Electrical Energy Storage R&D at PNNL

Vincent Sprenkle

2012 DOE-Energy Storage System Program Review

September 26, 2012

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PNNL Electrical Energy Storage (EES) R&D strategy

Technology Transfer

Grid Analytics

- Roles of storage in US grids
- Value, locations, targets

EES Technologies

Novel redox flow batteries

Next gen Na-batteries

Low cost, long life Li-ion,

New concepts, emerging technologies

Cost Analysis

- Cost and performance requirements

Crosscutting science

Computer Modeling

- Mass/charge transport
- Electrochemical
- Flow, thermal, …

Advanced diagnostic study, NMR, TEM, etc.

- Basic chemistry
- Materials structure
- Physical properties

Electrochemical study

- Electrochemical activity
- Reaction kinetics
- Performance

Academic/National Lab/Industrial Collaborations

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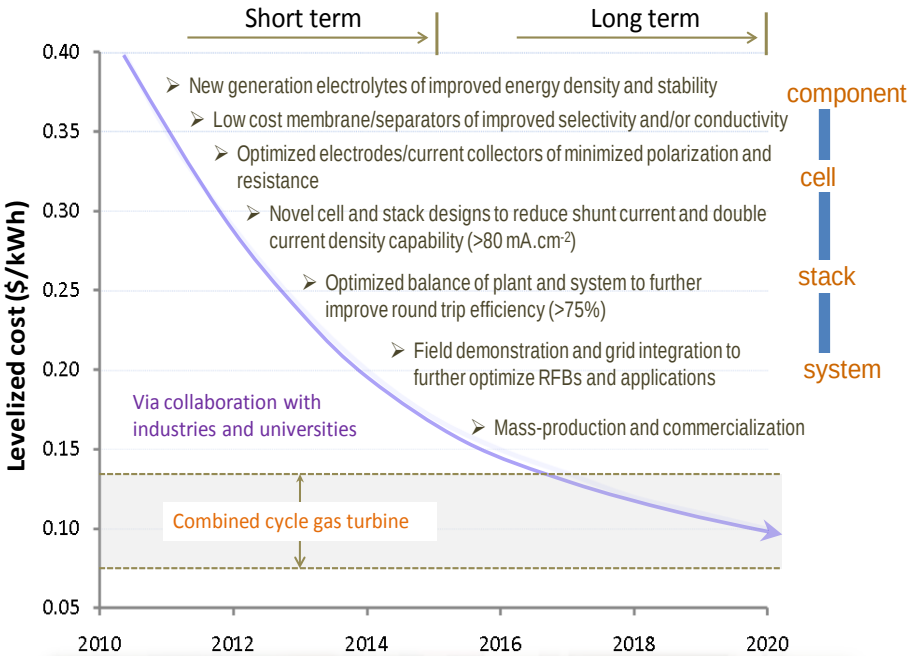
Next Generation Redox Flow Batteries

Developed next generation redox flow battery (RFB) that can demonstrate substantial improvement in performance and economics, to accelerate its commercialization and market penetration, via collaborations with industries and universities



1 kW/1kWh V/V Redox Battery System Demonstration.

FY12 accomplishments

- Licensed new V/V redox chemistry for commercial development.
- Developed Shunt Current Model and low pressure drop stack design.
- Demonstrated 1 kW/1kWh V/V Redox flow battery
  - 1.1kW / 1.4 kWh
  - 82% efficiency at 80mA/cm^2
  - Projected cost < $560 kW at 1MW/4 MWh scale.
- Breakthrough in development of low-cost V/V membrane/separator

S. Kim (Poster) - 9/26
V. Sprenkle – 9/28 – 11:10am
W. Wang – 9/28 – 11:25 am

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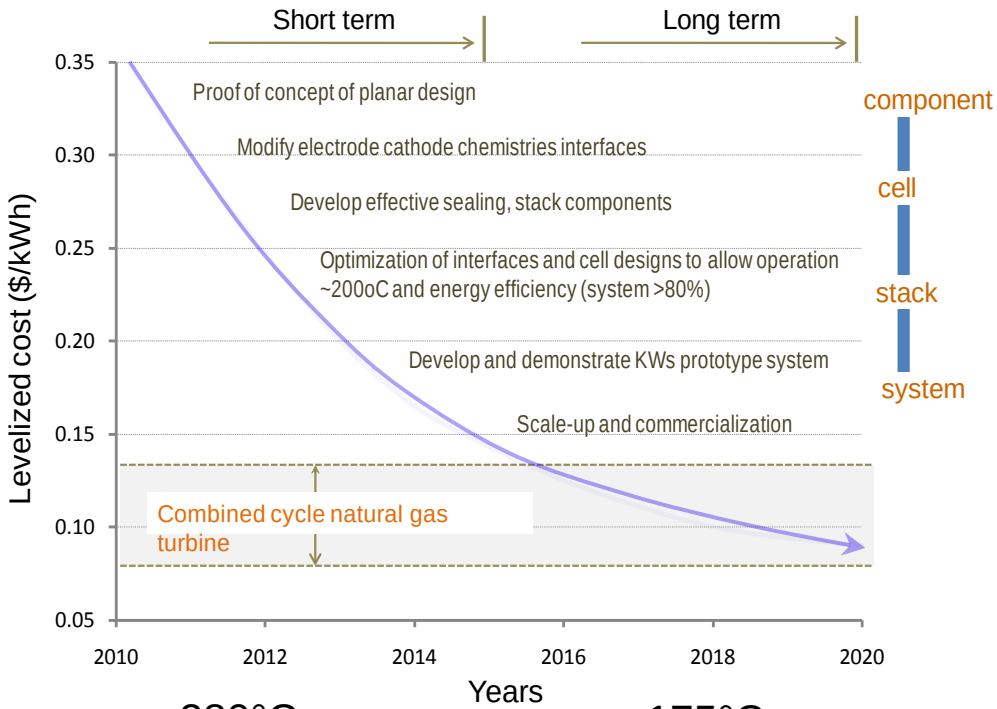
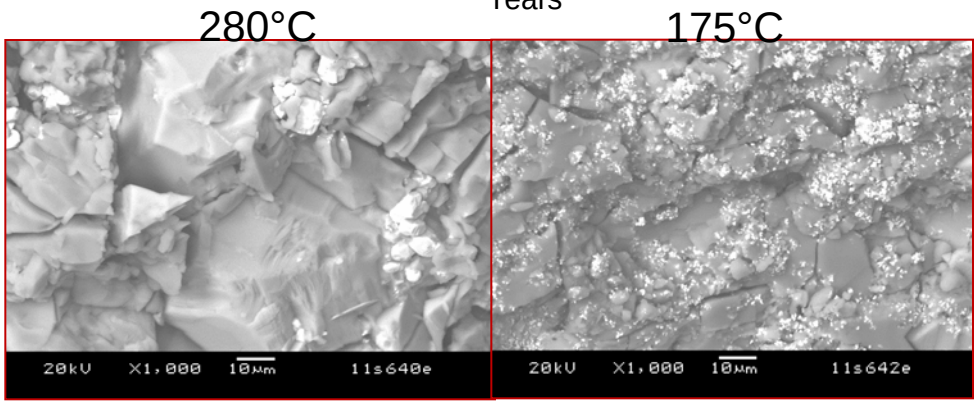
Sodium (Na) - Metal Halide Batteries

Develop novel Na-metal halide batteries that can meet cost and performance targets for renewable integration and grid applications, via introduction of planar designs and new minor chemistries and interfaces





Comparison of Na-metal halide battery microstructure after 280°C and 175°C operation resulting in enhanced durability at lower temperature

FY12 accomplishments

- Demonstrated stable battery performance at <200°C and c/3 in 3 cm^2 format. Lower operating temperature leads to lower capital and operating costs.
- Developed novel catholyte for < 200°C operation.
- Completed development of thin-electrode supported electrolyte with low resistance.
- Developed cost effective Zn based cathode chemistry to replace expensive Ni in 3 cm^2 format.
- Overcome Na wetting issues to enable < 200°C operation.
- 3 patent applications.

JY Kim – 9/27 – 10:00 am

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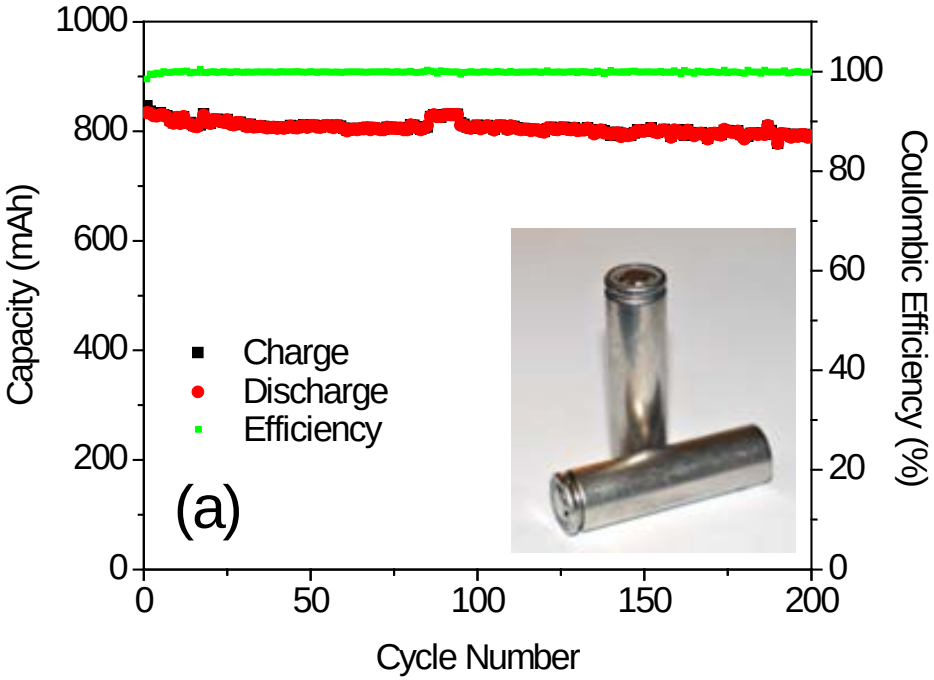
Unique Li-ion for community storage

Develop unique Li-ion batteries that are made from low cost (<$250/kWh), high cycle life (>5,000 deep cycles) electrode materials so that can meet, in particular, the cost and performance requirements for community storage

$LiFePO_4$ / $Li_4Ti_5O_{12}$ 18650 Full Cell



FY12 accomplishments

- Second batch $LiFePO_4/Li_4Ti_5O_{12}$ based 18650 cells fabricated (K2 Energy).
- Initial rate and cycling performance collected
- $LiMn_{0.9}Fe_{0.1}PO_4$, $LiFeBO_3$, and Li_2FeSiO_4 materials synthesized and electrochemically characterized.
- Zn_2GeO_4 anode with specific capacity of ~1,000mAh/g was developed with Penn State University

D. Choi – 9/27 – 10:55 am

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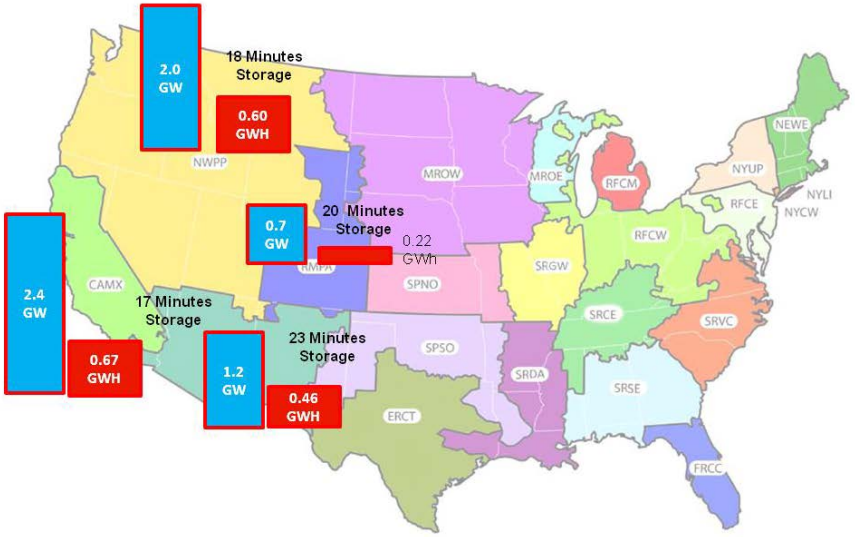
Grid Storage and Cost Analysis Projects

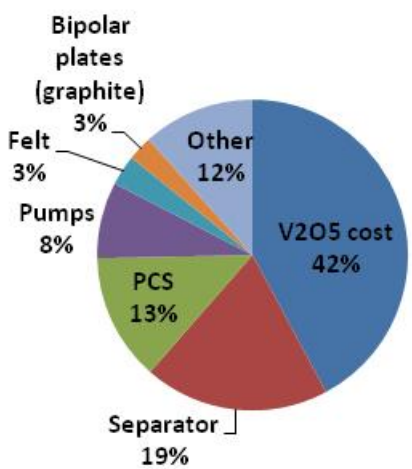
Analysis of the current and future grid to determine impact of energy storage solutions and to determine where R&D dollars can be most effectively directed to advance state-of-the-art storage solutions to meet cost/performance targets.



Incremental Intra-Hour Balancing Requirements for WECC for a 2020

FY12 accomplishments

- Completed National Assessment of Energy Storage : Phase 1: WECC
- Developed a candidate battery performance testing protocol for grid applications
- Developed components cost model for Redox Flow storage technology which:
  - Integrates shunt current and pumping losses
  - Optimizes operational parameters such as flow rate, SOC range, power density performed to yield lowest cost/kWh for 1 MW, 0.25 MWh, 1 MWh and 4 MWh systems



Detailed component cost breakdown V-V Gen 2 Redox Flow Battery, 1MW/4 MWh

M. Kintner-Meyer (Poster) – 9/26
V. Viswanathan – 9/28 – 9:45 am
M. Kintner-Meyer – 9/28 – 2:00pm
V. Viswanathan – 9/28 – 11:40 pm

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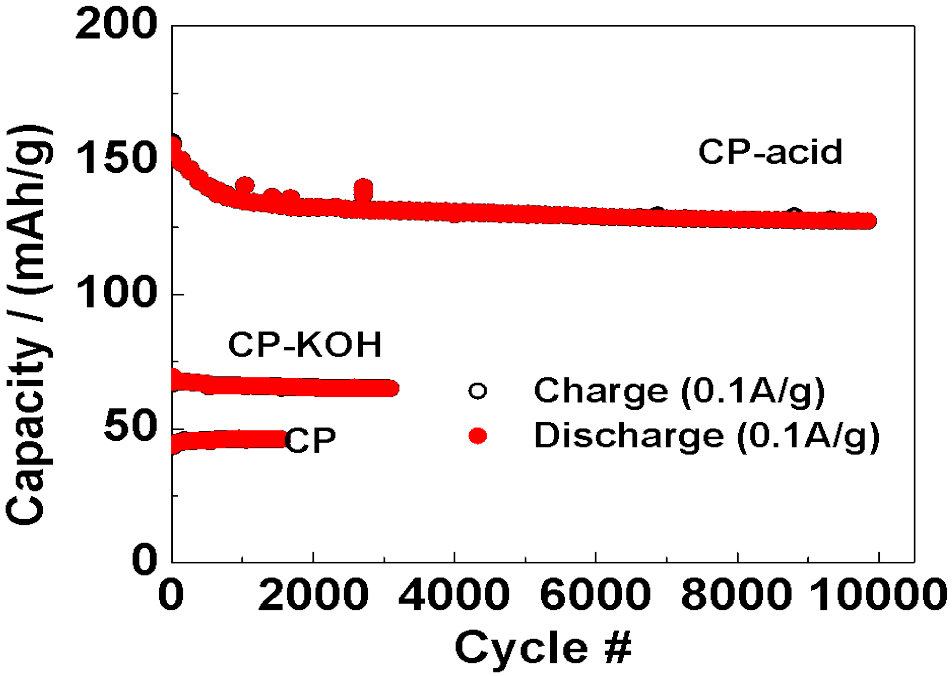
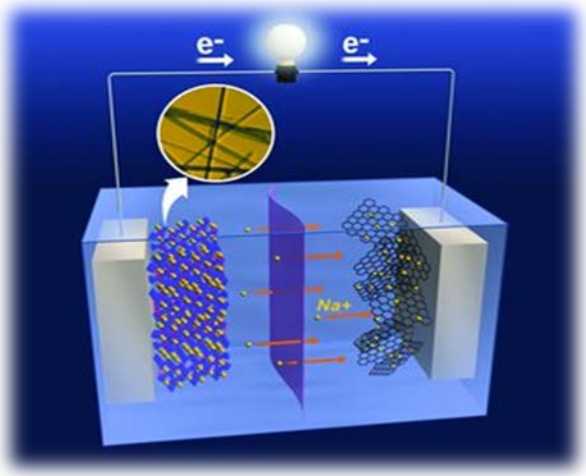
Na-ion battery

Discover novel material structures that allow for facile Na^+ transport at RT and develop low cost Na-ion batteries that can demonstrate satisfactory performance.



>80% capacity retention in 10000 cycles



FY12 accomplishments

- Demonstrated >80% capacity retention in 10000 cycles
- Investigated monolith carbon electrode materials as the cathode for Na-ion Batteries

J. Liu– 9/27 – 10:45 am

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Acknowledgements

- DOE-OE Energy Storage Program, Dr. Imre Gyuk

Energy Storage Staff at PNNL:

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Cui Jun, Jin Yong Kim, Xiaochun Lu, Guosheng Li, Kerry Meinhardt, Dave Reed, Brent Kirby, …

Jun Liu, Yuyan Shao, Yuliang Chao, M. Vijayakumar, …

Michael Kintner-Meyer, Vish Viswanathan, …

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