Alkaline Zn-MnO_2 Batteries

Jinchao Huang

NAATBatt INTERNATIONAL

CUNY Energy Institute

URBAN ELECTRIC POWER

Zn-MnO_2 Batteries

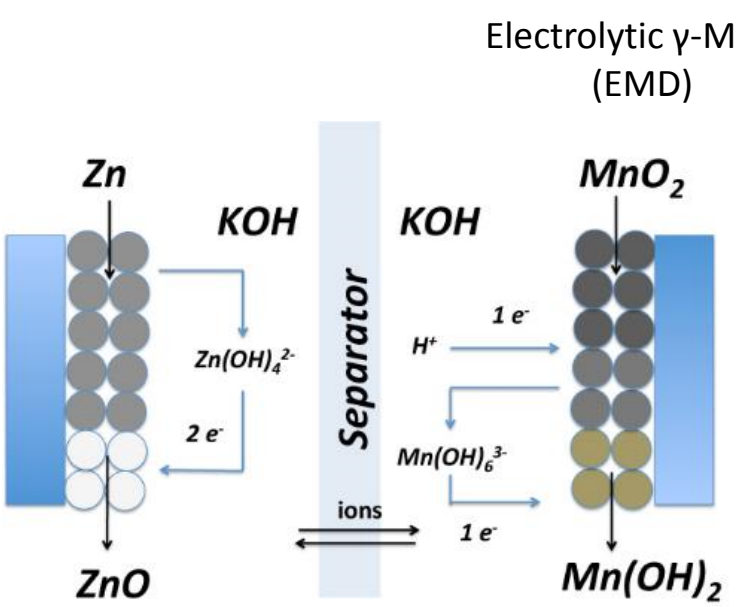
- Lowest bill of materials cost, low manufacturing capex
- Established supply chain for high volume manufacturing
- Readily be produced in larger form factors for grid applications
- Traditionally primary batteries at $18-25/kWh with long shelf life
- Do not have the temperature limitations of Li-ion/Pb-acid
- Inherently safer, e.g. EPA certified for landfill disposal

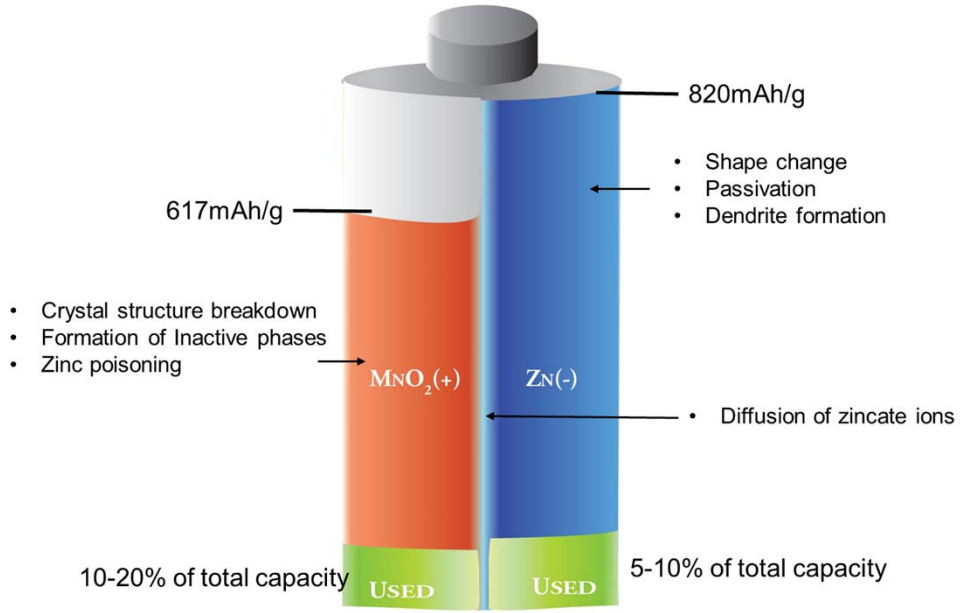
- The ultimate challenge in Zn-MnO_2 batteries is reversibility

Making Zn-MnO_2 Rechargeable

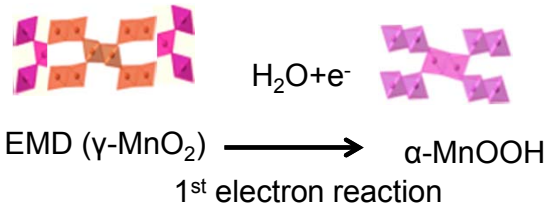
- Earlier approaches to make rechargeable Zn-MnO_2 cells not successful
  - Dendrite formation, passivation and shape change on cycling Zn anode; crystal structure collapse and formation of inactive species on cycling MnO_2 cathode
- CUNY approach for long cycle life at 10-20% utilization
  - Innovations for anode: charging protocol, electrode additives, electrolyte composition, and zinc metal anode coating/binding/pore structure to mitigate shape change, passivation and pore plugging
  - Innovations for cathode: electrode composition, coating procedures, electrolyte composition, controlled porosity and conductivity, and charge/discharge protocol

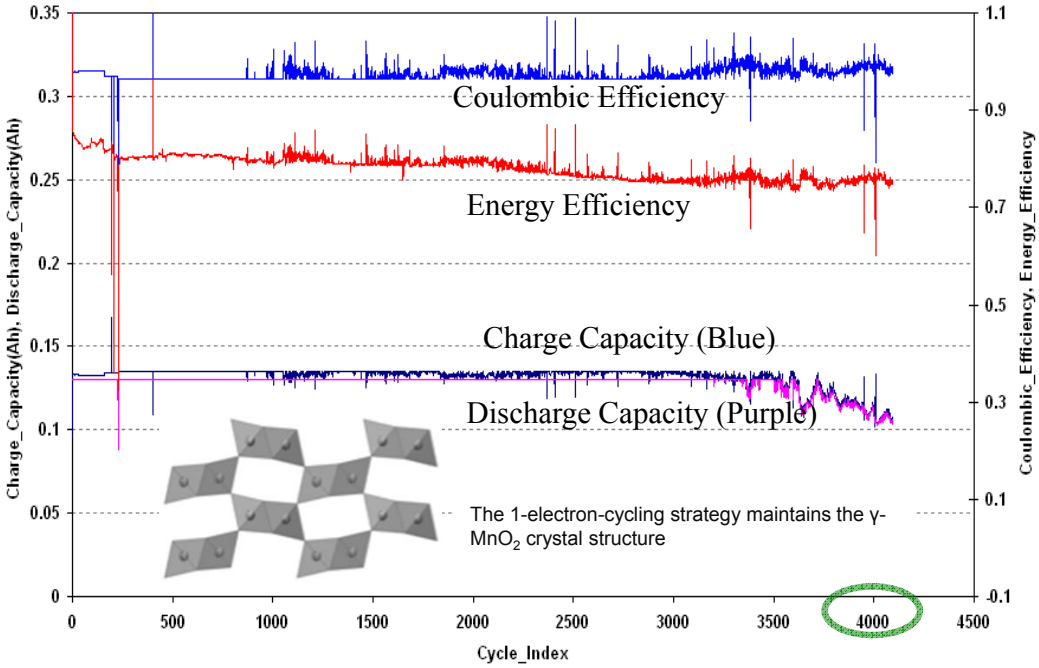
Limiting the Depth of Discharge to Achieve Long Cycle Life





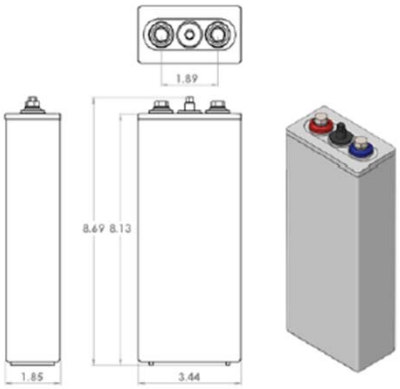
Shallow-Cycled 1-e Zn-MnO_2 Success



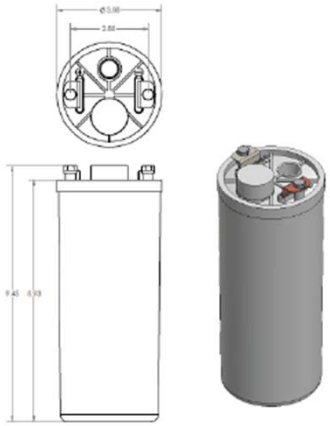


1-electron Zn-MnO_2 cells with 4000 cycles led to first products by Urban Electric Power

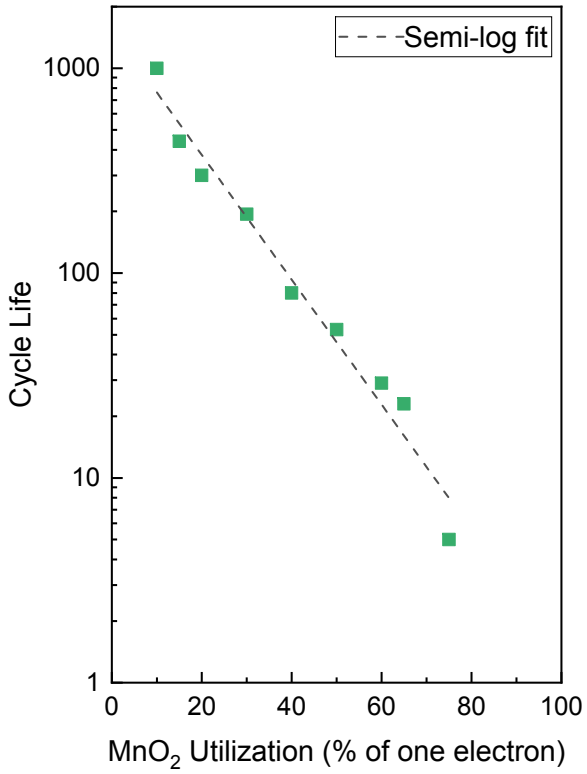
UEP Product Evolution: 100Ah Prismatic to 200Ah Cylindrical



Width inches (mm)	Height inches (mm)	Weight lbs (kg)
1.85 (46.9)	8.69 (220.7)	3.52 (1.6)

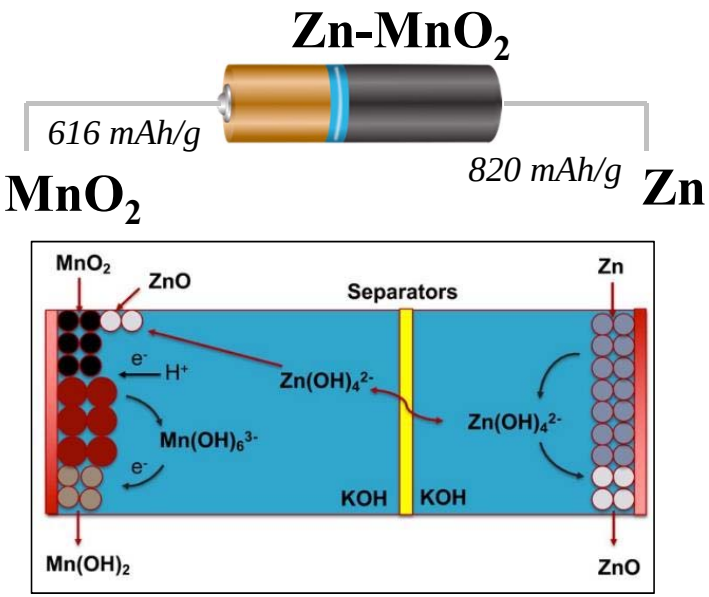


Diameter inches (mm)	Height inches (mm)	Weight lbs (kg)
3.88 (98.6)	9.45 (240)	5.82 (2.64)



- Two prismatic cells are equivalent to one cylindrical cell in capacity
- Electrodes and separators have identical thicknesses and compositions
- Performance characteristics of both types are very similar

Utilization of 2e - Challenges



On the MnO_2 Cathode

- Crystal structure breakdown
- Formation of Inactive phases
- Reducing susceptibility to Zinc poisoning

Separator:

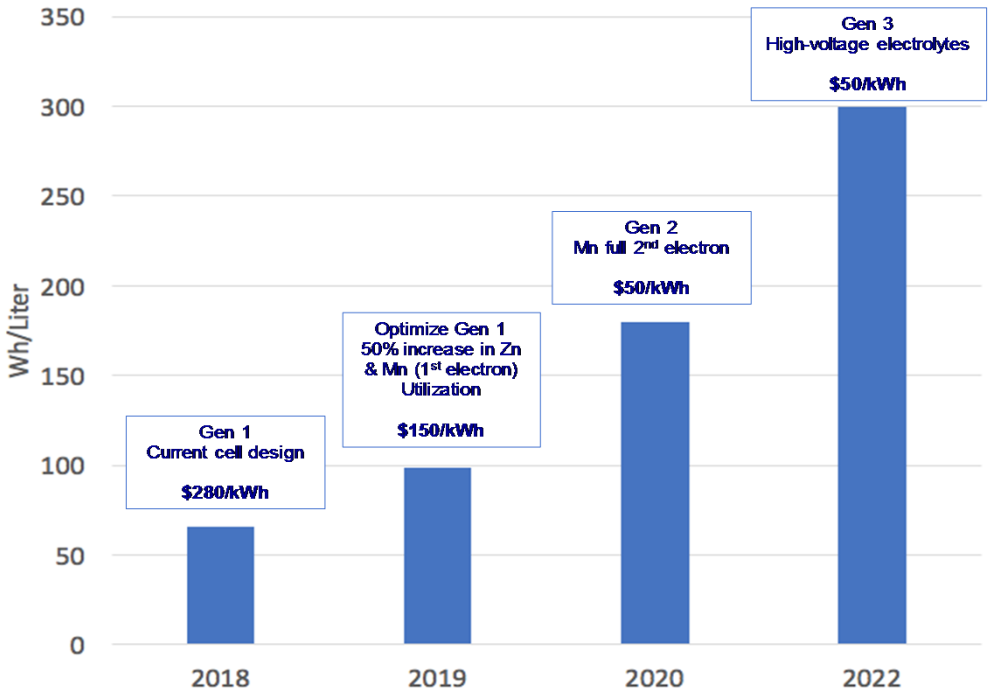
- Reduce Zincate crossover

On the Zn Anode:

- Control shape change
- Passivation
- Reduce dendrite formation

Need improvements in materials utilization, process optimization and engineering larger format cells.

Potential for Zn-MnO_2 Cells: $50/kWh



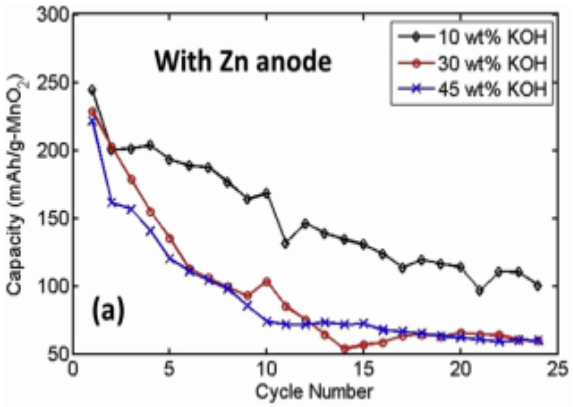
Source: CUNY Energy Institute

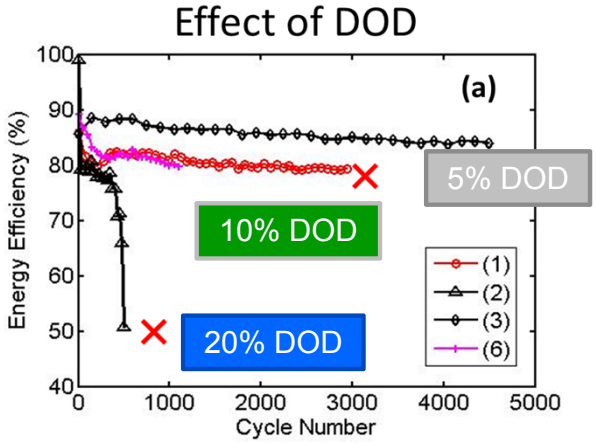
URBAN ELECTRIC POWER

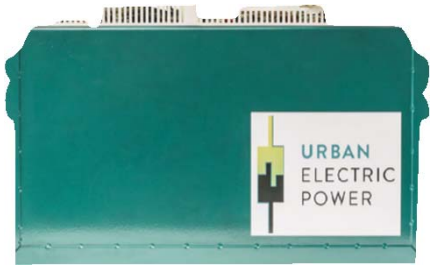
- Recent breakthroughs in making MnO_2 fully rechargeable. Based on the formation of a layered birnessite MnO_2 structure and stabilizing this structure for thousands of cycles.
- Improvement in energy density and cost by improvement in zinc utilization
- Cathode degradation mitigation by improvements controlling Zn migration across separator
- Potential for $50/Wh cells with high cycle-rechargeability of Zn-MnO_2

Thank you!

Low DOD discharge makes for a viable technology

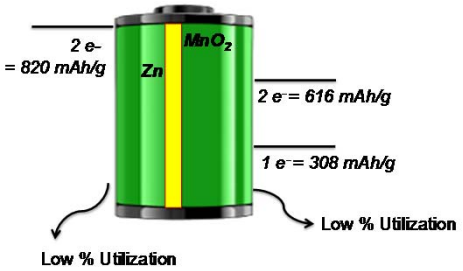




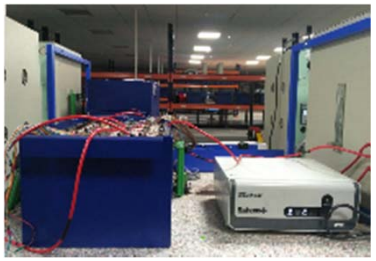


RAPID CELL DEATH >30% DOD

Single-use Alkaline Battery



Gen 1 Alkaline Battery



http://www.urbanelectricpower.com