SECONDARY BATTERY
ENERGY MATERIAL COMPANY

PRIONE

PRIONE

Focusing on today, envisioning tomorrow, evolving together.

We embrace challenges and push boundaries to ensure steady growth, even amidst change and adversity. By listening closely to our customers, we create essential values and experiences, continuing our journey of innovation through creative exploration. Guided by a steadfast sense of responsibility, we build lasting trust and strive to be a lifelong partner to our customers.

CORE VALUES

BEST VALUE INNOVATION

Challenge Communication Creativity Trust

HISTORY

PRIONE: A Continuous **Challenge** Toward the **Future**

2020.10
Established PRIONE Corporation
Established PRIONE Co., Ltd.

2020.12
Signed MOU with Korea Maritime & Ocean University
Joint University-Industry R&D

2021.10
Acquisition of Advanced Technology via Transfer from KMOU
Executed Technology Assignment Agreement for Sodium-ion Battery

2022.01
Established Corporate R&D Center
Establishment of JEIL E&S Corporate R&D Center

2023.04
Development of Pilot Equipment for Seawater Battery Anodes
Establishment of a Pilot Line for Transferred Technology

2024.01 ~
Development of Seawater Battery Cells & Pouches
Development of Seawater Batteries Based on PRIONE Anode Materials

TRUE INNOVATION SEAWATER BATTERY

PRIONE: Defining New Paths in **Seawater Battery Technology.**

Established in 2020, PRIONE is a specialized energy materials company focused on the secondary battery sector, dedicated to the research and development of seawater batteries based on sodium-ion technology.

We manufacture high-performance anode materials using our proprietary plasma technology and have developed a unique separator for seawater batteries, securing a powerful competitive advantage in the global market.

Through relentless R&D and commitment, **we hold numerous intellectual property rights related to seawater battery technology.** Leveraging these advantages, **we aim to localize energy solutions in a sector heavily dependent on imports and develop and sell high-value-added products** through the futuristic medium of seawater batteries.

As the demand for batteries in ESS (Energy Storage Systems) and renewable energy sectors continues to rise, we are committed to leading both domestic and global markets by commercializing our superior technology.

CERTIFICATE & PUBLICATION RECORD

Corporate credibility validated by recognized certifications.

CERTIFICATE


제 1288 호

Certificate of Family Company

산학협력가족회사 인증서

프리원 주식회사
대표 김민강

귀사는 산학협력을 선도하는 우수기업으로서 우리 대학교와의 산학공동기술개발, 현장실습, 정보교류 등의 상호협력을 위한 산학협력가족회사로 인증합니다.

2022년 1월 27일

한국해양대학교 총장 도 덕 희

한국해양대학교

Certificate of Industry–University Cooperation Partnership


기업부설연구소 인정서

과학기술정보통신부

한국산업기술진흥협회

Certificate of Corporate R&D Center


벤처기업확인서

벤처기업확인기관

Certificate of Venture Enterprise Confirmation

PUBLICATION RECORD

Carbon Composite Manufacturing Technology


Method for Manufacturing Heteroatom-Doped Porous Carbon and Heteroatom-Doped Porous Carbon Manufactured Therefrom


Method for Synthesizing Silicon–Carbon Composites Using Liquid Plasma and Silicon–Carbon Composites Synthesized Therefrom


Method for Increasing the Reversible Capacity of Anode Electrode Materials for Alkali-Ion Batteries


Lithium–Carbon Composite with Internal Voids and Method for Manufacturing the Same


Organometallic–Carbon Composite Doped with Metal Atoms and Method for Manufacturing the Same


Anode Active Material for Lithium Secondary Batteries Containing Silicon Nanoparticles and Method for Manufacturing the Same


Carbon Nanoparticle–Carbon Material Composite and Method for Manufacturing the Same


Metal–Carbon Nanocomposite with Encapsulated Metal Particles and Method for Manufacturing the Same


Method for Manufacturing Lithium Hydroxide Using a Carbon Source

Carbon Nanotube and Sodium-Ion Battery Technology


Method for Manufacturing Nitrogen–Carbon Aggregates with Hierarchical Pore Structures, Nitrogen–Carbon Aggregates Manufactured Therefrom, and Sodium-Ion Batteries Including the Same


Method for Mass Production of Carbon Nanotubes Using Alkali Metal Catalysts and Carbon Nanotubes Synthesized Therefrom


Method for Mass Production of Carbon Nanotubes and Carbon Nanotubes Synthesized Therefrom


Method for Manufacturing Carbon Materials and Carbon Materials Manufactured Thereby


Method for Manufacturing Carbon Materials and Carbon Materials Manufactured Thereby

PRODUCTS & TECHNOLOGY

SEAWATER BATTERY

Seawater batteries are eco-friendly energy storage devices that utilize seawater as an electrolyte, replacing rare metals like lithium and cobalt with abundant sodium. These batteries operate on the principle of storing and releasing electricity as ions move between the anode and cathode.

By utilizing sodium ions directly from seawater, they offer significant advantages in resource accessibility and cost reduction. Furthermore, they provide exceptional safety with a minimal risk of fire or explosion. Their capacity for large-scale energy storage makes them ideal for integration with offshore power generation and renewable energy sources.

The applications for seawater batteries are diverse, ranging from supporting power grids to supplying energy to marine sensors. Consequently, seawater battery technology is gaining attention as a next-generation alternative to lithium-ion batteries—an innovative solution that enables low-cost, large-capacity energy storage while minimizing environmental impact.

BEST VALUE INNOVATION PRIONE

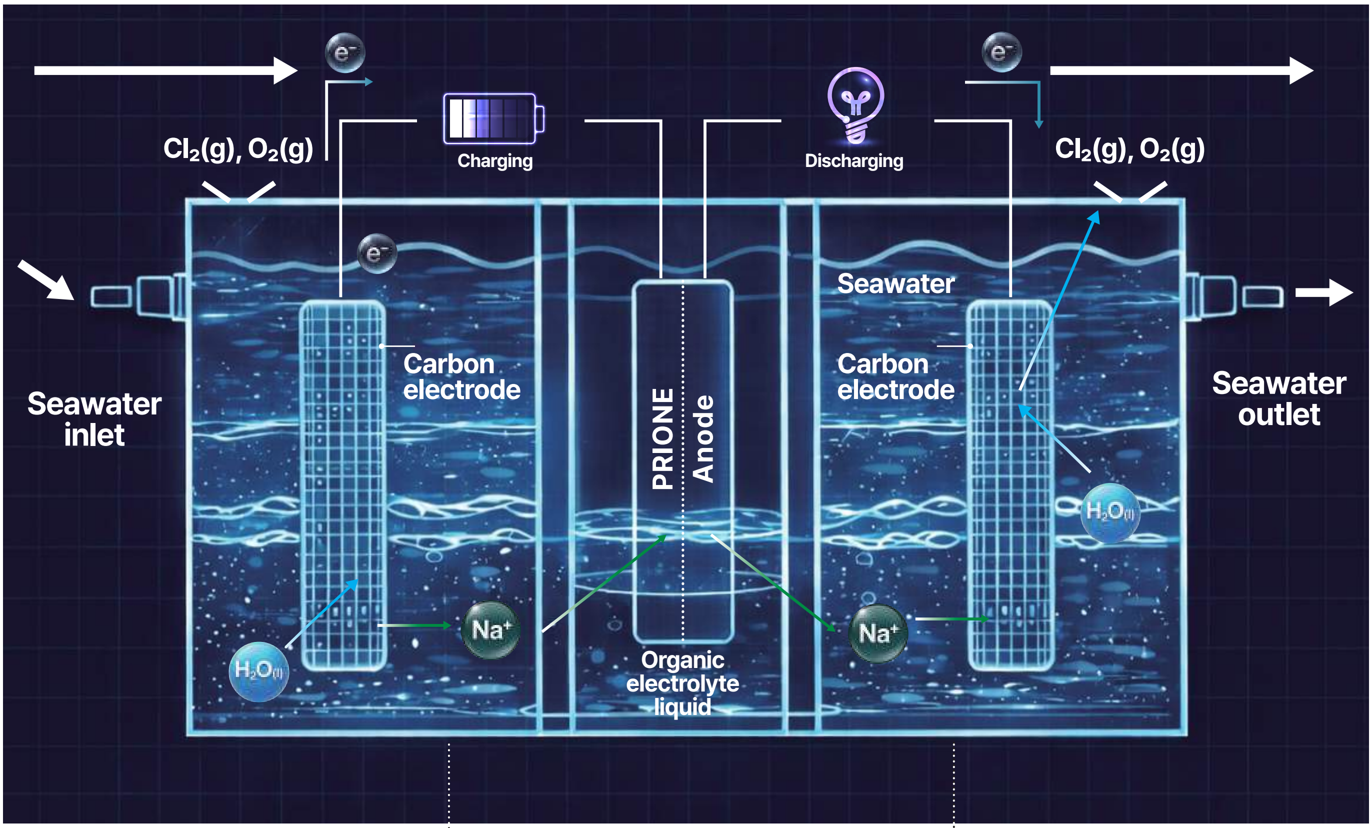
Next-Generation Eco-Friendly Energy Storage Technology

KEY ADVANTAGES

- **Eco-friendly**
  Seawater-Based, Eco-Positive
- **Low Cost**
  Replacing Rare Metals,
  Maximizing Cost Efficiency
- **High Safety**
  Low Fire & Explosion Risk
- **Large-Scale Energy Storage**
  Long-Duration and
  Large-Scale Energy Storage Capacity

ECO-FRIENDLY BATTERIES POWERED BY SEAWATER

A device that stores electrical energy using sodium ions (Na^+) and water from seawater as an electrolyte.



CHARGING

Utilizes sodium from seawater during charging

Hydroxide ions(OH^-) in seawater produce O_2, H_2O while separating electrons(e^-) through Oxygen Evolution Reaction(OER).

Sodium ions dissolved in seawater move to the anode through the electrolyte.

Electrons (e^-) move through the external circuit.

DISCHARGING

Sodium intercalated at the anode generates sodium ions(Na^+) and electrons(e^-).

Sodium ions (Na^+)move to the cathode (seawater) through the electrolyte.

Electrons(e^-) flow through the circuit to the cathode, forming an electric current.

At the cathode, sodium hydroxide(NaOH) is produced through the Oxygen Reduction Reaction(ORR) by combining sodium ions(Na^+), electrons(e^-), dissolved oxygen(O_2), and H_2O from the seawater.

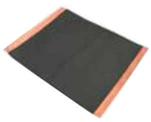
Advancements in Seawater Batteries: 1st vs 2nd Generation Comparison

First-Generation Seawater Battery

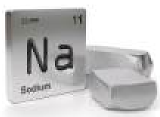
First-Generation Anode

· **Electrode Type**
- **Hard Carbon:** Extremely **low energy density**
- **Sodium Metal: Risk of explosion in case of cell leakage**

· **Electrodeless Type (Anolyte)**
- Sodium is dissolved at high concentrations to compensate for the disadvantages of sodium metal
- Ionic liquids and sodium **biphenyl for Anolyte production are extremely expensive**



Electrode Type 1: Hard Carbon

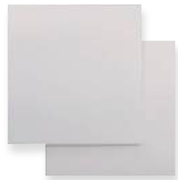


Electrode Type 2: Sodium Metal

Electrodeless Type: Anolyte

NASICON

· **NA** Super **I**on **CON**ductor
· Composition: $Na_3Zr_2Si_2PO_{12}$
· **Highly fragile to physical impact**
· Incompatible with metal pouches (cannot be bonded)
→ **Leads to sealing issues**



Various Prototypes

· Focused primarily on prismatic and pouch types
· **Low durability requires grid-shaped guards**
· Failed to reach commercialization during module production due to low voltage and efficiency

Second-Generation Seawater Battery (PRIONE)

Polymer Membrane

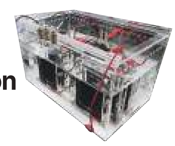
· **Developed second-generation polymer membranes to replace NASICON**
· Compensates for the weakness of low durability
· Achieved through the use of membranes and anode materials

High-Performance Anode Material

· **Capacity :** 600~700mAh/g(1C)
· **Cycle Life :** 3,000 cycle
· **Development Status :** Pilot equipment production completed
· Suitable as a high-power material

Seawater Battery

· **High energy density**
· **Capable of large-scale cell production**
· **Eco-friendly battery with carbon reduction**



Comparative Analysis of Seawater Batteries

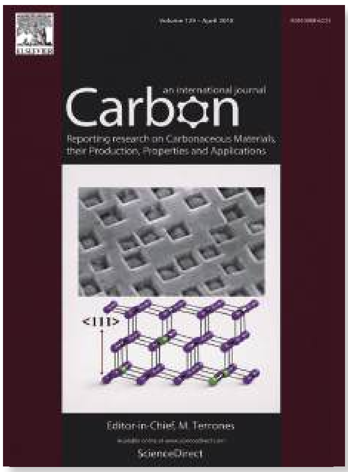
Category	Capacity	Current Density	Energy Capacity	Volume	Weight	Anode Material			Separator		
						Type	Material	Characteristics	Type	Manufacturing Process	Mass Production
2nd Generation	1.1Ah	1C	3.5Wh	120*160*3	45g	Hybrid (Electrode – Electrode-Free)	Nano carbon	High Capacity High Power Density High Energy Density	PB-PVDF	Roll to Roll	Available
1st Generation	1.1Ah	0.008C	3Wh	120*190*3.8	73g	Electrode Type	Hard-carbon	Low Capacity	NASICON	Press	Unavailable
							Na metal	High Risk			
						Electrode -Free Type	Anolyte	High Cost			

PUBLICATION RECORD

Journal of Materials Chemistry A

Carbon-metal complex as a functional material that governs the efficient conversion of Li_2CO_3 to $LiOH{\cdot}H_2O$
* I.F 14.511 / * 2024 Journal of Materials Chemistry A (Cover)

Novel synthesis of highly phosphorus-doped carbon as an ultrahighrate anode for sodium ion batteries.




Carbon

Novel synthesis of highly phosphorus-doped carbon as an ultrahigh-rate anode for sodium ion batteries

PCB-500: The Future of Ultra-High Rate Sodium-Ion Batteries

Revolutionary P-Doped Carbon Anode Technology

The global shift toward electric vehicles and sustainable energy demands batteries that are not only high-performing but also cost-effective. **PCB-500** represents a breakthrough in **Sodium-Ion Battery (SIB)** technology, offering a sustainable, high-power alternative to traditional Lithium-ion systems.

Core Technology & Innovation

1. Advanced Solution Plasma Process (SPP)

· **Novel Synthesis:** Utilizing a simple, in-situ solution plasma process to create high-quality P-doped carbon balls.
· **Solid-to-Liquid Precursor:** A unique approach using molten triphenylphosphine as a single precursor for both Carbon and Phosphorus.
· **Economical Production:** Heat-treated at a low temperature of 500°C, significantly reducing manufacturing energy costs compared to traditional methods.

2. Superior Material Engineering

· **High Phosphorus Doping:** Successfully achieved a 4 at% Phosphorus content, doubling the doping level of conventional carbon anodes to maximize active sites.
· **Hierarchical Pore Structure:** A complex architecture of micro-, meso-, and macropores that shortens Na^+ diffusion paths for ultra-fast ion transport.
· **Amorphous Stability:** A disordered amorphous structure that provides excellent structural integrity during long-term cycling.

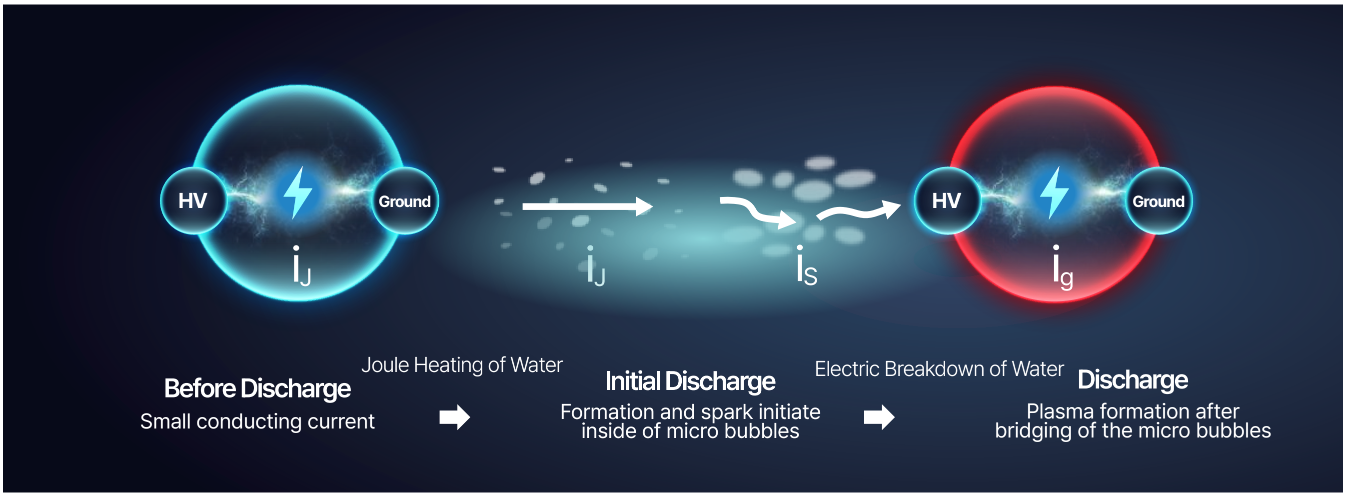
Key Commercial Advantages

· **Unmatched Safety:** The sloping-region dominant discharge profile eliminates safety concerns regarding sodium dendrite growth.
· **Rapid Charging Capabilities:** Engineered for high-power applications, delivering the best rate performance among carbonaceous materials reported to date.
· **Cost-Efficient & Sustainable:** Leverages abundant sodium resources and a simplified synthesis route to reduce the total cost of energy storage.

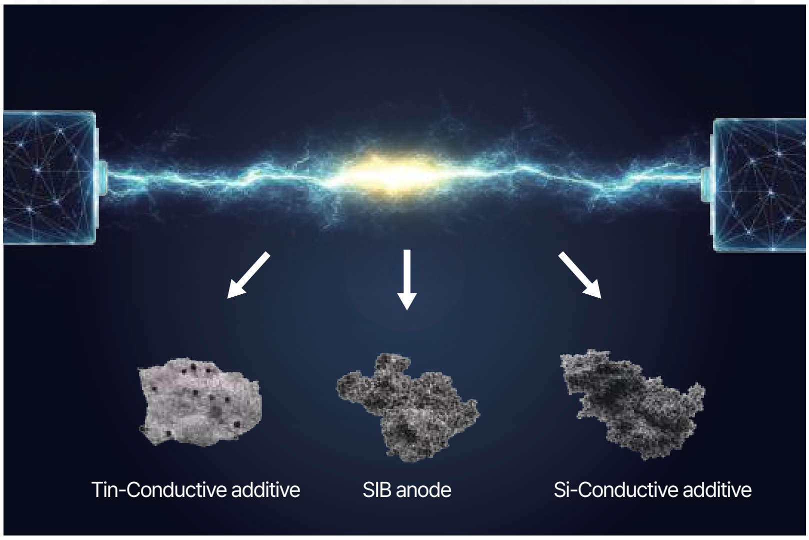
PLP PLASMA IN LIQUID PROCESS

PRIONE develops various carbon composites through solution plasma discharge, utilizing carbon precursors and any wire-formable metal.
This innovative approach resolves material volume challenges without requiring complex hardware configurations.

▪ Plasma Generation via Electrical Bridging at Room Temperature and Atmospheric Pressure



▪ Formation of Carbon Nanoparticles Using the PLP Process

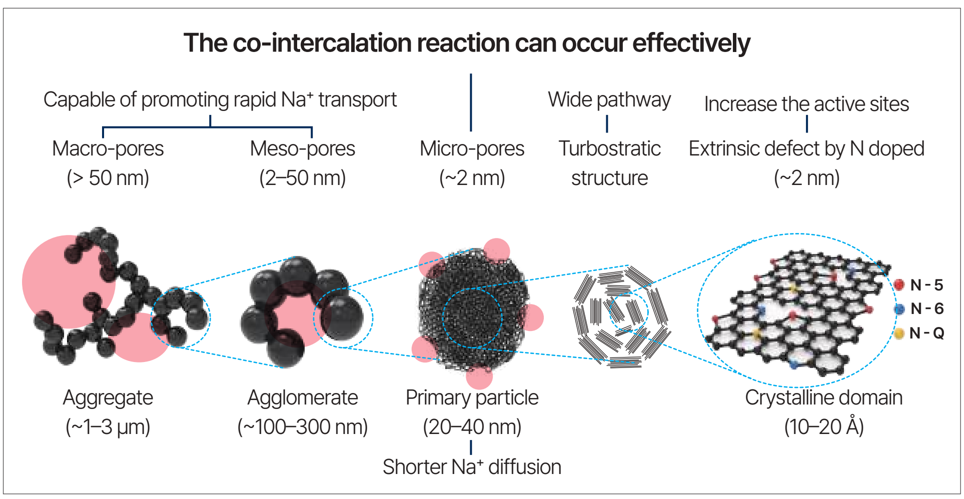


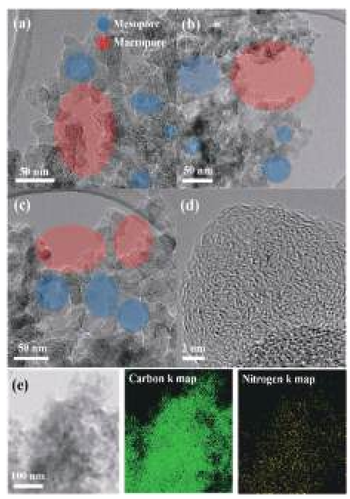
Simplified System Setup
- Composed only of a power supply, electrodes, solution, and reactor.

Platform Process
- Synthesis of various materials achievable through a single PLP process
- Synthesis of nanoparticles via plasma reduction of any metal capable of existing as ions in solution
- Synthesis of nanoparticles via sputtering of any metal formable into electrode wires

Synthesis of nanomaterials through solution decomposition, recombination,and electrode materials
- Synthesis of carbon nanomaterials through the decomposition and recombination of organic solvents
- Formation of nanoparticles in various sizes via plasma discharge

▪ Nanostructure design for Na^+ diffusion



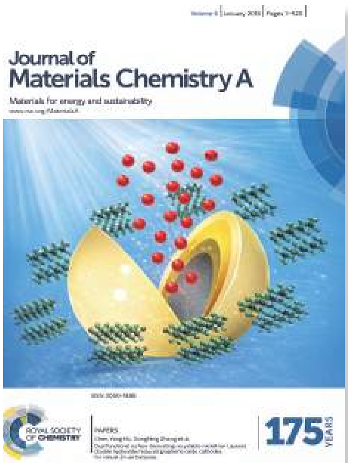


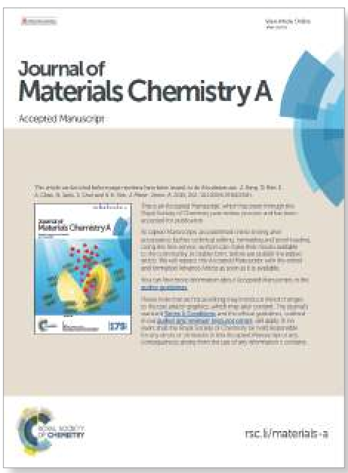
PUBLICATION RECORD

Journal of Materials Chemistry A

Maximization of sodium storage capacity of pure carbon material used in sodium-ion batteries
* I.F 14.511 / * 2013 Journal of Materials Chemistry A (Cover)

Na-C: Pre-Doped Carbon Anode for High-Capacity Sodium-Ion Batteries





1. Technical Breakthrough

· **In-situ Na Pre-doping:** By integrating sodium atoms directly into the carbon matrix during synthesis, the material inherently compensates for capacity loss.

· **Advanced Co-intercalation Mechanism:** Utilizes ether-based electrolytes to facilitate the seamless movement of solvated Na^+ complexes, maximizing storage efficiency.

· **SEI-Free Interface:** The unique surface architecture prevents the formation of a thick Solid-Electrolyte Interphase (SEI) layer, significantly reducing internal resistance.

2. Game-Changing Performance

· **Self-Compensating Efficiency:** The released pre-doped sodium drives the Coulombic Efficiency (CE) beyond **100% (up to 104%)** during cycling, a phenomenon unique to this technology.

· **Capacity Growth Effect:** As pre-doped sodium is released, new internal voids are created, allowing the reversible capacity to increase progressively over cycle numbers.

· **Ultra-Fast Kinetics:** Demonstrates exceptional power density, maintaining over **76% capacity even at a 100C** discharge rate.

Key Technical Specifications

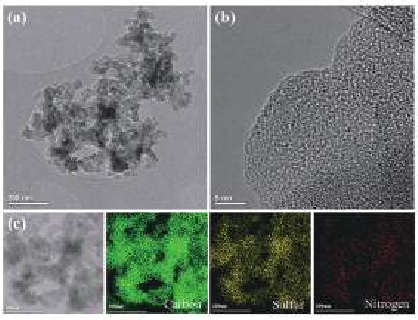
Feature	Metrics	Technical Insight
Initial Coulombic Efficiency	85%	Unprecedented ICE for high-surface-area nanomaterials
Maximum Reversible Capacity	>400mAh/g	2.5x higher than conventional hard carbon anodes.
Power Retention	76% @ 100C	Minimal charge-transfer resistance for high-power output.
Cycle Life	>1,000 Cycles	Sustained long-term stability with increasing capacity

SIB ANODE MATERIAL

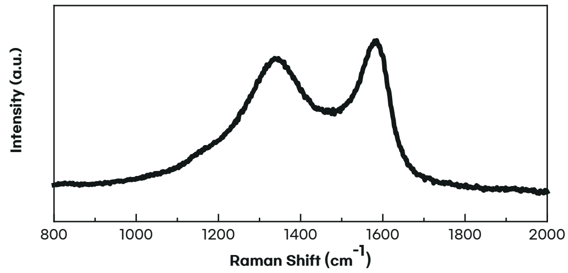
Analysis Data for SIB Anode

- Easy and Uniform Heteroatom Doping Using the PLP Process
- Higher Surface Area Compared to Competitors

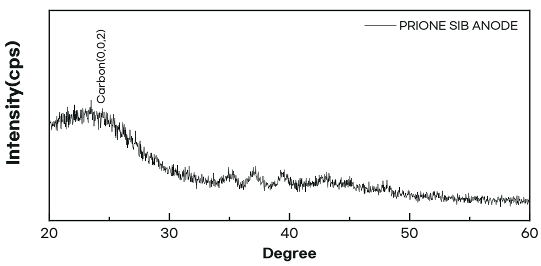
TEM



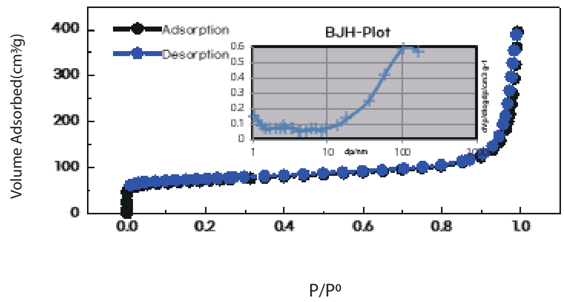
RAMAN



XRD



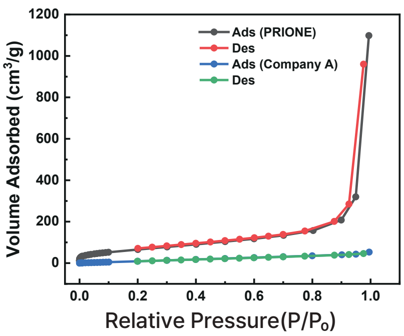
BET

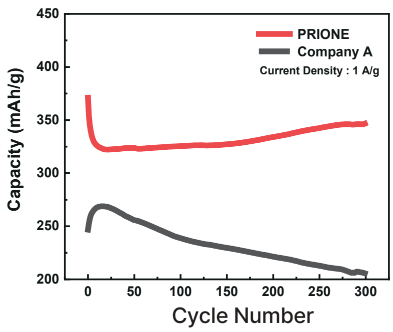


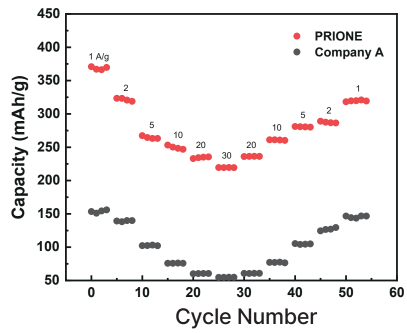
	Size(nm)	Capacity(1A/g)	ICE(1A/g)	Surface area(m^2/g)	Total pore volume(cm^3/g)	Average pore diameter(nm)
SIB Anode	20~30	380mAh/g	92%	223.906	1.325	12.4

Anode Material Data Comparison

- Comparison with Hard Carbon Used in First-Generation Seawater Batteries
- Using the developed PRIONE anode material, improvements were made to the issues of Hard Carbon used in first-generation seawater batteries (low power characteristics and capacity).
- Replacing the NASICON separator used in first-generation seawater batteries with a polymer separator under development enables high ionic conductivity while reinforcing the physical strength issues encountered during mass production.







High specific surface area provides excellent power performance, making it suitable for ESS applications.

Excellent power efficiency due to high capacity and outstanding cycle stability.

Can be applied to various applications due to excellent stability and capacity retention at high current density.

PATENT TRACK RECORD

Patented Innovation in Energy Storage

Seawater Battery comprising a heteroelement-doped nanoporous carbon composite cathode and a porous polymer-Prussian blue composite separator

Synergy of Dual-Heteroelement Doped Anodes & Prussian Blue Composite Separators

Our newly patented technology (Application No. 10-2026-0010082) addresses the critical limitations of conventional hard carbon anodes and non-selective polymer separators. By combining advanced material engineering with selective ion-conduction, we deliver a high-capacity, ultra-stable energy storage solution for marine and aqueous environments.

Technical Innovation

The global shift toward electric vehicles and sustainable energy demands batteries that are not only high-performing but also cost-effective. PCB-500 represents a breakthrough in Sodium-Ion Battery (SIB) technology, offering a sustainable, high-power alternative to traditional Lithium-ion systems

1. NS-Doped Nanoporous Carbon Composite Anode

· **Dual-Heteroelement Doping:** Nitrogen (N) and Sulfur (S) are co-doped into a nanoporous carbon framework to maximize Na^+ adsorption and storage capacity.
· **High-Rate Performance**: This structure overcomes the high-rate limitations of traditional biomass-derived hard carbons, ensuring stable capacity recovery even at high current densities.
· **Controlled Nanostructure:** Precise control over specific surface area and nanopore distribution prevents the capacity decay typically seen in high-current operations.

2. Porous Polymer-Prussian Blue (PB) Composite Separator

· **Selective Ion Channels:** Prussian Blue (PB) micro-particles are uniformly dispersed within a porous polymer matrix (such as PVDF or PTFE) to provide selective Na^+ ion pathways.
· **Structural Integrity:** The 3D Fe-C≡N-Fe network of Prussian Blue allows for reversible sodium insertion and extraction while filtering out seawater contaminants.Reduced Interface
· **Resistance**: Unlike conventional non-selective membranes (PP/PE), our composite separator minimizes interface resistance and prevents structural degradation caused by metal ion elution.

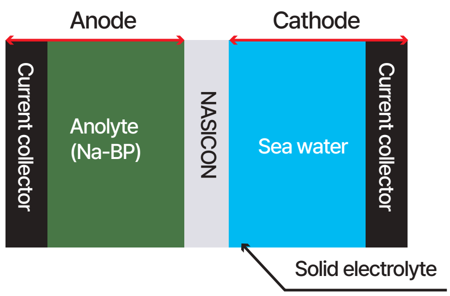
Key Performance Advantages

Feature	Technical Benefit	Impact on Seawater Battery
High Initial Coulombic Efficiency (ICE)	Mitigates the 60~80% ICE limitation of standard hard carbons.	Higher energy density and lower processing costs.
Cycle Stability	Prevents structural decay and metal elution during long-term cycling.	Reliable operation in harsh, saline environments.
Sodium Ion Selectivity	Selective conduction via the open-channel structure of Prussian Blue.	Superior ion conductivity and low internal resistance.
Rapid Recovery	Restores initial capacity even after switching from 5C to 0.1C current densities.	Optimized for high-power discharge requirements.

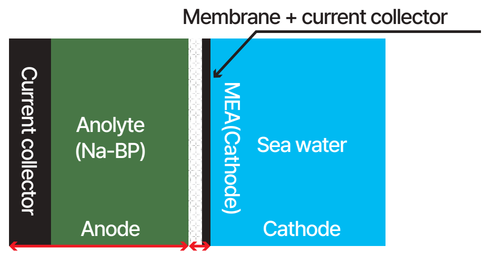
PRIONE SEAWATER BATTERTY

PRIONE's Second-Generation Seawater Battery Separator

- **Limitations of Conventional NASICON Separators**
  - Low mechanical stability
  - Limited electrochemical performance
  - → Need for next-generation separator technology
- **Performance Improvement Points**
  - Thickness reduced to approximately 80%
  - Improved flexibility
  - Reduced stack resistance
  - → Enhanced battery efficiency
- **Core Technology Elements**
  - Maintains Na^+ selectivity during the charging process
  - Higher performance than existing technologies with improved stability
- **Technical Significance**
  - Overcomes the structural and performance limitations of first-generationseparators
  - Combines Na^+ selectivity with enhanced stability
  - Improved manufacturability and applicability to next-generation seawater batteries



Conventional (1st-Generation) Seawater Battery



2nd-Generation Seawater Battery

Development of core organic–inorganic composite separator technology that blocks water transport within the cathode while enabling selective Na^+ ion transport.

- 80% Reduction in Thickness Compared to Conventional Separators
- Minimized Interfacial Resistance
- Reduced resistance and improved uniformity at the electrode–catalyst interface.

Separator Durability

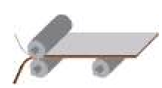
Brittle
Low durability

Flexible
High Durability

Mass Production of Cell Manufacturing

Brittle
Low durability

Flexible Compatible with Continuous Processing (Roll to Roll)

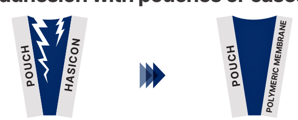


Applicability to Various Cell Structures

Brittle
Consistent Shape

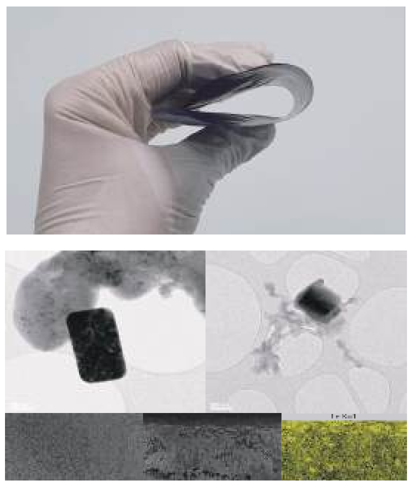
Flexible
Various Shapes

outstanding or enhancing adhesion with pouches or cases

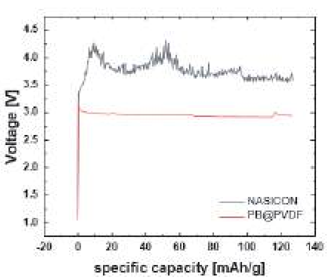


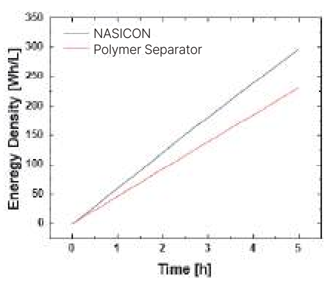
Ceramic Material
Low adhesion
to pouches

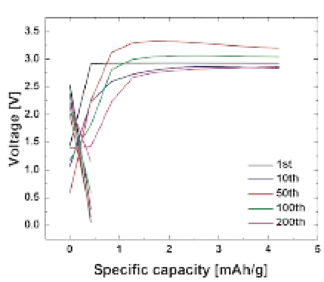
Polymer Material
High adhesion
to pouches

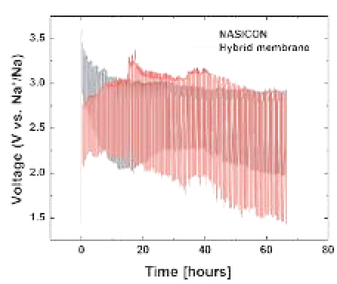


PRIONE Hybrid Membrane







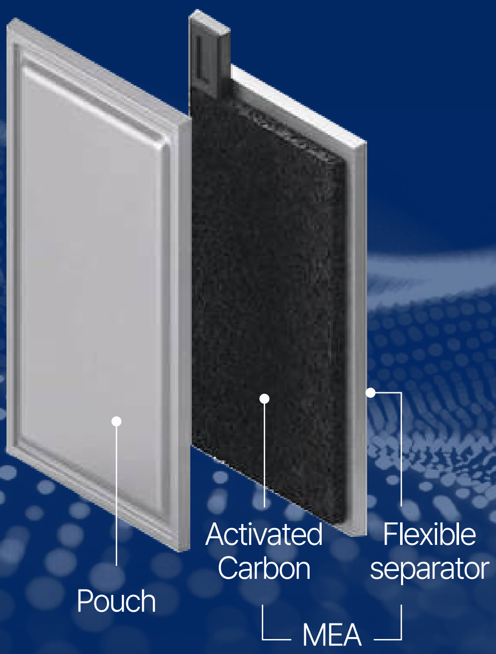


- Achieved an energy storage density of 231 Wh/L after 5 hours of charging, reaching approximately 76.7% of conventional seawater batteries (w/NASICON).
- Although voltage stability over 200 cycles is lower than that of NASICON, it maintains a level above 3V.

POUCH CELL

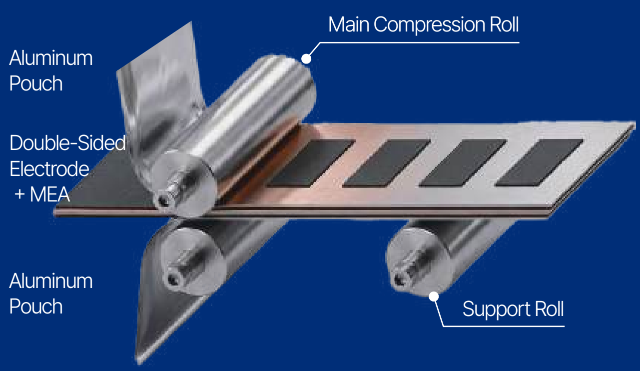
▪ Schematic Diagram of PRIONE's Second-Generation Seawater Battery

This structure plays a critical role in storing and releasing energy through electrochemical reactions within the battery cell.
When the battery is charged, electrons move from the cathode to the anode, thereby storing energy, while the reverse process occurs during discharge.
Each component plays an important role in optimizing this process and ensuring the stability of the battery.



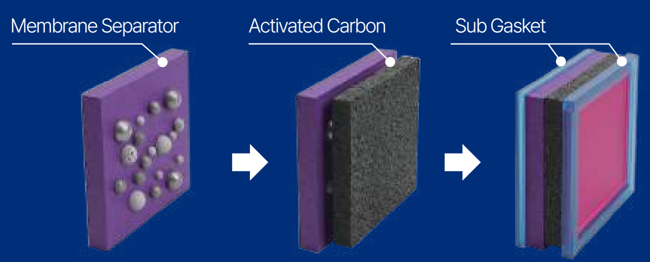
▪ Roll-to-Roll Process and MEA (Membrane Electrode Assembly)

A manufacturing method that adds a compression process to the R2R (Roll-to-Roll) system, which processes materials in a continuous roll form, to produce products for specific purposes.

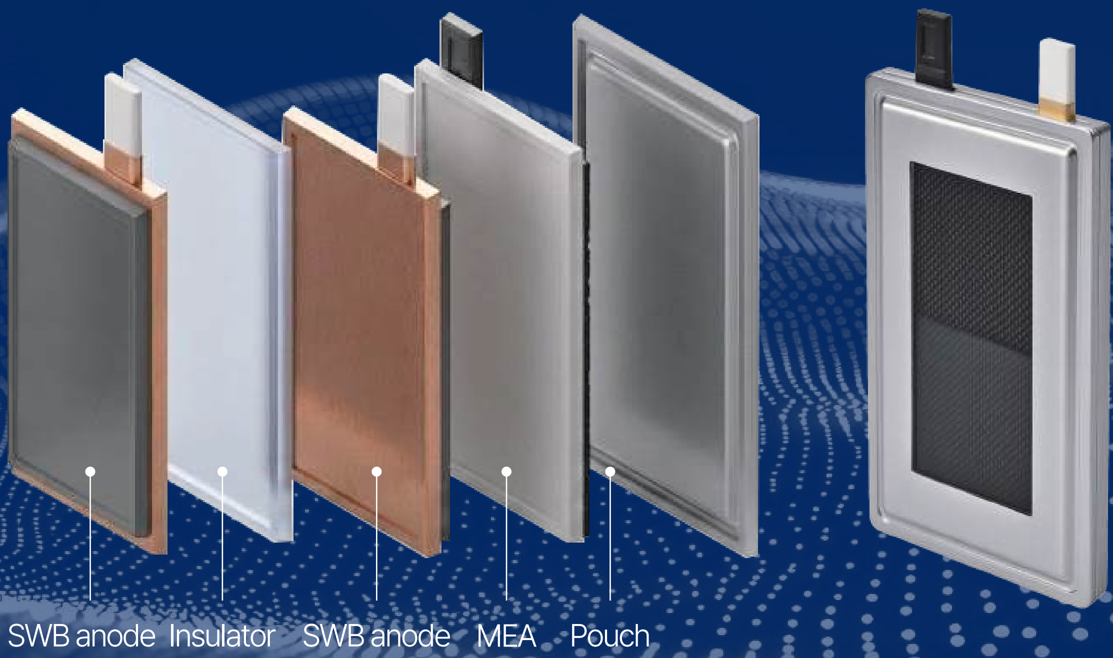


The polymer separator and anode electrodes are laminated through two or more compression rolls.

MEA(Membrane - Electrode Assembly)



- **Features**
  Core component of electrochemical devices such as fuel cells and batteries
- **Role**
  Generates electrical energy through electrochemical reactions
- **Composition**
  Composed of a polymer separator and an activated carbon layer



Second-Generation Polymer Separator

Easy shape modification and support for various designs require **Flexible Polymer Composite Materials.**

Anode Material for Seawater Batteries

Anode material for seawater batteries with **high capacity and long-term stability** – maximizing energy storage and seawater desalination performance.

Double-Sided Electrode Structure

Utilizing both sides of the electrode as active layers to maximize energy storage capacity.

▪ Roll to Roll 장점

· Increased Productivity

Rapid product manufacturing enabled through the adoption of Roll-to-Roll technology.

· Continuous Processing

Enables continuous processing using rolls, optimized for mass production.

· Consistent Thickness

Maintains a uniform material thickness through consistent pressure.

· Enhanced Bonding Strength

Strong bonding strength is achieved through compression when combining multiple material layers.

PRIONE

PUBLICATION RECORD

Carbon an international journal

Facile in situ synthesis of dual-heteroatom-doped high-rate capability carbon anode for rechargeable seawater batteries

Ultra-High Rate & Long-Life Carbon Anodes for Next-Generation Energy Storage

Optimized for large-scale Energy Storage Systems (ESS), our carbon anode lineup is synthesized via an innovative Solution Plasma Process (SPP). These materials overcome the traditional limitations of sodium-based batteries, providing high-rate capability and long-term stability using earth-abundant resources.

Core Technology & Innovation

·**In-situ SPP Synthesis:** A facile, one-step plasma-in-liquid process that synthesizes high-quality carbon directly from precursors, significantly simplifying the manufacturing route.

·**Strategic Heteroatom Doping:** High-concentration doping of Phosphorus (P) or dual-doping of Nitrogen (N) and Sulfur (S) to maximize electrical conductivity and active storage sites.

·**SEI-Free Technology**: Advanced surface engineering and the use of ether-based electrolytes allow for a co-intercalation reaction that avoids the formation of a thick Solid Electrolyte Interphase (SEI) layer.

---

1. PCB-500: Ultra-High Rate P-Doped Carbon

·**P-Doping:** 4 at% Phosphorus content creates abundant active sites for rapid sodium adsorption.

·**Performance:** Achieves a reversible capacity of 340 mAh g^{-1} at1 A g^{-1} and survives 40,000 cycles even at an ultra-high current density of 100 A g^{-1}.

2. Na-C: Self-Compensating Pre-Doped Carbon

·**Mechanism:** Sodium is pre-doped during synthesis; its release during discharge compensates for initial capacity loss.

·**Performance:** Exhibits a Coulombic Efficiency (CE) exceeding 100% (up to 104%) during cycling, with reversible capacity increasing over time as new void spaces are created.

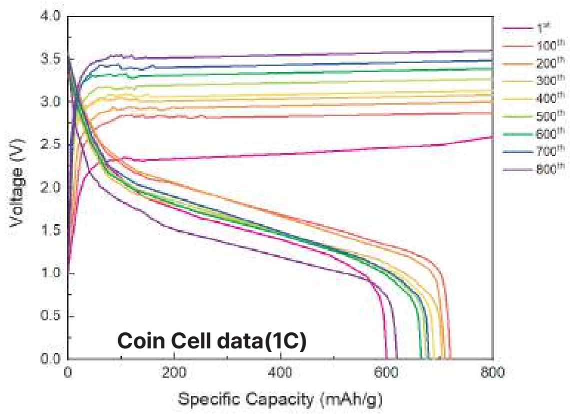
3. NS/C: Dual-Doped Carbon for Seawater Batteries

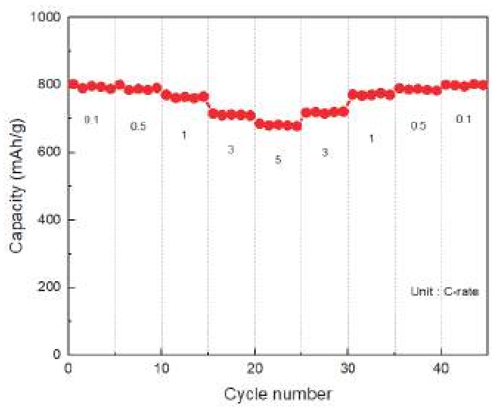
· **Design:** Specifically engineered with N and S co-doping for stable operation in seawater environments.

· **Seawater Application:** Validated with over 1,500 cycles at a high current density of 10 A g^{-1}, proving its practical viability for marine ESS.

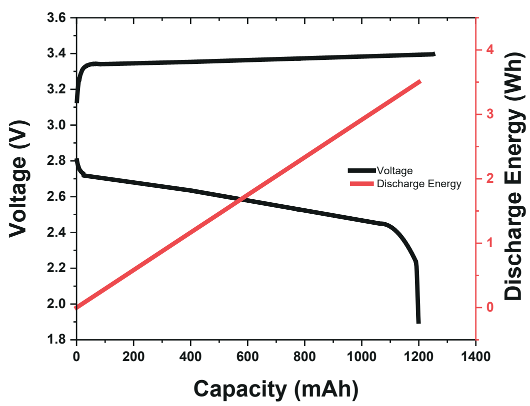
SEAWATER BATTERY CELL PERFORMANCE EVALUATION

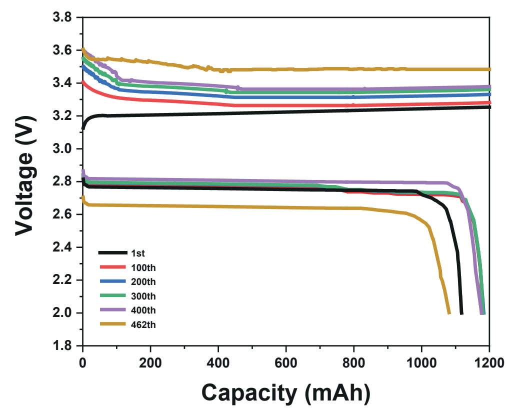
▪ Seawater Coin Cell





▪ Pouch cell





Category	PRIONE	Company A
Energy Capacity (Wh)	3.5	3
Cell Cross-Sectional Area (cm²)	192	192
Current Density (C-rate)	3	0.007(8mA)
Cell Capacity (mAh)	1138	1209

▪ Cost Benefits

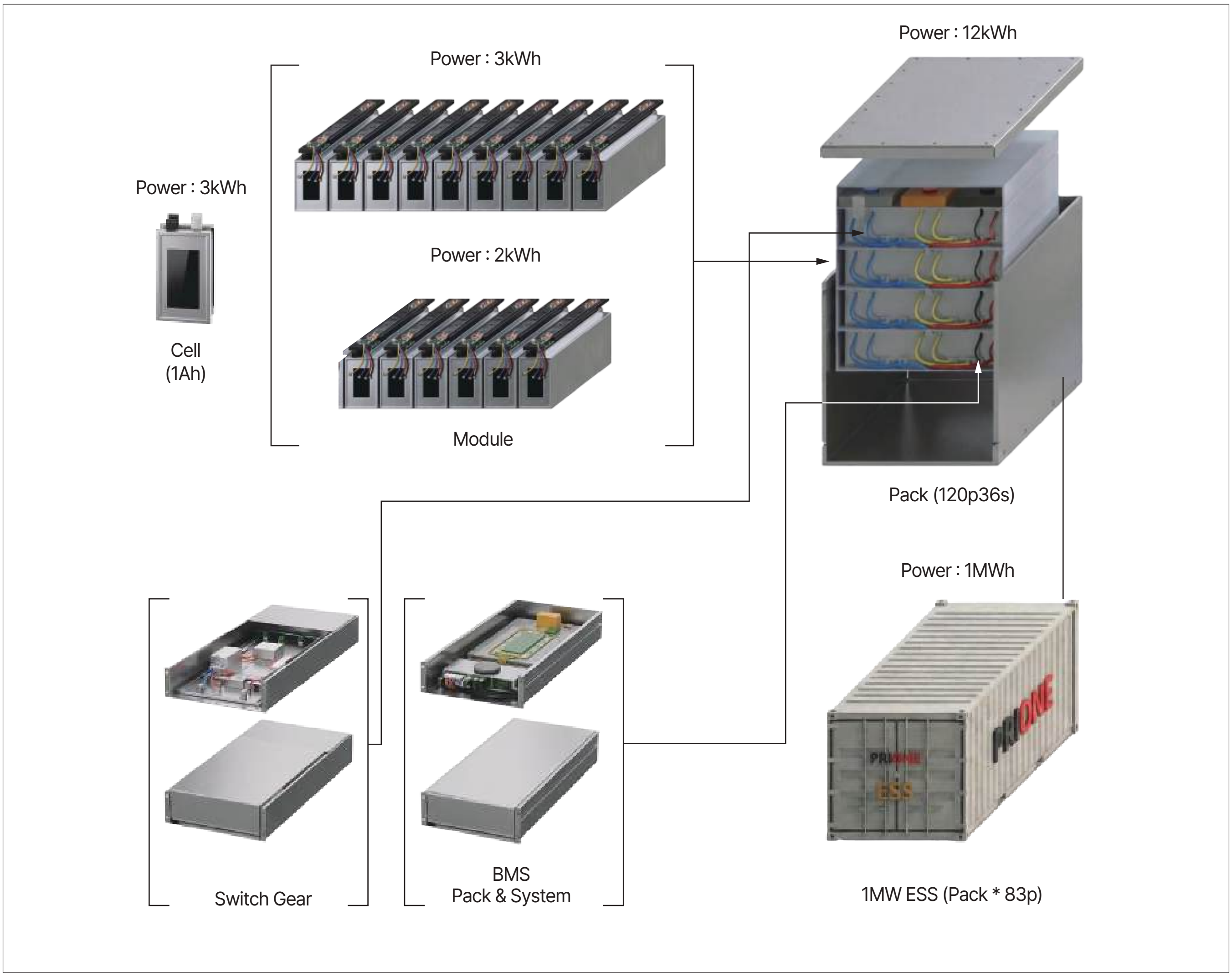
Category	USD/kWH	USD/kWH
	Cell	ESS
NCM	112	300
LFP	52	230
SWB (Seawater Battery)	48	150

※ Why SWBs Can Be More Cost-Effective than NCM and LFP Batteries

1. In the case of SWBs, the use of seawater eliminates the need for a cooling system.
2. Due to the structural characteristics of SWBs, costs are reduced because no cathode material is used.

SEAWATER BATTERY ESS OVERVIEW

▪ Scalable Structure of Seawater Battery ESS



From small cells to megawatt-scale systems, seawater batteries enable scalable ESS solutions.

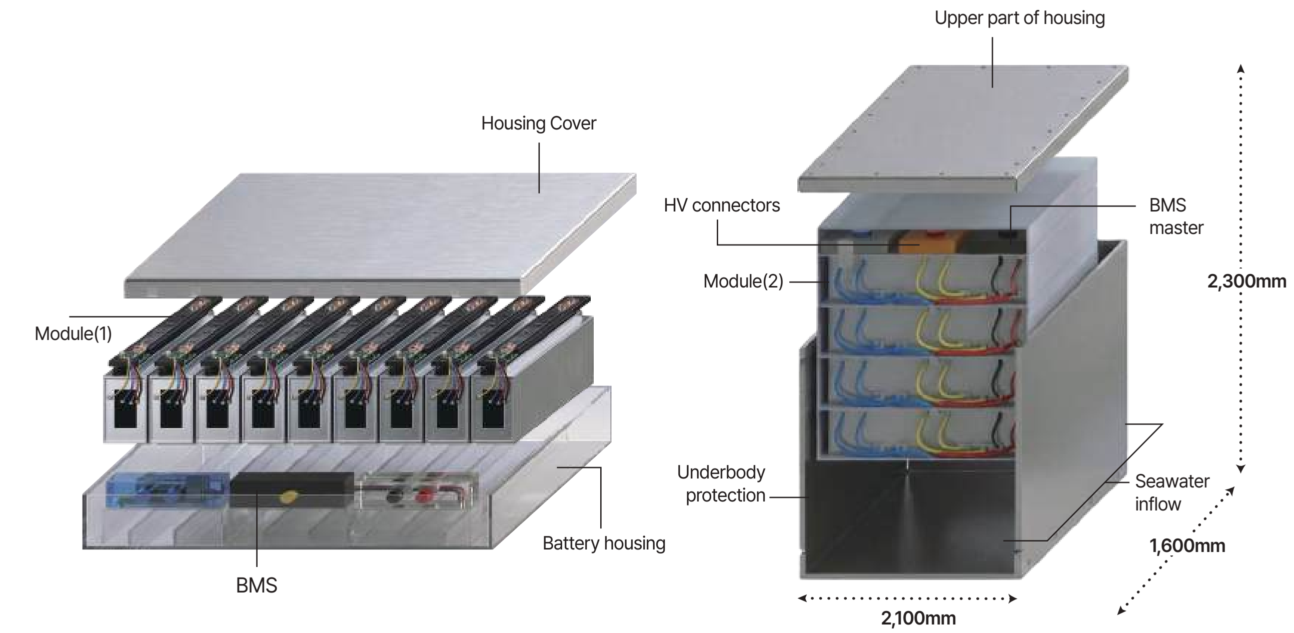
A new energy standard that delivers safety, cost-effectiveness, and durability.

Seawater batteries are a next-generation secondary battery technology that utilizes sodium ions in seawater, offering a promising alternative capable of overcoming the limitations of conventional lithium-ion battery ESS systems. Since seawater is used as the electrolyte instead of organic solvents, the risk of fire or explosion is extremely low, providing significantly enhanced safety compared to lithium-ion-based ESS facilities, where fire incidents have frequently occurred. This serves as a key differentiator, as it can fundamentally address one of the biggest risk factors in large-scale power grid ESS systems: fire hazards.

Cost-effectiveness is another major advantage. Seawater batteries are highly competitive in terms of economics because seawater is an almost unlimited resource and can replace scarce metals such as lithium, cobalt, and nickel. This enables a more stable supply chain compared to lithium-ion batteries, which are highly sensitive to fluctuations in raw material prices, and positions seawater batteries as a low-cost ESS solution in the long term. Considering the rapid global growth in renewable energy generation and the explosive increase in ESS demand, seawater batteries have strong potential to secure a strategic position in the renewable energy-linked ESS market.

Lithium-Ion Battery ESS VS Seawater Battery ESS

ESS(Energy Storage System)



[SWB packaging]

Lithium-Ion Battery ESS	VS	Seawater Battery ESS
Higher Risk of Ignition		Zero Fire Risk
Temperature Sensitive		Uses Seawater Zero Temperature Variation
Battery Replacement Issues		Zero Battery Replacement Issues
Waste Generation		No Toxic Metals
High Initial Cost		Reduced Initial Cost
The densely packed battery structure can cause even a small fire to result in significant damage.		A seawater-based system with zero risk of fire occurrence.
Cooling and temperature control systems are required due to battery heat generation issues.		Battery operation in seawater eliminates the need for a separate cooling system.
Costs increase due to the use of various rare metals, temperature control systems, and fire safety equipment.		Cost reduction effects achieved through the elimination of the cathode component and fire safety systems.

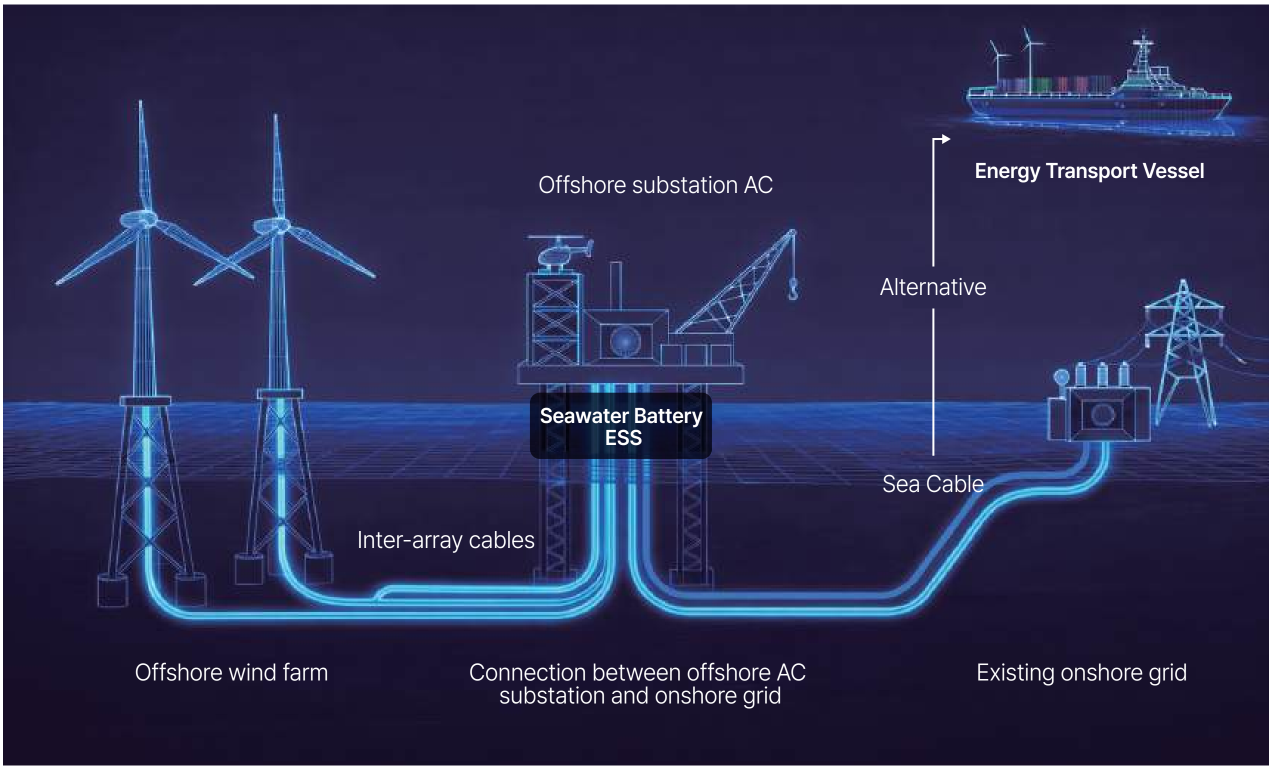
ENERGY STORAGE SYSTEM APPLICATION AREAS

Applications of Seawater Battery ESS

ESS Applications 01

Offshore Wind Energy & Energy Transport Vessels

Energy Transfer | Maintenance Support | Storage and Distribution



Offshore wind power generation produces electricity using wind turbines installed at sea. Since offshore environments provide stronger and more consistent winds than on land, they offer more favorable conditions for wind energy production. The generated electricity is transmitted from offshore facilities to land-based power grids. This approach is well suited for large-scale power generation and plays a key role in ensuring a sustainable energy supply.

Energy transport vessels are specialized ships designed to transport electricity generated offshore, such as from offshore wind farms, to land. These vessels play an important role in safely and efficiently delivering energy from offshore sites to onshore facilities.
In addition, energy transport vessels can be equipped with energy storage systems that allow them to store a certain amount of electricity before delivering it to land. This enables a stable supply of electricity generated from offshore wind power whenever needed, while supporting the efficient transmission and distribution of renewable energy.

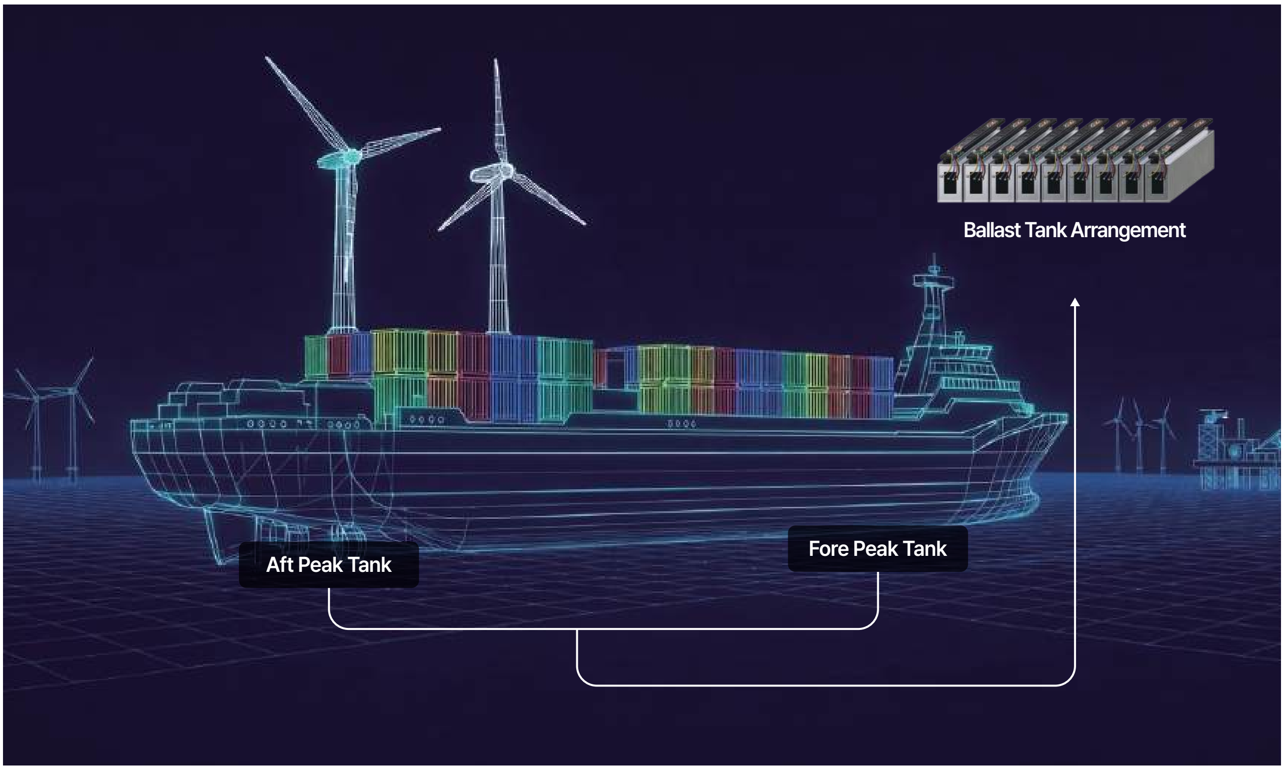
ESS Applications 02

Sustainable ship

Reduced Carbon Emissions

Improved Fuel Efficiency

Marine Environmental Protection



This is an eco-friendly vessel concept that integrates an energy system by utilizing the ballast tank structure of conventional ships.
Based on the configuration of the Fore Peak Tank, Aft Peak Tank, and central Ballast Tank, which are responsible for vessel stability, the system is designed to efficiently accommodate seawater battery ESS and energy management systems.

Role of the Ballast Tank Arrangement

· Fore Peak Tank

A tank located at the bow that is responsible for longitudinal stability and trim control of the vessel. In eco-friendly ships integrated with energy systems, it serves as a key structure for maintaining load balance.

· Aft Peak Tank

Located at the stern, it stabilizes the center of gravity near the propulsion system. When integrated with energy storage modules, it contributes to propulsion efficiency and vessel stability.

· Central Ballast Tank

The ballast tank positioned at the center of the hull can store large volumes of seawater, providing an ideal space for electrolyte utilization in seawater battery ESS and energy system integration.

ENERGY STORAGE SYSTEM APPLICATION AREAS

Applications of Seawater Battery ESS

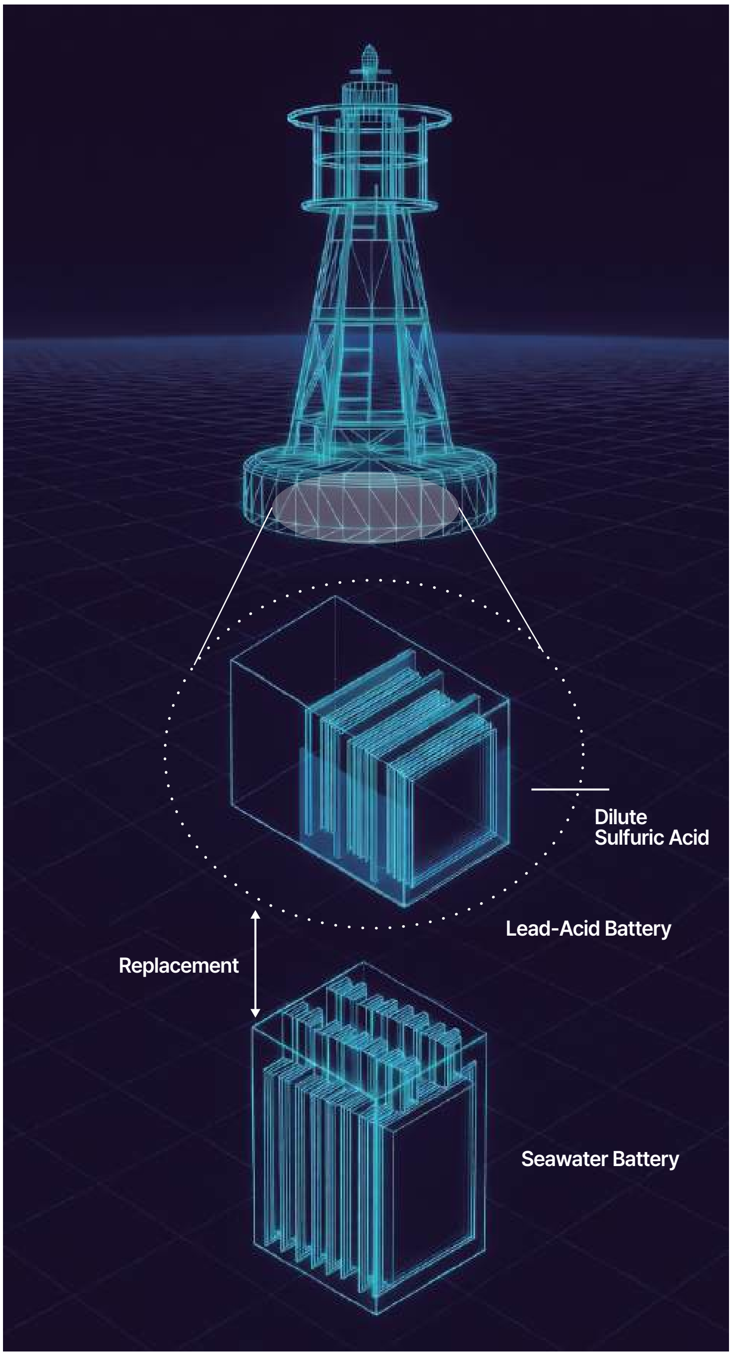
ESS Applications 03

Optical Wave Marker

Stable Power Supply for Unmanned Marine Facilities

Eco-Friendly

Renewable Energy-Linked Self-Sustaining Operation



Light beacons are one of the representative maritime applications of seawater battery ESS, serving as self-sustaining signaling systems designed to reliably indicate the location and status of offshore structures.
By utilizing seawater battery-based ESS, which uses seawater as the electrolyte, continuous signal operation is possible without dependence on external power infrastructure.

In marine environments, stable power supply is difficult to maintain, making energy independence and reliability critical factors for beacon systems.
Seawater battery ESS is an energy storage solution optimized for such conditions, supporting long-term uninterrupted operation of light beacon systems.

ESS Applications 04

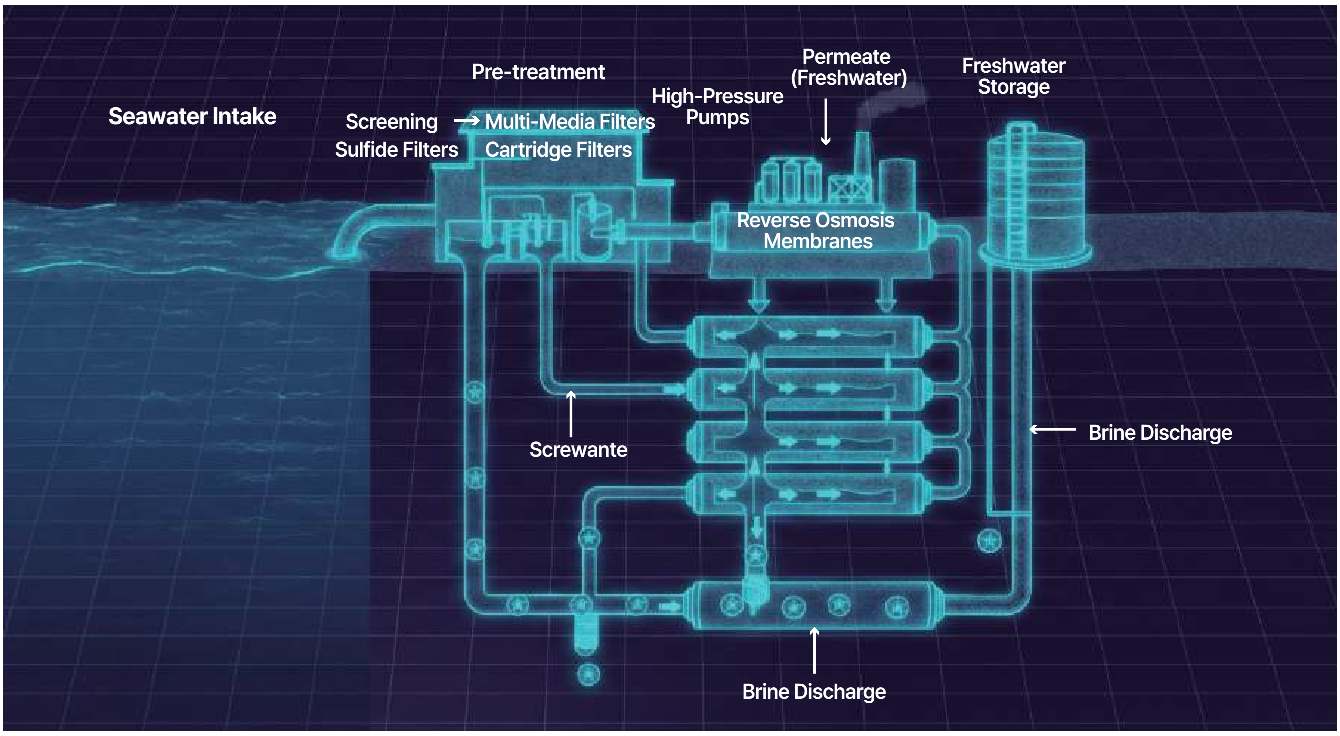
Marine Desalination

Efficient Salt Removal

Sustainable Water Resource Supply

Energy Efficiency

Seawater desalination is a key technology for addressing water scarcity, but it is also one of the most energy-intensive systems. Our seawater desalination technology is designed based on an electrochemical ion separation process, considering both energy efficiency and system stability. In particular, integration with a seawater battery-based energy storage system enables sustainable freshwater production.



Efficient Pretreatment

Removes impurities contained in seawater in advance, improving electrochemical reaction stability and membrane lifespan.

Selective Ion Separation

Through AEM·CEM-based selective ion transport, Na^+ and Cl^- are effectively separated to produce desalinated freshwater.

Electrochemical Energy Flow

Electron flow is generated through electrode reactions, and the power required for the desalination process is efficientlymanaged.

Stable Water & Energy Output

Freshwater is supplied stably, while concentrated brine is processed in a controlled manner to maximize process efficiency.

SECONDARY BATTERY
ENERGY MATERIAL COMPANY

BEST VALUE INNOVATION PRIONE

PRIONE

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