



Energy Storage: Technology Summary

Eos Innovation: First Ever Long-Life Zinc-Air Electrically Rechargeable Battery

Eos has developed the **Eos Aurora**, a proprietary zinc-air battery that can be used to meet the energy storage needs of utilities, electric vehicles, the military, and major industrial and commercial enterprises:

- **Most cycles ever realized by metal-air battery** >1000 battery cycles demonstrated to date with no physical degradation
- **Proprietary innovations overcome historical limitations to electric rechargeability of zinc-air batteries**
- **Safe, non-toxic, stable** electrolyte and materials, **safe and self-healing** battery operation
- **Low cost per kWh**, due to low cost materials, architecture, and manufacturing methods

Zinc-Air Advantages

- **Proven technology:** widely used today for disposable, high-energy density, low-cost applications (e.g. hearing aids)

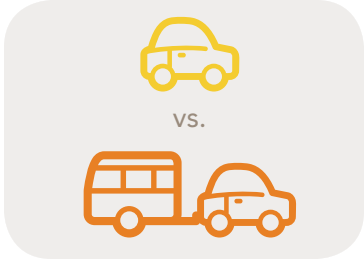
Eos Aurora 1000 6000	
Low capital cost	\$1000/kW initial price; \$160/kWh
Large volume of energy and power	1 MW and 6 MWh standard system size (made of 17KW/100KWh building blocks)
Long life-cycle	Designed for > 10,000 true cycles* and 30 calendar years of operation
Quick response time	Response time: Immediate
Safe to locate in urban load centers	Non toxic, environmentally benign and stable
Instantly deployable	Delivered in a standard ISO 40' shipping container
Low operating and maintenance costs	No periodic replacement of components (e.g., membranes, cells, battery packs) required

- **Historically difficult to make rechargeable** due to architecture, electrolyte, materials and operational challenges
- **Based on similar chemistry used in standard alkaline AA and AAA batteries** (Zn/MnO₂), however the manganese dioxide (MnO₂) is replaced with a thin air electrode
- **"Breathes" air:** oxygen from ambient air is used as cathode reactant, saving space and cost
- **High energy density** because there is no need to integrate a cathode reactant
- **Environmentally friendly:** recyclable materials
- **Made from safe, low cost, locally sourced, readily available materials including:**
 - Zinc: One of the world's most plentiful and inexpensive metals, stable, non toxic, energy dense, locally available (US, Canada and Australia are three of top five global zinc producers)
 - Air

Based on proven high energy density disposable battery technology

Other batteries need to hold a large amount of cathode reactant, equivalent to pulling a trailer full of air to oxidize the tank of gasoline in your car. Zinc-air batteries have higher energy density since they—like gasoline engines—use oxygen from ambient air as a reactant, and therefore do not need to carry it in the cell.

Zinc-Air Batteries:
The Cost And
Energy Density
Advantage



Eos Resolves Historical Challenges of Zinc-Air Rechargeability

Many challenges have prevented the rechargeability of zinc-air batteries. Eos has achieved electrical rechargeability through fundamental proprietary innovations that address battery architecture, electrolyte composition and management, materials, systems and manufacturing processes.

"[Eos'] novel non-flow design offers elegant approach to management of prior zinc-air issues."
– EPRI (Electric Power Research Institute)

Zinc-Air Rechargeability Challenge	Eos Solution
<ul style="list-style-type: none"> Air electrode clogging due to carbonate, as a result of CO₂ absorption from KOH electrolyte 	<ul style="list-style-type: none"> Novel aqueous electrolyte with near neutral pH
<ul style="list-style-type: none"> Rupture of ion-selective membrane due to pressure and dendrite formation of Zn metal, caused by electrolyte and wear and tear over time 	<ul style="list-style-type: none"> No membrane required and electrolyte is non-dendritic
<ul style="list-style-type: none"> Electrolyte drying out over time as oxygen enters 	<ul style="list-style-type: none"> Electrolyte management system and self-filling/healing system operation
<ul style="list-style-type: none"> Zinc electrode changes shape due to expansion from the change in density from zinc metal to zinc oxide 	<ul style="list-style-type: none"> Electrode maintains integrity and shape during charge and discharge cycles
<ul style="list-style-type: none"> Zinc corrodes due to inefficient plating 	<ul style="list-style-type: none"> Proprietary additives optimize zinc plating
<ul style="list-style-type: none"> Materials degradation/corrosion over time 	<ul style="list-style-type: none"> Selection and proprietary treatment of materials
<ul style="list-style-type: none"> Cell ionic and electrical connection failure 	<ul style="list-style-type: none"> Integral and redundant electrical and ionic connections



Other Eos Battery Technologies in Development

Eos Corona Advanced Lead Acid Battery

Lead acid is a low cost power storage technology. Traditionally at full depth of discharge, however, its cycle life is too short to be economically viable for many grid, vehicle and commercial applications.

Eos' advanced lead acid system resolves this cycle life and depth of discharge limitation while maintaining the low cost per kW of traditional lead acid batteries. Eos' lead acid system benefits include:

- Long life (10 years) with full depth of discharge and a full duty cycle
- Increased energy storage and access, and higher gravimetric energy density. Same low cost per kW and a lower cost per kWh as lead acid SLI (starting-lighting-ignition) batteries, creating new opportunities for grid regulation, electric vehicle acceleration, UPS (uninterrupted power supply) systems, and numerous other power-focused applications
- In combination with Eos zinc-air battery for range, lighter weight for comparable power and energy makes Eos Corona suitable for powering electric vehicles

Eos Vista Zinc-Air Flow Battery

Eos is also developing a zinc-air flow battery, designed to provide flexible vehicle range and enable immediate **refueling** in addition to standard recharging.

Eos has developed energy storage that is: "low-cost, rugged, long-life, non toxic and (with a) compact design for stationary and mobile applications."

– KEMA Energy Consultants

Strong IP Protection

Multiple patents issued and pending with over 100 claims covering:

- Cell configuration and architecture
- Cathode design, materials and catalysts
- Electrolyte and additives
- System configuration and electrolyte system

Eos develops novel, low-cost energy storage solutions for the electric utility and transportation industries. Eos' mission is to produce the most cost effective energy storage solutions that are not only less expensive than other battery technologies, but less expensive than the most economical alternative used today to provide the same services—a gas turbine for power generation or an internal combustion engine for vehicle power.

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