SYNVISTA

Research and Solutions for Fire Prevention in Lithium Battery Applications

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Energy Storage Accident Analysis

1 Energy Storage Accident Analysis

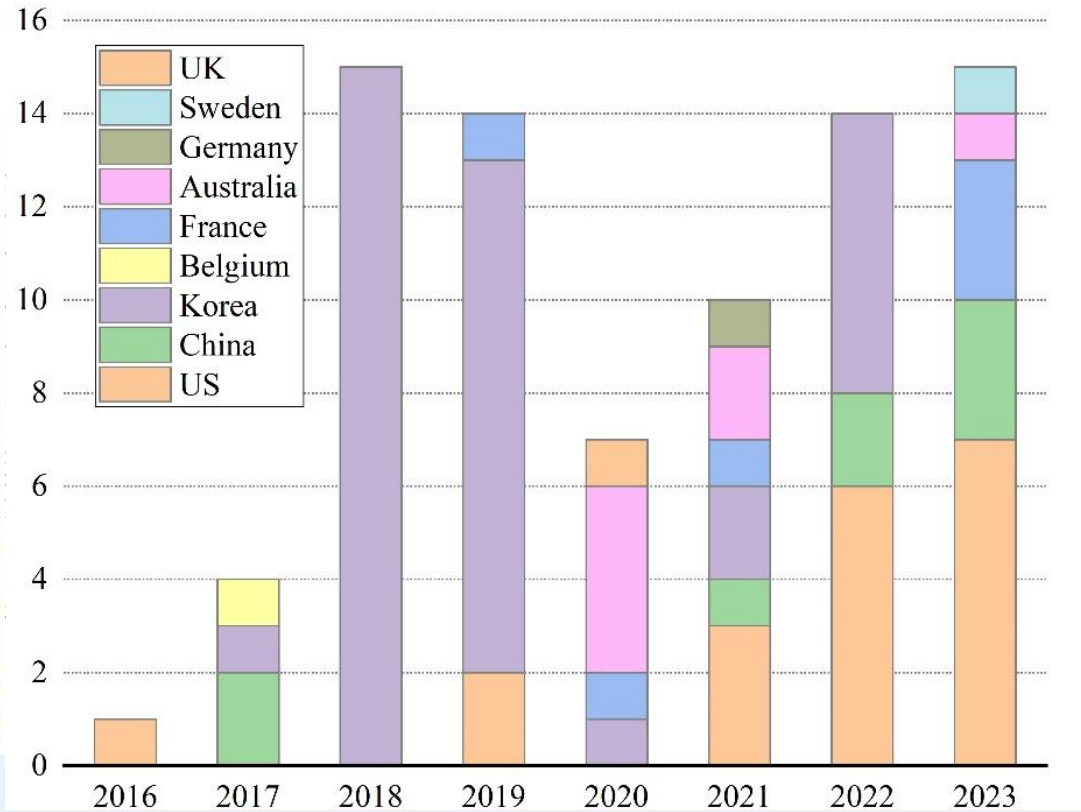
🔥 Global Overview of Reported Energy Storage Fire Incidents

Since 2017, nearly **100 publicly reported energy storage station fire accidents** have occurred globally.
Between **2018 and 2023**, the average number of incidents exceeded **10 per year**, with most accidents concentrated in **South Korea, the United States, Australia, and China**.

A fire and explosion at an energy storage project in Beijing

A fire incident involving a PV + BESS system in Seoul

Reported Fire Incidents by Country (2016–2023)



Data Source: EPRI

Energy Storage Accident Analysis

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Root Causes

Battery Quality Issues

Internal defects (e.g. dendrites, aging) and external abuse can cause short circuits or thermal runaway.

Electrical Imbalance

Inconsistent state-of-charge between battery packs may lead to loop current and overcharge.

BMS Malfunction

Outdated software or poor data sampling may cause failure in early fault detection.

Wiring & Cabling Issues

Poor layout, no fireproofing, or signal interference increases fire risk.

Fire Protection Design

Lack of venting or insulation may fail to suppress fire/explosion effectively.

Gas Detection & Water Suppression

Faulty sensors + conductive water can escalate high-voltage faults.

Environmental Conditions

Dust, humidity, and sand may affect insulation and cooling, leading to overheating.

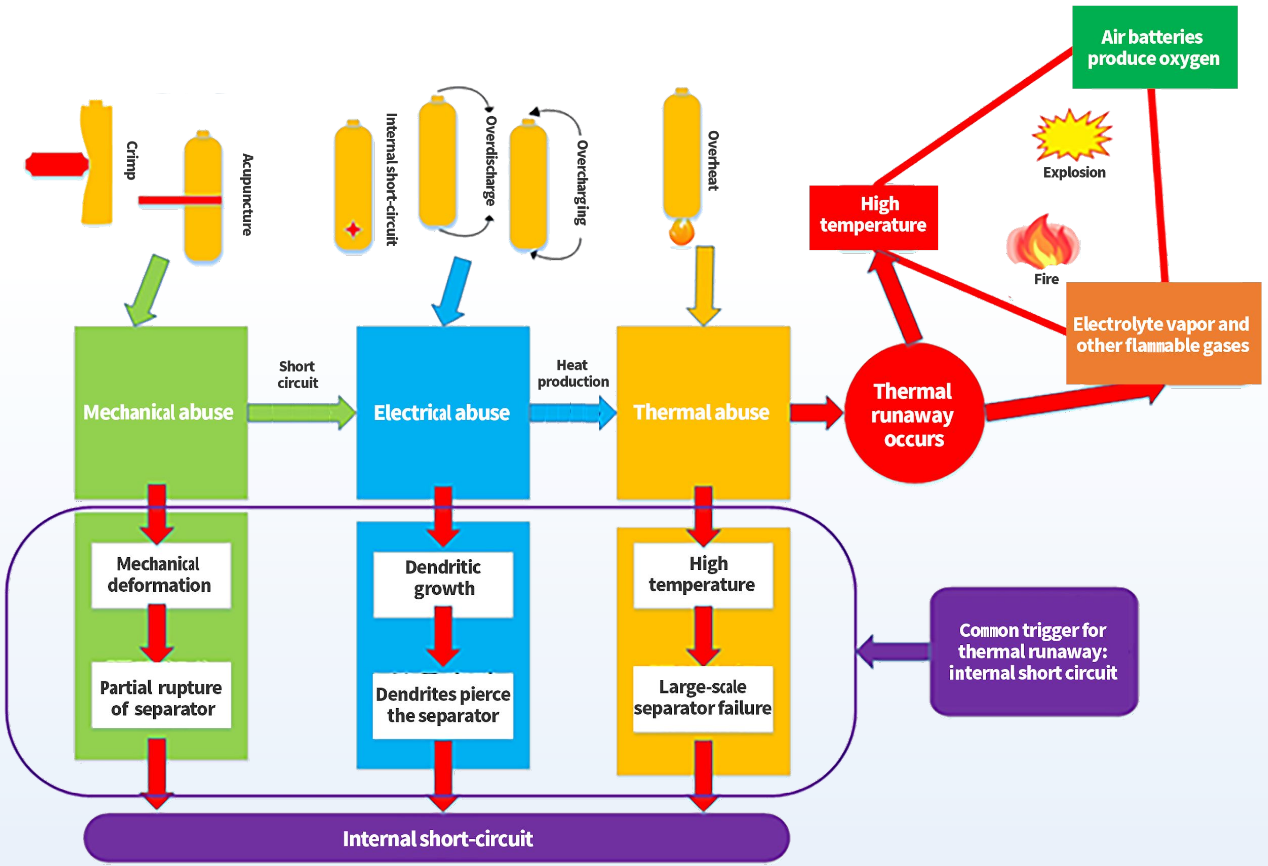
Human Operation & Management

Unsafe actions or lack of training during on-site operation may trigger safety events.

Mechanism

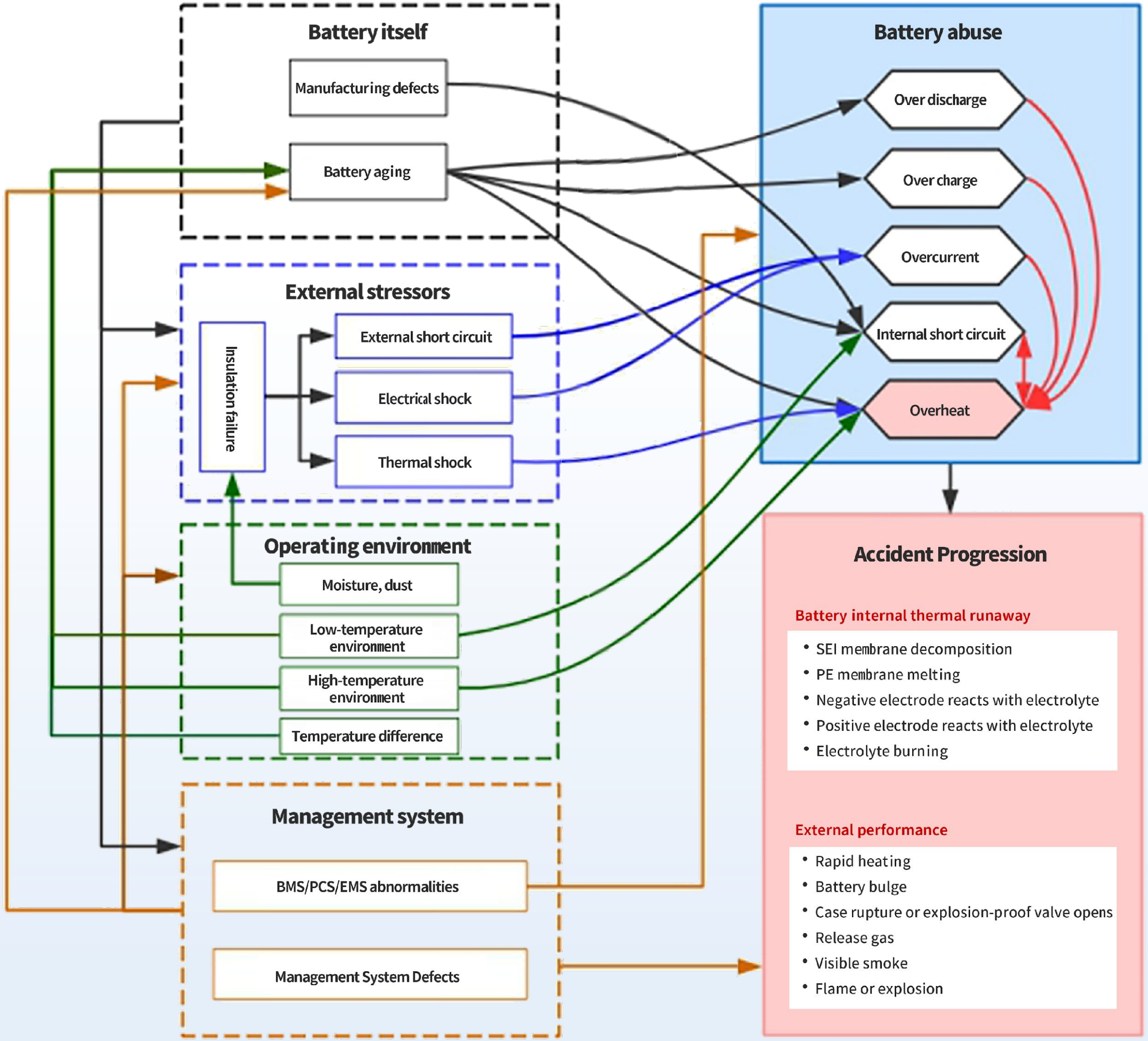
Lithium-ion Battery Thermal Runaway Mechanism

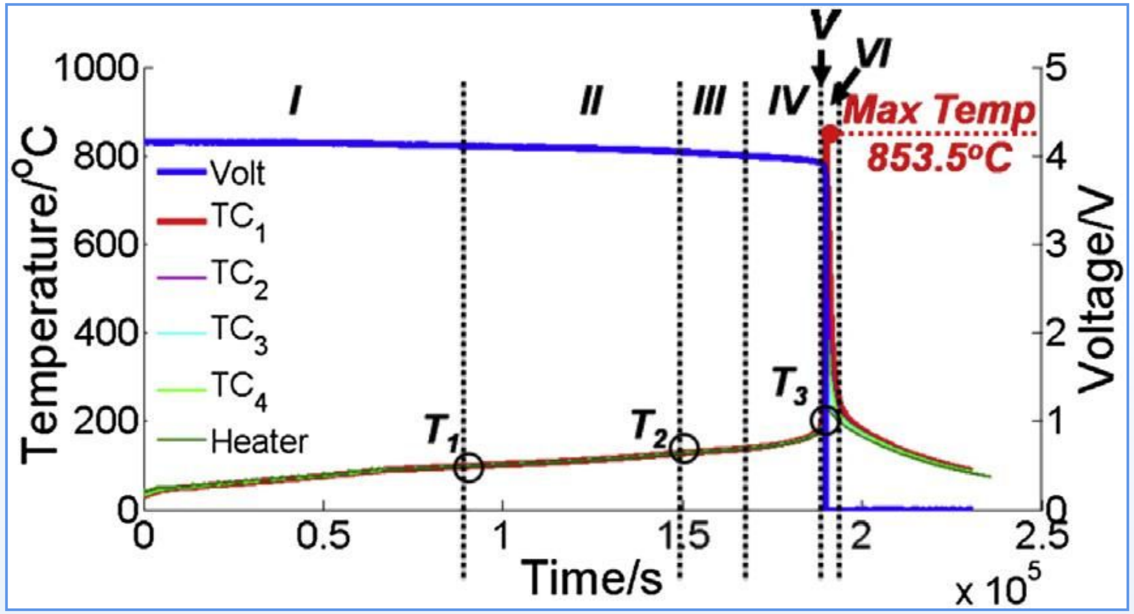
- **Abusive conditions** (e.g., overcharge, short circuit, high temperature) accelerate internal chemical reactions.
- **Heat generation** increases **exponentially**, but **heat dissipation** only increases **linearly**.
- This **imbalance** causes **rapid heat accumulation**.
- Triggers a **self-accelerating loop** → leads to **thermal runaway**.



Energy Storage Accident Analysis

Process





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Temperature Characteristics

Low to Mid Temperature Behavior (0–120°C)

0°C – 45°C: Minimal side reactions

Safe operating range for lithium-ion batteries.

45°C – 60°C: Slight increase in reactions under small currents

Need to monitor for anomalies.

60°C –100°C: Side reactions increase

Capacity fades as temperature rises above 60°C.

80°C – 120°C: SEI (Solid Electrolyte Interface) layer starts decomposing

Reactions intensify.

High Temperature Risks (130–650°C)

130°C – 250°C: Negative electrode reacts with electrolyte

Massive heat release.

120°C – 270°C: Separator shrinks/melts

Short circuit between electrodes → Rapid temperature rise

150°C – 450°C: Gas pressure builds

Safety valve opens, gases eject (CO_2, H_2, etc.).

350°C – 650°C: Flammable gases ignite or explode when mixed with air

Temps can exceed 900°C.

Lithium Battery Fire Risk

There is currently no universally accepted classification standard for the fire risk of lithium-ion batteries

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Research on Safety Grading Evaluation Methods for Lithium Battery Systems

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Lithium Battery System Safety Grading

- Cell Level
- System Design
- Early Warning & Prevention
- Mitigation Measures
- Operation & Maintenance Assurance

Cell Level → Module Level → Unit Level → Installation Level

Risk Level	Surface Temperature Tmax	HRR (kW/m²)	System	Module	Pack	Cell
I	≥ 600°C	≥ 170	Extreme	Extreme	Severe	Moderate
II	450–600°C	80–170	Extreme	Severe	Moderate	Mild
III	130–450°C	29–80	Severe	Moderate	Mild	Mild
IV	≤ 130°C	≤ 29	Moderate	Mild	Mild	Mild

Assessed Unit	Heat Release Rate HRR (kW/m²)	RT–130°C (I)	130–160°C (II)	160–220°C (III)	>220°C (IV)
Cell	≥ 170	Extreme	Extreme	Extreme	Extreme
	80 – 170	Extreme	Severe	Severe	Severe
	29 – 80	Extreme	Severe	Moderate	Moderate
	≤ 29	Extreme	Moderate	Moderate	Mild
	Cell Thermal Runaway Tmax	≥ 450°C	300–450°C	130–300°C	≤ 130°C

→

- **Cell level**
- **Module level**
- **System/Installation level**

Problems & Countermeasures

Problems

- Thermal runaway cannot be fundamentally eliminated
- Fully effective extinguishing agents are still under exploration

Countermeasures

1

A **systematic and scientific** approach is required to ensure lithium-ion battery safety;

Control potential thermal runaway triggers (e.g., mechanical abuse, heat, electricity, impurities);

Strengthen safety management and technical measures across the full lifecycle: planning, design, procurement, construction, operation;

Keep fire risk within acceptable range.

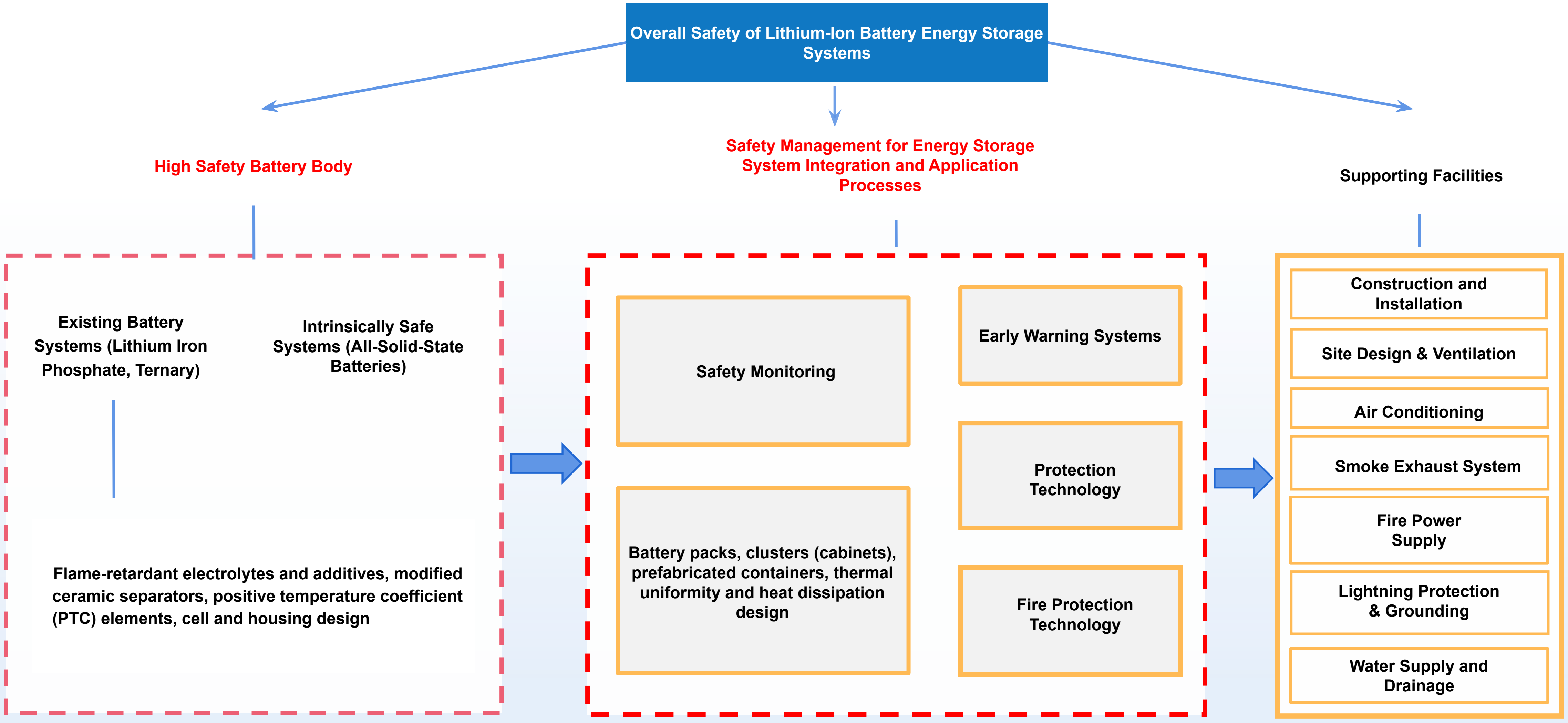
2

Current technologies, standards, and evaluation systems remain incomplete;

Emphasis on **empirical validation** and **real-world testing.**

Fire Prevention in Energy Storage Stations

Overall Safety



2 Fire Prevention in Energy Storage Stations

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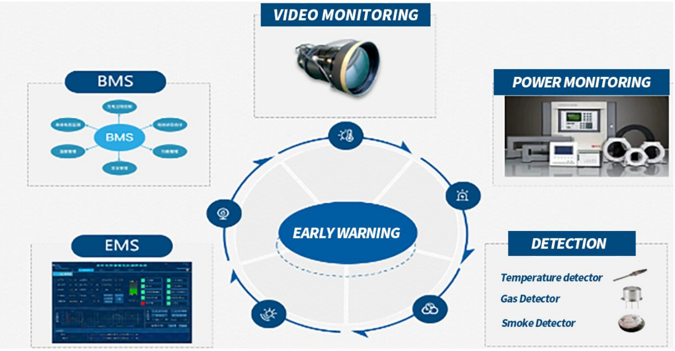
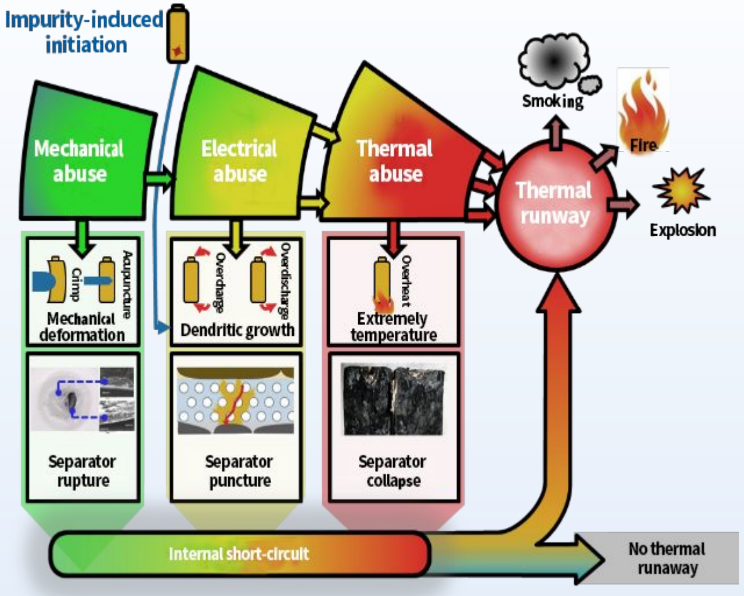
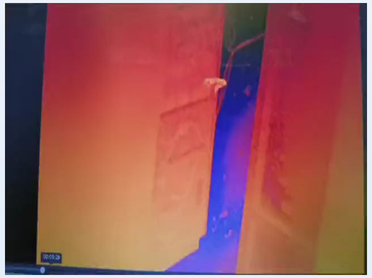
Key Points

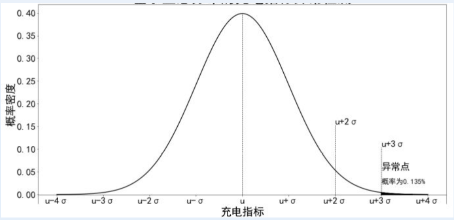
- BMS / EMS / PCS integration with the fire protection control system
- Early warning and suppression within battery PACKs
- Water-based fire suppression capability
- Thermal management
- Enhanced electrical fire protection for battery systems
- Big data-driven early warning
- Periodic safety assessments
- Post-thermal runaway handling processes and mitigation measures





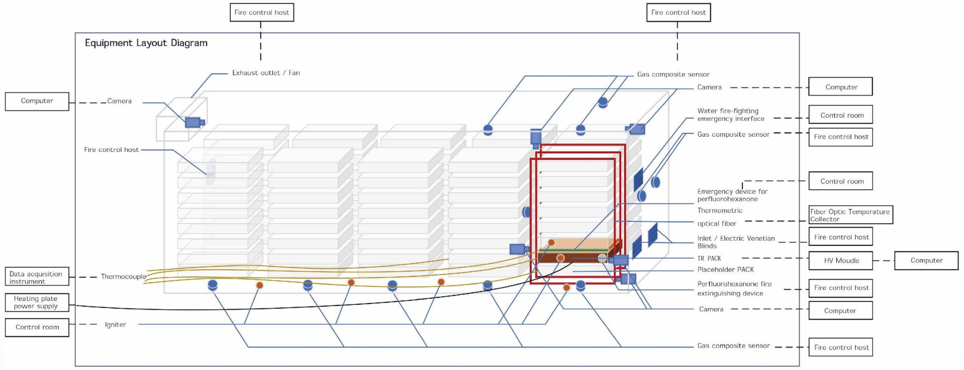


Temperature / Temperature Difference / Rate / Pressure Difference Deviation

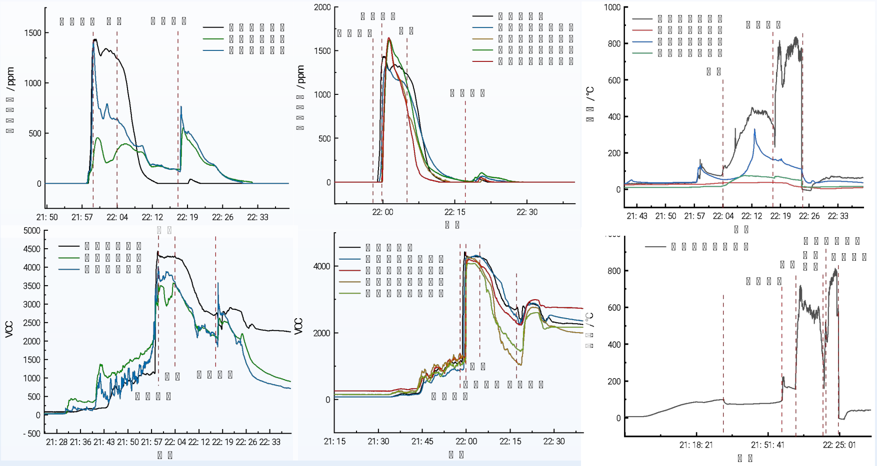


Empirical Testing

Full-Scale Fire Test Research on Energy Storage Systems



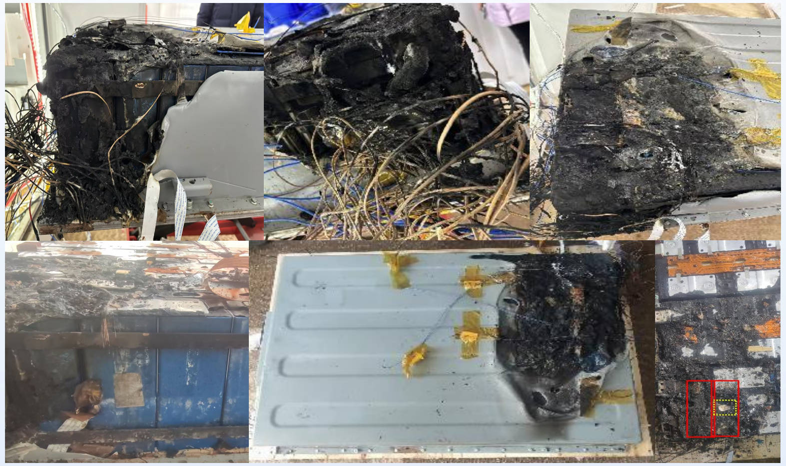
Full-Scale Fire Test Platform Design

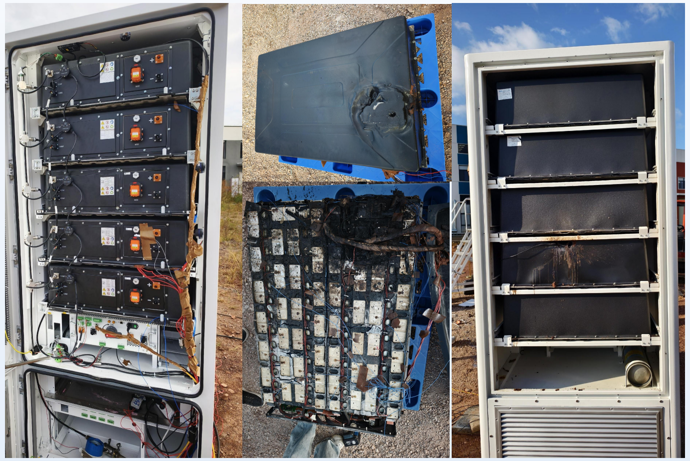


Temperature and Gas Behavior Study During Full-Scale Fire Test

Full-Scale Fire Test of Prefabricated Energy Storage Cabin

Full-Scale Fire Test of Commercial and Industrial Energy Storage





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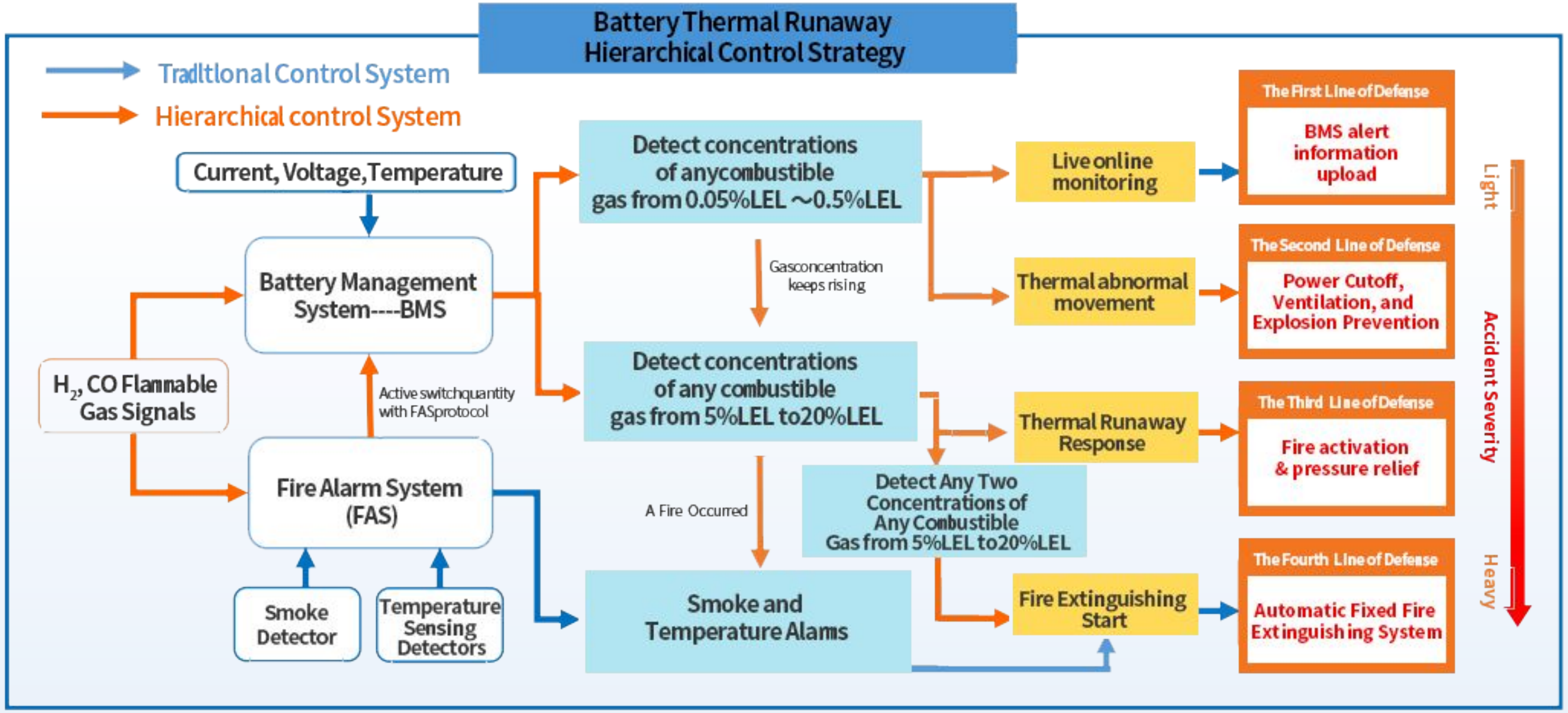
Coordinated Response Strategy

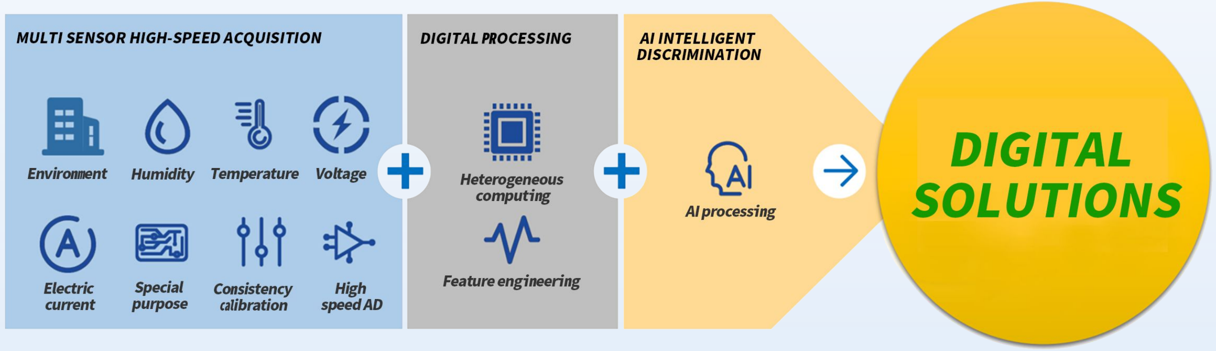
- Traditional fire protection systems operate independently
- Achieve true integration between fire control and BMS/PCS/EMS
- Leverage sensor data from the battery system itself
- Empirical study on coordinated control strategies

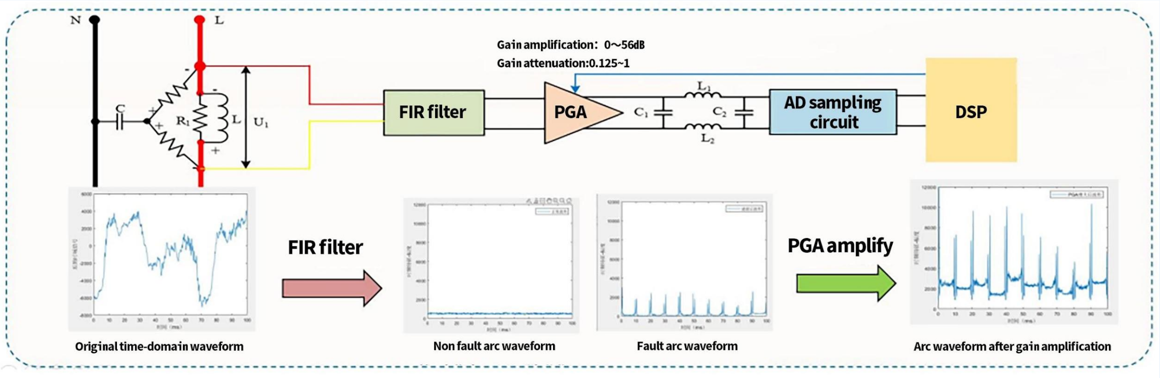


Fire Prevention in Energy Storage Stations

Coordinated Response Strategy

- Power battery statistics show that leakage and electrical faults are the main causes of failure.
- Electrical systems in energy storage are more complex, and electrical issues may become the primary cause.
- Compared to other electrical components, batteries are more “sensitive” or “delicate.”
- Currently not given enough attention — this issue needs to be addressed.
- Conduct targeted research on electrical fire prevention for lithium batteries.





3 Safety Design of Energy Storage Products

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Energy Storage Product Safety Design

Electrical safety

◆ Selection of insulating materials

Materials	Thickness(mm)	Dielectric strength（kV/mm）
Silicone rubber	1	14
PC sheet	0.5	20
PBT + 30% GF	1.5	20
PA + GF (Glass Fiber)	2	35

 Insulation Resistance Test

Standard	Test Voltage	Insulation resistance
UL 9450 IEC 62933-5-2	2500V@60s	>1MΩ
GB/T 36276	2500V@60s	>1.5MΩ
SYNVISTA	2500V@60s	>1GΩ

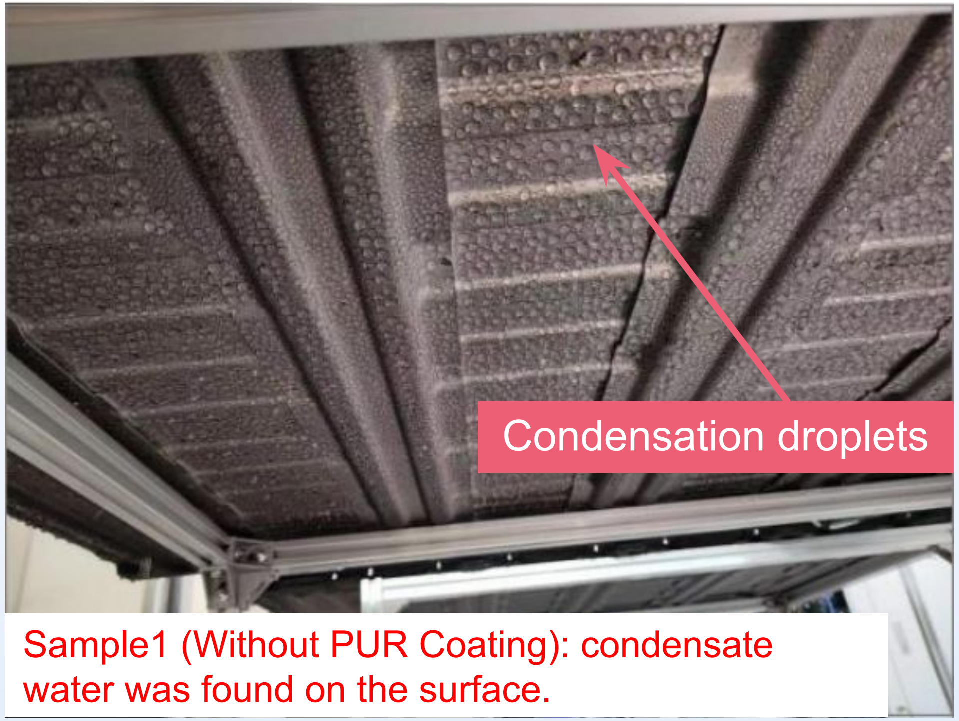
 Dielectric Voltage Withstand Test

Standard	Test Voltage	Criteria for Judgement
UL 62368-1	4000VDC@60s	No electric breakdown or flashover occurred
IEC 62933-5-2	4200VDC@60s	No electric breakdown or flashover occurred
GB/T 36276	4380VDC@60s	No electric breakdown or flashover occurred, and the leakage current is less than 10 mA.
SYNVISTA	4500VDC@60s	No electric breakdown or flashover occurred, and the leakage current is **less than 1 mA**.

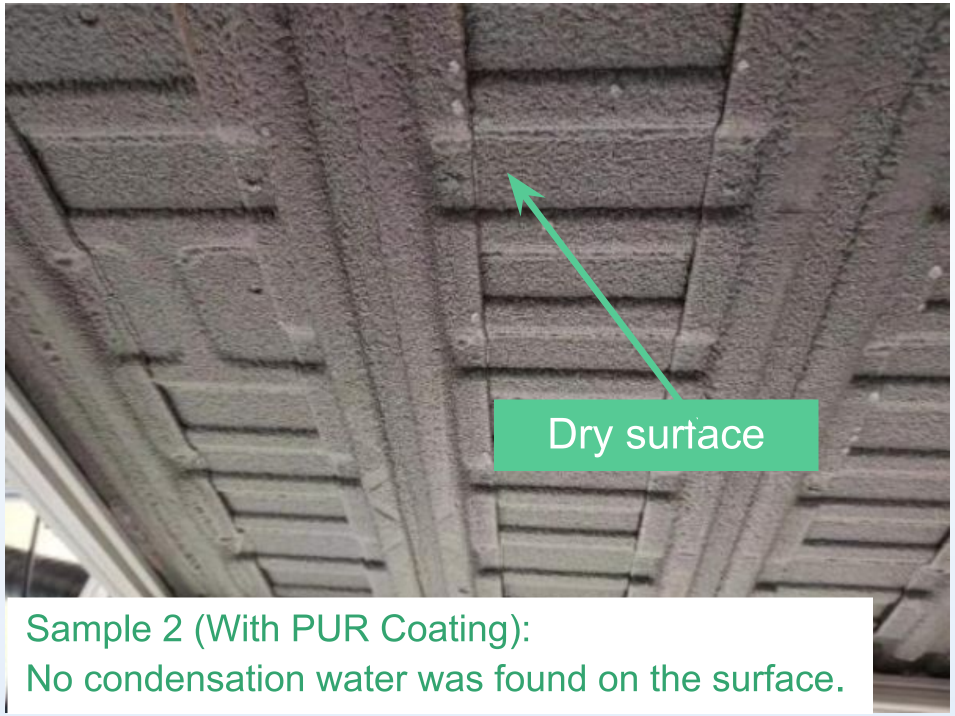
Anti-Condensation design

- **Design for Anti-Condensation on Liquid-Cooled Plate: Spray PUR with a Thickness of ≥3mm on the Bottom of the Pack**

To reduce the cold loss from the bottom of the cold plate and increase the temperature of the contact surface, PUR (polyurethane foam) is sprayed onto the bottom of the cold plate.



Not spraye PUR



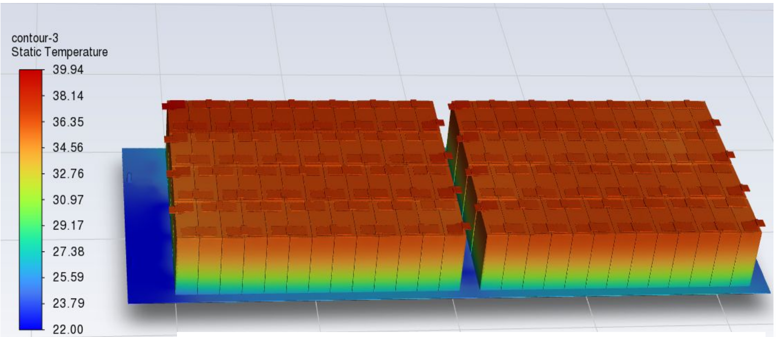
Spraye PUR

Thermal Management Design

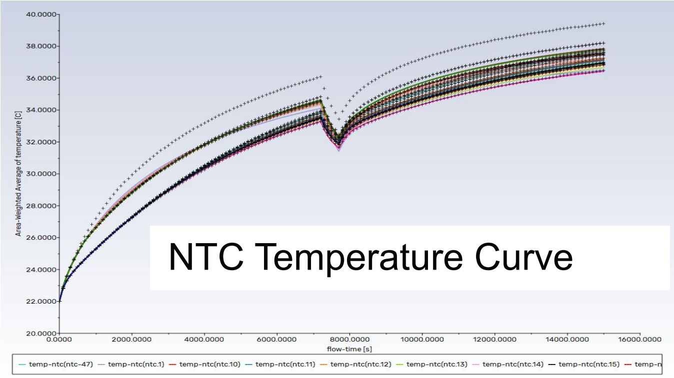
Thermal Simulation

Simulation results indicate that throughout the entire charge and discharge cycle:

- ✔ The highest temperature of NTC (cell) is 39.4℃ < 45℃;
- ✔ The maximum temperature difference of NTC (cell) is 2.9℃ < 3℃.



Pack Temperature Cloud Chart

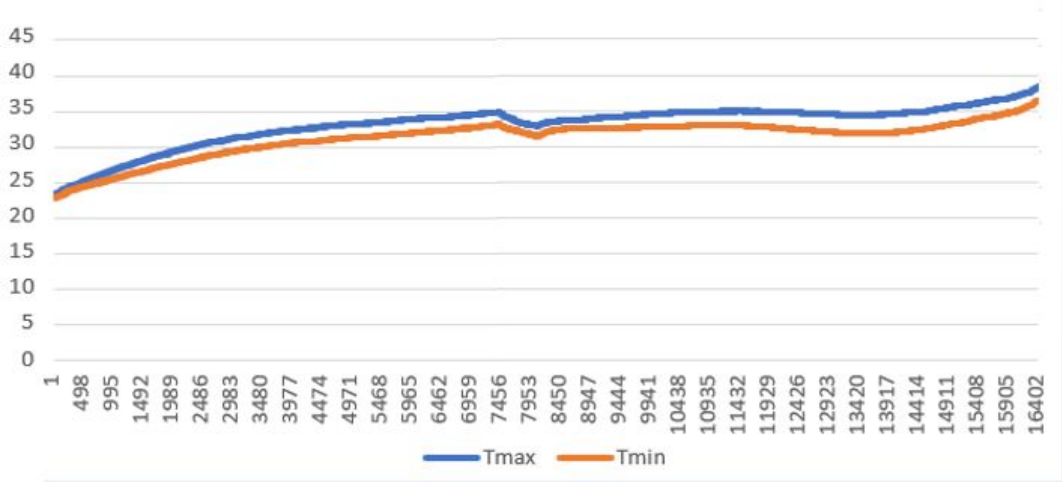


NTC Temperature Curve

Test Verification

Test results show that throughout the entire charge and discharge cycle:

- ✔ The highest temperature of NTC (cell) is 38.4℃ < 45℃;
- ✔ The maximum temperature difference of NTC (cell) is 2.8℃ < 3℃.



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Noise Design：Noise mitigation protocols in place

▯ Test Methods

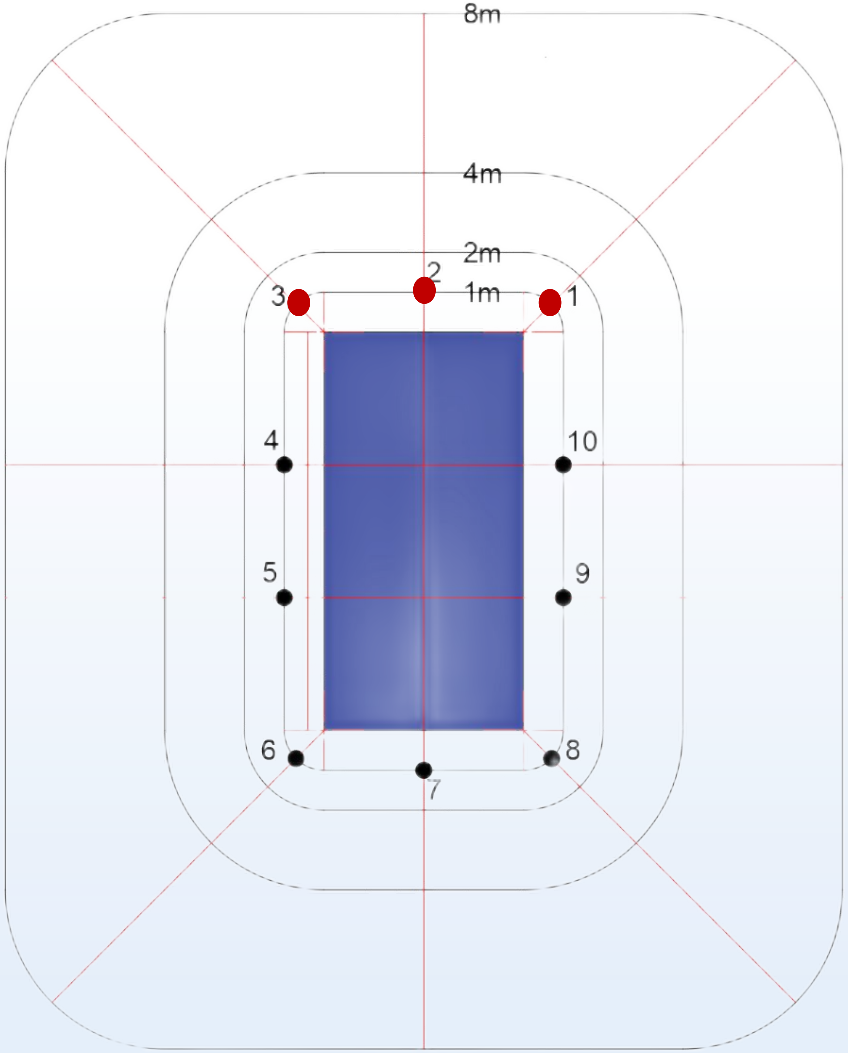
Measure noise at 1m/2m/4m/8m from the battery container using a sound pressure level meter. Test points are arranged around the container, with noise measured at each distance at each point.

▯ Test Records

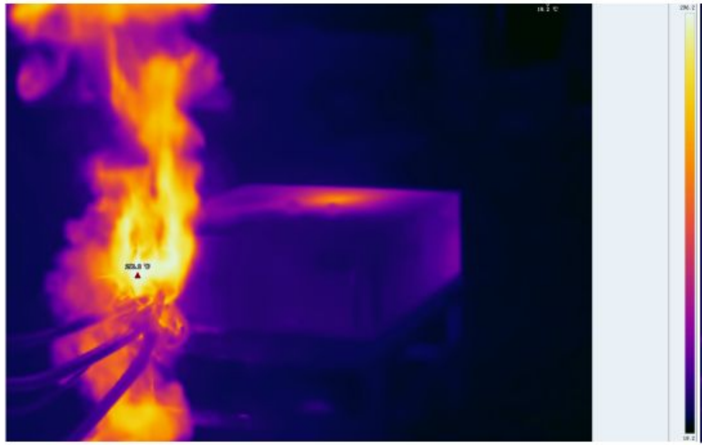
1.Background Noise: Measured with fan off and no charging/discharging
2.Fan Noise: Measured with fan at full speed and no charging/discharging.
3.Combined Noise: Measured with fan at full speed.

▯ Test Results

The maximum sound pressure during charging and discharging was **80dB**

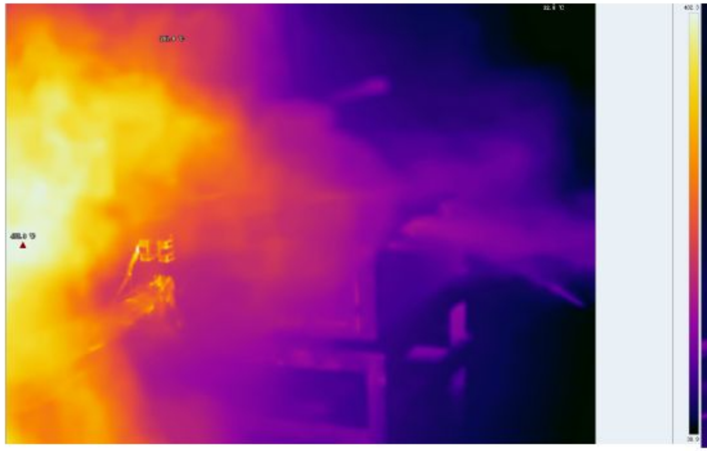


Fire Suppression Strategy

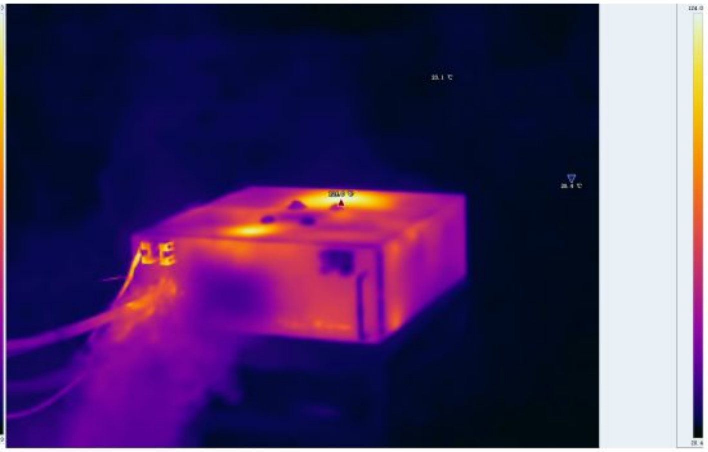


Temperature at Ignition

Temperature During Flame Burning



Temperature at Aerosol Discharge



Post-Extinguishing Temperature

- When flammable gases ignite, the external battery cabinet temperature can reach **296.2°C**.
- During peak flame burning and aerosol discharge, the **maximum temperature** observed was **481.2°C**.
- After fire suppression, the cabinet temperature dropped to approximately **124.0°C**.
- The **aerosol-based fire suppression system**, deployed inside the battery pack, can **directly target the ignition source**, significantly reducing the ignition temperature.
- This greatly improves **fire suppression efficiency** compared to traditional extinguishing systems.

4 SynVista Overview

4

Concord New Energy

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Concord New Energy Group (CNE) is a leading renewable energy company based in Singapore, specializing in wind and solar energy development, as well as energy storage solutions. Listed on the Hong Kong Stock Exchange, CNE is dedicated to providing high-quality clean energy and promoting sustainability for a harmonious future between people and nature.

4615MW
Total Installed Capacity

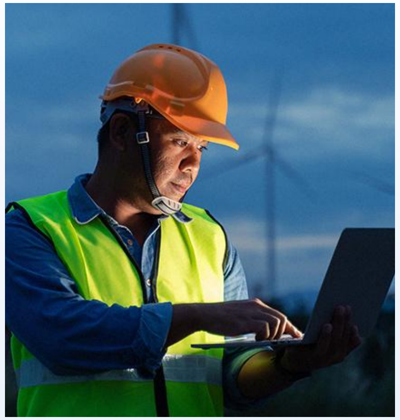
83
Wind and Photovoltaic Power Plants

72740 GWh
Total Power Generation Capacity

40GW+
Maintenance Capacity

Investment in Power Plant
Investments in wind power, solar energy, and renewable sectors span Asia, North America, Europe, and the Pacific regions.

Energy Storage and Service
The company features a 10 GWh BESS system with global service capabilities, AI-powered solutions, and a comprehensive energy storage project framework.



Consultation, Design, and Total Commitment
The total capacity for consultation or design commitments includes over 50 GW in wind power, 18 GW in solar energy, and 7 GW in energy storage.

Intelligent Asset Management
With over 17 years of experience in asset management overseeing more than 40 GW of capacity, the company employs AI-based trading strategies, intelligent robotics for unmanned site management, and AI-driven predictive site failure analysis.

4 SynVista Business

SynVista is **headquartered in Singapore**. SynVista's core business covers energy storage product development and manufacturing services, system integration & deployment, BT and O&M. The company provides customers with comprehensive and customized solutions for renewable energy to meet the the diversified global demand for energy storage.

ESS System Development & Deployment Kit

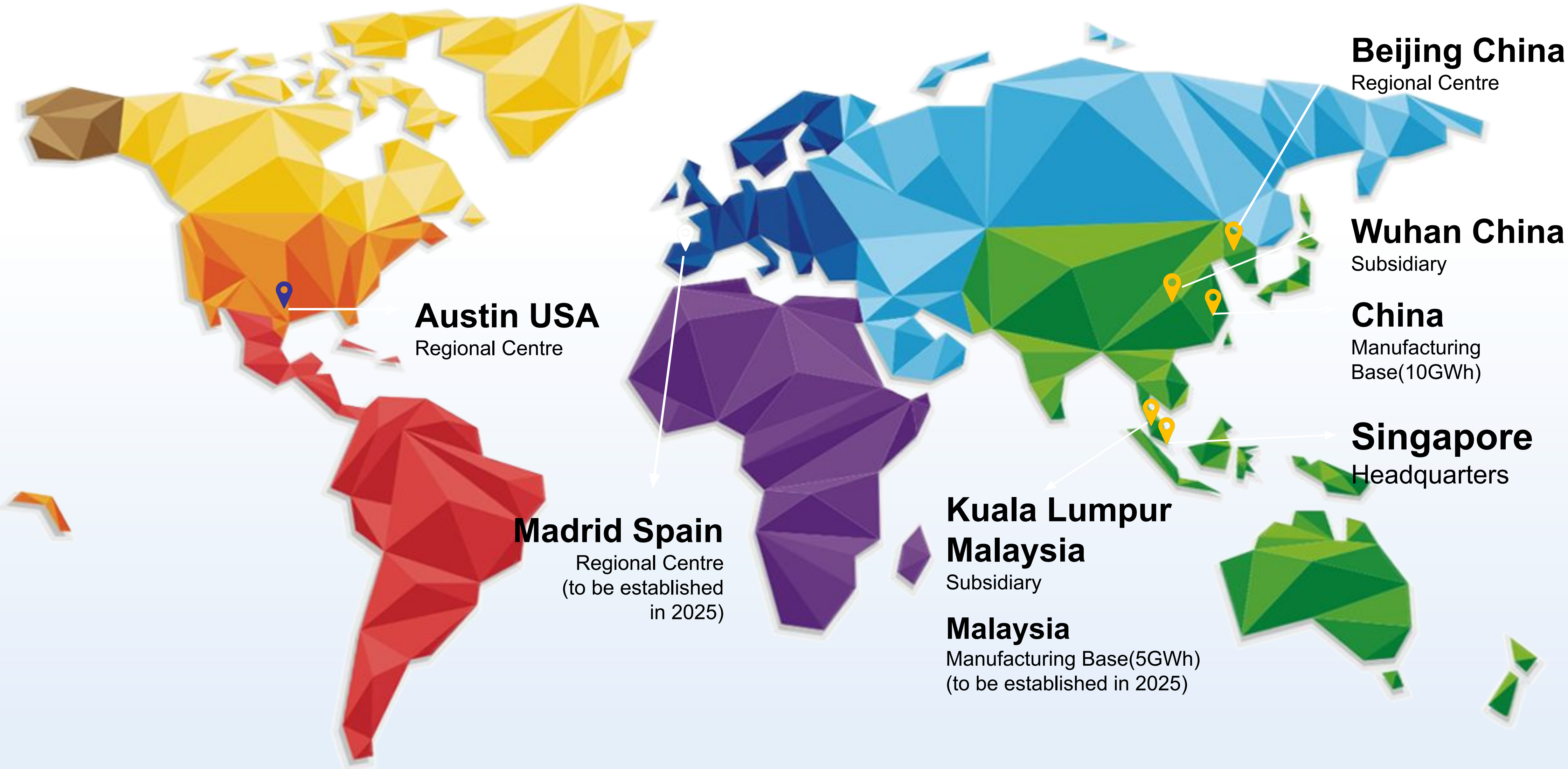
ESS Doctor™ O&M Service

ESS Operation System

Project Development → Construction → Operation → Exit

We offer a complete energy storage solution covering the full lifecycle

SynVista Business Footprint



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Globalized Production and Supply Chain

Manufacturing base：

Anhui Province（2023）Jiangsu Province（2024）

LFP Pack

Production capacity of **10** GWh per year

DC Block and C&I Cabinet

Production capacity of **10** GWh per year

ISO45001 ISO9001 ISO14001

Manufacturing base in planning:

Malaysia（2026）, LFP Pack and DC Block/C&I Cabinet, **3** GWh

Accessary parts manufacturing: BMS, cooling system, etc.

US（2027）, DC Block, **2** GWh

4 Summary and Outlook

Fire Prevention: A Core Element in Lithium Battery Safety

Provides the foundation for long-term reliability, operational safety, and risk control in battery applications.

Scenario-Oriented Risk Assessment and Control

SynVista offers fire prevention strategies tailored to different application environments, combining detection, early warning, and intervention.

Towards Safer, Smarter Energy Systems

SynVista continues to innovate fire safety technologies, supporting the safe adoption of lithium batteries across energy storage, mobility, and industrial applications.

Elite Energy Storage For Generations

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