14 Outline Battery Safety Mangement Plan

Executive Summary

This Outline Battery Safety Management Plan (OBSMP) has been prepared in relation to the Limekiln Battery Energy Storage System (BESS) and associated infrastructure sits within the footprint of the operational Limekiln Wind Farm, south of Reay in Caithness, Highlands. The installation in totality is henceforth referred to in the report as the Limekiln Site. The Limekiln BESS units will most likely use Lithium Ferrous Phosphate (LFP) chemistry cells, but this is subject to advances in technology.

This OBSMP, and associated project Hazard Log [Ref. 1] provides details of the safety management processes and procedures to be implemented at the Limekiln site to satisfy the prevailing safety requirements for the Limekiln Site and BESS system specifically. The safety management approach to be adopted follows the ethos of 'As Low As Reasonably Practicable' (ALARP), the Health and Safety Executive (HSE) 'Reducing Risk, Protecting People' Guidance [Ref. 2], National Fire Chiefs Council (NFCC) Guidance for BESS installations [Ref. 8], the associated FM Global Datasheet 5-33 [Re. 7], and the Department for Energy Security and Net Zero (DESNZ) Health and Safety Guidance for Electrical Energy Storage Systems [Ref. 10].

Whilst the make and model of the BESS units to be employed at the Limekiln Site has yet to be determined, the selection of the BESS units will require that the design, development, and manufacture of the BESS by the Original Equipment Manufacturer (OEM), demonstrates that the development and maintenance is of high standards, in respect of safety and operational sustainability, can be evidenced. This will be achieved through adherence to internationally acknowledged codes of practice for Lithium-Ion BESS including International Electrotechnical Commission (IEC) 62619:2022 [Ref. 3], United Nations (UN)38.3 [Ref. 4], Underwriters Laboratories (UL)1973 [Ref. 5] and UL9540A [Ref. 6].

Consultation with the Fire and Rescue Services (FRS) at similar BESS installations has concluded that "*the developer should produce a risk reduction strategy*" incorporating safety measures and risk mitigation in collaboration with the associated Regional FRS and covering the construction, operational and decommissioning phases of the project. This has been conducted for this installation and is detailed in Section 6.0 of this OBSMP. The developer must ensure the risk of fire is minimised, this may be by way of any or all the following measures:

- Procuring components and using construction techniques which comply with all relevant legislation.
- Including automatic fire detection systems in the development design.
- Including automatic fire suppressions systems on the development design.
- Including redundancy in the design to provide multiple layers of protection.

- Designing the development to contain and restrict the spread of fire using fire-resistant materials and adequate separation between elements of the BESS.
- Developing an Emergency Response Plan (ERP) with FRS to minimise the impact of an incident during construction, operation, and decommissioning of the facility.
- Ensuring the BESS is located away from residential areas. Prevailing wind directions should be factored into the location of the BESS to minimise the impact of a fire involving Lithium-Ion batteries due to the toxic fumes produced.

14. Introduction

14.1.1. 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). The OBSMP has been prepared on behalf of Boralex Ltd in relation to the Battery Energy Storage System (BESS) facility at Limekiln.

14.1.2. This OBSMP has been developed to outline the potential risks presented by the BESS and its operation / maintenance. This OBSMP provides a robust safety strategy, supported by evidence to support full commissioning. The final design and equipment detail is yet to be fully backed off and is based on the intended site layout plan and associated details currently available and provided by Boralex Ltd at this juncture.

14.2. Background

14.2.1. ARC has conducted the Hazard Identification of the Limekiln site. This analysis has provided the necessary foundation for the identification of hazards and the development of a preliminary Hazard Log [Ref. 1], which contains:

- Consolidated list of hazards and hazard descriptions.
- Associated causes of the hazards with linkage to the relevant hazard(s).
- Design controls implemented to ameliorate / mitigate the causes.
- Identification of the potential outcomes or consequences from the hazards.
- Identification and linkage to mitigating factors that could ameliorate the severity or frequency of occurrence of the outcomes (consequences).
- Identification of any mitigation that will further ameliorate the probability of hazard or consequence frequencies and be contained in the Emergency Response Plan (ERP).

14.3. Aim

14.3.1. The overall safety aim is that the levels of risk of accident, death or injury to personnel or other parties, and risks to the environment due to the construction, operation and decommissioning are to be 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) [Ref. 2]. For the OBSMP specifically, the document presents an initial appraisal of the safety risks including:

- An overview of the main characteristics and the associated design guidelines and legislative and compliance requirements.
- The identification of safety risks (with consideration to proximity and pathways to sensitive receptors).
- The identification of inherent safety features and measures additional safety recommendations (e.g. emergency response planning) to be secured through the OBSMP at detailed design stage and secured by planning conditions.
- Determination of the identified safety risks and their significance.

14.4. Scope

Site

14.4.1. The scope of the OBSMP for the Limekiln Site and capability covers the physical and functional aspects of the equipment. The safety management covers design, validation, and operation. It also includes any remote monitoring and control, maintenance, storage / transportation, and calibration.

14.4.2. Predominantly the Site is not in an area of flood risk from rivers or the sea or from surface water flooding. There are no public rights of way affecting the Site.

14.5. Site Access

14.5.1. The proposed development sits within the footprint of the operational Limekiln Wind Farm, south of Reay in Caithness, Highlands. The site entrance is located off the A832 Road 1km west of Limekiln Station. The site is accessed by a private estate road for 700 metres, followed by a descending branch leftwards to the installation. The primary access track is constructed using a crushed / compacted stone and capable of withstanding 20 tonne payloads.

Frequently Asked Questions

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

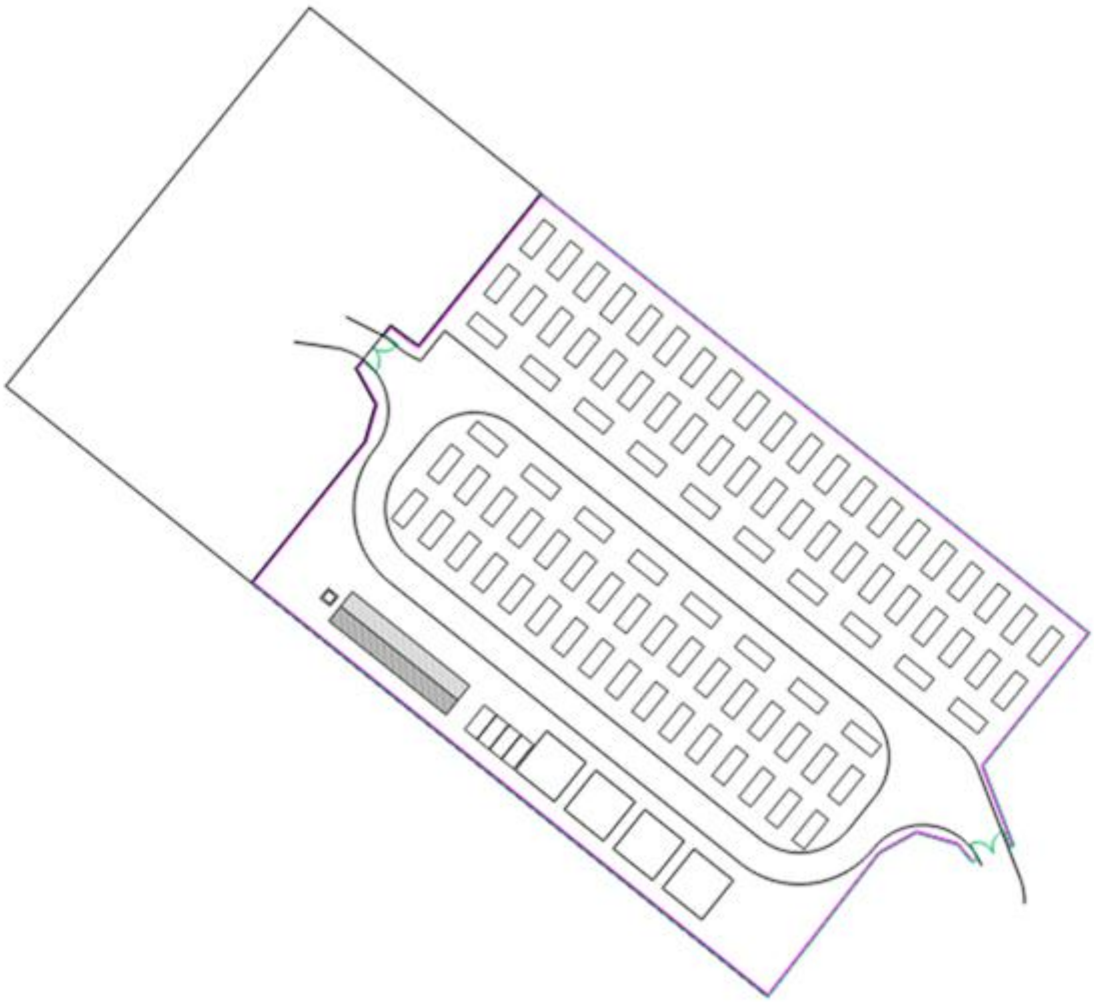

Figure 4-1 Limekiln BESS facility layout

14.6. Safety Requirements

High Level Safety Objective

14.6.1. The primary safety objective is to comply with applicable legal requirements and relevant good practice for large / grid scale BESS. Compliance with these requirements will be used as part of the safety evidence, to demonstrate that '*the risk posed to individuals, the environment and property has been reduced to a level that is as low as reasonably* practicable'. The Hazard Log (HL) produced for the Limekiln site is to be used to ensure that all direct and indirect safety requirements are met, and the system remains safety compliant through the life of the installation.

14.7. Legislation and Compliance Requirements

14.7.1. Legislative compliance, specifically safety, will be demonstrated by compliance with the United Kingdom (UK) Health and Safety at Work Act (HSAWA) 1974 and the appropriate underlying legislation that is enacted through the HSAWA. The following legislation and industry guidance has been determined as applicable to this installation.

14.7.2. Legislation (Scotland specifically):

- Health and Safety at Work etc. Act 1974 – UKSI1974/0037.
- Control of Noise at Work Regulations 2005 – UKSI 2005/1643.
- Control of Substances Hazardous to Health Regulations 2002 – UKSI 2002/2677.
- Control of Vibration at Work Regulations 2005 – UKSI2005/1093.
- Electrical Equipment (Safety) Regulations SI 1994/3260.
- Electro-magnetic Compatibility Regulations SI 2006/3418.
- Fire Safety (Scotland) Amendment Regulations SI 2010/393.
- Lifting Operations and Lifting Equipment Regulations 1998 – UKSI1998/2307.
- Management of Health and Safety at Work Regulations 1999 – UKSI1999/3242.
- Manual Handling Operations Regulations 1992 – UKSI1992/2793.
- Personal Protective Equipment Regulations 2002 – UKSI2002/1144.
- Provision and Use of Work Equipment Regulations 1998 – UKSI1998/2306.
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations SI2013/1471.
- Supply of Machinery (Safety) Regulations 2008 – UKSI2008/1597.

- Workplace (Health, Safety and Welfare) Regulations 1992 – UKSI1992/3004.
- Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations (REACH) – 1907/2006.
- Restriction of Hazardous Substances Directive (RoHS) – 2011/65/EU.
- Dangerous Substances and Explosive Substances Regulations 2002 - SI 2002/2776.
- Construction (Design and Management) Regulations - SI 2015/51.

14.7.3. Industry Guidance and Best Practice Documents:

- UN38.3 – Standard Requirements for Lithium-Ion Battery Production [Ref. 4].
- Underwriters Laboratory (UL)1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications [Ref. 5].
- UL9540A – BESS Test Methods [Ref. 6].
- FM Global Property Loss Datasheet 5-33 – Lithium-Ion BESS [Ref. 7].
- NFCC Grid Scale BESS planning – Guidance for FRS [Ref. 8].
- National Fire Protection Association (NFPA) 885 – Standard for the Installation of Stationary Energy Storage Systems [Ref. 9].
- Department for Energy Security and Net Zero (DESNZ) – Health and Safety Guidance for Electrical Energy Storage Systems [Ref. 10].

14.8. FRS Consultation

14.8.1. The Site's location falls within the jurisdiction of Scottish FRS (SFRS). Consultation with the SFRS will continue as necessary throughout the project development, construction and operation.

14.9. NFCC Guidance

14.9.1. The NFCC Report Grid Scale Battery Energy Storage System Planning – Guidance for FRS [Ref. 8] details the FRS recommendations for BESS installations. These have been distilled at Table 5-1 cognisant of the site layout at Figure 4-1.

14.9.2. At the time of the planning submission there was no specific UK regulation regarding fire safety of BESS facilities. However, the DESNZ has produced the Health and Safety Guidance for Electrical Energy Storage Systems report, providing risk mitigation techniques for BESS installations [Ref. 10]. For the BESS units, the NFPA 855:2023 [Ref. 9] code is the most internationally recognised and this will be considered in the procurement of the BESS units and ancillary equipment.

Table 5-1 - NFCC Recommendations Cross-Referenced to the Limekiln Site

Criterion	NFCC Recommendation	Status	NFCC Comment
1	Access - Minimum of two separate access points to the site	**Compliant**	The site has a common access from the A832 but forks as it heads north to the site, this allows for primary access to the site from the west and emergency access from the east. Recourse to metrological data indicates that the wind direction in this location is from the west, as such obscuration of the primary point of access is unlikely.
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 proposed site access from the public road leading to the site entrance is approximately 5.0m wide. There is no extreme of gradient at the site, access to the site does rise by approx. 20m over a 450m distance to the site's primary entrance. All internal services roads have been designed with a 10m radii and are compatible for a DB32 Fire Appliance.
3	A perimeter road or roads with passing places suitable for fire service vehicles	**Compliant**	The BESS compound service roads are 4.0m wide hard surface access running around the site allowing access to all BESS units, Figure 4-1 refers, given the circular nature and compactness of the site the ability to drive-in and drive-out without the need for passing points or the need to reverse is provided. Section 13.4 of Approved Document B5 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 minimised to situations in which use of the perimeter service road is not possible, and in these circumstances, reversing more than 20m is not a requirement. 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 BESS compound access service roads run around the BESS units, thus allowing access to all BESS units. The site meets the requirements of Approved Document B5 Vol 2 allowing all points on the site to be within 45m of a fire appliance.
5	Turning circles, passing places etc. size to be advised by FRS depending on fleet	**Complaint**	The BESS compound access service roads allow access to all BESS units; Figure 4-1 refers in two differing directions and allows FRS vehicles to drive in and out without the need to reverse. Liaison and consultation with the FRS will establish if these arrangements are satisfactory. The site is designed such that all routes have the capacity to allow for a Fire Tender (based on DB31 Fire Appliance).
6	Distance from BESS units to occupied buildings & site boundaries. Initial	**Compliant**	There are no occupied buildings within 25m of the BESS compound, the nearest residential dwelling is more than 750m distance to the west.

Criterion	NFCC Recommendation	Status	NFCC Comment
	min distance of 25m		
7	Access between BESS unit – minimum of 6.0m suggested. If reducing distances, a clear, evidence-based, case for the reduction should be shown	**Compliant**	The suggested 6.0m 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 again in Jan 2024, it now details the following: 1. For containerised Lithium-Ion Battery Energy Storage System (LIB-ESS) comprised of Lithium iron phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors, or deflagration vents. 2. For containerised LIB-ESS comprised of Lithium nickel manganese cobalt (NMC) cells where wall construction is unknown or has an American Society for Testing and Materials (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 containerised NMC LIB-ESS where wall construction is documented as having at least a 1-hour rating in accordance with ASTM E119, aisle separation of at least 8 ft (2.4 m) is acceptable. Additionally, the DESNZ published in March 2024 their Health and Safety Guidance for BESS in which it is stated that the separation distance, for sides with access panel, doors or deflagration panels should be a minimum of 1.5m. It has been noted that the current NFCC guidance is being revised and a consultation document has been promulgated. The draft consultation version removes the 6.0m separation distance and refers out to NFPA 855 for guidance on separation. Following this revision to the Datasheet, the BESS containers on-site will be compliant with the minimum distances and conformance to ASTM E119 1-hour fire rating will be confirmed on the down select of the BESS units to be procured. Current NFCC guidance recommends 6.0m, unless deemed acceptable to be closer based on manufacturers UL testing / fire rating qualification. The BESS units on the site are a minimum of 3.0m apart, which given current FM Global and DESNZ guidance, is twice the recommended 1.5m spacing. BESS technology is so rapidly changing and at the planning stage, the manufacturer and type of BESS unit is not usually known, and prevalence has been set by the decisions made for the Langford and Cleve Hill BESS sites.
8	Site Conditions – areas within 10m of BESS units should be cleared of combustible vegetation	**Compliant**	Although on a greenfield site the BESS and other installations will be positioned on concrete foundations that form part of the fire water runoff retention bunding design. All areas within 10m of the BESS are to be cleared of vegetation
9	Water Supplies	**Compliant**	The site has three Standby Water Tanks, each with a capacity of 230,000L, two of which will contain dedicated firefighting water, a total capacity for firefighting purposes of 460,000L. The third tanks will remain empty, allowing for the water runoff from the bund to be directed to the

Criterion	NFCC Recommendation	Status	NFCC Comment
			empty tank for containment. Should an event arise whereby the 460,000L is depleted then the runoff water can be used and recycled back onto the fire.
10	Signage	**Compliant**	Signage will be positioned at the entrance to the Site, including a site layout plan and details of key personnel.
11	Emergency Plans	**Compliant**	An ERP will be developed for the Site.
12	Environmental Impacts	**Compliant**	A range of environmental consultees, including NatureScot, the Scottish Environment Protection Agency (SEPA), Historic Environment Scotland, Scottish Forestry, and Transport Scotland, will be engaged during the application process and for the preparation of the associated Environmental Report. Outflow from the sites SUDS will, by means of pipework, limit the outflow rate. This outflow will be valve controlled and will have an actuator on it to ensure that if a fire alarm occurs the valve will be closed to ensure accumulated firewater will not discharge. Electronically actuated valves will have a manual over-ride.
13	System design, construction, testing and decommissioning	**Compliant**	Testing and decommissioning will only be available in later stages of the programme. Compliant at this juncture in the planning process.
14	Deflagration Prevention and venting	**Compliant**	This element will not be apparent up to the point where the decision is made as to what BESS is being used. Deflagration venting is possibly most effective when fitted to the roof of the BESS units, deflecting blast upwards and away from FRS personnel. Compliant at this juncture in the planning process.

14.10. Implemented Safety Strategy

Introduction

14.10.1. A safety strategy is required to support the design, development, and installation providing the necessary assurance that the safety of the Limekiln site is at an acceptable level for its role in its intended operating environment. The safety strategy employed provides a logically stated and convincingly demonstrated reason that all safety requirements are met. The overarching safety claim has the following elements:

14.10.2. A Technical Risk Element:

- 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.
- It will identify system hazards and the causes that can contribute to these hazards.
- It will specify the risk analysis conducted, and risk reduction requirements implemented.
- It will provide the evidence to support any risk reduction claimed.

14.10.3. A Confidence (Assurance) Element:

- This part seeks to demonstrate that the processes used to design, implement, and verify the product is 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.
- The development of the HL and identification of imbedded physical attributes that support risk reduction.
- 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.

14.11. Safety Integrity Level Requirements

14.11.1. The Safety Integrity Level requirements for the BESS units specifically are driven by the functionality implemented in the design solution. The BESS supplier will be beholden to demonstrate with evidence a layered protection approach from cell to container to remote monitoring. The envisaged safety control measures and design features within the BESS are detailed in the HL, albeit at this stage generically, tabulated against the appropriate cause that they control. The HL will be revised and supplemented with actual evidence once the BESS units to be employed have been selected.

14.12. Modular Safety Assurance

14.12.1. The construct of the safety assurance in the design of a BESS unit is vested in a ground up approach from cell to battery to rack to fully built BESS, comprising:

- IEC 62619:2022 Safety requirements for secondary lithium cells and batteries, for use in industrial applications [Ref. 3] This specifies requirements and tests for the safe operation of secondary lithium cells and batteries used in industrial applications, including stationary applications. Safety Management Strategy and Activities.
- UN38.3 Testing - UN38.3 [Ref. 4] is the United Nations standard that lithium batteries must meet if they are to be certified as safe to transport. Whilst lithium batteries have safeguards built-in to withstand the environmental and physical hazards they may encounter during transportation, UN38.3 acts as a ‘rubber stamp’ and shows that batteries are safe to move from one location to another.
- UL1973 (the Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications) [Ref. 5]. This is the safety standard for energy storage systems. It specifies detailed requirements that manufacturers of BESS must meet to qualify for safety certification. UL1973 certification ensures that the BESS system is safe and reliable for use in real-world conditions. Compliance with UL1973 is necessary to ensure the safety, reliability, and proper functioning of the battery components of a BESS system.
- UL9540A (BESS Test Method) is the Standard for Safety Test Method for Evaluating Thermal Runaway (TR) Fire Propagation in Battery Energy Storage Systems [Ref. 6]. There are four stages in the UL9540A test method:
- Cell Level Test: Assessing whether a cell can exhibit TR. It also checks its characteristics and flammability.
- Module (Battery) Level Test: The objective is to determine if TR propagates with the module. In addition, it establishes the heat release and gas composition.
- Rack Level Test: Assessment of the whole unit to establish initially how quickly fire spreads and secondly for the heat and gas release rates and relationship with other emerging hazards.
- Installation Level Test: For completeness installation testing is conducted. This is an optional test, but the objective is to determine how effective the product fire protection is.

Certification

14.12.2. The BESS units to be procured will be designed to meet relevant industry standards and legal requirements which contain specific safety requirements, Section 5.2 refers.

14.13. Safety Management

Hazardous Material

14.13.1. Any hazardous materials held and stored at the BESS facility will be fully justified and will be detailed in the Limekiln ERP, detailing the location, description, precautions to be adopted and quantity.

14.14. Emergency Response Plan

14.14.1. As part of the initial development, an ERP will be developed, in conjunction with the SFRS, that outlines how the operator will respond to incident and accident scenarios at the site. This includes the interfaces with external first responder organisations. The ERP is iterative in approach and has been developed in parallel with technical safety requirements. This ensures that the site design and ERP are properly integrated, and that appropriate information can be provided to first responders to include in their planning activities.

14.15. BESS Hazard Log

14.15.1. The BESS HL [Ref. 1] is currently managed in the form of an excel spreadsheet and is currently generic, detailing the risks most commonly present in a BESS utilising LFP technology. The benefit of using a HL tool is that it provides an auditable record of all decisions made for the assessment of risk for the BESS Project which will be managed through life on a central repository.

14.16. Safety Management Structure

14.16.1. The BESS 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 BESS. At this juncture 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.

14.17. Overarching Policy

14.17.1. 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.

14.18. Management Plan

14.18.1. 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. Further details will be captured within the OBSMP to be secured by planning conditions.

14.19. Staff Competence

14.19.1. 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.

14.20. Conclusions and Recommendations

Results

14.20.1. The HL [Ref. 1] is the tool used to monitor and manage hazards, causes and controls associated with this site. The HL is used to tabulate the level of residual risk posed by the installation. The Site Safety Audit will determine that the control measures identified are present.

14.21. Conclusions

14.21.1. It is concluded that, as far as reasonably practicable and for the Limekiln site, that currently foreseeable hazards associated with the equipment have been identified, and these are contained in the HL [Ref. 1]. These hazards are actively managed and added to as necessary and will be reported on at each Safety Working Group (SWG).

14.21.2. This OBSMP has been developed using existing knowledge of renewable and BESS capability and leans heavily on the subject matter expertise that ARC has in this technological domain. Installation of the BESS in accordance with OEM instructions followed by a period of qualification and testing will provide the supporting evidence. This will also allow for the consolidation of control evidence and enhanced development of mitigation to further reduce the level of risk posed.

14.22. Recommendations

14.22.1. It is recommended that the safety management, as defined in this OBSMP, is adhered to throughout the site life to ensure that safety management is developed as the programme progresses and remains valid through the life of the site.

14.22.2. Given the current understanding of the site layout, systems to be employed, and control measures to be implemented it has been determined that the residual risk is Class C and this is detailed in the site specific hazard log. The Class C hazards all relate to maintainer hazards and represent the worst-case scenario. Periodic review of the HL [Ref. 1] will identify further opportunities to improve these hazards.

14.22.3. Adherence to the recommendations and safety principles through detailed design, installation and operation will be demonstrated through the Operational Safety Audit Report to be approved prior to commercial operation of the site.

14.22.4. Given the above discourse and output of the Site Safety Audit, it will be possible to declare ALARP, cognisant of continued implementation of the proposed framework for safety management presented in this OBSMP.

References

1. Limekiln BESS Hazard Log - ARC-1266-002-R2, Draft A, June 2025.

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

3. IEC 61619 - Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications – Edition 2 dated 2022.

4. UN38.3 Standard Requirements for Lithium Battery Production - 4th Revision.

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

6. UL9540A – BESS Test Methods.

7. Factory Mutual Property Loss Prevention Datasheet 5-33 dated Jan 2024 (Interim Revision).

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

9. NFPA 855 Standard for the Installation of Stationary Energy Storage Systems dated Aug 2023.

10. Department for Energy Security and Net Zero (DESNZ) – Health and Safety Guidance for Electrical Energy Storage Systems. Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems (publishing.service.gov.uk)

14.23. Appendix A – BESS Frequently Asked Questions

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. The primary 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 (REPD). From the quarterly extract (dated Apr 2025) the data has been filtered for BESS installations in the UK and the following salient points are deduced[1]: 1. As of Apr 2025, there are approx. 132 operational BESS sites listed in the REPD[2], 8 having been decommissioned, 96 are under construction and a further 834 have planning consent and are awaiting construction. 2. The current operational BESS provides the UK with an estimated 2.6GWelec storage and those awaiting construction will provide an additional 5.4GWelec of storage. 3. Since 2006 UK BESS installations have accumulated an estimated 700 years of operation, this equates to 240,000 days of operation.

[1] The REPD tracks the progress of energy projects, including BESSs, through the planning system. Until 2021, the REPD only recorded projects with a capacity over 1 MW). Since 2021, it also includes projects with a capacity over 150 kilowatts (kW). Therefore, BESSs that were going through the planning system before 2021 may not have been captured in the REPD – Source: Commons Library Research Briefing, 19 April 2024 – BESS.

[2] This is a conservative figure as the REPD did not account for project under 1MW until 2021.

Ser	Question	Answer
		4. There have currently been only two reported BESS fires in the UK that have required FRS attendance, these occurred at Carnegie Road, Liverpool in Sept 2020 and East Tilbury in Feb 2025, the cause of the latter is yet to be declared. Given the estimated 6 million hours of operation, extrapolates out to approx. 3.3E-07 (0.00000014) failures per hour (fph) for BESS in the UK. 5. To date nobody in the UK has been killed in a BESS incident and there has been no damage to 3rd parties or the environment due to a BESS fire.
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 battery management system (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. 3. Over-temperature in the cell because of: . Over-charging (which is controlled by 2 separate BMS – battery and rack). . High ambient temperature – controlled by the ECU.

<table>
<tr><th>Ser</th><th>Question</th><th>Answer</th></tr>
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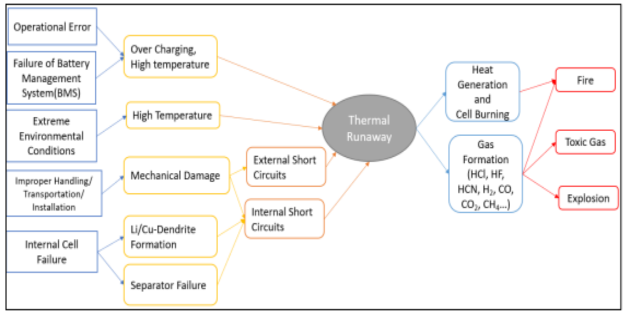
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<tr><td>5</td><td>How can TR be controlled?</td><td>TR is not always inevitable, and the nature of the cell design is such that early warning signs of a stressed cell can be detected by the BMS. Initial signs of cell degradation are an increase in 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.</td></tr>
<tr><td>6</td><td>How is a BESS fire controlled and suppressed?</td><td>If the TR is not controlled and spreads, known as Thermal Runaway Propagation, the fire detection and suppression system (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:</td></tr>
</table>

Ser	Question	Answer
		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 systems generally require a more complex and intricate delivery system to reach all areas of the container. 4. Gaseous systems require 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.
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 BESS 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 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 BESS fire amongst the general gases released are CO, 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. Further to this the recent fire at Moss Landing California (Feb 2025), was monitored at 1 second intervals for toxic substances in the smoke plume. It was established that the composition of the plume emanating from the fire was within US Air Pollution limits.
9	How is the BESS site secured?	The BESS Site is 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.