PNNL OE Program Overview

Sept. 29th, 2020

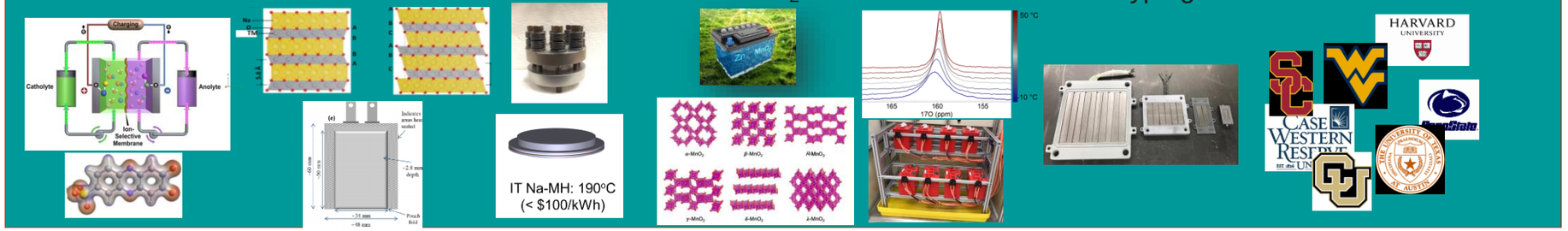
Vincent Sprenkle, David Reed

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

OE Energy Storage Program at PNNL

Cost Competitive Technologies

Flow Batteries | Na-ion | Na metal | $ZnMnO_2$ | Pb Acid | Prototyping | Universities

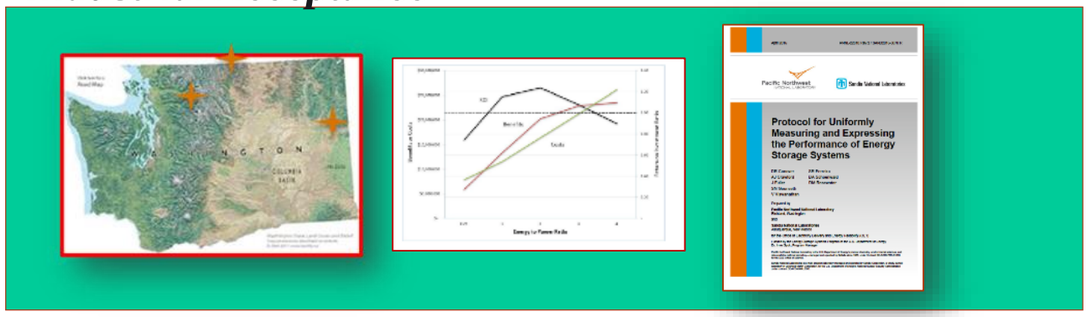


Safety and Reliability

Safety & Reliability C&S | Reliability Testing | *In-situ* testing | GIMRE & 2nd Life

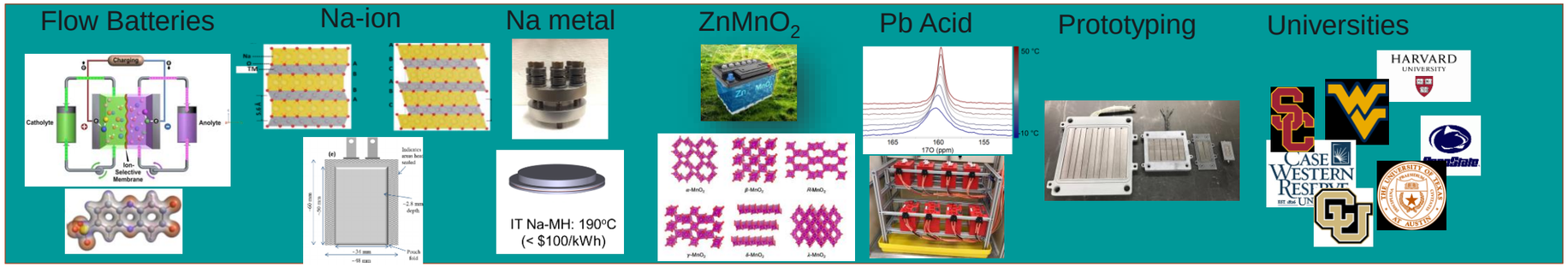
Regulatory Support

Industrial Acceptance



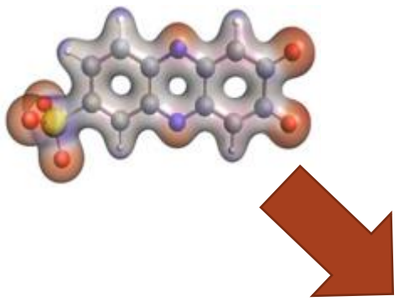
OE Energy Storage Program at PNNL

Cost Competitive Technologies



Aqueous Soluble Organic (ASO) Flow

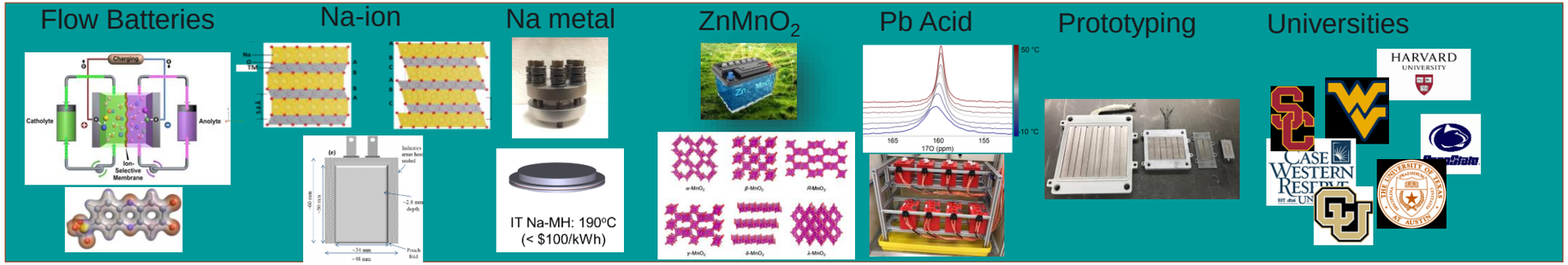
- W. Wang, 10/1 10:35 pm – RFB Summary
- A. Hollas, 10/1 11:00 am – Phenazine ASO Development
- M. Aziz (Harvard), 10/1 1:05 pm – Flow Battery Capacity Fade
- V. Murugesan (Poster #179 – Accelerated Designing of Materials)
- X. Zhang (Poster #180 – Crystallization Kinetics Vanadium Flow)
- A. Hollas
  - Poster #181 – Degradation Mechanisms,
  - Poster #182 – Dihydrophenazine isomers)
- J. Bao (Poster #184 – Machine Learning Modeling)



OE Energy Storage Program at PNNL

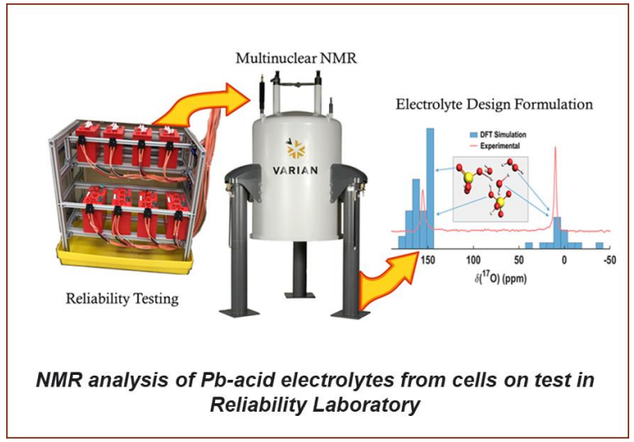
Pacific Northwest NATIONAL LABORATORY

Cost Competitive Technologies



Lead-acid

- V. Murugesan/T. Fister 10/1 11:55 am – Optimal Electrolytes for Pb-acid
- V. Murugesan (Poster #196 Pb-acid Solvation Chemistry)



NMR analysis of Pb-acid electrolytes from cells on test in Reliability Laboratory

Na Batteries

- G. Li 10/1 2:40 pm - Intermediate Temperature Na-metal
- B. Xiao , 10/1 2:55 pm - Advanced Na-ion
- D. Wang (Penn State –Poster #171 Sulfur base solid electrolyte)
- F. Omenya (Poster #175 Na-ion Scale-up)

Zn- batteries

- X. Li (Advanced Zn/MnO_2 9/30 4:25 pm
- M. Fayette (Poster #157 Zinc anodes)
- H.J. Chang (Poster #158 H_2O based binders)
- X. Liu (West Virginia – Poster #168 MnO_2 cathodes)
- I. Rodriguez-Perez (Poster #195 –Dual-Ion Graphite| Zn Batteries)

Long Duration Storage

- G. Li 10/1 3:25 pm – Strategies for long duration storage

OE Energy Storage Program at PNNL

Safety and Reliability

Safety Codes and Standards

- M. Paiss – 9/30 11:40 am Energy Storage Safety Collaborative,

Storage Reliability Testing

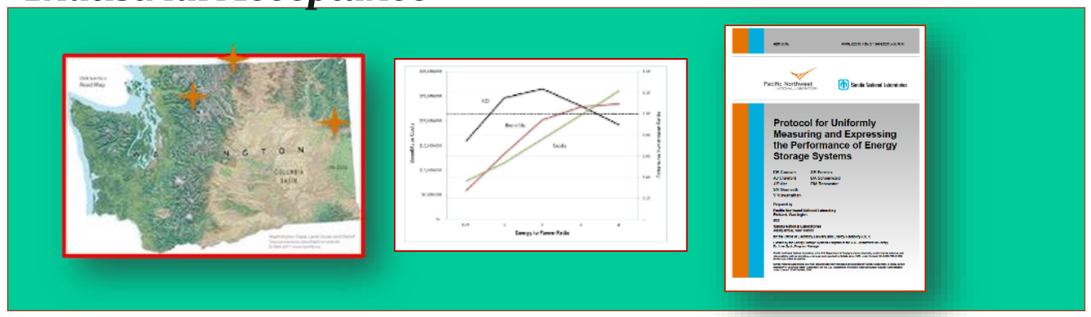
- C. Vartanian, 9/29 3:20 pm – Reliability Overview
- A. Crawford 9/29 3:40 pm – Li ion State of Health
- D. Choi 9/29 3:55 pm – Reliability Assessment
- E. Thomson 9/29 4:10 pm - kw Scale Reliability Testing
- S. Willard (EPRI) 9/29 4:25 pm - Reliability Database
- Q. Huang (Poster #124 – Li-ion degradation)
- N. Shamin (Poster #125 – Pb-acid Testing)
- G. Li (Poster #126 – Na metal Halide Testing)
- V. Viswanathan (Poster #127 – ESS standards)
- T. Swanson (KCM Poster #134 – 2nd Use Testing)

2020 Storage Safety and Reliability Forum
Largest attendance to date ~ 130

OE Energy Storage Program at PNNL

Regulatory Support

Industrial Acceptance



Regulatory Support

- J. Twitchell, 9/29 1:35 pm
- J. Twitchell (Poster #122 – Storage Ownership Models)
- C. Holland (Poster #123 – Retrofitting PV with Storage – North Carolina

Industrial Acceptance

- D. Wu 10/1 5:25 pm – MASCORE Microgrid Tool
- J. Alam 10/1 5:40 pm – Realizing Economic Benefits
- J. Alam, (Poster #100 – Marine Renewable Integration)
- D. Wang, (Poster #101 – Northampton Microgrid)
- T. Ramachandran, (Poster #102 – Power to Gas)
- S. Hanif, (Poster #103 – Distribution Modeling ESS)
- V. Fotedar, (Poster #104 – Partial String Failure)
- A. Crawford (Poster #105 – Data Management)
- X. Ma (Poster #107 – Policy-Based Dispatch)
- D. Huang (Alaska-Fairbanks Poster #108 Thermal+Electrical Storage)

Grid Storage Launchpad (GSL)

Advancing U.S. R&D leadership in energy storage technologies

- ***Validation***:

  Independent testing of next generation storage materials and systems under realistic grid operating conditions

- ***Acceleration***:

  De-risk and speed the development of new technologies by propagating rigorous grid performance requirements to all stages of development

- ***Collaboration***:

  Link DOE and storage R&D communities in a new collaboration center, to solve key crosscutting challenges

Selected FY20 OE Program Publications

1. X. Zhan, JF. Bonnett, MH Engelhard, DM Reed, VL Sprenkle, G. Li."A High-Performance Na–Al Battery Based on Reversible $NaAlCl_4$ Catholyte."*Advanced Energy Materials* Article number 2001378.
2. K. Lu, B. Li, X. Zhan, F. Xia, OJ. Dahunsi, S. Gao, DM Reed, VL. Sprenkle, G. Le, Yingwen Cheng."Elastic Na_xMoS_2-Carbon-BASE Triple Interface Direct Robust Solid–Solid Interface for All-Solid-State Na–S Batteries."*Nano Letters* 20:(9), 6837-684.
3. X. Zhan, X Lu, DM Reed, VL Sprenkle, and G. Li."Emerging soluble organic redox materials for next-generation grid energy-storage applications."*MRS Communications* 10 (2):215-229
4. B. Xiao."Intercalated water in aqueous batteries."*Carbon Energy* 2 (2):251-264
5. Y. Zhang, Y. Lin, L. He, V. Murugesan, G. Pawar, BM. Sivakumar, H. Ding, D. Ding, B. Liaw, EJ Dufek, and B. Li."Dual Functional Ni_3S_2@Ni Core–Shell Nanoparticles Decorating Nanoporous Carbon as Cathode Scaffolds for Lithium–Sulfur Battery with Lean Electrolytes."d*ACS Applied Energy Materials*3 (5):4173-4179.
6. D. Wu, X Ma, S. Huang, T. Fu, P. Balducci."Stochastic optimal sizing of distributed energy resources for a cost-effective and resilient Microgrid."*Energy* 198
7. J. Alam, P. Balducci, K. Whitener, S. Cox."Energy Storage Control Capability Expansion: Achieving Better Technoeconomic Benefits at Portland General Electric's Salem Smart Power Center."*IEEE Power and Energy Magazine* 18 (2) (March 2020).
8. X. Zhan, ME. Bowden, X. Lu, JF Bonnett, T. Lemmon, DM Reed, VL Sprenkle, and G. L. " A Low-Cost Durable Na-$FeCl_2$ Battery with Ultrahigh Rate Capability " *Advanced Energy Materials.*
9. X. Zhan, JP. Sepulveda, X. Lu, JF. Bonnett, NL Canfield, TL. Lemmon, K. Jung. DM. Reed, VL Sprenkle, G. Li. " Elucidating the role of anionic chemistry towards high-rate intermediate-temperature Na-metal halide batteries." *Energy Storage Materials* 24:177-187
10. X. Zang, L. Yan, Y. Yang, H. Pan, Z. Nie, K. Won J.,Zhiqun, D. Deng, and W. Wang."Monitoring the State-of-Charge of a Vanadium Redox Flow Battery with the Acoustic Attenuation Coefficient: An In Operando Noninvasive Method."*Small Methos.*
11. J. Bao, V. Murugesan, CJ Kamp, Y. Shao, L. Yan, W. Wang."Machine Learning Coupled Multi-Scale Modeling for Redox Flow Batteries."*Advanced Theory and Simulations* 3 (2):article number 1900167
12. Power-to-Gas Tool: User's Guide T Ramachandran, P Balducci, and D Wu. 2020. PNNL-ACT-10097,
13. Power-to-Gas System Valuation: Final Report P Balducci, D Wu, T Ramachandran, A Campbell, V Fotedar, K Mongird, S Huang, D Bhatnagar, S Jones, C Smith, B Beauregard, and J. Zwirko. 2020. PNNL-ACT-10095,
14. Planning Considerations for Energy Storage in Resilience Applications - Outcomes from the NELHA Energy Storage Conference's Policy and Regulatory Workshop JB Twitchell, SF Newman, RS O'Neil, MT McDonnell. 2020. PNNL-29738,
15. Development and Analysis of Control Strategies for a 1 MW/3.2 MWh Energy Storage System at Avista Utilities Jan Alam, Patrick Balducci, Trevor Hardy. 2020.
16. Southeastern Energy Storage Symposium and Workshop - Report on Proceedings and Lessons Learned JB Twitchell, RS O'Neil, AL Cooke, HD Passell. 2020. PNNL-29591
17. Washington Clean Energy Fund: Energy Storage System Consolidated Performance Test Results A Crawford, D Wu, V Viswanathan, P Balducci, C Vartanian, T Hardy, J Alam, and K Mongird. 2020. PNNL-29378,