Water in Salt

Technology Whitepaper v1.0

Membrane-Free Zinc-Manganese Flow Battery

A Breakthrough in Grid-Scale Energy Storage Technology

Abstract: This whitepaper presents Water in Salt's innovative membrane-free zinc-manganese flow battery technology. By eliminating the costly membrane component and utilizing abundant, non-toxic materials, our solution achieves up to **70% lower costs** compared to lithium-ion batteries while ensuring complete safety and 100% recyclability. The technology addresses the critical need for affordable, safe, and sustainable grid-scale energy storage to enable the global transition to renewable energy.

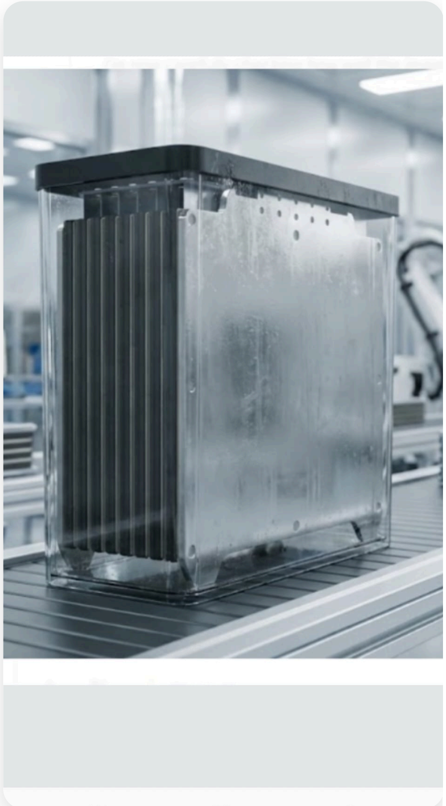
1. Introduction

The global energy transition demands massive deployment of energy storage systems. Renewable energy sources like solar and wind are inherently intermittent—producing peak energy during low-demand periods while consumption peaks occur at different times.

Key challenges with current storage technologies:

- **Lithium-ion:** High cost, thermal runaway risk, 6-10k cycle life, rare material dependency
- **Vanadium redox:** Complex membrane systems, high cost, vanadium supply constraints
- **Lead-acid:** Low energy density, short lifespan, environmental concerns

Water in Salt has developed a zinc-manganese membrane-free flow battery that overcomes these limitations through innovative chemistry and cell design.



Working MVP Prototype
Membrane-free cell with carbon electrodes
Stage I: 100W Module

2. Technology Overview

2.1 Operating Principle

Our battery operates on the reversible electrochemical reactions between zinc and manganese dioxide in an aqueous electrolyte:

Cathode (Oxidation): $Mn^{2+} + 2H_2O - 2e^- \rightarrow MnO_2 + 4H^+$ ($E° = +1.23V$ vs SHE)
Anode (Reduction): $Zn^{2+} + 2e^- \rightarrow Zn$ ($E° = -0.76V$ vs SHE)
Cell Voltage: ~2V

2.2 Membrane-Free Design — Our Core Innovation

□ **Key Innovation:** Traditional flow batteries require expensive ion-exchange membranes ($50-100/m²) to separate electrolytes. Our design **eliminates the membrane entirely**, reducing production costs by approximately **40%** while simplifying manufacturing and maintenance.

How It Works:

- **Single-electrolyte system:** Both active species (Zn^{2+}, Mn^{2+}) operate in a shared aqueous electrolyte
- **Controlled flow dynamics:** Proprietary flow patterns prevent cross-contamination
- **Electrode engineering:** Specialized high-surface-area carbon electrodes

Benefits:

- 40% lower production cost
- Simpler manufacturing process
- Reduced maintenance requirements
- No membrane degradation over time
- Easier scalability

2.3 Breakthrough Electrode Technology

Our R&D has achieved a significant breakthrough in carbon electrode development:

200 m²/g	143×	Stable
Surface Area	Surface Increase	Cycle Performance
↑ from 1.4 m²/g	R&D breakthrough	500+ cycles verified

This massive increase in electrode surface area directly improves energy storage efficiency and power density, providing a substantial technological edge.

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3. Materials & Chemistry

□ Zinc (Zn)

Role: Anode active material
Abundance: 23rd most common element
Cost: ~$2,500/ton
Safety: Non-toxic, recyclable

□ Manganese (Mn)

Role: Cathode active material
Abundance: 12th most common element
Cost: ~$1,500/ton
Safety: Non-toxic, recyclable

● Carbon (C)

Role: Electrode substrate
Surface: 200 m²/g (optimized)
Cost: Low
Safety: Inert, recyclable

□ **No Critical Materials:** Unlike lithium-ion batteries, our technology does not require lithium, cobalt, nickel, or rare earth elements. All materials are abundant, EU-sourceable, and fully recyclable.

4. Performance Specifications

4.1 Current MVP vs Target Performance

Parameter	Current MVP	Target (Stage IV)	Notes
Coulombic Efficiency	**96%**	>98%	Excellent charge retention
Energy Efficiency	67%	**79%**	System-level (incl. BOP)
Volumetric Capacity	20 Wh/L	**80 Wh/L**	4× improvement planned
Cycle Life (verified)	500 cycles	**25,000 cycles**	No degradation observed
Cell Voltage	**2V**		Zn/Mn electrochemistry
Operating Temperature	-20°C to +50°C	-30°C to +60°C	No active cooling needed
Calendar Life	**20-30 years**		Aqueous electrolyte stability

4.2 System-Level Advantages

□ Safety

- Non-flammable aqueous electrolyte
- No thermal runaway risk
- No toxic gas emissions
- Safe for urban/indoor deployment
- No fire suppression systems needed

□ Environmental

- 100% recyclable materials
- No rare earth elements
- Non-toxic components
- EU Battery Regulation compliant
- Circular economy compatible

5. Competitive Analysis

Parameter	Water in Salt	Li-ion (LFP)	Vanadium Flow	Fe-Air

Safety	□ **Excellent**	⚠ Fire risk	□ Good	□ Good
System Efficiency	70-80%	**88-94%**	70-80%	40-60%
Installed Cost ($/kWh)	**80-120**	120-180	200-350	N/A
Cycle Life	**20-25k**	6-10k	20k+	20+ yrs
Best Duration	2-24h	1-4h	6-12h	20-100h
30-Year TCO ($/kWh)	**650**	2,300	~1,000	TBD
Recyclability	**100%**	~5%	High	High

□ **Key Differentiator:** We don't compete on peak efficiency—we compete on **30-year total cost of ownership**. Lower auxiliary power, no cooling systems, and no mid-life replacements result in superior economics for grid-scale applications.

6. Development Roadmap

Stage	Scale	TRL	Timeline	Investment	Key Milestones
I - Basic Module	100W	4-5	☐ Complete	$0.7M	500 cycles, 96% efficiency
II - Demonstration	10kW	5-7	6-12 months	$1.5M	Multi-cell stack, BMS
III - Pilot	100kW/400kWh	6-8	6 months	$2.3M	Containerized system, field test
IV - Commercial	1MW/4MWh	8-9	18 months	$4.7M	Production system, certification

7. Intellectual Property

☐ Current Protection

Know-How: All core innovations are actively protected through comprehensive documentation, trade secret management, and NDA agreements.

- Electrode manufacturing parameters
- Electrolyte preparation procedures
- Cell assembly processes
- Performance optimization algorithms

☐ Patents in Preparation

Filing Target: Q2 2025

- **P1:** Membrane-free cell architecture
- **P2:** Electrolyte composition & formulation
- **P3:** High-surface carbon electrode manufacturing

PCT international filing planned for Q1 2026

8. Target Applications

☐ Utility-Scale
10-100+ MWh installations
RES integration
Grid frequency regulation
Peak shaving

☐ Commercial/Industrial
1-10 MWh systems
Behind-the-meter storage
Backup power
EV charging

☐ Microgrids
0.5-5 MWh
Island/off-grid
Critical infrastructure
Remote locations

9. Conclusion

Water in Salt's membrane-free zinc-manganese flow battery represents a breakthrough in grid-scale energy storage. By combining innovative chemistry with practical engineering, we have developed a solution that addresses the critical limitations of existing technologies:

> **70% lower cost** than lithium-ion through membrane elimination and abundant materials
> **Inherent safety** with non-flammable aqueous chemistry — zero fire risk
> **25+ year lifespan** eliminating mid-life replacement costs
> **100% recyclability** supporting circular economy and EU regulations

All-climate operation without complex thermal management systems

With €2M in Pre-Seed funding, we will complete Stage II (10kW demonstration) within 18 months. Subsequent Seed (€5-7M) and Series A (€15-20M) rounds will fund pilot deployment and commercial production, positioning Water in Salt as a leader in sustainable, affordable energy storage.

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