HELIOS RENEWABLE ENERGY PROJECT

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Environmental Statement Appendix 3.1: Battery Safety Management Plan

February 2025

Abbott Risk Consulting Limited

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Battery Energy Storage System – Helios Renewable Energy Project

Outline Battery Safety Management Plan

Issue 5 – February 2025

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Executive Summary

This Outline Battery Safety Management Plan (‘OBSMP’) is for the Battery Energy Storage System (‘BESS’) proposed for the Helios Renewable Energy Project, a proposed solar farm that will connect to the National Grid (the ‘Proposed Development’). The Proposed Development comprises the construction, operation, and maintenance, and decommissioning of a solar photo-voltaic (‘Photo-Voltaic (PV)’) array electricity generating facility with a total capacity exceeding 50MW across 475ha of land within the administrative boundary of North Yorkshire Council (a unitary authority).

Due to the scale of the Proposed Development, an application to the Planning Inspectorate will be submitted under the Nationally Significant Infrastructure Project (‘NSIP’) regime (Planning Act 2008).

The aim of the OBSMP, at this early stage of the Proposed Development is to define the proposed safety strategy, requirements, and processes necessary to meet agreed safety objectives and to set a level of safety performance that the BESS is to be measured against. It also provides the basis for the safety management processes and procedures required to satisfy the identified safety requirements for the BESS.

A preliminary safety hazard identification and analysis, based on like for like energy storage systems of this type, anticipated to be Lithium-Ion Battery technology, has determined the likely hazards associated with the BESS and enabled the initial identification of potential control measures to ameliorate the level of risk posed to an acceptable level.

It is proposed that at this early stage of the Proposed Development, the currently foreseeable hazards associated with the technology proposed have been identified, based on the premise that the BESS will employ Lithium-Ion storage systems. These will form the initial safety foundation going forwards and be actively managed as the Proposed Development matures.

The design, development, and manufacture of the BESS requires the development and maintenance of high standards in respect of safety and operational sustainability. It will be the responsibility of all personnel involved in the future development of the Proposed Development to strive to reduce the potential for accidents to the lowest practicable level by being ‘risk aware’ and promoting a supportive environment and safety culture at all stages of the Proposed Development.

Abbreviations

ALARP	As Low As Reasonably Practicable
ARC	Abbott Risk Consulting Ltd
BESS	Battery Energy Storage System
BMS	Battery Management System
BoM	Bill of Material
CHG	Charge
DBSMP	Detailed Battery Safety Management Plan
DSG	Discharge
EM	Electro-Magnetic
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FRS	Fire and Rescue Service
HSAWA	Health and Safety at Work Act
HAZID	Hazard Identification
HSE	Health and Safety Executive
HV	High Voltage
IPS	independent Protection System
LFP	Lithium Ferrous Phosphate
OBSMP	Outline Battery Safety Management Plan
OC	Over Current
OEM	Original Equipment Manufacturer
OV	Over Voltage
PV	Photo-Voltaic
REACH	Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations
RoHS	Restriction of Hazardous Substances Directive
S&E	Safety and Environmental
OBSMP	Safety Management Report
SME	Subject Matter Expert
SMS	Safety Management System
SQEP	Suitably Qualified and Experienced Person
SRD	System Requirement Document
SWG	Safety Working Group
UK	United Kingdom
US	United States
UV	Under-Voltage

Contents

1.0 Introduction

This OBSMP has been developed by Abbott Risk Consulting Ltd (‘ARC’) in the role of the Safety Subject Matter Expert (SME) and aims to provide the safety requirements (and any additional derived safety requirements) so that safety criteria can be established, targets set and so that the Proposed Development can be assessed against a common benchmark.

This OBSMP is an outline document and has been developed at this early stage of the Proposed Development to assess the potential risks associated with the design, construction, operation and maintenance, and decommissioning phases of the BESS. The BESS OBSMP provides a robust safety case, supported by evidence, and will be built upon throughout the lifecycle of the Proposed Development, in the following four phases:

1. **OBSMP (Requirements) –** Outlines the processes, procedures and means by which the BESS safety management is to be carried out, ensuring BESS design and development, initial construction and operation safety performance can be undertaken with an acceptable level of residual risk. Identifies the level of risk posed by the design of the BESS to individuals (including operators and third parties), the immediate environment, the asset itself (BESS), interfacing / interdependent assets and property / equipment that could be affected by operation of the BESS (such as noise and radiated emissions etc.). This element will develop upon the identified risks in the OBSMP.

2. **Detailed Battery Safety Management Plan (DBSMP) (Design and Qualification) –** Identifies the processes and procedures used to validate the control measures and models employed in determining the level of risk posed by the design. This element also provides the necessary confidence that the control measures within the design function as intended, most notably the ability to Remote Monitor and Control the BESS.

3. **Site Safety Audit (Operation) –** Outlines the risk posed by site specific placements of the BESS and the processes and procedures required to ensure that the risk posed by the design remains within the established bounds i.e., training, provision of Personal Protective Equipment (PPE), calibration, scheduled maintenance etc.

As this OBSMP is further refined throughout the above phases, it has also been informed by consultation with the North Yorkshire Fire and Rescue Service (NYFRS). This consultation will be documented in a separate Fire Liaison Framework document. This early consultation will ensure the latest technology, information, operational and environmental excellence can be integrated into the Proposed Development, further supplementing the safety case outlined in this OBSMP.

2.0 Background

ARC have conducted an initial hazard identification (HAZID) of the BESS as a conceptual model, based upon experience and expertise of similar BESS systems in use and under development in the UK and overseas. This analysis has provided the necessary foundation for the identification of potential hazards and the development of a formalised Hazard Log, ARC-1168-003-R2 [Ref. 1], which contains:

1. Consolidated list of hazards and hazard descriptions;
2. Associated potential causes driving the hazards with linkage to the relevant hazard(s);
3. Design controls in place that ameliorate the causes;
4. Identification of the potential outcomes or consequence from the hazards;

5. Identification and linkage to mitigating factors that could ameliorate the severity or frequency of occurrence of the outcomes (consequences); and
6. Identification of additional design controls and mitigating factors that will further ameliorate the probability of hazard or consequence frequencies.

3.0 Aim

The overall BESS safety aim is that the level of risk of accident, death or injury to personnel or other parties or to the environment because of the BESS, are broadly acceptable or tolerable and As Low As Reasonably Practicable (ALARP), in accordance with the Health and Safety Executive (HSE) Reducing Risk, Protecting People (R2P2) Guidance [Ref. 2].

3.1 Frequently Asked Questions

Appendix A of this OBSMP contains frequently asked questions (FAQs) and is provided for assurance and a greater awareness of BESS and Lithium-Ion technologies in general.

4.0 Scope

The scope of the safety management for the proposed BESS concerns the physical and functional aspects of the equipment. The BESS safety management will address activities throughout the construction, operation and maintenance, and decommissioning phases. For avoidance of doubt, it also includes provisions which address design, validation, siting, remote monitoring and control, storage / transportation, and calibration.

5.0 Safety Requirements

5.1 High Level Safety Objective

The primary safety objective for the BESS is to comply with applicable legal requirements and relevant and emerging good practice for large / grid scale battery energy storage systems. These will be distilled into safety requirements that will be detailed in the System Requirement Document (SRD), which in turn will be flowed down to prospective suppliers. Compliance with these safety requirements (by potential suppliers) will be used as part of the safety case, to demonstrate that '***The risk posed to individuals, the environment and property from the BESS programme of work has been reduced to a level that is Broadly Acceptable or Tolerable and ALARP'.*** The SRD produced for the BESS development will be used to ensure that all direct and indirect safety requirements for BESS are met and the supplier(s) is safety compliant.

5.2 BESS Safety Guidance

Safety Guidance for the BESS installation will be demonstrated by alignment with prevailing industry guidance, both national and globally. The following industry guidance / best practice has been determined as applicable to this BESS installation:

1. PPG Renewables and Low Carbon Energy, which refers out to;
    a. National Fire Chiefs Council (NFCC) Grid Scale BESS planning – Guidance for Fire and Rescue Service (FRS).
    b. FM Global Property Loss Datasheet 5-33 – Lithium-Ion BESS.

2. National Fire Protection Association (NFPA) – Energy Storage Systems and Solar Safety, which refers out to:
    a. Underwriters Laboratory (UL)1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications.
    b. UL9540A – BESS Test Methods.
    c. UN38.3 – Standard Requirements for Lithium-Ion Battery Production.
3. International Electrotechnical Commission (IEC) 61508 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety related Systems (E/E/PE, or E/E/PES).

5.3 Legislation and Compliance Requirements

Legislative compliance, specifically safety, for the BESS will be demonstrated by compliance with the UK Health and Safety at Work Act (HSAWA) 1974 and the appropriate underlying legislation that is enacted through the HSAWA. The following legislation (which is not exhaustive at this stage), has been determined to be applicable to the development of the BESS:

4. Health and Safety at Work etc. Act 1974 – UKSI1974/0037.
5. Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations SI 2009/1348.
6. Chemical Hazard Information & Packaging for Supply Regulations 2009 UKSI – 2009/0716.
7. Control of Noise at Work Regulations 2005 – UKSI 2005/1643.
8. Control of Substances Hazardous to Health Regulations 2002 – UKSI 2002/2677.
9. Control of Vibration at Work Regulations 2005 – UKSI2005/1093.
10. Corporate Manslaughter and Corporate Homicide Act 2007 – UKSI2007/0019.
11. Electrical Equipment (Safety) Regulations SI 1994/3260.
12. Electro-magnetic Compatibility Regulations SI 2006/3418.
13. Fire Safety (Employees' Capabilities) (England) Regulations SI 2010/471.
14. Lifting Operations and Lifting Equipment Regulations 1998 – UKSI1998/2307.
15. Management of Health and Safety at Work Regulations 1999 – UKSI1999/3242.
16. Manual Handling Operations Regulations 1992 – UKSI1992/2793.
17. PPE Regulations 2002 – UKSI2002/1144.
18. Provision and Use of Work Equipment Regulations 1998 – UKSI1998/2306.
19. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations SI2013/1471.
20. Supply of Machinery (Safety) Regulations 2008 – UKSI2008/1597.
21. Workplace (Health, Safety and Welfare) Regulations 1992 – UKSI1992/3004.
22. Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations (REACH) – 1907/2006.
23. Restriction of Hazardous Substances Directive (RoHS) – 2011/65/EU.
24. Dangerous Substances and Explosive Substances Regulations 2002 - SI 2002/2776.

25. Construction (Design and Management) Regulations - SI 2015/51.

5.4 NFCC Requirements

The NFCC Report Grid Scale Battery Energy Storage System Planning – Guidance for details the FRS requirements anticipated at BESS installations. The recommendations in the NFCC Guidance have been distilled at Table 5-1 and cross-referenced to the site location and layout to determine compliance or otherwise. The Site Layout is at Figure 5-1.

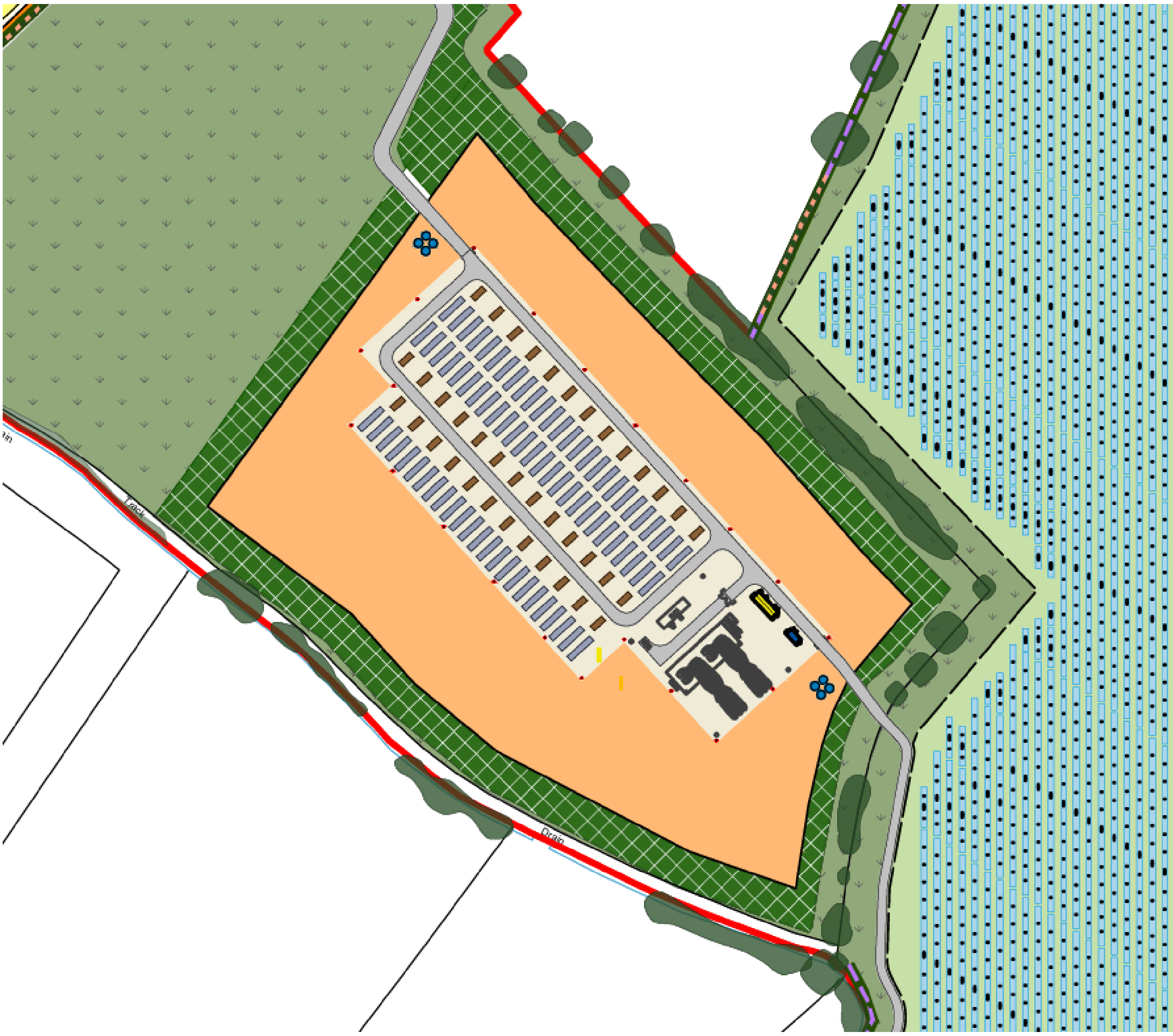


Figure 5-1 BESS Site Layout

Ser	NFCC Recommendation	Site Status	Comments
1	Access - Minimum of two separate access points to the site	**Compliant**	As shown in Figure 5-1, there are two separate points of vehicular access to the site from the northwest and the southwest.
2	Roads/hard standing capable of accommodating fire service vehicles in all weather conditions. As such there should be no extremes of grade	**Compliant**	The site has a circular service road allowing access to all the BESS containers. Given the requirement to position the ISO containers as part of the construction the service road will have the capacity to accommodate FRS vehicles and will be maintained in good condition throughout the operational life of the site – on commissioning of the site an Emergency Response Plan will be promulgated to FRS, this will include a Site Layout Plan. There are no extreme gradients in the development footprint across the site.
3	A perimeter road or roads with passing places suitable for fire service vehicles	**Compliant**	The service road that loops around the site allowing access to all BESS and a single spur road provides access to the electrical sub-station, part of the associated infrastructure – on commissioning of the site an Emergency Response Plan will be promulgated to NYFRS, this will include a Site Layout Plan. The Building Regulations, Approved Document B5 Section 13.4 states that FRS vehicles should not have to reverse more that 20m from the end of an access road – given the provision of a circular perimeter service road the requirement for FRS vehicles to reverse is minimized to situations in which use of the perimeter service road is not possible, and in these circumstances, reversing more than 20m would not be required. Section 13.4 references Table 13.1 of the Approved Document B5 which contains typical FRS vehicle access route specifications – the site meets these specifications.
4	Road networks on sites must enable unobstructed access to all areas of the facility	**Compliant**	The service road at the site provides unobstructed access to all BESS containers – on commissioning of the site an Emergency Response Plan will be promulgated to the NYFRS, this will include a Site Layout Plan. The site meets the requirements of Building Regulations Approved Document B5 Vol 2 as all points on the site are within 45m of a point at which a fire appliance can be positioned.
5	Turning circles, passing places etc. size to be advised by FRS depending on fleet	**Compliant**	This OBSMP will be promulgated to the NYFRS to determine their satisfaction with the arrangements at the site.

Ser	NFCC Recommendation	Site Status	Comments
6	Distance from BESS units to occupied buildings & site boundaries. Initial min distance of 25m	**Compliant**	All BESS containers are a minimum of 25m from the nearest occupied buildings and a minimum of 25m from Public Rights of Way and Site Boundaries.
7	Access between BESS unit – minimum of 6 metres suggested. If reducing distances, a clear, evidence based, case for the reduction should be shown	**Compliant**	Spacing between BESS units is a minimum of 2m, with associated infrastructure placed between BESS that will provide blast and heat attenuation between BESS in the event of a fire. The suggested 6m separation, in the NFCC recommendation, is based on a 2017 Issue of the FM Global Loss and Prevention Datasheet 5-33 (footnote 9 in the NFCC Guidance refers). This datasheet was revised in July 2023 and now details the following: 1. *For containerized BESS comprised of lithium nickel manganese cobalt (NMC[1]) cells where wall construction is unknown or has an American Society for Test and Measurement (ASTM) E119 rating less than 1 hour, provide aisle separation of at least 13 ft (4.0 m) on sides that contain access panels, doors, or deflagration vents. For containerized NMC BESS where wall construction is documented as having at least a 1-hour rating in accordance with ASTM E119[2], aisle separation of at least 8 ft (2.4 m) is acceptable.* 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.* Given the revision to the FM Global Datasheet 5-33, the BESS containers on site, which utilise a minimum of 2m spacing, the site layout is compliant. Conformance to ASTM E119 1-hour fire rating (or equivalent) will be confirmed in the DBSMP.

[1] NMC being the closest equivalent to NCA.
[2] EN 13501-2 and EN1364-1 being the European equivalents.

Ser	NFCC Recommendation	Site Status	Comments
8	Site Conditions – areas within 10m of BESS Units should be cleared of combustible vegetation	**Compliant**	The BESS and other installations will be positioned on concrete plinths / standing and the land between laid out to hardcore with a gravel cover. Surfacing will comprise a 150mm top layer of 20-32mm Clean Stone, laid over 450mm of Type 6F5 Hardcore. Vegetation within a 10m area will be non-combustible, i.e., grass cut to a maximum of 25cm. All BESS containers will be 10m or more distant from hedgerows and trees.
9	Water Supplies	**Compliant**	There are two sets of four Water Tanks at the site for the purpose of firefighting. Additionally, all BESS containers will be fitted with bespoke Fire Detection Suppression System. In the unlikely scenario that the fire detection and suppression system (FDSS) does not extinguish the fire, the understood and interpreted approach to BESS fires being to let them BESS burn out and contain the fire, making use of the water supply at site if it is required. The BESS compound will be lined with an impermeable liner, and will have a flood bund around the BESS compound which would contain any run-off within the bunded area in event of a fire.
10	Signage	**Compliant**	This forms an element of the Emergency Response Plan which includes a Site Layout Plan. Details of Emergency Response Personnel will be contained at the site entrance along with a site plan and other information.
11	Emergency Plans	**Compliant**	Future iteration of the OBSMP to DBSMP will roll up the Emergency Response Plan outlining who and how FRS will be alerted, facility description, number of operatives, detailed site plan etc. On commissioning of the site an Emergency Response Plan will be promulgated to the FRS, this will include a Site Layout Plan.
12	Environmental Impacts	**Compliant**	The site design has considered and assessed the environmental impacts. See serial nine for detail on potential fire water run-off impact to aquatic habitats and argument against direct use of water on the BESS containers. The site has been subject to assessment for drainage and the containment of any firefighting water run-off within the pen-stocked attenuation basins, Figure 5-1 refers.

Ser	NFCC Recommendation	Site Status	Comments
13	System design, construction, testing and decommissioning	**Compliant**	Several of the elements under this aspect of the NFCC Guidance are contained in this OBSMP, however details of the construction, testing and decommissioning will be in the DBSMP.
14	Deflagration Prevention and venting	**Compliant**	The BESS to be used has deflagration panels fitted to the roof of the ISO Containers and venting requirements form an overall element of the design as part of the Environmental Conditioning Units. The BESS will be compliant with prevailing National Legislation and International guidance for the design and qualification of BESS.

6.0 Safety Case

6.1 Introduction

A safety case is required to support the design, construction, operation and maintenance, and decommissioning of the BESS and is required to justify that its safety is at an acceptable level for its role, in its intended operating environment. A safety case is defined as "a logically stated and convincingly demonstrated reason why safety requirements are met". The BESS safety case will have the following elements:

1. A Technical Risk Case:
    a. An element that provides the case that articulates the technical aspects of the design which serve to control the identified hazards, through the application of design control measures.
    b. It will identify system hazards and the causes that can contribute to these hazards.
    c. It will specify the risk analysis conducted and risk reduction requirements implemented.
    d. It will provide the evidence to support any risk reduction claimed.
2. A Confidence (Assurance) Case:
    a. This part will focus on demonstrating that the processes used to design, implement, and verify the product are appropriate to its contribution to overall risk – this being specific to the development of software and provide the required audit trail to validate any claimed safety reliability.
    b. The development of the Hazard Log and identification of imbedded physical attributes that help reduce risk.
    c. The cross-referencing of these physical attributes (and any supporting qualification data / certification) to the relevant cause(s), providing the evidence of validity of the control measure claimed.

6.2 Safety Integrity Level Requirements

The Safety Integrity Level requirements for the BESS will be driven by the functionality implemented in the final BESS design. As a minimum it will be a requirement placed on the BESS supplier to provide a layered protection approach (from battery cell to container to remote monitoring). The envisaged safety control measures and design features under consideration, and those that will be provided to the prospective suppliers in the SRD, include:

1. Appropriate battery chemistry selection – balancing energy density requirements against available volume and operating parameters. The preferred option under consideration is Lithium Titanate Oxide, which is in use in the public transport sector, including Underground and Overground Rail systems.

2. Cell level control – consideration of the use of battery technology incorporating Current Interrupt Devices and Positive Thermal Coefficient protection, enabling the cell to disconnect from the battery in the event of cell failure.

3. Implementation in the design of an approved Battery Management System (BMS).
4. Implementation in the design of an Independent Protection System (IPS) and electronic Safety Supervisor Systems.
5. 24/7 Remote Monitoring and Control and automated shut-down.
6. Segregation of Containers.
7. Quench and suppression systems fitted to containers.
8. Site Security and Monitoring.

7.0 Safety Management Strategy and Activities

7.1 Introduction

The BESS will be designed to meet relevant industry standards and legal requirements which contain specific safety requirements (as described in Section 5.2).

7.2 Safety Criteria

The consequence for each potential occurrence involving the BESS is categorised according to classification which accounts for both frequency of occurrence and severity of outcome (risk) as defined in the following:

1. The consequence definitions are defined in Table 7-1.
2. The probability definitions and bands used are detailed in Table 7-2[3].
3. The Risk Class Matrix is shown in Table 7-3.
4. The Risk Class definitions are given in Table 7-4.

The safety criteria used in this document have been adapted from those defined within the US Department of Defence Mil-Spec 882E [Ref. 2] and using safety target and limit benchmarks from the HSE R2P2 [Ref. 2]. This assessment criteria will be flowed to prospective suppliers in the SRD.

[3] These are derivations of quantitative targets.

Table 7-1 – Consequence Definitions

Risk Category		BESS Description			
		Asset	Capability	Environmental	Human
Catastrophic	**1**	Complete loss of BESS and surrounding 3rd party assets	Capability lost	Irreversible and significant environmental impact	Fatality or permanent life changing disability
Critical	**2**	Complete loss of BESS	Full capability of site seriously affected	Reversible but significant environmental impact (long-term)	Permanent partial disability, injuries, or occupational illness
Marginal	**3**	Partial loss of BESS Not repairable – components retrievable	Capability less seriously affected	Reversible moderate (decontamination possible) environmental impact	Less serious personal injury, illness – A&E / GP assistance required
Negligible	**4**	Minor BESS damage – repairable	Capability impaired but possible	Minimal (self-recoverable) environmental impact	Negligible injury or illness. Treatable without recourse to A&E / GP

Table 7-2 – Frequency Definitions

Accident Frequency		Occurrence rate		Qualitative Definition
	Class	Occurrence rate	Per Annum 8760 hrs (fph)	
Frequent	A	10% < P	1.15E-04	Likely to occur often (repeatedly) in the Lifetime (40 years of operation).
Probable	B	1% < P ≤ 10%	1.0E-03 or greater	Will occur several times in the Lifetime
Occasional	C	0.1% < P ≤ 1%	1.0E-04 to 1.0E-05	Likely to occur sometime in the Lifetime
Remote	D	0.01% < P ≤ 0.1%	1.0E-05 to 1.0E-06	Unlikely, but possible to occur in the Lifetime
Improbable	E	P ≤ 0.01%	1.0E-06 to 1.0E-07	So unlikely, it can be assumed occurrence may not be experienced in the Lifetime
Eliminated	F	Incredible (physically impossible) of occurrence within the life of an item. This category is to be used when potential hazards are identified and later eliminated. (Nominally the occurrence rate has been assessed as <1.0E-08)		

Table 7-3 – Risk Class Matrix

	Severity			
	Catastrophic	Critical	Marginal	Negligible
Frequency	1	2	3	4
Frequent	A	A	A	B
Probable	A	A	B	C
Occasional	A	B	C	D
Remote	B	C	D	D
Improbable	C	D	D	D
Eliminated	E	E	E	E

Table 7-4 – Risk Class Definitions

Risk Class	Risk Class Definition
(A) *Intolerable*	Intolerable: Risks must be reduced.
(B) *Undesirable*	Undesirable: Risks should be reduced.
(C) *Limited Tolerable*	Limited Tolerable: Risks can be reduced.
(D) *Tolerable*	Broadly Acceptable: No action required.
(E) *No Risk*	

8.0 Components of the Safety Case

8.1 BESS Safety Working Group

A BESS Safety Working Group (SWG) is proposed to be established, following planning acceptance. This will be the forum for the review and continued validity of key elements which support the safety case. The BESS SWG will comprise Suitably Qualified and Experienced Person (SQEP) stakeholders who are drawn from various stakeholder communities because of their tacit knowledge and experience.

The BESS SWG will be responsible for the oversight of BESS safety management and supporting safety artefacts to ensure they are reviewed and updated. One of the key tasks is the production of the Hazard Log for the equipment and the management of this throughout operation utilising Hazard Identification and Hazard Analysis techniques. The BESS SWG is also the forum for addressing equipment safety issues.

The overall principal tasks, duties, and responsibilities of the BESS SWG are defined in Section 9.0. The meeting frequency of the BESS SWG will be dependent on the activities required for the prevailing stage of the Proposed Development.

8.2 Hazardous Material

Any hazardous materials used in the BESS development will need to be fully justified and captured in the BESS Hazardous Materials Register, a sub-set of the Bill of Materials (BoM). The register is used to highlight the hazardous materials contained within the BESS and provides justification as to why they cannot be eliminated. It will identify exact quantities of hazardous materials that are present to satisfy legislative requirements. The BESS Hazardous Materials Register will be made available to the local emergency services.

8.3 Safety Disposal Considerations

Disposal activities will be considered at the BESS concept stage and will be included within the BESS safety management process. As the Proposed Development advances through the development phases, the Hazard Log will be expanded to cover each phase.

8.4 Forward Plans

This is the initial OBSMP for BESS and as such the identification of potential hazards, causes and controls is limited to the concept stage, i.e., the BESS concept design and the initial proof of design artefact. Therefore, several of the controls identified are also conceptual and subject to technological assessment, as such no ALARP statements can yet be prepared.

To date, all control measures identified are founded on good practice and based on previous knowledge of BESS systems in use and other associated products using Lithium-Ion electrical storage technology. These mitigations may in some instances require further development and ratification as the Proposed Development advances through the development phases. Upon successful implementation, and with suitable evidence available to validate effectiveness, reassessment can be conducted with the aim to consider the reduced the level of risk.

8.5 Emergency Plans

As part of the initial development of the BESS, Emergency Plans will be developed that will outline how the operator will respond to incident and accident scenarios at site. This will include the interfaces with external first responder organisations. The Emergency Plans will be developed in an iterative manner in parallel to technical safety requirements. This will ensure that the BESS design and Emergency Plans are properly integrated (e.g., that BESS layout ensures access for first responders) and that appropriate information can be provided to first responders (e.g., the type and meaning of external indication on containers) to include in their planning activities.

8.6 BESS Hazard Log

The preliminary BESS Hazard Log is currently managed in the form of an excel spreadsheet and is provided as an example of the risks most commonly present in an energy storage system utilising Lithium-Ion technology. The benefit of using this Hazard Log tool is that it provides an auditable record of all decisions made for the assessment of risk for the BESS which can be managed through life on a central repository. The BESS Hazard Log is summarised at Appendix B.

9.0 BESS Safety Management Team

9.1 Safety Management System

The Safety Management System (SMS) provides a system of management that ensures that all safety related aspects are managed in accordance with applicable industry standards and United Kingdom (UK) legislation. Within the safety context, the BESS SMS ensures that the risks associated with the BESS will be managed such that they are ALARP and broadly acceptable or tolerable and will remain so throughout the lifetime of the equipment.

Some of these safety requirements and consequential decisions will need to be balanced against practicability of implementation, cost and the associated risk reduction. Likewise, when the occurrence of a hazard has been reduced to a level where it is considered eliminated, further risk reduction will only be implemented because of indirect risk reduction measures, implemented for other hazards or causes. The SMS will further facilitate the strong safety culture for the BESS development, including and encompassing sub-contractors, suppliers and the wider stakeholder community who interface with the BESS.

9.2 Safety Management Structure

The BESS safety management structure has yet to be fully defined and will be subject to safety management strategies and procedures implemented by the successful supplier and installer of the BESS. Currently the minimum requirement is a formal top-down management structure that has the authority and responsibility to ensure safety management and environmental risk is at the forefront of products, procedures, and services.

9.3 Overarching Policy

All BESS development activities shall consider safety and environment as an integrated part of the BESS life cycle and shall be assessed from a safety viewpoint. This safety-focused approach shall span all development phases. This encourages and develops a safety and environmental culture that spans all levels of the organisation and encompasses all aspects of its working practices. It views safety as a holistic quantity that is owned by the organisation rather than something to be passed by function.

This safety culture is supported by training to develop and maintain expertise and awareness for good practice, knowledge of emerging standards and in the understanding of legislation.

9.4 Management Plan

This OBSMP incorporates the management activities relevant to safety. This includes the planning for Quality, Engineering Development and Configuration Management. These are important disciplines that underpin arguments for safety and environment. This OBSMP will be periodically revisited and revised to accommodate any changes or enhancements to the Proposed Development throughout construction, operation and maintenance, and decommissioning.

9.5 Staff Competence

The BESS safety and environmental management programme shall ensure that all personnel who have any responsibility for a safety or environmental activity are competent to discharge those responsibilities or are adequately supervised/approved by someone with appropriate competencies.

9.6 Overview

The implementation of safety management and safety activities will be given the highest priority throughout construction, operation, and maintenance, and decommissioning of the Proposed Development. It is recognised that the management of safety is an integral part of the safety assurance process, and the observance of the requirements specified in this report will be mandatory for all involved with the BESS.

10.0 Conclusions and Recommendations

10.1 Conclusions

In conclusion, as far as reasonably practicable for this stage in the planning process, the currently foreseeable hazards associated with the BESS equipment have been identified. These hazards will be actively managed and added to as the BESS develops and will be reported on at each SWG. This OBSMP has been developed using existing knowledge of BESS systems and leans heavily on the subject matter expertise that ARC have in this technological domain. Further development of the BESS design will provide more detailed information that will enhance future safety analysis and management.

10.2 Recommendations

It is recommended that the BESS safety management and criteria (for assessment and analysis) as defined in this OBSMP, is adhered to throughout the lifecycle of the BESS facility to ensure that safety management is developed throughout the Proposed Development construction, operation and maintenance, and decommissioning.

It is recommended that to reduce the level of residual risk to meet the **LOW** ‘tolerable’ region that all the identified control measures are assessed as the design matures to prompt; applicability, feasibility and the potential enhancement provided. At this early stage of the Proposed Development, it is not possible to declare ALARP, however successful implementation of the proposed framework for safety management presented in this OBSMP will provide the necessary case and supporting evidence to make such a claim.

11.0 References

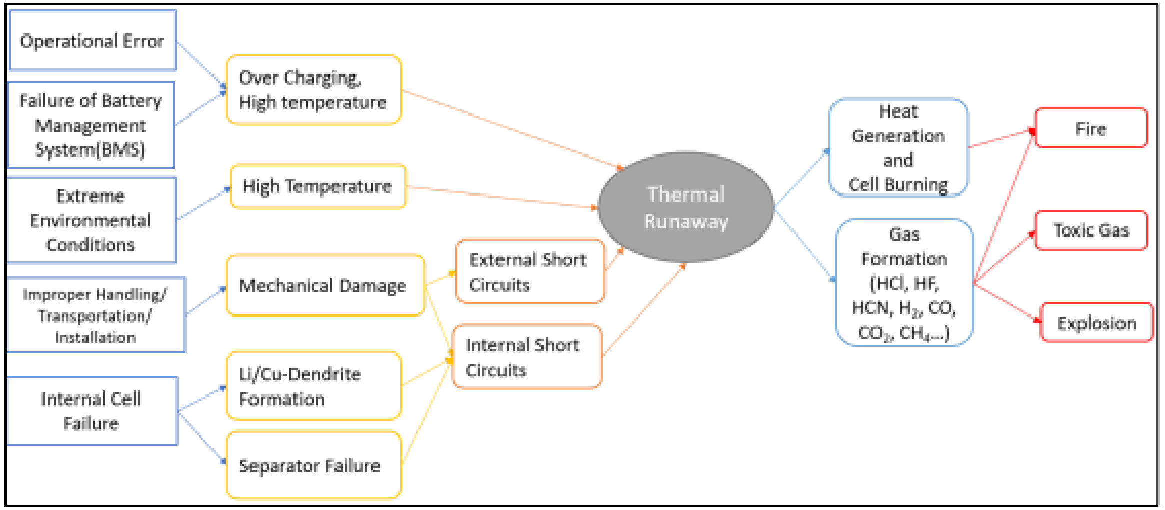
1. BESS Hazard Log - ARC-1168-003-R2, Draft A, June 2023.

2. Reducing Risk, Protecting People (HSE Publications) - https://www.hse.gov.uk/risk/theory/r2p2.pdf.

MIL-STD-882E, Department of Defence Standard Practice: Safety Systems Dated May 2012.

Appendix A – FAQs

Ser	Question	Answer
1	How does a BESS work?	A BESS employs technology to temporarily store electrical energy, very much in the same manner as a mobile phone or laptop battery, but on a much bigger scale. The energy can be stored and released when demand on the National Grid is high and assists in balancing out variations in demand. BESS can be connected to a PV Solar Farm and store energy throughout the day for release in the evening and in this mode of operation is a green renewable technology. An alternative use for BESS is to store electrical energy generated by energy suppliers during period of low demand and releasing in periods of high demand, thus balancing out changes in supply and demand on the National Grid.
2	How safe is a BESS?	The Department for Energy Security and Net Zero, promulgates on a regular basis the Renewable Energy Planning Database. From the quarterly extract (dated Oct 2024) the data has been filtered for BESS installations in the UK and the following salient points are deduced: 1. As of Oct 2024, there are approx. 117 BESS sites are operational across the UK, 8 having been decommissioned and a further 91 are under construction. 2. The total energy capable of being stored is estimated at 2.5GW 3. Since 2006 BESS have operated (those now decommissioned + those in operation) for approximately 6.2 million hours (data details 6,226,392 hours) which is equivalent to 710 years of operation. 4. There has currently been only one reported UK BESS fire that required FRS attendance, this occurred at Carnegie Road, Liverpool in Sept 2020. Given the 6.2 million hours of operation, this equates to 1.6E-07 (0.00000016) failures per hour (fph) for BESS in the UK. 1. HSE R2P2 Guidance [Ref. 1] states that 1.0E-06 fph as being the ‘societally acceptable’ safety rate for the public, the level achieved by UK BESS is better than that expected using this HSE guidance. Noting that to date nobody in the UK has been killed in a BESS incident.
3	Lithium-Ion is sensitive to temperature variations – how is this controlled?	The batteries are housed in an ISO container which is fitted with an Environmental Control Unit (ECU). The ECU maintains the temperature and humidity within the container, allowing the Lithium-Ion batteries to operate within the optimum temperature range. The temperature of individual cells in each battery is monitored by the BMS and is reported back to the container level BMS which adjusts the internal temperature in response. Should the ECU develop a fault the container will isolate charge and discharge to the batteries until the fault has been rectified. All faults in the BESS are remotely fed to a centralised Control Room.

<table>
<tr><th>Ser</th><th>Question</th><th>Answer</th></tr>
<tr><td>4</td><td>What is Thermal Runaway?</td><td>Thermal Runaway (TR) is the term used to describe an internal short-circuit in one of the battery cells that can lead to cell over-pressure and the venting of combustible gases. Should this gas ignite then the cell will increase in over-pressure and the resulting fire will be self-sustaining until all the material in the cell is expended. Short-circuits in cells are generally a result of:
1. Cell penetration by a foreign object (not usually an issue for a BESS as the batteries are housed in sturdy containers).
2. Impurities in the electrolyte (deposited during the manufacturing process), which over time can lead to the formation of dendrites (electrolytic crystals) which puncture the membrane isolating the anode and cathode – this can, but not always result in a short-circuit and TR.
3. Over temperature in the cell because of:
a. Over-charging (which is controlled by two separate BMS – battery and rack).
b. High ambient temperature – controlled by the ECU.
The illustration below provides an outline of the possible causes of TR.

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</table>

Ser	Question	Answer
5	How can TR be controlled?	A cell fire does not necessarily always result in a TR, and the nature of the cell design is such that early warning signs of a stressed cell can be detected by the BMS. Initial signs of cell degradation are an increase in the time it takes the cells to reach full charge (maximum voltage) and a decrease in the time it takes to discharge. These indicators are picked up by the BMS and if persistent the BMS will isolate (prevent charge and discharge) to the battery and inform the centralised Control Room. In turn an engineer will be dispatched to remove the battery and replace it with a serviceable item. Since the early inception of BESS safeguards in the design have developed and are now details in UL1973 and BESS are assessed against UL9540A. If these indicators are not present, and the cell enters early stages of short-circuit the over-pressure in the cell will result in the venting of off-gas which is detected by the off-gas detectors built into the container heating, Ventilation and Air Conditioning unit (the ECU). This will result in the container disabling the charge and discharge (the act of charging and discharging the batteries generates heat, which is what we want to avoid) and setting the ECU to maximum volume setting. This has a twofold effect, it clears the container of combustible gas and cools the internals, taking the energy out of the cells (the cells used in BESS, like other batteries do not perform well in low temperature conditions). It should be noted that most BESS only operate at between 80-90% of capacity provide an engineering margin that mitigates the probability of over-charging the cells.

Ser	Question	Answer
6	How is a BESS fire controlled and suppressed?	If the TR is not controlled and spreads, known as Thermal Runaway Propagation the FDSS will activate. There are currently two types of FDSS that are used in BESS; gaseous systems and aerosol systems. Each system has advantages and disadvantages: 1. Aerosol systems are better in terms of extinguishing the fire and benefit against gaseous systems, which generally supress the fire by reducing the level of oxygen in the container. 2. Gaseous systems are instantaneous in operation, the gas being kept under pressure in bottles. Aerosol, by the nature of the deployment as a fine mist, take a little longer to reach all areas of the container. 3. Aerosol system generally require a more complex and intricate delivery system to reach all areas of the container. 4. Gaseous system requires a sealed environment in which to operate. As such if the container is opened and oxygen reintroduced it can lead to the fire reigniting, as such they require the ECU to close prior to activation (to prevent the ECU from pushing out the extinguishing medium). 5. Various FDSS aerosols (also known as aqueous) and gaseous systems are available, and they use a variety of aerosol solutions. Under consideration for this site is the use of an aerosol aqueous solution containing potassium carbonate (K_2CO_3) – this inhibits the fire by isolating at a molecular level with the chemical chain reactions forming the flame front. This aerosol is non-harmful to the environment and presents no health and safety concerns to first responders.

Ser	Question	Answer
7	What are the environmental consequences of a BESS fire?	In the event of a BESS fire several chemicals in gaseous form can be released and the composition and concentration of the plume (also referred to as the vapour cloud). In the event of a BESS fire amongst the general gases released are Carbon Monoxide (CO), Hydrogen Fluoride (HF), Oxygen and Hydrogen. The only UK BESS fire (Carnegie Road, Liverpool – Sept 2020) was monitored and the resultant composition of the plume was determined as being negligible in toxic gas concentration. Should the resulting fire be treated with water in the presence of HF the result can be the formation of a HF acid which can be detrimental to the environment, especially the aquatic habitat. To prevent this, it is possible to contain the fire run-off water but often best to let the fire run its course and burn out. It is worth noting that the fire run-off water at Carnegie is considered to have been neutralised by the lime-based gravel covering used at the base of the BESS and on testing was found to be a low alkaline level, as opposed to acidic. The analysis of the fire water run-off, as tested by Bureau Veritas, (Significant Incident Report 018965 – 15092020 Summary and Key Learning (Page 4) Bullet 12 refers), states 'Once water was applied, the resulting run-off contained Hydrofluoric Acid (HF) (confirmed by Bureau Veritas) as a product of reaction between the cells and water contact. "Firefighting run-off was low due to the container involved being sited on a gravel base. Run-off was periodically checked for contamination, which was low. Appropriate environmental protection measures were put in place at the earliest opportunity". The run-off was mainly contained to the site'. The site will be lined and any run-off directed to an attenuation basin for capture, treatment and onward disposal.
8	How is the BESS site secured?	BESS Site are secured through fences / walls and monitored remotely via security cameras. Warning signs along the fence indicates the presence of electrical storage facilities within the site.
9	How is the serviceability of the BESS assured?	The Health and Usage data for each BESS is remoted to a centralised Control Room and the serviceability of each battery determined on an hour-to-hour basis. Given that the batteries have a finite number of cycles over a given period it is envisaged that the batteries will be renewed multiple times in the 40-year life of the site.

Appendix B – BESS Hazard Log

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst Case Severity	Classification
Haz_BESS_001	Uncontrolled release of chemical energy - TR	Cse_BESS_001	Internal failure of cell	Ctrl_BESS_001	The cell has been selected and configured such that the loading of the cell does not cause excessive stress. The design of the BESS will be compliant to UL1973, and the BESS has been qualified to UL9540A	Improbable	Improbable	Marginal	D
				Ctrl_BESS_002	The cell will have been tested at the expected stress levels to show no signs of premature venting/failure or excessive voltage drop or temperature rise in accordance with the requirements of UL9540A				
				Ctrl_BESS_003	The battery design spaces cells as far apart as possible to reduce direct heating effect from one cell to another, in accordance with UL1973				
				Ctrl_BESS_004	The cells are certified by an approved 3rd party to meet UN38.3 transport test requirements and IEC62619 Safety Requirements				
		Cse_BESS_003	Over Temperature	Ctrl_BESS_005	The BMS senses the individual battery temperature will isolate the Charge (CHG) and Discharge (DSG) of the totality of BESS.	Improbable			
				Ctrl_BESS_006	The BESS is remotely monitored and managed. Allowing the BESS to be electrically isolated from the supply (removing the charge will remove any external stimulus to the batteries).				
		Cse_BESS_004	OC - Excessive Charge Current	Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single	Improbable			

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst Case Severity	Classification
					battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.				
				Ctrl_BESS_020	Fail safe: BMS is backed up by an Over Current Protection Fuse				
		Cse_BESS_005	OC - Excessive Discharge (Surge)	Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.	Improbable			
				Ctrl_BESS_020	Fail safe: BMS is backed up by an Over Current Protection Fuse				
				Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS				
		Cse_BESS_006	Over Voltage (OV) - Continuous Charge	Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS	Improbable			
				Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.				

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst Case Severity	Classification
		Cse_BESS_007	Low Temperature Charging	Ctrtl_BESS_021	The BESS is a temperature-controlled environment and as such unlikely to be subject to temperatures below the operating capability of the Li-Ion Cells. In the event of ECU failure (or failure to maintain the temperature parameters, the BESS will inhibit charging)	Improbable			
				Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS				
		Cse_BESS_008	Under-Voltage (UV) - Continuous Discharge	Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS	Improbable			
				Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to prevent further discharge.				
Haz_BESS_002A	Contact with exposed electrical components - HV-3P	Cse_BESS_009	Exposure to electrical source (e.g., contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras.	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the invertors is controlled and the access secured when in operation.	Improbable			

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst Case Severity	Classification
		Cse_BESS_010	Effect of high current pulses (EM) introduce a conductive path	Ctrl_BESS_010	3P cables are routed in separate cable tray and kept distant from other cables to reduce propensity for current induction	Improbable			
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	Inverters will be fully earthed to ground	Improbable			
Haz_BESS_002B	Contact with exposed electrical components - HV-DC	Cse_BESS_009	Exposure to electrical source (e.g., contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras.	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the BESS is controlled and the access secured when in operation.				
		Cse_BESS_010	Effect of high current pulses (EM) introduce a conductive path	Ctrl_BESS_010	BESS sourced will be EMC certified to IEC 61000-6-2 and IEC 61000-6-4	Improbable			
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	All infrastructure is fully earthed to ground and monitored. All infrastructure is subject to periodic inspection	Improbable			
Haz_BESS_002C	Contact with exposed electrical components - LV-DC	Cse_BESS_009	Exposure to electrical source (e.g. contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the BESS is controlled and the access secured when in operation.				
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	BESS units are fully earthed to ground and monitored by the BESS BMS	Improbable			

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst Case Severity	Classification
Haz_BESS_003	Failure of EMC/EMI protection impacts on system functionality	Cse_BESS_012	BESS not EM compatible with environment in which it is located	Ctrl_BESS_012	BESS is located remotely and EMC compatible with all associated site infrastructure	Improbable	Improbable	Marginal	D
Haz_BESS_004	Operator / maintainer exposure to Hazardous substances	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_013	All hazardous substance listed in the Original Equipment Manufacturer (OEM) documentation. All maintainers provided with the appropriate PPE. A list of hazardous substance held on site is detailed in the ERP	Occasional	Occasional	Marginal	C
Haz_BESS_005	Ingress of water	Cse_BESS_014	Water Ingress into the BESS internals excessive to the degree that it effects the functionality of BESS	Ctrl_BESS_014	BESS is housed in a Container and a minimum of IP44 compliant and elevated on concrete plinths	Remote	Remote	Marginal	D
				Ctrl_BESS_015	The BESS design is such that the batteries are off the floor and held in shelving				
Haz_BESS_006	Maintainers required to access in the internals of BESS	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A Safe System of Work (SSOW) is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable	Improbable	Critical	D
Haz_BESS_007	Maintainer required to lift, move, or carry heavy BESS components (in confined spaces)	Cse_BESS_015	Maintainer required to access and remove/refit heavy BESS components	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Occasional	Occasional	Marginal	C
				Ctrl_BESS_018	MHE to be provided for the movement of components more than 25kg				
Haz_BESS_008	Gases vented during BESS operation (off-nominal) accumulate within enclosure	Cse_BESS_013	Cells stressed through failure of BMS to monitor status correctly	Ctril_BESS_016	BESS are fitted with off-gas sensors that activate ECU on detection of off-gas from cells and concurrently notify the 24/7 Remote Monitoring Facility for additional action	Improbable	Improbable	Critical	D

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst Case Severity	Classification
			Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable			
Haz_BESS_009	Operation / maintenance of the BESS exposes the user to sharp edges and hard surfaces	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Occasional	Occasional	Marginal	**C**
				Ctrl_BESS_019	All sharp edges to be radiused or covered to ameliorate				
Haz_BESS_010	Operator / Maintainer exposure to biological growth in the BESS	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS (after a prolonged period of use)	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable	Improbable	Negligible	**D**