

Fortifying the Future: How BYD's Multi-Dimensional Fire Safety Design Redefines Energy Storage Standards



Finer Storage Greener Energy

Factors Leading to Fire Risks in BESS

■ The sequence of fire incidents in BESS

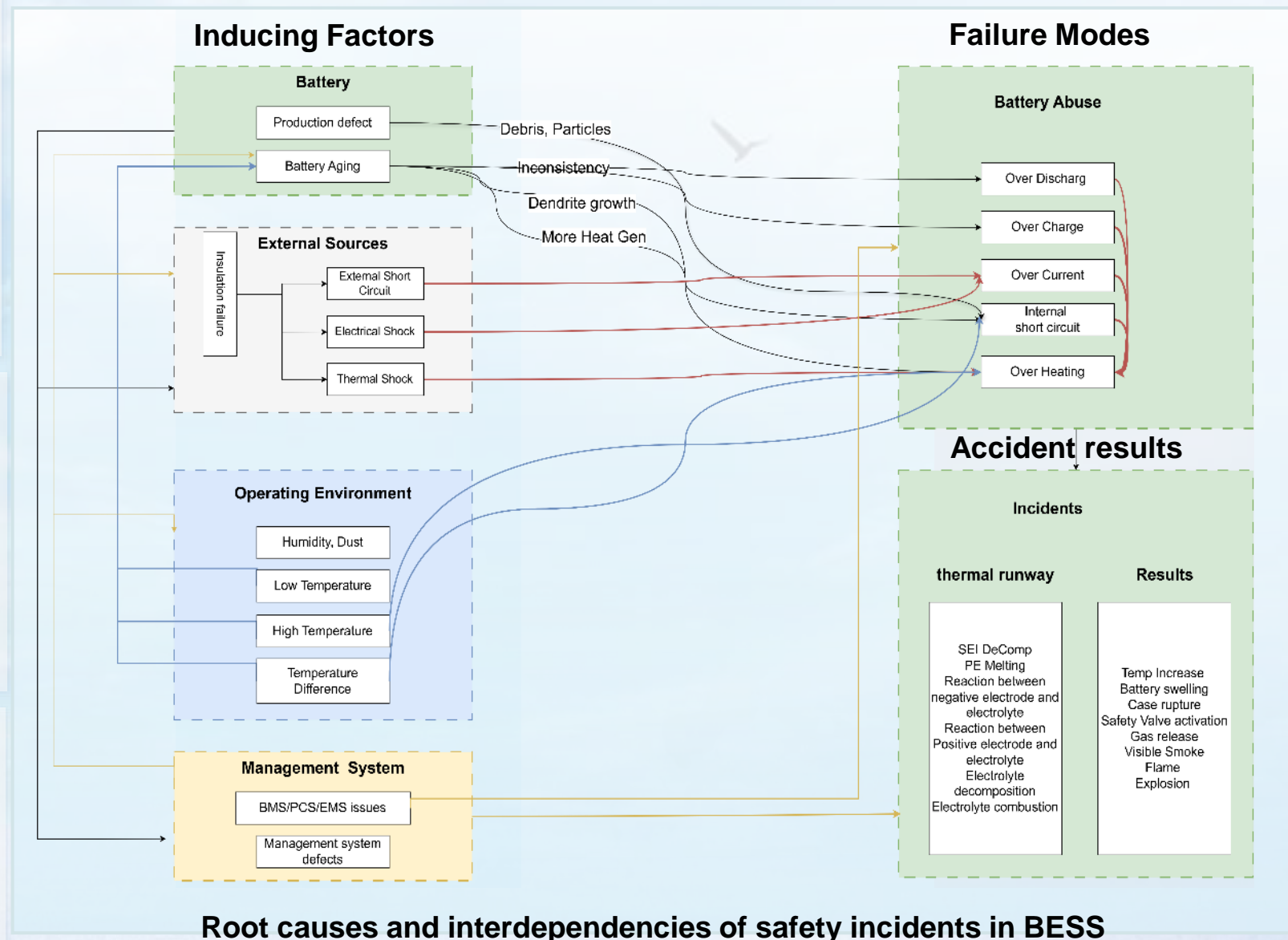
- Faults induced
- Battery Failure
- Accident progression

■ The fault-induced factors for fire accidents in BESS

- Battery
- Management Systems
- External Sources
- Operating Environment

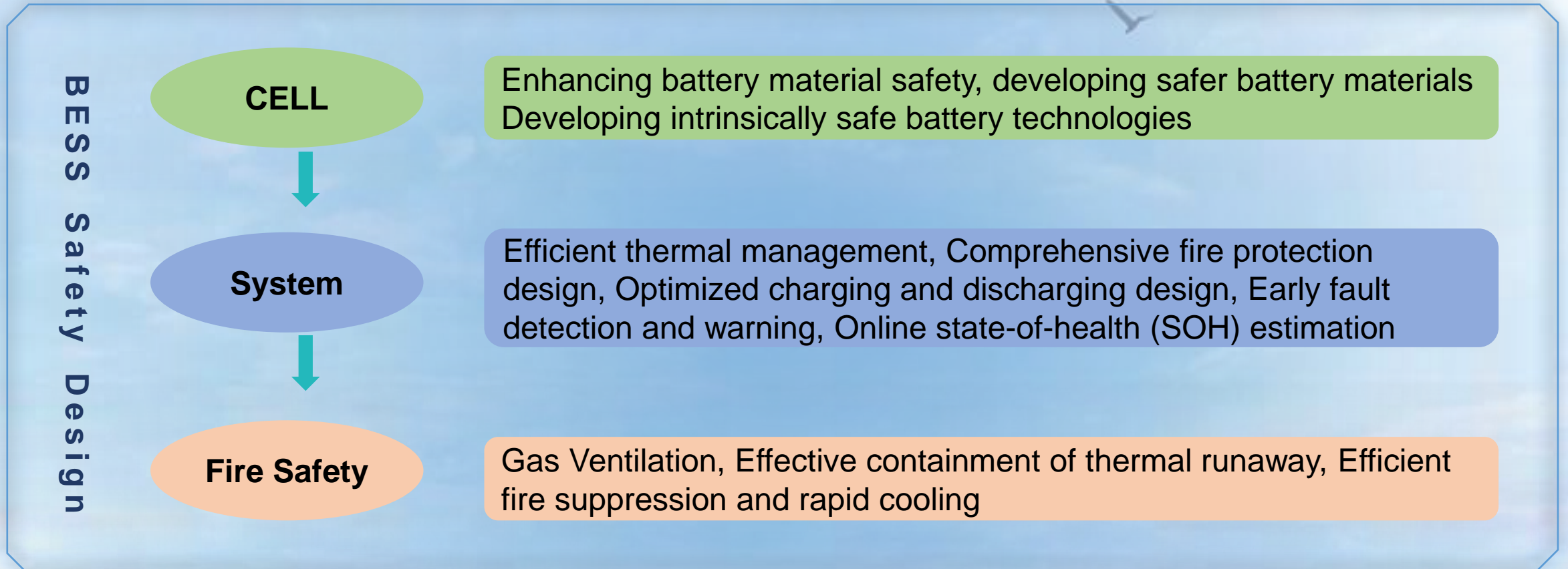
■ The characteristics of the fire accident

- High Temperature
- Toxicity
- Explosion



BESS Safety Design

To address the unique characteristics of battery fires, the energy storage industry has established a three-tier safety system for BESS products, focusing on: 1) intrinsic safety of cells, 2) system process safety, and 3) fire safety.

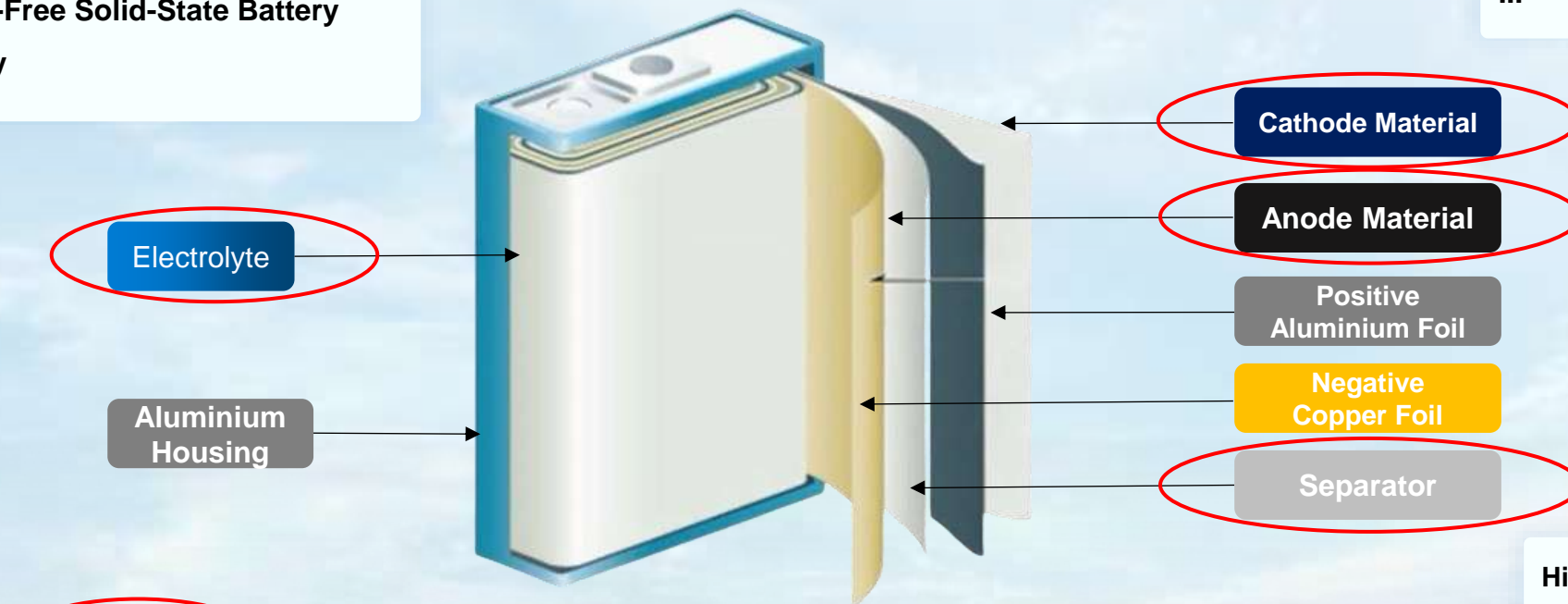


Through sophisticated design and rigorous management, BESS can achieve the ultimate level of safety.

ESS Intrinsic Safety - Sources of Battery Safety Issues

Electrolyte Solvent Modification
Electrolyte Lithium Salt Modification
High-Safety Additives
Electrolyte-Free Solid-State Battery
Technology

High-Safety Cathode Materials
Surface Coating with Inert Layers
Incorporation of Flame Retardants
...



Electrolyte

Aluminium
Housing

Cathode Material

Anode Material

Positive
Aluminium Foil

Negative
Copper Foil

Separator

High Temperature Resistant Separator
Separator Surface Modification
Thermally Sealed Separators
Heat absorbing separators.....

the combustible or exothermic
decomposition components.

Prismatic Battery

BYD Cell Safety - high-safety cathode materials

- Choosing LFP cathode materials with **high thermal decomposition temperature** and **low heat generation** helps to improve battery safety.
- The PO₄ groups in lithium iron phosphate have more stable P=O bonds, making it less likely to release oxygen during decomposition reactions, and making it more difficult for violent thermal runaway to occur

Thermal Decomposition Reactions and Data Comparison of Common Cathode Materials

Cathode Material	Thermal Decomposition Temperature /°C	Heat Generation J/Kg	Reaction Formula
Lithium Cobalt Oxide (LCO)	~ 150 °C	1.40×10^5	$\text{Li}_{0.5}\text{CoO}_2 \rightarrow 1/2\text{LiCoO}_2 + 1/6\text{Co}_3\text{O}_4 + 1/6\text{O}_2\uparrow$ $\text{Li}_x\text{CoO}_2 \rightarrow x\text{LiCoO}_2 + (1-x)/3\text{Co}_3\text{O}_4 + (1-x)/3\text{O}_2\uparrow$
Nickel-Manganese-Cobalt (NCM)	~ 220 °C	1.30×10^5	$\text{Li}_{0.35}(\text{NiCoMn})_{1/3}\text{O}_2 \rightarrow \text{Li}_{0.35}(\text{NiCoMn})_{1/3}\text{O}_{2-y} + y/2\text{O}_2\uparrow$
Lithium Iron Phosphate (LFP)	~ 300 °C	1.03×10^5	$\text{FePO}_4 + \text{PF}_4 \rightarrow \text{Fe}_2\text{P}_2\text{O}_7 + \text{F}_2 + \text{PF}_3\text{O}_2$ $\text{FePO}_4 \rightarrow \text{Fe}_2\text{P}_2\text{O}_7 + 1/2\text{O}_2\uparrow$

BYD Cell Safety - Better Heat Dissipation Structure

The relative surface area of the 377Ah Blade Battery is approximately 1.83 times than that of the 320Ah VDA Battery, and the available heat exchange area per Wh is approximately 1.98 times than that of the 320Ah VDA Battery.

- Ultra-high aspect ratio design, higher heat transfer efficiency



- Blade battery with full electrode tab design, lower heat generation at the same size



Comparison of Blade Battery and VDA Battery Heat Dissipation Capability

Battery Parameters	Cell Capacity (Ah)	Cell Energy (Wh)	Length (mm)	Thickness (mm)	Width (mm)	Total Volume (m ³)	Total Surface Area (m ²)	Relative Surface Area (1/m)	Available Heat Exchange Area per Wh (cm ² /Wh)	Normalized Available Heat Exchange Area per Wh
Blade battery	377	1206.4	961.60	28.00	122.45	0.003296942	0.29620264	89.84	2.455	1.97
	403	1289.6	961.60	28.00	122.45	0.003296942	0.29620264	89.84	2.297	1.85
VDA Battery	314	1004.8	174.30	71.65	204.41	0.002552208	0.12550438	49.17	1.249	1.00
	320	1024.0	174.70	71.65	207.11	0.002592449	0.12707760	49.02	1.241	0.99
	587	1878.4	274.00	73.00	215.00	0.00430043	0.18921400	44.00	1.007	0.81

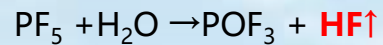
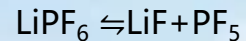
Relative surface area = surface area / volume, which represents the efficiency of heat exchange with the outside environment. The larger the relative surface area, the faster the heat transfer rate.

BYD Cell Safety - No C-angle, Less Free Electrolyte

Stacking JR design without C angle, high space utilization; less free electrolyte for the same capacity.

During the combustion reaction of electrolyte, the following products are generated.

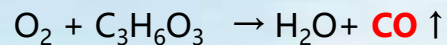
Lithium hexafluorophosphate :



Ethylene carbonate -EC :



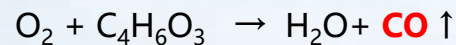
Dimethyl carbonate -DMC :



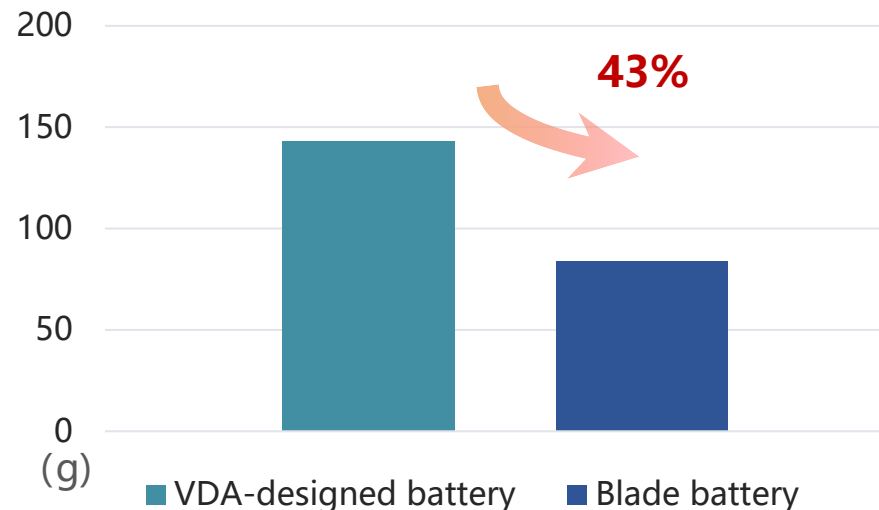
Diethyl carbonate -DEC :



Propylene carbonate -PC :



Free electrolyte comparison of 377Ah Blade battery and 320Ah VDA battery



- Commercial carbonate electrolyte has low flash point, high volatility, and high flammability
- Blade battery reduces the amount of free electrolyte, reducing the heat and gas generated during thermal runaway

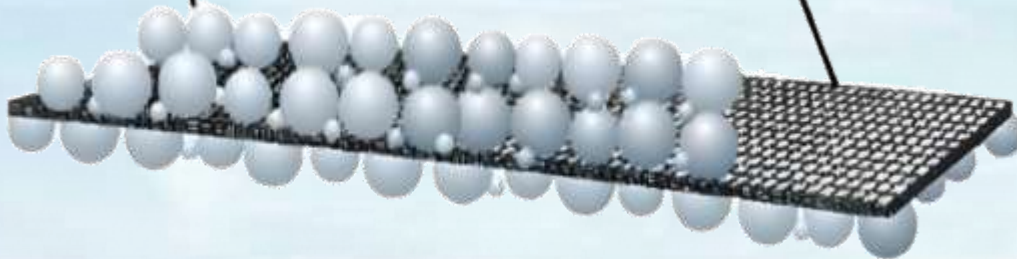
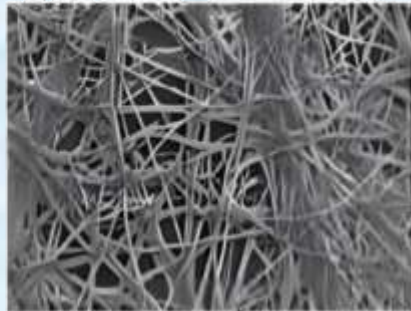
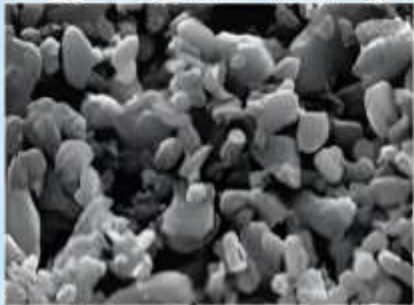
BYD Cell Safety - Ceramic Separator

The ceramic separator, fabricated by coating a layer of nano-scale ceramic particles onto a substrate of PP, PE, or multi-layer composite membranes, is a significant approach to addressing the safety issues of lithium-ion batteries.

High
temperature
resistance

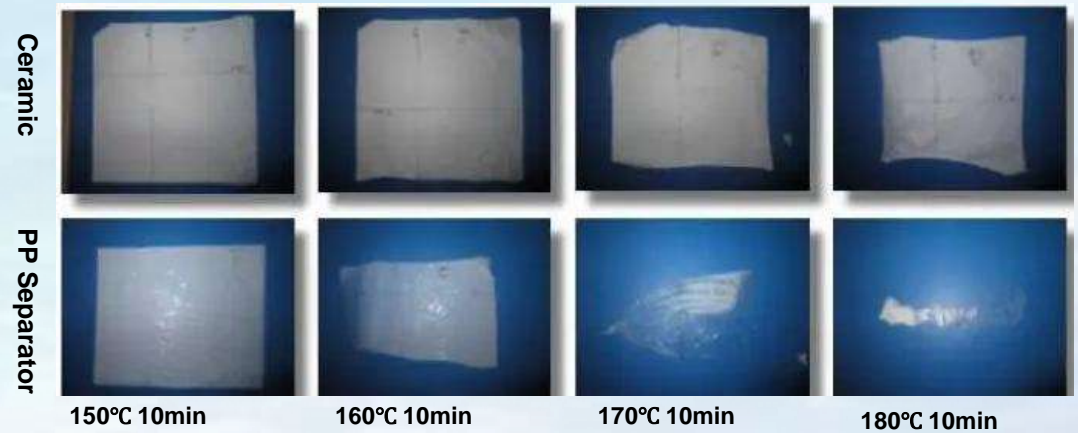
Heat Shrinkage
Resistance

High
penetration
strength



Ceramic Separator

Type	Melting /°C	decomposition /°C	thermal shrinkage rate/% (150°C 1h)
PE	110-140	250-350	融化
PP	160-170	300-350	~ 55%
Ceramic	200-300	400-600	~ 2%



Ceramic vs PP

Ceramic separators can raise the thermal runaway trigger temperature, effectively improving the thermal safety

| BESS System Level Safety

Online Fault
Diagnosis

Efficient Thermal
Management

Online SoH
Evaluation



DC Combiner
Design

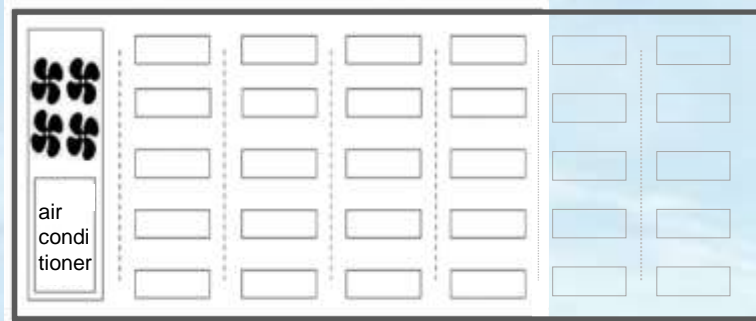
Electrical
Protection
Design

Fault Isolation

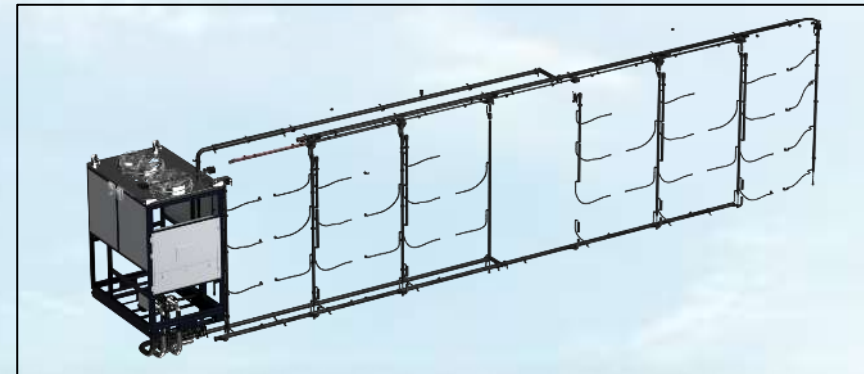
BESS System Level Safety——Efficient Thermal Management

- Independent cabinet HVAC design, improving temperature consistency
- Centralized heat management: centralized management of the entire cabin. Long path, lead uneven cooling liquid flow within the cluster, poor temperature consistency; large impact of faults
- Distributed heat management: one cluster one management. Short path, uniform cooling liquid flow, good temperature consistency; independent temperature control at the cluster level, small impact of faults

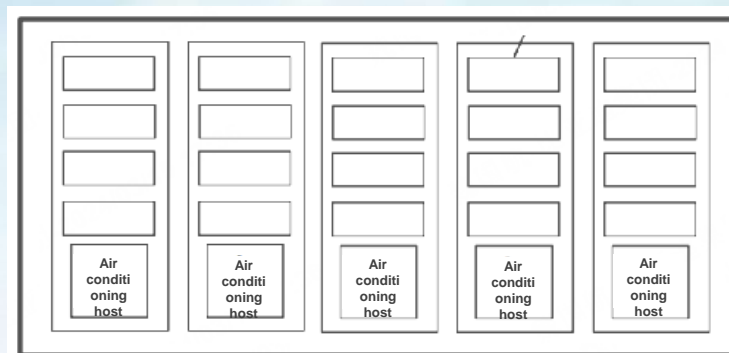
Centralized thermal management structure diagram



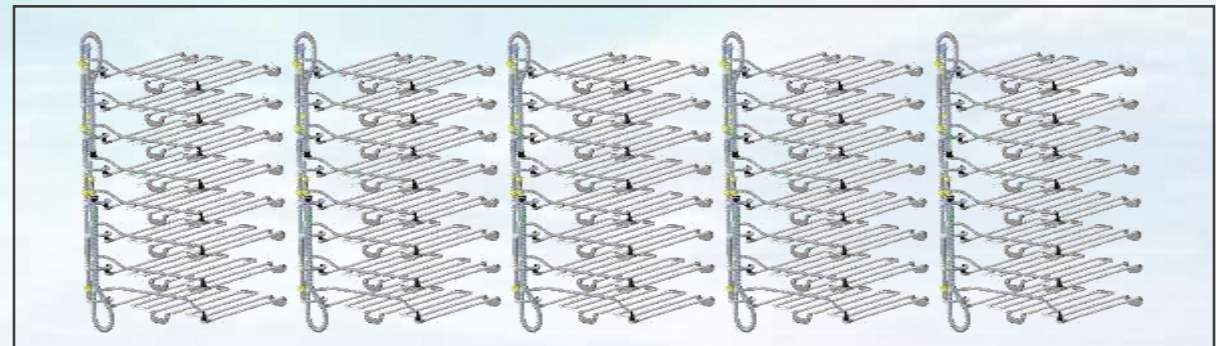
Centralized liquid cooling pipeline diagram



Distributed thermal management structure diagram

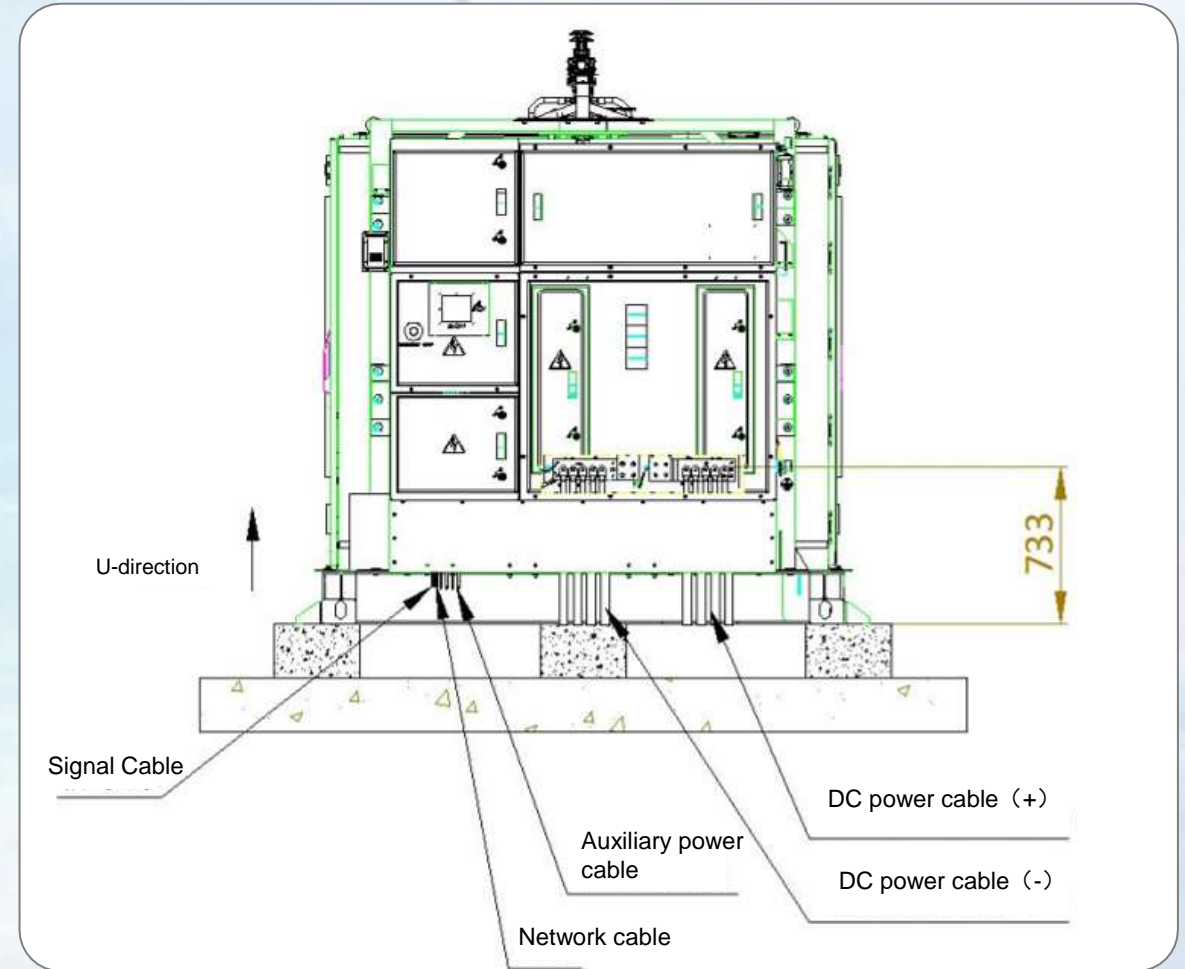
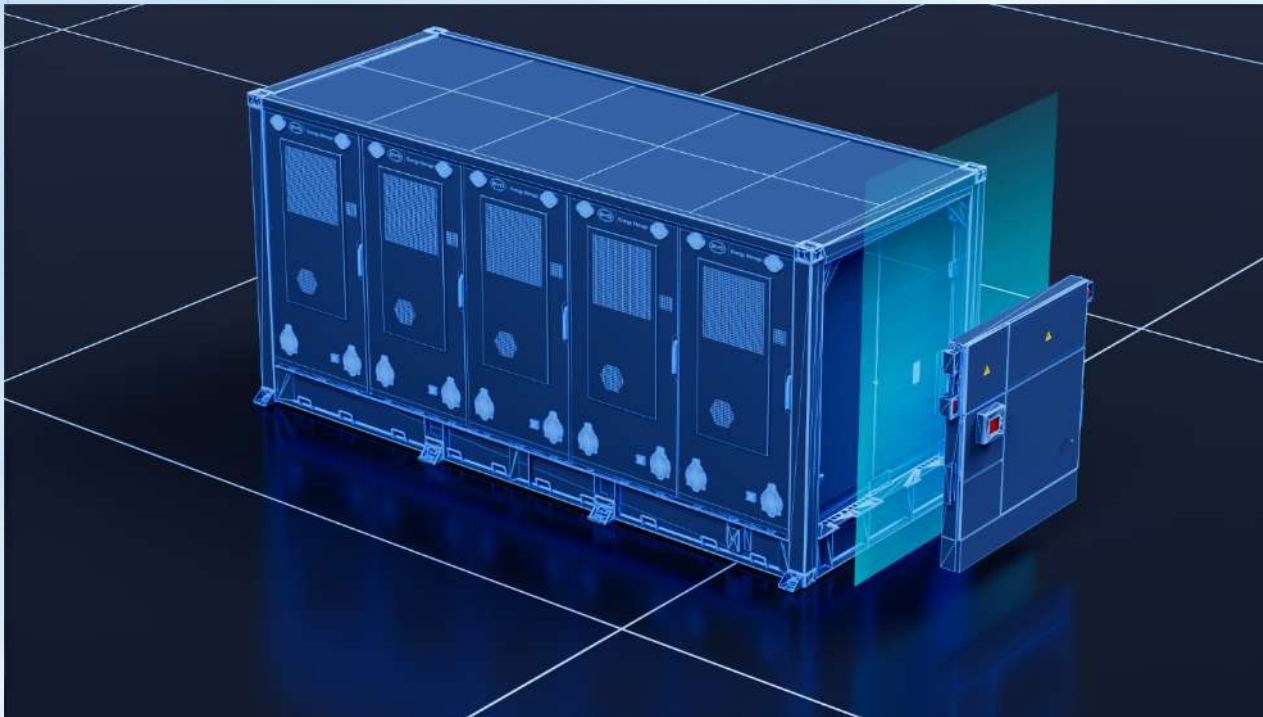


Distributed liquid cooling pipeline diagram



BESS System Level Safety——Electrical isolation

- Independent Design of Distribution Management Cabinet, System Electrical Completely Isolated
- Convenient System On-site Construction, Safer Operation and Maintenance



| BESS System Level Safety——Fault isolation

- By establishing multi-dimensional active and passive disconnection mechanisms at the module, string, and system levels, we can quickly and accurately cut off the circuit current in the battery system when abnormalities occur in certain circuits.

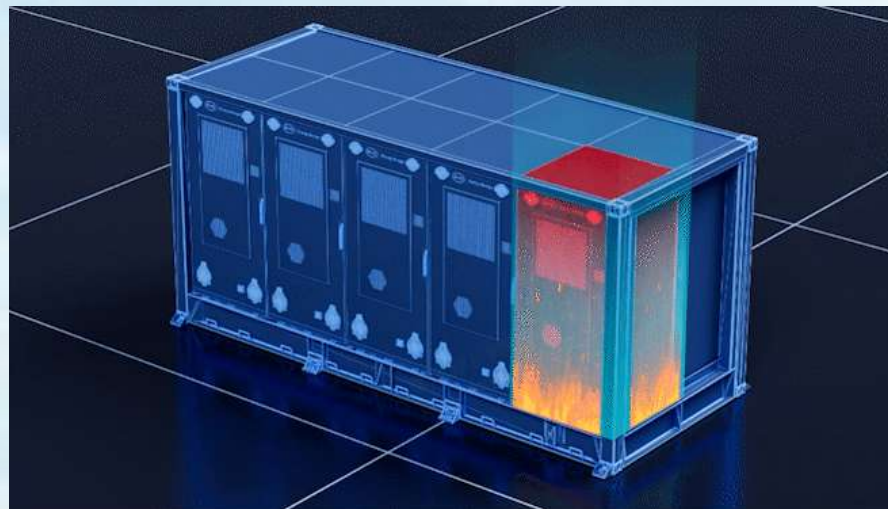
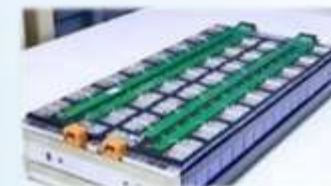


BMS

Contactor control

Battery

Busbar with
built-in fuses

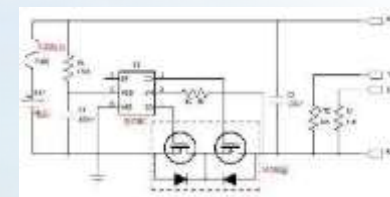


Container

Fuse in the distribution box
Busbar short-circuit protection

Battery String

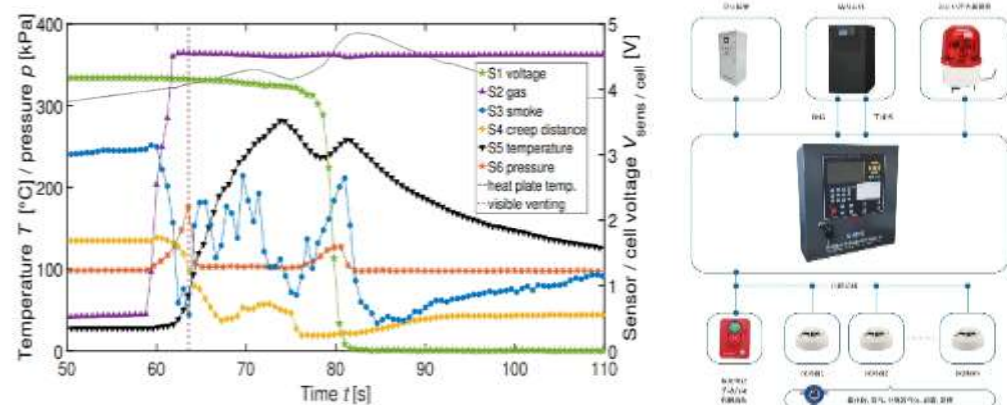
HV box fuse SCP



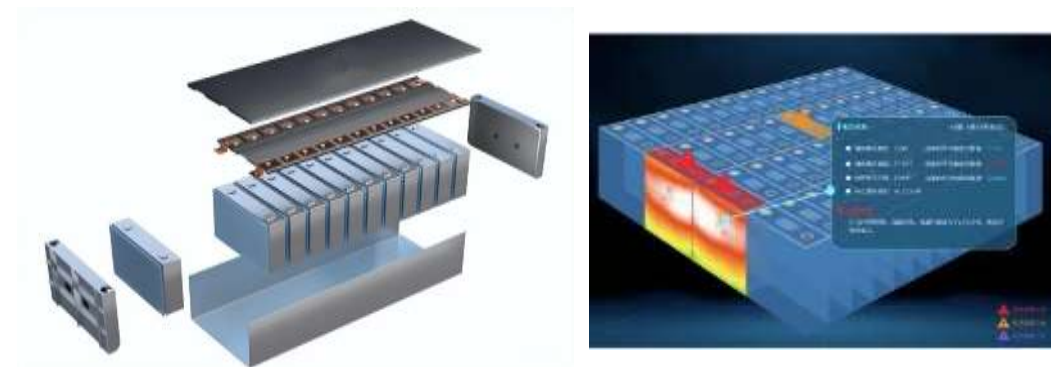
BESS Fire System Design

- the fire system design divided into below four parts:

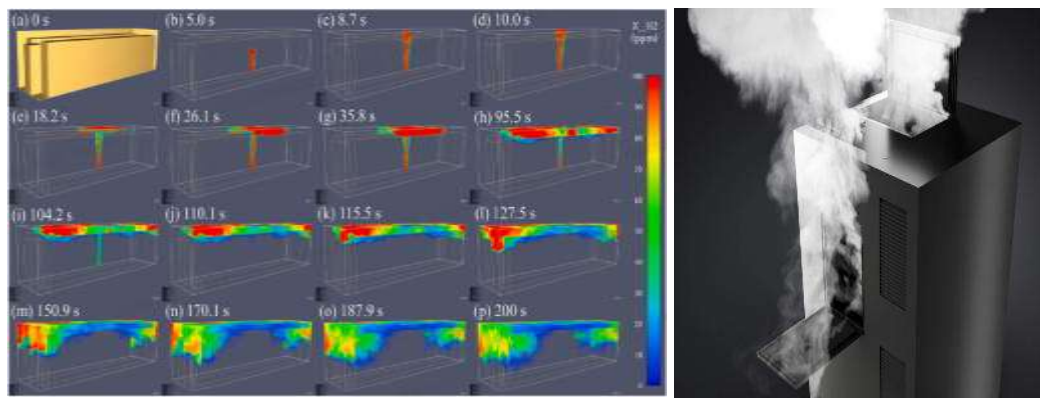
Fire Early Warning



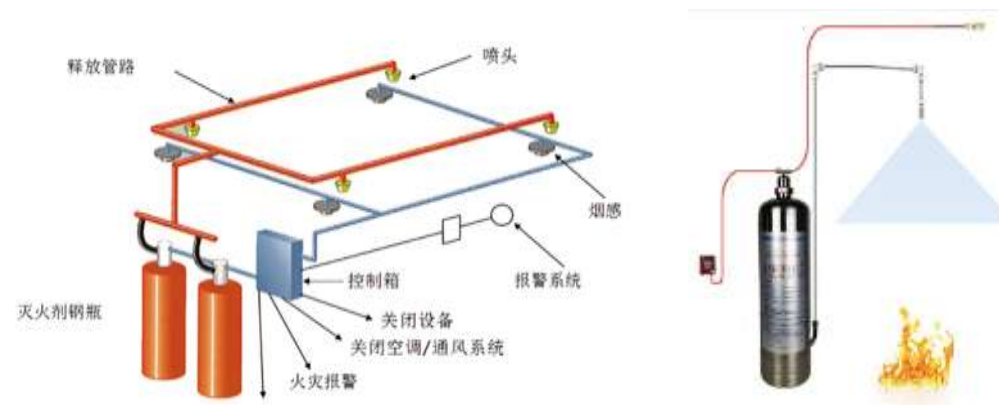
Fire/Heat Isolation



explosion prevention and pressure relief



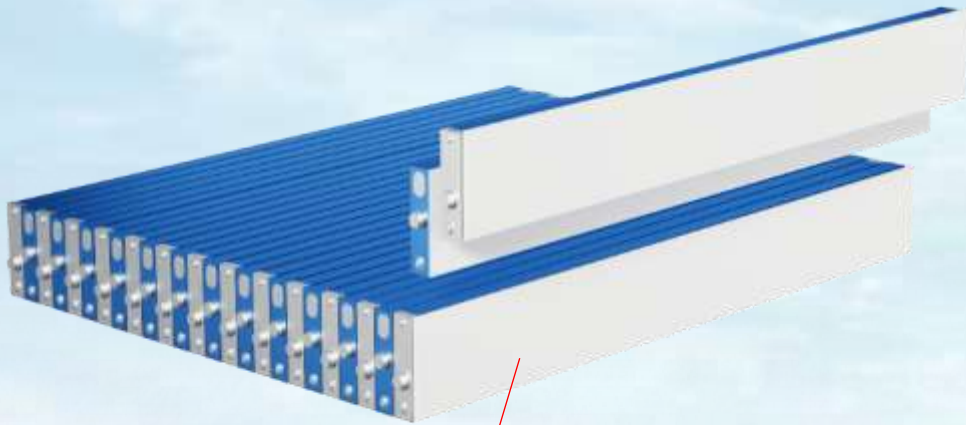
Fire extinguishing



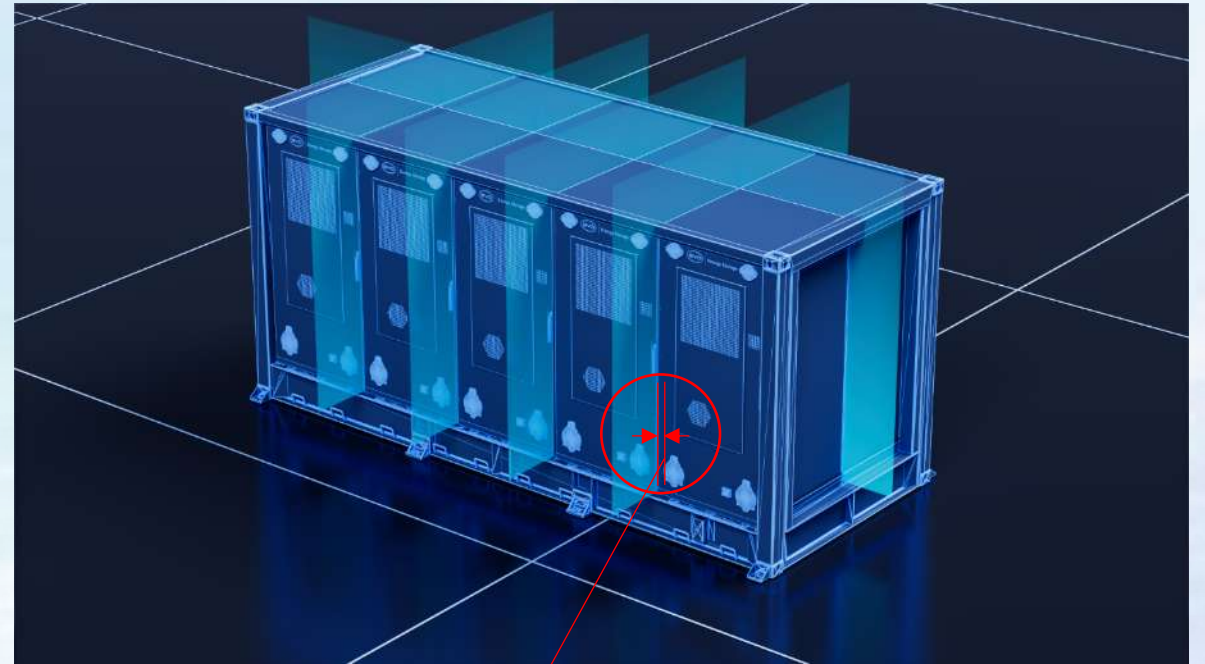
Fire Safety Design — Heat and fire resistant

Gap Design + Thermal Insulation

- Inter-cell insulation with aerogel effectively blocks heat transfer.
- The single cabinet enclosure is protected by fire-resistant steel plates, and air gap insulation is implemented between cabinets to increase the thermal resistance between systems, suppress lateral spread of heat sources, and protect system safety.



Passive aerogel insulation



2cm spacing air insulation

Fire Safety Design — Explosion Venting/Pressure Relief

- The system's explosion-proof ventilation design can effectively remove gases and electrolyte vapors generated by battery thermal runaway in the battery compartment, improving safety.
- The passive safety explosion relief design effectively suppresses pressure rise within the Pack and battery compartment, mitigating the risk of explosion.

Explosion-Proof Ventilation



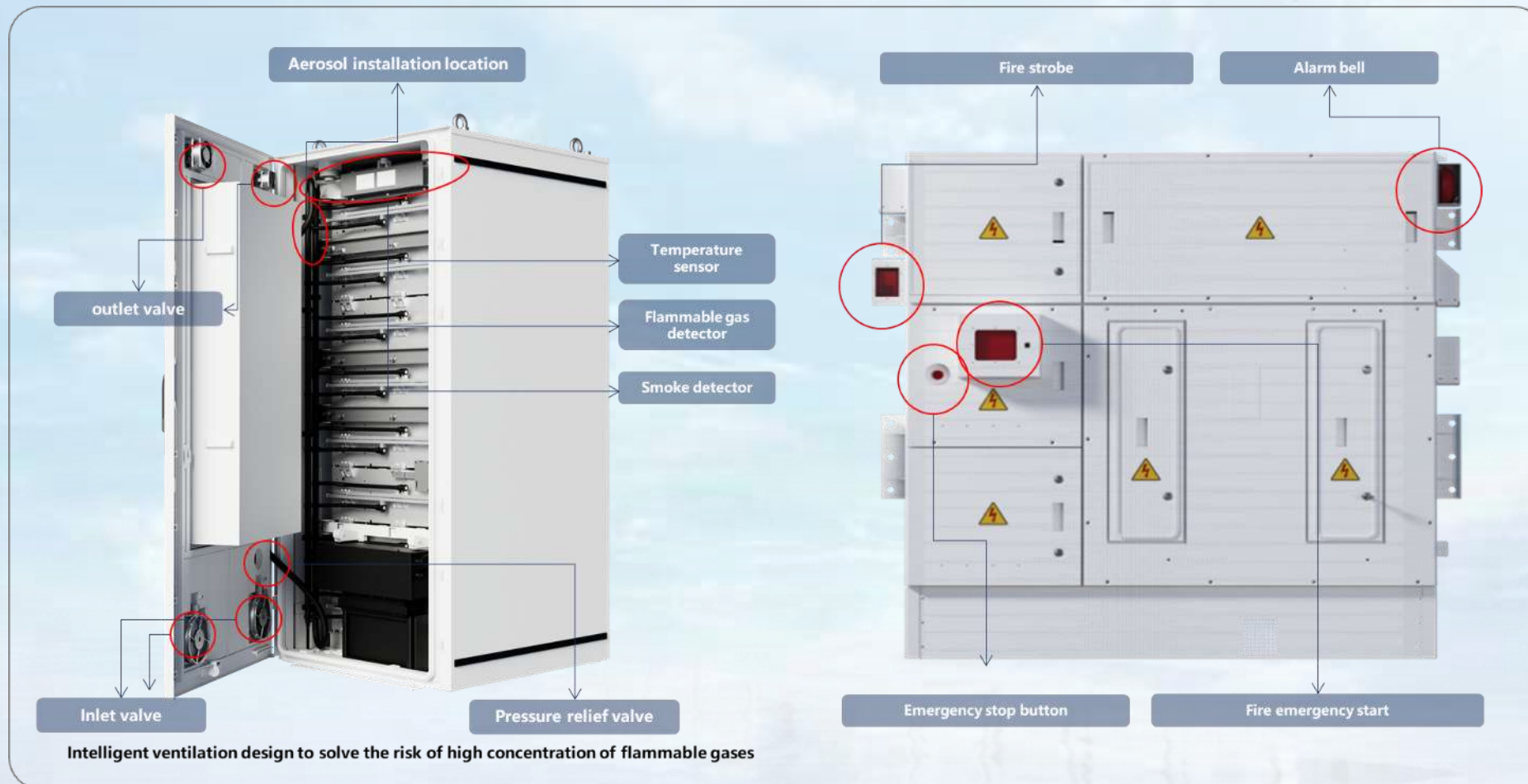
Passive Safety Explosion Relief



Fire Safety Design — Fire system design

Fire system design

- The fire protection system for energy storage battery compartments mainly includes a fire control panel and three modules: **fire detection and early warning facilities, fire suppression facilities, and exhaust and pressure relief devices.**



| Summary

- **To enhance the safety of battery systems, we focus on improving the high-temperature resistance of battery materials and optimizing structural design. This approach aims to achieve intrinsic safety and reduce both the likelihood and impact of fire incidents.**
- **In terms of operational safety, various measures are implemented to maintain a comfortable environment for the battery system, preventing misuse. Early fault warnings and rapid shutdowns are employed to ensure both efficient and safe system operation, thereby minimizing the risk of accidents.**
- **Regarding fire system design, early detection and assessment of fire conditions are achieved using various types of fire detection sensors. A system-level fire compartmentalization structure is implemented to prevent the spread of heat. Active and passive venting systems are utilized to mitigate explosion risks. Additionally, a scientifically designed fire suppression system, combined with effective extinguishing agents, ensures the rapid containment and extinguishment of fires.**

A wide-angle view of Earth from space, showing the curvature of the planet and a bright light source (the sun) on the horizon, creating a lens flare effect. The sky is dark with visible stars.

CLEAN ENERGY FOR A BETTER LIFE

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