
Inno
Energy
World Leading Advanced
Battery Storage Solution.
Thermal resonance superconductivity material + Cell-level temperature
control system
InnoEnergy.com.au

"Through our Australian patents and cutting-edge technology, we're propelling the battery storage industry forward, setting global standards with our safe, efficient, and durable energy solutions. This not only reinforces Australia's manufacturing prowess but also establishes Australia’s leadership on the world stage."

InnoCool: Patented Super Thermal Resonance Heat Transfer Technology

Introduction - InnoCool

Inno Energy Group has developed a heat transfer technology, known as InnoCool, which solves the fundamental issue of heat dissipation in all electronic products, which significantly affects its service lifespan and safety. InnoCool operates as a passive cooling system, obviating the need for external power sources such as gravity or siphon forces. Design considerations prioritise optimal flow rates and pipe dimensions within the heat transfer channel.

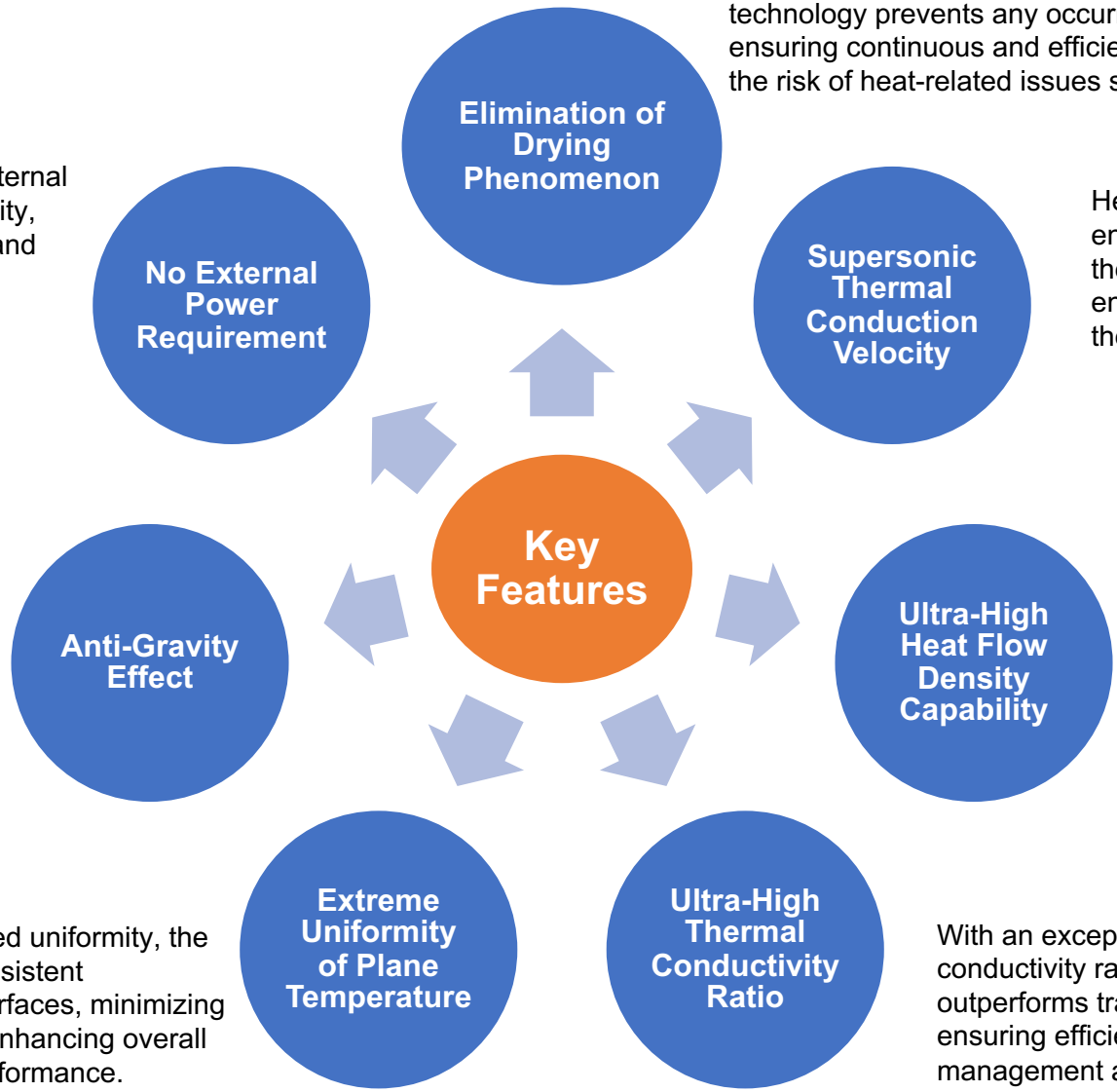
Advantages of InnoCool Superconducting Heat Transfer Technology

- Enhanced heat flow density, accelerated heat transfer rates, and increased heat transfer efficiency broaden the scope of application. This advancement is characterized by a significant geometric escalation in heat flow density, transfer speed, and coefficient, bolstered by enhanced anti-gravity capabilities within fluid heat transfer.
- InnoCool technology represents a departure from traditional heat transfer methods such as conduction, convection, and radiation. Its efficacy is independent of medium movement, eliminating reliance on medium cooling during transit.

Advantages of InnoCool Materials in Device Application Design

- **Rapid Heat Transfer:** Ensures fast heat dissipation and maintains temperature uniformity.
- **Versatility:** Enables easy reprocessing and surface treatment, such as painting, anodic oxidation, and electroplating. It can also be welded, folded, bent, cut, drilled, and connected to sheet metal according to structural requirements.
- **Durability:** Exhibits strong resistance to degeneration, weathering, oxidation, corrosion, and impact.
- **Reliable Performance:** Offers stable operation, good reliability, long service life, and requires zero maintenance.

Key Features



Under ultra-high heat flow density conditions, the technology prevents any occurrence of drying, ensuring continuous and efficient heat transfer without the risk of heat-related issues such as drying out.

Heat is conducted at supersonic speeds, enabling rapid and efficient dissipation of thermal energy throughout the system, ensuring swift response to changing thermal conditions.

The technology excels in managing ultra-high heat flow density scenarios, maintaining optimal heat transfer performance even under extreme thermal loads.

With an exceptional thermal conductivity ratio, the technology outperforms traditional methods, ensuring efficient thermal management and distribution.

Achieving unprecedented uniformity, the technology ensures consistent temperatures across surfaces, minimizing thermal gradients and enhancing overall system stability and performance.

The technology harnesses an anti-gravity effect, allowing for efficient heat transfer in various orientations without reliance on external gravitational forces, ensuring versatility in application.

Operating autonomously, the technology does not require external power sources for its functionality, reducing energy consumption and enhancing reliability.

Technical Data

InnoCool Material Properties

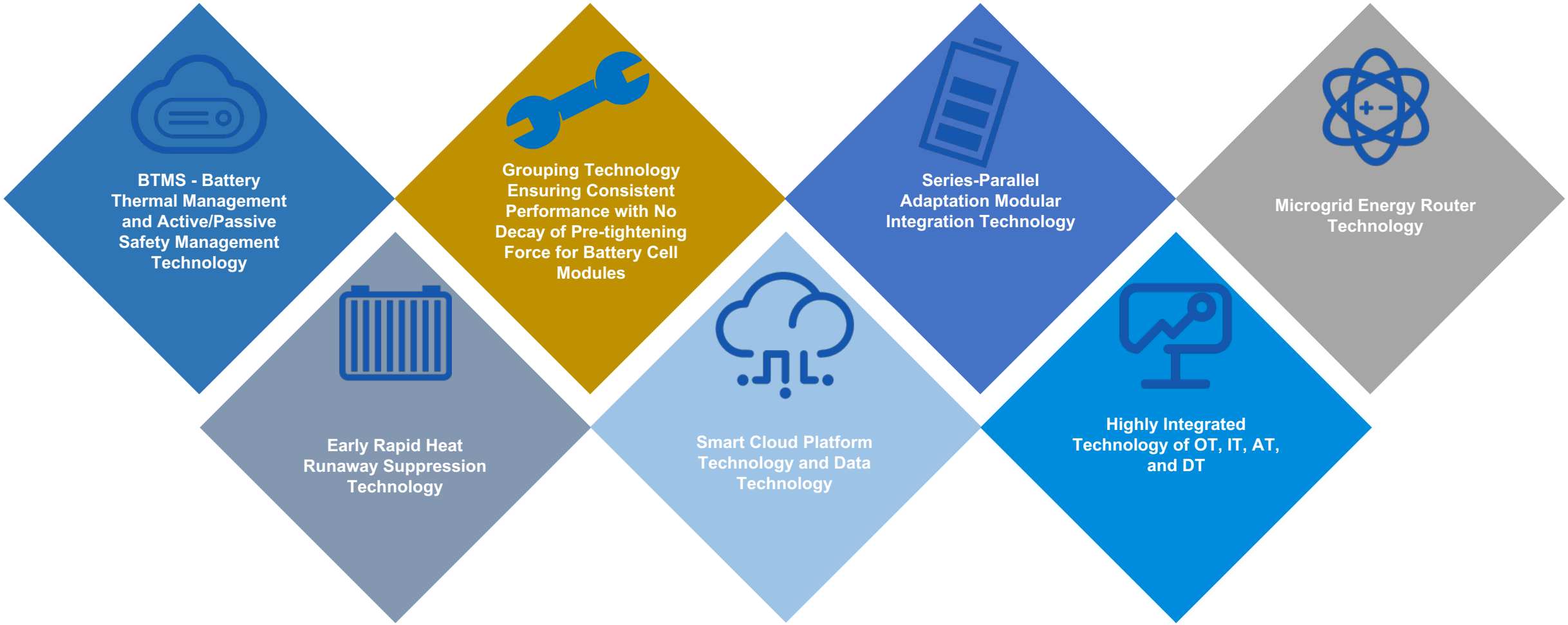
Heat transfer properties	Index
Density	100-200 W/cm^2
Capacity	>1,000 W/2mm(cross section)
K Value	3,000-4,000
Speed	>340 m/s
Ratio	>6,000
Cross Section	0.6-3 mm
Heat Dissipation Cross-section / Surface Ratio	0.6 / ∞
Interface	1
Structural Strength Of The Closed Inner Micro-nest Chamber	>12 MP
Heat Transfer Power / Area / Weight Ratio	100 W/0.3 m^2/0.9 kg
Effective Working Temperature	-40 ℃ - 110 ℃
Recommended Working Temperature	10 ℃ - 100 ℃

Heat Transfer Comparison

Material	Coefficient of heat transfer (W/mK)	Density (Kg/m^3)
Gold (Au)	315-317	19,320
Silver (Ag)	429	10,502
Aluminum (Al)	237	2,699
Copper (Cu)	398-401	8,900
Iron (Fe)	80	7,870
Heat Conduction Silicone Fat	1.0-5.0	1,500-2,500
Heat Conduction Silicone	0.6-2.0	1,500-2,500
Phase Change Thermal Conductivity Glue	0.8-5.0	1,500-2,500
Copper Heat Pipe (Heat Plate)	2,500	≈8,900
InnoCool Panel	**> 6,000**	**≈2,700**

Battery Storage Technological Advancement

Technological Advancement:
Ultimate Safety, Enhanced Efficiency & Extended Lifespan



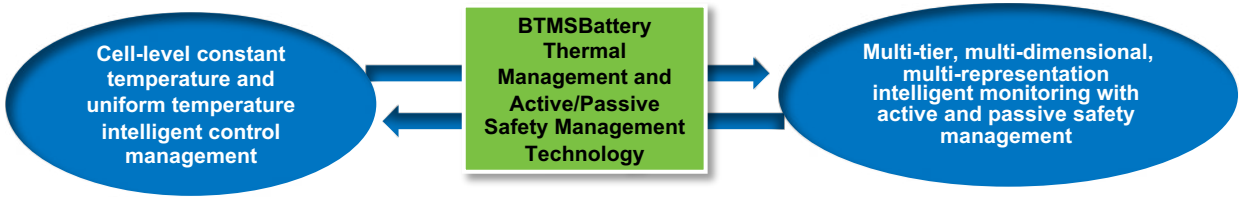
BTMS - Battery Thermal Management and Active/Passive Safety Management Technology

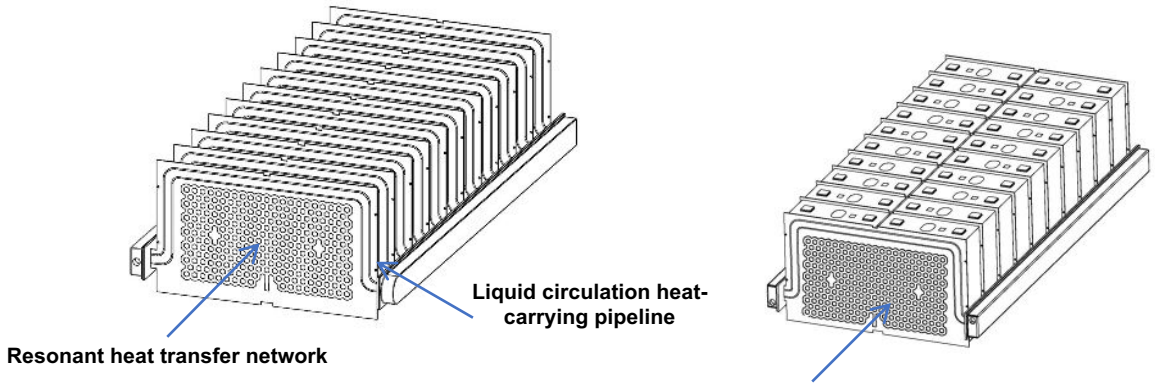
1) Battery Thermal Management (BTMS)

- The world's first resonance heat transfer combined with large-diameter single-flow channel liquid circulation integrated composite liquid cooling/heating technology, with ultra-high heat dissipation efficiency, and a maximum heat dissipation power of up to 160KW.
- The large-side parallel equal-path liquid circulation thermal management technology for battery cells maximizes the effective heat exchange area of the outer surface of the battery cells, reaching up to 88%.
- The world’s first unique large-side, large-diameter single-flow channel cell-level parallel networking technology features a flexible pipe network that effectively releases stress, ensuring high flow capacity, excellent fluidity, and precise controllability.
- Comprehensive cell temperature monitoring with a three-tier architecture and proactive intelligent temperature control technology.

2) Multi-level, multi-dimensional, multi-representation intelligent monitoring with active and passive safety management technology

- Cell-level voltage, temperature, and deformation monitoring, diagnosis, early warning, control, and management technology.
- Pack-level aerosol, temperature, CO, VOC, and pressure diagnostic, early warning, and management technology.
- Pack-level liquid leakage monitoring, early warning, diagnosis, control, and management technology.
- Pack-level Anti-Condensation Technology.
- Multi-dimensional big data-driven combined with electrochemical model-driven, cloud-edge collaborative computing and processing, online cloud-based monitoring, diagnostic, early warning, control, and management technology.





Achievements

- Ultimate safety and reliability for batteries;
- Stable and constant temperature environment for batteries;
- Ensure high consistency of battery temperature, reduce the barrel effect, improve output level, and minimize capacity loss

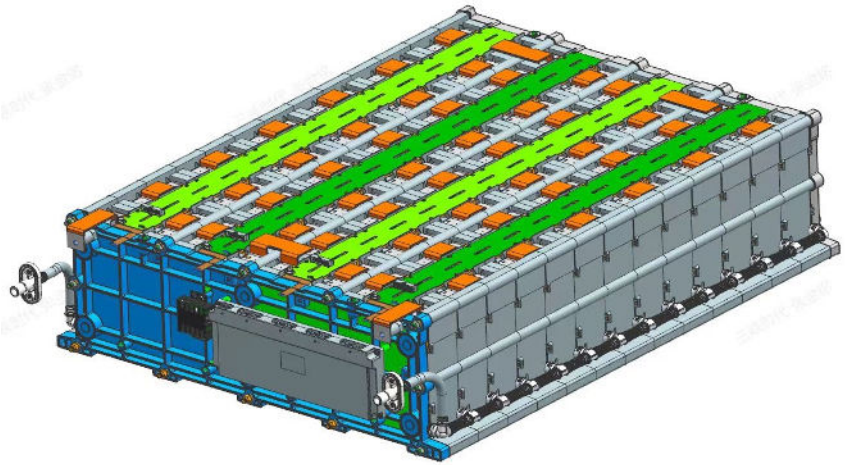
For power batteries, with an ultra-high heat dissipation power (160KW), there is a significant surplus to match the high-density high-power (such as ternary batteries) battery charging and discharging heat generation power. It is fully capable of achieving ultra-fast charging of 4C and above, which gives it a significant advantage compared to other thermal management technologies.

Grouping Technology Ensuring Consistent Performance with No Decay of Pre-tightening Force for Battery Cell Modules

The world's first square-shaped cell frame assembly structure

The world's first adhesive-free and welding-free mechanical locking structure

Cell expansion constraint limitation, stress buffering absorption structure.



Enhancing technological significance and user value

Maintaining Pre-tightening Force

The continuous and uniform maintenance of pre-tightening force on the cells; restriction of cell expansion; buffering and absorption of expansion stress on the cells. This physical mechanical approach maximally ensures the structural safety and lifespan of the cells, thereby extending battery life by approximately 20-30%.

Individual cell compartments

Each cell is housed within an individual isolated compartment, providing insulation and minimizing the impact of ambient temperature or neighbouring cell temperature. It remains unaffected by external environmental temperatures, effectively preventing heat diffusion.

Non-destructive disassembly

Enabling non-destructive disassembly and replacement at the cell level, avoiding whole-pack scrap during production and use, providing a better cell-level solution for maintenance, tiered applications, and recycling disassembly and utilization.

Minimization of thermal resistance

Integration of cell, liquid cooling plate, thermally conductive silicone rubber curing layer, and inner framework ensures permanent and continuous tight adhesion between the cell and the liquid cooling plate, preventing separation. The adhesion force remains constant over time, ensuring that the interface thermal resistance does not increase.

Series-Parallel Adaptation Modular Integration Technology

Rack-level optimized balancing coordination and independent control of charging and discharging;

- Each pack is fully charged and discharged, with no series cell imbalance;
- No circulating current: Precise control of voltage and current for each cluster
- Ultimate safety: Battery pack port voltage is 0.

Series-parallel adaptation

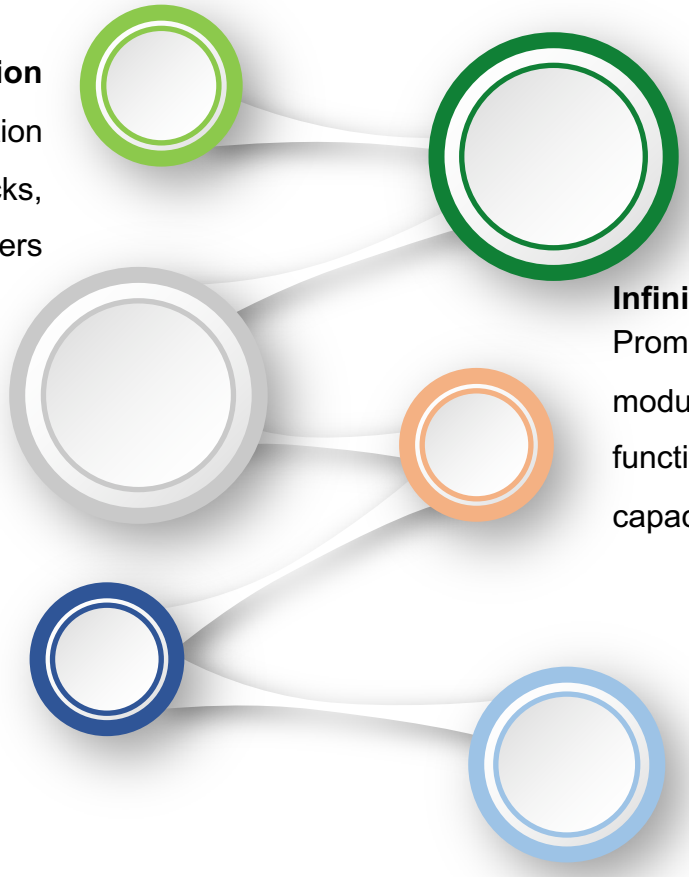
Multi-level module series/parallel adaptation and integration technology for cells, packs, clusters, and containers

Balancing control

Modular technology for intelligent balancing control of differences between various hierarchical modules

Cascade integration

Multi-cluster or multi-all-in-one machine module-level cascading high-voltage direct-hanging integration technology, enabling large-capacity expansion



Safety Upgrade

Enhancing system processing capability, reducing capacity loss, and essentially eliminating the safety risks associated with direct current arcing

Infinite scalability

Promoting large-scale modular integration, balanced control of module standardization and consistency, enabling plug-and-play functionality for individual module units, while also facilitating high-capacity infinite expansion with multiple module units.;

Large-scale integration

Enhanced and optimized the integrated expansion capability of battery storage products, providing support for the later development of large-scale lithium-ion battery storage systems, containerized battery cabinets for ships, and other product forms

Microgrid Energy Router Technology

Features

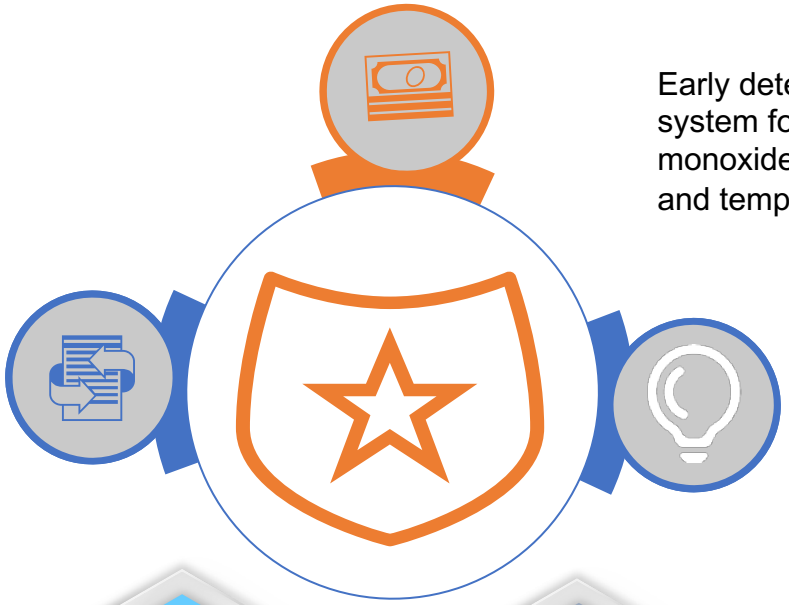
Silicon carbide power conversion module equipped with dual buses (AC/DC) and related circuits. It provides power for various sources such as solar and wind, allowing for direct or indirect access, conversion, and storage of wide voltage ranges. The module offers multiple output voltages, flexible modular configuration, and unlimited stacking for capacity expansion in microgrid energy routing technology.

It supports grid-connected, off-grid, and island operations. Multiple units can work in parallel through intelligent control and balancing, enabling efficient operation. Additionally, it allows direct connection to solar panels without extra inverters and supports direct connection to 380VAC loads.

Technical significance and enhancement of user value

The versatility of battery storage integrated units has expanded, now covering a wide range of scenarios including generation, grid management, load balancing, storage, charging, and monitoring, either individually or in combination. With a single hardware platform supporting various software, the product customization process is significantly shortened. This encourages universalization and standardization of the product.

Early Rapid Heat Runaway Suppression Technology (Pack Level)



Early detection, analysis, diagnosis, and warning system for thermal runaway, covering smoke, carbon monoxide (CO), volatile organic compounds (VOC), and temperature

Sustains multiple consecutive spot sprays to prevent temperature from rising.

In the initial phase of thermal runaway, automatic spraying and immersion of perfluorohexane at the pack level rapidly and effectively cool down, preventing the onset of thermal runaway.

Cell-level temperature and deformation monitoring

Pack-level monitoring of water immersion, air pressure, VOC, CO, smoke, temperature, etc

Pack-level rapid cooling with perfluorohexane

Early warning system utilizing big data analysis.

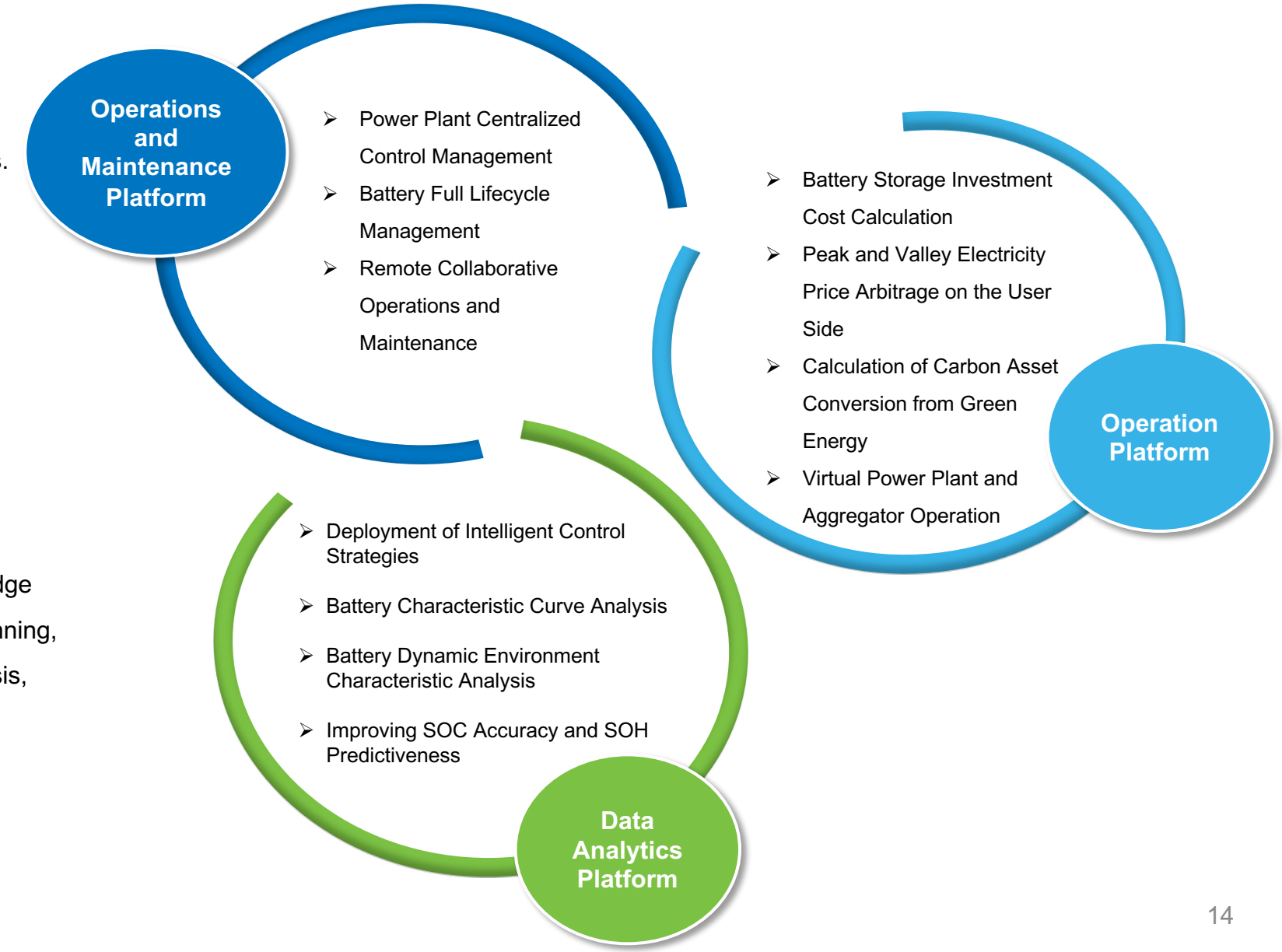
This technology acts as a critical complementary technique to BTMS, enhancing the capability for predicting and suppressing thermal runaway triggered by internal cell factors. It essentially eliminates the risk of battery combustion, ensuring utmost battery safety.

Smart Cloud Platform Technology and Data Technology

Advanced AI algorithms, including State of Charge (SOC) and State of Health (SOH), powered by both models and data stored in cloud backend databases.

Comprehensive diagnostic, warning, control, and management technology utilizing multilevel, multidimensional, multiparameter, and multimodel approaches.

Built upon foundational technologies like big data processing, analysis, and mining, as well as communication, artificial intelligence, the Internet, edge computing, edge-cloud collaboration, and digital twinning, cloud backend technology facilitates remote diagnosis, warning, control, operation, and maintenance.



Highly integrated technology encompassing Operational Technology (OT), Information Technology (IT), Automation Technology (AT), and Digital Twinning (DT).

The integration of automation technology, computer technology, communication technology, artificial intelligence technology, and big data technology.

Multi-System Integration Technology

Local, Edge, and Cloud Backend Collaboration Technology

Technological Significance

Empower battery storage systems and their operation throughout their entire lifecycle to attain genuine intelligence.

Product Application

Overview

- Commercial and Industrial Battery Storage System
- Residential Battery Storage System
- Electric Vessels Power Battery
- Construction Machinery (especially loaders) Power Battery

Ultimate Safety and High Reliability

- Mitigates the risk of battery explosion from heat build-up and thermal runaway.
- Monitoring, early warning, diagnosis, control, and management of voltage, temperature, and deformation at the cell level.
- Aerosol, temperature, CO, and VOC monitoring, early warning, diagnosis, and management at the pack level.
- Leakage monitoring, early warning, diagnosis, control, and management technology at the pack level.
- Anti-caking technology at the pack level.
- Multi-level, multi-dimensional, multi-parameter dual-driven algorithms with models.

High Performance

- Integrated Compound Liquid Cooling/Heating Technology utilizes Resonant Heat Transfer and Large Diameter Single-Channel Liquid Circulation.
- 85% of the battery cell's outer surface serves as effective heat exchange area.
- Parallel Equilibrium Liquid Circulation Thermal Management on the large side surface of the battery cell is implemented.
- Large-Surface, Large-Diameter Single-Channel Battery Cell Parallel Network Process Technology, with Soft Connections in the Network, effectively relieves various stresses, offering good fluidity, high flow rate, and excellent controllability.
- Temperature monitoring of all battery cells is implemented, with a Three-Level Architecture for Intelligent Temperature Control.

World-leading Technological Indicators

25~45℃ **Consistent Temperature**
Temperature Control Range of Individual Battery Cells under all Operating Conditions.

≤3℃ **Uniform Temperature**
Temperature Difference Between Individual Battery Cells Throughout the Entire System.

≤2℃ **Temperature Difference Between Battery Cells**
Temperature Difference Between Individual Battery Cells Inside the PACK.

≤1℃ **Temperature Difference in the Liquid**
Temperature Difference between Battery Cells and Circulating Liquid within the System.

Enhancement of User Value

Extended Lifespan Over competitor 30~50%

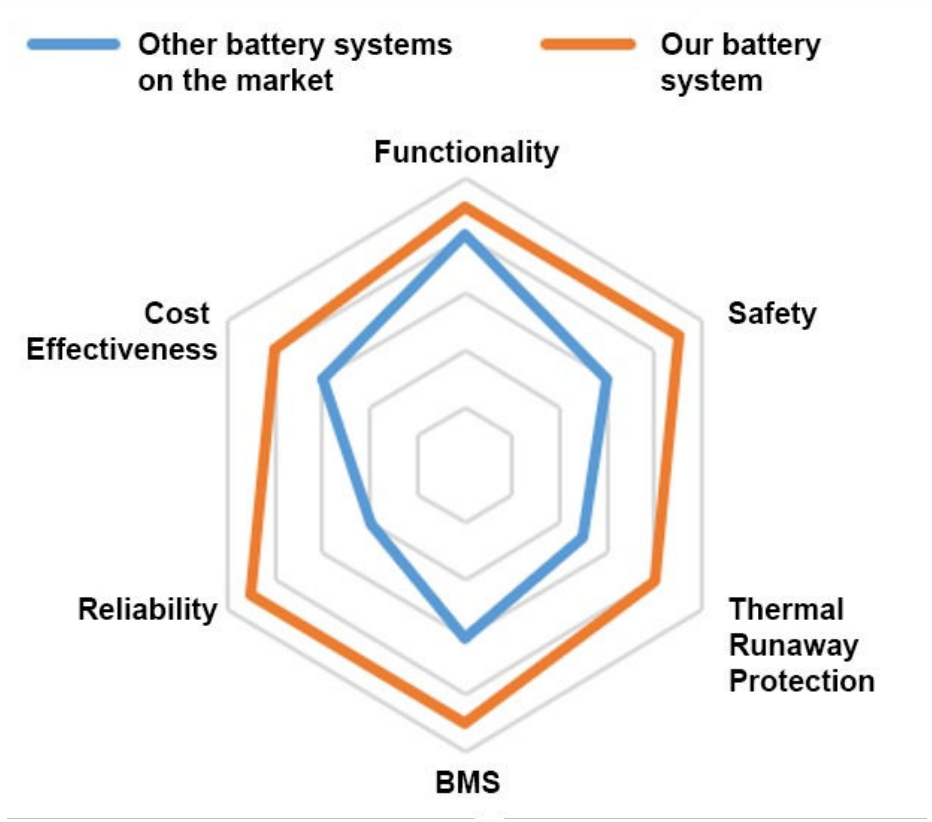
Reduced Decay Rate Over competitor 30%

Enhanced Conversion Rate Over competitor 5%

Reduced Capacity Loss Rate Over competitor 8%

Advantages of InnoCool Battery Storage Solution

- Globally leading and unique material science expertise (superconducting thermal materials).
- Fully independent development of Battery Thermal Management Systems (BTMS) and Battery Management Systems (BMS), with cloud-to-end (AI adaptive algorithm) control.
- Proprietary development of core production lines for modules and PACKs; leveraging high levels of automation and intelligence to enhance efficiency.
- Participation in battery system certification and formulation of safety standards.
- Long-term collaboration with top-tier battery cell research team; providing in-depth understanding of cell chemistry characteristics to optimize battery system design.
- Over 10 years of experience in battery system development by our research and development team.
- High system reliability validated through various types of product testing.



Product Advantages

- **Ultimate Safety**: World-leading safety standards are adopted to effectively mitigate safety hazards and risks, such as battery combustion resulting from thermal runaway and heat generation.

- **Enhanced efficiency**: Efficiency is increased by up to 40-50% compared to existing battery storage systems.

- **Extended lifespan:** Service life is improved by 30%-50% compared to existing battery storage systems. This substantial improvement ensures prolonged functionality and reliability.

- **Reduced Levelized Cost of Energy (LCOE):** our innovative methodology results in a significant reduction in LCOE for power stations. By streamlining operational processes and enhancing overall system performance, we achieve notable reductions in operating costs, making power generation more economically sustainable.

Thermal Rise Testing of Commercial All-in-One Pack

- Product Specification: PACK 46kW/h 1P52S equipped with InnoCool
- Experimental Method: Temperature sensors are placed near the electrode of Battery Cell
- Methodology:
  1. Initial Stabilization:
     a) Allow the all-in-one pack to stabilize at room temperature (~30°C).
  2. Charging Phase:
     a) Charge the pack at 0.5C until cutoff voltage.
     b) Without Water Cooling: Record core temperature rise.
     c) With Water Cooling: Activate water cooling during charging and record core temperature.
  3. Idle Phase:
     a) Let the pack idle until core temperature stabilizes (~30°C).
  4. Discharging Phase:
     a) Discharge the pack at 0.5C until cutoff voltage.
     b) Without Water Cooling: Record core temperature rise.
     c) With Water Cooling: Activate water cooling during discharging, adjust water to 20°C and flow rate of 6L/min, and record core temperature.

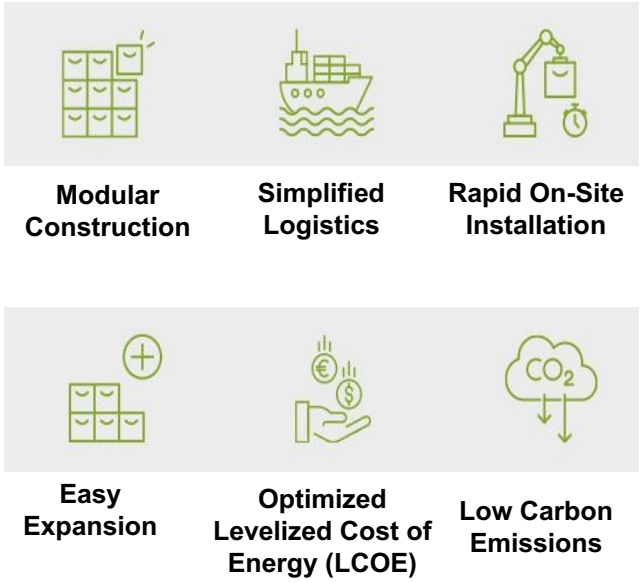
Experimental Conditions	Charging Stage: 0.5C Constant Power (Room Temperature: ~28°C)						
	Start			End			Max Temp Difference during process
	Highest Cell Temp	Lowest Cell Temp	Temp Difference	Highest Cell Temp	Lowest Cell Temp	Temp Difference	
Without Water Cooling Unit	32.2 ℃	30.3 ℃	1.9 ℃	44.1 ℃	39.8 ℃	4.3 ℃	4.4 ℃
With Water Cooling Unit 20℃ @ 6L/min	31.0 ℃	30.3 ℃	0.7 ℃	27.1 ℃	25.3 ℃	1.8 ℃	1.9 ℃

Conclusion

- During the charging process, significant variations in core temperature were observed, whether the water cooling unit was activated or not.
- Activating the water cooling unit led to a noticeable reduction in core temperature during charging.
- The temperature difference between cells was smaller when the water cooling unit was active, suggesting a more uniform temperature distribution.
- The temperature gap between using and not using the water cooling unit reached up to 17°C.

Application –Commercial and Industrial Battery Storage

- Modular and Scalable Concept
- Plug-and-Play, Easy to Connect
- Simplified Logistics
- Rapid On-Site Installation
- Integration of Battery Auxiliary Equipment
- Reduced Carbon Emissions
- Optimized Levelized Cost of Energy (LCOE)



Application – Residential Battery Storage (Modular Solution)

Our core patented cooling technology is engineered to deliver exceptional efficiency and safety.

- Unparalleled commitment to safety, our intelligent thermal management system mitigates the risk of battery explosion from heat buildup and thermal runaway.
- Class-leading energy efficiency.
- Prolonged life span and performance.
- Integrated cabinet design, modular assembly and anti-collision design, more convenient installation and replacement.
- IP65 protection grade.
- Excellent safety protection mechanism to provide safe power to users.
- Stacked design, more simple connection, more comfortable use.

Application – Large Scale Battery Storage

Performance Pack

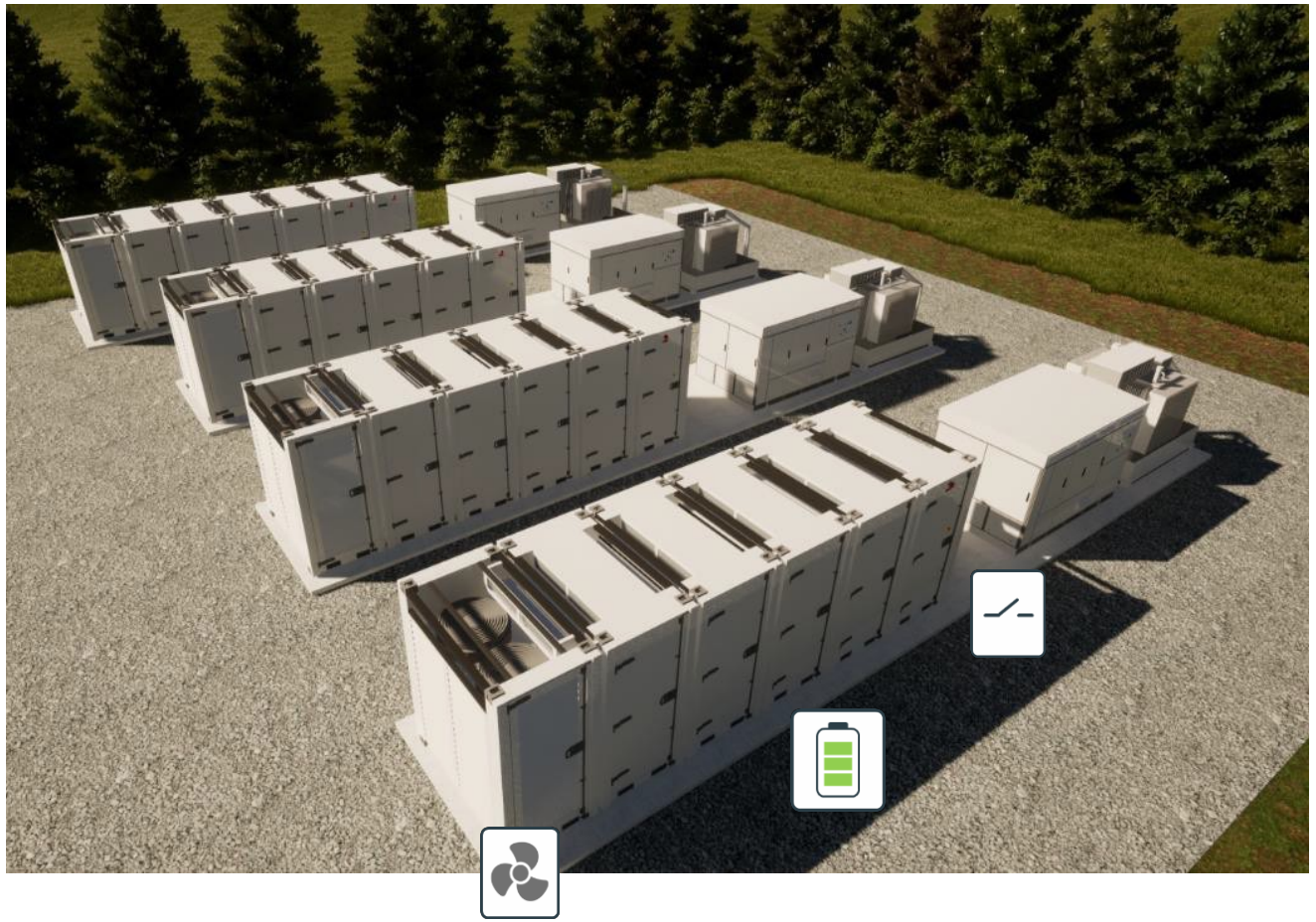
- Ranging from 0.1C to 2C
- Foundation of Virtual Power Plants
- Doubling Lifespan and Performance

Thermal Control

- Constant Temperature Control System - High Safety
- No Climate Limitations
- Energy Saving (Reduced Self-Consumption)

Artificial Intelligence (AI)

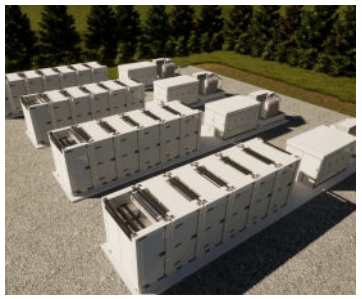
- TCO Cycle Monitoring
- Operations and Strategy
- Sequential Data Retrieval Chain



Battery Storage System

Advantages and Characteristics

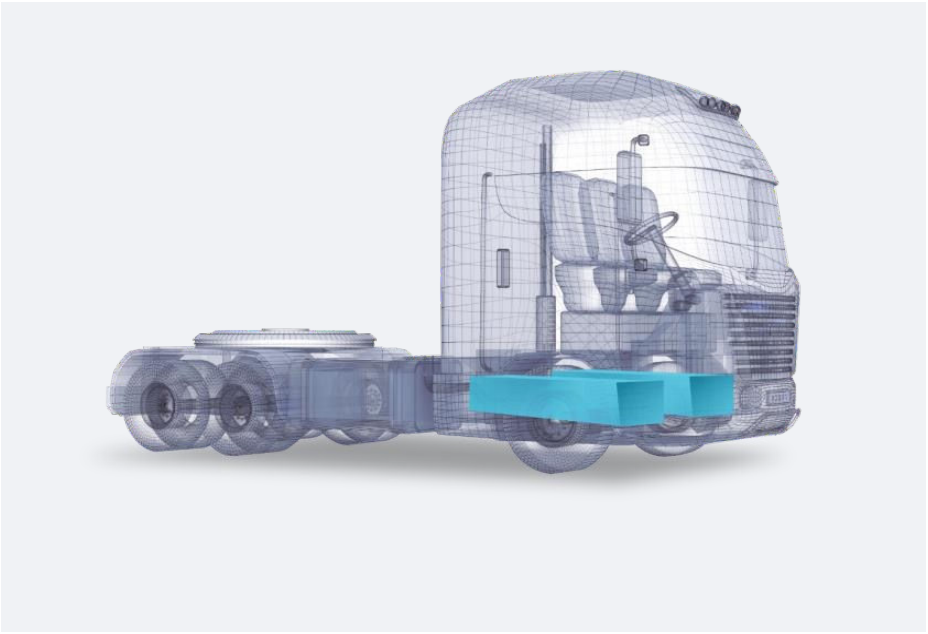
- Constant Temperature and Uniform Temperature Control: Ensures consistent and even temperature distribution at the pack level, with a rapid early-stage thermal runaway suppression system.
- Pack-level Halon, Cluster-level Aerosol, Water Firefighting: Implements a three-tier fire protection system for enhanced safety.
- High Power Density and High-Power Output at 1,500VDC: Achieves high power density and output capacity at 1,500VDC.
- Active Balancing at Pack Level and Intelligent Coordination Control of Rack-level Power: Utilizes active balancing at the pack level and intelligent coordination control of rack-level power, employing a distributed series-parallel topology architecture.
- Unique Internal Framework Technology: Utilizes a unique internal framework technology that eliminates the need for glue inside the pack, facilitating easy disassembly and recycling.
- Modular Design: Features a modular design with reserved access points for photovoltaic, wind power, external charging interfaces, and more.



Parameters

Specification	
Rated Capacity	Prefabricated Battery System for Large-scale Battery Storage Stations（2,000kWh and above）
	Integrated Battery Storage Solutions for Industrial and Commercial Use(100-372KWh per unit)
	Residential Battery Storage System（5-20KWh）
Temperature Control System	Intelligent Constant Temperature and Uniform Temperature Control System
Fire Protection System	Comprehensive Cloud-Based Intelligent Management Platform Covering PACK Level, Cluster Level, and Compartment Level

Application – Heavy Duty Truck Battery Storage

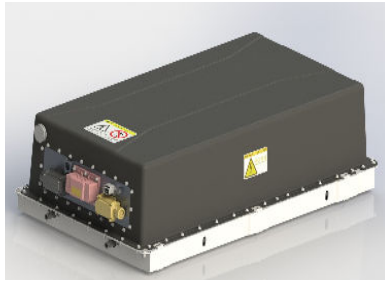


The high-performance constant temperature battery system provides power for heavy-duty trucks, addressing the impact of extreme weather conditions on battery performance. Throughout its lifecycle, it enhances user economy, thus contributing to reducing environmental impact and improving sustainability.

Heavy Duty Truck Battery Storage

Advantages and Characteristics

- Constant Temperature Control: Utilizes Resonant Heat Transfer, Liquid Circulation Heat Conduction, Liquid/Electric Heating, and Insulation System.
- Dual Mode Charging: Offers both Fast and Slow Charge options.
- Operating Temperature: -40℃ to 60℃.
- Ultra-Low Temperature Self-Heating Start-up: Enables start-up even at ultra-low temperatures.
- Remote Digital Operations and Cloud-Based Diagnostic Alerts: Allows remote management and provides diagnostic alerts via cloud-based system.
- Cold Climate Version: Includes Pack-Level and Rack-Level Insulation Cover, Increased Backup Power Capacity, and Battery Heating Function.

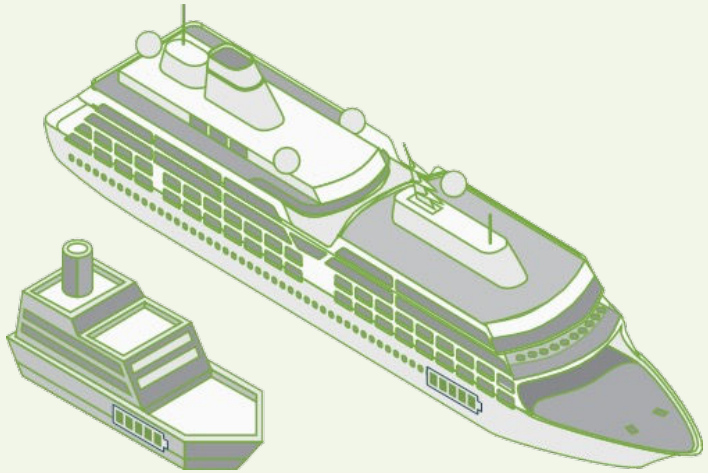


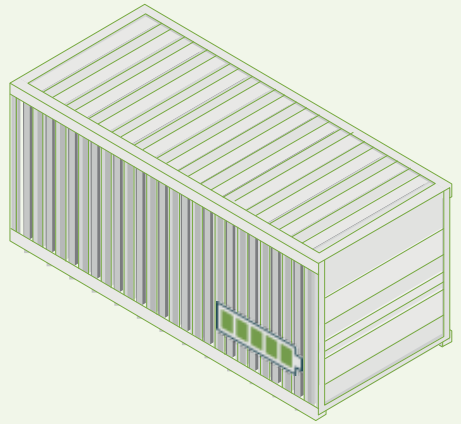
Parameters

Specification	
Dimension	2496 x 2230 x 850
Capacity	282kWh / 350kWh / 423kWh / 564kWh
Thermal Management	Resonant Heat Transfer and Parallel Liquid Circulation Heat Transfer Composite Thermal Management
Balancing Method	Active Balancing + Passive Balancing
Weight	3T

Application – Electric Vessel

Port Interchangeable Battery Solution





20-foot Container Battery System
(1,950 kWh)

Reliability, All-Weather Adaptation to Increase Lifespan

High Safety Protection

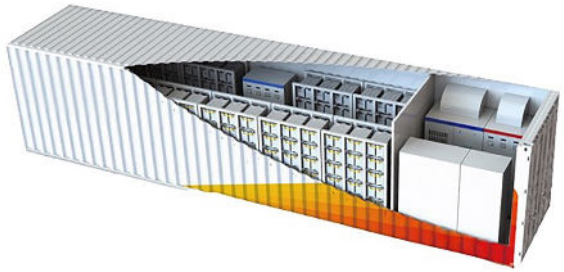
Meets Certification Standard Requirements (CCS/Ship Inspection Centre)

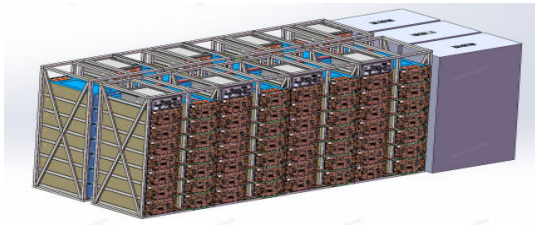
Containerized Battery System, Suitable for Port Operations, Charging, and Easy Configuration in Various Combinations

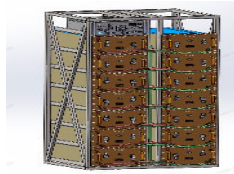
Electric Vessel Battery System

Advantages and Characteristics

- Ensures consistent and even temperature regulation, incorporating a pack-level rapid early-stage thermal runaway suppression system.
- Implements a three-tier fire protection system utilizing heptafluoropropane at the pack level, hexafluoropropane at pack level, and water-based firefighting.
- Offers both fast and slow charging and discharging options.
- Integrates firefighting systems, dynamic environment monitoring, Battery Management System (BMS), Battery Thermal Management System (BTMS), and Human-Machine Interaction for comprehensive control.
- Facilitates remote digital operations and maintenance, utilizing cloud backend diagnosis and early warning systems for efficient management.



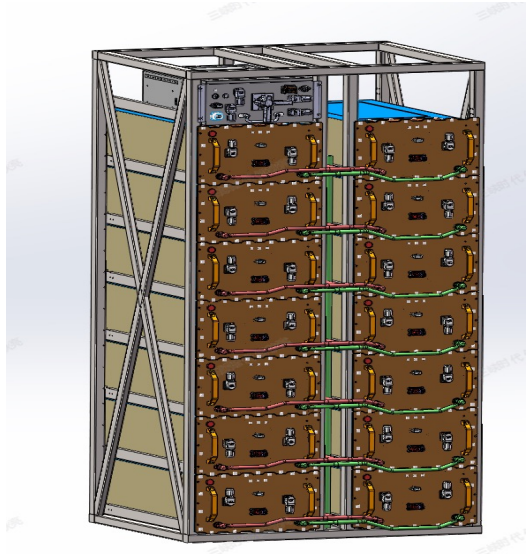


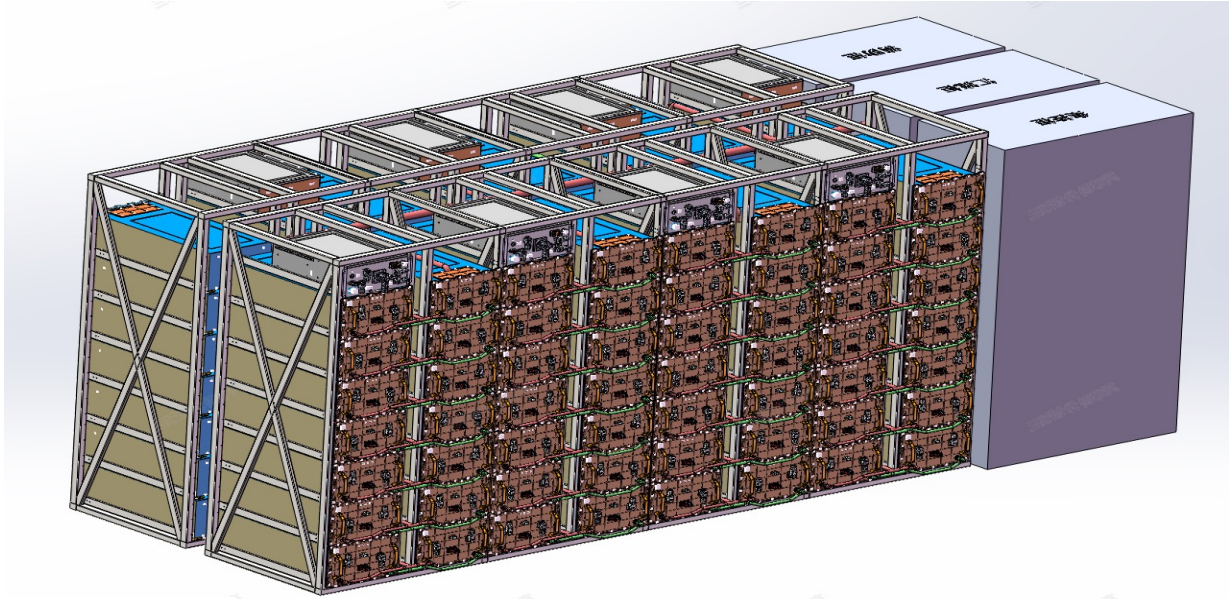


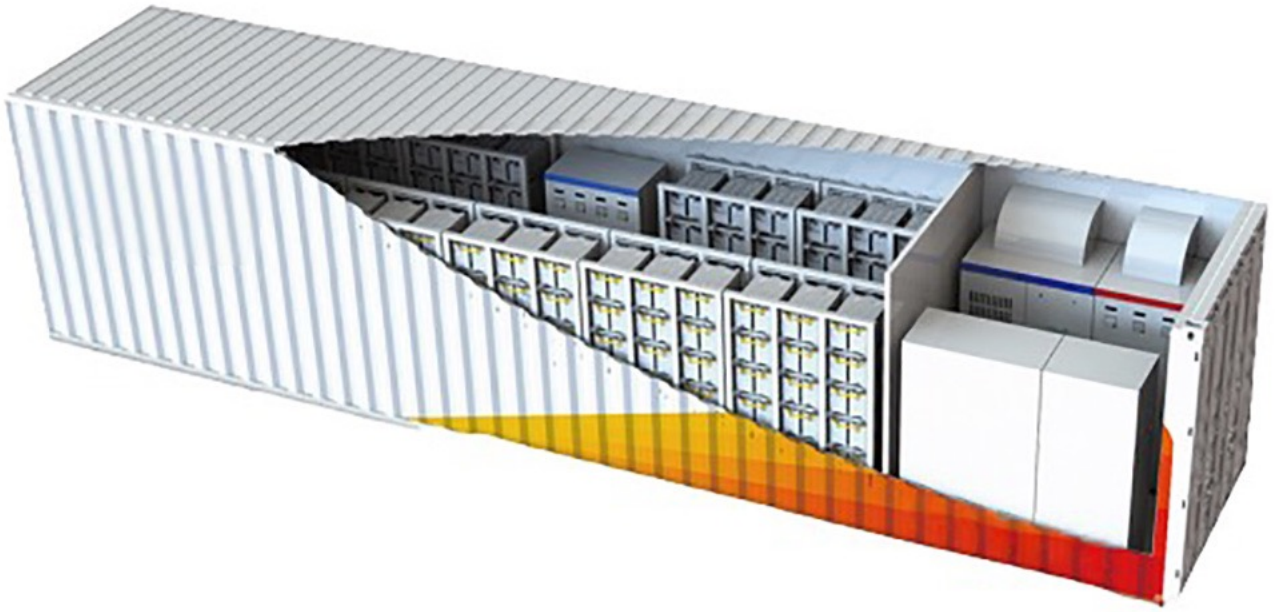
Parameters

Specification	20-foot container
Rated Capacity	2MWh
Temperature Control System	Intelligent Constant Temperature and Uniform Temperature Control System
Fire Protection System	Comprehensive Cloud-Based Intelligent Management Platform Covering PACK Level, Cluster Level, and Compartment Level
Weight	27 T

Electric Vessel Battery System



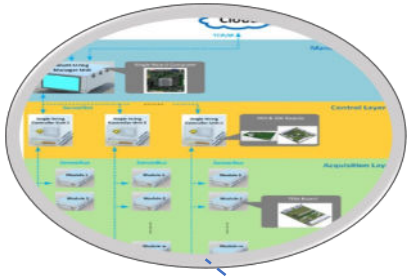




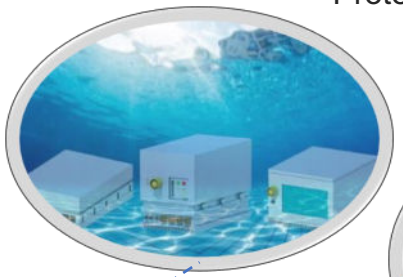
Containerized Shipboard Power Battery System with a capacity of 2000kWh, supporting dual-mode charging and discharging.

Key Aspects of InnoEnergy Battery Systems

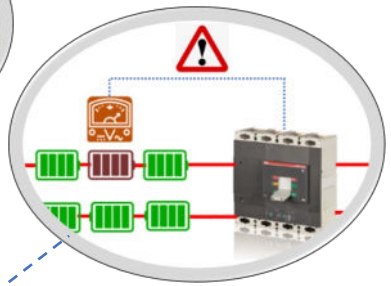
InnoEnergy-BTMS: World Leading Battery Thermal Management System (BTMS) Technology



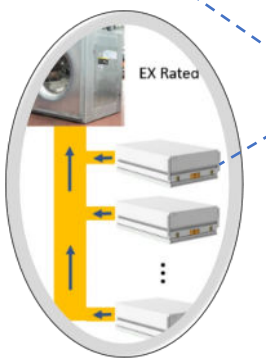
IP67 Protection



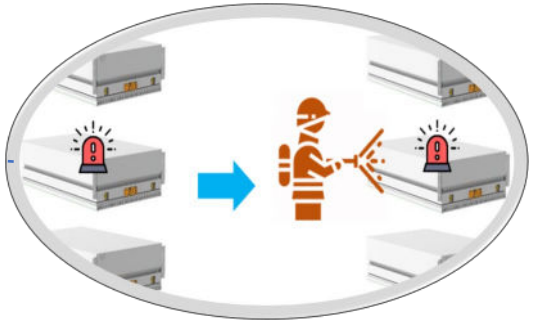
Global Cloud Data Monitoring System



Independent Hardware Protection



Embedded Combustible Gas Extraction Pipeline within the System



Smart Induction Fire Alarm System

Four-Tiered Security and Performance Protection

InnoEnergy's battery system utilize a multi-tiered thermal runaway prevention design with InnoCool technology and materials. This design effectively eliminates safety hazards arising from battery subjected to heat; providing the safest solution for all lithium battery applications.

➢ **First Level of Protection:**

Intelligent Overvoltage and Overtemperature Monitoring

➢ **Second Level of Protection:**

Intelligent Smoke Detection + Fire Alarm System

➢ **Third Level of Protection:**

Global Cloud Data Real-time Monitoring System

➢ **Core Level of Protection:**

Cell-Level Constant Temperature Maintenance System

In recent years, lithium battery fires and explosions have occurred frequently worldwide, sounding a safety alarm for the industry!

Manufacturing Principles and Processes

Intelligent Manufacturing Platform

A world-leading, large-side liquid-cooling, vehicle-grade, flexible intelligent manufacturing platform compatible with both residential and commercial battery storage batteries.

16949Certification

Fully Automated Intelligent Production Line

Highly Compatible Flexible Production Line

Advanced Process Assembly Technology

MES Digital Production Management and Control System

Battery Module Design and Manufacturing Process

The modular assembly manufacturing design of InnoCool enables a wider range of battery storage solutions, making Australian manufacturing economically viable.

- Manufacturing: High production capacity design with independently developed core production lines, facilitating the establishment of the battery manufacturing industry chain in Australia.
- Energy Density (Wh/kg): Improved by 15%-20% compared to previous generation modules.
- Configuration Assembly: Supports multiple configurations for rapid adaptation to market changes.
- Size (Volume): More compact design with a 10% increase in volume compared to the previous generation modules.
- Structure: Incorporates high-precision laser assembly and a newly patented architecture system.
- Temperature Control: Implements cell-level constant temperature control, enhancing reliability and reducing operating costs.

InnoCool Thermal Management

The thermal runaway monitoring and early warning equipment can issue warnings up to 30 minutes in advance.

The design and application philosophy of the detector is focused on utilizing high-sensitivity detection capabilities and unique algorithms to proactively warn of thermal runaway occurrences. This preemptive warning system notifies other relevant systems to intervene, such as stopping charging or discharging processes, thus preventing thermal runaway and fire incidents. This approach represents a shift from firefighting and containment after a fire occurs to preventing thermal runaway and fire incidents before they happen. It marks a transition from inevitable losses to preventing losses altogether.

InnoCool Cell Level Intelligent Temperature Control

Integrated Cell-Level Intelligent Parallel Circulating Liquid Cooling System for Temperature Control and Equalization

Fig 1: Soft Package Lithium Battery Cell Series with Integrated Liquid Cooling Parallel Circulating Channel Network.

Fig 2: Square Aluminum Shell Lithium Battery Cell Series with Integrated Liquid Cooling Parallel Circulating Channel Network.

Fig 3: Cylindrical batteries connected in series with liquid cooling.

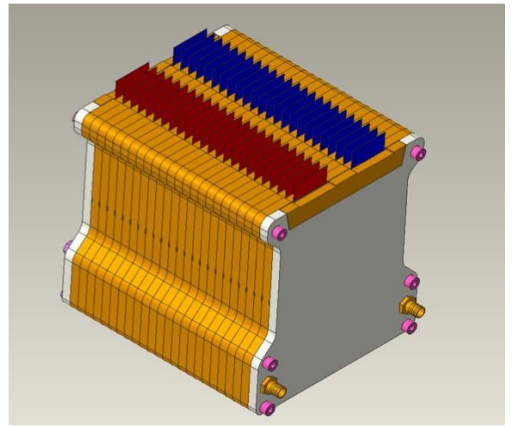


Fig 1: Soft Package Lithium Battery Cell

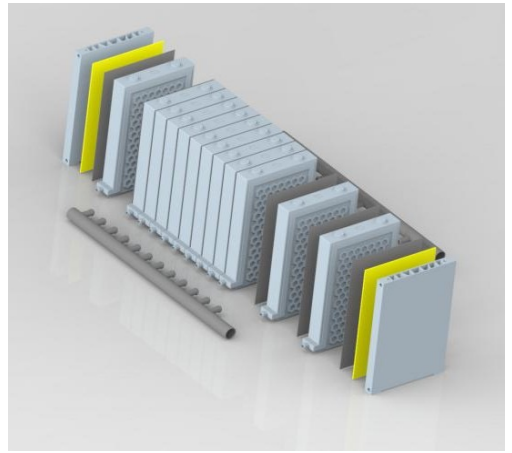


Fig 2: Square Aluminum Shell Battery Cell

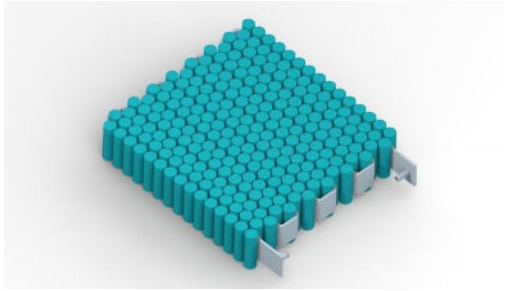


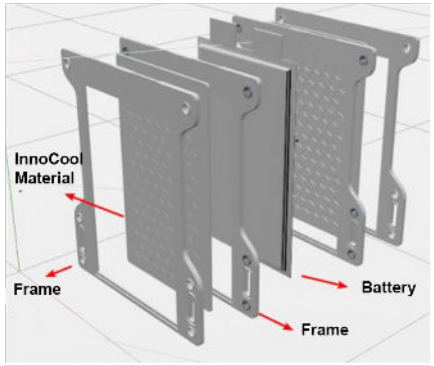
Fig 3: Cylindrical Battery Cells

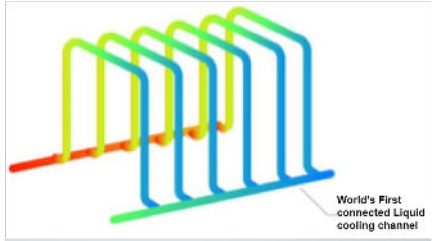
Features

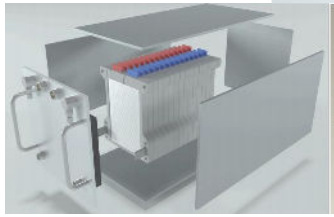
Integrated Liquid Cooling Plate with InnoCool Heat Transfer at the Cell Level or Cell Body Level and Parallel Circulating Channel: This technology achieves efficient heat transfer and uniform heating of the cells. By integrating InnoCool heat transfer technology with a parallel circulating channel liquid cooling plate, the heat generated by the cells is effectively dissipated to the InnoCool board, and then carried away by high-speed circulating liquid flow, ultimately releasing it to the external air. This greatly improves heat transfer and heat dissipation efficiency, ensuring uniform temperature for each individual cell. Parallel circulating liquid flow also quickly achieves uniform temperature among all cells within the battery pack.

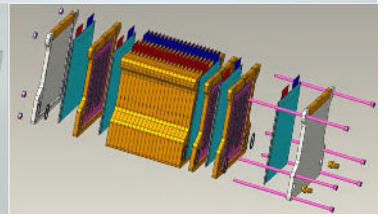
Temperature Sensor Monitoring and Intelligent Control: Each cell is equipped with a temperature sensor that can monitor cell temperature in real-time. Through temperature control assemblies, adjustment commands are issued to promptly regulate the output liquid temperature and circulation flow rate of the liquid cooling/heating unit, thereby controlling the temperature rise and temperature difference of the battery. These integrated intelligent control systems ensures that the battery system maintains a stable temperature and constant temperature state.

Technical Specifications of the Intelligent Constant Temperature Control System: This control system regulates the battery system temperature within the range of 25°C to 45°C and limits the temperature difference between cells within 2°C. Achieving these technical specifications ensures that the performance and cycle life of the battery system can meet the theoretical design targets. It provides the most ideal and reliable temperature protection, eliminating fire and safety concerns due to temperature rises and allows for further research and development of more efficient and powerful battery cells.





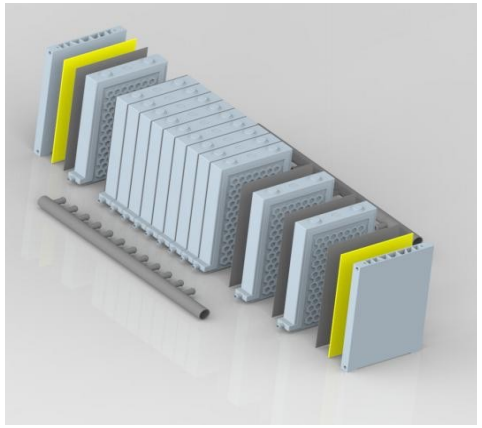




Three-in-One Heat Transfer Technology: Cell Body, InnoCool Thermal Conductivity, and Active Fluid Heat Transmission

1. Specifications

- Aluminum substrate, height, width, and thickness customizable to cell design requirements.
- Plate wall thickness designed within the range of 0.6 mm to 5.8 mm.
- Tube cross-section: 2 - 4 mm x 20 – 40 mm.

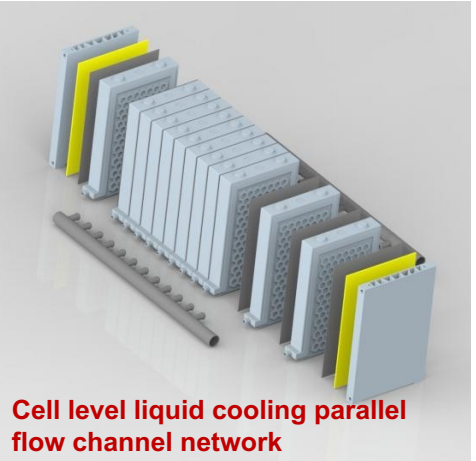


Effectively maintains uniform monomer cell temperature with ultra-fast heat dissipation. Rapidly balances cell temperature to delay occurrence of accidents and improve safety performance.

2. Advantages

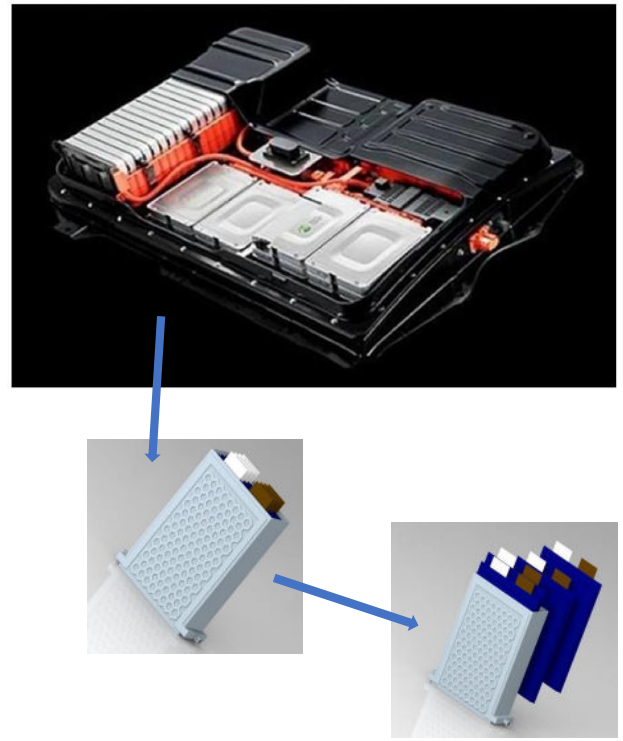
- Harnesses the benefits of InnoCool, including superconducting heat transfer and supersonic heat conduction.
- Integrates aluminum substrate with InnoCool heat transfer micro-nest and built-in liquid/gas circulation heat transfer pipeline.
- Direct exchange of the cell’s internal heat to InnoCool panel through large heat exchange interface for rapid heat transfer.
- High efficiency and speed achieved through integrated InnoCool internal heat conduction and efficient InnoCool /fluid heat exchange.
- Offers minimal heat exchange interfaces, reduced heat conduction medium, fewer heat transfer links, shorter paths, lower thermal resistance, and higher heat dissipation efficiency compared to other heat dissipation technologies.
- Pipeline can be connected in series/parallel networks to external fluid cooling/heating circulation or air conditioning systems for precise temperature control of fluid flow/rate.

Three-in-One Heat Transfer Technology: Cell Body, InnoCool Thermal Conductivity, and Active Fluid Heat Transmission



Cell level liquid cooling parallel flow channel network

Using InnoCool materials as the shell for batteries eliminates the need for excessive thermal conductive plates and other structural components during assembly. This allows for the simple, convenient, and efficient grouping of batteries. Additionally, incorporating liquid cooling pipelines to the battery modules' shells enables direct connection to liquid cooling/heating systems. By controlling the flow of cooling/heating fluid through the pipelines, the battery temperature can be regulated, ensuring optimal operating conditions.

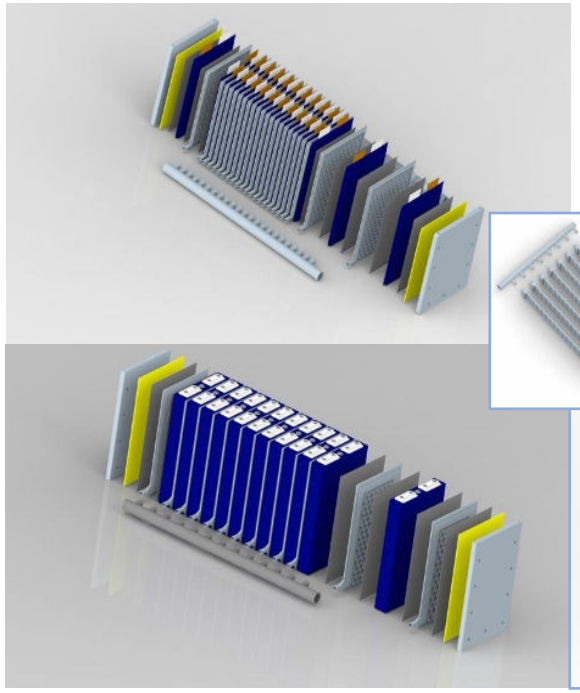


The solution for soft pack battery modules involves combining multiple battery cells into a small module. Given the soft packaging of the batteries with aluminum-plastic shells, some companies reinforce the structural strength by enclosing them in aluminum shells before grouping them together, as shown in the diagram on the right.

Replacing the aluminum shell of the soft pack modules with InnoCool materials and utilising InnoCool integrated thermal conductivity liquid cooling technology can significantly enhance heat transfer efficiency and control the temperature of the battery modules.

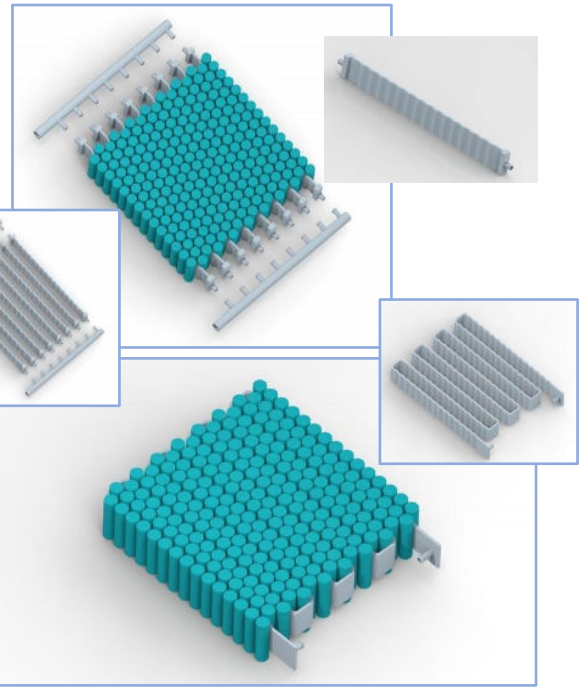
InnoCool combines ultra-strong heat transfer capability with the fluid's exceptional heat exchange and heat carrying capacities.

Cell Level Integration - Incorporating InnoCool material and active liquid cooling thermal control.

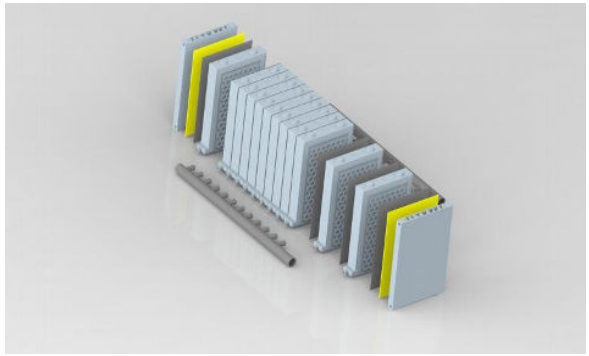


Large-diameter, single-channel and liquid-cooled parallel circulation channel network.

Cylindrical batteries connected in parallel with liquid cooling.

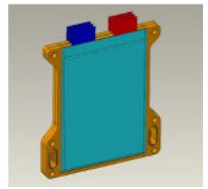


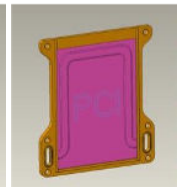
Cylindrical batteries connected in series with liquid cooling.

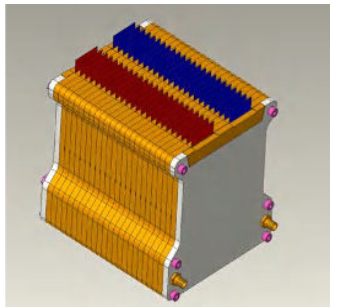


The simplest and most efficient liquid-cooled parallel circulation channel network at the cell level.

InnoCool Technology for grouping soft pouch lithium battery cells in series and liquid-cooled parallel circulation channel networks.







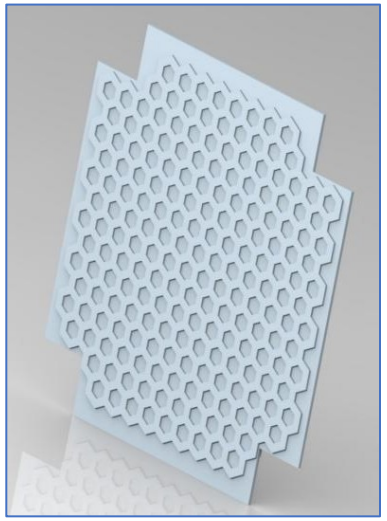
Battery cell-level integration of InnoCool material with immersion-based active/passive fluid heat exchange technology

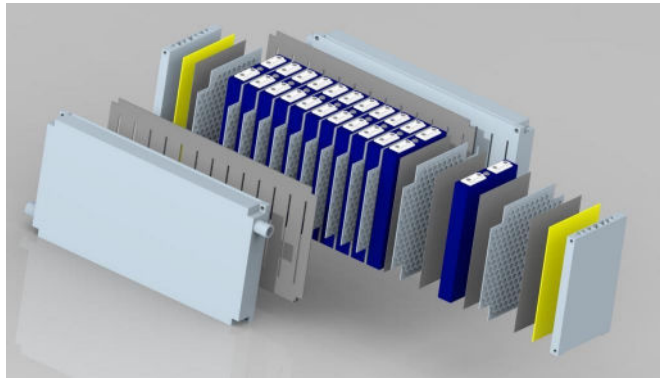
1.Heat from the battery cell surface is conducted to the InnoCool heat transfer plate, to ensure uniform heat distribution within InnoCool system.

2.Part of the InnoCool heat transfer plate extends from both sides of the battery cell (similar to fins) and is inserted into and immersed in water/air boxes arranged on both sides of the battery stack. This facilitates seamless and highly efficient heat exchange between the InnoCool heat transfer plate and the fluid through immersion.

3.The advantages of immersion-based heat exchange include; a large heat exchange interface where the heat exchange interface achieves seamless integration without any intermediate heat conduction medium. In the absence of external power driving the fluid for active circulation, this approach maximizes heat transfer efficiency.

4.The water/air fluid boxes can have inlet and outlet ports which can be configured in serial or parallel networks and can be connected to external fluid cooling/heating active circulation systems or air conditioning units.





Battery cell-level integration of InnoCool heat transfer with immersion-based active/passive fluid heat exchange for unified thermal control assembly.

The system achieves heat dissipation while allowing precise temperature control by regulating the fluid's temperature, flow rate, and velocity.

Applicability:
1. Most suitable for square-shaped lithium batteries.
2. Also applicable for soft pouch lithium batteries.

Semi-immersed fin battery module grouping scheme.

The InnoCool plate has a simple structure, making it convenient for battery grouping, and fully utilizes the high thermal conductivity properties of InnoCool material to quickly dissipate heat from the centre of the battery cell.

Water tanks (immersion tanks) are added on both sides of the module. InnoCool fins are inserted into the centre of the water tanks, enabling efficient heat exchange through liquid immersion and convection, thus controlling the temperature of the battery cells.

Sustainable Development from Australian Manufacturing: Scaling for Competitive Costs

World-Leading Technological Foundation

- InnoCool has various application cases ranging from materials, batteries, modules, battery packs, and racks to the underlying module (hardware) research and development platform supporting cross-industry applications.
- Industry-leading energy management software platform (BMS-BTMS-EMS), applicable to a range of applications including renewable energy integration, grid support services, extending to vehicle energy management units – integration with other software.

Competitive Cost Bases

- Electrochemical packs combine high energy density and long-life cycles, achieving the lowest cost per kilowatt-hour of battery.
- Ability to triple production capacity for enhanced efficiency.
- Leveraging proprietary automotive industry technology licenses for procurement scale and profitability (temperature control).

Inno Energy

Building a Greener Tomorrow.

InnoEnergy.com.au