Abbott Risk Consulting Limited

ARC-1205-004-R1

Castle Road Battery Energy Storage System – Outline Battery Safety Management Plan

Issue 2 – February 2025

DRAFT

Prepared for:

REWE 7 Limited

APPROVAL AND REVISION RECORD					
Issue No.	**Date**	**Prepared**	**Reviewed**	**Approved**	**Revision Notes**
Draft A	July 2024	J Tough	T Lambert	T Lambert	Draft for client comment
Draft B	January 2025	J Tough	T Lambert	T Lambert	Layout revision
Issue 1	January 2025	J Tough	M Mankel	N Harty	Formal Issue
Issue 2	February 2025	J Tough	M Mankel	R Davies	Layout revision

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Executive Summary

This Outline Battery Safety Management Plan (OBSMP) is in support of a proposed Battery Energy Storage System (BESS) on land north of Castle Road, near Rhoose in the Vale of Glamorgan, South Wales henceforth referred to in this OBSMP as the "Proposed Development". The aim of this OBSMP, is to support the Planning Application for the installation and to identify and define the safety strategy and processes necessary to meet the derived safety measures in the:

1. Fire and Rescue requirements detailed in the National Fire Chiefs Council (NFCC) Report Grid Scale BESS Planning – Guidance for Fire and Rescue Services (FRS).

2. Factory Mutual (FM) Global Loss and Prevention Datasheet 5-33 (as cited in the NFCC Report).

This OBSMP sets the level of safety performance that the installation will meet. It also provides the basis for the safety management processes and procedures required to satisfy the identified safety requirements for the Proposed Development capability.

The preliminary safety hazard identification and analysis, based on like for like energy storage systems of this type, namely Lithium Battery technology, has determined the likely causes and hazards associated with BESS technology of this type and enabled the initial identification of potential control measures that when implemented will ameliorate the level of risk posed to an acceptable level.

It is proposed that, as far as reasonably practicable and for this planning stage of the Proposed Development, that the currently foreseeable hazards have been identified. These will form the initial safety foundation going forwards and be actively managed as the project and installation matures. At this juncture of the planning process it is expected that the SolBank 3.0 system will be used but this is to be confirmed at the Detailed Battery Safety Management Plan stage.

The design, development, and manufacture of the Proposed Development requires the implementation and maintenance of high standards in respect of safety and operational sustainability. It will be the responsibility of all personnel involved in the engineering and construction of the proposed undertaking to strive to reduce the potential for accidents to the lowest practicable level by being a 'risk aware' and promoting a supportive safety and environmental culture at all stages of the development. This OBSMP is the starting point from which the safety management of the project will progress.

Abbreviations

ALARP	As Low As Reasonably Practicable
ARC	Abbott Risk Consulting Ltd
BESS	Battery Energy Storage System
BMS	Battery Management System
CO	Carbon Monoxide
DBSMP	Detailed Battery Safety Management Plan
ECU	Environmental Control Unit
ERP	Emergency Response Plan
FAQs	Frequently Asked Questions
FDSS	Fire Detection and Suppression System
FM	Factory Mutual
fph	failures per hour
FRS	Fire and Rescue Service
H_2	Hydrogen
HF	Hydrogen Fluoride
HSAWA	Health and Safety at Work Act
HSE	Health and Safety Executive
IEC	International Electrotechnical Commission
LFP	Lithium Ferrous Phosphate
NFCC	National Fire Chiefs Council
NFPA	National Fire Prevention Association
NMC	Nickel Manganese Cobalt
OBSMP	Outline Battery Safety Management Plan
PPG	Planning Practice Guidance
R2P2	Reducing Risk, Protecting People
SIL	Safety Integrity Level
SME	Subject Matter Expert
SMS	Safety Management System
SQEP	Suitably Qualified and Experienced Person
SWFRS	South Wales Fire and Rescue Service
SWG	Safety Working Group
TR	Thermal Runaway
UK	United Kingdom
UL	Underwriters Laboratory
US	United States

Contents

1.0 Introduction

This Outline Battery Safety Management Plan (OBSMP) has been developed by Abbott Risk Consulting Ltd (ARC) in the role of the Safety Subject Matter Expert (SME). It aims to satisfy, where currently possible, the safety requirements (and any additional derived safety requirements) such that the Proposed Development can be assessed, in accordance with Health and Safety Executive (HSE) policy and guidance, and that the residual risk to life and property can be demonstrated as being As Low As Reasonably Practicable (ALARP). ARC has been instrumental in the development of OBSMP for sites in England, Scotland and Wales and represented clients as the Battery Energy Storage Systems (BESS) Safety SME at Public Inquires and Public Consultations.

This OBSMP has been developed at the planning stage to identify and assess the potential risks associated with the Proposed Development design, installation, and operating capability, and to provide a robust safety argument, supported by evidence, prior to full commissioning. It is proposed that the safety programme will develop following three phases reflecting the maturity of the programme:

1. **OBSMP (Concept and Design) –** this report. Outlines the processes, procedures and means by which the BESS safety management is to be conducted, implemented, and assessed, such that the BESS design and development, initial construction, and operation safety performance can be conducted with an acceptable level of residual risk.

2. **Detailed Battery Safety Management Plan (DBSMP) (Requirements) –** Identifying the level of risk posed by the BESS design to individuals (both those directly involved in the operation and 3rd parties), the immediate environment, the asset (the BESS), interfacing / interdependent assets and property / equipment that could be affected by the operation of the BESS (noise, radiated emissions etc.). This element will develop upon the identified risks in the OBSMP.

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 bounds established i.e., training, provision of Personal Protective Equipment, calibration, scheduled maintenance etc.

2.0 Background

ARC have conducted an initial hazard identification of the BESS capability as a conceptual model. This analysis has provided the necessary foundation for the identification of potential hazards and the development of a formalised Hazard Log, ARC-1205-004-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 frequency of hazards or their consequences.

3.0 Aim

The aim of this report is to outline the safety management approach that will be adopted, furthermore, the overall safety aim is that the levels of risk of accident, death or injury to personnel or other parties, and to the environment due to BESS activities are to be broadly acceptable or tolerable and ALARP, in accordance with the HSE Reducing Risk, Protecting People (R2P2) [Ref. 2].

3.1 Scope

The scope of this report for the Proposed Development and capability covers the physical and functional aspects of the equipment. The safety management will cover design, validation, siting, operation, and removal from site (post use). It will also include any remote monitoring and control, maintenance, storage / transportation, and calibration.

3.2 Frequently Asked Questions

Appendix A to 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 Safety Requirements

4.1 High Level Safety Objective

The primary safety objective for the Proposed Development is to comply with applicable legal requirements and relevant emerging good practice for large / grid scale BESSs. These will be distilled into safety requirements that will be included in the requests for quotations and be flowed down to prospective suppliers. Compliance with these safety requirements (by the potential suppliers) will be used as part of the safety argument, to ultimately demonstrate on commissioning that '***The risk posed to individuals, the environment and property from the programme of work has been reduced to a level that is Broadly Acceptable or Tolerable and ALARP'***. These derived safety requirements will be fundamental to the Proposed Development and will be used to ensure that all direct and indirect safety requirements are met, and that the supplier(s) is(are) safety compliant.

4.2 Safety Guidance

Safety Guidance for the Proposed Development 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 the Proposed Development:

1. National Fire Chiefs Council (NFCC) Grid Scale BESS planning – Guidance for Fire and Rescue Services (FRS).
2. Factory Mutual (FM) Global Property Loss Datasheet 5-33 – Lithium-Ion BESS.
3. 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.

4. International Electrotechnical Commission (IEC) 61508 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems (E/E/PE, or E/E/PES).

4.3 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 has been determined as applicable to the BESS development:

1. Health and Safety at Work etc. Act 1974 – UKSI1974/0037.
2. Control of Noise at Work Regulations 2005 – UKSI 2005/1643.
3. Control of Substances Hazardous to Health Regulations 2002 – UKSI 2002/2677.
4. Control of Vibration at Work Regulations 2005 – UKSI2005/1093.
5. Electrical Equipment (Safety) Regulations SI 1994/3260.
6. Electro-magnetic Compatibility Regulations SI 2006/3418.
7. Lifting Operations and Lifting Equipment Regulations 1998 – UKSI1998/2307.
8. Management of Health and Safety at Work Regulations 1999 – UKSI1999/3242.
9. Manual Handling Operations Regulations 1992 – UKSI1992/2793.
10. Personal Protective Equipment Regulations 2002 – UKSI2002/1144.
11. Provision and Use of Work Equipment Regulations 1998 – UKSI1998/2306.
12. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations SI2013/1471.
13. Supply of Machinery (Safety) Regulations 2008 – UKSI2008/1597.
14. Workplace (Health, Safety and Welfare) Regulations 1992 – UKSI1992/3004.
15. Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations – 1907/2006.
16. Restriction of Hazardous Substances Directive – 2011/65/EU.
17. Dangerous Substances and Explosive Substances Regulations 2002 - SI 2002/2776.
18. Construction (Design and Management) Regulations - SI 2015/51.

5.0 Safety Argument

5.1 Introduction

A safety argument is required to support the design, development, installation, and use of the Proposed Development, arguing that the safety is at an acceptable level for its role in its intended operating environment. A safety argument is defined as "a logically stated and convincingly demonstrated reason why safety requirements are met". The safety argument will have the following elements:

1. A Technical Risk Argument:
    a. An element that provides the argument 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) Argument:
    a. This part will focus on arguing that the processes used to design, implement, and verify the product are appropriate to its contribution to overall system risk – this being specific to the development of software and provide the requisite audit trail to validate any claimed Safety Integrity Level (SIL) in accordance with IEC61508.
    b. The development of the Hazard Log and identification of imbedded physical attributes that support risk reduction.
    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.

5.2 Safety Integrity Level Requirements

The SIL requirements for the Proposed Development will be driven by the functionality implemented in the successful design solution. The supplier and operator will provide a layered protection approach from cell to container to remote monitoring. The envisaged safety control measures and design features under consideration, and those that will be flowed to the prospective suppliers, include:

1. Appropriate battery chemistry selection - balancing energy density requirements against available volume and operating parameters.
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 or cell temperatures exceeding the operating range.
3. Implementation in the design of an approved Battery Management System (BMS) and a layered protection system in accordance with UL1973 [Ref. 5] guidelines.

4. Safety certification and qualification to UL9540A [Ref. 6] or equivalent.
5. The ability for 24/7 Remote Monitoring and Control and automated shut-down.
6. Off-gas detection to allow for preventative interaction.
7. Lithium Ferrous Phosphate (LFP) bespoke Fire Detection and Suppression Systems (FDSS) fitted to containers.
8. Site Security and Monitoring.
9. At a site and installation level:

    a. The segregation of containers in accordance with the FM Global 5-33 datasheet guidance detailed in this report.
    b. The maintenance of vegetation to provide a natural firebreak.
    c. The provision of suitable and sufficient access / passing points for emergency services.
    d. Communication with local emergency services and the provision of site maps, detailing BESS locations, access points etc.

5.3 NFCC Requirements

The South Wales Fire and Rescue Service (SWFRS) is the regional FRS for the site. Consultation with the SWFRS is on-going as part of pre-application process for the Proposed Development.

The NFCC Report Grid Scale BESS Planning – Guidance for FRS [Ref. 7] details the FRS requirements anticipated at BESS installations. The recommendations in the NFCC Guidance have been distilled in Table 5-1 and cross-referenced to the Proposed Development (shown in Figure 5-1) to determine compliance or otherwise.

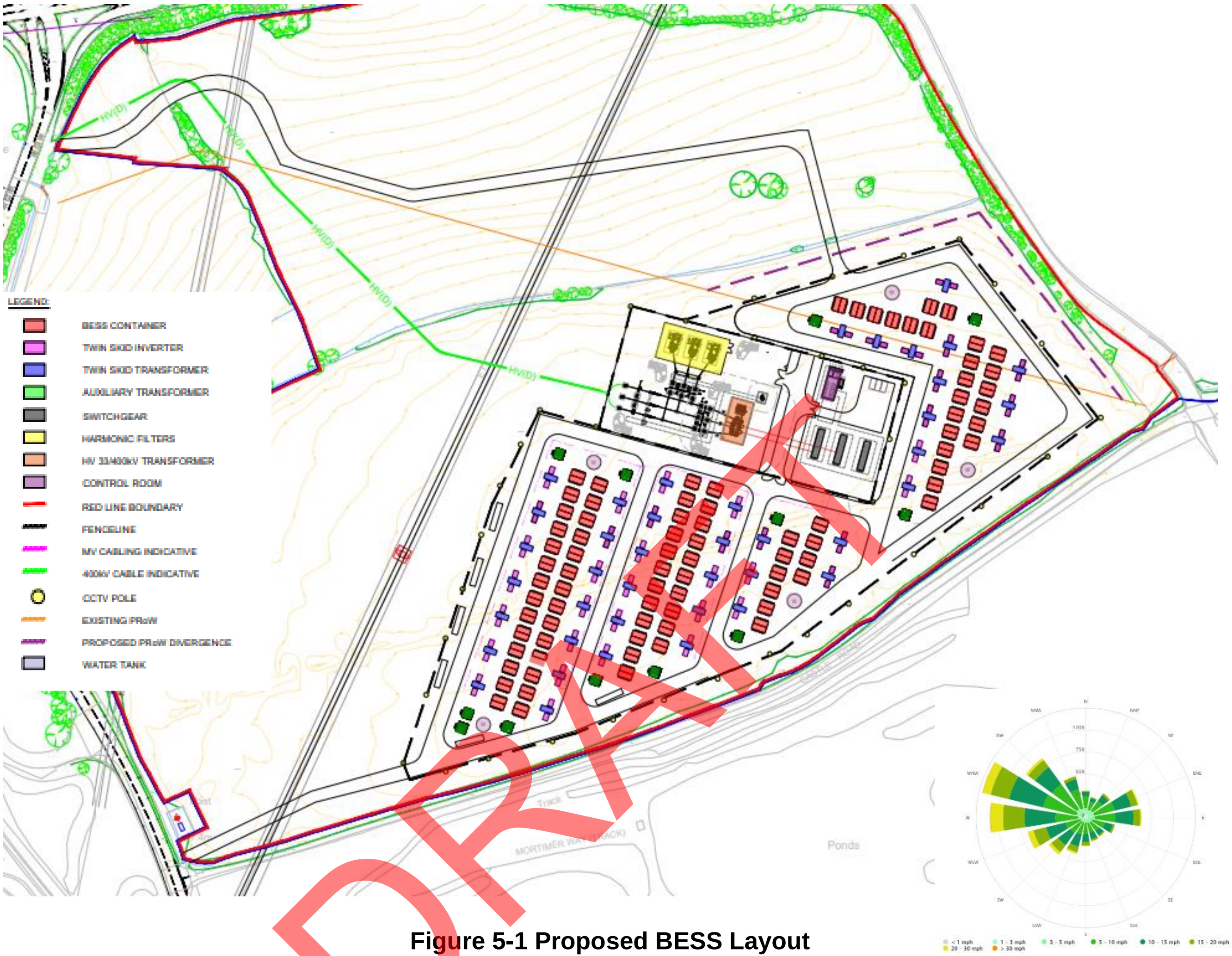


Figure 5-1 Proposed BESS Layout

Table 5-1 – NFCC FRS Requirements X-Ref to Proposed Development

Ser	Requirement	Site Status	Comments
1	Access - Minimum of two separate access points to the site	**Compliant**	The BESS compound has two points of access from the public highway, northwest and southwest. It is noted that the predominant wind direction is from the northwest and west, Figure 5-1 refers, as such obscuration of both access points at the same time is not envisaged.
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 network of service roads leading to all the BESS containers. Given the requirement to position the ISO containers as part of the construction all service roads 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 (ERP) will be promulgated to the 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**	A series of perimeter roads with interlinking roads between banks of BESS form part of the service road infrastructure and these are suitable for FRS vehicles– on commissioning of the Site, an ERP will be promulgated to the FRS, this will include a Site Layout Plan.
4	Road networks on sites must enable unobstructed access to all areas of the facility	**Compliant**	The service road network on the Site has unobstructed access to all BESS containers – on commissioning of the Site an ERP will be promulgated to the FRS, this will include a Site Layout Plan.
5	Turning circles, passing places etc. size to be advised by FRS depending on fleet	**Compliant**	The FRS will be consulted on the proposed Site layout at pre-application stage to determine their satisfaction with the arrangements at the Site. The circuitous nature of the service roads on-site allows for drive in, drive off capability without the need to reverse.
6	Distance from BESS units to occupied buildings and site boundaries. Initial min distance of 25m	**Compliant**	All BESS containers are a minimum of 50m from the nearest residential buildings 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**	The suggested 6m separation 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: *For containerized LFP BESS cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors, or deflagration vents.*

Ser	Requirement	Site Status	Comments
			Following this revision to the Datasheet, the BESS containers on-site, which utilise a LFP chemistry are a minimum of 3.5m apart (on sides containing openings) and conformance to ASTM E119 1-hour fire rating will be confirmed on the down select of the BESS units to be procured.
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. Vegetation within a 10m area will be non-combustible, i.e., grass cut to a maximum of 25mm or put over to hardcore with a gravel topping. All BESS containers are 10m or more distant from hedgerows and trees.
9	Water Supplies	**Compliant**	Water tanks form and element of the Site design, with tanks located in the BESS compound at locations that allow access to all BESS units.
10	Signage	**Compliant**	On commissioning of the Site an Emergency Response Plan (ERP) will be promulgated to the local FRS, this will include details on signage.
11	Emergency Plans	**Compliant**	Future iteration of the OBSMP to DBSMP will set out the ERP, outlining how the FRS will be alerted to an incident, facility description, number of operatives, detailed Site plan etc. On commissioning of the Site the ERP will be promulgated to the local FRS, this will include a detailed Site Layout Plan.
12	Environmental Impacts	**Compliant**	The Site design has considered and assessed the environmental impacts, and these have been deemed to be low in relation to fire safety. See Appendix A, serial 8 for detail on potential fire water run-off impact to aquatic habitats and argument against direct use of water on the BESS containers.
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 actual BESS chemistry, rack layout, suppression systems, detection, decommissioning will only be in the DBSMP as and when the decision on what is being used has been determined.
14	Deflagration Prevention and venting	**Compliant**	The BESS to be used has yet to be determined but deflagration and venting requirements will form an overall element of the design and down selection process. The BESS selected will be compliant with prevailing National Legislation and International Guidance for the design and qualification of BESS.

6.0 Safety Management Strategy and Activities

6.1 Introduction

The Proposed Development will be designed to meet relevant industry standards and legal requirements which contain specific safety requirements, section 4.0 refers.

6.2 Safety Criteria

The consequence for each potential occurrence shall be 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 6-1.
2. The frequency definitions and bands used are detailed in Table 6-2.
3. The Risk Class Matrix is shown in Table 6-3.
4. The Risk Class definitions are given in Table 6-4.

The safety criteria used in this document have been amended and adapted from those defined within the United States (US) Department of Defence Mil-Spec 882E [Ref. 3] and the Ministry of Defence UK Defence Standard 00-56 [Ref. 4], using safety target and limit benchmarks from the HSE R2P2 [Ref. 2]. This assessment criteria will be used to ascertain the residual risk posed by prospective suppliers BESS.

Table 6-1 – Consequence Definitions

Risk Category	BESS Description			
	Asset	Capability	Environmental	Human
Catastrophic	Complete loss of BESS and surrounding 3rd party assets	Capability lost	Irreversible and significant environmental impact	Fatality or permanent life changing disability
Critical	Complete loss of BESS	Capability seriously affected	Reversible but significant environmental impact (long-term)	Permanent partial disability, injuries, or occupational illness
Marginal	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	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 6-2 – Frequency Definitions

Accident Frequency	Occurrence Rate		Qualitative Definition
	Probability (P) Range	Frequency Per Annum (8760 hrs) (fph)	
Frequent	10% < P	1.0E-03 or greater	Likely to occur often (repeatedly) in the 40-year operating period.
Probable	1% < P ≤ 10%	1.0E-04 to 1.0E-05	Will occur several times in the Lifetime
Occasional	0.1% < P ≤ 1%	1.0E-05 to 1.0E-06	Likely to occur sometime in the Lifetime
Remote	0.01% < P ≤ 0.1%	1.0E-06 to 1.0E-07	Unlikely, but possible to occur in the Lifetime
Improbable	P ≤ 0.01%	1.0E-07 or less	So unlikely, it can be assumed occurrence may not be experienced in the Lifetime
Eliminated	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 6-3 – 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 6-4 – Risk Class Definitions

Risk Class	Risk Class Definition
(A = HIGH) *Intolerable*	Intolerable: Risks must be reduced.
(B = SERIOUS) *Undesirable*	Undesirable: Risks should be reduced. ALARP must be demonstrated.
(C = MEDIUM) *Limited Tolerable*	Limited Tolerable: Risks can be reduced. ALARP must be demonstrated.
(D =LOW) *Tolerable*	Tolerable: No action required. ALARP must be demonstrated.
E = No Risk	No action required.

7.0 Safety Argument

7.1 Safety Working Group

A Safety Working Group (SWG) is proposed post planning acceptance, which will be the forum for the review and continued validity of key elements which support the safety argument. The SWG will comprise Suitably Qualified and Experienced Person (SQEP) stakeholders drawn from various stakeholder communities because of their relevant knowledge and experience.

The SWG will be responsible for the oversight of 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 through life utilising Hazard Identification and Hazard Analysis techniques. The BESS SWG is also the forum for capturing equipment safety issues that require addressing, terms of reference for the SWG will be captured in the DBSMP.

The overall principal tasks, duties, and responsibilities of the SWG are defined in Section 8.0. The SWG frequency being dependent on the activities required for the prevailing stage of the project.

7.2 Hazard Log

The preliminary Hazard Log (Ref. 1) 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 Proposed Development which can be managed through life on a central repository.

7.3 Hazardous Material

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

7.4 Safety Disposal Considerations

Disposal activities will be considered in the DBSMP and form a part of the BESS safety management process. As the programme matures the Hazard Log will be expanded to cover each phase of product development and installation.

7.5 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 controls have been identified that are also conceptual and subject to technological assessment, as such no ALARP statements can yet be formulated.

All the control measures identified thus far are founded on good practice and based on previous knowledge of BESS systems in use and other associated products using LFP electrical storage technology. These mitigations may in some instances require further development and ratification as the programme progresses. Upon successful implementation, and with suitable evidence available to validate effectiveness, reassessment can be conducted with the aim to consider the reduced level of risk.

7.6 Emergency Response Plan

As part of the initial development of the site, an ERP 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 ERP will be developed in an iterative manner in parallel to technical safety requirements. This will ensure that the BESS design and ERP 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.

The ERP will be formed through two distinct elements, both of which will be promulgated to the FRS on commissioning of the BESS Site, these being:

1. The Risk Management Plan, a distillation of the OBSMP and DBSMP which will include:

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

    b. Any safety issues for the FRS 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.
   d. The adequacy of proposed FDSSs (i.e., bespoke FDSS fitted to BESS containers, off-gas detection systems, enclosure fire rating etc.)
   e. Any natural or built infrastructure and on-site processes that may impact or delay effective emergency response.

2. The ERP itself, which will include:

   a. How the FRS will be alerted.
   b. The site layout including infrastructure details, operations, number of personnel, and operating hours.
   c. A site plan depicting key infrastructure in overview: site access points and internal roads.
   d. Details of emergency resources, including FDSSs and equipment; gas detection; spill containment systems and equipment; emergency warning systems; communication systems; personal protective equipment; 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 any dangerous goods stored on-site.
   g. Site evacuation procedures.
   h. Emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire and vegetation / flora fire.

8.0 Safety Management Team

8.1 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 SMS ensures that the risks associated with the Proposed Development 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 the practicability of implementation for the Proposed Development and an affordability balanced against the risk reduction afforded. Likewise, when a hazard occurrence has been reduced to a level whereby 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, through the application, further facilitate the strong safety culture for the Proposed Development, including and encompassing sub-contractors and suppliers and the wider stakeholder community who interface with the capability.

8.2 Safety Management Structure

The safety management structure has yet to be fully defined and will be subject to the safety management strategies and procedures that are in place with the successful supplier and installer of the Proposed Development. The minimum requirement is a formal top-down management structure that has the authority and responsibility to ensure that safety management and environmental risk is at the forefront of products, procedures, and services. This will need to be expanded as the project develops.

8.3 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 programme 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.

8.4 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 programme.

8.5 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.

8.6 Overview

The implementation of safety management and safety activities will be given the highest priority during the BESS programme. 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 Proposed Development.

9.0 Conclusions and Recommendations

9.1 Conclusions

It is concluded that, as far as reasonably practicable and for this planning stage of the BESS project, the currently foreseeable hazards associated with the equipment have been identified, and that these will be flowed to prospective suppliers. These hazards will be actively managed throughout the life of the installation and added to as necessary as the Proposed Development matures and will be reported on at each SWG.

This OBSMP has been developed using existing knowledge of the BESS capability 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, where further understanding of the hazards and development of mitigations can be undertaken to reduce the potential level of risk posed by BESS.

9.2 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 BESS project lifecycle to ensure that safety management is developed as the programme progresses and remains valid through the life of the BESS capability.

Given this initial assessment the residual risk is **LOW** ‘tolerable’ and that all the identified control measures are reassessed as the programme matures. At this juncture of the programme, it is not possible to formally declare ALARP, however upon successful implementation of the safety management plan for the Proposed Development this should be possible. It is anticipated that a DBSMP will be a condition of any planning permission granted for the Proposed Development, and would be required to be in accordance with this report.

10.0 References

1. BESS Hazard Log - ARC-1168-001-R12, Draft A, April 2023.

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

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

4. Defence Standard 00-56, Ministry of Defence: Safety Management Requirements for Defence Systems July 2012.

5. UL1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications.

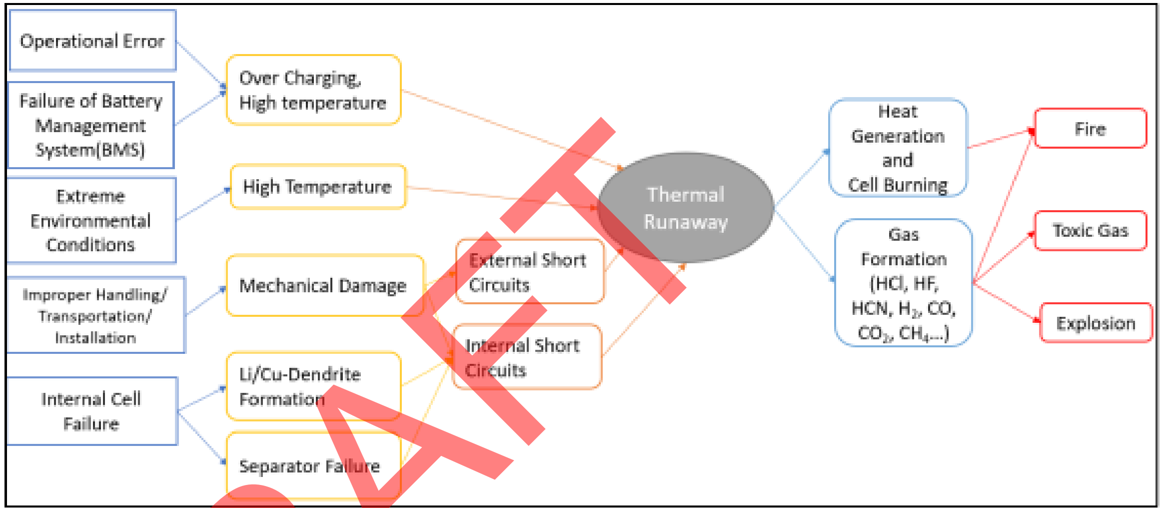
6. UL9540A – BESS Test Methods.

7. NFCC Grid Scale BESS Planning – Guidance for FRS dated Nov 2022.

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 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. It is anticipated that this site will use LFP chemistry cells in the BESS, the alternative being Nickel Cobalt Manganese (NMC). LFP batteries are possibly the best types of batteries for BESS. They provide cleaner energy since LFPs use iron, which is a relatively green resource compared to cobalt and nickel. Iron is also cheaper and more available than many other resources, helping reduce costs. The overall production cost is lower as well. LFP batteries have a lower power density, but this characteristic is less important for energy storage systems than it is for Electric Vehicles, as BESS can occupy larger spaces without concern. LFP batteries are also safer because thermal runaways are less likely, and they have a higher life cycle (between 2,000 and 5,000 cycles) than most other Li-ion battery technologies.
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.

Ser	Question	Answer
		5. 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 LFP batteries are housed in a Metal 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.
4	What is Thermal Runaway?	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. Dendrite formation was a common problem in early NMC battery chemistries but is not prevalent in LFP battery chemistries. 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.

Ser	Question	Answer
		
5	How can TR be controlled?	TR is not always inevitable, 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 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. Commercially prominent 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.
7	Can water be used to extinguish a Lithium-Ion fire?	The use of water to extinguish a BESS fire has some drawbacks and disadvantages over bespoke FDSS aerosol mediums, these being: 1. Due to the design of the batteries and racks (in which they are contained), the inability of water to cool the cell interiors may result in re-ignition of a fire once the water application is halted. 2. The high conductivity of water may cause short circuiting of cells presenting collateral damage risk and increase the spread of the fire internal in the BESS. 3. A high volume of water is required to cool the cells below the critical temperature to prevent TR propagation, this results in a high volume of fire water run-off and a potential environmental impact. 4. The application of water on a BESS fire increases the generation of gases such as Carbon Monoxide (CO), Hydrogen (H_2) and Hydrogen Fluoride (HF). Applying water causes incomplete combustion of organic substances inside the battery resulting in production of CO rather than Carbon Dioxide (CO_2); when water is applied, H_2 is released that, without combustion, can react with phosphorus pentafluoride, if present in free form, to produce gaseous HF.

Ser	Question	Answer
8	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 fire amongst the general gases released are CO, HF, Oxygen (O) and H_2. 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, in rural locations, 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[1].
9	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.
10	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.

[1]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*'.