Parc Ynni Calon y Gwynt

ENVIRONMENTAL STATEMENT

Appendix 4A: Outline Battery Safety Management Plan

62282400_APP4A_003
JULY 2026

PUBLIC

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1 INTRODUCTION

1.1 BACKGROUND

1.1.1 WSP UK Ltd (the Consultant) has been appointed by Parc Ynni Calon y Gwnt Cyf (the Client), a joint venture between Wind2 Ltd and companies managed by Octopus Energy Generation, to prepare an outline Battery Fire Safety Management Plan (BFSMP) for the Battery Energy Storage Site (BESS) element of this project. As part of preparation of the BFSMP, the Client will consider the latest guidance, policy and good practices for battery fire detection and prevention, along with the Emergency Response Plan (ERP) and Risk Management Plan (RMP), as guidance continues to develop in the UK and globally.

1.1.2 This document provides a summary of the fire safety related information requirements which would be provided in advance of construction of the BESS. The purpose of this outline BFSMP is to identify how the Client would use good industry practice to reduce risk to life, property, and the environment from the BESS facility.

1.1.3 An indicative layout of the BESS compound has been provided for the purpose of this document, developed by WSP and can be seen in and as such WSP have developed this BFSMP around the Sungrow PowerTitan 2.0 BESS container, a lithium-ion based battery chemistry. The ultimate decision regarding the selection of BESS suppliers or integrators will be made by the Client.

1.2 APPROACH

1.2.1 The goal of the BFSMP is to prevent fire events from occurring and introducing mitigations to reduce the risk of propagation in the event of a fire to minimise damage to people and property. The BFSMP covers the following key areas:

1.2.2 Organisation - overview of the organisation including roles and responsibilities.

1.2.3 Fire Safety Arrangements for the Site, including:

- Risk Assessment - comprehensive risk assessment covering both common and critical failure modes experienced by the BESS and PCS/ transformer skid. The risk assessment includes prevention measures and mitigations that must be implemented throughout the pre-construction, construction, and operational phases of the project.
- Recommendations List - the recommendations list contains technical guidance from international standards, independent insurers and known best practice to enhance the design of the facility to mitigate fire risk as far as reasonably possible.

1.2.4 Monitoring - evacuation drills, checks, maintenance and testing, record keeping.

1.2.5 Audit and Review - review schedule, audit trail requirements and response to changes.

1.2.6 BFSMPs do not usually include:

- Specific Personal Emergency Evacuation Plans (PEEPs).
- Emergency Response Plan (ERP).
- Fire training syllabus.
- Design details.
- Operating instructions for systems/ equipment.

2 ORGANISATION

2.1 ROLES AND RESPONSIBILITIES

2.1.1 The table below sets out the recommended fire safety roles and responsibilities relevant to the management structure.

Table 4A-1 - Roles and Responsibilities

Role	Summary of Responsibilities
Board/ Directors	▪ Ensure that the fire safety policies/ codes of practice that complement this management plan are in place, properly implemented and reviewed. ▪ Ensure that qualified people are appointed to oversee and implement fire safety arrangements and ensure that they are competent and appropriately trained to undertake their duties. ▪ Ensure that arrangements are in place for the completion of Fire Risk Assessments and Fire Risk Assessment reviews, including, where appropriate, technical surveys in respect of fire protection. ▪ Ensure that fire, security, and health and safety arrangements at the premises are complementary. ▪ Ensure that the plant has adequate insurance coverage.
Fire Safety Manager	▪ Ensure that Fire Risk Assessments and reviews are carried out when required. ▪ Ensure that fire safety systems and equipment are appropriately located and properly maintained. ▪ Ensure that a robust and effective Emergency Response Plan is in place to safely evacuate all persons, whether employees, visitors etc. This emergency plan must consider people with mobility, sensory and learning impairments, including those with temporary impairments. ▪ Arrange for the Fire Emergency Plan to be issued to the employees, visitors etc. to inform them what to do in the event of fire, particularly safe evacuation. ▪ Ensure that staff are appropriately trained in fire safety procedures to reflect the requirements of the Fire Risk Assessment. ▪ Ensure that a copy of the current Fire Risk Assessment for the premises is readily accessible, and its contents are complied with. ▪ Ensure that fire risk assessments are reviewed at appropriate intervals. ▪ Ensure that effective arrangements are in place for contacting the emergency services. ▪ Ensure that the Fire and Rescue Service are aware of any significant hazards associated with the premises e.g., ethanol and any other dangerous substances.

Role	Summary of Responsibilities
Competent/ Designated Persons	▪ Assist and support with the preparation and review (at least annually) of Fire Risk Assessments. ▪ Ensure compliance with the outcomes of the Fire Risk Assessment and that the necessary control measures are implemented. ▪ Prepare and review the Fire Emergency Plan and ensure it is issued to all staff. ▪ Ensure information on fire safety arrangements is available to staff. ▪ Ensure all staff, visitors etc are inducted on the contents of the Fire Emergency Plan. ▪ Arrange and review fire drills at a suitable frequency. ▪ Specify the arrangements for assisting visitors, disabled people or those with temporary physical impairments to safely evacuate the premises. Where appropriate, a PEEP must be developed. ▪ Ensure Fire Alarms are tested in accordance with the testing and maintenance schedule. ▪ Monitor that all fire safety equipment and systems are appropriately and regularly maintained. ▪ Ensure the Fire Safety Logbook is kept up to date. ▪ Ensure that Fire Action Notices and fire signage are appropriate and kept up to date. ▪ Ensure all escape routes are kept clear of obstructions and that access to fire extinguishers and fire alarms is not impeded. ▪ Ensure that all relevant fire prevention procedures are put into effect. ▪ Ensure that fire safety inspections of the premises are carried out. ▪ Ensure local fire related safety policies including no-smoking.
Employees	▪ Ensure familiarity with the Fire Emergency Plan for the premises and co–operate by participating in fire evacuation/ drill procedures and by observing practical fire safety arrangements. ▪ Fully conversant with Site strategy and steps to be taken during any events related to fire. ▪ Know, and co-operate with, the fire safety manager(s) for the premises. ▪ Report to a relevant manager any concerns about fire safety ▪ Be familiar with all escape routes. ▪ Take care to not wedge fire doors open, nor block or obstruct them.

Role	Summary of Responsibilities
	▪ Be aware of the action to be taken on discovering a fire, hearing a fire alarm, for raising the alarm (including the location of fire alarm call points) and for calling the Fire and Rescue Service. ▪ Promptly evacuate the premises, in accordance with the Fire Emergency Plan, to a place of safety without putting themselves and others at risk, and NOT attempt to extinguish a fire unless they have been specifically trained. ▪ Comply with the No Smoking policy in place.

2.1.2 In the absence of the primary designated person, a deputy will be nominated to perform essential functions.

2.2 COMPETENCE AND AUTHORITY

2.2.1 All individuals assigned roles and responsibilities under the BFSMP shall be competent, with competence demonstrated through appropriate knowledge, training, and experience.

2.2.2 Individuals with designated responsibilities will be granted the necessary authority to make decisions and undertake actions commensurate with their roles.

2.3 COMMUNICATION BETWEEN STAKEHOLDERS

2.3.1 Appropriate communication methods will be established to ensure the effective sharing and exchange of fire safety information.

2.3.2 The key areas for communication are outlined in **Table 4A-2** below:

Table 4A-2 - Key Communications

Subject	Method/ Procedure
▪ Dissemination of information about fire hazards	▪ Safety briefings and meetings. ▪ Exchange of documents.
Fire prevention arrangements	Included within staff training and refresher meetings.
Emergency fire response procedure	Included with staff training and refresher meetings.
Reporting system for concerns or deficiencies in fire safety matters	e.g., verbal, submit hard-copy form, e-form via app.
Liaison with local Fire & Rescue Service	Familiarity visits.
Informing relevant parties on the stakeholder management plan	Communication via phone, email and meetings.

2.3.3 Clear and effective communication among all relevant parties during the construction phase is essential to ensure Site fire safety.

2.3.4 **Table 4A-3** below provides guidance on the principal coordination requirements between the Client, the BESS Supplier, the Engineering, Procurement, and Construction (EPC) or Civil Contractor, the Independent Connection Provider (ICP) Contractor, and other Site Personnel.

Table 4A-3 - Project Development Cycle Communication Requirements

Subject	Key Summary	Notes
Significant Fire Hazards	The Client will be responsible for ensuring the correct information flow between the relevant parties regarding significant fire hazards, their locations, quantities and any key precautions to be taken.	Precautions covered within Section 3.1
Communications	Agree process for communicating: ▪ Warning of fire. ▪ Other fire-related alerts. ▪ Changes in fire hazards ▪ Reports of fire concerns affecting other party's area.	Other alerts may include investigating potential concerns (e.g. smell of smoke). Meetings (routine or *ad-hoc*) may be arranged.
Emergency Response	Agreements on: ▪ Designated escape routes. ▪ Shared escape routes. ▪ Assembly points. ▪ Meeting fire crews attending. ▪ Step by step guide for evaluating any potential BESS facility fires. ▪ Post-incident de-brief/ remediation.	
First Aid	Provide information on first aid provisions on Site, nearest hospitals and emergency contact details.	

3 FIRE RISK MANAGEMENT PLAN

3.1 RISK ASSESSMENT

3.1.1 The EPC contractor retains control of the fire safety design until handover to the Client. The EPC contractor will be responsible for integrating the Site wide fire protection and suppression strategy.

The following risk matrix considers the probability and the impact of the potential failure modes, any prevention/mitigations measure that could reduce the probability and the severity of the potential failures.

Table 4A-4 - Risk Assessment Scoring Matrix

			Probability (P)				
		Severity Description	1	2	3	4	5
			(Remote)	(Unlikely)	(Possible)	(Probable)	(Almost Certain)
Severity (S)	5 - Catastrophic	Risk of death, explosion, complete loss of facility, catastrophic environmental damage	HIGH	CRITICAL	CRITICAL	CRITICAL	CRITICAL
	4 - Major	Life changing injury, extensive damage to facility, significant environmental damage	HIGH	HIGH	CRITICAL	CRITICAL	CRITICAL
	3 - Moderate	Significant non-life changing injury, significant damage to facility, minor environmental damage	MEDIUM	MEDIUM	HIGH	HIGH	CRITICAL
	2 - Minor	Minor injury, minor damage to facility	LOW	LOW	MEDIUM	HIGH	HIGH
	1 - Inconvenience	No risk of injury, no damage to facility and no environmental damage	LOW	LOW	LOW	MEDIUM	MEDIUM

Table 4A-5 - Site Risk Assessment Matrix

No.	Component	Hazard	Cause of Hazard	Consequence	Initial Risk Assessment			Prevention/ Mitigation Strategy	Residual Risk Assessment			Further Comments
					S	P	Risk		S	P	Risk	
1	Battery	Battery fire	Transportation	▪ Personnel injury. ▪ Physical damage to battery. ▪ Toxic chemicals leak. ▪ Explosion.	3	3	High	Lithium batteries are required to pass Section 38.3 of the UN Manual of Tests and Criteria (UN Transportation Testing). The provision of a UN 38.3 or UN transportation testing report is required for transportation. UN 38.3 requires several tests to prove the battery design is safe for transportation including thermal, vibration, shock, short circuit, and impact testing. The chosen technology has certification to UN 38.3 to prove the design is safe for transportation.	2	3	Medium	Certification of UN 38.3 to be requested from OEM.
2	Natural Hazard	Water damage	Flooding	▪ Water damage to BESS equipment/ submerged Site.	3	2	Medium	A Flood Consequence Assessment (FCA) has been completed for the Site (Appendix 9A of the ES), the location of the BESS has been situated in a low flood risk area. Safe access and egress to the Site is likely to be available during extreme flood events. An outline drainage strategy has been produced and has been incorporated into the FCA (Appendix 9A of the ES). This provides specific information in relation to the management of surface water drainage on the Site. All major assets such as BESS containers, PCS, transformers and substations shall be installed on concrete slabs or plinths raised off the ground to further protect the facility.	1	2	Low	Flooding events more common due to climate change. Prevention strategy decreases the effects of this, but maintenance of drainage works throughout year will decrease residual risk of water damage.
3	Battery	Thermal Hazard	Battery Cell/ Module Over/ Under Temperature	▪ Injuries to personnel (burns, smoke, and chemical inhalation). ▪ Damage to battery cell and BESS container.	3	3	High	The BESS containers are liquid cooled using a heat exchanger, expansion vessel, pump and associated small bore pipe work to infer heat transfer from the battery cells. The battery cells will have a target temperature which is pre-programmed by the OEM in the Battery Management System (BMS) which communicates with the Industrial Personal Computer (IPC) or package controller within the control panel. This then drives the cooling system to act to maintain an optimum ambient temperature to maintain the pre-programmed operating environment. Where the cooling system develops a fault, alarms will immediately be sent via the BESS Supervisory Control And Data Acquisition (SCADA) system to the operators/ control room. The BESS container will automatically be prevented from charging/ discharging, to allow the operators time to rectify the fault. Continuous preventative maintenance as advised by the OEM.	2	2	Low	
4	Battery	Thermal hazard	Fire Detection System Failure	▪ Injuries to personnel (burns, smoke, and chemical inhalation). ▪ Damage to battery cell and surrounding	4	3	Critical	The BESS containers are fitted with 4 x smoke detectors, 2 x heat detectors and 1 x flammable gas detector. The heat detectors and two of the smoke detectors are evenly set in the BESS container, one smoke detector is set in the middle of the top of the integration cabinet, and one smoke detector is located in the middle of the PCS compartment, preventing redundancy as they are not connected on the same line.	3	2	Medium	BESS supplier to provide specification and datasheet to the Client evidencing the detection system and what occurs if it fails.

No.	Component	Hazard	Cause of Hazard	Consequence	Initial Risk Assessment			Prevention/ Mitigation Strategy	Residual Risk Assessment			Further Comments
					S	P	Risk		S	P	Risk	
				BESS infrastructure.				When one of the smoke/ heat detectors are triggered, it is raised as a first level alarm through the fire alarm control panel (FACP) and activates an external sound beacon. When both smoke and heat detectors are triggered simultaneously, it is raised as a second level alarm through the FACP and the external alarm bell will be activated. In the rare event of a complete fire detection system failure, the initial communication loss or any continuous rise in temperature or electrical fault would be detected by the BMS and error messages communicated to the SCADA for operator rectification. Maintenance of the fire detection system is critical to ensure operation, at regular intervals as dictated by the OEM, the operator will conduct checks on the full detection system using simulated smoke and heat to ensure correct operation of the fire detection panel and the automatic engagement of the fire suppression system.				
5	Battery	Thermal hazard	Fire Suppression System Failure	▪ Injuries to personnel (burns, smoke, and chemical inhalation). ▪ Damage to battery cell and surrounding BESS infrastructure.	4	3	Critical	Where the fire suppression system fails to activate when required, the emergency response plan for the Site should be followed. Upon the initial activation of the fire suppression system, the SCADA system will notify the operators to enable the emergency response plan and contact the Local Fire Rescue Service (FRS) for assistance. Note that as well as the FK 5-1-12 gas fire extinguishing system, there are two additional, optional fire suppression systems; aerosol gas fire extinguishing system and a water fire suppression system. If the optional water fire suppression system is selected by the Client and in the event of the base system smoke/ heat detectors failing, the water fire suppression system will activate fused sprinklers through heat sensitive components.	2	3	Medium	Please note that the Client determines the use of the optional fire suppression systems. In the event that water fire suppression system is incorporated into fire protection strategy; Contaminated firewater will need to be safely contained and stored on Site, before being removed.
6	Battery	Thermal hazard	Battery Cell/ Module Failure - Thermal Runaway	▪ Injuries to personnel (burns, smoke, and chemical inhalation). ▪ Damage to battery cell and surrounding BESS infrastructure.	5	2	High	The fire suppression system should activate upon thermal runaway being detected by the smoke and/ or heat detectors. When activated, the released clean agent FK 5-1-12 will extract heat from the BESS and cool the system down in an attempt to extinguish the fire. Nearby water hydrants will be provided by the Client to cool down the exterior of the BESS enclosure, preventing propagation to BESS containers in close proximity. The battery modules and enclosures selected during the tender process are all proven to UL 9540A[1]. UL 9540A[1] standard subjects the battery modules and enclosure to large scale fire testing. Batteries are forced into thermal runaway, held for a period of time and then proven to not propagate from battery to battery and enclosure to enclosure respectively.	3	2	Medium	The EPC/ BESS integrator should provide a detailed methodology of the purpose of the fire detection and suppression system, with particular emphasis on the disconnection of the BESS, interlocking of the container and liquid cooling systems. Local FRS to be engaged with the emergency plan in the event of thermal runaway. First responders to be advised of procedure to follow.

[1] UL 9540A - Battery Energy Storage System (ESS) Test Method.

No.	Component	Hazard	Cause of Hazard	Consequence	Initial Risk Assessment			Prevention/ Mitigation Strategy	Residual Risk Assessment			Further Comments
					S	P	Risk		S	P	Risk	
7	Battery	Explosion	Battery Cell/ Module Failure - Thermal Runaway. Cascading failure/ thermal effects from adjacent battery cells within pack.	▪ Damage to battery components and surrounding BESS infrastructure ▪ Release of toxic gases - pollution. ▪ Injury to Site personnel (burns, smoke and chemical inhalation. ▪ Release of flammable gasses due to overcharging.	5	2	Critical	WSP suggest that the following parts of NFPA 855 (2026)[2] are considered. Section 9.7.6.7 of this states that: 9.7.6.7.3 - All ESSs shall be provided with a reliable explosion control and prevention system designed, installed, operated, maintained, and tested in accordance with NFPA 69[3]. 9.7.6.7.3.1 - A partial volume deflagration evaluation shall be conducted in accordance with NFPA 68[4]. 9.7.6.7.3.3 - Where approved, ESSs designed to ensure that no hazardous pressure waves, debris, shrapnel or enclosure pieces are ejected, as validated by installation-level fire and explosion testing and an engineering evaluation performed by a registered design professional complying with Section 9.2 that includes the cabinet, shall be permitted in lieu of providing explosion control and prevention that complies with NFPA 69[3]. WSP suggest that the BESS supplier provides evidence that the BESS system meets both NFPA 68[4] and NFPA 69[3]. WSP expects that the Clients obtains UL 9540A[1] test reports and evaluates them, ensuring no module-to-module thermal runaway propagation occurred.	5	1	High	The flammable gas detector is triggered when the gas concentration reaches 10% of Lower Explosive Limit (LEL), activating the ventilation system. If a second level alarm (smoke and heat detector triggered simultaneously) is raised, the ventilation system will close in preparation for the gas fire extinguishing system. The BESS supplier also offers an optional Explosion Vent panel system for pressure relief which the Client can choose to include in their selection.
8	Battery	Thermal hazard	Battery Cell/ Module Over/ Under Voltage	▪ Irreversible Battery damage. ▪ Efficiency reduction. ▪ Thermal Runaway.	3	2	Medium	Batteries should be continuously monitored by the BMS, where the BMS detects a cell in under voltage, Under Voltage Protection (UVP), an alarm would be sent to the SCADA to inform the operator and the BMS should take corrective action to increase the cells voltage. Where the battery cell is detected to have an overvoltage, Over Voltage (OVP) will be activated. The BMS will force shut the battery rack contractors, bringing the rack offline and isolated from the remainder of the unit. Further investigations will be required, but it is likely that the battery module will be replaced by the OEM.	2	1	Low	BESS supplier to provide documentation evidencing this.
9	All BESS equipment	Electrical hazard	Communications Failure	▪ Damage to battery cell and BESS container.	2	2	Low	Where a rare communications failure occurs within the BESS containers, the system will lock in, and all DC contactors will close to isolate the effected BESS enclosure. The auxiliary power will be maintained to provide power to monitoring systems of the BESS. For a Site-wide power outage, there is a large Uninterruptible Power Supply (UPS) which is used to power the auxiliary circuits until the power can be returned. The UPS will undergo continuous maintenance as part of the O&M regime.	1	2	Low	The communications logic from each BESS supplier will vary, the communications logic is usually CANbus between each rack and the system BMS, then MODbus RS484 or TCP/ IP to the EMS and onwards to the SCADA. The SCADA then provides access to the operators through a local or remote Human Machine Interface (HMI), then finally on to the

[2] NFPA 855 (2026) - Standard for the Installation of Stationary Energy Storage Systems, 2026.
[3] NFPA 69 - Standard on Explosion Prevention Systems.
[4] NFPA 68 - Standard on Explosion Protection by Deflagration Venting.

No.	Component	Hazard	Cause of Hazard	Consequence	Initial Risk Assessment			Prevention/ Mitigation Strategy	Residual Risk Assessment			Further Comments
					S	P	Risk		S	P	Risk	
												integration with the grid where applicable. BESS supplier to provide documentation evidencing this.
10	Battery	Thermal hazard	Liquid Cooling System Failure	▪ Injuries to personnel (burns, smoke, and chemical inhalation). ▪ Electrical and fire damage to battery cell.	3	2	Medium	Entering standby mode allows the affected BESS enclosure to prevent any unintended temperature increases due to charging/ discharging. The temperature will gradually increase/ decrease to the local ambient temperature over time. The operators will be alerted through the SCADA and can immediately proceed with corrective actions using the on-Site spares contingent. Maintenance of the liquid cooling system is critical to ensure reliable operation. At regular intervals as dictated by the OEM, the operator will conduct preventative maintenance including coolant checks/ top-ups and related activities to ensure reliable operation.	2	1	Low	The cooling system is normally powered from the auxiliary circuit for the Site, which is fed from the main grid voltage via a step-down transformer and in-line UPS. Where the system fails through mechanical, electrical or software means, the operators will be notified via the EMS / SCADA system that an error has occurred. The affected BESS enclosure will automatically enter standby mode by not importing/ exporting from the batteries.
11	All BESS equipment	Electronical Failure and Thermal Hazard	Energy Storage Plant Controller Failure	▪ Electrical and fire damage to battery cell and other Site equipment.	2	1	Low	Where a very unlikely error occurs with the energy storage plant controller and too much power is imported from the grid or too much power is exported from the BESS, there are multiple lines of protection. The transformers on each BESS block are likely to be protected via voltage transformers and current transformers' measurements. These protective devices would trip the Site or BESS block off as required. The PCS also has voltage protection and would trip when outside of the expected voltage range.	1	1	Low	
12	Transformer/ Power Conversion System	Thermal and Environmental hazard	Transformer/ Power Conversion System Failure	▪ Fire spreading to surrounding BESS containers and/ or surrounding environment.	4	2	High	It is advised that the transformers and PCS are packaged together in a skid configuration. The skid is positioned according to the manufacturer's guidance, and the components will be spaced in accordance with NFPA 855 (2026)[2] and BS EN/ IEC 61936[5].	3	2	Medium	Transformer/PCS Skid supplier is yet to be confirmed.
13	Transformer/ Power Conversion System	Electrical Hazard	Incorrect separation distances between equipment	▪ Equipment failure. ▪ Reduced efficiency and/ or increased wear of equipment.	3	3	High	WSP recommends that the transformer/ PCS skids and BESS containers are subject to NFPA 855 (2026)[2] requirements and shall be separated from other enclosures with minimum separation distances according to BS EN/ IEC 61936-1[5] standard.	3	1	Medium	

[5] BS EN/ IEC 61936 - Secondary cells and batteries containing alkaline or other non-acid electrolytes & Safety requirements for secondary lithium cells and batteries, for use in industrial applications.

No.	Component	Hazard	Cause of Hazard	Consequence	Initial Risk Assessment			Prevention/ Mitigation Strategy	Residual Risk Assessment			Further Comments
					S	P	Risk		S	P	Risk	
				▪ Injury to humans.				Complying with the separation distance requirements reduces heat transfer between equipment which contributes to keeping equipment in the operating temperature range provided by the OEM. Separation distance requirements also establish adequate maintenance and access for personnel to service equipment safely.				
14	Transformer/ Power Conversion System BESS	Electrical hazard	Arcing or short circuit	▪ Electrocution resulting in injury or fatality. ▪ Ignition to start fire.	4	3	Critical	The BESS supplier has included arc flash protection on the module and string level. The relevant contractors will conduct arc flash/ fault level studies for the HV switchgear according to IEEE 1584[6] or equivalent and provide arc-flash personal protective equipment (PPE) requirements for relevant equipment on Site. All equipment on Site will be subject to an intensive maintenance regime in accordance with the relevant OEM.	3	2	Medium	BESS supplier to provide documentation evidencing arc flash protection. Arc flash studies provider to be confirmed in scope/responsibility. OEM to provide maintenance regimes.
15	All BESS equipment	Electrical hazard	Failure to follow maintenance regime	▪ Reduced BESS lifetime. ▪ Battery efficiency and capacity decrease.	1	2	Low	The BESS OEM provides a minimum recommended operations and maintenance regime that must be followed throughout the lifetime of the facility. The BESS operator and OEM are both incentivised to fully implement the maintenance regime, as the financial performance from both parties may be significantly impacted from premature degradation, unexpected downtime or loss of systems. The operator should carry out periodic inspections and Site meetings to ensure that the O&M provider is adhering to the recommended guidance.	1	1	Low	Annex E of NFPA 855 (2026)[2] includes a sample inspection/ audit checklist that provides guidance for what is expected to be inspected. Site specific requirements and UK specific requirements will need to be taken into consideration.
16	All BESS equipment	Environmental hazard	Failure to follow vegetation management/ debris management	▪ Injuries to Site personnel. ▪ Damage to BESS infrastructure. ▪ Damage to surrounding environment and wildlife. ▪ Wildfire.	1	2	Low	The operator has signed an agreement with an Operations and Maintenance (O&M) provider to ensure that the BESS Site is well maintained. The operator has delegated the Site maintenance including vegetation management to the O&M provider. The O&M provider shall ensure that there is no over-hanging vegetation across the Site boundaries, all BESS containers including transformer/ PCS must be completely free of over-hanging tree branches and a minimum of 3 m from the closest vegetation in accordance with NFPA 855 (2026)[2].	1	1	Low	NFCC[7] guidance recommends that areas within 10 m of BESS units are kept clear of combustible vegetation and that any other vegetation on Site should be kept in a condition such that they do not increase the risk of fire on Site. This is a more conservative approach than required to comply with NFPA 855 (2026)[2], however it would reduce the risk of fire spreading.
17	Natural Hazard	Environmental Pollution	Exposure of contaminated fire water to environment	▪ Soil pollution. ▪ Local ecosystem impacts.	4	3	Critical	Site specific fire water containment strategy to be developed by a technical expert appointed by the Client. This should be developed following guidance from FM Global[8] to prevent contaminated water leakage.	4	1	High	NFCC[7] Guidance recommends that water run-off and potential impact on the environment, along with

[6] IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations.
[7] National Fire Chiefs Council (NFCC) - Grid-Scale Battery Energy Storage System planning, Guidance for FRS, Version 2.0 October 2025.
[8] FM Global - Property Loss Prevention Datasheets, 5-33 Lithium-Ion Battery Energy Storage Systems, Interim Revision April 2026.

No.	Component	Hazard	Cause of Hazard	Consequence	Initial Risk Assessment			Prevention/ Mitigation Strategy	Residual Risk Assessment			Further Comments
					S	P	Risk		S	P	Risk	
				▪ Injury to humans.				Health and safety in grid scale electrical energy storage systems published by DESNZ[9] recommends that management of potential chemical release through water and drainage management (including for contaminated run off) should be included in the Site Emergency Response Plan. Containment strategy may include bunding of the BESS area, use of appropriately sized water tank to store contaminated water and/ or a Site drainage network that can be isolated to ensure containment.				mitigation measures, should be considered and detailed in the Emergency Response Plan (EPR). It is the role of the Principal Contractor to create the EPR, before handing over to the Site owner.
18	Natural Hazard	Release of toxic gases.	Battery fire Vented toxic gas due to battery overcharging or exposure to fault conditions	▪ Respiratory issues, eye and skin irritation, long-term health problems to humans. ▪ Environmental damage to local wildlife, ecosystems, and water sources. ▪ Air quality degradation.	4	3	Critical	The DESNZ[9] guidance recommends that the Site Emergency Response Plan should include the management of potential chemical release. A Computational Fluid Dynamics (CFD) plume assessment can be utilised post-planning, to analyse the behaviour of fumes released by the BESS in the event of a fire or the release of toxic gases due to battery overcharging or fault conditions. This is critical as it identifies likely receptors that would be impacted in the event of a fire. This is used to influence changes that can be made to the Site to eliminate impacts. In cases where impacts cannot be eliminated, the Health & Safety Executive hierarchy of controls should be followed. This involves substituting hazardous materials where possible, implementing engineering controls, utilizing administrative controls, and, as a last resort, relying on PPE to mitigate the effects of chemical toxins released during a fire.	3	3	High	
19	All BESS Equipment	Fire	Emergency services unable to respond effectively due to lack of knowledge of battery chemistry, system size and procedure.	▪ Unwarranted damage to BESS equipment and surrounding infrastructure. ▪ Financial cost to replace and repair damage. ▪ Injury to first responders/ SFRS.	4	3	Critical	FM Global Datasheet 10-1[8], Pre-Incident and Emergency Response Planning provides recommendations that the Client should follow to develop a pre-incident and emergency response plan in the event of a fire or explosion. The aim is to develop a plan in partnership with the local Fire Rescue Service to improve their ability to respond effectively and improve their safety. FM Global Datasheet 10-1[8] lists clear steps for creating a plan in conjunction with Fire Rescue Service. It is recommended that the local Fire Rescue Service is consulted in the creation and assessment of the pre-incident and emergency response plans, and that they should be updated regularly. Site personnel should be training in emergency plan priorities and actions to follow in the event of an incident.	2	2	Low	The DESNZ[9] guidance identifies the inability of emergency services to respond effectively as an initiating event of a fire. It may not be an initiating event, but it can contribute to the severity of a fire incident and the consequences. Owners and developers directly benefit from developing an effective emergency plan as it can mitigate the overall scope of property damage and increases the likelihood of the facility to maintain continuity of operations.

[9] Department for Energy Security and Net Zero (DESNZ) - Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems, March 2024.

3.2 RECOMMENDATIONS

3.2.1 The recommended guidance found in **Annex 4A.2** covers technical guidance and key loss prevention recommendations as advised by the NFCC, international standards and independent insurers. This covers the; Design, operation, protection, inspection, maintenance, and testing of BESS systems that utilise Lithium-Ion batteries in order to reduce the likelihood and impact of BESS related fires.

3.2.2 The recommendations will need to be reviewed and adapted as the project proceeds throughout its development lifecycle. WSP also recommend arranging a Site visit and consultation with the Local Fire Authority to incorporate their recommendations into Site safety. This would need to be agreed with the Local Fire Authority and undertaken post-consent following approval of the BESS compound construction.

3.3 PROTECTION MEASURE, TRAINING AND FIREFIGHTING FACILITIES

3.3.1 Passive and active fire protection measures should be maintained in good order to ensure their effectiveness. Active fire protection measures have been introduced throughout the Site design, covering fire detection and suppression especially on the BESS containers as these are flagged as the highest risk assets. Passive fire protection has been included by following NFPA 855 (2026) guidance for the Site layout design and firefighting equipment on Site.

3.3.2 They will be subjected to checks, tests and maintenance as detailed in **Table 4A-6** below. (Different frequencies may be appropriate - manufacturers or supplier's recommendations should be followed).

Table 4A-6 - Recommended Maintenance Schedule

System	Frequency	Comment
Fire Panel Alarms	Monthly	User operation test.
	Quarterly	Check/ service by specialist contractor.
BESS Smoke Detectors	As agreed with BESS Supplier	All sensors checked in accordance with interval specified by OEM including link to SCADA/ HMI.
BESS Gas Detectors	As agreed with BESS Supplier	All sensors checked to confirm correct operation when sensing H2 LEL and also testing link to Fire Panel.
BESS Purge Ventilation	As agreed with BESS Supplier	Ventilation functionality and backup supply tested to ensure correct operation regularly as a critical safety system
BESS Heat Detectors	As agreed with BESS Supplier	All sensors checked in accordance with interval specified by OEM including link to SCADA/ HMI.
BESS Fire Suppression	As agreed with BESS Supplier	All fire suppression devices checked in accordance with interval specified by OEM including link to SCADA/ HMI.

System	Frequency	Comment
BESS Audible Alarm	As agreed with BESS Supplier	All fire alarms checked in accordance with interval specified by OEM including link to SCADA/ HMI.
BESS Visual Alarm	As agreed with BESS Supplier	All fire alarms checked in accordance with interval specified by OEM including link to SCADA/ HMI.
Emergency Lighting	Monthly	User operation test.
	Annually	Check/ service by specialist contractor.
Sprinkler System	Weekly	Check by user.
	Quarterly	Check / service by specialist contractor.
Fire Hydrants	Weekly	Check by user for obstructions.
	Annually	Check/ service by specialist contractor.
Fire Doors	6-monthly	Inspection by user.
Fire Exits	Monthly	User check for ease of opening.
Fire Extinguishers	Monthly	Inspection by user.
	Annually	Check/ service by specialist contractor.
Fire door/ shutter release mechanisms	Weekly	Operation check by user.
	Annually	Check/ service by specialist contractor.

3.3.3 Passive fire precautions are concerned with the physical conditions in the premises which are designed to facilitate containment of fire by design, construction and layout, effective communication and safe evacuation. Active fire precautions are those features of the fire safety management system that detect and operate in the event of a fire, including fire alarm systems, emergency lighting systems, firefighting equipment and fire shutters/ curtains.

3.3.4 Passive and active fire protection measures will be maintained in good working order in accordance with manufacturer's instructions and British Standard guidance where applicable. They will be subjected to checks, tests and maintenance as detailed in **Table 4A-6**.

3.3.5 All staff will receive appropriate fire safety training. The main features of the training will be as shown in **Table 4A-7**.

Table 4A-7 - Training Schedule

Training	Content	Frequency
General Fire Safety Induction - All Staff	Site layout familiarisation. Identification of escape routes and assembly point. Fire detection, suppression, and warning arrangements. Emergency procedures.	On commencement
Routine Staff Training - All Staff	Emergency plan and procedures. Roll call procedures. Fire prevention (including BESS). Roles and responsibilities. Key points from fire risk assessment. False alarms - review and prevention measures. Fire events (and near-misses). Special instruction relevant to particular role (e.g. calling fire service, assisting person as part of PEEP).	Initial Annual refresher
Evacuation Practice	Full evacuation drill testing all procedures. Review and communication of feedback to all.	6 monthly (for each shift group)
Portable Fire Extinguisher Training (Designated Staff only)	Practical firefighting using portable equipment of types as installed in the premises.	Initial Periodic refresher
Nominated Person Training/ Fire Warden	Role and responsibilities detail. Routine fire checks. Understanding fire-related systems and equipment. Assisting evacuation process. Checking premises/ areas safely. Liaison with Fire Service. Reporting procedures for faults, near-misses.	Initial Annual refresher

3.3.6 Training should be provided at the intervals stated in the schedule; however, it may be appropriate to update training in circumstances such as changes to the Site layout, introduction of new fire risks, changes to the emergency procedures. Such issues should be highlighted through the ongoing fire risk assessment process.

3.3.7 Detailed records should be kept of all fire safety training, including the dates, subjects covered and names of those receiving the training.

3.3.8 There will be certain facilities on the Site to assist with Fire Service operations. These are likely to comprise:

- Fire hydrants.
- Water storage tanks where connection to water mains is not available.
- Fire vehicle access route.

3.3.9 The local Fire Service should be invited to Site to attend training and familiarise themselves with the Site, BESS equipment and the firefighting facilities. Ongoing liaison will be maintained.

3.3.10 Only staff who have been nominated and who have received appropriate training may use the fire extinguishers provided on Site.

3.3.11 Personal safety is paramount and, if in any doubt about safety, no first-aid firefighting will be carried out. The judgement as to safety must only be made by the trained operator.

3.3.12 In the event of a fire or thermal runaway, water will be utilised to negate the spread in an attempt to reduce the damage to the BESS equipment within the compound and further prevent any consequent damages to the local environment.

3.3.13 This will result in contaminated runoff water which needs to be safely contained within the Site and safely removed. Allowance will need to be made as part of the detailed drainage strategy for the containment of potentially contaminated fire-fighting water in the event of a fire within the BESS. This could comprise of an underground storage tank through which runoff from the BESS is passed. During normal conditions this tank is allowed to drain via the infiltration process outlined above, however in the event of a fire, a control valve on the outlet of the tank is closed prior to the deployment of firefighting water.

3.3.14 The full firewater runoff strategy will be developed during the detailed design stage of the Project.

3.4 EVACUATION AND EMERGENCY PROCEDURE

3.4.1 All staff should be trained in necessary actions in the event of fire.

3.4.2 The emergency evacuation procedures are in **Table 4A-8**. Evacuation procedure notices are displayed at key locations around the building as a reminder to staff.

Table 4A-8 - Fire Emergency Response Procedure

Task	Action
What People/ Staff Should Do If They Discover a Fire	▪ Raise the alarm by operating the nearest fire alarm call point.
What People/ Staff Should Do If They Hear the Fire Alarm	▪ Leave the Site by the nearest exit. ▪ Evacuate to the designated assembly point. ▪ Do not stop or return to collect personal belongings. ▪ Close any doors en-route without delaying your escape. ▪ Remain at the assembly place. ▪ Return to the Site only when authorised to do so by

Task	Action
	▪ authorised personnel or attending Fire Officer. ▪ A person who discovered the fire should immediately pass ▪ any information to the supervising manager at the assembly point. ▪ For those with specific designated duties: ▪ Call the Fire & Rescue Service by dialling 999. ▪ Tackle the fire only if trained and where appropriate. ▪ Those with responsibilities for assisting persons with Personal Emergency Evacuation Plans should respond as required following the actions as identified in the Plan. ▪ Ensure any visitors are escorted from the Site to the assembly point. ▪ During joint occupation (Contractor still present), notify the Contractor following the agreed protocol.
What Designated Staff Should Do if a False Activation has Occurred	▪ Reset the Fire Alarm. ▪ Advise staff that it is safe to return to the Site. ▪ Record the event in the Logbook.
Arrival of Visitors	▪ All Visitors are logged in and out of the Site by use of the ▪ Visitors Book. ▪ All Visitors are made aware of the Fire Evacuation Procedures on arrival. ▪ The designated person will take the Visitors Book to the Assembly Point in the event of an evacuation and perform a roll call. ▪ The Fire & Rescue Service will be made aware of any suspected missing person.
Contacting the Fire & Rescue Service	▪ Information on escape routes, fire alarms and procedures will need to be detailed verbally at reception area when signing in as standard printed information will not be adequate.
Fire & Rescue Service Liaison Procedure	▪ On the arrival of the Fire & Rescue Service the following should be done: • The designated staff member will make themselves known to the Officer in Charge of the attending crew on their arrival (meeting them at the designated location. • The designated staff member will provide all known details to the Fire & Rescue Service on arrival • The designated staff member will continue to act as liaison/ point of contact at the direction of the Fire Incident Commander.

Task	Action
Specific Information for the Fire & Rescue Service	▪ The designated staff member will give the Fire & Rescue Service specific information such as: • Location of the fire/ incident. • Location of fire panel. • Missing persons • Flammable material stores. • Location of high risk areas. • Any unusual activities such as Site works or temporary structures. Contractor to include procedure to follow if they have a fire emergency on their Site with regards to notification of responsible persons/ tenants.

3.4.3 The evacuation strategy for fire is for total simultaneous evacuation. All Site occupants will evacuate from all areas of the Site when the fire alarm warning is given.

3.4.4 Trained staff, in accordance with specific instructions given to them, may approach the reported place of fire origin and carry out first-aid fighting with portable equipment.

3.4.5 There is a specific assembly point to which all occupants must report in the event of an evacuation.

3.4.6 Attendance records and the visitor book will be taken to the assembly point to enable a roll call to be made.

3.4.7 Attending Fire Service crews will be met at the Site Main Entrance and will be briefed by personnel with designated responsibility with all available relevant information including details of the roll call.

4 MONITORING, AUDITING AND REVIEWING

4.1 EVACUATION DRILLS

4.1.1 Routine evacuation drills should be organised and monitored by the Fire Safety Manager. Records will be kept of each evacuation drill.

4.1.2 The below tables detail three Standard Personal Emergency Evacuation Plans (PEEPs). Standards PEEPs are for use when a person who requires assistance in an emergency comes to the premises as a visitor. In other circumstances it will be appropriate to have a specific PEEP for anyone requiring one.

Table 4A-9 - Plan 1 - Person with Sight Impairment

Key Points	Key Summary
Requirement	▪ Person is partially sighted or blind making it difficult to locate and negotiate escape routes.
Escape Procedure	▪ The person's host will take them to a safe position outside the Site. (It is not anticipated that visitors with sight impairments will be allowed unaccompanied access around the Site).
Specialist Equipment	▪ None specified for this plan.
Fire Warden Assistance	▪ None specified for this plan.
Communications	▪ Information on escape routes, fire alarms and procedures will need to be detailed verbally at reception area when signing in as standard printed information will not be adequate.

Table 4A 10 - Plan 2 - Person with Hearing Impairment

Key Points	Key Summary
Requirement	▪ Person has hearing impairment making it difficult to hear the fire alarm clearly, or the person is totally deaf making it impossible to hear the fire alarm.
Escape Procedure	▪ The person will be alerted by their host, or by a companion/ colleague who is visiting with them. ▪ Or the person will be alerted by seeing a fire alarm visual warning device. ▪ It is anticipated that independent escape can then be made following the signed escape routes.

Key Points	Key Summary
Specialist Equipment	▪ Some visual warning devices are in place where visitors may be unaccompanied, e.g. toilets.
Fire Warden Assistance	▪ None specified for this plan.
Communications	▪ Availability of visual information in reception area to inform visitors of escape routes and procedures.

4.2 CHECKS, MAINTENANCE AND TESTING

4.2.1 All fire safety equipment and systems will be subject to routine checks, tests and maintenance at periods recommended by manufacturers/ suppliers, British Standards or general fire safety guides. The testing and maintenance schedule is detailed in the below **Table 4A-6.**

4.2.2 Fire safety records should be kept up to date and available for inspection on Site. The summary of fire safety records to be kept is as follows:

- Staff fire safety training.
- Equipment and systems testing and checks.
- Equipment and systems routine maintenance and servicing.
- Fire alarm activations.
- Fire events.
- Fire risk assessment and associated action plans.
- Fire safety officer visits and associated correspondence.
- Evacuations planned and unplanned.

4.3 FIRE RISK ASSESSMENT REVIEW

4.3.1 The fire risk assessment should be reviewed at least annually. A review shall also take place in the event of significant changes, such as:

- Increase in number of people likely to be in the Site.
- Proposed alterations in the layout of the Site.
- Increase in fire loading in the Site.
- Proposed changes to this BFSMP or the arrangements specified within it.
- The fire risk assessment and procedures should also be reviewed following any occurrence of any fire, minor or major and any reported fire-related near-miss.

4.3.2 Whenever changes are made that necessitate review of fire risk assessment and/or affect the management structure or arrangements of the premises. The impact of those changes on this BFSMP should be evaluated and modifications made as necessary.

4.4 AUDIT AND FORMAL REVIEW

4.4.1 The fire safety records listed in **Section 4.2** should be audited annually by personnel with designated responsibility.

4.4.2 The BFSMP shall be subject to an annual review. The outcomes of this review shall be documented, and any required amendments shall be implemented accordingly.

4.4.3 The review shall be carried out by a competent individual appointed by personnel with designated responsibility.

5 CONCLUSION

5.1.1 WSP have provided the Client with a Battery Fire Safety Management Plan (BFSMP) for the Energy Storage System (BESS) elements of the Proposed Development. This BFSMP has been prepared to support the development of the BESS, setting out the proposed framework for managing fire safety risks throughout the project's operation.

5.1.2 The assessment demonstrates that, while grid-scale lithium-ion BESS installations can present high risk fire and explosion hazards, these risks can be effectively managed through the implementation of robust design measures, operational controls, and emergency response arrangements. The risk assessment undertaken identifies failure modes and confirms that, with appropriate prevention and mitigation measures in place, residual risks will be reduced to manageable and acceptable levels.

5.1.3 The BFSMP defines clear roles and responsibilities, structured communication between stakeholders, and the integration of industry best practice and recognised standards such as NFPA 855, FM Global, and NFCC guidance. It provides protocol and procedures in the event of emergencies with defined evacuation procedures, staff training, and liaison with the local Fire and Rescue Services, forming an integral part of the overall safety approach.

5.1.4 It is recognised that aspects of the design, including final equipment selection, fire suppression strategy, and fire water containment arrangements, will be refined as the project progresses. Accordingly, this BFSMP should be revised in line with ongoing updates of detailed design development, stakeholder input, and evolving industry guidance.

5.1.5 The implementation of the measures set out within this BFSMP will provide a robust framework to minimise the risk to life, property, and the environment, and to support the safe delivery and operation of the BESS facility.

Annex 4A.1

INDICATIVE LAYOUT

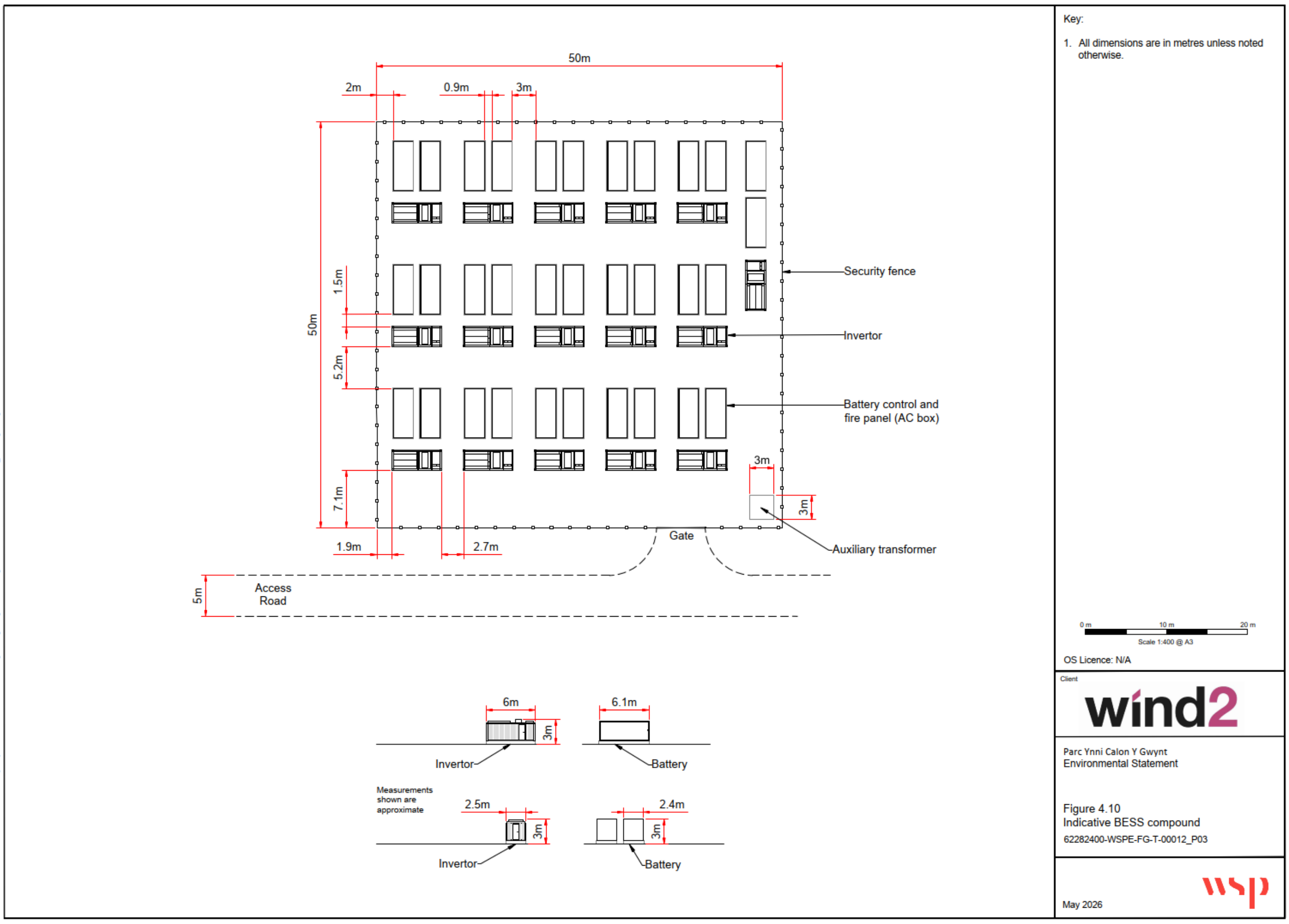
PUBLIC

The BESS has a rated power of 40MW and a storage duration of 4 hours, resulting in a resulting capacity of 160MWh.

The BESS will be located on a 50m x 50m hardstanding compound located adjacent to the substation and control building compound.

There will be 32 BESS containers, arranged in a 'back to back' arrangement, with each unit measuring approximately 6m x 2.4m wide and 2.9m high.

For the purpose of the layout and this document, the Sungrow PowerTitan 2.0 BESS container, a lithium-ion based battery chemistry has been selected and subsequently designed with.



Annex 4A.2

REFERENCED RECOMMENDATIONS

PUBLIC

FM Global, Property Loss Prevention Datasheets, 5-33 Lithium-Ion Battery Energy Storage Systems, Interim Revision April 2026.

Lithium-Ion Battery Energy Storage System (LIB-ESS) Selection

2.2.1 Verify with the manufacturer or integrator that the LIB-ESS design, including cell type, BMS, etc., is appropriate for the application.

2.2.2 Establish a management of change procedure to ensure that batteries or BMS components are compatible with modified system requirements or that replacements are appropriate to the existing system requirements.

2.2.3 Do not use refurbished or previously used ESS components, including cells or modules.

ESS Enclosures

2.3.2.1 Select or construct LIB-ESS enclosures/ containers using only non-combustible materials.

Separation distance is based on doors being located on only one side of the enclosure and no vents or unprotected openings on any other sides. It is also based on active systems (HVAC or liquid cooling) maintaining cell or module temperatures in the target enclosure or container.

2.3.2.2 For containerized LIB-ESS comprised of lithium iron phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors or deflagration vents.

2.3.2.4 Provide separation between solid walls having no openings based on installation-level testing that demonstrates thermal runaway cannot propagate between containers. Where a fire test report is not available or the test did not result in a fire in the unit of origin, provide separation as indicated in Sections 2.3.2.2 or 2.3.2.3 as appropriate.

2.3.2.4.1 If any penetrations are present, the separation should be extended, or the penetrations should be protected or equipped with FM Approved fire-safe wall penetrations.

2.3.2.4.2 Where explosion vents or other penetrations are provided, ensure they are arranged and directed away from surrounding equipment and buildings.

In a fire, these enclosures may have vents or penetrations that could allow hot gas and products of combustion to escape the enclosure, causing an exposure to adjacent equipment or buildings. Penetrations could include electrical conduit, doors, HVAC units, etc.

2.3.2.5 Provide a minimum space separation between LIB-ESS enclosures and adjacent buildings or critical Site utilities or equipment in accordance with Data Sheet 1-20, Protection Against Exterior Fire Exposure, using hazard category 3 for the exposing building occupancy.

Equipment and Processes

2.5.1 Electrical System Protection

2.5.1.1 Perform a system short circuit and protection coordination study to ensure the adequacy of rating and relay settings for existing circuit breakers when the electrical energy storage system adds power to the existing electrical system at a facility. For additional information on short circuit and protection coordination, see Data Sheet 5-20, Electrical Testing.

Equipment Protection

2.5.2.1 Provide a disconnect device for maintenance needs or abnormal events for each rack.

2.5.2.2 Provide a method of manual, remote, and local disconnect for the LIB-ESS. A remote disconnect should be in an accessible area that is monitored 24/7. A local disconnect should be provided adjacent to the ESS space.

2.5.2.3 Provide temperature monitoring with high alarm for LIB-ESS room, building, or enclosure. Have alarms routed to a continuously attended location or specific operations personnel.

LIB-ESS Rack

2.5.2.4.1 Provide DC ground fault protection for grounded battery systems. For ungrounded battery systems, provide DC ground fault monitoring with alarming function. Have the alarm routed to a constantly attended location or specific operations personnel.

2.5.2.4.2 Provide overcurrent protection against overload and short-circuit faults.

2.5.2.4.3 Provide overvoltage and under-voltage protection against overcharging and over-discharging.

Battery Management System Safety Functions

2.5.3.1 Provide battery management systems with the following safety functions:

A. High cell temperature trip (cell level): This function isolates the module or battery rack when detecting cell temperatures that exceed limits. A common design is to have modules hard-wired in series within a rack. Therefore, the smallest unit that can be isolated is generally the rack. Where a design accommodates it, isolating a module is acceptable.

B. Thermal runaway trip (cell level): This function trips the entire system when a cell is detected to have entered a thermal runaway condition. In scenarios involving a thermal runaway, this function is the first to activate when thermal runaway conditions are detected.

C. Rack switch fail-to-trip (rack level): This function identifies any failure from the pack switch to trip once a trip command is initiated. The rack switch is also known as the "pack switch." It is a switch that disconnects a single rack in response to an abnormal condition. The rack switch is shown separately from the "master" level in Figure 2.5.3.1 for clarity. It is generally incorporated into the BMS.

D. Inverter/ charger fail-to-trip (supervisor level): This function initiates a trip command to an upstream breaker to isolate the LIB-ESS if the inverter/ charger fails to respond to a trip command. The "supervisor" control system controls the entire system, including the combination of racks, the environmental support systems, and the charging/ discharging status. The supervisor level should isolate the ESS if the inverter/ charger fails to trip on an appropriate signal, or if communication is disrupted between the inverter/ charger and the supervisor control.

Online Condition Monitoring

2.5.3.2.1 Provide online condition monitoring systems that will monitor battery room temperature and the following parameters, at a minimum, at the battery module and/ or cell level:

- Charging and discharging voltage and current.
- Temperature • Internal ohmic (resistance).
- Capacity
- SoC.

- State of health (SoH).
- Alarm or fault log.

2.5.3.2.2 Provide online condition monitoring systems with the following features:

A. The ability to transmit data to a constantly attended location or specific operations personnel.

B. The ability to generate alarms when unusual conditions are detected.

C. The ability to analyse monitored parameters and generate a summary of the condition of the battery.

D. Security to prevent unauthorized changes of critical parameter limits, such as voltage, temperature, and current, which are essential to maintain reliable lithium-ion battery operation.

E. Self-diagnostic capability

Early Intervention Thermal Runaway Prevention

2.5.3.3.1 Incorporate an early intervention system to automatically and electrically isolate the LIB-ESS, using one of the following approaches:

1. High cell temperature: The cell manufacturer should provide the threshold temperature indicating an abuse condition based on 100% SoC. The majority of cells within a module should be constantly monitored.

2. Off-gas detection: Provide gas detectors capable of detecting the volatile organic compounds associated with the off-gas event that precedes thermal runaway.

Power Conversion Equipment

2.5.4.1 Provide overcurrent protection against overload and short-circuit faults on the AC side.

2.5.4.2 Provide surge arrestors on the AC side for voltage transient "voltage spike" protection. For additional information on voltage transient protection, see Data Sheet 5-11.

2.5.4.3 Provide transformer electrical protection in accordance with Data Sheet 5-4, Transformers or 5-20, Electrical Testing, as applicable.

Air Circulation/ Mechanical Ventilation

2.5.5.1 Locate the circulation/ ventilation system to take suction at or near the ceiling.

2.5.5.2 Install an FM Approved hydrogen detector that will alarm if the level of hydrogen exceeds 10% LEL, electrically isolate the LIB-ESS, and initiate emergency exhaust ventilation in accordance with Section 2.5.5.3.

2.5.5.3 Install an emergency exhaust ventilation system that will increase the ventilation rate to 2.5 cfm/ft2 (0.75 m3/min/ m2) of floor area if hydrogen is detected at 10% of the LEL and exhaust all air directly to outdoors.

2.5.5.3.1 Route the emergency exhaust ventilation system through a system of blowers, fans, and ductwork terminating outdoors away from air inlets, doorways, and other openings.

2.5.5.3.2 Construct ductwork of non-combustible materials.

2.5.5.3.3 Provide make-up air inlets in exterior walls, in a remote location from exhaust outlets to prevent entrainment of exhaust gases.

2.5.5.4 Arrange the circulation/ ventilation system controls to alarm to a constantly-attended location or to specific operations personnel.

Operation

2.6.1.1 Install, operate, and maintain batteries and battery management systems in accordance with manufacturer's recommendations.

2.6.1.2 As part of commissioning, verify proper operation of all monitoring and protective devices.

A. Inspect the battery system thoroughly for indication of overheating, abnormal vibration, abnormal noise, or malfunction. This should occur daily for a minimum of one week of normal operation.

B. Perform infrared scanning and check battery operating and monitoring parameters to determine if any damage was sustained in shipping and installation.

Equipment Maintenance

2.6.2.1.1 Perform electrical system inspection, testing and maintenance of LIB-ESS systems in accordance with Data Sheet 5-20, Electrical Testing. Establish and implement a LIB-ESS system inspection, testing, and maintenance program. See Data Sheet 9-0, Asset Integrity, for guidance on developing an asset integrity program.

Battery Management System

2.6.2.2.1 The inspection, testing, and maintenance program for the BMS should include at least the following:

A. Periodic system self-test to ensure all critical systems are available and operational.

B. Periodic pack switch maintenance. This may involve cycling the switch to ensure mechanical integrity and tightness of cable connections by torquing to specifications.

C. HVAC maintenance. This may include change of air filters at periodic intervals. These intervals may vary depending on the location of the Site. Dusty locations may require more frequent air filter replacement.

Other HVAC maintenance items may include coolant check, compressor/ heater core check and duct/ cable check.

D. Periodic check of spare battery modules to ensure they are maintained in charged state.

E. Periodic tracking of SoH values, which is the percent of remaining capacity (based on design capacity) in the battery packs.

2.6.2.3 Establish a battery replacement program for aged batteries. Review the battery replacement program regularly and include, at a minimum, the following components:

A. The OEM design life expectancy of the LIB-ESS batteries. This will be a number in years that the system is expected to perform adequately. After this point, the batteries should be replaced. This establishes the replacement timeline.

B. Regular monitoring of the LIB-ESS SoH, which is the percent of remaining capacity based on design capacity. This information should be available through the BMS, which continuously tracks SoH.

Unexpected component malfunctions or failures and operating outside design parameters can age batteries faster than when operating within design limits. The BMS will be able to monitor these unexpected issues and adjust the SoH of the system.

C. Regular review of the replacement program, ensuring there is a method of adjusting the replacement timeline. The plan should allow for adjusting the replacement timeline if feedback from the BMS shows the SoH indicates accelerated aging. The following factors justify earlier replacement:

1. Significant changes or trends in the condition monitoring data that indicate development problems with the battery system

2. Advice from the OEM of design problems that require replacement

3. Operating experience and failure history that indicates the battery should be replaced

4. Exposure to severe operating conditions

D. A method of managing changes. This should consider major changes that affect the life expectancy and replacement timeline of the LIB-ESS. Changes could include replacement of the BMS, modifying the thermal management system, and changes in application or operational modes (e.g., modifying the BMS to operate based on an arbitrage mode vs. electric supply capacity).

2.7 Training

2.7.1 Have operation personnel trained by the supplier/ manufacturer of the LIB-ESS equipment.

2.7.2 Provide other training in accordance with Data Sheet 10-8, Operators.

2.8 Human Factors

2.8.1 Housekeeping

2.8.1.1 Do not store combustible material in LIB-ESS enclosures, buildings, or cutoff rooms.

Emergency Response and Pre-Incident Planning

2.8.2.1 Develop an emergency response plan to address the potential fire hazards associated with energy storage systems. Refer to Data Sheet 10-1, Pre-Incident Planning, for general guidelines on establishing and maintaining an emergency response plan.

2.8.2.2 Develop a pre-incident plan with the fire service in accordance with Data Sheet 10-1, Pre-Incident Planning. Arrange and prepare the plan with documented procedures to expedite safe entry and emergency response to fires in LIB-ESS storage area, including the following:

- Manual disconnection.
- Access routes.
- Manual fire protection methods.
- Manual smoke ventilation (if provided).
- Safety Datasheet for battery cells.

2.8.2.3 Develop a post-incident recovery plan that addresses the potential for reignition of LIB-ESS, as well as removal and disposal of damaged equipment.

2.8.2.3.1 A fire watch should be present until all potentially damaged LIB-ESS equipment containing Li-ion batteries is removed from the area following a fire event. The water supply should be replenished as quickly as feasible.

Fires involving Li-ion batteries are known to reignite. Li-ion batteries involved in or exposed to fires should be adequately cooled to prevent reignition.

2.8.2.3.2 Identify the equipment needed to safely remove and replace damaged equipment and the supporting infrastructure to facilitate prompt removal. The plan should include service or equipment providers needed for recovery infrastructure. The OEM or integrator should provide guidance on decommissioning, removal of damaged equipment, and proper disposal in accordance with local regulations.

2.9 Utilities

2.9.1 In extreme environments, provide an emergency power supply to the HVAC systems. An extreme environment mentioned here is one that could allow cell-level temperatures to rise or fall outside the maximum operating temperature range of -4.0° F (-20° C) to 120° F (50° C) despite BMS control.

2.9.2 Ensure LIB-ESS enclosures with common HVAC components, such as a common condensing unit (cooling tower), are designed to shut down the LIB-ESS in the event of a component failure.

National Fire Chiefs Council (NFCC), Grid-Scale Battery Energy Storage System planning - Guidance for FRS, Version 2.0 October 2025.

System Design, Construction, Testing and decommissioning

Fire and rescue services should seek to obtain as much information as possible at the earliest opportunity to enable an initial appraisal of the BESS. It is the responsibility of the Client / developer / designer / manufacturer to provide this information to the fire and rescue service. Additionally, they must provide the fire and rescue service with appropriate evidence to support any claims made on performance and cite appropriate standards for installation.

Fire and rescue services should recognise that the development timeline of some projects may span several years. Consequently, initial information may be provided at the outline stage, with more detailed information following as the project progresses. This information should be made available to operational risk teams within fire and rescue services for inclusion in SSRI records.

The fire and rescue service may wish to clarify the following areas with the Site developer at the pre application/engagement phase:

1. Thermal events and events leading deflagration:

   - How will the proposed BESS perform in a thermal event / deflagration, and what proactive or reactive systems are proposed to mitigate this?
   - How will the thermal event be contained to the BESS cabinet of origin without the radiant heat affecting other cabinets?
   - How has the performance of the BESS in a thermal runaway event influenced Site design?
   - Has the proposed equipment undergone any full-scale fire testing or has it been certified by a reputable body such as Underwriters Laboratory (UL 9540A)?

2. Site plans:
    - What are the assumptions about active firefighting within the emergency response plan, and what measures are in place to reduce the scale of an incident?
    - Are the incident assumptions realistic? What is the role of the fire and rescue service at an incident? Are they realistic? What is the expectation of the fire and rescue service in terms of the fire strategy at a thermal event?
    - What is the provision for firefighting access to, around, and within the Site?
3. Water supply and suppression systems:
    - What is the type, purpose, and effect of any fire suppression system installed?
    - What is the purpose of the water supply provision on Site? Is it intended for boundary cooling / defensive firefighting or active suppression?
    - How will water run-off be managed?
4. BESS design:
    - What is the size, quantity, and capacity of each BESS unit?
    - Is the BESS design appropriate for the weather at the proposed location in terms of preventing water ingress and impact of temperature range on cooling systems?
    - Does the Client / developer have relevant competence and experience in the field of BESS design and deployment on the scale of the proposed development? If not, do they have access to specialist advisors to support?
    - What are the arrangements for ongoing monitoring of the BESS?
    - What is the response time for onSite technical assistance in the event of an incident?
5. Detection and monitoring:
    - How will the BESS and associated equipment be monitored, and what is the process for alerting the fire and rescue service?
    - How will the fire and rescue service align their approach to handling calls to BESS Sites to their unwanted fire signals position?
6. Environmental receptors

<u>Detection and monitoring</u>

An effective and appropriate method of early detection of a fault within the batteries should be in place, with immediate disconnection of the affected battery/ batteries. This may be achieved automatically through the provision of an effective BMS and/ or a specific electrolyte vapour detection system.

Should thermal runaway conditions be detected then there should be the facility in place for the early alerting of emergency services.

Detection systems should also be in place for alerting to other fires that do not involve thermal runaway (for example, fires involving electrical wiring).

Continuous combustible gas monitoring within units should be provided. Gas detectors should alarm at the presence of flammable gas (yes/ no), shut down the ESS, and cause the switchover to full exhaust of the ventilation system. Sensor location should be appropriate for the type of gas detected e.g. hydrogen, carbon monoxide, volatile organic compounds.

External audible and visual warning devices (such as cabinet level strobing lights), as well as addressable identification at control and indicating equipment, should be linked to:

1. Battery Management System (when a thermal runaway event is identified).

2. Detection and suppression system activation.

This will enable first responders to understand what the warning is in relation to. This will aid in their decision-making.

Suppression systems

Suitable fixed suppression systems should be installed in units in order to help prevent or limit propagation between modules.

Where it is suggested that suppression systems are not required in the design, this choice should be supported by an evidence-based justification and Emergency Response Plan that is designed with this approach in mind (for example, risk assessed controlled burn strategies, and external sprinkler systems).

Whilst gaseous suppression systems have been proposed previously, current research indicates the installation of water-based suppression systems for fires involving cell modules is more effective.

The installation of gaseous suppression systems for electrical fires that do not involve cell modules may be appropriate but should be built into a wider suppression strategy.

FM Global cite the following reasons for not recommending gaseous protection systems:

1. Efficacy relative to the hazard. As of 2019, there is no evidence that gaseous protection is effective in extinguishing or controlling a fire involving energy storage systems. Gaseous protection systems may inert or interrupt the chemical reaction of the fire, but only for the duration of the hold time. The hold time is generally ten minutes, not long enough to fully extinguish an ESS fire or to prevent thermal runaway from propagating to adjacent modules or racks.

2. Cooling. FM Global research has shown that cooling the surroundings is a critical factor to protecting the structure or surrounding occupancy because there is currently no way to extinguish an ESS fire with sprinklers. Gaseous protection systems do not provide cooling of the ESS or the surrounding occupancy.

3. Limited Discharge. FM Global research has shown that ESS fires can reignite hours after the initial event is believed to be extinguished. As gaseous protection systems can only be discharged once, the subsequent reignition would occur in an unprotected occupancy.

The choice of a suppression system should be informed by liaison with a competent system designer who can relate the system choice to the risk identified and the duration of its required activation. Such a choice must be evidence based.

Any calculations for sufficient water supply for an appropriate suppression system will need to be completed by a competent person considering the appropriate risk and duration of any fire.

Water run-off and potential impact on the environment, along with mitigation measures, should be considered and detailed in the Emergency Response Plan.

Lack of sufficient water supplies at a particular Site location should not be considered as the basis for a suppression system choice. Such an approach could result in potentially ineffective and/ or dangerous system designs.

Explosion control (deflagration protection)

Explosive vapours will be produced which - through the process of thermal runaway and depending on the battery chemistry - may transition to flaming combustion, or remain as a vapour cloud that could lead to an explosion hazard that personnel need to be aware of.

BESS containers should be fitted with explosion protection or deflagration venting appropriate to the hazard and battery technology deployed. Designs should be developed by competent persons, with design suitability able to be evidenced by utilising British Standards or equivalent National Fire Protection Association (NFPA) Standards, as follows:

- BS EN 16009:2011 Flameless Explosive Venting Devices
- BS EN 14373:2021 Explosion Suppression Systems
- BS EN 14797:2007 Explosion Venting Devices
- NFPA 68 Standard on Explosion Protection by Deflagration Venting
- NFPA 69 Standard on Explosion Prevention Systems

Exhaust systems designed to prevent deflagration should keep the environment below 25% of the lower explosive limit (LEL).

Flames and materials discharged during venting should be directed safely outside. Measures must be in place to ensure they do not cause fire spread beyond the affected unit, or pose additional risks to people near the originating BESS cabinet or enclosure. The likely path of any vented gases or materials should be identified in emergency response plans to reduce the risk to responders.

The position of any venting should take account of the likelihood of weather-related ingress of water. The aim is to minimise the risk of water damage during the ordinary functioning of the BESS.

Designs should also give consideration to leakage paths for explosive vapour via cable trunks and routes to other structures, which could result in a secondary remote vapour cloud explosion, as in the Dahongmen incident in Beijing in 2021.

Explosion/deflagration strategies should be built into the emergency response plan to ensure that responders understand the strategies and how their actions may influence them. For example, personnel may open the door to a unit, which may negate the potential effect of deflagration vents due to an alternative path of least resistance having been created.

Where emergency ventilation is used to mitigate an explosion hazard, the isolation/disconnect for the ventilation system should be clearly marked. Signage should warn personnel or operational crews not to disconnect the power supply to the ventilation system during an evolving incident (NFPA (2026) Standard for the Installation of Stationary Energy Storage Systems. The remaining unaffected cells need to continue to be maintained within their operating temperature.

The chosen method of explosion control system should be supported by evidence from a competent person or an approved institution, such as Underwriters Laboratories (UL) or the NFPA.

Access

Site access

Suitable facilities for safely accessing and egressing the Site should be provided. Designs should be developed in close liaison with the local FRS as specific requirements may apply due to variations in vehicles and equipment.

This should include:

- At least 2 separate access points to the Site to account for oppoSite wind conditions/direction.
- Roads/ hard standing capable of accommodating fire service vehicles in all weather conditions. As such there should be no extremes of grade.
- A perimeter road or roads with passing places suitable for fire service vehicles.
- Road networks on Sites must enable unobstructed access to all areas of the facility.
- Turning circles, passing places etc size to be advised by FRS depending on fleet.

Access between BESS units and unit spacing

In the event of a fire involving a BESS unit, one of the primary tactics employed will be to prevent further unit to unit fire spread. Suitable access for firefighters to operate unimpeded between units will therefore be required. This should allow for the laying and movement of hose lines and, as such, access should be free of restrictions and obstacles. The presence of High Voltage DC Electrical Systems is a risk, and their location should be identified. Exclusion zones should be identified.

A standard minimum spacing between units of 6 metres is suggested unless suitable design features can be introduced to reduce that spacing. If reducing distances a clear, evidence based, case for the reduction should be shown.

Any reduction in this separation distance should be design based by a competent fire engineer. There should be consideration for the fire separation internally and the total realistic load of fire. Proposed distances should be based on radiant heat flux (output) as an ignition source.

The NFCC does not support the stacking of containers/ units on top of one another on the basis of the level of risk in relation to fire loading, potential fire spread, and restrictions on access.

Distance from BESS units to occupied buildings & Site boundaries.

Individual Site designs will mean that distances between BESS units and occupied buildings/ Site boundaries will vary. Proposed distances should take into account risk and mitigation factors. However, an initial minimum distance of 25 metres is proposed prior to any mitigation such as blast walls. Reduction of distances may be possible in areas of lower risk (e.g. rural settings). Where possible buildings should be located upwind.

Site Conditions

Sites should be maintained in order that, in the event of fire, the risk of propagation between units is reduced. This will include ensuring that combustibles are not stored adjacent to units and access is clear and maintained. Areas within 10 metres of BESS units should be cleared of combustible vegetation and any other vegetation on Site should be kept in a condition such that they do not increase the risk of fire on Site. Areas with wildfire risk or vegetation that would result in significant size fires should be factored into this assessment and additional cleared distances maintained as required.

Water Supplies

Pumping fire appliances in the UK typically have a water storage capacity of approximately 1,800–2,000L of water. This capacity can be exhausted in under five minutes per appliance. Therefore, an additional on-Site water supply must be accessible to fire and rescue services in the event of an emergency.

There should be enough water available to meet firefighting requirements and to manage a reasonable worst-case scenario. Depending on the Site, this may be provided through storage tanks, on-Site lagoons, hydrants, or mains water supply.

The amount of water required will vary depending on a number of factors, including:

- The size of the incident to be dealt with, for example 1 x BESS cabinet/enclosure
- The principles set out in the emergency response plan and the expected role of the fire and rescue service (firefighting strategy)
- Access and facilities for personnel on Site
- BESS cabinet/enclosure location and proximity to infrastructure or populated areas
- The requirement to supplement any on-Site firefighting facility such as a dry pipe sprinkler or deluge system

Several manufacturers of BESS now advocate that if a thermal event occurs in a BESS unit and this progresses to thermal runaway, the BESS cabinet/enclosure should be allowed to consume itself or in other words, burn itself out. Furthermore, an increasing number of BESS manufacturers suggest that applying firefighting jets to the BESS cabinet/enclosure will have limited effect and could prolong the duration of the thermal event unnecessarily. In these instances, water fog or spray pattern branches should only be directed to areas to ensure the incident does not spread to adjacent BESS.

If it can be confirmed that the manufacturer's recommended firefighting tactic for the BESS cabinet/enclosure is to defensively firefight and boundary cool whilst allowing the BESS cabinet/enclosure to consume itself without spreading to neighbouring cabinets, this may reduce the water requirements - and thus the drainage / environmental protection requirements - significantly.

Water requirements will vary depending on the layout, design and number of BESS cabinets on the Site. The number of elevations that would need to be cooled to prevent fire spread should be considered in the discussions with developers.

Ingress Protection (IP) ratings of BESS cabinets/enclosures should be known, to understand the risks associated with boundary cooling.

In order to form an Emergency Response Plan, it is imperative to follow the manufacturer's instructions. This is to ensure that any incident is resolved swiftly and safely with minimal damage to the environment and the local area.

Any required installations of fire hydrants and connections to any dry pipe on the BESS Site should comply with BS 9990 Non-automatic firefighting systems in buildings code of practice (current edition). They should be identified in accordance with BS 3251 Indicator Plates for Fire Hydrants (current edition).

Fire hydrants provided should achieve a flow rate of no less than 25L/sec at any hydrant on the Site. This figure is based on the National Guidance Document on the Provision of Water for Firefighting (2025), produced by Water UK and the Local Government Association (LGA). The flow rate for transportation has been selected as the comparative value for flow rates, rather than that of a domestic housing development or an industrial setting.

Where a flow of 25L/sec cannot be achieved, it would be prudent to provide an equivalent static supply of water on Site that will provide for the same flow rate for a duration of 120 minutes. This equates to approximately 180,000L of water. The management of water run-off should be considered as part of the Site design (for example, drainage systems, interceptors, and bunded lagoons).

Water supplies for any on-Site suppression system must be independently calculated by a competent fire engineer, based on the design fire size of the BESS.

Any static water storage tanks designed to be used for firefighting should be located at least 10m away from any BESS container/cabinet to allow for safe access and usage. They should be clearly marked with appropriate signage and be easily accessible to fire and rescue service vehicles. Their location should be considered as part of a risk assessed approach that takes into account potential fire development and impacts. Outlets and connections should be agreed with the local fire and rescue service. Any outlets and hard suction points should be protected from mechanical damage (for example, through use of bollards).

Outline Battery Safety Management Plan

To ensure the provision of risk information to the fire and rescue service, the Site operator should develop and share an outline battery safety management plan with the local fire and rescue service point of contact. The layout and design of each operator's outline battery safety management plan will vary, but it should contain the following broad subject areas:

- How the fire and rescue service will be alerted
- A facility description, including infrastructure details, operations, number of personnel, and operating hours
- A Site plan depicting key infrastructure: Site access points and internal roads, firefighting facilities (for example, water tanks, pumps, booster systems, fire hydrants, and fire hose reels), drainage, and neighbouring properties
- Details of the emergency response coordinator, including the subject-matter expert for the Site
- Safe access to and within the facility for emergency vehicles and responders, including to key Site infrastructure and fire protection systems
- Details and explanation of warning systems and alarms on Site and locations of alarm annunciators with alarm details (smoke, gas, temperature)
- Hazards and potential risks at the facility and details of their proposed management
- The role of the fire and rescue service at incidents involving a fire, thermal event or fire spreading to the Site
- Emergency shutoff or isolator locations

Site Plans and Maps

In addition, Site plans should be provided to the fire and rescue that include:

- The layout of structures
- Any areas where hazardous and flammable materials are stored on Site (location of gas cylinders, process areas, chemicals, piles of combustible wastes, oil and fuel tanks)
- All permanent ignition sources on the Site and show they are a minimum of 6m away from combustible and flammable waste
- Any areas where combustible waste is being treated or stored, including non-waste material
- All separation distances
- Any areas where combustible liquid wastes are being stored
- Main access routes for fire engines and any alternative access
- Access points around the Site perimeter to assist firefighting
- Hydrants and water supplies
- Areas of natural and unmade ground
- The location of fixed plant or storage location of mobile plant when not in use
- The location of spill kits
- Any other relevant Site-specific information
- Drainage runs, pollution control features such as drain closure valves, and fire water containment systems such as bunded or kerbed areas (this may be easier to show on a separate drainage plan)

Plans provided must show all sensitive receptors within a 1km radius of the Site that could be affected by a fire. Examples of sensitive receptors may include:

- Schools, hospitals, nursing and care homes, residential areas, and workplaces
- Protected habitats, watercourses, groundwater, boreholes, wells, and springs supplying water for human consumption (Further habitat information can be found on the Defra MAGiC map)
- Roads, railways, bus stations, pylons (on or immediately adjacent to the Site only), utilities, and airports
- Plans should have a compass rose showing north and the prevailing wind direction.

Environmental Impacts

Suitable environmental protection measures should be provided. This should include systems for containing and managing water runoff. System capability/ capacity should be based on anticipated water application rates, including the impact of water based fixed suppression systems.

Sites located in flood zones should have details of flood protection or mitigation measures.

Recovery

The operator should develop a post-incident recovery plan that addresses the potential for reignition of ESS and de-energizing the system, as well as removal and disposal of damaged equipment.

O'Brien, D, Fletcher, S (Frazer-Nash Consultancy), Department for Energy Security and Net Zero (DESNZ), Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems, March 2024.

BESS Risk Assessment

Effective assessment of potential risks is central to management of health and safety at the outset of a project.

When considering the BESS context, hazards should be considered for all stages of the system lifecycle which are applicable to the organisation (either directly or indirectly). All system components should be designed, manufactured, and tested in accordance with relevant safety standards. The integration of BESS components should also be considered when performing a risk assessment, in particular any incompatibilities between components which may present a risk to H&S. The assessment should consider the total energy stored in the BESS and the population which may be affected by particular hazards.

As introduced in IEC 62933-5-2:2020, the international standard for electrochemical-based EES system safety requirements, is a standard which describes safety aspects for grid-connected electrochemical energy storage systems. IEC 62933-5-2 provides an assessment framework for the reduction of the risk associated with BESS as manufactured and intended to be installed.

Further detailed information on designer's considerations for risk assessments are presented in the Construction Industry Research and Information Association (CIRIA) guidance.

Planning applications and decisions should always be taken with a complete assessment of risks and impacts, both of the facility and the surrounding environment.

There should be a full consideration of risks including, but not limited to, accidental or intentional damage and natural phenomena and security. Note that risk assessments should be bidirectional - i.e., include both risks to the project and from the project. The planning process should assess the following risks and describe how the credible worst case has been mitigated.

Due to the potential hazards to the surroundings of any BESS, careful considerations must be made as to its location to determine the risks that the storage proposes. With lithium-based technologies, thermal runaway is a key failure mode which can lead to hazards to the nearby environment. Thermal runaway can be caused by a wide variety of internal and external factors, including physical damage, misuse, aging and fluctuating temperatures outside of the safe temperature range. Thermal runaway can lead to:

- Fire.
- Explosion.
- Release of toxic gases or water run-off.

These hazards pose a serious risk to the immediate vicinity of any BESS, which places an emphasis on the consideration of Site location, a few of which are explored in the following subsections. More detailed information on the hazards posed by chemical storage can be found in Annex 4A.2.

Battery system

Battery chemistry

There are a range of battery types available which suit different use cases, have a different maturity and which present different risks and safety profiles. Lithium-ion batteries make up the majority of the current grid-scale BESS global market share, due to their ideal characteristics of high energy density, high energy efficiency, and a long cycle life.

There are multiple variants of li-ion batteries, with Lithium Nickel Manganese Cobalt Oxide (NMC) and LFP the two main chemistries that dominate stationary li-ion energy storage projects. There are multiple trade-offs when selecting a battery cell types, including: power and energy density, availability, cost, and safety. From a safety perspective, it is noted that LFP batteries typically have better thermal stability (lowering the probability of thermal runaway) than NMC batteries. Battery chemistries will influence vapour cloud formation in the event of a battery fire. This can impact recommendations for system layout and fire containment.

Battery system capabilities, architecture and control

Battery systems are developed in a modular fashion, where individual battery cells are combined to create modules, modules are combined within racks, and these can then be combined to make fully containerised battery systems (usually with in-built control, protection and safety functions). Grid scale applications consist of multiple containers, connected via multiple inverters, transformers and switchgear under a single point of connection to the electrical grid. The individual batteries are monitored and controller via BMS (often with hierarchical control from modules up to overall containers), with an overall Plant Controller coordinating full BESS system operation (including interfacing with individual BMSs and other control systems such as the EMS). An onSite and/or remote-control room will provide a HMI to enable operator control. Sites may also integrate a third-party control/ control signals for service optimisers or Route to Market providers.

All aspects of this modular architecture can affect the capabilities and safety of the battery system. Specific safety considerations include:

- Equipment certification - having battery components tested under standards such as IEC 62619 and UL9540A is a key step in ensuring the robustness of battery installations. However, project integrators should not fully rely on test compliance, and ensure that their own specific system configuration matches standard test conditions. Potential issues may include:
- Insufficient segregation or partitioning between battery modules, where adjacent modules may drive an increase in temperature increase.
- Ineffective management of off gases between racks within a container.
- Insufficient separation between containers.
- Use case - The system is designed and operated to match its intended use case (s) (e.g. energy arbitrage, frequency response, stability support). Specific characteristics may include appropriate charge/ discharge cycling capability and tolerance to rapid discharge and how asset health may degrade over time based on how the battery is used. The use case for the battery system may change over time (e.g. to provide new grid services) and as such you may want to specify equipment with operating margins to safely manage future use cases. Battery manufacturers will be able to advise on the capability of their specific systems.

- Detection and monitoring - available technologies to identify and warn of developing hazards, (such as thermal runaway, cell venting or leakage) include BMSs able to detect developing fault conditions, electrolyte vapour detection systems, combustible gas monitoring with the ability to control container ventilation systems, and external audible and visual warning devices. Specific devices to assist in monitoring cell and container conditions are commercially available and can be deployed in addition to existing BMSs. Site level monitoring should be provided via the control room. The safety implications of any remote monitoring and control systems failures (e.g. due to a communication network failure) should also be assessed. This should inform design aspects such as communication reliability, availability, redundancy and back up control arrangements.
- Electrical configuration and interface - batteries can rapidly discharge significant amounts of electrical energy and as such electrical protection should be used to manage these hazards. Hazards such as arc flash are discussed further in section 3.2.2.1.
- Designing for location weather - consideration should be given to how weather at the selected battery Site may impact operating capabilities or asset degradation. Obvious examples include ambient temperature and how this might change over time (including the impacts of climate change and the possibility of extreme heatwaves). This could impact asset operation and cooling requirements. Other considerations include locations near the coast, where coastal 'salt air' can accelerate corrosion.

Lithium-ion specific standards

As a maturing technology there are standards addressing the full lifecycle of Li-ion battery developments, however these standards are also being constantly updated as technology progresses and risks are better understood.

BS EN IEC 62619:2022 covers the safety requirements and tests for the safe operation for secondary lithium cells and batteries, for industrial applications, which includes stationary applications. Published under the IEC 62619 umbrella, BS EN IEC 63056:2020 is specific towards lithium cells and batteries for use in BESS and covers the requirements and tests for product safety. Both documents make a normative reference towards BS EN 62620:2015, which also covers the marking, tests, and requirements for lithium secondary cells.

Monitoring, Fire Detection and Suppression

The selection of appropriate equipment for hazard mitigation can have a significant impact on overall system risk. Key considerations, particularly related to fire and explosion risks, are:

- Fire Detection and monitoring - detection of developing hazards such as fire, thermal runaway, cell venting or leakage through battery management systems (as discussed above) or separate smoke detectors, heat sensor, off-gas detection etc.
- Fire alerting - fire detection system should be linked to on-Site alarms sirens, control centres and the fire services for appropriate response.
- Fire suppression - this needs to be considered at both at a module and Site level, and approaches will depend on how fire spread is mitigated (e.g. separation as discussed in section 3.4) and the firefighting strategy for the facility (discussed more in section 3.5). Options include water or aerosol-based systems, with the NFCC highlighting that water-based systems are considered more effective than gaseous systems for fires involving battery cell modules.
- Venting and exhaust systems - to effectively mitigate explosion and deflagration hazards, BESS containers should be fitted with venting and explosion protection. The NFCC [5] recommend that exhaust systems should be specified to maintain an environment below 25% of LEL (in line with

similar industry guidance such as that from NFPA) and discharge vented flames and materials to a safe location where it will not contribute to further fire propagation.

- Security systems - including CCTV, alarms, motion sensors, container door sensors to enable remote Site monitoring and prevent unauthorised access.

As above, the safety implications of any remote monitoring and control systems failures (e.g. due to a communication network failure) should be assessed. This should inform design aspects such as communication reliability, availability, redundancy and back up control arrangements.

There is ongoing work within the industry to determine the most effective approaches for managing battery fires and as such guidance around this will likely change over time. To incorporate up to date good practice at the time of battery system development, it is important to seek advice from qualified persons. Engagement with the Fire and Rescue Service at this stage of development will also enable fire suppression systems to be aligned with a wider firefighting strategy.

Equipment Location

The physical distance between equipment is the most significant factor in how fire can spread within a BESS Site, so maintaining adequate separation is crucial to minimising its potential impacts. Containers housing battery cells, being the most likely source of a fire, must be separated from each other and from other equipment such as transformers, control equipment, office buildings, and from the Site perimeter. These separating areas, in addition to being physically large enough to prevent fire spreading across them, should be kept clear of obstruction and regularly assessed for contamination, e.g. with plant growth or spilled substances which could assist in fire propagation.

Guidance on appropriate separation distance varies across existing guidance documents, and as with all standards these are subject to change over time. It is advised that the relevant competent duty holder take a precautionary approach based on available standards and always conduct their own fire risk assessment to understand Site specific risks and demonstrate that appropriate mitigations for fire spread are in place.

Current standards include:

- NPFA 855 requires a standard separation distance of a minimum of 10 ft (3048 mm), with the opportunity to reduce this to 3 ft (914 mm) where design mitigations have been taken such as large-scale fire testing (complying with UL 9540A or equivalent test standard), the use of non-combustible walls or containers with 2-hour fire resistance rating established in accordance with ASTM E119 or UL 263.
- FM Global differentiate requirements for different battery chemistries. For outdoor containers made of non-combustible materials:
  1. Where the BESS comprises of LFP cell type, separation of at least 5 ft (1.5 m) on sides that contain access panels, doors or deflagration vents is recommended.
  2. Where the BESS comprises of NMC cell type, separation of at least 13 ft (4.0 m) on sides that contain access panels, doors, or deflagration vents is recommended. Where containers have at least a 1-hour rating in accordance with ASTM E119, aisle separation of at least 8 ft (2.4 m) is acceptable.

Guidance on appropriate separation distances between BESS containers is provided by the NFCC.

The location and routing of cables, pipes and other conduits should also be considered at this stage, for example whether cables should be buried in the ground or carried by overhead gantries.

Access Routes

Emergency scenarios - consider how emergency responders, such as the Fire and Rescue Service or paramedics, can obtain access to and move around the Site in the event of a fire or other emergency. This will likely necessitate at least two separate access routes onto the Site in case one becomes obstructed or inaccessible.

Further guidance on Site access requirements for response to emergency situations is provided by the NFCC.

Emergency Planning

Emergency response arrangements and preparedness plans should be developed as early as possible in the system lifecycle and be considered at each stage. Services such as the local Fire and Rescue Service should be consulted primarily in the Design & Planning stage to understand emergency response requirements (e.g. the potential firefighting strategy) and inform the stakeholders (Asset Owners and Designers) of the H&S requirements for their application. This engagement is encouraged by government within BESS planning guidance.

Documented procedures for emergency access and plans to minimise fire risk will also contribute to the avoidance of incidents and damage to both the assets, the environment, and potential injury to workers and emergency response personnel. Having the Fire and Rescue Service, or similar, consulting on the project/ design of a project will also ensure they are aware of potential hazards installed in their area which may include natural, human-error or technical fault events that can occur at any time.

An ERP should be produced detailing key actions and arrangements for foreseeable emergencies, including:

- Response to fire incidents, including the firefighting strategy for large scale fires.
- Management of potential chemical release (e.g. assessment of smoke plume impacts during fires, water and drainage management, including for contaminated run-off).
- Response to severe environmental hazards such as flooding and operating in high winds (including responding to emergencies in these conditions).
- Access/ egress routes for staff, emergency responders and vehicles during emergencies including routes.
- In and out of Site, access to key equipment, out-of-hours response, Site visibility particularly in dark conditions, sufficient turning circles secondary routes available if primary routes are blocked.
- Response to security incidents including cybersecurity attacks.

The ERP should also made available to the local Fire and Rescue Service for review. Once finalised the ERP should be stored in a clearly marked location on Site, so that emergency responders are able to identify and access it quickly. Duty holders responsible for Sites containing 25 tonnes or more of dangerous substances must notify fire and rescue services under the NAMOS Regulations 1990.

It is noted that the American Clean Power Association (ACP) have published a Draft Emergency Response Plan, with the intention that this be adapted by their members. This may serve as a useful reference when developing a Site ERP.

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