Transforming Risk To Resilience in BESS

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“You don’t build resilience by avoiding risk.

“You build it by engaging with risk — and managing it smarter.”

— *Inspired by Nassim Nicholas Taleb (Author of “Antifragile”)*

Contents

Navigating BESS Deployment Risks

- Investors face high costs
- Uncertain ROI
- Limited insurance support

- Evolving regional energy policies
- AHJ safety expectations

- Complexity of grid interactions while ensuring equipment performance reliability

- Cell thermal runaway
- Passive & active fire mitigation strategies

Stakeholders, Our Priority

Addressing their respective risk

Stakeholders

- Authorities Having Jurisdiction (SCDF, EMA, SP)
- Insurance & re-insurance companies
- Fire protection engineers (Mechanical QP)
- Engineering, Procurement, and Construction (EPC)
- Energy Storage System (ESS) developers / Investors
- Large scale BESS OEMs

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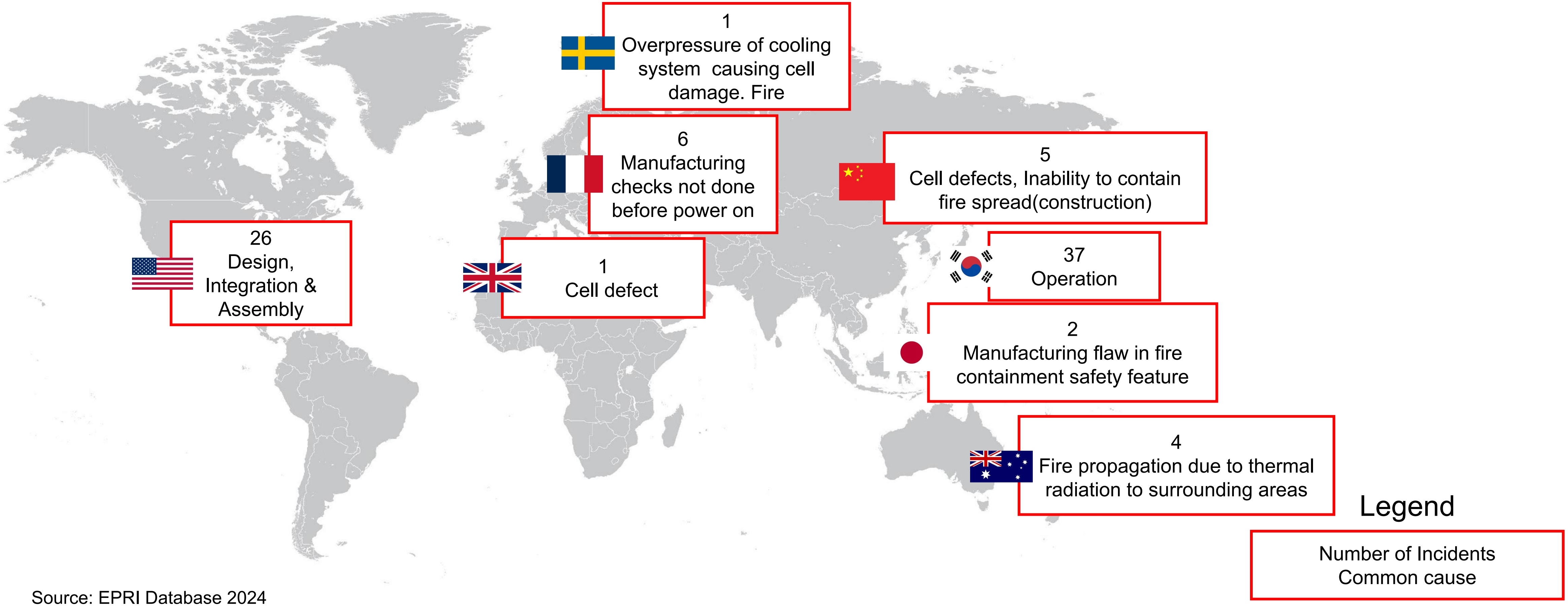
A multi-dimensional role to address concerns & queries:

- Approvals from AHJs & aligning with stakeholders
- Risk assessment and HAZOP analysis
- Develop site fire protection plan / Emergency first responder plans
- Failure mode & Effects (FMEA) analysis
- Maintenance protocols

Lessons from Industry Experience

- Understanding the most common cause of fire has led to stronger understanding of safety protocols and technical knowledge to ensure safer implementation in BESS



Source: EPRI Database 2024

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Gothenburg, Sweden

Incident Overview

- 2023 – Fire & explosion at an 875kWh 20-foot battery container
- Unit was undergoing further integration works & prelim commissioning under shelter.

What went wrong?

- Prelim analysis believes that during water pressure testing of the battery packs, some minor damage was done on the cells.
- White smoke was seen emitting out of the unit; leading first responders to close the container door & attempt to bring it to open spaces.
- While trying to bring the unit out, one of the trolley wheels disconnected, leading to more time wasted.
- It is believed that as the door was closed, the air mixture finally became deadly and sparked off the explosion.

What was learnt?

- Mandatory pressure relief mechanisms (deflagration panel) in battery containers. If possible, emergency systems to be connected to 230VAC supply.
- Emergency BESS-specific fire training for responders.

Ref: RBFRS

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Isa City, Kagoshima, Japan

Incident Overview:

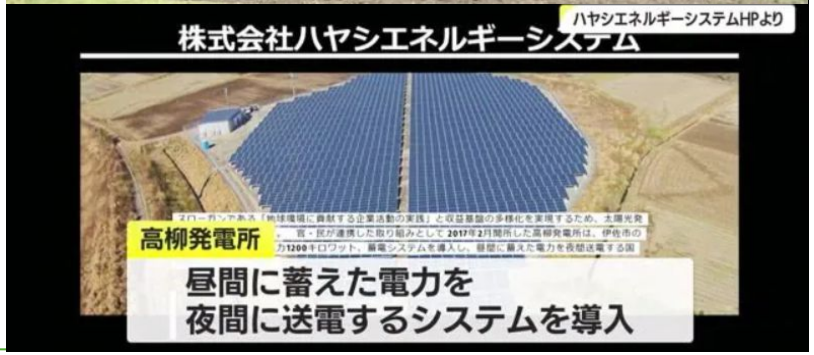
- 2024 – Fire and explosion in **BESS system co-located** with 1.2MWp **solar plant**.
- 4 firefighters injured due to the explosion.

What went wrong?

- BESS housed in the building, air cooled type of cells started to emit smoke
- First responders saw it was filled with smoke & activated the building's exhaust system—an explosion occurred shortly after, collapsing the entire building.
- Fire extinguished 1.5 days later.

What was learnt?

- Use of water cooled cells preferred, along with possibly putting it outdoors.
- Automated fire suppression systems for the BESS must match the building exhaust exchange/flow rate.
- Training programs for responders should include controlled explosion risks.



Ref: EPRI

Innovations that reduce Technical Risk

Main pillar to address all other types of risk

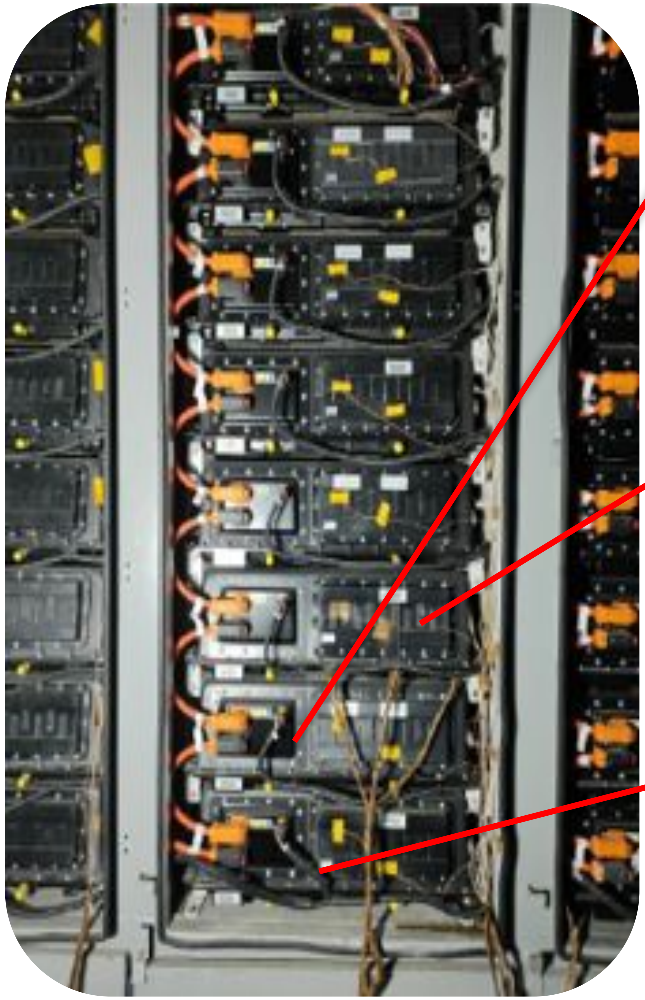
Addressing Technical risk

UL9540A Compliance with Unique Cell Chemistry
Ensuring thermal stability and fire safety from within the cells

Hardware-Based Fire Mitigation Features
Integration of fire suppression, construction of container, and fail-safes within the unit

Addressing Technical Risk

Innovating thru chemistry



(d) Cell Thermal runaway [00:59:45]

Initiating cell (Cell 20) Thermal runaway trigger

(e) Cell 19 Thermal runaway [01:01:07]

Thermal runaway **1 hour** later at **Cell 19**

(f) Cell 21 Thermal runaway [01:30:00]

Thermal runaway 1.5 hours later at **Cell 21**

Cell 20: Module casing remains intact despite thermal runaway –signs of heat exposure, no burn-through, no fragmentation

Test Results

No further smoke propagation observed in other adjacent battery packs

Minimal damage to all modules as seen above.

UL9540A report findings & conclusions

Summary of BESS Unit Test Results
Performance Criteria in accordance with Table 9.1 for Indoor Floor Mounted non-residential unit

1 Maximum Target BESS temperature averaged on 60 seconds.
2 Maximum wall surface temperature averaged on 60 seconds.

UL 9540A, Edition 4

[X] Flaming outside the initiating BESS unit was not observed; [X] Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit did not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8; [X] For BESS units intended for installation in locations with combustible constructions, surface temperature measurements on wall surfaces did not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15; [X] Explosion hazards were not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and [X] Heat flux in the center of the accessible means of egress did not exceed 1.3 kW/m².
Necessity for an Installation level test
[ ] The performance criteria of the unit level test as indicated in Table 9.1 of UL 9540A 4th edition has not been met, therefore an installation level testing in accordance with UL 9540A will need to be conducted on the representative the installation with this unit installed. [X] The performance criteria of the unit level tests as indicated in Table 9.1 of UL 9540A 4th edition has been met, therefore an installation level testing in accordance with UL 9540A need not be conducted.

The unit met UL 9540A (4th ed.) eliminating the need for installation-level testing.

Key Performance Findings:

- No external flaming was observed outside the initiating BESS unit
- Wall surface temperatures remained within safe limits: Did not exceed 97 °C (175°F) above ambient, even with combustible constructions
- No explosion hazards were detected: No deflagration, detonation or accumulation of battery vent gases
- Heat flux at egress points stayed below critical limits: Did not exceed 1.3kW/m² at accessible means of exit

Hardware-Based Fire Mitigation Features

Why these features are important

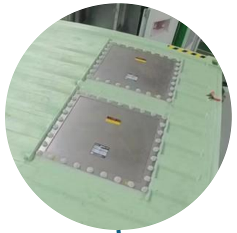
Working with dedicated flammable gas detection system

Active ventilation vents

Electric inlet louver

Provide air circulation of 9 air changes per hour

Deflagration panels



Water sprinkler system with flow rate 12.2mm/min

Direct water injection inlet to allow for water immersion

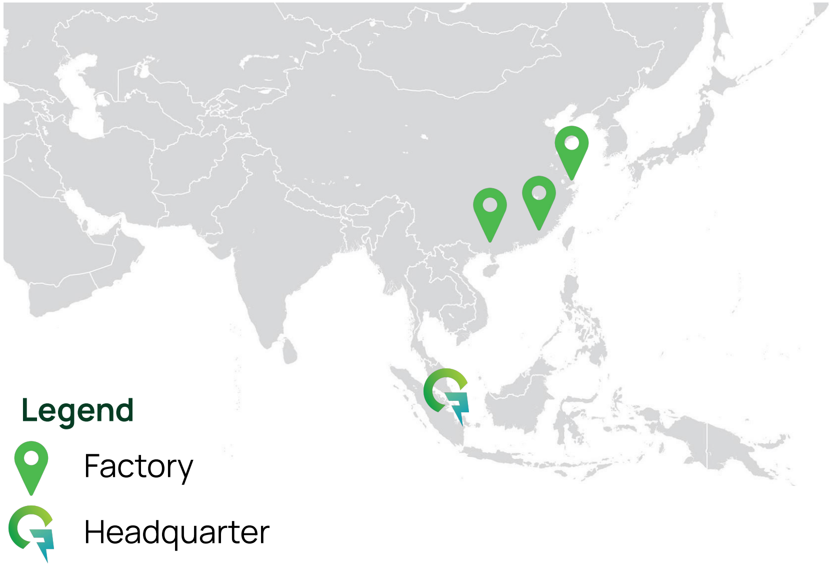
Fire resistant wall (2 hrs in accordance to BS EN 476-4 / 20 / 21)

Food for thought

If my BESS is fully compliant to all these safety features as you have listed;
Can I deploy this BESS within my electrical room?

Safety & Precision Built from Within

Rooted in advanced BESS container engineering, backed by our own factories



🏭 Why It Matters:

Operates a **fully owned and dedicated manufacturing facility**

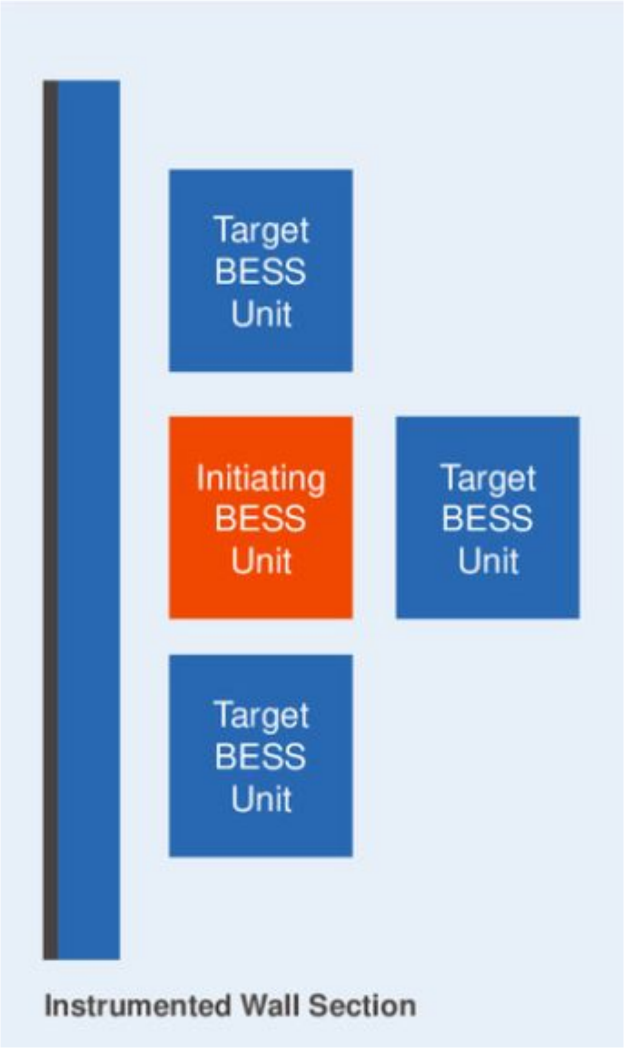
Maintains **end-to-end control** over the entire production process

Offers **customized fabrication** to meet **precise technical specifications**

Delivers **consistent quality** with quicker turnaround times

Gap identified in current testing standards

- UL9540A is traditionally used as the main standard in evaluating thermal runaway fire propagation.
- Cell to cell propagation may occur, but cell gases may not ignite causing a result of “no fire condition” achieved.
- Might not capture fire conditions that might be caused by external ignition sources such as cabling / connectors / HVAC/ weather.
- This may not simulate real life fire conditions leaving uncertainty about how a fire may spread in large scale ESS installations.
- Thus, another testing standard for large scale fire testing is developed and this is where the hardware based fire mitigation measures play an important role!



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"Risk is where the battery begins. Resilience is where the future is stored."

— Deloitte. (2025, February 11). *Risk and resilience*

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For more information

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