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BATTERY
ENERGY
STORAGE SYSTEM

Utility-Scale BESS: Health and Safety Standards

Applicable standards • Thermal Runaway prevention • Cyber-physical security considerations

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Global Energy Alliance
for people and planet

CESI
Inspired with innovation



INTEGRATION
environment & energy

Agenda

1 Application Standards

2 Thermal Runaway (prevention)

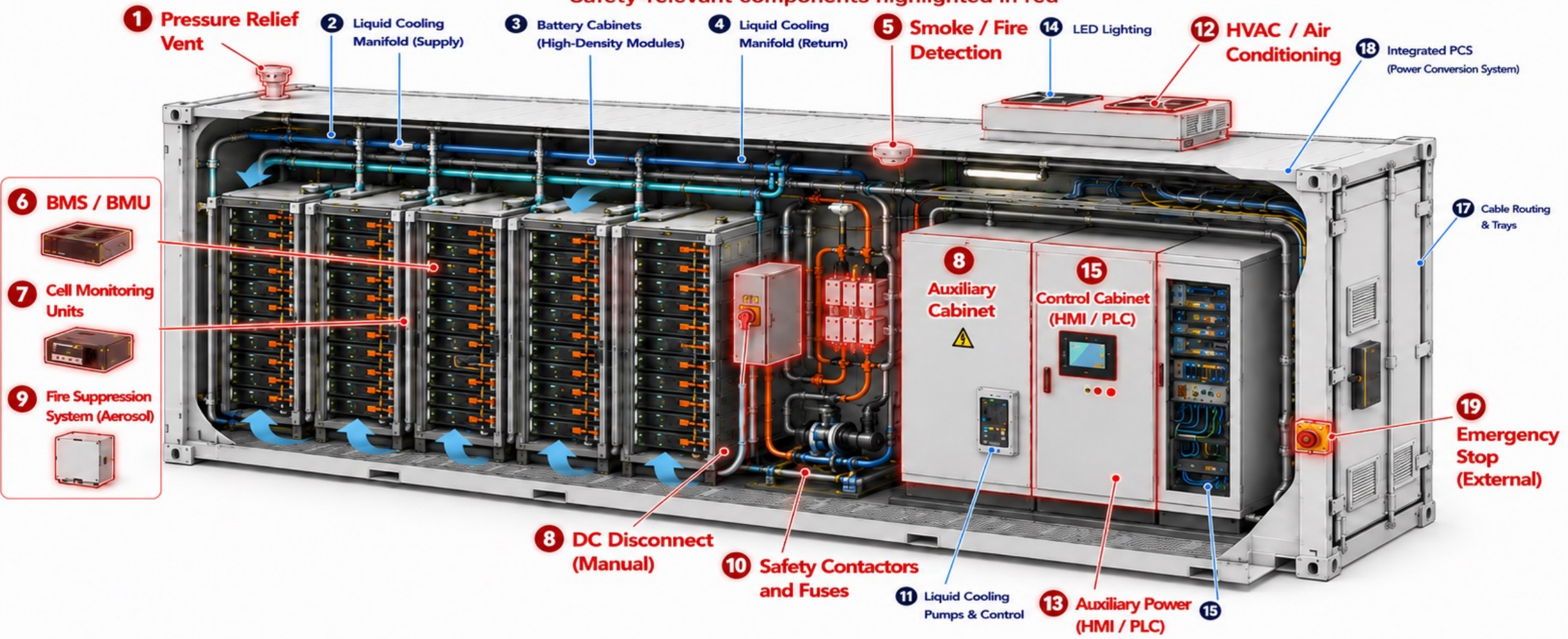
3 Cyber-physical security considerations

4 Takeaways

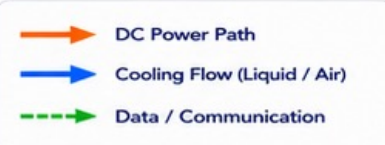
Utility-scale BESS | Circular
Economy & Safety Standards

BESS Container, Type B, High-Density Integrated System

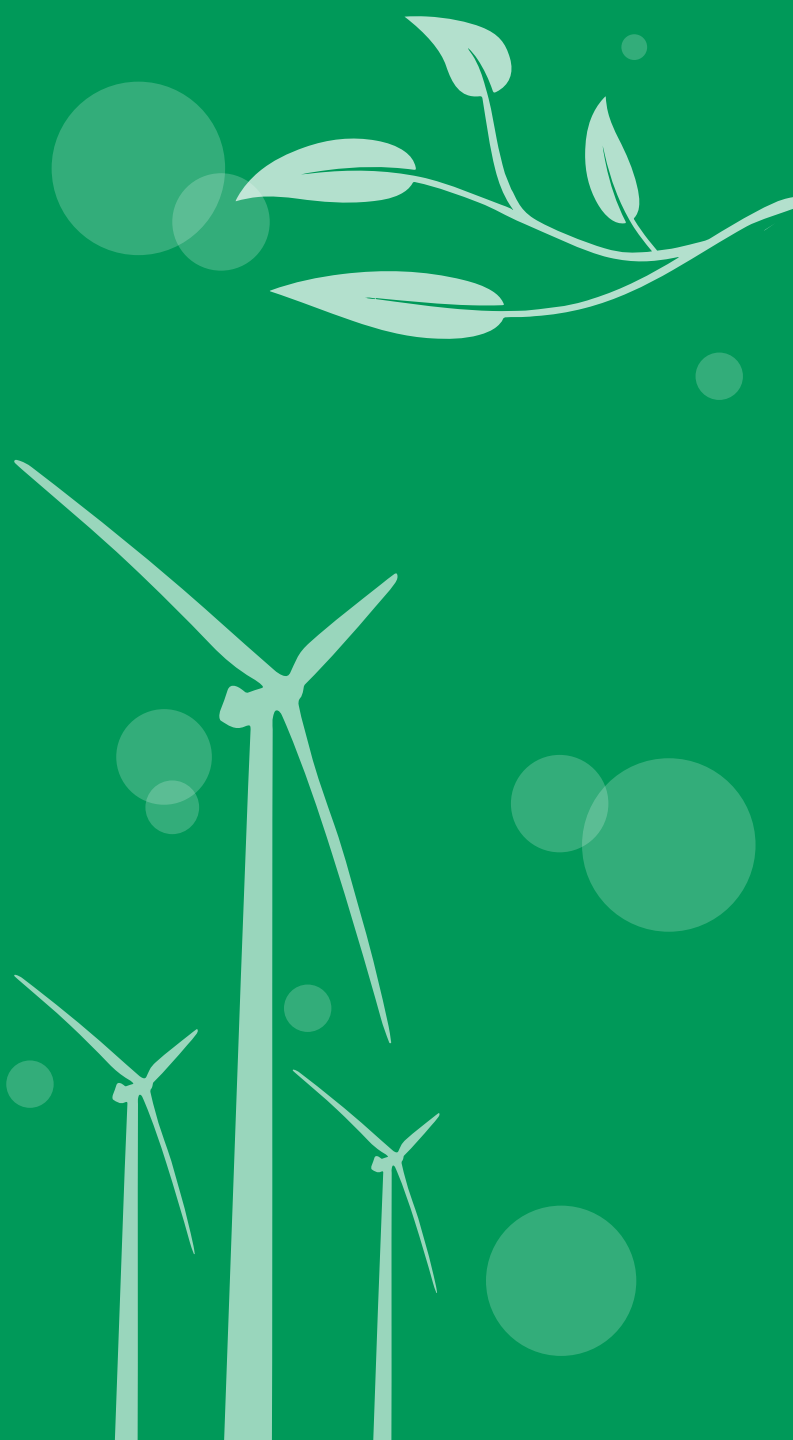
Safety-relevant components highlighted in red



- | | | | |
|--|---|--|--|
| <ul style="list-style-type: none"> 1 Pressure Relief Vent 2 Liquid Cooling Manifold (Supply) 3 Battery Cabinets (High-Density Modules) 4 Liquid Cooling Manifold (Return) 5 Smoke / Fire Detection 6 BMS / BMU | <ul style="list-style-type: none"> 7 Cell Monitoring Units 8 DC Disconnect (Manual) 9 Fire Suppression System (Aerosol) 10 Safety Contactors and Fuses 11 Liquid Cooling Pumps & Control 12 HVAC / Air Conditioning | <ul style="list-style-type: none"> 13 Auxiliary Power Supply (AC/DC) 14 LED Lighting 15 Control Cabinet (HMI / PLC) 16 Communications Cabinet 17 Cable Routing & Trays 18 Integrated PCS (Power Conversion System) | <ul style="list-style-type: none"> 19 Emergency Stop (External) |
|--|---|--|--|

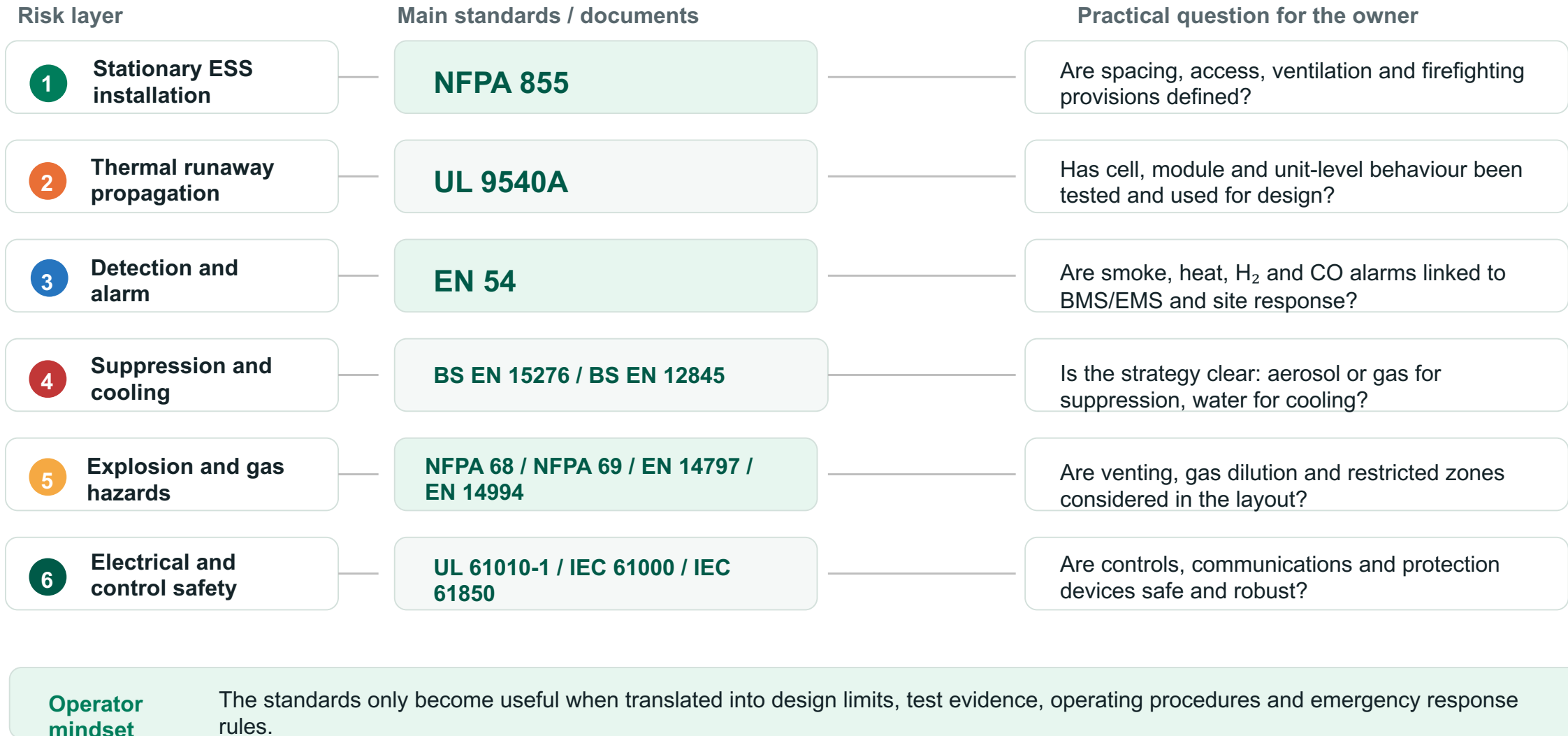


1) Application Standards



Standards map: each standard covers a different risk

Use standards as a structured safety argument, not as a checklist of certificates.



NFPA 855

Standard for the Installation of Stationary Energy Storage Systems

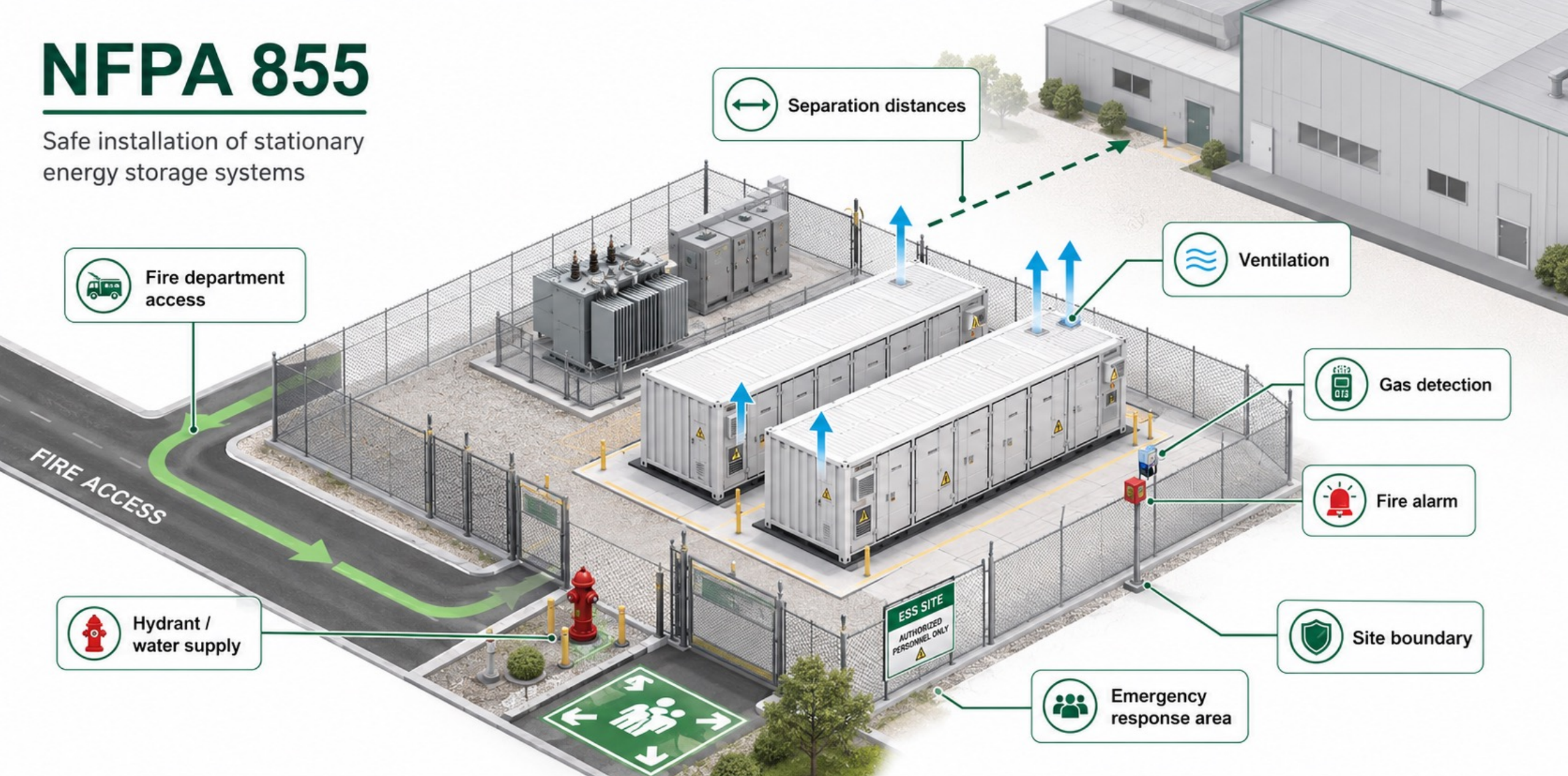
It defines how a stationary BESS must be safely installed on site

NFPA means	National Fire Protection Association.
What it is	A fire and life-safety standard for stationary energy storage systems.
What it is for	Site layout, spacing, access, ventilation, fire protection and emergency response.
Who made it	NFPA, through its Technical Committee on Energy Storage Systems.
Where applied	Where referenced by codes, authorities, insurers or project requirements.
Since when	Developed from 2016, first edition 2020. Current edition 2026.

Simple takeaway: NFPA 855 is not a battery certificate, it is the site safety standard.

NFPA 855

Safe installation of stationary energy storage systems



↔ Separation distances

🚒 Fire department access

🌊 Ventilation

📡 Gas detection

🚨 Fire alarm

🚒 Hydrant / water supply

🛡️ Site boundary

👥 Emergency response area

✅ Defines the safe installation envelope so one battery event does not become a site emergency.

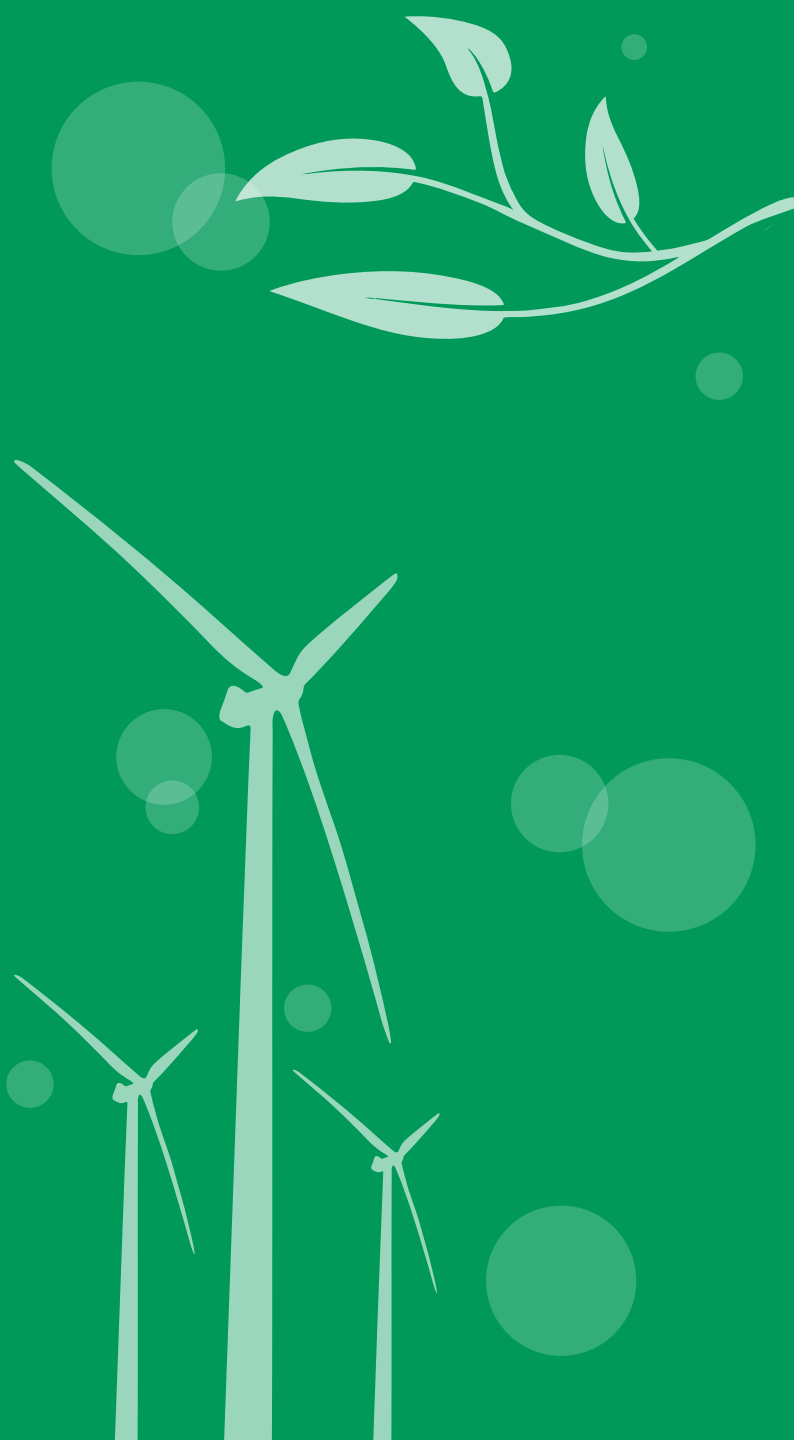


Key Takeaways

Standard/Norms

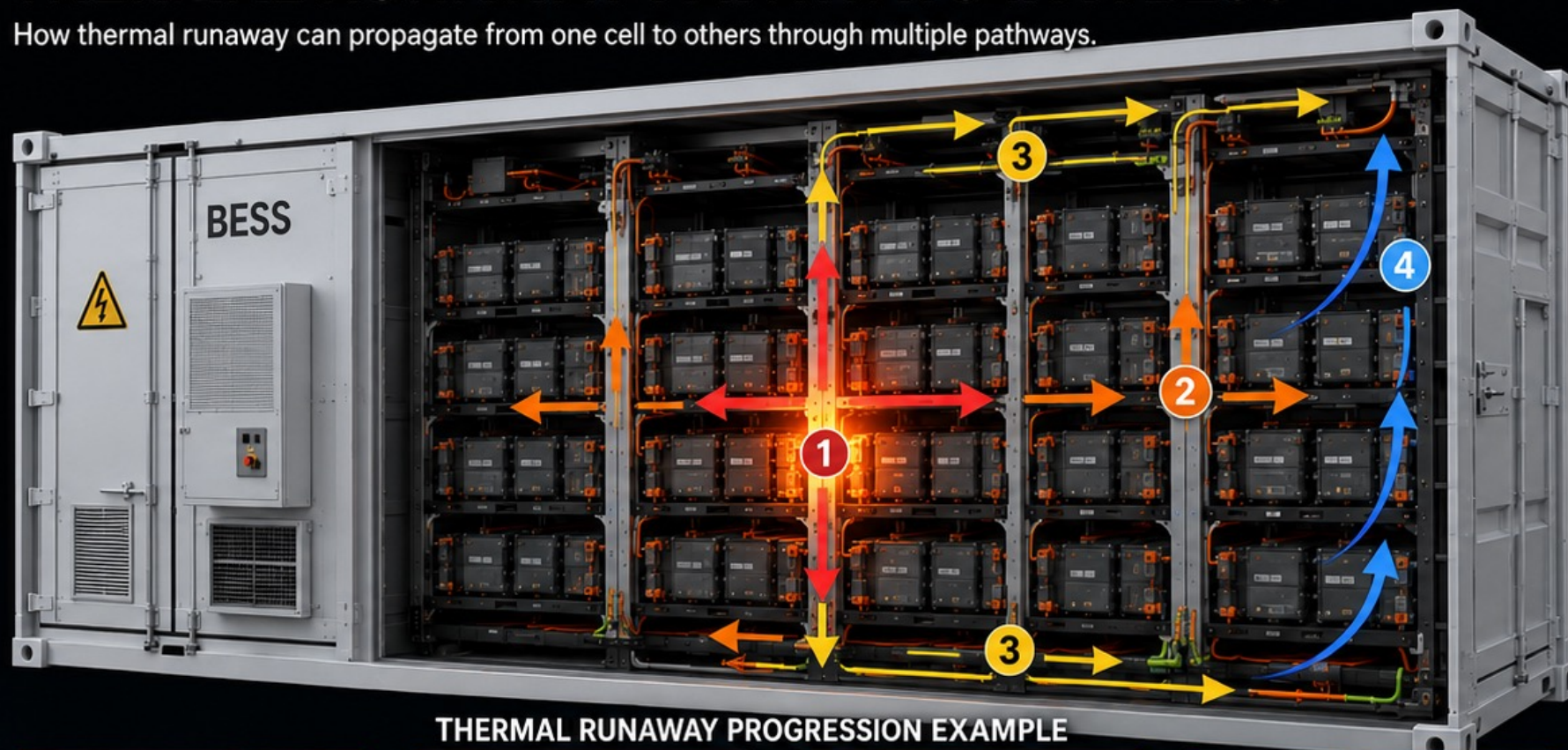
- **Standards define the safety framework, not only certificates.**
They translate BESS risks into design, testing, installation and operation requirements.
- **No single standard covers the full BESS risk profile.**
A safe project needs a combination of installation, fire, electrical, control, communication and emergency-response standards.
- **The most important point is practical implementation.**
Standards must become layout rules, equipment requirements, test evidence, operating procedures and emergency plans.
- **Owner requirements should be clear before procurement.**
The tender should define which standards are mandatory, which test reports are required and how compliance will be verified.

2) Thermal Runaway (prevention)



THERMAL RUNAWAY PATHWAYS IN A BESS

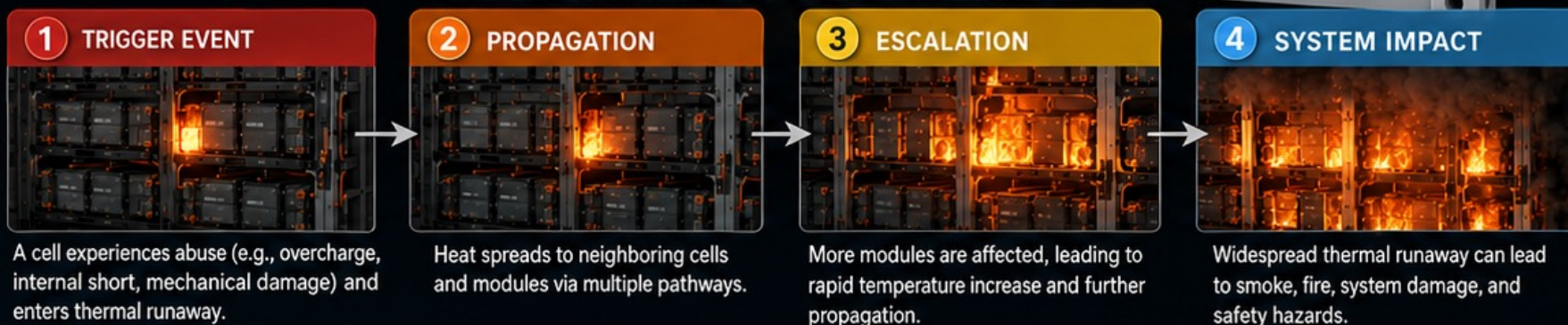
How thermal runaway can propagate from one cell to others through multiple pathways.



THERMAL RUNAWAY PATHWAYS

- 1 Cell to cell**
Direct heat transfer to adjacent cells
- 2 Module to module**
Heat transfer through module structures or proximity
- 3 Through busbars and cables**
Heat conducted through conductors
- 4 Via airflow (convection)**
Hot gases transfer heat to other cells or modules

THERMAL RUNAWAY PROGRESSION EXAMPLE



RISK MITIGATION MEASURES

- Thermal management (cooling, insulation)
- Physical separation between modules
- Airflow design optimization
- Early detection (sensors, monitoring)
- Fire suppression systems



Thermal runaway in a BESS can propagate through multiple pathways simultaneously. Understanding these pathways is critical for safe design and effective risk mitigation.

NORMAL OPERATION

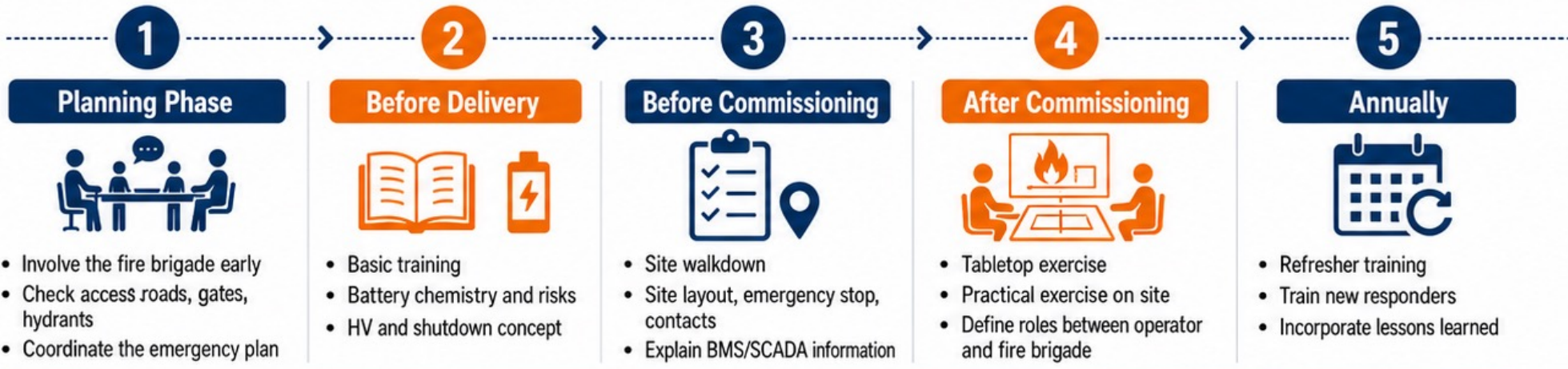
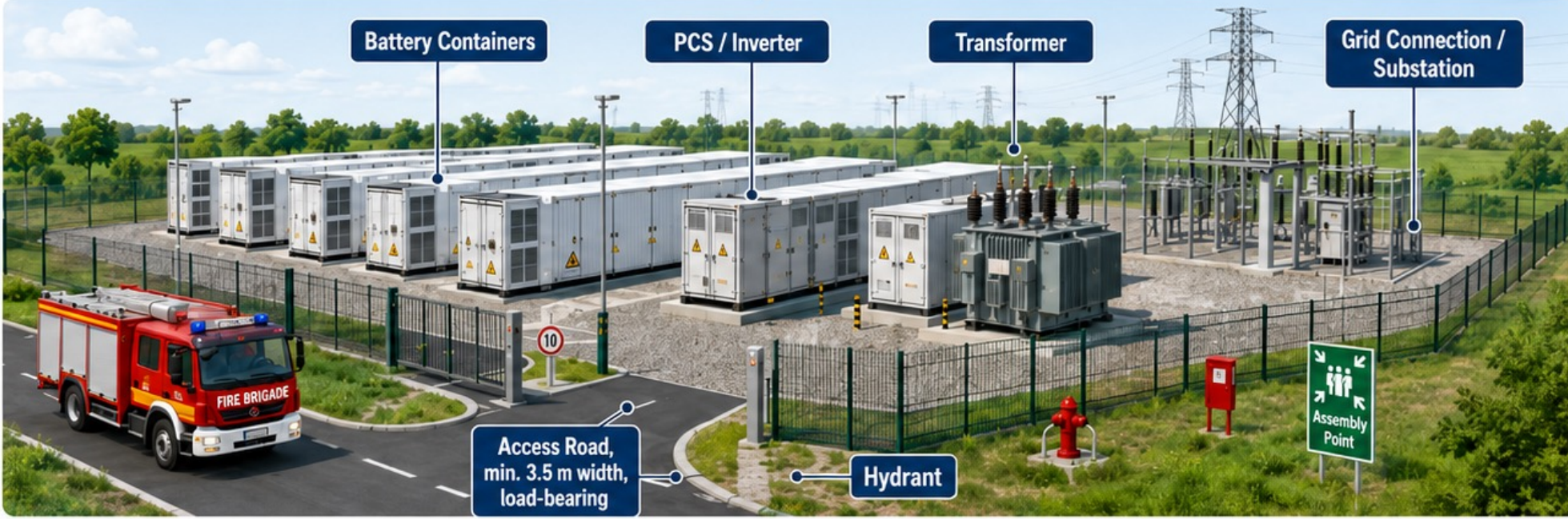
THERMAL RUNAWAY

NORMAL OPERATION

NORMAL OPERATION



Preparation of the Local Fire Brigade for a Grid-Scale BESS



What the Fire Brigade Must Receive in Advance

- Site Layout Plan
- Emergency Response Plan
- Safety Data Sheets
- Shutdown Points
- 24/7-Contact Chain
- Fire Water and Access Concept

Goal: Rapid situation assessment, safe decisions, and effective measures during a BESS incident.

Thermal Runaway in a Grid-Scale BESS, what is used to extinguish it?

Yes, for the fire brigade, water is generally the extinguishing agent of choice, primarily for cooling, containment, and preventing spread.

WHAT WATER DOES



- 1 Cools the container and lowers the temperature



- 2 Can prevent or delay thermal runaway in adjacent modules/containers



- 3 Prevents fire spread to adjacent equipment



- 4 Protects emergency responders and the surroundings



- 5 Used for prolonged cooling and monitoring



WHAT IS NOT THE MAIN SOLUTION



- 1 CO₂, dry powder, or foam usually do not reliably stop the cell reaction inside



- 2 Do not open the container in an uncontrolled manner



- 3 Do not treat it like a normal building fire



- 4 Work only with the operator/OEM and BMS data



- 5 Continue monitoring re-ignition and fire water



Key message:

For grid-scale lithium-ion BESS, water is usually used as the extinguishing agent of choice, primarily for cooling and containment, not because the internal cell reaction can simply be 'smothered' immediately.



Water,
standard tactic



CO₂,
only limited effectiveness

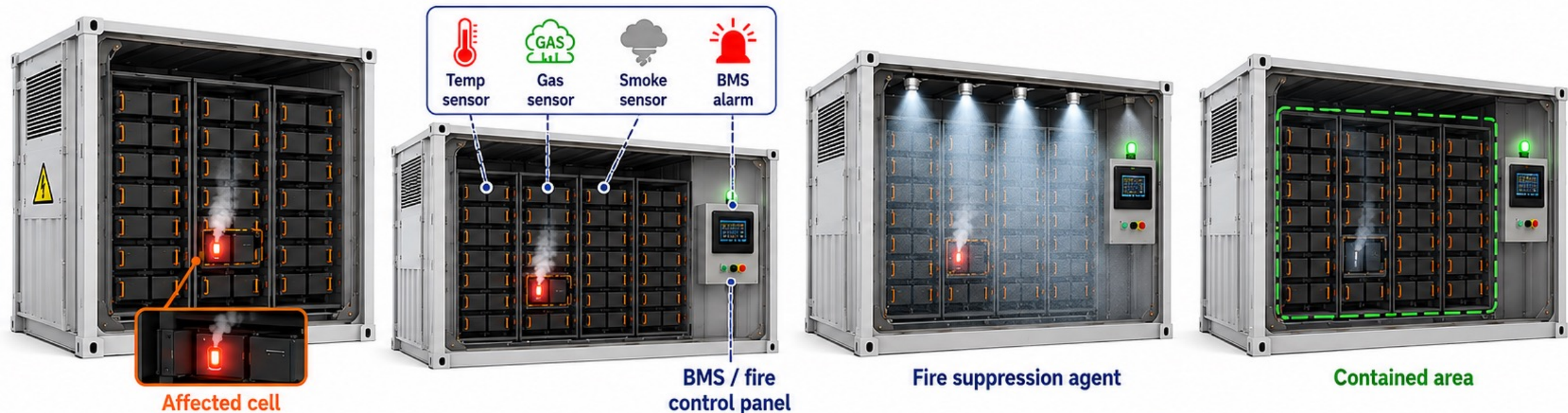


Foam/dry powder,
not the main strategy

Early Cell Thermal Runaway Detection and Fire Suppression

How a small battery event is detected and contained

- 1 Abnormal cell**
One cell overheats
- 2 Detection**
Sensors and BMS alarm
- 3 Fire suppression**
Nozzles discharge agent
- 4 Containment**
Event stays localized



What is fire suppression?

Automatic system releasing suppressant inside the enclosure.



How does it work?

Sensors trigger the control system and activate suppression.



Important note

Containment helps, but cooling and monitoring may still be needed.



Detect early



Suppress immediately



Contain locally



Key Takeaways

Thermal Runaway

- **Thermal runaway cannot be fully excluded, but it can be controlled**

The design target is early detection, isolation, cooling and prevention of propagation.

- **Fire suppression alone is not enough**

Aerosol or gas systems can suppress flames, but water access and cooling strategy are needed to manage heat and prevent re-ignition.

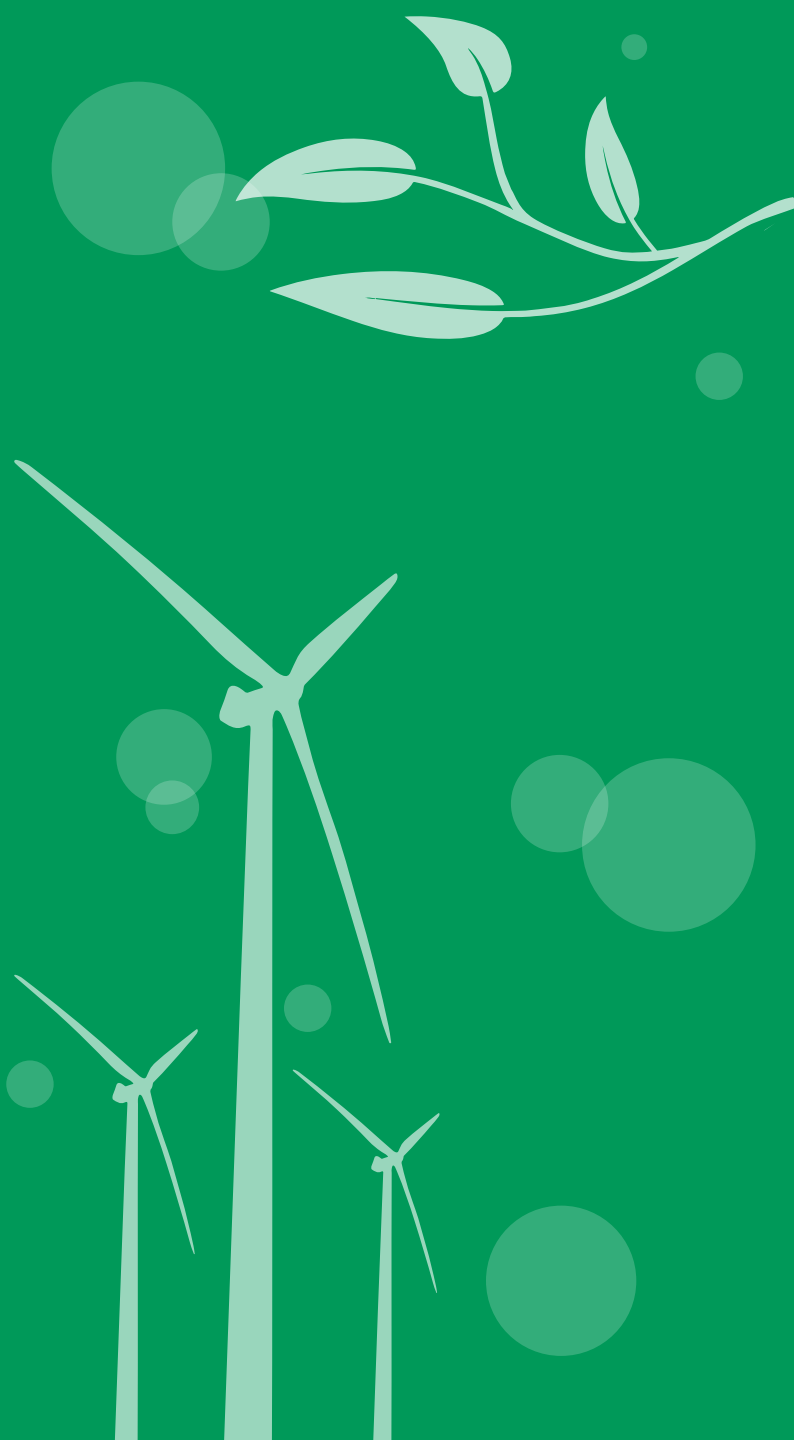
- **Detection must happen before visible fire**

Smoke, heat, gas, cell voltage and temperature monitoring should trigger alarms and automatic safety actions.

- **Emergency response must be planned before operation**

Local fire brigades need site information, access routes, isolation points, safe distances and training for BESS-specific incidents.

2) Cyber-physical security considerations



Cyber-physical security considerations for grid-scale BESS



CYBER THREATS



Unauthorized remote access



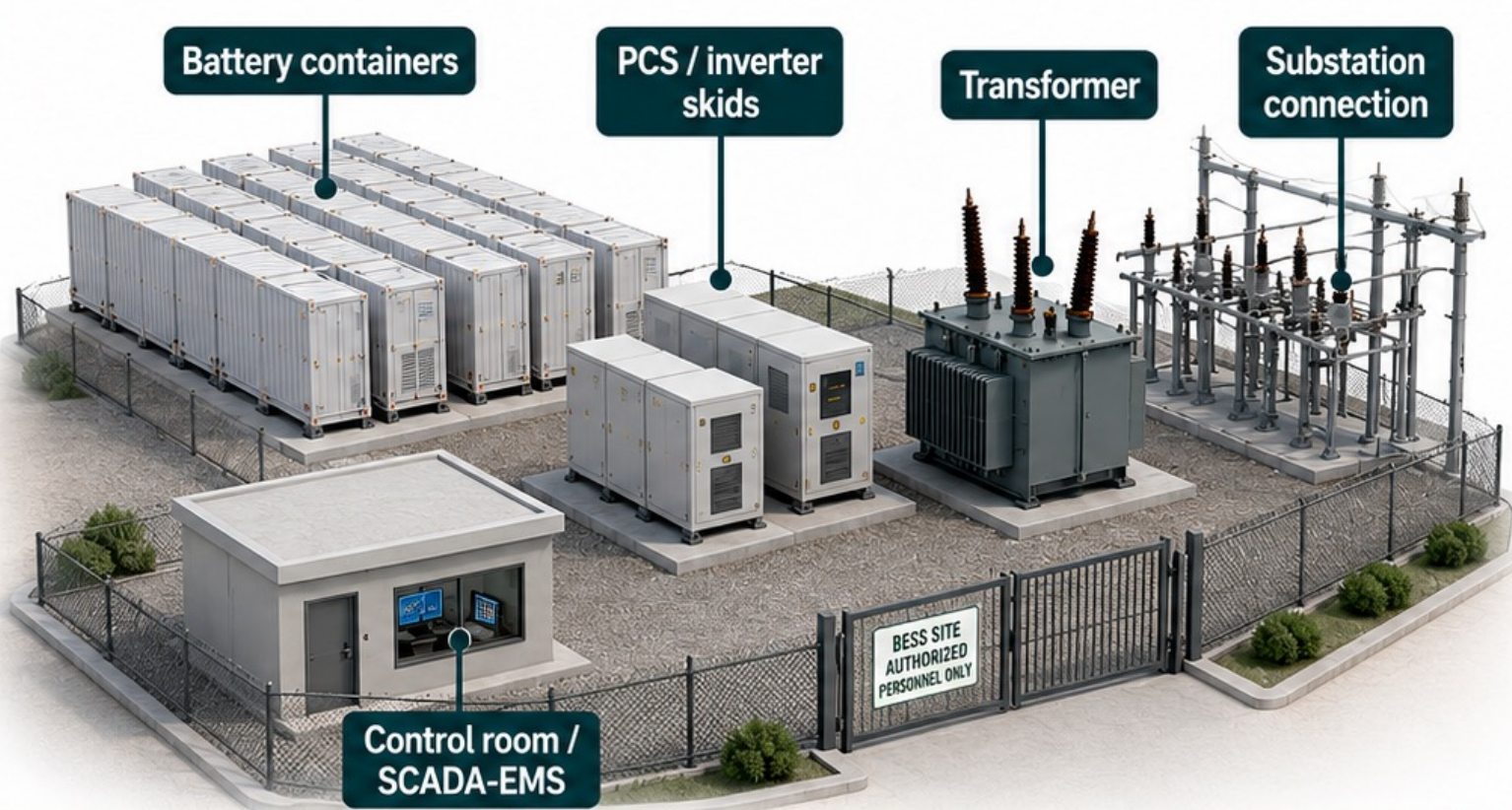
Malware / ransomware



Manipulated SCADA / EMS commands



Network intrusion



PHYSICAL THREATS



Unauthorized entry / tampering



Theft / sabotage



Fire / overheating risk



Insider threat



KEY PROTECTIONS



Network segmentation



Secure remote access



Role-based access control



Logging and monitoring



Independent safety interlocks



Fire detection and suppression



CCTV and perimeter fence



Incident response plan



POTENTIAL IMPACTS



Equipment damage



Safety incident



Grid instability



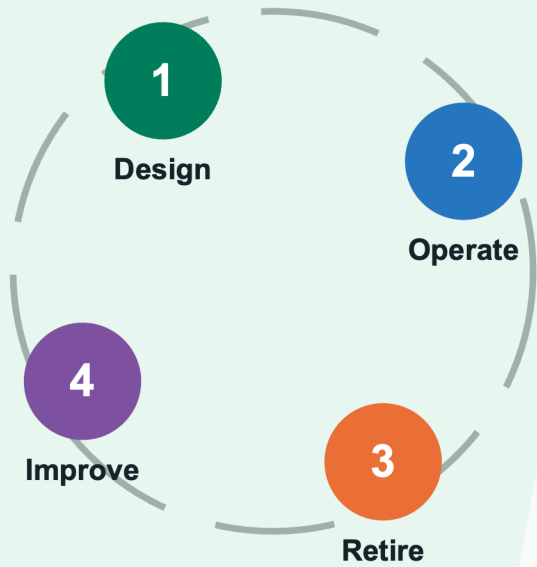
Loss of availability / revenue



Key Takeaways

Cyber-physical security considerations

- **A BESS is both an energy asset and a digital control system**
Cyber incidents can create physical consequences, including unsafe dispatch, loss of control or incorrect protection actions.
- **The most critical interfaces are EMS, BMS, PCS, SCADA and remote access**
These systems must be protected with access control, secure communication, logging and clear responsibility
- **Cybersecurity must be linked to functional safety**
The system should fail safely if communication is lost, commands are invalid or control signals are manipulated
- **Security is an operational process, not a one-time design item**
Patch management, user rights, monitoring, incident response and supplier access rules must be maintained during the full BESS lifetime.



Thank you

Questions & discussion

Utility-scale BESS: Circular Economy & Health and Safety Standards

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Closing thought

A safe BESS project is not only built well - it is operated, monitored and retired well.