PERFORMANCE-IMPROVING STRATEGIES FOR ZINC-AIR BATTERIES FOR THE GRID-SCALE STORAGE MARKET

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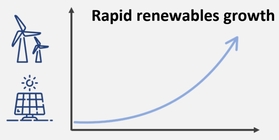
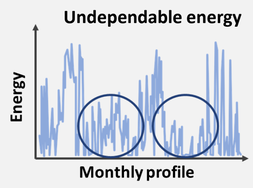
Introduction

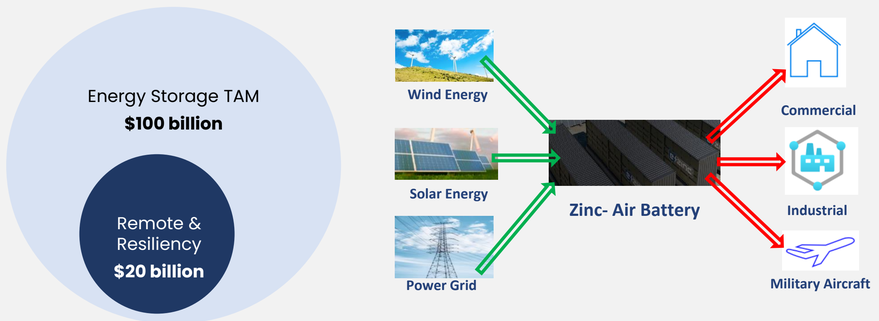
Long-duration energy storage (LDES) for grid-sector purpose

- Power sector generates one third of domestic emissions in US
- To meet 100% carbon-pollution free electricity, renewables (e.g. winds, solar) is required to be used
- Key for the decarbonized power system



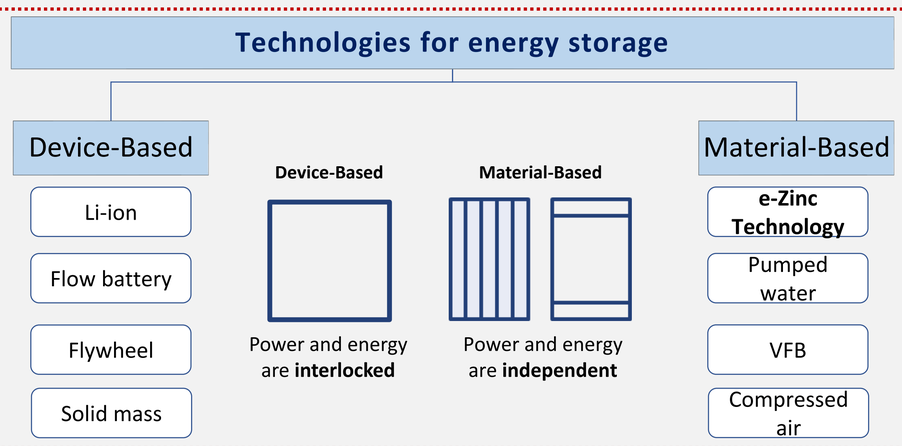


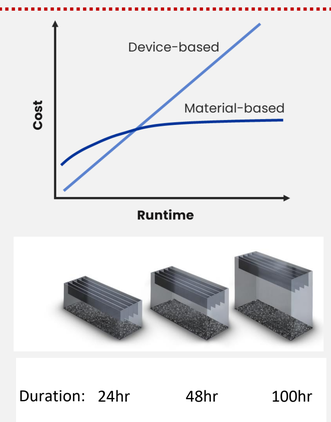
Energy Storage and Metal-Air Market



- Metal-Air Battery Market is projected to grow from USD $498M in 2022 to USD $993M by 2027, at a CAGR of 14.8%
- By metal, zinc segment is estimated to lead metal-air battery market in 2022

Technologies for energy storage





Advantages of e-Zinc's device-based technology

Lowest Capital Cost
- Scale energy capacity independently from power
- Up to **90% less than Li-ion cost** for energy capacity

Flexible & Scalable
- **Energy:** hours, multi-day, or longer
- **Power:** residential / C&I (kW) to grid / utility (MW)

Advantages of the Zinc Air Battery

- Higher energy capacity
- Cost effectiveness
- Safe to use compared to LIB
- Environmentally friendly nature

Electrochemical reactions in zinc–air battery

$$Cathodic:\ Zn(OH)_{4(aq)}^{2-} + 2e^- \rightarrow Zn_{(s)} + 4OH_{(aq)}^-$$

$$Anodic\ :\ 4OH_{(aq)}^- \rightarrow 2H_2O_{(aq)} + O_{2\,(aq)} + 4e^-$$

Charge: − / +

$$Cathodic:\ O_{2\,(aq)} + 2H_2O_{(aq)} + 4e^- \rightarrow 4OH_{(aq)}^-$$

$$Anodic:\ Zn_{(s)} + 4OH_{(aq)}^- \rightarrow Zn(OH)_{4(aq)}^{2-} + 2e^-$$

Discharge: + / −

e-Zinc Technology: Structural design of the electrochemical cell

Breakdown of the three independent sections of (a) energy absorption, (b) storage volume, and (c) energy delivery in a singular form factor, with possibility of separation into discrete containers.

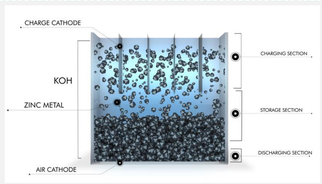
Simplified illustration of the basic structural design of a scalable aqueous zinc-air cell

Schematic illustration of the possibility of (a) scaling the cell for (b) power capacity , (c) energy capacity , (d) and prototype cell made

e-Zinc Technology Features Over Other Zn-Air Technologies

Charge / Discharge Decoupling

- Independent operation of charging and discharging
- Independent scaling of power and energy capabilities
- Scaling up at low cost of the storage capacity



Single Container for the Charge & Discharge

- No efficiency losses due to moving the zinc metal

Resolving the jamming issues during Zinc transferring

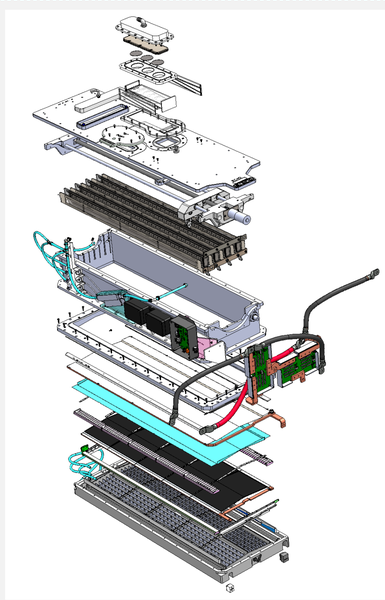
- Transporting the zinc metal within the same assembly using gravity

Dendritic Zinc Tolerant

- Dendritic nature can be easily removed from the surface of the cathode using a unique wiper design at charge section
- Good kinetics at a wide range of currents during discharge

Electrolyte circulation System

- Homogenize the electrolyte concentration in different locations within the cell
- Improve the performance of the electrochemical system at charge & discharge



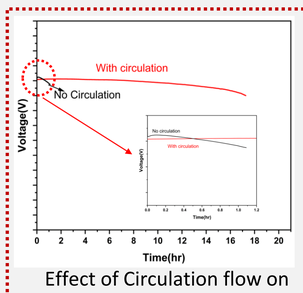
Conclusion

- Demonstrated successfully a novel scalable aqueous zinc-air cell with flexibility to target high-power & high-capacity grid storage application.
- Unique design approach and the decoupled charge and discharge principle has enabled e-Zinc to overcome fundamental challenges of zinc-air battery technology.

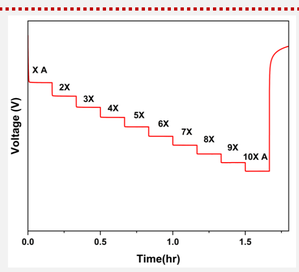
Acknowledgment

- E-Zinc acknowledges the Sustainable Development Technology Canada (STDC) for their support to accelerate commercialization of its breakthrough energy storage technology

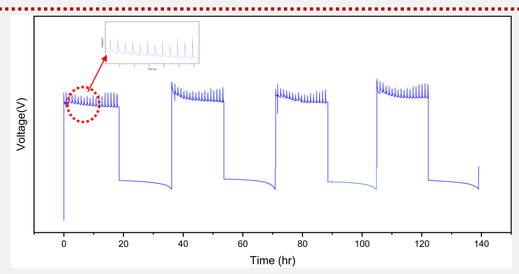
Cell Performance Analysis



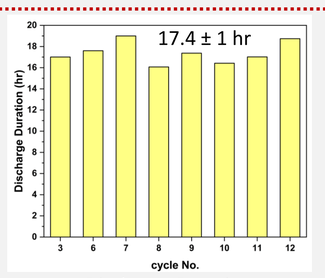
Effect of Circulation flow on discharge performance



Polarization Profile



Cycling performance of the e-Zinc cell with a constant current



Discharge Duration

Reference

- G. X. Zhang, "A dual power cell for storing electricity in zinc metal," *Journal of Power Sources*, vol. 285, pp. 580–587, 2015. doi:10.1016/j.jpowsour.2015.03.084
- Z. Shao and X. Xu, *Zinc-Air Batteries: Introduction, Design Principles and Emerging Technologies*. Newark: John Wiley & Sons, Incorporated, 2023.