

# Zinc

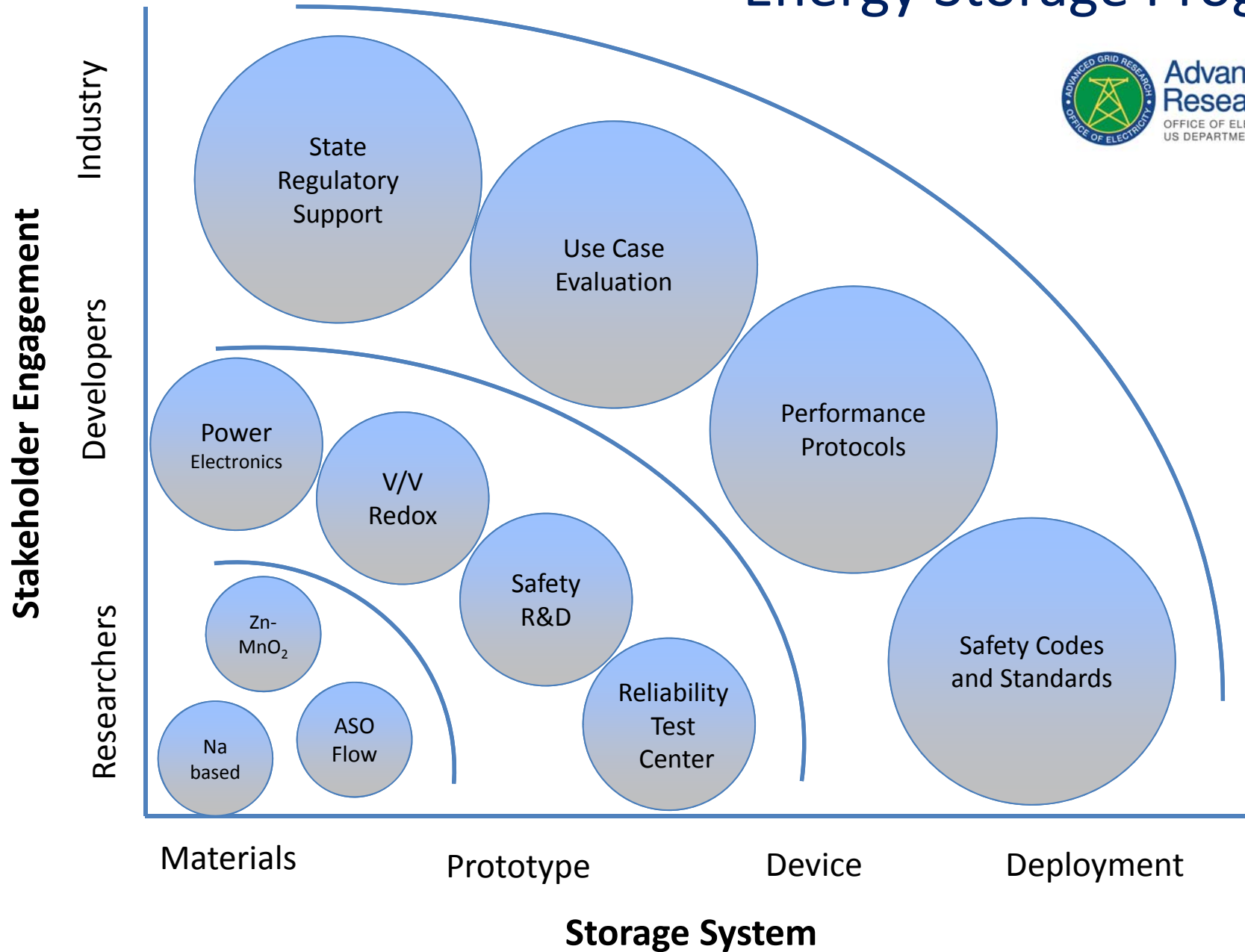
## for Grid Scale Energy Storage

IMRE GYUK, DIRECTOR,  
ENERGY STORAGE RESEARCH, DOE-OE

# Office of Electricity, Priorities:

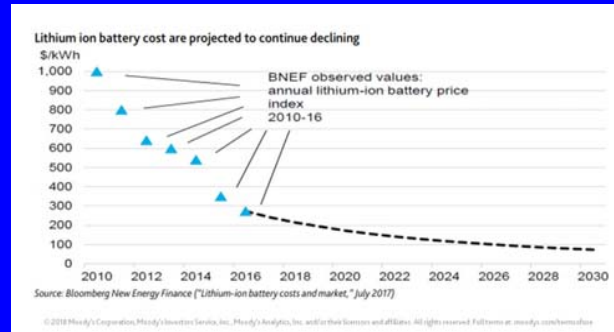
- Puerto Rico and U.S. Virgin Islands  
Restoration and Resiliency Efforts
- North American Energy Systems Resiliency Model
- **Mega-Watt Scale Grid Storage**
- Revolutionize Sensing Technology Utilization
- Operational Strategy for Cyber and Physical Threats

# Energy Storage Program



# Li-ion Batteries?

Low cost, market ready

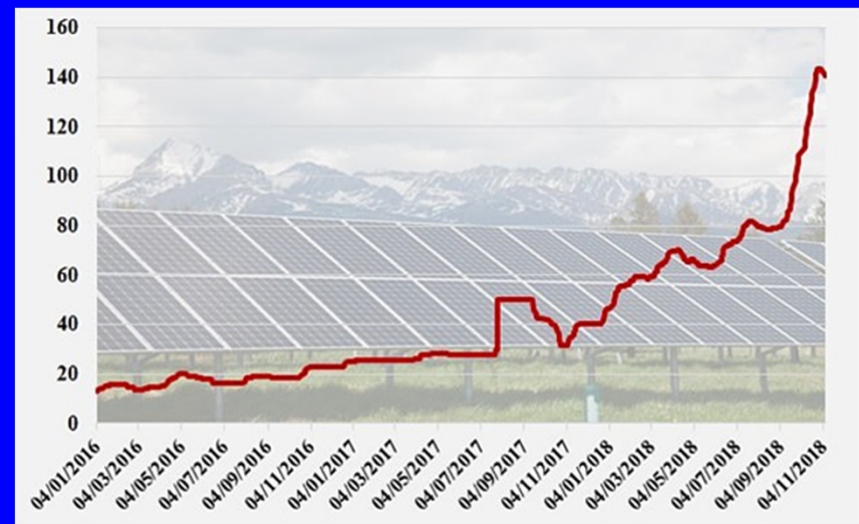
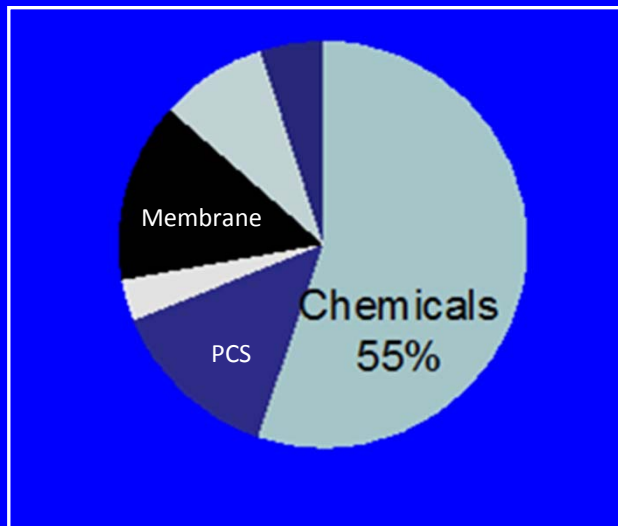


Cycle life <<20years  
No Recycling!  
No U.S. Manufacture



# Mixed Acid V/V Redox Flow Battery

Enhanced Temperature Range, Good Energy Density,  
Cost Estimate \$300/kWh, 20 year Cycle Life  
Recycleable, Commercially Available



## Cost Goals for Focus Technologies

Manufactured at scale

Aqueous Soluble Organic (ASO)  
Redox Flow Batteries (Stack+PE)      \$125/kWh

Zinc Manganese Oxide (Zn-MnO<sub>2</sub>)  
2 Electron System      \$ 50/kWh

Low Temperature Na-NaI  
based Batteries      \$ 60/kWh

# Zinc, Zn

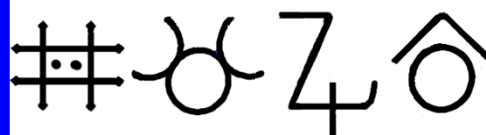


Zinke ?

سنگ ?



PARACELSUS 1493 –1541



# Electrochemistry!

1800

Alessandro Volta's  
Electric Organ

aka

Columnar Apparatus

aka

Voltaic Pile

Silver, **Zinc**

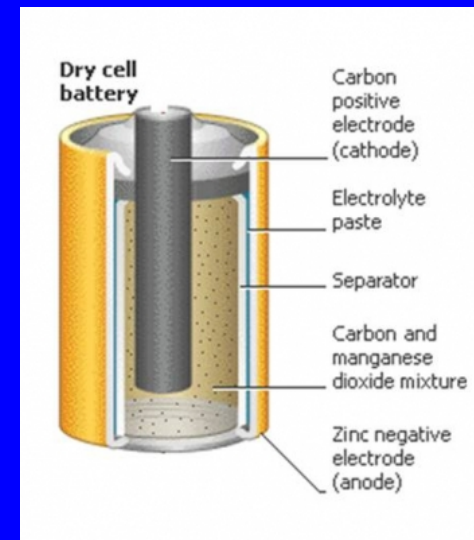
Blotting Paper,  
and Salt Water

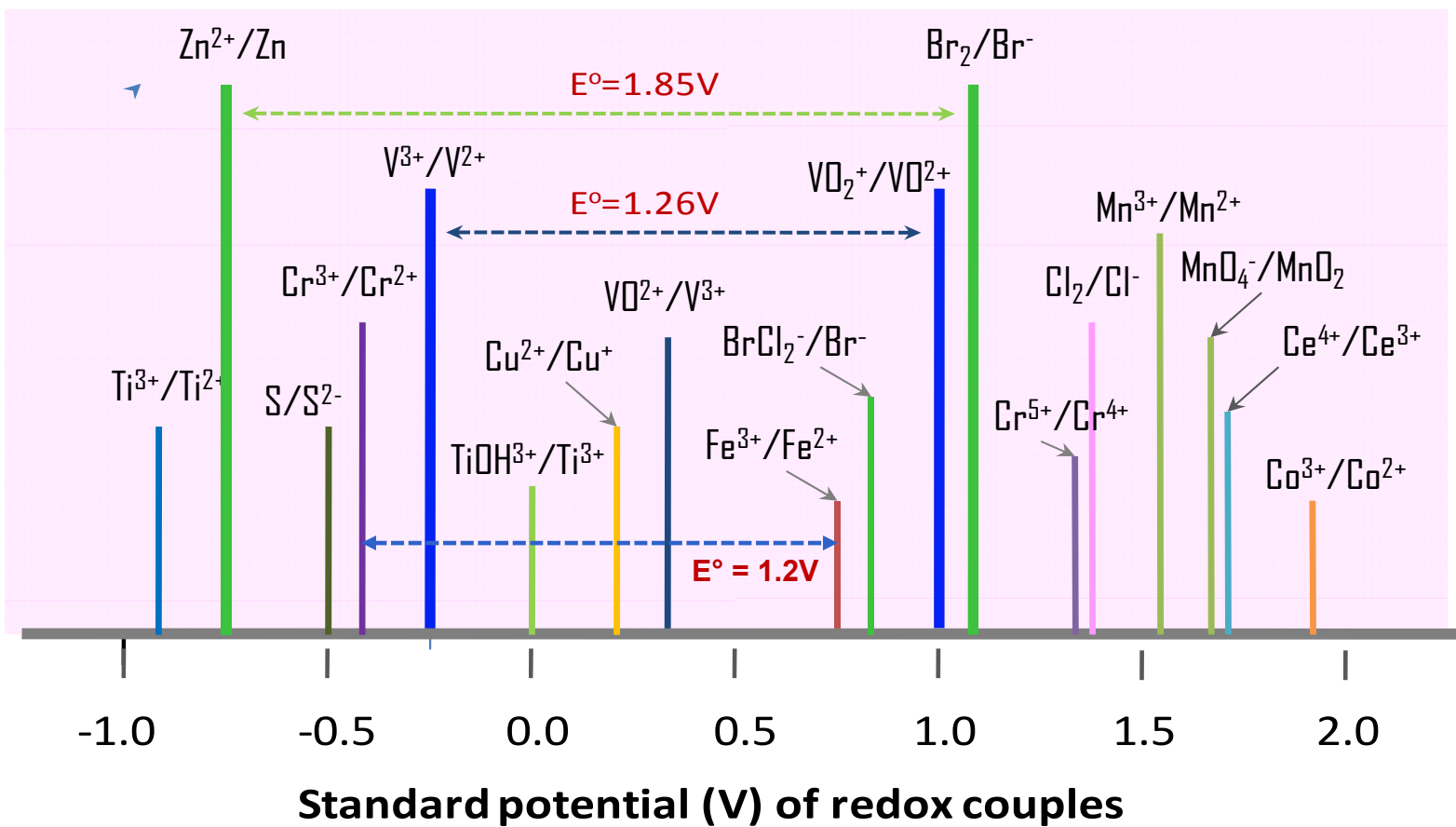




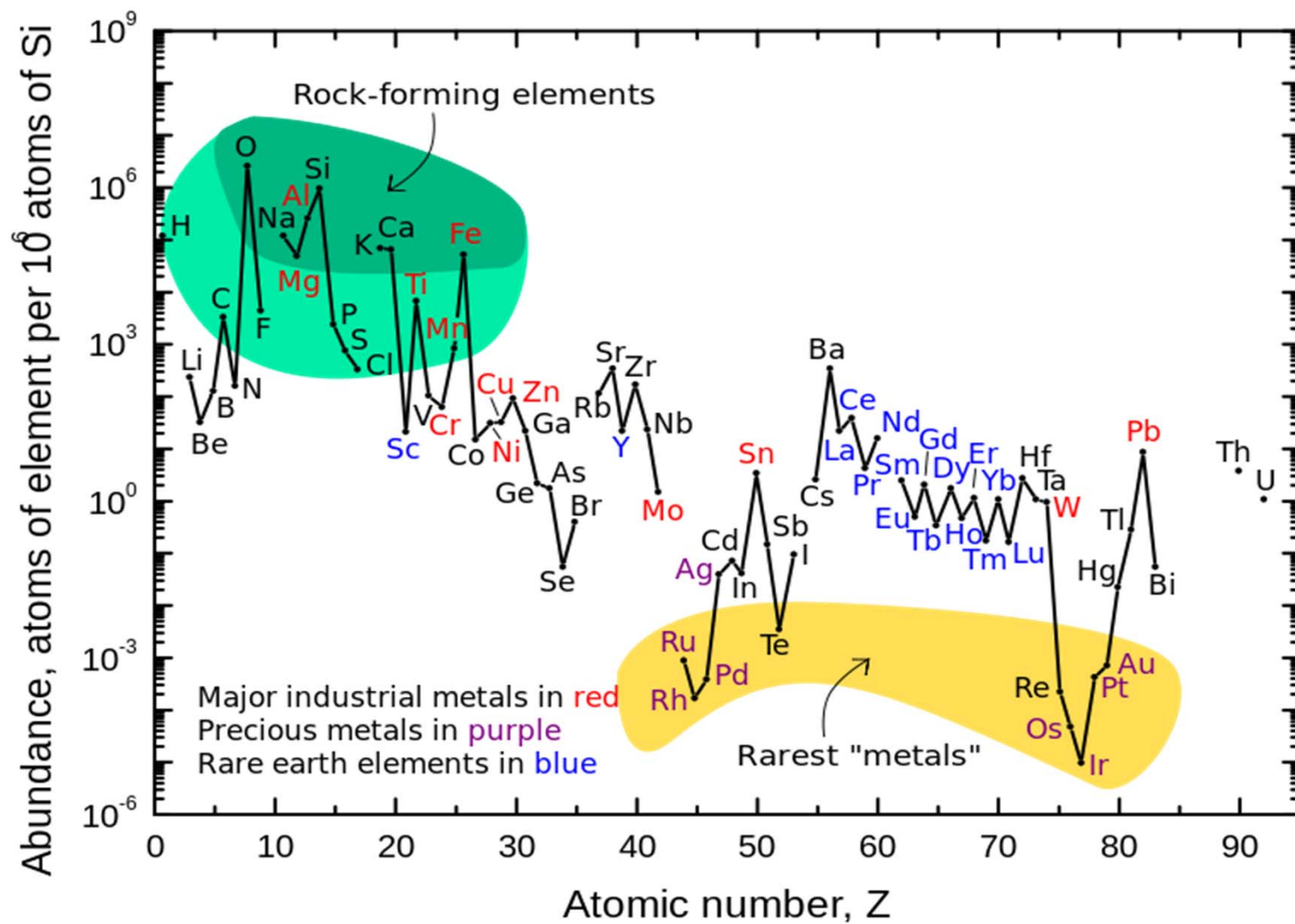
# 1866 Leclanché cell

- Zn-MnO<sub>2</sub> 1.4V
- Ammonium Chloride
- Porous Pot!



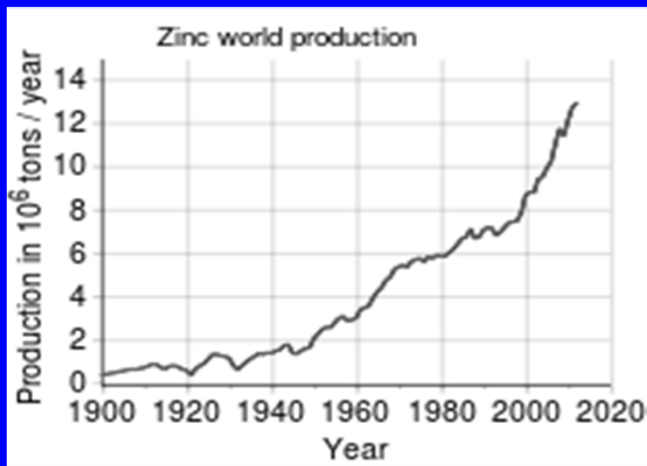


We want high Potential !



We want low Cost !

Iron	\$ 529
Zinc	\$ 2,636
Aluminium	\$ 2,104
Lead	\$ 2,284
Copper	\$ 6,320
Nickel	\$14,115
Tin	\$19,770
Vanadium	\$29,000



Country	Tons
China	5,000,000
Australia	1,500,000
Peru	1,300,000
India	820,000
United States	700,000
Mexico	700,000

## Zinc Batteries:

Zinc Manganese Oxide

Zinc Bromine

Zinc Air

Nickel Zinc

Zinc Silver

## Zinc Batteries have:

Low Material Cost

Easily Recycled

No Strategic Vulnerability

Fire Safe, Low Toxicity

Show Considerable Promise and are  
well worth Research Investment!