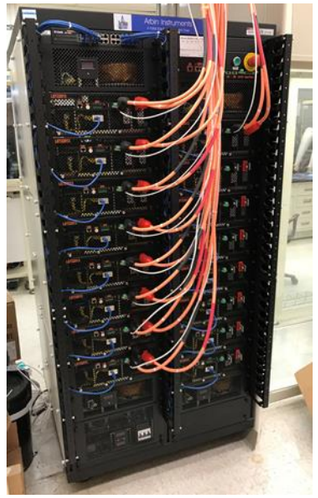
- Establish a world class battery testing laboratory to predict the lifetime of battery components
- Utilize strong on-site characterization facilities (i.e. NMR, XPS, TEM, APT, etc.) to understand degradation mechanisms on batteries tested under grid duty cycles.
- Create innovative material solutions to existing technologies to increase reliability by understanding Materials-Performance relations for various battery technologies
- Provide battery operation guidelines and independent validation of performance to end users to maximize battery lifetime

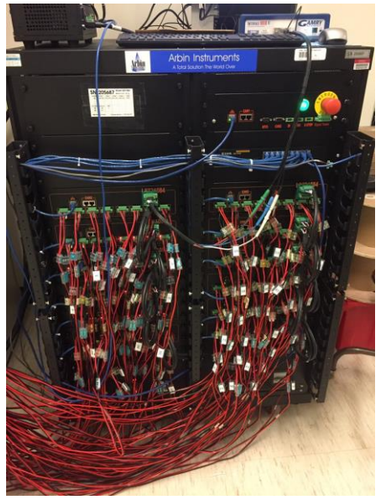
Duty Cycles



Battery Cycling Capabilities

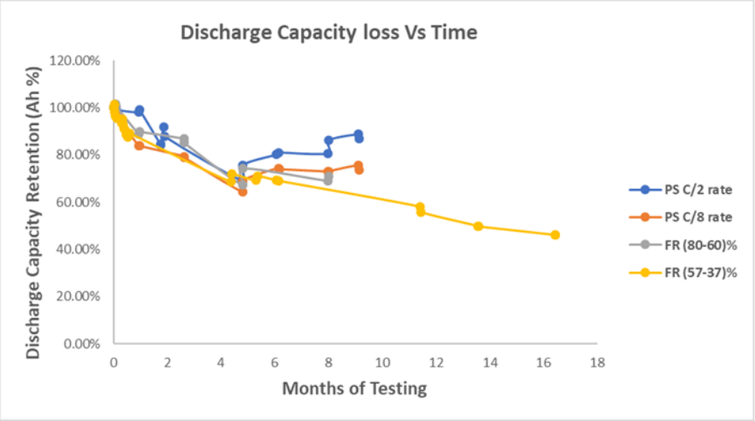
- 9 Channels 120V DC 200A (Regenerative)
- 16 Channels 60V DC 50A
- 192 Channels of single cell testing
- Modules up to 10kW
- Lead Acid, Na metal halide, Iron nickel, Lithium, and redox flow batteries

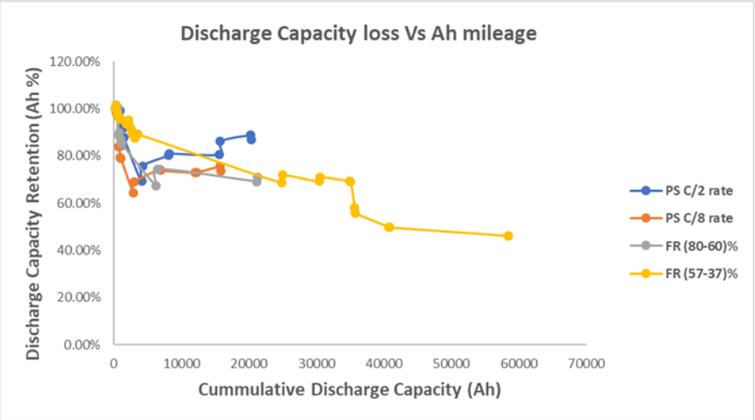




Lead Acid Testing

- C&D Batteries are being tested at 2 peak shaving conditions and to frequency regulation conditions.
- Peak shifting done at C/2 and C/8 rate at 50% DOD from 100% SOC
- Frequency regulation done at same power level (maximum 1090W) at 57-37% SOC and 80-60% SOC
- Degradation rate not affected by duty cycle
- Recovery in capacity probably associated with reconversion of dead zones related to insulating PbSO4 back to Pb at negative and PbO2 at positive for modules with minimum SOC at 50%
  - This does not happen when the low end of SOC is 37% - more difficult to convert PbSO4
- See poster session “Lead Acid Battery Module Testing for Grid Services” and “Towards building optimal electrolytes for Pb-acid battery through tunable solvation chemistry”





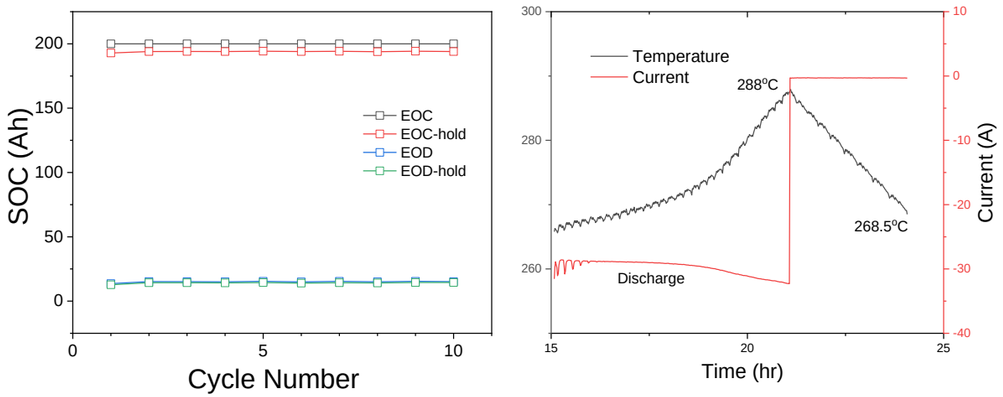
Na Metal Halide Testing

- Under peak shaving test at various power levels for the last 6 month
- Most test at greater than 80% capacity utilization
- Over 100 cycles
- Total energy 1100 kWh charge 820 kWh discharge (9.6 kWh/module)
- No significant degradation to date
- See poster session “Testing Na-$NiCl_2$ (Zebra) battery module for daily peak shaving applications”

(48TL200 Module)

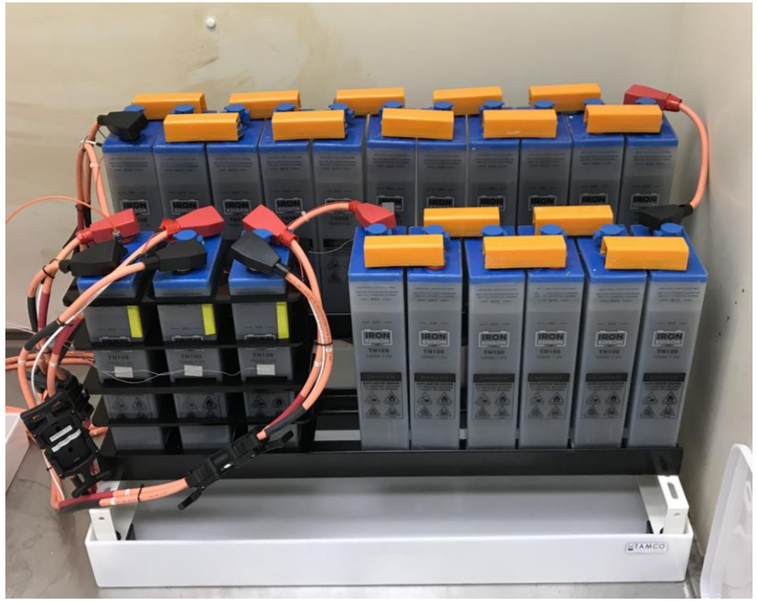
- Nominal Voltage: **48 VDC**
- Module Energy: **9.6 kWh**
- Module Capacity: **200 Ah**
- Module Power: **2.3 kWh** (C/4, discharge)
- Energy Density: **91.4 kWh/kg**
- Dimension: **19.5″(w) x 21.9″(d) x 12.6″(h)**
- Cost: **~1,000 $/kWh**
- Environment Temp: **-40 to 60°C**

6 hrs Discharge for 8.5 kWh



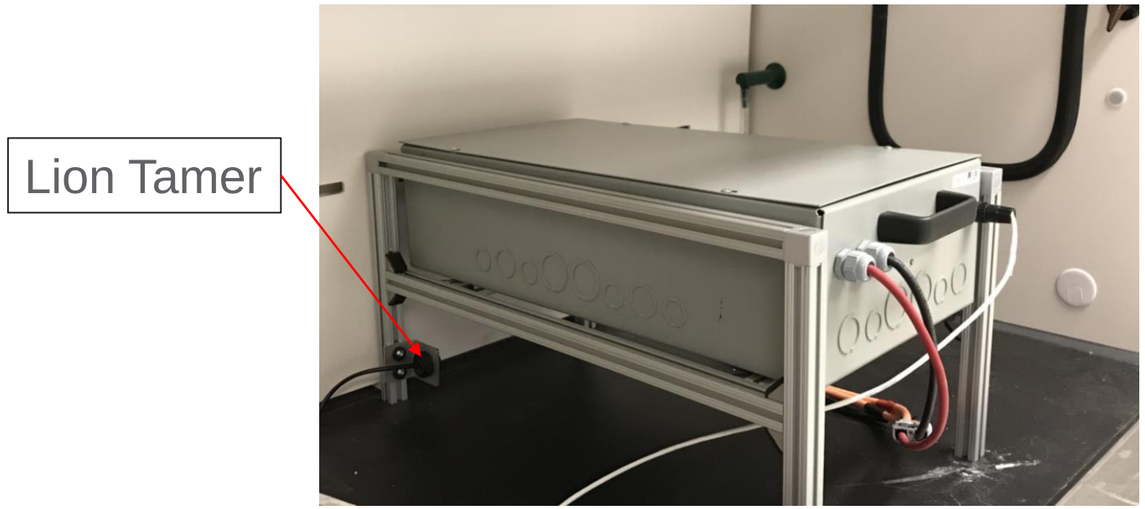
Iron Nickel Battery Testing

- Most testing to this point has been investigating optimum battery operating conditions.
- Monitoring gas evolution (H_2 and O_2) during battery cycling under various conditions.
- Applying peak shaving schedules for single cell unit (100 Ah/cell) testing.
- Testing a serially connected battery module (2 kWh/module, 20 cells) for various grid applications.



Lithium Module Testing

- ALLCell NMC module
- K2 Iron Phosphate module
- Initial testing has begun
- Systems to safely operate the modules have been installed
- There are still some communication issues to be sorted out.
- Testing will be done in same fashion as single cell testing also being done on the project

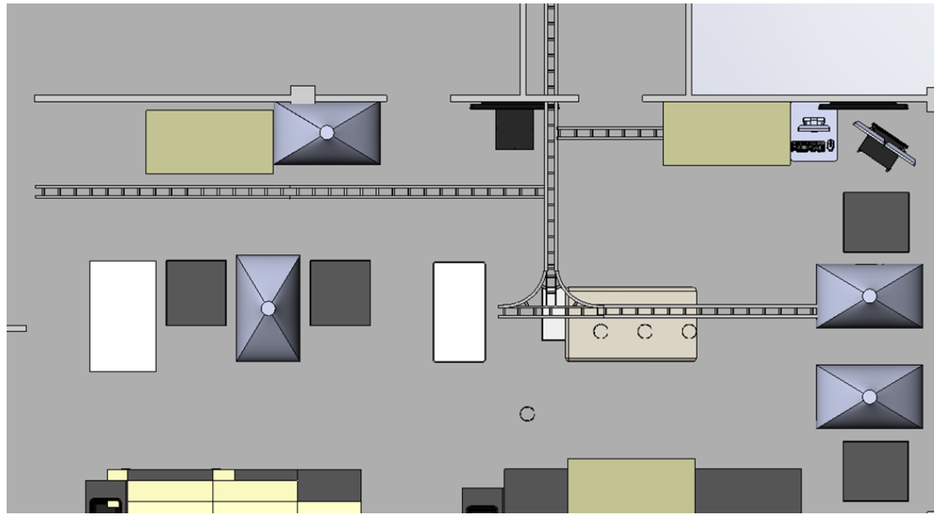


Flow Battery Testing

- UET mixed Acid Vanadium
- Storion Bi Additive Vanadium
- Both modules have been installed in the lab testing will be started in Q1 of FY 2021

Future Work

- Additional battery cycler with 4 channels capable of 100V DC 200A
- Ventilated space for testing
- Saltwater battery module
- 2 more lithium modules
- Zinc module
- BAE flooded and sealed lead acid
- 192 additional single cell lithium
- Construction on ventilation and electrical work should begin soon



Acknowledgments

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Mission – to ensure a resilient, reliable, and flexible electricity system through research, partnerships, facilitation, modeling and analytics, and emergency preparedness.

https://www.energy.gov/oe/activities/technology-development/energy-storage

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Thank you