Tillbridge Solar

Tillbridge Solar Project

EN010142

Volume 7
Framework Battery Safety Management Plan

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1. Introduction

1.1 Background

1.1.1 Tillbridge Solar Ltd (hereafter referred to as 'the Applicant') has commissioned AECOM to prepare this Framework Battery Safety Management Plan (FBSMP) for the proposed Tillbridge Solar Project (hereafter referred to as the 'Scheme').

1.1.2 The Scheme will comprise the construction, operation (including maintenance), and decommissioning of ground-mounted solar photovoltaic (PV) arrays. The Scheme will also include associated development to support the solar PV arrays.

1.1.3 The Scheme is made up of the Principal Site, the Cable Route Corridor and works to the existing National Grid Cottam Substation. The Principal Site comprises the solar PV arrays, electrical substations, grid balancing infrastructure, cabling and areas for landscaping and ecological enhancement.

1.1.4 The associated development element of the Scheme includes but is not limited to access provision; a Battery Energy Storage System (BESS), to support the operation of the ground mounted solar PV arrays; the development of on-site substations; underground cabling between the different areas of solar PV arrays; and areas of landscaping and biodiversity enhancement.

1.1.5 The Scheme also includes a 400kV underground Cable Route Corridor of approximately 18.5km in length connecting the Principal Site to the National Electricity Transmission System (NETS) at the existing National Grid Cottam Substation. The Scheme will export and import electricity to the NETS.

1.1.6 A full description of the Scheme is included in **Chapter 3: Scheme Description** of the Environmental Statement **[EN010142/APP/6.1].** An overview of the Scheme and its environmental impacts is provided in the Environmental Statement **Non-Technical Summary [EN010142/APP/6.4]**.

1.1.7 The Applicant has had regard to feedback received during consultation with stakeholders and updated this FBSMP, as appropriate (refer to Section 4 for further information). It is proposed that the implementation of the FBSMP will be secured through a Requirement in Schedule 2 of the **draft Development Consent Order (DCO) [EN010142/APP/6.1]**. This will stipulate that a detailed Battery Safety Management Plan will be submitted to and approved in consultation with the Fire and Rescue Service (FRS) by the relevant planning authorities prior to the commencement of the works for the BESS. This plan will be substantially in accordance with this FBSMP.

1.2 Technical Terms and Definitions

1.2.1 The following technical terms and definitions have been used in the document and/or reference documents and will form the basis of understanding (refer to **Table 1-1**).

1.2.2 Refer to **Chapter 0: Contents and Glossary** of the ES **[EN010142/APP/6.1]** for definitions of general terms.

Table 1-1: Technical Terms and Definitions

Term	Definition
Battery Energy Storage System (BESS)	Batteries with associated infrastructure to store, import and export electricity to the national grid.
BESS Enclosure	Refers to the enclosed structure containing each BESS
Cell	Refers to the Li-ion unit that provides a source of electrical energy by direct conversion of chemical energy.
Developer	Individual, association, corporation, or other legal entity that owns, operates, or proposes to construct, own, or operate, a project. I.e., Tillbridge Solar Ltd.
EMC	Electromagnetic Compatibility.
EMS/BMS	Energy Management System/Battery Management System.
Energy Storage System (ESS)	Device or group of devices assembled that is to convert the electrical energy from power systems and store energy in order to supply electrical energy at a later time when needed.
Fire Suppression System	Active fire prevention system placed inside the battery enclosure.
FM Global	Factory Mutual (FM) Global is an American mutual insurance company specialising in loss prevention for large corporations in the Highly Protected Risk property insurance market sector.
FPA	The Fire Protection Association (FPA) is the UK's national fire safety organisation who work to identify the dangers of fire and help their clients reduce fire-related risks.
FRS	Fire and Rescue Service.
Heating and Cooling System	System which regulates temperature and humidity within the BESS enclosure.
Installer	Individual or company in charge of BESS installation.
Inverter	Inverters are required to convert the DC electricity collected by the PV modules into alternating current (AC), which allows the electricity generated to be exported to the National Grid.
LEL/LFL	Lower Explosive Limit / Lower Flammable Limit.
BESS / ESS Manufacturer	Company who manufactures the Scheme's BESS and ESS equipment.

Term	Definition
Tier 1 BESS OEM / Integrator	North American, Korean or European Battery OEM / BESS Integrator, CATL, EVE & BYD (China) are also classified as Tier 1 suppliers. . In this report they are the suppliers of the BESS systems.
Maximum parameters	These defines the worst-case extent of design elements of the Scheme, or factors arising from them, for example maximum fire load depending on the selected battery technology.
Module	Compact module that integrates several Li-ion cells.
Mitigation	Measures including any process, activity, or design to avoid, prevent, reduce, or, if possible, offset any identified significant adverse effects on the environment.
NFCC	UK National Fire Chiefs Council.
NFPA	The National Fire Protection Association (NFPA) is an international non-profit organisation devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards.
Off-Gassing	The event in which the battery cell case vents due to a rise in internal pressure.
Operator	Individual/s in charge of day to day operations within the BESS.
Rack	Composed of several modules in series, including their management system.
The Scheme	The Scheme is the collective term for the Principal Site and Cable Route Corridor. The boundary of the Scheme is defined as the Order limits.
On-site substations	Compound containing electrical equipment to enable connection to the national grid.
National Grid Cottam Substation	The substation at Cottam Power Station located south of Cottam village, Nottinghamshire owned and operated by National Grid and where the Grid Connection Cable will connect to.
Temporary construction compound	Any working area defined for the purpose of storage of plant, materials, or equipment or for the use of welfare and site management.
Transformers	Transformers control the voltage of the electricity generated across the Principal Site before it reaches the On-site substations.

2. Scheme Description

2.1 Introduction

2.1.1 This report presents an FBSMP for the BESS[1] proposed for the Scheme.

2.1.2 As stated in **Chapter 1: Introduction** of the ES **[EN010142/APP/6.1]**, the Scheme comprises two distinct sections. These sections are:

a. 'The Principal Site', which is the location where ground mounted solar photovoltaic (PV) panels, electrical sub-stations and energy storage facilities will be installed; and

b. 'The Cable Route Corridor', which will comprise the underground electrical infrastructure required to connect the Principal Site to the National Grid Cottam Substation.

2.1.3 The Principal Site is located to the south of Harpswell Lane (A631), to the west of Middle Street (B1398) and largely to the north of Kexby Road and to the east of Springthorpe. The Principal Site covers an area of approximately 1,350ha and is located entirely within the administrative area of West Lindsey District Council in Lincolnshire. The Principal Site will be connected by the Cable Route Corridor to the Cottam National Grid Substation, located at the decommissioned Cottam Power Station in Cottam, within the administrative area of Bassetlaw District Council on the Nottinghamshire border.

2.2 General Arrangement

2.2.1 The Scheme will consist of the following components:

a. Solar PV panels;

b. Solar Stations (inverter, transformer and switchgear);

c. BESS (comprising BESS Stations);

d. Battery Direct Current (DC)/DC convertors;

e. On-site cabling;

f. On-site sub-stations;

g. Solar farm control centre;

h. Equipment storage;

i. Fencing, security and lighting;

j. Site access and access tracks;

k. Surface water drainage; and

l. Electricity connection to National Grid via Cable Route Corridor.

2.2.2 The Tillbridge circuit will be connected to an existing free bay at Cottam sub-station.

[1]At this stage, BESS Technology is assumed based on a lithium-ion chemistry technology.

2.2.3 Refer to **Chapter 3: Scheme Description** of the ES **[EN010142/APP/6.1]** for a detailed description of the components of the Scheme.

2.2.4 During the construction phase, temporary construction compounds will be required as well as temporary roadways to facilitate access to all land within the Order limits.

2.2.5 The Scheme will include BESS as an associated development and is primarily required for the operation of the solar PV panels. The BESS is designed to provide peak generation and grid balancing services to the electricity grid by allowing excess electricity generated either from the solar PV panels, or imported from the electricity grid, to be stored in batteries and dispatched, when required.

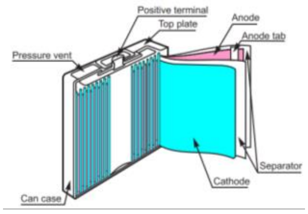
2.2.6 The illustrative design for the Scheme comprises of up to 140 BESS Stations co-located alongside Solar Stations, spread across up to 50 locations on the Principal Site. However the precise number of individual battery energy storage enclosures will depend upon the level of power capacity and duration of energy storage that the Scheme will require.

2.2.7 The exact locations of the BESS, transformers, and dedicated switchgear are yet to be determined, but the BESS will be DC-coupled, which means electricity flows from solar panels and directly feeds into a battery system with no inversion of electricity from DC to AC and back to DC before storage in the batteries. As such, BESS will be spread across the Principal Site and located alongside the Solar Stations. By comparison an AC-coupled system would require greater consolidation as electricity from the solar panels would be required to be inverted from DC to AC through additional equipment before storage. The DC-coupled concept results in minimal system and cable losses between the components. **Figure 3-1** of the ES **[EN010142/APP/6.3]** comprises an Indicative Principal Site Layout Plan and shows the potential number and distribution of BESS and Solar Stations across the Scheme. The final location of BESS would be established within areas marked as Work No. 2 on **Works Plans [EN010142/APP/2.3]** and in accordance with the **Outline Design Principles Statement [EN010142/APP/7.4].** An illustrative battery enclosure is shown below.

2.2.8 It is known that the BESS's will consist of a compound and battery array. **Table 2-1** outlines the limits of the design parameters for the BESS, which will allow flexibility and optimisation of the Scheme moving forward.

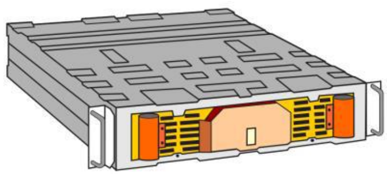
Table 2-1: BESS Design Parameters

Scheme Component	Applicable Design Parameters
Cell	The batteries selected for use on the Scheme will be from tier 1 manufacturers and will utilise a lithium-ion battery chemistry. Cell design will be certified to UL 1973 (Ref. 1) and tested to UL 9540A (Ref. 2) unit or installation level for BESS designs.

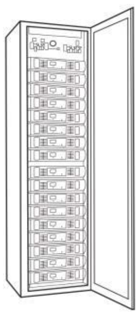
<table>
<tr><th>Scheme Component</th><th>Applicable Design Parameters</th></tr>
<tr><td></td><td>

Typical Prismatic cell (Ref. 4).</td></tr>
<tr><td>Module</td><td>Battery modules are comprised of multiple cells. Safety Certifications and mitigation features typically found within the battery module design, which the Applicant will commit to for the Scheme, include:

Internal fuses
Liquid cooling system with automated fail-safe operation
Active thermal management system
Contactor at rack/string and bank level
Overcharge safety device
Internal passive protection products
Venting systems and gas channels
Thermal or multi-sensor monitoring devices. .. In all cases, the module design will be certified to UL 1973 (Ref. 1) and tested to UL 9540A (Ref. 2) unit or installation level for BESS designs.



Typical Enclosed Module (Ref. 4).</td></tr>
<tr><td>Rack</td><td>There are a wide range of BESS battery rack designs. Rack design will have been tested to UL 9540A unit or installation level. Passive protection, ventilation and integrated suppression system (defined as thermal management systems) designs for lithium-ion battery systems will have been validated during large scale testing (UL and / or 3rd party fire and explosion testing stipulated in NFPA 855 (2023) (Ref. 3).

Typical Rack (Ref. 2). 6 MW Leighton Buzzard</td></tr>
</table>

Scheme Component	Applicable Design Parameters
BESS Enclosure *Mobile Energy Storage Container*	The BESS enclosure will have multiple racks with direct access either from the ends or side of the enclosure depending on the manufacturer. Typically, construction will be in the form of modified 20-foot / 40-foot ISO shipping containers OR modular premanufactured containers classified as cabinet systems (NFPA 855) / enclosures. The BESS enclosure design will be tested to UL 9540A unit or installation level and will either integrate a gas exhaust / ventilation system performance tested through full scale fire and explosion testing or comply with NFPA 69 (Ref. 5) explosion prevention standards. Complimentary deflagration vent designs should meet NFPA 68 (Ref. 6) standards or be fully validated through significant scale testing (i.e. Tesla Megapack system).
Operational Office / Warehouse Building	A Solar Farm Control Centre will be included within the Scheme. It will consist of: • Central Control Room where all operational data of the whole plant will be controlled and monitored; • Central CCTV and security control of the whole plant including access gates to fenced areas; • Welfare facility for staff and subcontractors; • Parking area for staff and visitors; and • Own power supply including emergency power supply. The Scheme will require spare parts for operation over time. Storage will be provided for spare solar PV panels, trackers, inverters, spare parts for the transformer, switchyard, BESS, CCTV, metrological stations, as well as extra cable reels. Storage of BESS and their components involve risks that have been studied in this report proposing possible mitigation measures.
Energy Storage System (ESS) equipment	Equipment located within or in close proximity to the BESS enclosure. Typical equipment includes transformers, switchgear, power conversion system (PCS) or inverter, and other ancillary equipment.
Substations	The substations will consist of electrical infrastructure such as the transformers, switchgear and metering equipment required to facilitate the export of electricity from the Principal Site to the National Grid. The substations will operate at 400kV/33kV and there will be two substations on-site.
Firefighting Water Storage Tanks and/or Hydrants	The BESS Stations will be designed to integrate pressure fed fire hydrants and/or static water tanks (tanks can be integrated above or below ground) for firefighting, depending on available water supply. Water provision will be designated for the cooling of adjacent BESS or ESS equipment. Water tanks will be located at least 10m from

Scheme Component	Applicable Design Parameters
	the nearest BESS enclosure. Water access points, whether hydrants or tank connections, would be located in consultation with the Lincolnshire Fire Rescue (LFR) to provide redundancy and safe operating distances for firefighters with 30 – 50m, which is considered an optimal safe distance. Tanks and water outlets would be clearly labelled with appropriate signage and marked on site plans. Additionally, to avoid any mechanical damage, outlets and hard suction points would be safeguarded with bollards. The number of water tanks and volume of the water supply will be agreed with the LFR and be validated by an Independent Fire Protection Engineer based upon BESS internal suppression system performance capability from significant scale fire and explosion testing. UK NFCC guidelines stipulate tanks and/or hydrants should be capable of delivering no less than 1,900 litres per minute for at least 2 hours. The firefighting water requirement will be fully assessed at the detailed design stage based upon BESS fire and explosion test data by an independent Fire Protection Engineer and water storage volumes will be agreed with Lincolnshire FRS during detailed design. They must be easily accessible to FRS vehicles and their siting should be considered as part of a risk assessed approach that considers potential fire development/impacts. Outlets and connections should be agreed with Lincolnshire FRS

3. Purpose and Scope

3.1.1 The scope of this FBSMP covers the life safety and property protection fire and explosion risk safety requirements of the BESS at the Scheme. The BESS will include integrated fire and explosion protection systems. Following industry good practice (e.g., NFPA 855 2023 (Ref. 3)) or based on 3rd party fire and explosion testing, gas venting systems will avoid build-up of explosive gases. A site-specific Emergency Response Plan (ERP) will be developed for the BESS post consent, based on national and international best practice measures.

3.1.2 The purpose of this FBSMP is to demonstrate that the location of BESS within the Scheme does not give rise to a significant increase in fire and explosion risk and that any risk that does exist can be addressed by ensuring that the Scheme is constructed, operated and decommissioned in accordance with this FBSMP.

3.1.3 Principal Site emergency response requirements are currently being discussed with the local authorities and LFR. This information will be considered to complete the Battery Safety Management. Once information is available it will be updated and secured via DCO requirement.

4. Consultation

4.1.1 Effective stakeholder engagement and consultation is a key requirement of the Planning Act 2008. The following stakeholders have been identified with the aim of ensuring collective agreement on the FBSMP:

a. **Tillbridge Solar Ltd** is the Applicant for the Scheme. Tillbridge Solar Ltd is a joint venture between Tribus Clean Energy and Recurrent Energy, a subsidiary of Canadian Solar.

b. **AECOM** is a multidisciplinary engineering consultancy appointed to advise on the environment and fire safety of this Scheme.

c. **Lincolnshire Fire and Rescue Service** is the statutory fire and rescue service covering Lincolnshire. They have been consulted in preparation of this FBSMP.

d. **Paul Gregory** is an independent BESS expert with significant experience testing and validating lithium ion battery and BESS safety solutions / equipment and has been appointed by the Applicant as a peer reviewer to provide guidance.

4.1.2 An e-mail response was received from Lincolnshire FRS on 2 January 2024 during targeted consultation for the Scheme. Meetings were also held with LFR on 16 August 2023 and 2 February 2024 to discuss site plans, FBSMP content, firefighting water supply and emergency access routes.

4.1.3 A summary of the matters raised by Lincolnshire FRS during consultation and where these are addressed in this FBSMP is provided in **Table 4-1**.

Table 4-1 Main matters raised during consutlation

Consultee	Summary of main matter raised	How has the matter been addressed?	Relevant location in this FBSMP
Lincolnshire Fire and Rescue	The developer should continue to engage with LFR as the project and safety measures evolve to ensure it complies with the statutory responsibilities that LFR enforce.	Consultation with LFR will continue as relevant, and the detailed Battery Safety Management Plan will be submitted to and approved in consultation with the LFR.	N/A
	The developer should produce a risk reduction strategy (Regulation 38 of the Building Regulations) as the responsible person for the scheme as stated in the Regulatory Reform (Fire Safety) Order 2005. The strategy should cover the construction, operational and decommissioning phases of the project.	This FBSMP details risk assessment tools that will be utilised together with site specific detailed consequence modelling to provide a comprehensive site operations and emergency response safety audit at the detailed design stage in accordance with the Building Regulations. This will ensure the highest levels of safety are secured during the construction, operational and decommissioning phases of the Scheme. The battery system mitigation measures adopted in a final Battery Safety Management Plan, will reflect the latest BESS safety codes and standards applicable at that stage. Mitigation measures will be discussed and coordinated with LFR.	Section 6.1
	LFR works within the guidance of the National Fire Chief's Council (NFCC) which constitutes LFR's requirements for new BESS development proposals	NFCC guidance has been applied as one of the minimum safety standards	Section 5.3.

Consultee	Summary of main matter raised	How has the matter been addressed?	Relevant location in this FBSMP
		proposed by this FBSMP for the Scheme.	
	LFR referenced the Department for Levelling Up, Housing and Communities (DLUHC) Planning Policy Guidance which has been updated to include reference to battery energy storage systems.	Noted. The Scheme will comply with the Department for Levelling Up, Housing and Communities (DLUHC) Planning Policy Guidance (2023).	Section 5.3
	LFR recommend applying the National Fire Protection Association (NFPA) 855 Standard for the Installation of Stationary Energy Storage Systems as the latest applicable guidance for our Scheme.	The Scheme will comply with the latest version of NFPA 855 (Ref. 3) relevant at the detailed design stage, the FBSMP complies with NFPA 855 (2023) standards and recommendations.	Section 5.3
	The site design should include a safe access route for fire appliances to manoeuvre within the site (including turning circles). An alternative access point and approach route should be provided and maintained to enable appliances to approach from an up-wind direction.	These design features will be dictated by the number and location of BESS Stations, integrated at the detailed design stage and agreed with LFR. Directional signage requirements will also be agreed with LFR at the detailed design stage.	Section 7.3
	Consideration should include the fixing of an Information Box (IB) at LFR access point(s). The purpose of the IB is to provide information for first responders e.g. Emergency Response Plan, to include water supplies for firefighting, drainage plans highlighting any Pollution Control Devices (PCDs) / Penstocks etc for LFR.	The Applicant will accommodate this request.	N/A

Consultee	Summary of main matter raised	How has the matter been addressed?	Relevant location in this FBSMP
	The water supply for each cluster of BESS Stations should be able to provide a minimum of 1,900 l/min for at least 120 minutes (2 hours). If hydrants are integrated on site, then these should be pressure fed and be strategically located across the development. These should be tested and serviced at regular intervals by the operator. If the site is remote from a pressure feed water supply, then an Emergency Water Supply (EWS) meeting the above standard should be incorporated into the design of the site e.g. an open water source and/or tank(s). If above ground EWS tanks are installed, these should include facilities for LFR to discharge (140/100mm RT outlet) and refill the tank.	Tillbridge is a DC coupled site spread over a wide area, so the Applicant has agreed to investigate the best solution for the site. This could include hydrant networks fed from water tanks, integrating a hydrant network would reduce the number of water tanks required to service the site and tanks could be located in fewer strategic locations where operability would not be impacted by wind direction and smoke impingement. The FBSMP references both a water tank option and a water tank + hydrants option.	Section 2.2 - Table 2-1.

5. Building Regulations, Safety Standards and Guidelines

5.1 General

5.1.1 The following standards and regulations are up to date as of the date of preparation of this report.

5.1.2 The FBSMP will be updated if relevant legislation / guidance is introduced that triggers a change to the Battery Safety Management Plan, or if there is a change to the Scheme (development or process) itself.

5.2 Building Regulations – BESS Fire and Explosion protection

5.2.1 NFPA 855 (2023) (Ref. 3) currently provides the most comprehensive guidelines for BESS design and site installation specifications. BESS design structural integrity must be demonstrated through full scale fire and explosion testing or by integrating NFPA 69 (Ref. 5) (Explosion prevention) and NFPA 68 (Ref. 6) (Explosion protection through deflagration venting) features.

5.3 Safety Standards and objectives

5.3.1 The safety objectives for the design of the BESS are:

a. To minimise the likelihood of an emergency event such as a fire;
b. To minimise the consequences should an event occur;
c. To restrict any event to the BESS site and minimise any impact on the surrounding areas;
d. To automatically detect and begin to control a fire as soon as possible;
e. To ensure any personnel on site can evacuate safely off site;
f. To ensure that firefighters can operate in reasonable safety where necessary;
g. To ensure that fire, smoke, and any release of toxic gases does not significantly affect site operations, first responders, and the local community;
h. To ensure that firewater run-off is contained and treated (if required).

5.3.2 BESS design and site layout should minimise the requirement for direct Fire and Rescue Service (FRS) intervention in a thermal runaway incident i.e. the use of direct hose streams or spray directly on BESS battery systems. FRS intervention in worst case scenarios would ideally be limited to boundary cooling of adjacent BESS and ESS units to prevent the fire from spreading. This strategy should be finalised with the LFR and be clearly communicated in the Emergency Response Plan.

5.3.3 Where the BESS system is designed to safely burn out to remove the risk of stranded energy in the battery systems, then full scale free burn testing will have been conducted prior to installation to demonstrate that loss will be safely limited to one enclosure without the intervention of the LFR.

5.3.4 There is currently limited UK specific guidance for BESS, so the Applicant has incorporated international best practice into these objectives and the FBSMP. This document considers the recommendations of the following minimum safety standards and best practice documentation currently used in the UK as shown in **Table 5-1**. Revisions to codes and standards generally works to three-year cycles and the final BSMP will incorporate the appropriate recommendation and standards relevant at the time of drafting.

Table 5-1: Applicable Safety Standards

Group Category	Standard	Year	Description
Fire Detection and Alarm	BS EN 54	-	All parts.
	BS 5839-1	2017	Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.
	BS 6266	2011	Fire protection for electronic equipment installations.
	BS EN 60079-29-3	2014	Part 29-3. Gas detectors. Guidance on functional safety of fixed gas detection systems.
Guidance	Department for Levelling Up, Housing and Communities (DLUHC) Planning Policy Guidance - Renewable and low carbon energy	2023	Guidance on the relevant planning considerations for renewable and low carbon energy projects (including BESS).
Automatic Fire protection	BS 5306-0	2020	Fire protection installations and equipment on premises. Guide for selection, use and application of fixed firefighting systems and other types of fire equipment.
	BS EN 12845	2015	Fixed firefighting systems. Automatic

Group Category	Standard	Year	Description
			sprinkler systems. Design, installation and maintenance.
	BS EN 14972-1	2020	Fixed firefighting system. Water mist Systems. Design, installation and maintenance.
	FM Global Property Loss Prevention Data Sheet 2-0	2021	Installation guidelines for automatic sprinklers.
	United Kingdom Power Networks (UKPN) Engineering Design Standard 07-0116	2016	Fire Protection Standard for UK Power Networks Operational Sites.
Battery Safety	UL 1973	2022	Batteries for Use in Stationary and Motive Auxiliary Power Applications.
	UL 9540A (4th Edition)	2019	Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.
	BS EN IEC 62619	2017	Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries, for use in industrial applications.
	UN 38.3		UN Recommendations on the Transport of Dangerous Goods Manual of Tests and Criteria
	BS EN IEC 62281	2019	Safety of primary and secondary lithium cells and batteries during transport.

Group Category	Standard	Year	Description
	BS EN IEC 61000-4-2	2008	Electromagnetic compatibility (EMC). Testing and measurement techniques. Electrostatic discharge immunity test.
	BS EN IEC 61000-4-3	2020	Electromagnetic compatibility (EMC). Testing and measurement techniques. Radiated, radiofrequency, electromagnetic field immunity test.
	BS EN IEC 61000-4-4	2012	Electromagnetic compatibility (EMC). Testing and measurement techniques. Electrical fast transient/burst immunity test.
ESS EMC Safety	BS EN IEC 61000-4-5	2014	Electromagnetic compatibility (EMC). Testing and measurement techniques. Surge immunity test.
	BS EN IEC 61000-4-6	2023	Electromagnetic compatibility (EMC). Testing and measurement techniques. Immunity to conducted disturbances, induced by radiofrequency fields.
	BS EN IEC 61000-4-8	2009	Electromagnetic compatibility(EMC). Testing and measurement techniques. Power frequency magnetic field immunity test.
	BS EN IEC 61000-6-2	2016	Electromagnetic compatibility (EMC). Generic standards.

Group Category	Standard	Year	Description
			Immunity standard for industrial environments.
	BS EN IEC 61000-6-4	2018	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments.
	IEC CISPR 11	2022	Industrial, scientific, and medical equipment. Radio-frequency disturbance characteristics. Limits and methods of measurement. Conducted emissions and Radiated emissions tests.
BESS Safety	NFPA 855	2023	Standard for the Installation of Stationary Energy Storage Systems.
	UL 9540	2023	Standard for Energy Storage Systems and Equipment.
	NFPA 70	2023	National Electric Code.
	NFPA 68	2018	Standard on Explosion Protection by Deflagration Venting.
	BS EN 14797	2007	Explosion venting devices
	NFPA 69	2019	Standard on Explosion Prevention Systems.
	BS EN 16009	2011	Flameless Explosion Venting Devices.
	BS EN 14373	2021	Explosion Suppression Systems.
	CE mark		European conformity - Low voltage and EMC directives.
	UKCA mark		UK conformity – Low voltage and EMC directives.

Group Category	Standard	Year	Description
	BS EN IEC 62933-2-1	2018	Electrical Energy Storage (EES) systems. Part 2-1 Unit parameters and testing methods - General Specification.
	BS EN IEC 62933-5-1	2020	Electrical energy storage (EES) systems – Part 5-1: Safety considerations for grid-integrated EES systems – General specification.
	BS EN IEC 62933-5-2	2020	Electrical Energy Storage (EES) systems. Part 5-2: Safety requirements for grid integrated EES systems. Electrochemical-based systems.
	BS EN IEC 61439-1	2020	Low-voltage switchgear and control gear assemblies – Part 1: General.
	BS EN IEC 61439-2	2020	Low-voltage switchgear and control gear. assemblies – Part 2: Power switchgear and control gear assemblies.
	BS EN IEC 60364	2009	Low-voltage electrical installations.
	FM DS 5-33	2017	FM Global Property Loss Prevention Data Sheets: Electrical Energy Storage Systems.
	BS EN IEC 60812	2018	Failure modes and effects analysis (FMEA and FMECA).
	EPRI 3002022540	2021	EPRI BATTERY STORAGE FIRE SAFETY ROADMAP: EPRI's Immediate, Near, and Medium-Term Research Priorities to Minimize Fire Risks for Energy Storage Owners

Group Category	Standard	Year	Description
			and Operators Around the World.
BESS Enclosure Integrity	BS EN IEC 60529	2013	Degree of Protection Provided by Enclosure (IP Code).
	UL 50E	2020	Enclosures for Electrical equipment, Environmental considerations.
	BS EN IEC 62262	2002	Degrees of Protection Provided by Enclosure for Electrical Equipment Against External Mechanical Impacts (IK code).
BESS Enclosure wall fire resistance (1 hour minimum)	BS EN 13501-2	2016	Fire classification of construction products and building elements. Classification using data from fire resistance tests, excluding ventilation services (E60/EI15 single wall, EI60 double wall).
	BS EN 1364-1	2015	Fire resistance tests for non-loadbearing elements: Walls.
ESS Seismic integrity (control and switchbox)	IEEE 693	2018	IEEE Recommended Practice for Seismic Design of Substations.
	BS EN IEC 60068-3-3	2019	Environmental testing. Supporting documentation and guidance. Seismic test methods for equipment.
PCS standards (common standards)	UL 1741	2021	Standard for Safety Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources.
	IEEE 1547	2018	IEEE Standard for Interconnection and

Group Category	Standard	Year	Description
			Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.
	CSA C22.2 No. 107.1:16	2021	Power conversion equipment.
	BS EN IEC 62109-1	2010	Safety of power converters for use in photovoltaic power systems. General requirements.
	BS EN IEC 62109-2	2011	Safety of power converters for use in photovoltaic power systems. Requirements for inverters.
	BS EN IEC 62477-1	2022	Safety requirements for power electronic converter systems and equipment. General.
	BS EN IEC 61000-6-2	2016	Electromagnetic compatibility (EMC). Generic standards. Immunity standard for industrial environments.
	BS EN IEC 61000-6-4	2018	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments.
	IEC CISPR 11	2022	Industrial, scientific, and medical equipment. Radiofrequency disturbance characteristics. Limits and methods of measurement. Conducted emissions and Radiated emissions tests.
	BS EN IEC 62909-1	2017	Bi-directional grid-connected power

Group Category	Standard	Year	Description
			converters. General requirements.
	BS EN IEC 62909-2	2019	Bi-directional grid-connected power converters. Interface of GCPC and distributed energy resources.
Fire and Rescue Service	Local Government Association and Water UK	2007	National Guidance Document on the Provision of Water for Firefighting.
	National Fire Chiefs Council (NFCC)	2023	National Operational Guidance. Hazard – Fire water run-off.
	National Fire Chiefs Council (NFCC)	2023	Grid Scale Battery Energy Storage System planning – Guidance for FRS.
Cybersecurity	UL 1741	2021	Standard for Safety Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources.
	UL 2941	2023	Outline of Investigation for Cybersecurity of Distributed Energy and Inverter-Based Resources.
	BS EN IEC 62433	2021	Security of Industrial Automation and Control Systems (IACS) (Ref. 8).
	IEEE 1547.3	2023	Guide for Cybersecurity of Distributed Energy Resources (DER) interconnection with Electric Power Systems (EPS) (Ref. 11).
	IEEE 1815	2012	Standard for EPS Communications - Distributed Network Protocol (DNP3) (Ref. 10).

6. Risk Assessment and Emergency Response Planning

6.1 General Risk Assessment information

6.1.1 The site owner during design development, as well as the operator once appointed, will work closely with LFR to provide all relevant information on BESS and site design features to inform all necessary hazard and risk analysis studies and assist in the development of comprehensive Risk Management and Emergency Response Plans (RM & ERP). The final BESS design for the Scheme will include this RM & ERP.

6.1.2 Information will be supplied as early as possible in the detailed design stage to allow an initial appraisal of the BESS to be made. This information will be provided to LFR with appropriate evidence provided to support any claims made on performance, and with appropriate standards cited for installation.

6.1.3 Such information should also be made available to LFR for inclusion in Site Specific Risk Information (SSRI) records.

6.1.4 BESS hazards for first responders and site operatives once a fire has started depend on the BESS design but are typically defined as: fire, explosion, chemical hazards, carbon monoxide, carbon dioxide, hydrocarbon gases, and hydrogen. Full PPE should be worn, and operations should not generally be conducted within any identified blast exclusion zones (close proximity to doors and deflagration vents).

6.1.5 NFPA 855 (2023) (Ref. 3) does define some basic emergency response protocols for any BESS design:

a. Potential debris impact radius is defined as 100 feet / 30.5 metres i.e., this is a typical explosion risk safe exclusion zone radius as modelling and previous BESS incidents typically show 25 metres to be maximum radius.

b. Automatic building evacuation area is defined as 200 feet / 61 metres from the affected BESS container.

6.1.6 NFPA 855 (2023) also defines five BESS hazard categories – hazards are assessed under both normal operating conditions and emergency / abnormal conditions:

a. Fire and explosion hazards;

b. Chemical hazards;

c. Electrical hazards;

d. Stored / stranded energy hazards; and

e. Physical hazards.

6.1.7 At the detailed design stage for the Scheme, risk assessment tools will be utilised together with detailed consequence modelling to provide a comprehensive site operations and emergency response safety audit.

6.1.8 As stipulated in NFPA 855 (2023):

A Failure Modes and Effects Analysis (FMEA) of the BESS will be conducted to lay the foundation for predictive maintenance requirements and complement the fault indicator capabilities of the BMS data analytics system.

Comprehensive Hazard Mitigation Analysis (HMA) will be conducted by a BESS specialist independent Fire Protection Engineer following NFPA 855 (2023) guidelines and recommendations. The HMA considers both BESS system and site-specific safety issues.

Additional site-specific risk assessments likely to be conducted at the detailed design stage are Fire Risk Analysis (FRA), Explosion Risk Analysis (ERA), Hazard and Operability Analysis (HAZOP). BESS 3rd Party risk analysis is sometimes automatically provided by Tier one BESS manufacturers and / or BESS integrators.

6.1.9 If the BESS system supplied differs from the specification considered for risk assessments and consequence modelling, then a full safety audit will be repeated for the new BESS system specification. These studies will be completed and signed off before construction commences.

6.1.10 Some example BESS and site design information which should be shared with LFR to establish a risk profile for first responders, are listed below:

a. Battery chemistry integrated into BESS – can provide fire and explosive risk profile.

b. Battery form factor (e.g., cylindrical, pouch, prismatic).

c. Battery energy Wh / kWh – confirmation of new vs second life cells.

d. Battery module cooling system details (e.g., liquid cooling design, air cooling design) – cooling system capability assessment to stop or reduce battery cell thermal runaway propagation.

e. Battery module vent or gas exhaust specifications.

f. Battery module kWh energy + number of cells contained in the module + battery circuitry details (number of cells in series vs number of cells in parallel).

g. Direct suppression system details – module or rack level integration.

h. Rack design – number of modules and kWh energy, spacing between modules, passive protection features, gas exhaust features, electrical isolation functions, heat or thermal runaway sensor integration, etc.

i. Rack configuration – spacing to adjacent racks, number of racks in BESS, spacing to walls, doors, gas vents and roof.

j. Type of BESS design e.g., container or cabinet, gas exhaust / ventilation features, deflagration vent design features, BESS enclosure level fire protection and suppression system details (proof of testing with BESS design + test data), additional fire or explosion protection features i.e., thermal barriers.

k. EMS / BMS data monitoring capabilities and incident response integration capacity.

l. Number of BESS containers/cabinets on site.

m. Size and MWh capacity of each BESS unit.

n. BESS and ESS equipment spacing; spacing to other equipment, boundaries, vegetation, roads or access routes, fire hydrants/water tanks, site building structures, etc.

o. Access routes, observations points, turning areas, FRS equipment and assets, water supply locations and capacity, drainage, and water capture design.

p. Definition and frequency of BESS equipment testing and maintenance requirements.

6.1.11 Digital provision of safety information and procedures must be provided to site operatives, first responders and Subject Matter Experts (SMEs) during BESS incident response – hard copy printed materials must be available onsite (location agreed with LFR). As a minimum content should include:

a. Digital emergency response plans.

b. Remote emergency shutoff procedures.

c. SDS / Hazardous material documentation.

d. Maps or design drawings.

e. Gas detection capabilities; could include multi-sensor data metrics e.g., Carbon Dioxide (CO2), Carbon Monoxide (CO), Hydrogen (H2), VOC off gas + overpressure + local temperatures.

f. Fire protection system data e.g., temperature, alarming, suppression status, etc. – establish discharge warrantee clauses, emergency BESS venting procedures, discharge times, impact on ventilation and detection systems, etc.

g. ERP training drills for site operatives + FRS engagement (site familiarisation + training drills) + SME engagement (fire protection experts or battery experts)

h. Other documentation as required by specific BESS project i.e., local response stipulations, contact information for nominated response personnel, community contacts, etc.

6.2 Emergency Planning requirements (based on UK NFCC guidelines)

6.2.1 A Risk Management Plan shall be developed by the Operator at detailed design stage which, as a minimum, provides advice in relation to potential emergency response implications including:

a. The hazards and risks at and to the facility and their proposed management.

b. Any safety issues for firefighters responding to emergencies at the facility.

c. Safe access to and within the facility for emergency vehicles and responders, including to key site infrastructure and fire protection systems. Establish response times and site arrival protocols.

d. The adequacy of proposed fire detection and suppression systems e.g., water supply on-site.

e. Natural and built infrastructure and on-site processes that may impact or delay effective emergency response i.e., firefighting water runoff capture.

6.2.2 An Emergency Response Plan (ERP) will be developed to facilitate effective and safe emergency response and should include as a minimum:

a. How the fire service will be alerted and incident communications and monitoring capabilities.

b. Facility description, including infrastructure details, operations, number of personnel, and operating hours.

c. Site plan depicting key infrastructure:

    i. Site access points, internal roads, agreed access routes, observation points, turning areas, etc.

    ii. Firefighting facilities (water tanks, pumps, booster systems, fire hydrants, fire hose reels etc).

    iii. Water supply locations and capacity.

    iv. Drainage and water capture design and locations.

d. Details of emergency resources, including fire detection and suppression systems and equipment; gas detection; emergency eye-wash and shower facilities; spill containment systems and equipment; emergency warning systems; communication systems; personal protective equipment; and first aid.

e. Up-to-date contact details for facility personnel, and any relevant off-site personnel that could provide technical support during an emergency.

f. A list of dangerous goods stored on site.

g. Site evacuation procedures.

h. Site operation Emergency Management protocols - 4 phases: discovery, initial response / notification, incident actions, resolution and post incident actions / responses

i. Emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire, wildfires, impacts on local respondents, impacts on transport infrastructure.

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

6.3 Environmental assessment and mitigation measures

6.3.1 At detailed design stage, suitable environmental protection measures should be provided for BESS sites. This should include systems for containing and managing firefighting water runoff. Internal BESS water based fixed suppression systems should have a separate water containment system because water runoff is likely to contain higher levels of pollution, see **Appendix 10-4: Drainage Strategy** of this ES **[EN010142/APP/6.3]**.

6.3.2 Sites located in flood zones must provide details of flood protection and / or mitigation measures.

7. Mitigation and Control Measures

7.1 General

7.1.1 This section details the possible methods used to mitigate the potential residual risks of fire event leading to the spread of heat and uncontrolled fire with associated emissions through the project cycle. The Scheme will minimise fire risk using life safety features that are listed, minimum code requirements as well as recommended industry practice (property protection) throughout the project lifecycle.

7.1.2 The priority of the risk mitigation approach must be:

a. Inherent fire and explosion safety design measures.

b. Monitoring, control, and protective devices such as BESS disconnection and shutdown controls.

c. Information and training for site operatives and first responders.

7.1.3 The battery system mitigation measures adopted in the FBSMP, which is to be approved in accordance with the requirements of the Development Consent Order, will reflect the latest BESS safety codes and standards applicable at that stage. Mitigation measures will be discussed and coordinated with LFR.

7.1.4 Cybersecurity will form a fundamental part of the system design and architecture as there is an increasing focus in this area from national and international regulatory bodies. International standards such as IEC 62443, UL 1741 (Ref. 9), IEEE 1815, and IEEE 1547.3 will be consulted and guidance from national sources such as National Cybersecurity Centre inform the implementation and protection measures. Reference should be made to the Health and Safety Executive (HSE) Operational Guidance document OG86.

7.1.5 UL published ‘UL 2941 (2023) Outline of Investigation for Cybersecurity of Distributed Energy and Inverter-Based Resources’ (Ref. 12). UL 2941 provides testable requirements for photovoltaic inverters, electric vehicle chargers, wind turbines, fuel cells and other resources essential to advancing grid operations. These new requirements prioritise cybersecurity enhancements for power systems that deal with high penetration inverter-based resources, including those interfacing with bulk power systems for periods of instantaneous high wind, solar and hybrid/storage generation. UL 2941 promotes the necessity to have cybersecurity designed into new inverter-based resources (IBR) and distributed energy resource (DER) systems, and the BESS system supplier at the detailed design stage will conform to these requirements.

7.1.6 The Site security profile will be assessed by the Applicant’s security team and the output from this assessment will inform the level of security measures used.

7.1.7 Where practical and required by LFR or risk assessment, each BESS Station will have security fencing with a minimum of two points of ingress / egress for first responders and will be clearly signed, with incident emergency response contact details, clear identification of BESS site hazards, details of site access arrangements such as key codes, which will be provided to the LFR.

7.1.8 The Site will also have Thermal Imaging Cameras to alert and locate on site fire risks and integrate high-definition CCTV with video analytics to alert and respond to unauthorised site access.

7.1.9 For the development of this FBSMP, the fire and explosion risks have been studied for the lithium ion BESS battery systems. integration into BESS systems.

7.1.10 The following key pillars have been considered in the development of the risk mitigation and control measures foreseen for the BESS:

a. BESS supply, transportation, installation, and decommissioning;
b. BESS layout and LFR access
c. Fire and gas detection;
d. Fire protection and suppression;
e. BESS explosive gas ventilation systems; and
f. Drainage.

7.1.11 The mitigation measures pertaining to each area are described in more detail below.

7.2 BESS manufacturing, transport, installation and decommissioning

7.2.1 The developer shall ensure that the BESS are acquired from manufacturers providing a fully UL 9540 compliant BESS as per NFPA 855 (Ref. 3) with battery system and fire protection system tested according to UL 9540A.

7.2.2 The BESS will likely be shipped as a module with batteries already installed. The developer shall require that the manufacturer or transportation company follows preventive actions to avoid risks of shock, vibration, etc.

7.2.3 The storage sites shall be safe places with restricted access to reduce the probability of shock or other external aggression occurrence, designed in compliance with NFPA 855. It is also important to assure that during the storage phase the temperature of the environment external to the battery system and modules is lower than the maximum recommended by the manufacturer.

7.2.4 During operation, a maintenance plan shall be planned and kept across all stages of the battery lifecycle.

7.2.5 Routine maintenance will be undertaken on the BESS equipment every 6-12 months depending on the risk profile of equipment. This typically consists of a major maintenance period and a minor maintenance period. This will encompass all BESS and supporting equipment supplied by the Original Equipment Manufacturer (OEM) including the fire protection and explosion prevention system. Minor maintenance is typically a visual inspection and rectification of any accumulated noncritical defects. All maintenance will be undertaken in a carefully controlled manner following the Site safety rules and in accordance with the Operational Environmental Management Plan (OEMP)

7.2.6 During operation all works on the Site will be controlled under safe systems of work. This will mean all work is risk assessed to protect both personnel and equipment. Therefore, safety systems such as fire systems will not be stopped or taken out of service without appropriate mitigation, following the system being made safe so far as is reasonably practicable, and only for the minimum time required to undertake any specific maintenance tasks.

7.2.7 The operation of the BESS will be managed in accordance with the OEMP and this FBMSP.

7.2.8 The transportation of the system from the factory will be a combination of sea and land freight. The system is certified for transportation in all potential environmental conditions. The equipment will be certified for transport to UN 38.3 (Ref. 13). Transportation will be managed in accordance with the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) 2019 and the UK guidance on the transport of dangerous goods “Moving dangerous goods, Guidance” Government webpage (Ref. 14).

7.2.9 The appointed contractor will ensure the transported BESS equipment will be prepopulated with batteries and will have undergone Factory Acceptance Testing (FAT) to IEC 62933-5-2 standards (Ref. 15). Site Acceptance Tests (SAT) will follow IEC 62933- 5-2 and IEEE 2962 (in development) standards and protocols.

7.2.10 Regarding the decommissioning of the BESS, the requirements will be determined at the procurement contract stage. The contractor will have certain obligations in respect of battery disposal or if placing them on the UK market, in accordance with the Waste Batteries and Accumulators Regulations 2009 (Ref. 17) (or such equivalent regulations in force at the time of decommissioning).

7.2.11 In the event of a defective module or cell being identified, the defective module shall be immediately placed out of service and be electrically disconnected from the system. A specific risk assessment shall be conducted prior to the removal of the defective module to ensure the safety of employees and contractors.

7.2.12 Once a defective module is safely removed in accordance with the specific risk assessment, it shall be placed in an approved protective container prior to being transported from the detective unit to a dedicated safe location for inspection by an authorised manufacturer’s representative.

7.2.13 All components replaced during the defects notification and warranty period will be taken back and recycled.

7.2.14 The Applicant will follow the hierarchy of waste management through the life of the Scheme as follows:

a. Reduce – the lithium-ion batteries have a finite life based on a number of factors, primarily the total number of cycles undertaken. The operation will attempt to manage the degradation by the selection of services and cycling that maximises the overall life. Consideration will be given to supplementation of the equipment or operation at a lower output.

b. Recycle – The supplying manufacturer will have obligations under the Waste Batteries and Accumulators Regulations 2009 (Ref. 17) (or such equivalent regulations in force at the time of decommissioning) and will be contractually obliged to offer a recycling service.

c. Recovery – The recycling should allow any useful materials to be recovered and re-enter the supply chain.

d. Disposal – Any disposal of batteries shall be undertaken in compliance with all applicable laws and all regulatory requirements, product stewardship, registration disposal and recycling or take back requirement.

7.3 BESS layout and fire service accessibility

Site access

7.3.1 UK National Fire Chiefs Council BESS planning guidance document published in April 2023, stipulates that 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.

7.3.2 This should include:

a. At least 2 separate access points to the site to account for opposite wind conditions/direction.

b. Roads/hard standing capable of accommodating fire service vehicles in all weather conditions. As such there should be no extremes of grade.

c. A perimeter road or roads with passing places suitable for fire service vehicles.

d. Road networks on sites must enable unobstructed access to all areas of the facility.

e. Turning circles, passing places etc size to be advised by FRS depending on fleet.

f. Emergency access route plans for first responders will be included in the Emergency Response Plans and hard copies will be available on site. Route sign requirements will be agreed with LFR.

7.3.3 Guidance for the Fire Service for dealing with sites such as powerplants, substations etc. is contained in the Fire Service Manual Volume 2 Fire Services Operations – Electricity (Ref. 18). The Fire Service Manual stipulates that in all cases involving electrical apparatus, it is essential to ensure, on arrival, that the apparatus is electrically isolated and safe to approach. This should be carried out by the operator at the premises concerned. It is strongly advised that electrical or associated equipment should not be touched or even approached unless it is confirmed to be isolated and safe.

7.3.4 In the event of a fire, the battery system and the transformers serving the BESS will be automatically electrically isolated when a fire is detected within a container. However, the batteries within the containers will still hold charge in the event of a fire, even after the electrical system is isolated. It will not be possible to confirm that there is no residual risk from the energised batteries within the container, and this will inform the strategy for firefighting in the emergency plan.

7.3.5 Signage should be installed in a suitable and visible location on the outside of the BESS units, identifying the presence of a BESS system. Signage would be as per NFCC guidelines and will also include details of:

a. Relevant hazards posed i.e., the presence of High Voltage DC Electrical Systems is a risk, therefore their location should be identified.

b. The type of technology associated with the BESS.

c. Any suppression system fitted.

d. 24/7 Emergency Contact Information.

7.3.6 Signs on the exterior of a building or enclosure will be sized such that at least one sign is legible at night at a distance of 30m or from the site boundary, whichever is closer.

7.3.7 The BESS Stations shall be designed to integrate firefighting water tanks located at least 10 metres from the nearest BESS enclosure, ideally upwind from the prevailing wind direction so that they are less likely to be impacted by smoke in the event of fire. Access provision is outlined in **Chapter 3: Scheme Description** of the ES **[EN010142/APP/6.1]** and secured through the **Framework Operational Environmental Management Plan** submitted with the DCO **[EN010142/APP/7.9]**.

BESS enclosure design and site integration

7.3.8 National Fire Protection Agency (NFPA) 855 (2023) (Ref. 3) defines basic operation Health & Safety (H&S) protocols for all BESS site designs which should be incorporated into emergency response plans:

a. Potential debris impact radius is defined as 100 feet (ft) or 30.5 metres (m) i.e. this is a typical explosion risk safe exclusion zone radius as modelling and previous BESS incidents typically show 25 m to be maximum radius.

b. Automatic building evacuation area is defined as 200 ft or 61 m from the affected BESS enclosure.

7.3.9 The layout of the Scheme provides adequate separation between BESS enclosures, additional ESS equipment, and other key site structures and infrastructure. The UK National Fire Chiefs Council (NFCC) ‘Grid Scale Battery Energy Storage System planning – Guidance for FRS (2023)’ (Ref. 7) will be followed at an indicative design stage, which comprises the following points:

a. In order to protect the BESS enclosures from exterior risks, they shall be provided with impact protection to prevent damage to battery enclosures by vehicles or construction equipment, as well as including Damage Limiting Constructions (DLC).

b. The BESS would be constructed in 2 distinct phases. Firstly, the civil works and balance of plant equipment would be started. Then at a suitable point the BESS equipment would be delivered to be installed on the foundations and connected to the balance of plant.

c. The installation would be subject to pre-requisites such as a contractor emergency protocol detailing the actions to be taken in an emergency. This will include the preparation of a construction emergency response plan that would be coordinated with LFR. In addition, installation would not take place until necessary provisions for emergencies are installed such as the water tanks were completed such as the water tanks being installed and filled for use in an emergency.

d. The vicinities of the BESS enclosures shall be designed to minimise the risk of fire and structural damage; therefore, BESS shall be installed on a non-combustible surface such as concrete. In addition, the BESS enclosures shall be separated by a distance recommended in NFCC guidelines at the detailed design stage (currently 6m), unless UL 9540A testing and / or 3rd Party Fire and Explosion testing has established closer spacing is safe. BESS enclosures will be locked to prevent unauthorised access and will have an internal fire resistance rating of 1 - 2 hours (according to NFPA 855, BR 187 and FM Global Datasheet 5-33 (Ref. 4)).

7.3.10 NFCC guidelines allow reduced separation distances between BESS enclosures if suitable design features can be introduced. If reducing distances between BESS enclosures, a clear, evidence-based case for the reduction will be shown in the detailed design phase and supported by heat flux test data i.e. UL 9540A unit or installation testing and / or third-party fire and explosion testing.

7.3.11 The separation of the inverters and transformers will, depending on the architecture, be optimised at detailed design stage to minimise the likelihood of any spread of fire between adjacent components.

7.3.12 Areas within 10m of BESS Enclosures do not contain combustible vegetation and would not be planted with any new combustible vegetation wherever possible. Where this is not feasible a full risk assessment would be conducted, and mitigation features applied if required by the LFR. Any other vegetation on site would be kept in a condition such that they do not increase the risk of fire on site.

7.3.13 Each BESS Station would be designed to integrate fire hydrants and/or static water tanks for firefighting, dependent on available water supply. Water tanks will be located at least 10m from the nearest BESS enclosure. Water access points, whether hydrants or tank connections, would be located in consultation with the LFR to provide redundancy and safe operating distances for firefighters with 30 – 50m, which is considered an optimal safe distance.

7.3.14 By adhering to the separation distances noted above, risk should be adequately minimised to limit a fire event to a single BESS or ESS structure.

7.3.15 Tanks and water outlets would be clearly labelled with appropriate signage and marked on site plans. Additionally, to avoid any mechanical damage, outlets and hard suction points would be safeguarded with bollards.

7.3.16 Each BESS enclosure will be installed by a certified and qualified installer. Each BESS enclosure will be UL9540 certificated. Ingress protection testing of BESS enclosures is conducted under UL9540 and/or IEC62933-5-2 certification of any BESS system. Typical BESS enclosure ingress protection levels are IP55 / NEMA 3R or IP66 / NEMA4. IEC Factory Acceptance Testing (FAT) or an independent manufacturing audit will be carried out to ensure the supplied BESS enclosures comply with the requisite certified ingress protection levels.

7.3.17 Ingress Protection (IP) ratings of BESS containers will be shared with LFR at the detailed design stage so that risks associated with boundary cooling can be understood and implemented into the ERP. Potential boundary cooling water ingress points such as Heating, Ventilation and Air Cooling (HVAC) systems and deflagration vents will be considered as part of an incident response strategy.

7.3.18 Where required, BESS enclosure walls will have a minimum one-hour fire resistance rating to BS EN 13501-2 and BS EN 1364-1 standards.

7.3.19 The Scheme shall be provided with enclosed wiring and buried cabling, except where required to be above-ground for grid connection, to protect from damage and prevent a fire or cable failure from spreading to any of the battery systems.

7.3.20 If possible, internal BESS monitoring data should be accessible to the fire service, access to information (e.g., temperature and gases) shall be provided digitally for first responders.

7.3.21 BESS enclosure gas exhaust vents and deflagration panels must direct flaming or toxic gases away from site personnel or first responders in line with NFPA 68 (Ref. 6) and BS EN 14797 (Ref. 22), doors cannot be used as deflagration vents.

7.4 Fire and gas detection

7.4.1 In order to achieve the safety objectives, the Scheme will employ monitoring systems that will help identify any abnormal operation and safely shutdown the system before it develops, these systems will be independent of the control systems and equipment that can cause the abnormal event and avoid the use of Safety Integrity Level (SIL) rated risk controls.

7.4.2 The BESS fire and gas detection system will comply with NFPA 855 (2023) (Ref. 3) and NFPA 69 (Ref. 5), this means that smoke, fire and gas detection equipment will be installed. New BESS multisensor equipment in development which measures combinations of air temperature, hydrogen, VOCs, overpressure, shock and vibration, and moisture ingress will also be considered if fully tested with the BESS design. The gas detection systems will have external BESS beacon and audible alert facility. All fire detection systems shall all be installed and commissioned to BS EN 54 (Ref. 19)BS EN 9999 (Ref. 20), NFPA 855 (Ref. 3), NFPA 850 (Ref. 21).

7.4.3 The final fire detection design will be validated by an independent Fire Protection Engineer and must be approved by LFR.

7.5 Early Intervention Thermal Runaway Prevention

7.5.1 In order to achieve the safety objectives, the Scheme will employ monitoring systems that will help identify any abnormal operation and safely shutdown the system before it develops, these systems will be independent of the control systems and equipment that can cause the abnormal event and avoid the use of Safety Integrity Level (SIL) rated risk controls. Other measures include:

a. Thermal monitoring of the battery containers and automated cut-out beyond safe parameters;

b. Battery cooling systems with automated fail-safe operation;

c. Emergency Stop – both remote and local.

7.5.2 Energy Storage Management Systems / Battery Management Systems (ESMS / Battery Management System (BMS) controls will be certified to UL 1973 standard (Ref. 1) and follow NFPA 855 (2023) (Ref. 3) recommendations. Battery system data analytics will be integrated into ESMS / BMS systems and controls which reduces Thermal Runaway risks. Data Analytics can also be used to predict accurate End-of-Life timeframes and provide operator maintenance alerts.

7.5.3 NFPA 855 (2023) stipulates that a BMS should at a minimum provide the following safety functions:

a. High cell temperature trip to isolate the module or rack when detecting cell temperatures that exceed limits.

b. Thermal runaway trip to isolate the battery system when a cell is detected to have entered a thermal runaway condition.

c. Rack switch fail-to-trip to disconnect the rack if any failure is detected. Inverter/charger fail-to-trip to isolate the BESS enclosure at the breaker if the inverter/charger fails to respond to a trip command.

d. Inverter/charger fall-to-trip (supervisor level): This function initiates a trip command to an upstream breaker to isolate the 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.

e. The BMS should, at minimum, incorporate NFPA 855 (2023) monitoring and control features. Three new IEEE standards are in development (IEEE P2686, IEEE P2688 and IEEE P2962 (Ref. 16)) which cover BESS data analytics, electrical controls and maintenance/replacement of battery components/systems. These standards should be adopted by the BESS system provider once the standards are published.

f. If data analytics are not directly integrated by the battery OEM or BESS integrator, the Applicant will ensure a Data Analytics package is integrated to provide a greater range of performance and safety data i.e. predict ageing of the cells in battery systems, alert BMS faults or malfunctions, identify electrical abuse during operations, alert the operator when modules need maintenance or decommissioning. Data Analytics facilitate more accurate assessment of operating temperature variations, voltage anomalies, State of Charge (SOC), and State of Health (SOH). Data Analytics can also monitor complimentary BESS safety features i.e. smoke and gas sensors, BESS multi-sensor equipment, ground fault detectors, etc.

7.5.4 The BESS will be monitored by the on-Site control systems as well as 24/7 monitoring by a remote-control room:

a. Staff will be fully trained and familiar with the BESS technologies and will be responsible for alerting LFR and for connecting LFR with BESS incident Subject Matter Experts (SMEs).

7.5.5 A 24/7 remote control facility will monitor the security of the BESS site, and monitoring and detection systems will be repurposed in an emergency to support first responders. NFPA 855 (2023) defines the minimum monitoring and control standards.

7.5.6 The 24/7 control facilities will have the capability to immediately shut the system down should an incident occur, and the need arise. It will also implement the ERP, acting as a point of contact to the emergency services.

7.5.7 In some circumstances it will be necessary to discharge the batteries to enable the first / second responders to deal with the incident. This capability could potentially be achieved through the remote facility (24/7). The precise methodology in this regard will be agreed in the ERP once the detailed design of the BESS is known. This will be prepared in conjunction with LFR and is secured through this document.

7.5.8 The control room will also be responsible for the security of the Site with state of-the-art detection and monitoring systems. These can be repurposed in an emergency to support first responders.

7.5.9 The control room will have the ability and authority to immediately shut the system down should the need arise.

7.5.10 The control room will be responsible for the implementation of the emergency plan acting as a point of contact to emergency services.

7.6 Fire protection and suppression

7.6.1 NFPA 855 (2023) confirms that water is the most effective battery fire suppression agent, therefore a dedicated water-based suppression system will be provided within each BESS container designed to control or fully suppress a fire, without the intervention of the FRS. The suppression system must be capable to operate effectively in conjunction with a gas exhaust / ventilation system to minimise deflagration risks.

7.6.2 The BESS fire suppression systems will conform to NFPA 855 (2023) guidelines, and the suppression system will be tested to UL 9540A latest standard or significant scale 3rd Party fire and explosion testing. Fire suppression system performance will be benchmarked against free burn testing. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided and validate the suppression system design. System design and water supply requirements must be fully agreed with LFR.

7.6.3 If the BESS system is designed to safely burn out without internal fire suppression systems, UL 9540A heat flux test data will establish safe distances between containers and ESS equipment and additional 3rd Party fire and explosion testing will be required to demonstrate that structural integrity is maintained and toxic gas emissions to the closest receptors are below PHE guidelines. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional 3rd Party fire and explosion test data which has been provided.

7.6.4 If the BESS system is designed to safely burn out to remove the risk of stranded energy in the battery systems, then full scale free burn testing will have been conducted to demonstrate that loss will be safely limited to one container without the intervention of LFR.

7.6.5 A post-incident recovery plan shall be developed that addresses the potential for reignition of BESS, as well as removal and disposal of damaged equipment. A fire watch should be present until all potentially damaged BESS 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.

7.7 BESS explosive gas ventilation and cooling / heating systems

7.7.1 As a minimum, a BESS ventilation system will comply with NFPA 855 (2023) (Ref. 3) / NFPA 69 (Ref. 5) guidelines which require the prevention of a dangerous build-up of explosive gases (25% LEL). The gas exhaust / ventilation system must have redundancy and can be separate to any HVAC system providing climate control. Backup power for the gas detection system must have a 24-hour duration in standby and 2 hours in alarm, as demonstrated via NFPA 72 compliant battery calculations and required by NFPA 855.

7.7.2 Heating and cooling of the battery modules will be provided by an independent liquid cooling system which is separate to any HVAC system providing climate control for the BESS enclosure. When mechanical ventilation is required to maintain concentrations below the required limits, it shall be interlocked, so that the system shuts down upon failure of the ventilation system.

7.7.3 The ventilation and gas extraction system shall also be designed to exhaust flames and gases safely outside the BESS enclosure, without compromising the safety of first responders. An NFPA 69 compliance report will be provided to demonstrate the compliance of the gas exhaust system with NFPA 855 explosion prevention system requirements.

7.7.4 Where emergency ventilation is used to mitigate an explosion hazard, the disconnect for the ventilation system should be clearly marked to notify personnel or first responders to not disconnect the power supply to the ventilation system during an evolving incident.

7.7.5 The ventilation system shall be provided with suitable ember protection to prevent embers from penetrating BESS enclosures (HVAC, gas exhaust, deflagration panels).

7.7.6 The BESS enclosure will be designed to withstand overpressures generated by the battery system during thermal runaway. An explosion prevention system to NFPA 69 standards will be integrated which can be complimented by an explosion protection system to NFPA 68 (Ref. 6) and BS EN 14797 standards (Ref. 22). If BESS design only integrates explosion protection systems i.e. deflagration panels, then performance must be validated through BESS free burn testing and requisite pressure testing required by NFPA and EN standards. Further, the BESS enclosure will have completed UL 9540A unit and / or installation testing or large-scale third-party fire and explosion testing without pressure waves occurring or shrapnel being ejected. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.

7.7.7 The HVAC systems should be designed to maintain temperatures within operating limits in the event of a single component failure. A safety shutdown of the system upon failure of the thermal management system shall be implemented unless it can be demonstrated that the thermal management system failure does not result in a hazardous situation. For BESS active liquid cooling / heating systems, a failure of the system due to breach or breakage in the cooling lines should not result in a leakage that will cause short circuiting of the cells inside the battery pack leading to a hazardous condition. Coolant leakage lines should be routed or secured to mitigate the potential for leakage on live parts and, if necessary, fluid monitor and controls of the coolant system may need to be provided. The heating and cooling system will be subject to routing maintenance inspections to ensure the risk of failure is minimised.

7.8 Drainage and separation from the environment

7.8.1 A fire water management plan should include provisions for the containment, monitoring and disposal of contaminated fire water, see **Appendix 10-4: Drainage Strategy** of this ES **[EN010142/APP/6.2]**. Infrastructure shall be provided for the containment and management of contaminated fire water runoff from BESS. This can include bunding, sumps, and purpose-built impervious retention facilities.

7.8.2 All process water used in the system shall be prevented from contaminating potable water sources in accordance with local regulations through the use of check valves or other means as part of the system design.

7.8.3 The BESS Stations require fire water tanks to supress a fire, should one break out in the BESS Station.

7.8.4 Fire water runoff may contain particles from a fire. In the unlikely event of fire water being discharged, the runoff must be contained and tested/treated before being allowed to discharge to the local watercourses.

7.8.5 Each BESS enclosure will be provided with a sump and drain valve to allow extraction of contaminated fire water and / or electrolyte spill without having to open the door of the enclosure and will prevent contamination of surrounding environment with the extracted liquid being taken off site for treatment. The sump construction will be designed to allow for chemical resistance of electrolyte which may be released from a battery fire and have capacity to hold the total volume of electrolyte plus a 10% safety factor. The sump will encompass the entire floor area of the BESS enclosure with a mentis grating type floor to allow spilled electrolyte to drain without pooling near other racks.

7.8.6 An extra layer of protection will be provided for containment of firewater external of the BESS enclosure in case of rupture or overflow of contaminants. The external floor surface surrounding each BESS container will be lined with an impermeable membrane. The membrane will direct firewater into a swale surrounding the BESS Stations which will contain the firewater runoff. The firewater will be tested post incident and if contaminated, will be tankered off site to a suitable waste facility for treatment. The swale will then be cleaned of all contaminants.

7.8.7 The swale will be lined to prevent any contaminants entering the ground.

7.8.8 The swale will be controlled by a penstock valve that can be closed before a fire is put out.

7.8.9 In order to determine the volume storage of firewater runoff, National Fire Chiefs Council (NFCC) guidance has been used which states firefighting supplies ‘should be capable of delivering no less than 1,900 litres per minute for at least 2 hours. On top of this supply requirement a 30% additional capacity has been applied for storage in the swale. This equates to approximately 300m^3. It should be noted that the 300m^3 storage is required for each group of BESS. I.e. 300m^3 will be required if there is 1 BESS on its own or 5 BESS grouped together. This is based on the likely scenario that only 1 BESS would be on fire at the same time.

7.8.10 By using the swale for firewater storage as well as surface water storage, there is the potential that in the event of a fire, the swale may already contain surface water and reduce the capacity for firewater storage. Therefore, the swale should be sized to serve both purposes. It has been deemed too conservative to provide the required firewater storage on top of the 1 in 100 year + 40% storage as it is extremely unlikely a fire will occur at the same time as the 1 in 100 year event. Therefore, in order to proceed with a sensible approach an allowance has been made that the 1 in 1 year event could occur at the same time as a fire. Therefore, the swale will need to contain the 1 in 1 year event plus the firewater storage runoff or the 1 in 100 year + 40% event on its own, whichever provides the worst case scenario.

7.8.11 The volume requirements for containment of fire water runoff within the swale and its configuration are subject to agreement with FRS.

7.8.12 IP ratings of BESS containers will be shared with the FRS at the detailed design stage so that risks associated with boundary cooling can be understood and implemented into the Emergency Response Plan (ERP). Potential boundary cooling water ingress points such as HVAC systems and deflagration vents will need to be considered as part of an incident response strategy.

8. Conclusion

8.1.1 This FBSMP has demonstrated in a systematic way the mitigation of the fire safety risks posed by the BESS in the Scheme.

8.1.2 The detailed design phase will determine the approach to addressing the following specific requirements, which will be updated prior to construction of the BESS and submitted to the local planning authority as a detailed BSSMP prior to the commencement of construction. The detailed BSSMP must include:

a. The detailed design, including drawings of the BESS;

b. A statement on the battery system specifications, including fire detection and suppression systems;

c. A statement on operational procedures and training requirements, including emergency operations;

d. A statement on the overall compliance of the system with applicable legislation;

e. An environmental risk assessment to ensure that the potential for indirect risks (e.g., through leakage or other emissions) is understood and mitigated; and

f. Emergency Response Plan(s) covering construction, operation and decommissioning phases will be developed once a construction team and an operator have been appointed. These plans will be developed in consultation LFR and other local emergency services to include the adequate provision of firefighting equipment onsite and ensure that fire, smoke, and any release of toxic gases from a thermal runaway incident does not significantly affect site operatives, first responders, and the local community.

8.1.3 The implementation of the FBSMP is secured through a Requirement in Schedule 2 of the DCO. This will stipulate that a detailed Battery Safety Management Plan will be submitted to and approved in consultation with the FRS by the relevant planning authorities prior to the commencement of the works for the BESS. This plan will be substantially in accordance with the FBSMP.

9. References

Ref. 1. UL 1973 (2022), Batteries for Use in Stationary and Motive Auxiliary Power Applications

Ref. 2. UL 9540A (4th Edition2019), Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Ref. 3. NFPA 855 (2023), Standard for the Installation of Stationary Energy Storage Systems.

Ref. 4. FM Global, “Datasheet 5-33 Electrical Energy Storage Systems,” Factory Mutual Insurance Company, 2020.

Ref. 5. NFPA 69 (2019), Standard on Explosion Prevention Systems

Ref. 6. NFPA 68 (2018), Standard on Explosion Protection by Deflagration Venting

Ref. 7. National Fire Chiefs Council (NFCC) 2023, Grid Scale Battery Energy Storage System planning – Guidance for FRS

Ref. 8. BS EN IEC 62433 (2021), Security of Industrial Automation and Control Systems (IACS)

Ref. 9. UL 1741 (2021), Standard for Safety Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources

Ref. 10. IEEE 1815 (2012), Standard for EPS Communications-Distributed Network Protocol (DNP3)

Ref. 11. IEEE 1547.3 (2023), Guide for Cybersecurity of Distributed Energy Resources (DER) interconnection with Electric Power Systems (EPS)

Ref. 12. UL 2941 (2023), Outline of Investigation for Cybersecurity of Distributed Energy and Inverter-Based Resources

Ref. 13. UN 38.3 UN Recommendations on the Transport of Dangerous Goods Manual of Tests and Criteria

Ref. 14. https://www.gov.uk/guidance/moving-dangerous-goods

Ref. 15. BS EN IEC 62933-5-2 (2020), Electrical Energy Storage (EES) systems. Part 5-2: Safety requirements for grid integrated EES systems. Electrochemical-based systems.

Ref. 16. IEEE P2962: Recommended Practice for Installation, Operation, Maintenance, Testing, and Replacement of Lithium-ion Batteries for Stationary Applications

Ref. 17. UK Statutory Instruments (2009) The Waste Batteries and Accumulators Regulations 2009

Ref. 18. Fire Service manual: Vol. 2 Fire service operations – Electricity (2014)

Ref. 19. BS EN 54: fire detection & alarm systems – all parts

Ref. 20. BS EN 9999:2017 Fire safety in the design, management and use of buildings - code of practice

Ref. 21. NFPA 850, Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, 2020

Ref. 22. BS EN 14797 (2007), Explosion venting devices.