

Development of an All-Aqueous Thermally Regenerative Redox Flow Battery to Support Fossil Fuel Assets

• Award Number: FE0032030-FOA 2332

★ The Pennsylvania State University

🧠 PI: Derek Hall

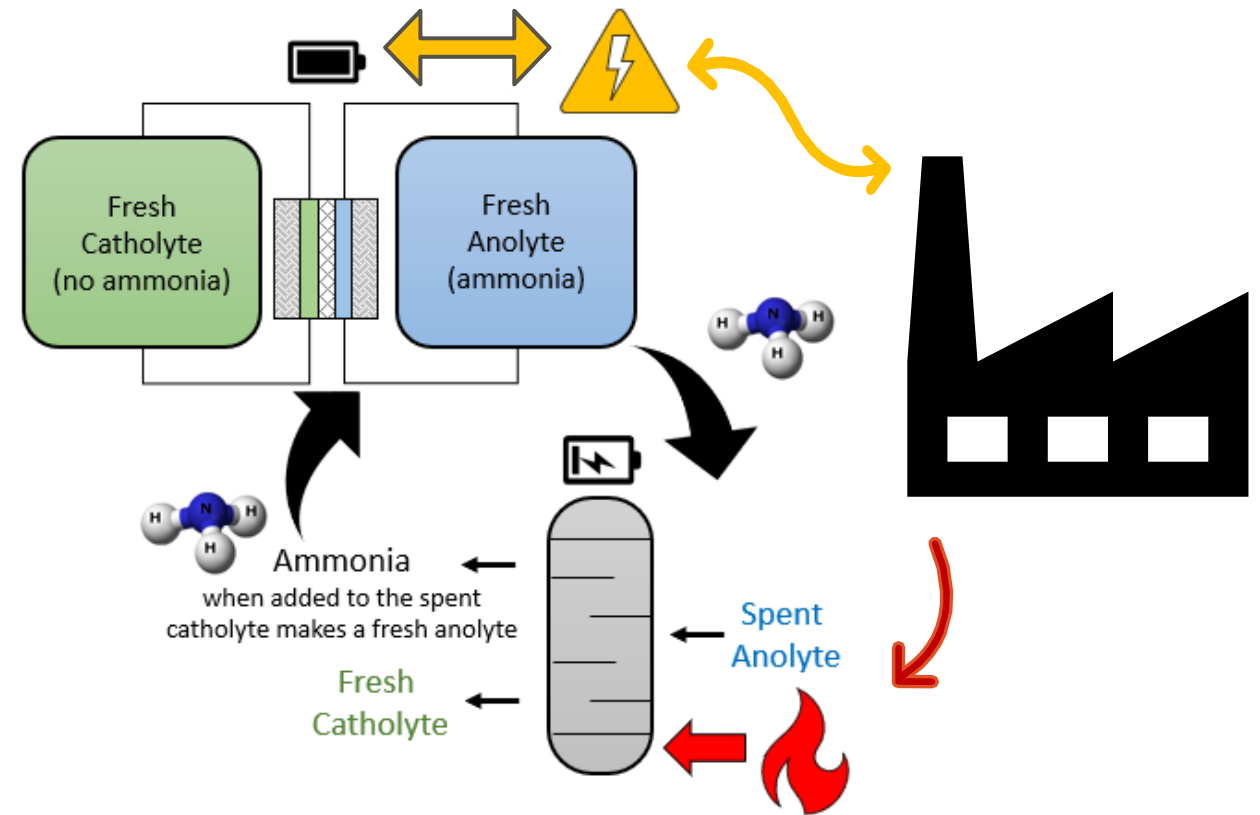
🤝 Sub-Recipients: None

📍 Location: University Park, PA

DOE: \$250,000

Non-DOE: \$62,500

Total: \$312,500



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Derek Hall

The EMS Energy Institute
Energy and Mineral Engineering



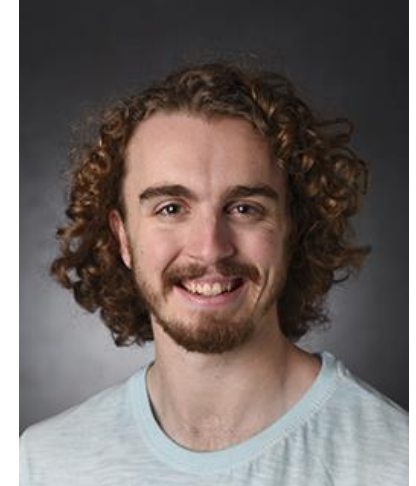
Serguei Lvov

The EMS Energy Institute
Energy and Mineral Engineering
Materials Science and Engineering



Matthew Rau

Mechanical Engineering



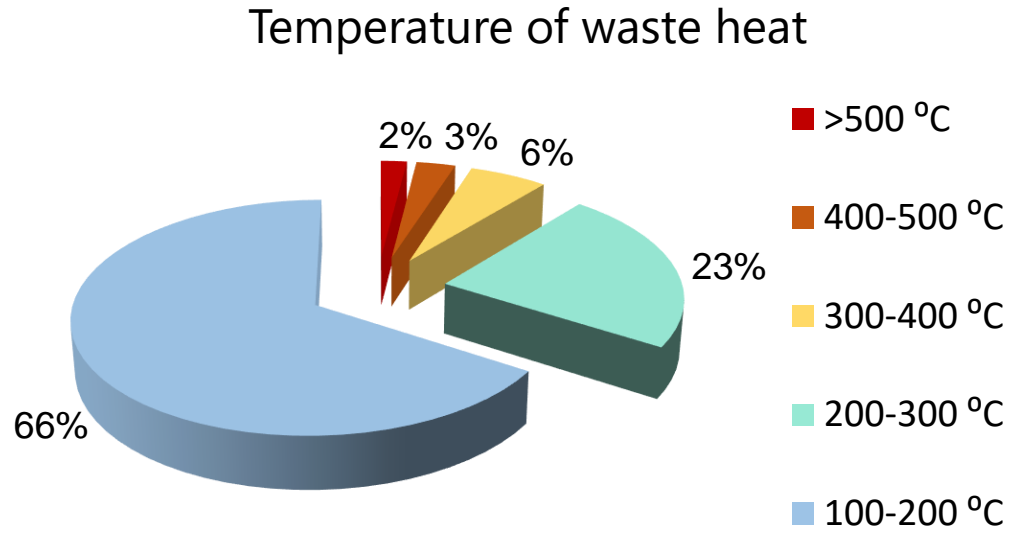
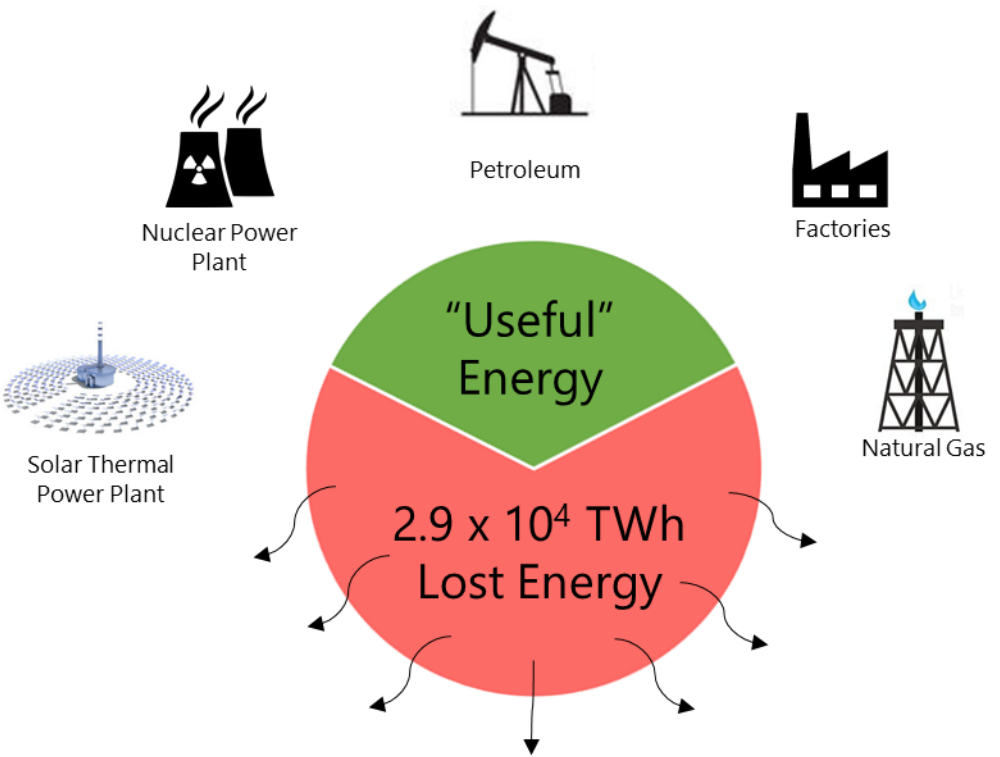
Nicholas Cross

Chemical Engineering

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The Untapped Potential: Low-Grade Waste Heat

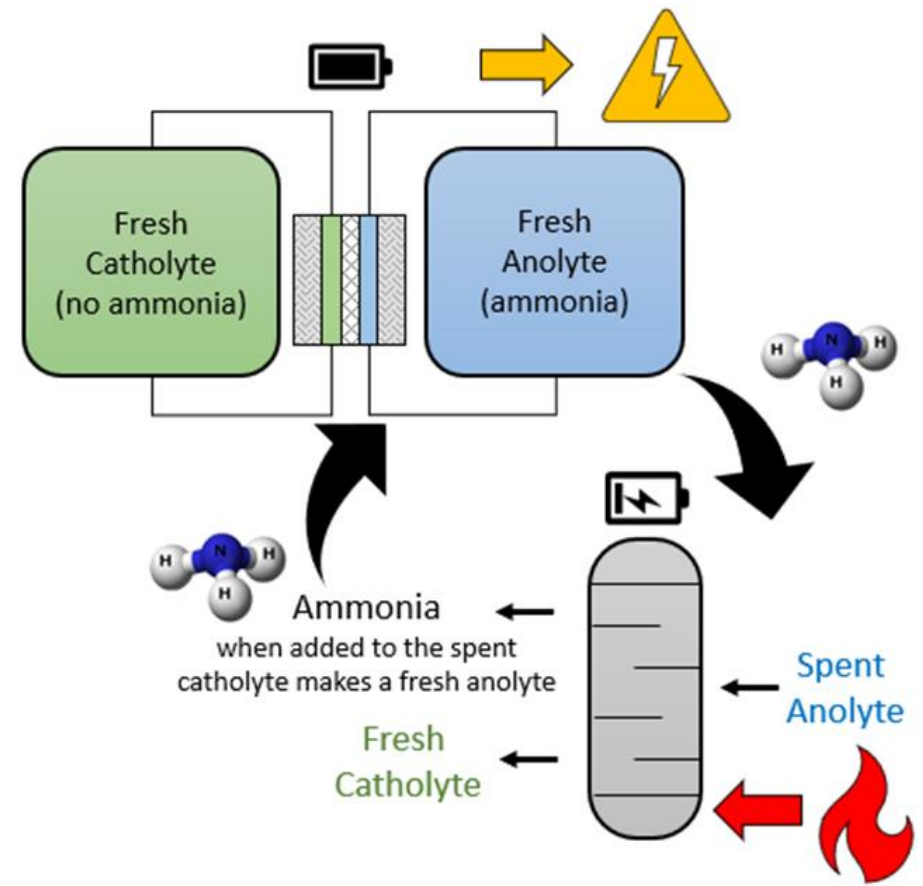
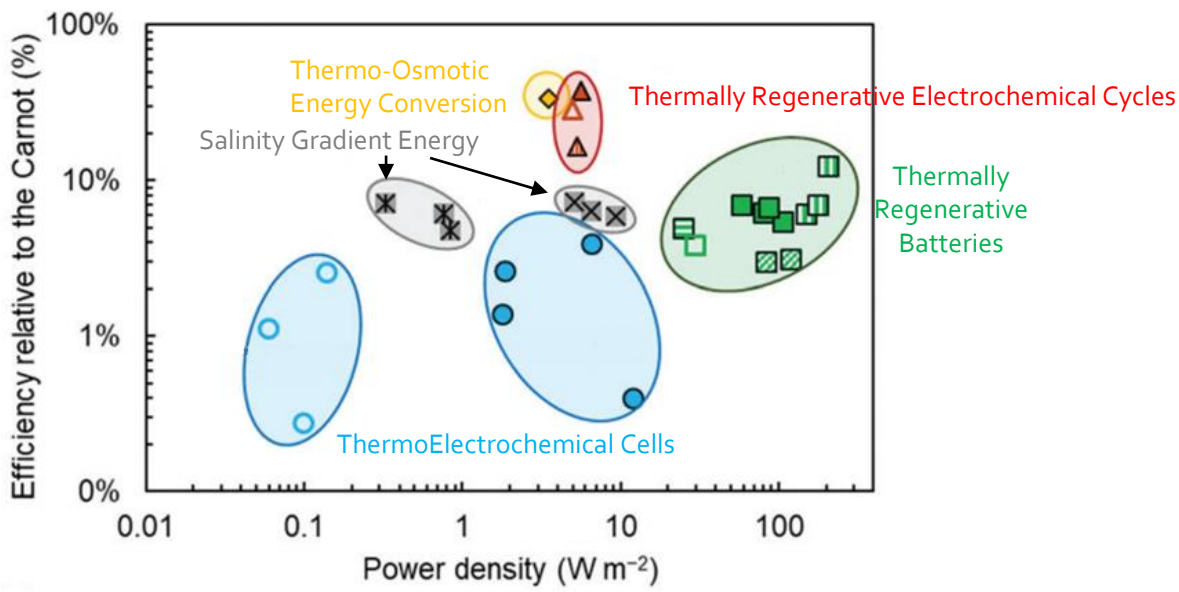


Adapted from M. Rahimi, A.P. Straub, F. Zhang, X. Zhu, M. Elimelech, C.A. Gorski, B.E. Logan, Emerging electrochemical and membrane-based systems to convert low-grade heat to electricity, Energy Environ. Sci. 11 (2018) 276–285.
Adapted from C. Haddad, C. Perilhon, A. Danlos, M-X. Francois, G. Descombes, Some efficient solutions to recover low and medium waste heat: competitiveness of the thermoacoustic technology, Energy Procedia 50 (2014) 1056-1069.

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The Technology: Thermally Regenerative Ammonia Batteries (TRABs)

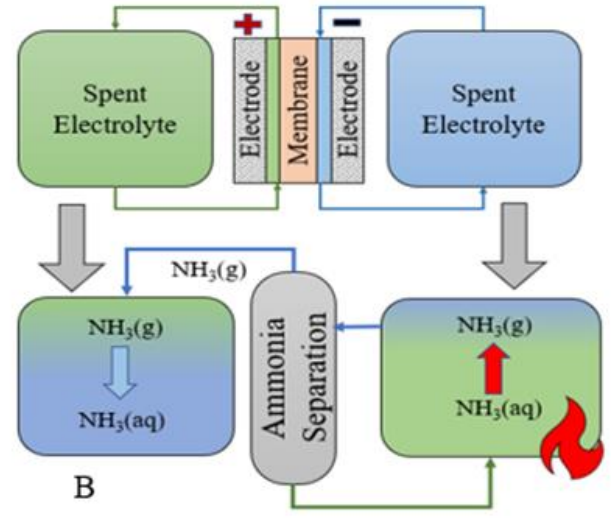
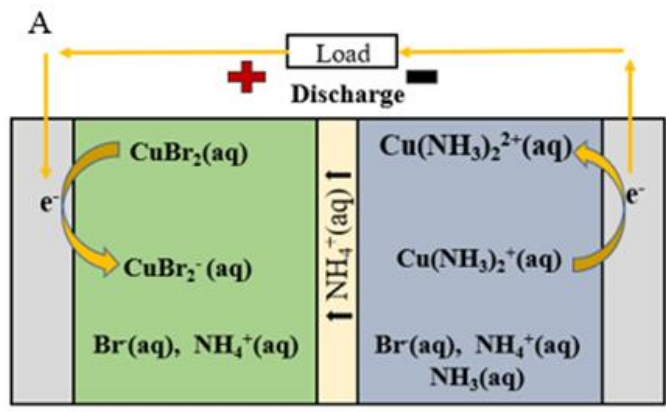
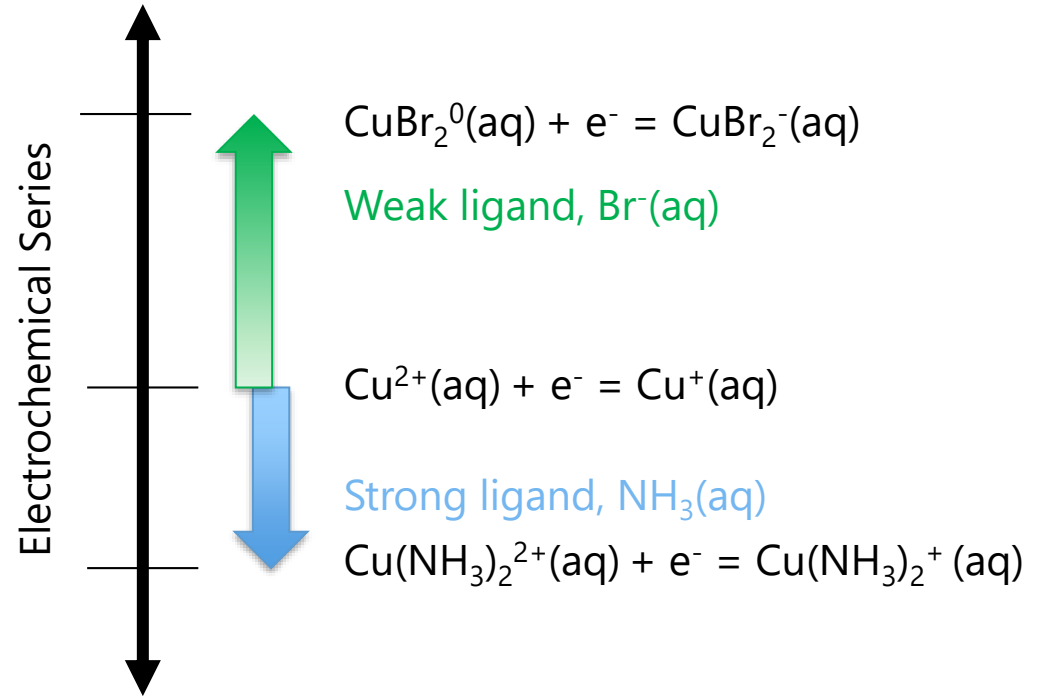


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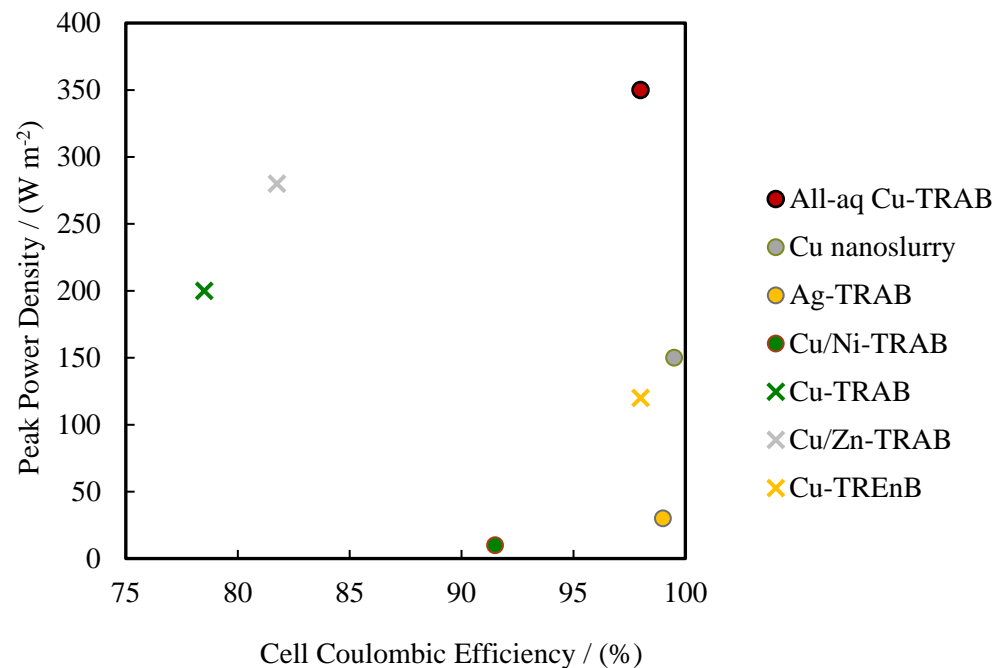
Our Approach: A New All-Aqueous Chemistry with High Performance



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Our Approach: A New All-Aqueous Chemistry with High Performance



Increases
power
density

Avoids
dendrite
formation

Increases
energy
density

High
coulombic
efficiency

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Project Benefits: TRABs Have the Potential to be Cost Competitive.

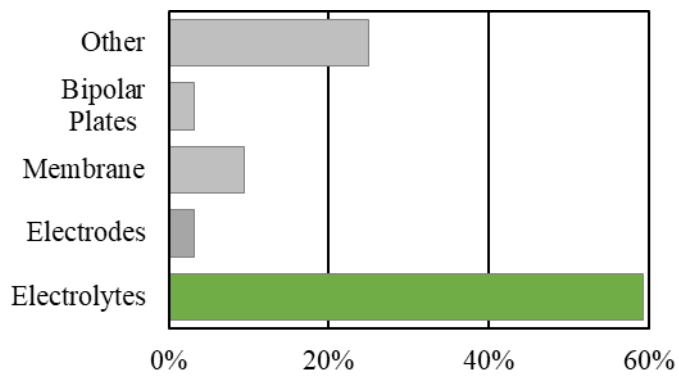
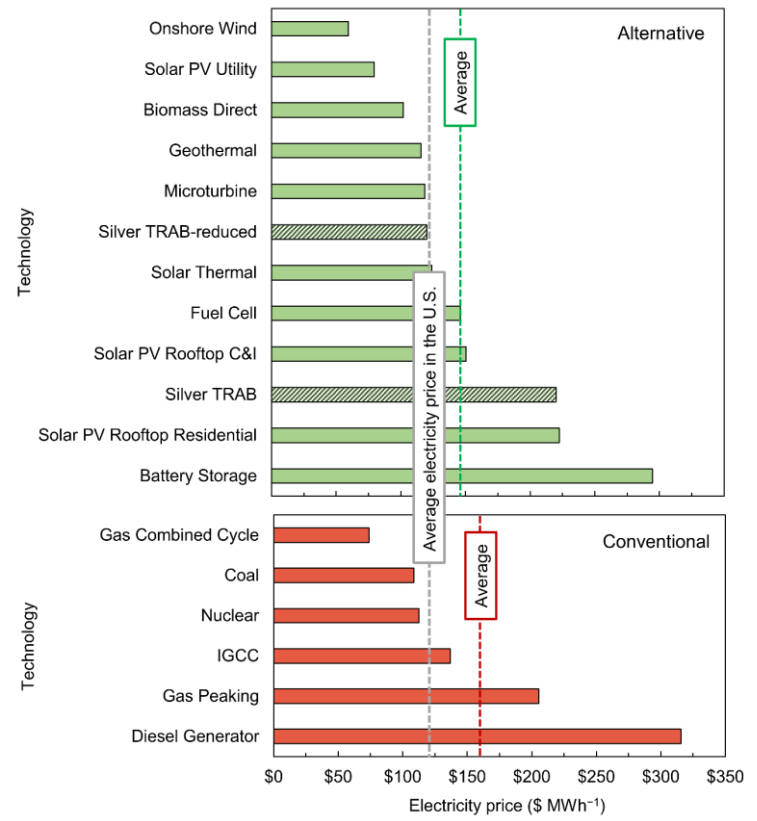


Figure 2. Cost Breakdown of an RFB.

Cost of metals

- Copper: \$0.66 / 100 g
- Vanadium: \$2.7 / 100 g
- Lithium: \$9.5 / 100 g



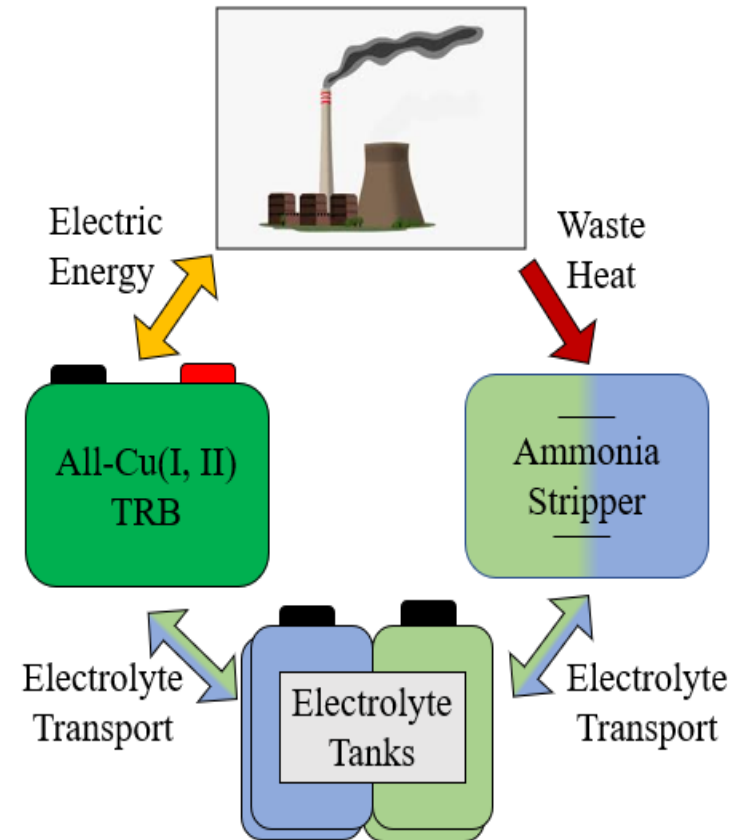
X. Wei, W. Pan, W. Duan, A. Hollas, Z. Yang, B. Li, Z. Nie, Materials and Systems for Organic Redox Flow Batteries: Status and Challenges, ACS Energy Lett. 2 (2017) 2187–2204.
 M. Rahimi, T. Kim, C.A. Gorski, B.E. Logan, A thermally regenerative ammonia battery with carbon-silver electrodes for converting low-grade waste heat to electricity, J. Power Sources. 373 (2018) 95–102.

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Project Benefits: TRABs can Improve the Efficiency of Fossil Fuel Assets

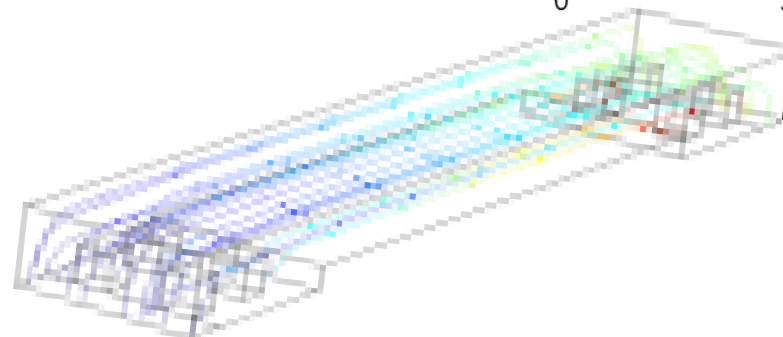
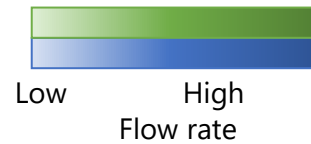
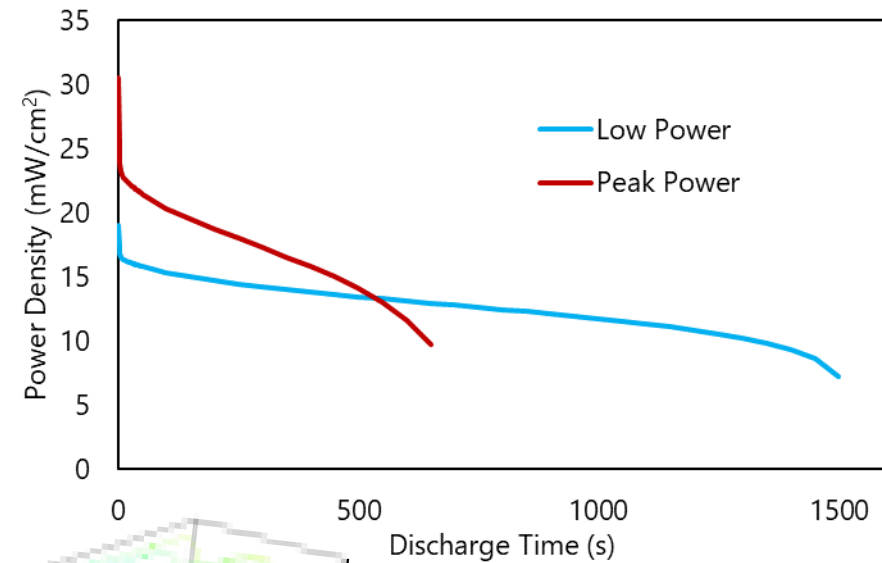
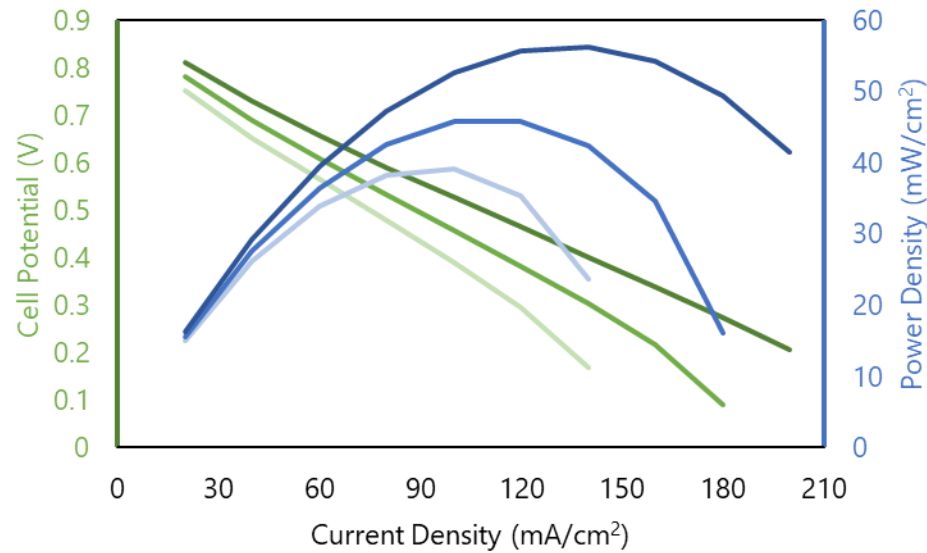
- The All-Aq TRB offers compelling integration options for fossil fuel assets as it can recharge with either electricity or low-grade thermal energy.
- When developed, this technology will be able to safely store large quantities of energy using materials that are inexpensive, readily accessible, and produced in large quantities.



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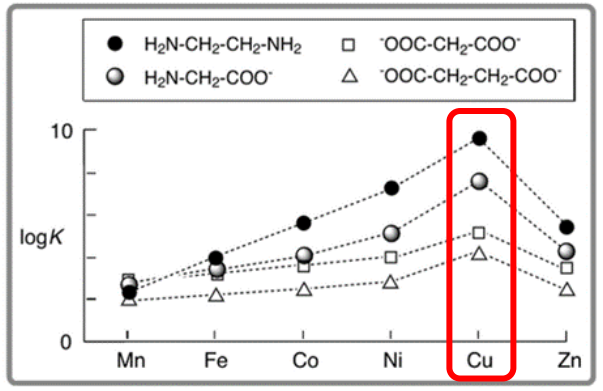
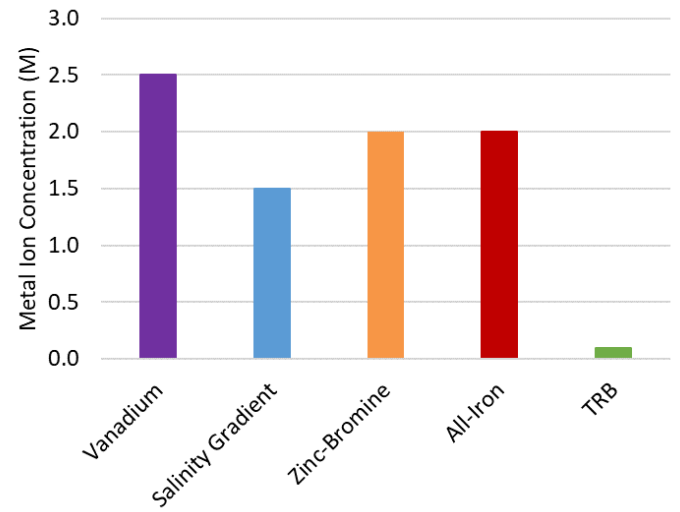
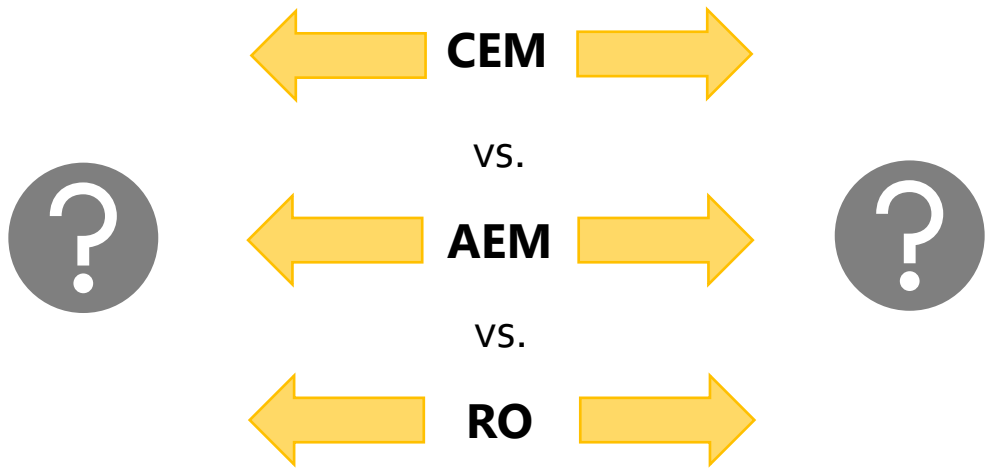
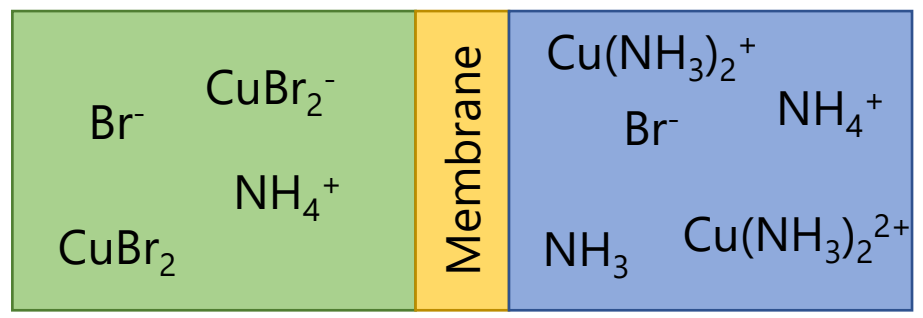
Project Objective: Construct a Robust Model of the New TRAB to Guide Further Development



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Challenges: Membrane Transport and Solubility Limits are not Known for Many TRAB Chemistries



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Thank you and please contact us with questions!



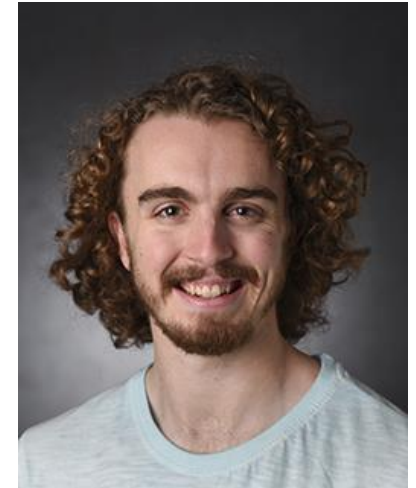
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