OAK RIDGE National Laboratory

Presentation #600

Enabling integration of renewable energy sources with long duration energy storage

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U.S. DEPARTMENT OF ENERGY

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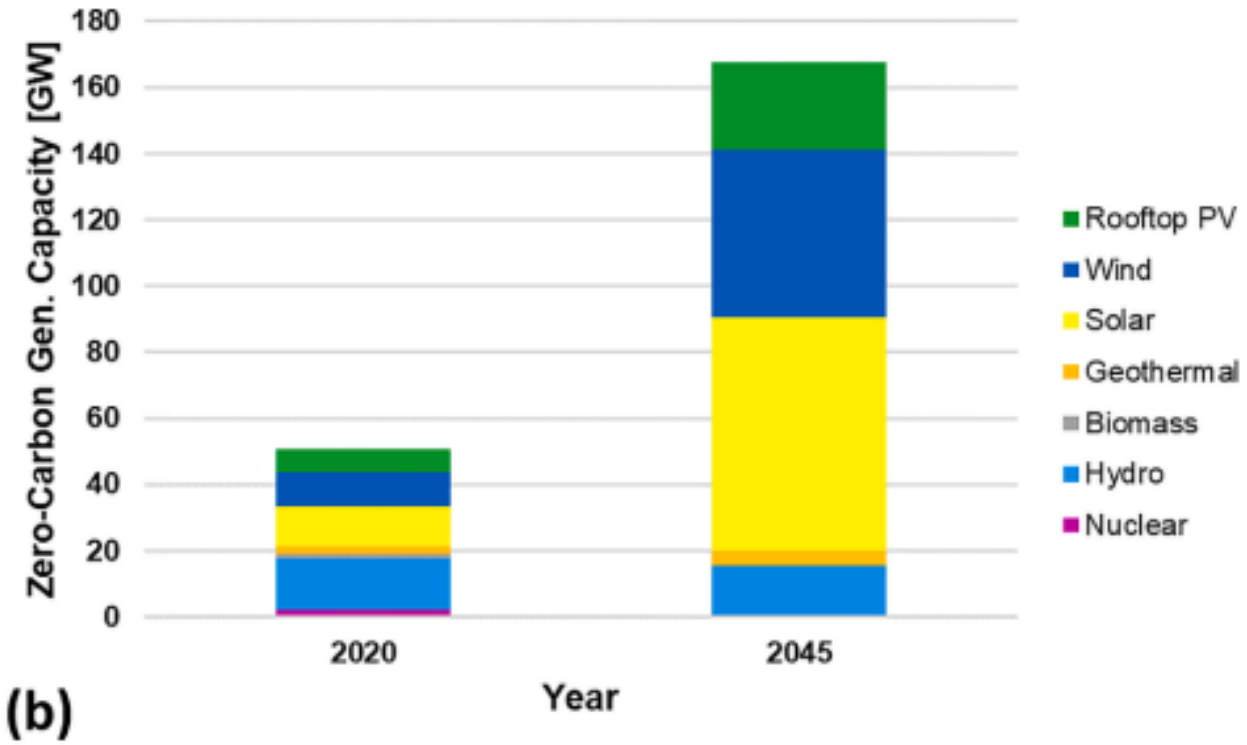
Critical National need to integrate long duration energy storage with renewable power generation

Projected renewable energy in California based on state laws



Applied Energy 300 (2021) 117354

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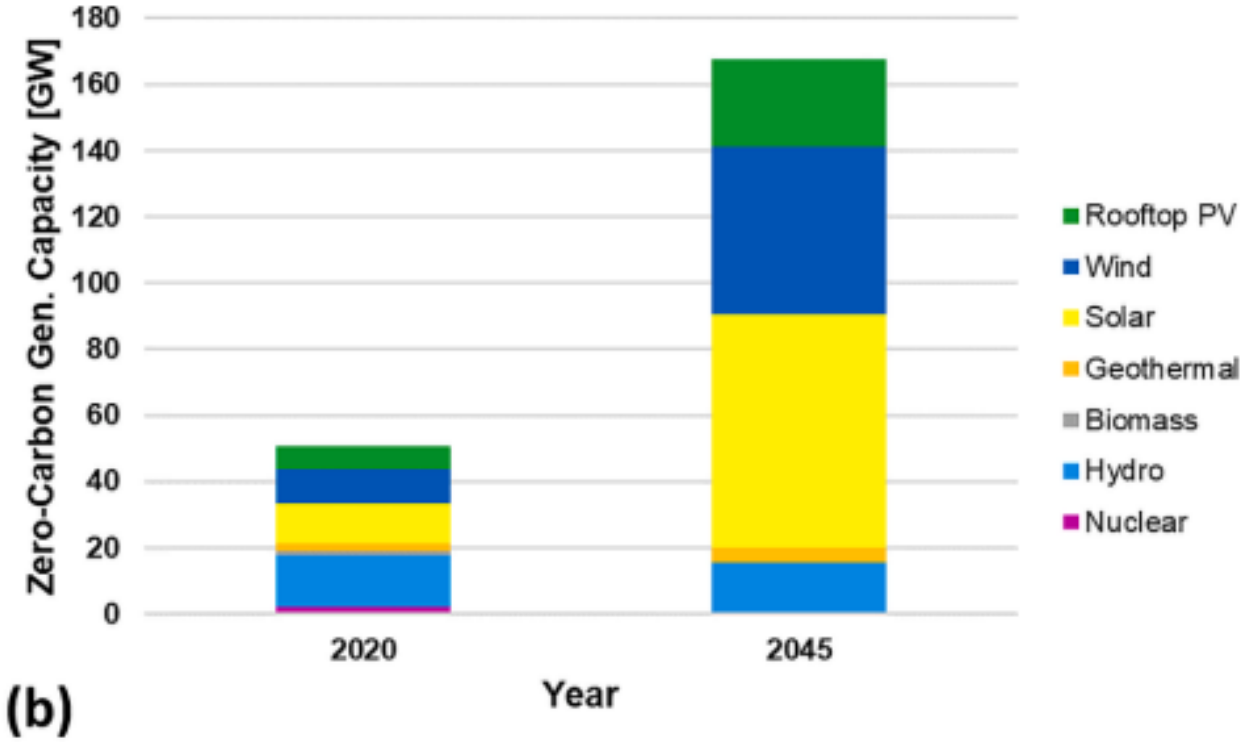

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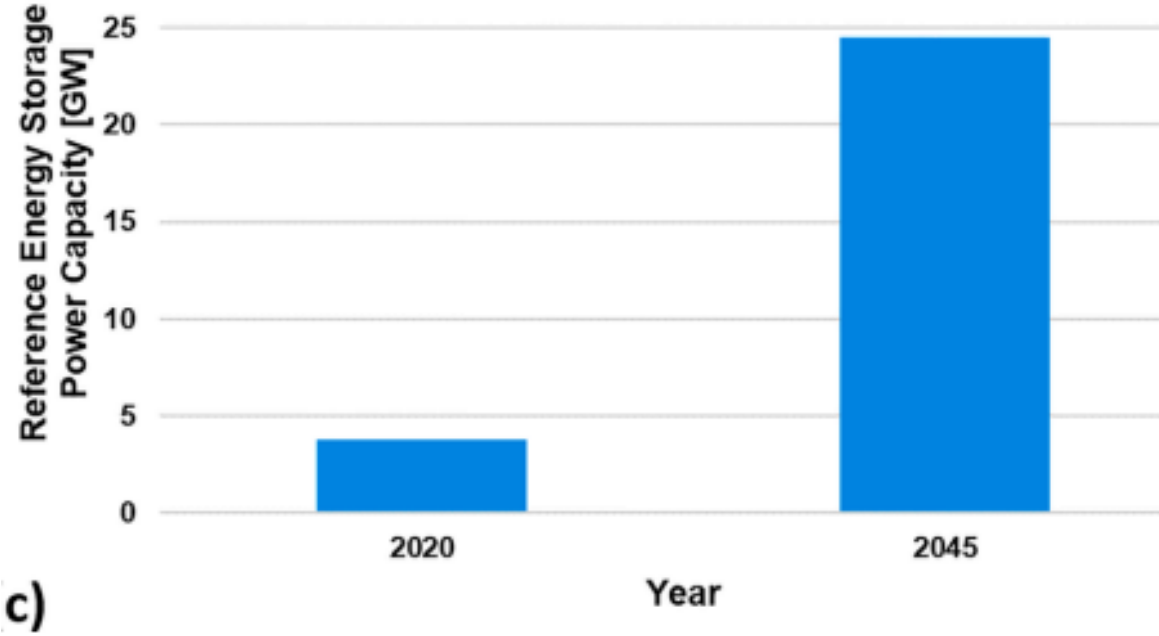
Required stationary storage for 5 hours of power



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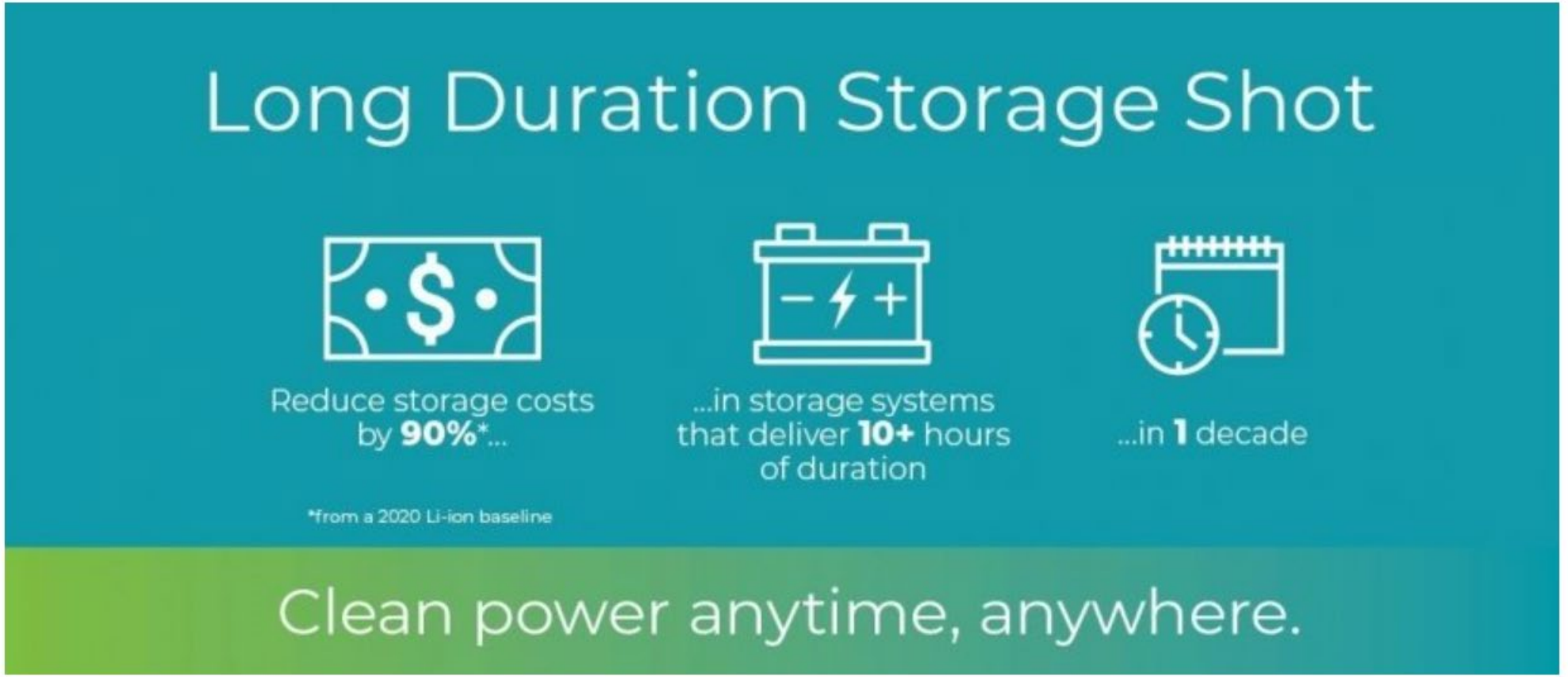
ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Storage™

Growing need for this type of storage where the OE program is leading the way



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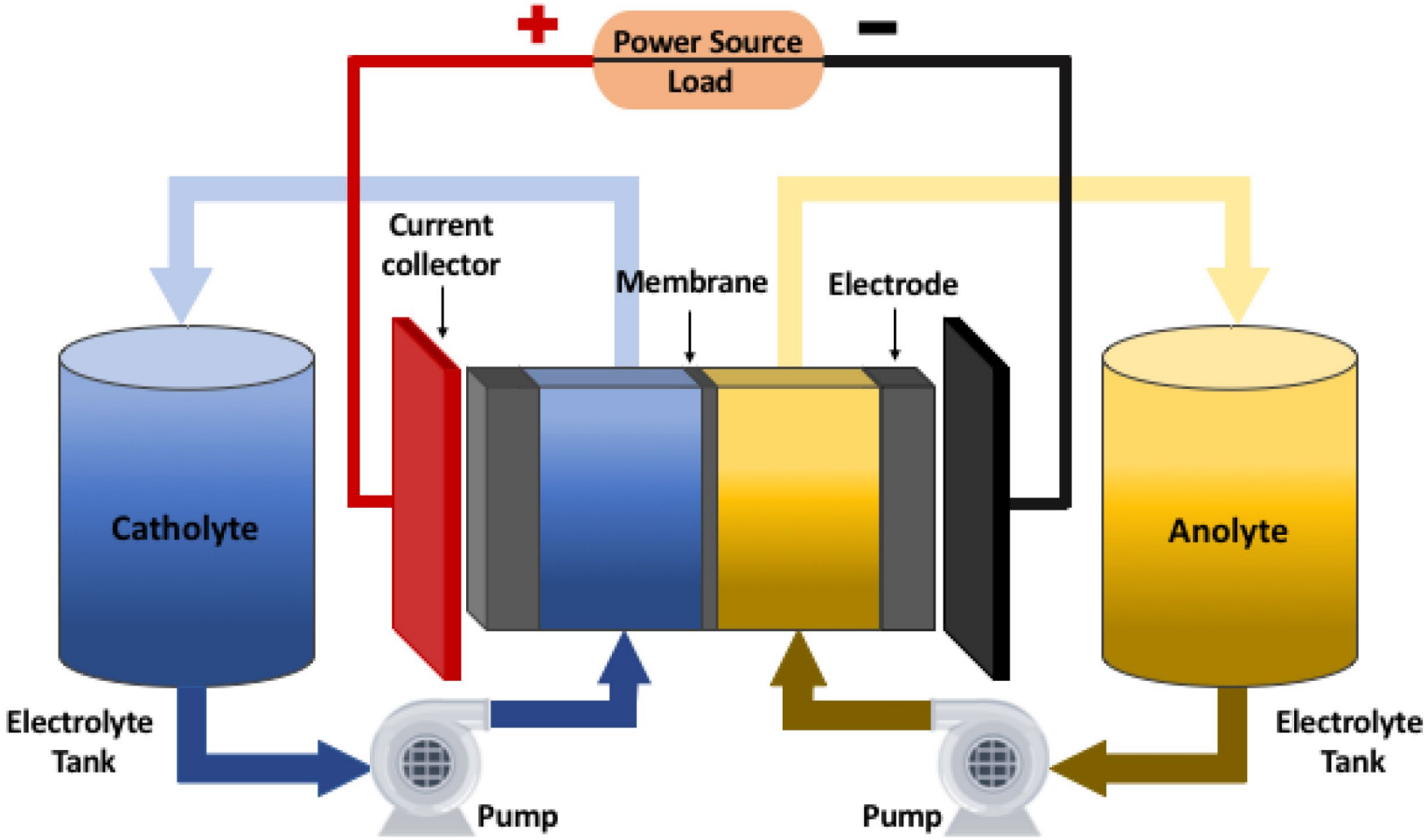
Redox Flow Batteries are one of the few scaleable technologies for long duration energy storage



Redox couples stored in tanks and pumped over electrodes to charge and discharge

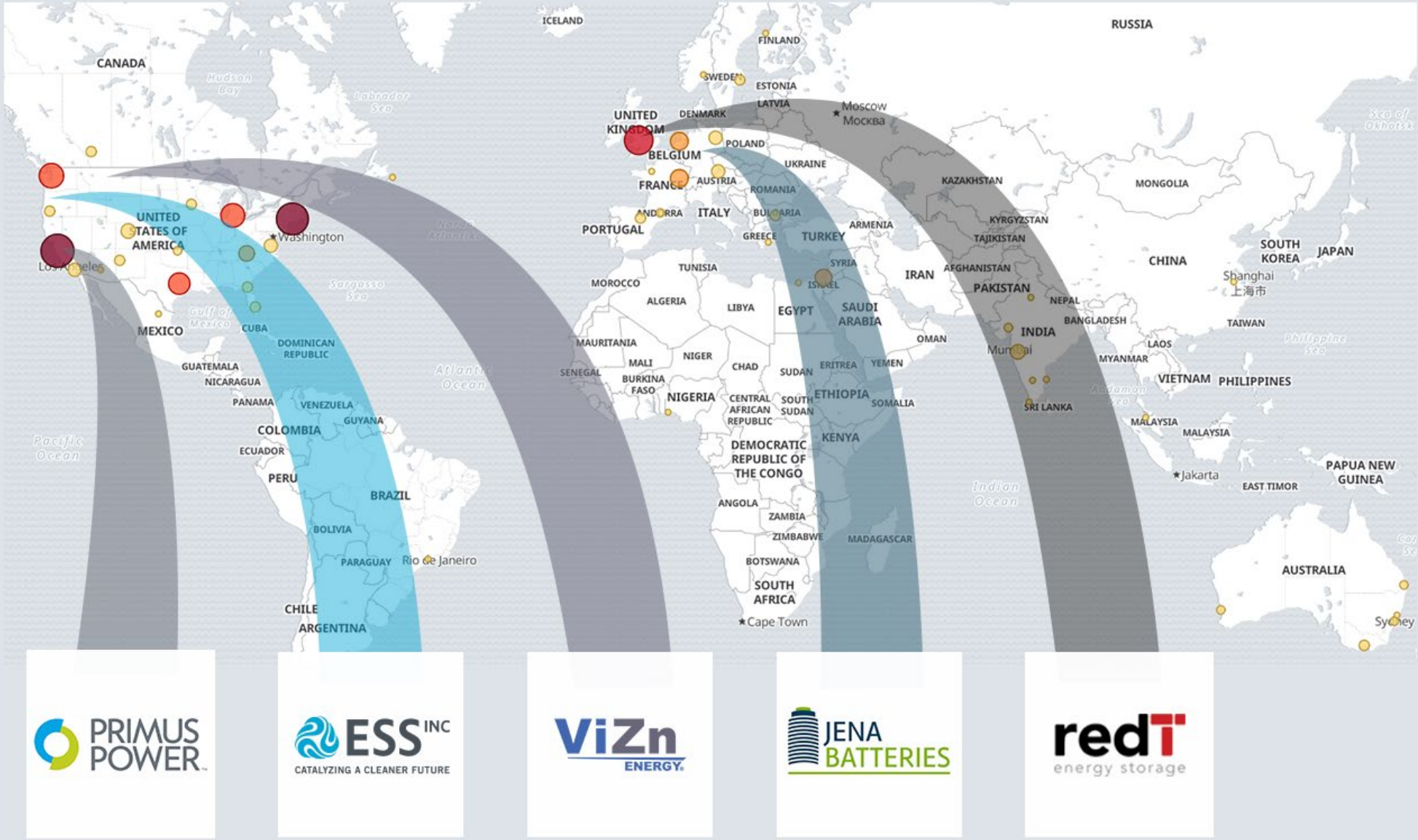
>125 companies world wide focused on various redox couples

Figure from *Electronics* 2020, 9(10), 1567 (2020)

5 Top Flow Battery Startups Impacting the Energy Industry

startus INSIGHTS

Mai 2019



PRIMUS POWER

ESS INC
CATALYZING A CLEANER FUTURE

ViZn ENERGY

JENA BATTERIES

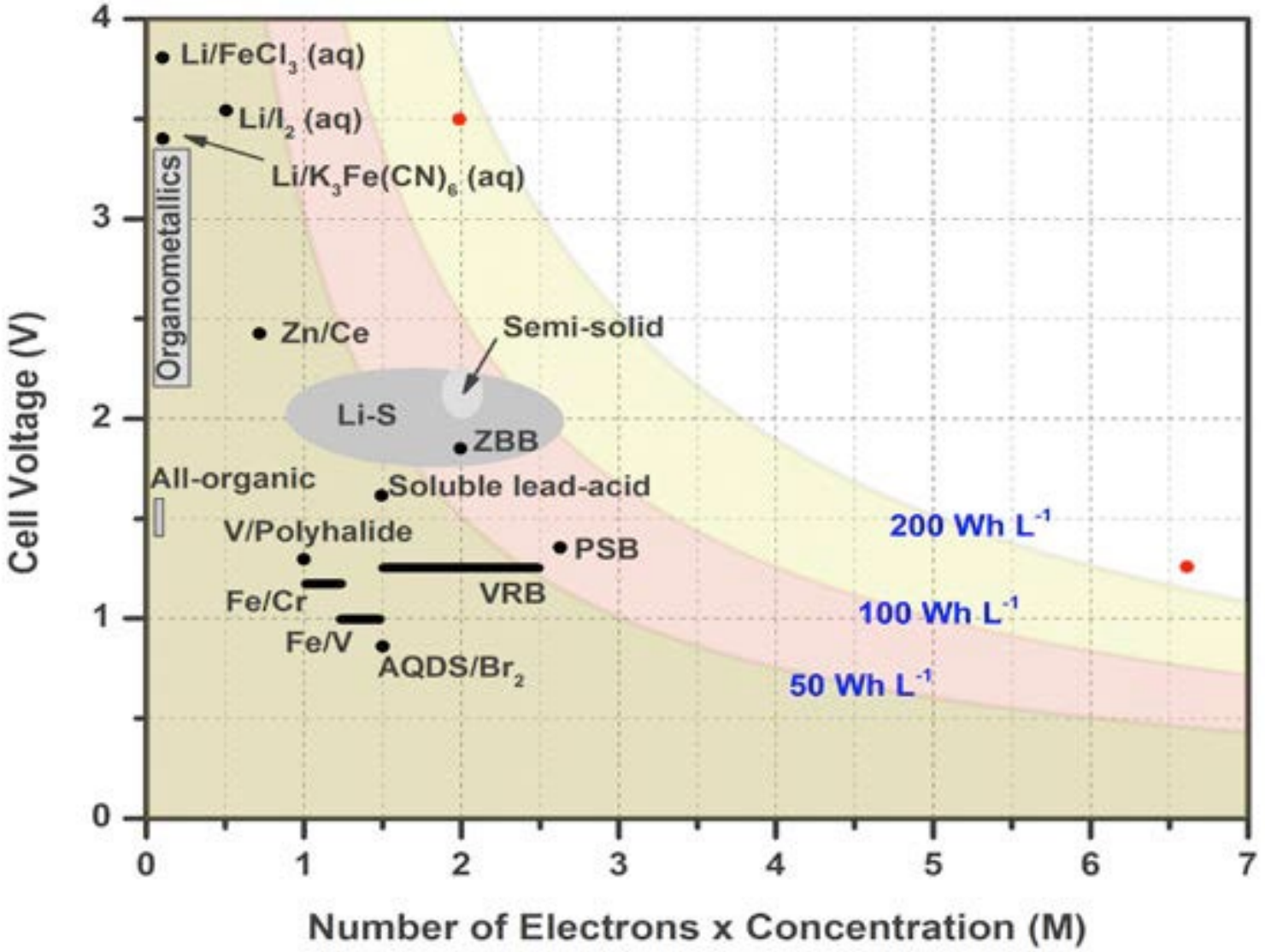
redT energy storage

This Heat Map illustrates the geographical distribution of 5 out of 124 flow battery startups disrupting the energy industry.

Scale power and energy density through design of cell stacks, volume materials, and redox couples

Figures from Tom Zawadzinski

Goal is to (1) reduce costs and (2) push energy density to higher values reducing footprint and driving functionality

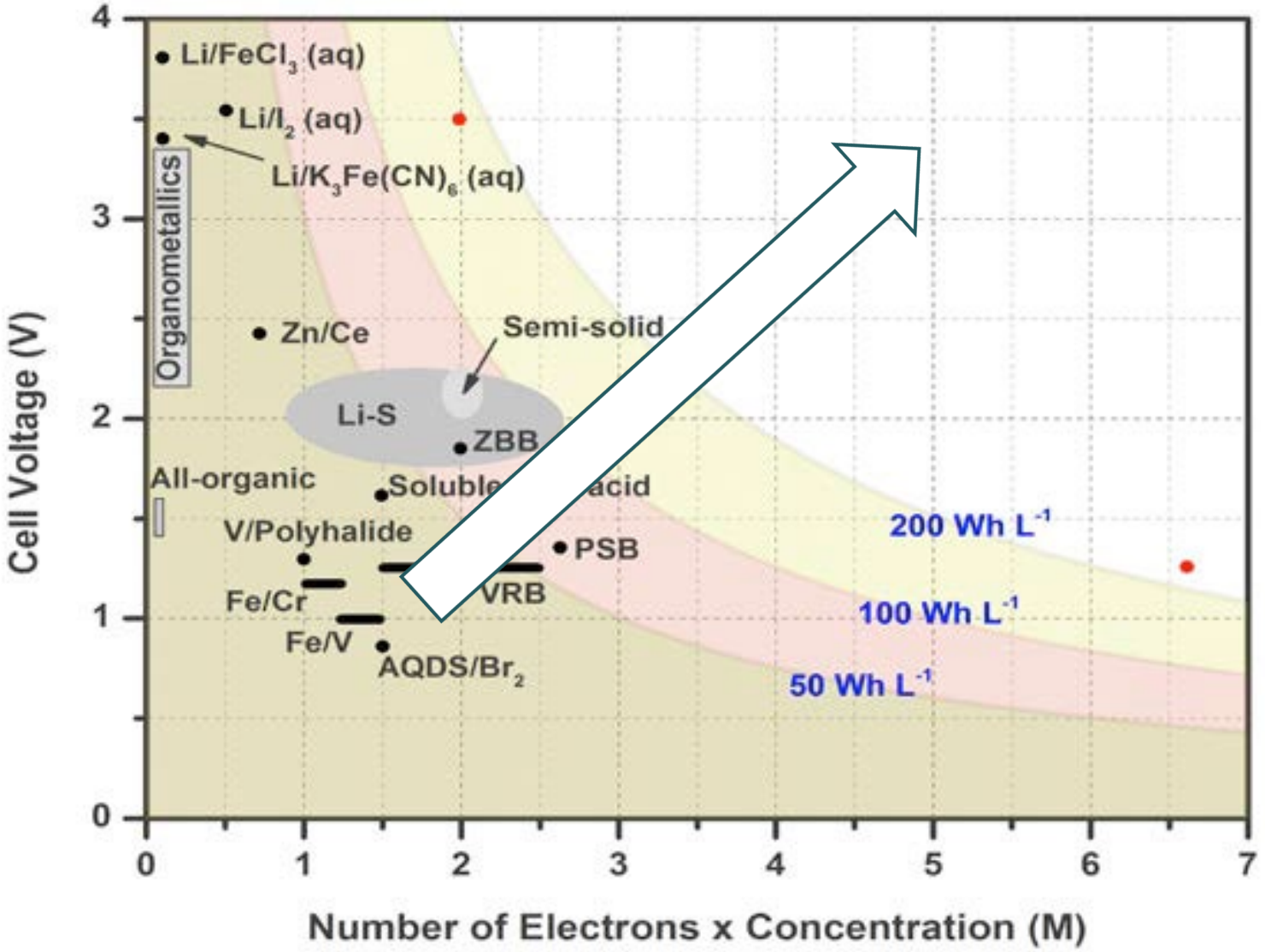


Lower cost to improve adoption
- VRFB about 60-80$/kWh (10% Vanadium)

Increase energy density to reduce capital costs
- Current generation of commercialized aqueous systems have relatively low energy density

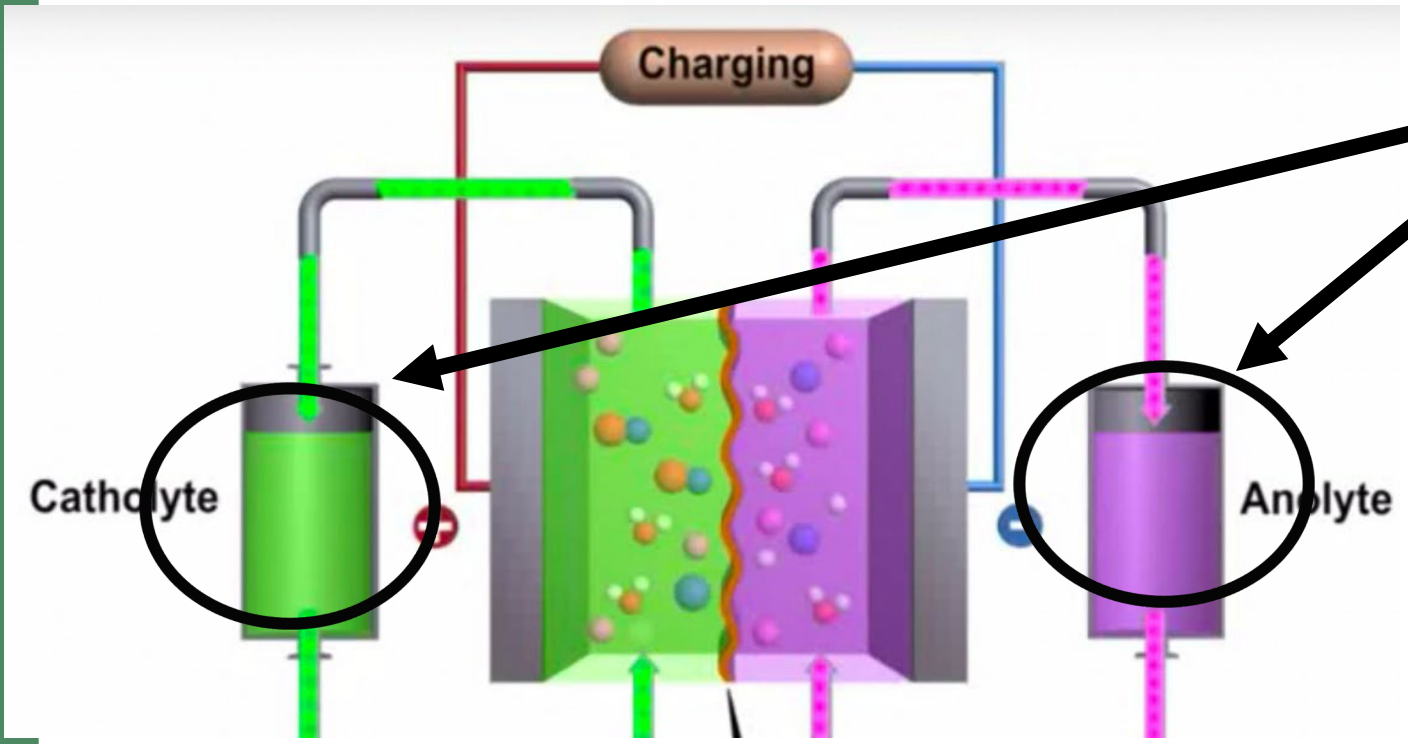
V-RFB ~25-35 Wh/L
Zn-Br ~70 Wh/L

Strong incentive to push energy density to higher values reducing footprint and driving functionality



Optimize will reduce the levelized cost of electricity

Major technological areas that need addressed



Challenge 1. Redox active species

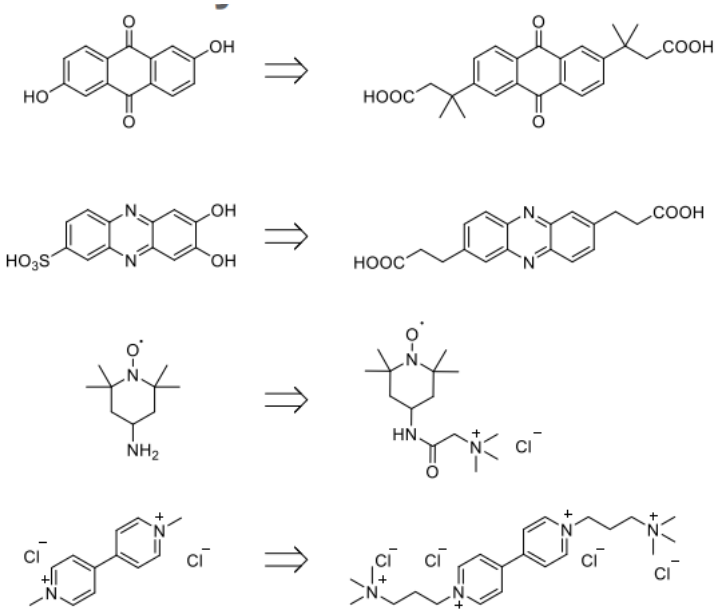
- Push to multivalent chemistry
- Non-aqueous species
- Soluble redox active organics
- Sulfides
- Stability with time and potential

Talk 601, 602, 605 – several posters

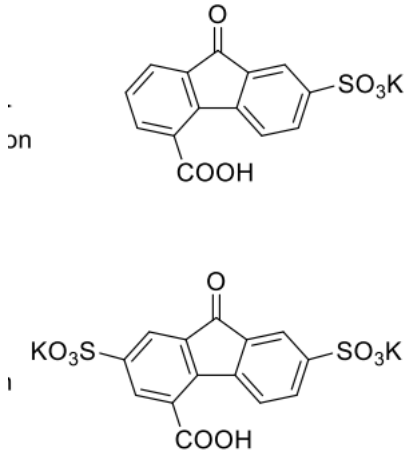
Figure from PNNL

Infinite number of redox couples enables critical science

Example of organic redox couples

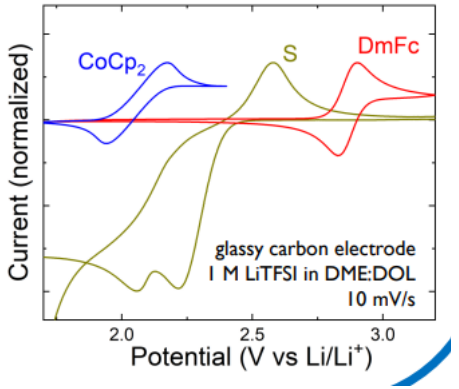


Talk 603

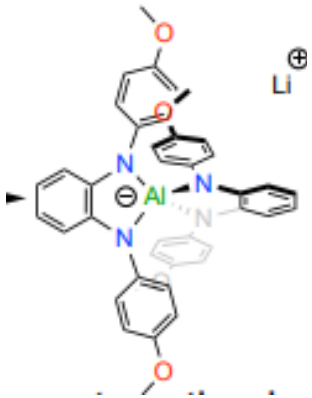


Talk 601

Example of inorganic redox couples



M. Gross Poster



M. Anstey Poster

Challenge:
Redox stability with time
Solubility
Cross-over

Opportunity:
Larger voltage window
Multi-electron processes
Cheaper than vanadium?

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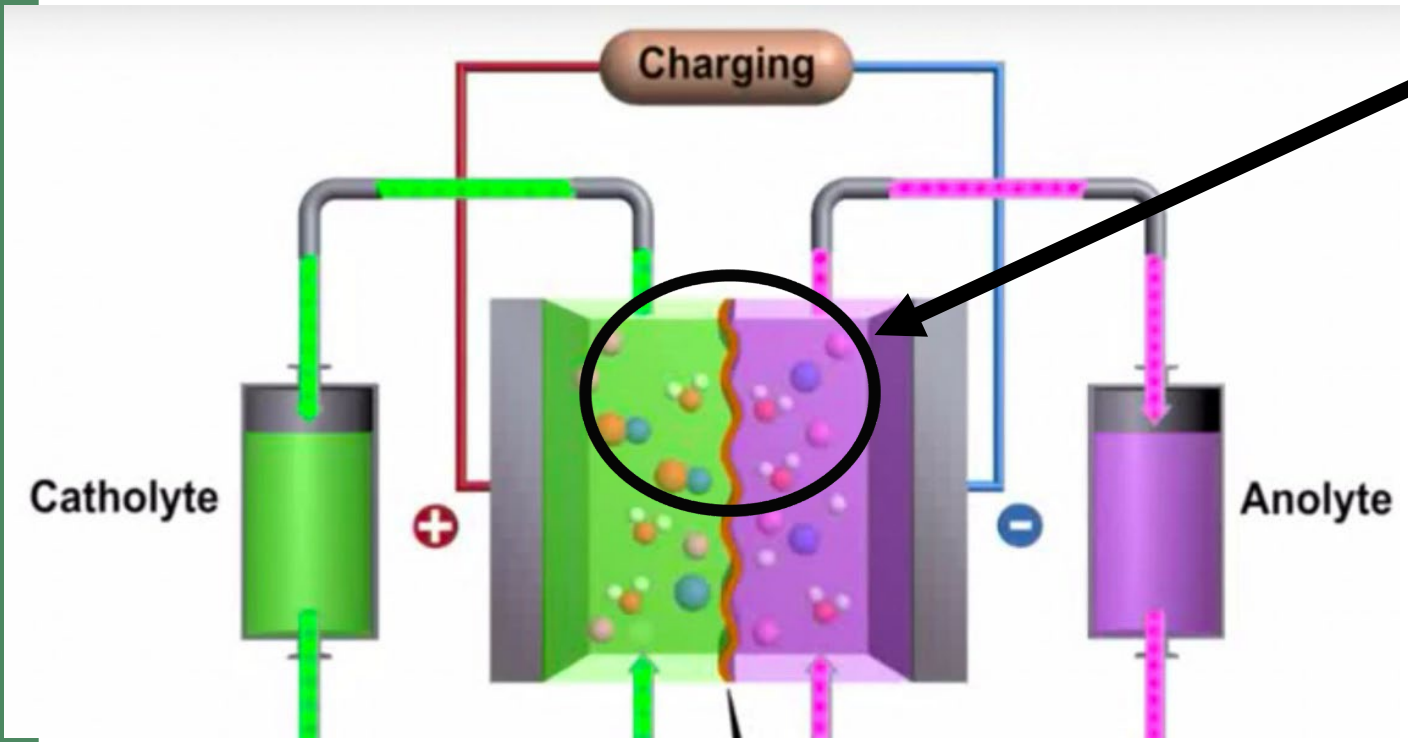
Major technological areas that need addressed



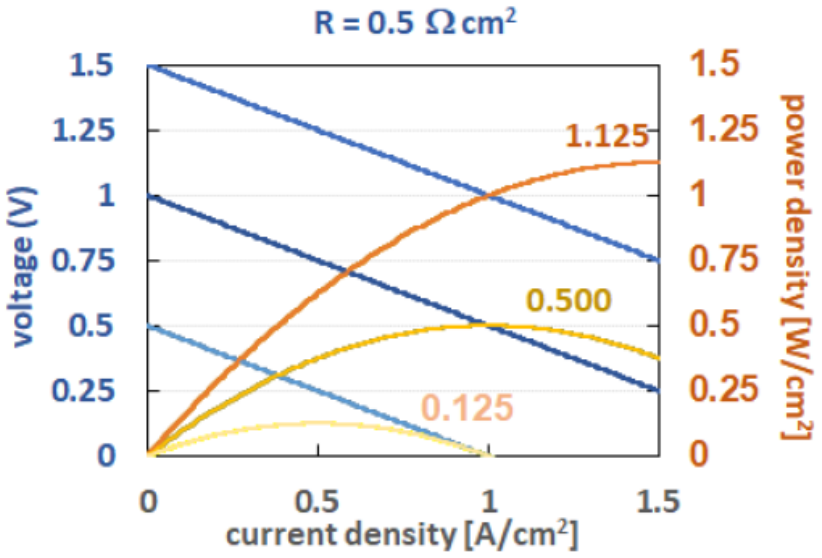
Challenge 2. membranes

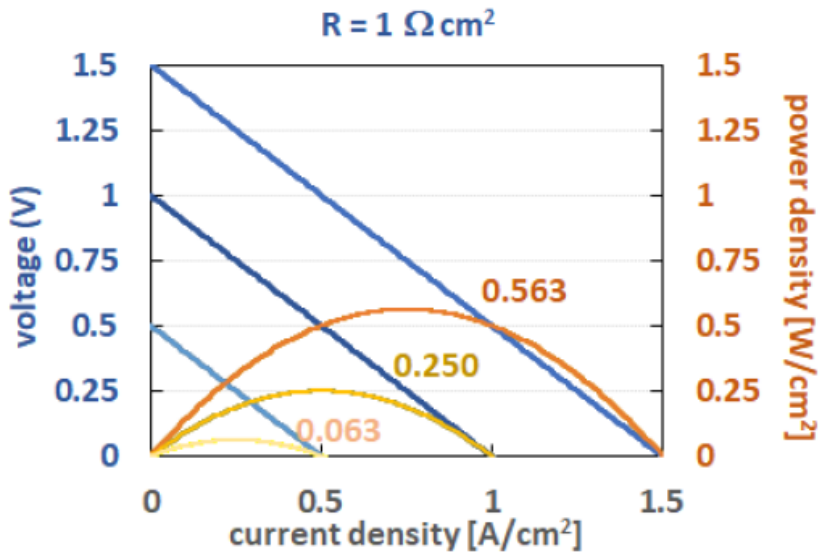
- Prevent diffusion of active species
- Enhance ion transport while reducing overvoltages
- Stability with time and potential
- Cost

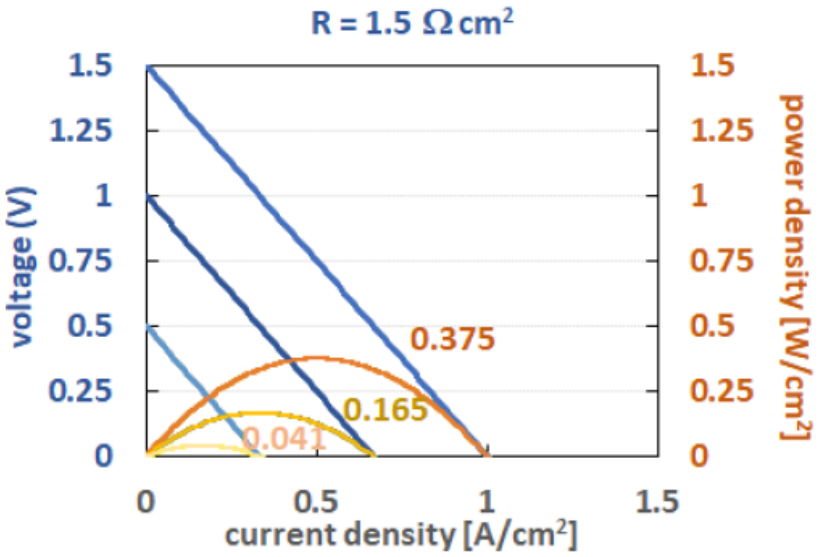
Talk 603, 604 – several posters

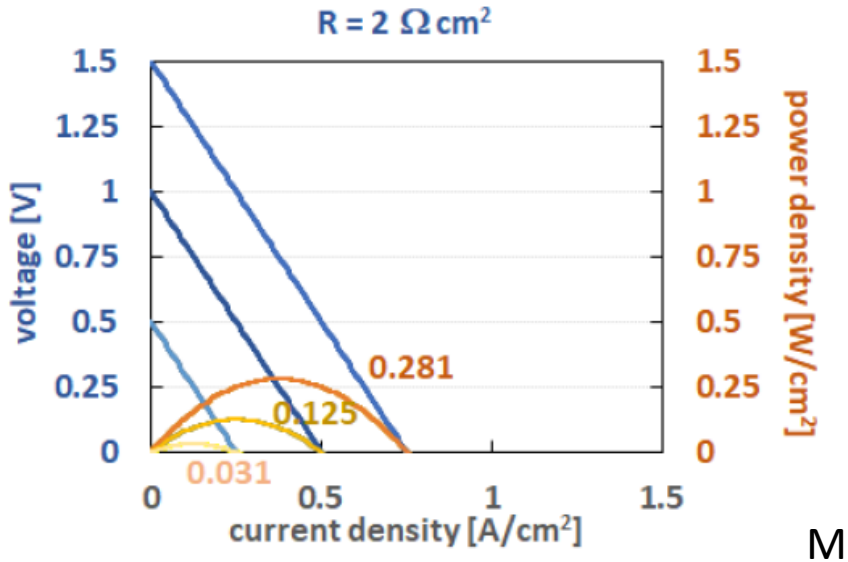
Figure from PNNL

Wrench out transport resistances to obtain maximum power





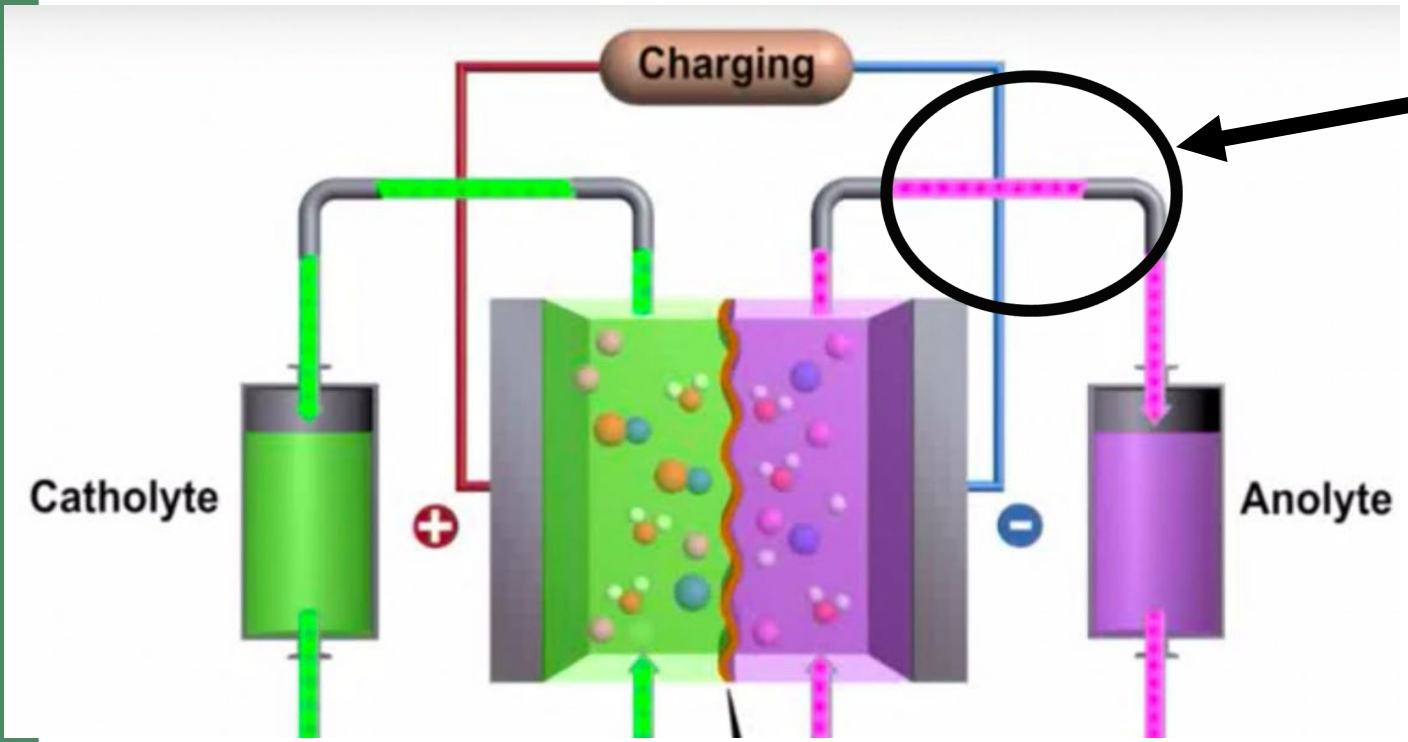




- Function of flow fields
- Ionic transport across membrane
- Desolvation kinetics/barriers

Molecules **2022**, 27, 560.

Major technological areas that need addressed



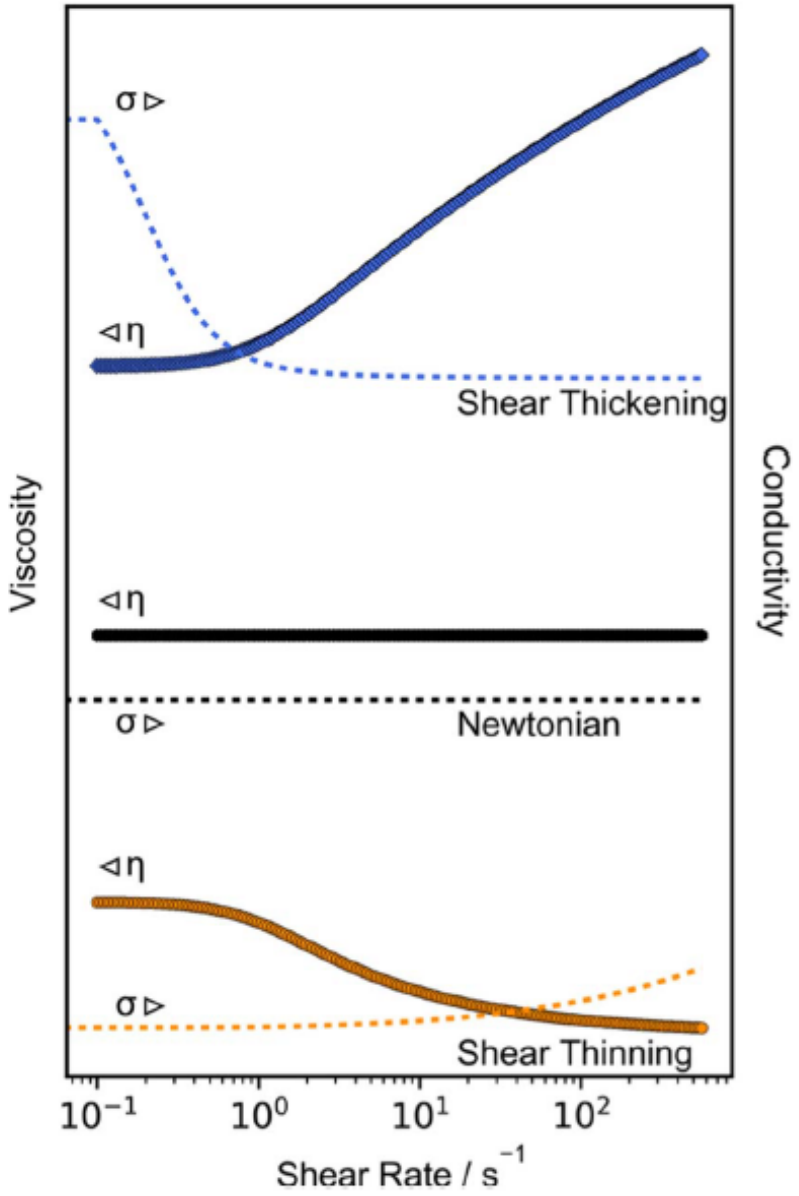
Challenge 3. Diffusion and transport kinetics

- Ionic conductivity as a function of viscosity
- Solubility of all species in solution
- Protic vs. Aprotic

Talk 603 – several posters

Figure from PNNL

Ionic conductivity under flow becomes challenge with solubilized species



Shear thickening electrolyte

Normal electrolyte

Shear thinning electrolyte

Stability with temperature and environment conditions

- Temperature in central Pennsylvania was 1°C 10/9/22 when the windmills were spinning
- Critical challenge is temperature swings which affect ion transport
- Materials stability
  - Redox molecules
  - Tanks
  - Pumps

Areas where there is lost of wind also have wide temperature swings but are used to seeing big tanks