

Abbott Risk Consulting Limited

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Root Power – Outline Battery Safety Management Plan – Luzlow Battery Energy Storage System (BESS)

Issue 2 – December 2024

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Executive Summary

This Outline Battery Safety Management Plan (OBSMP) is for the proposed Root Power Luzlow, Battery Energy Storage System (BESS) installation with ancillary infrastructure on land adjoining New House Farm, Luzlow, Bagnall, Stoke-On-Trent, ST9 9JZ, henceforth referred to in this OBSMP as the Luzlow BESS. The aim of this OBSMP, at this planning phase of the programme, is to define the proposed safety strategy, requirements, and processes necessary to meet derived safety objectives and to set a level of safety performance that the installation is to be measured against. These standards are derived from the following sources:

- Planning Practice Guidance (PPG) for Renewable and Low Carbon Energies [Ref. 1].
- Fire and Rescue requirements detailed in the National Fire Chiefs Council (NFCC) Report Grid Scale BESS Planning – Guidance for Fire and Rescue Service (FRS) [Ref. 2].
- Factory Mutual (FM) Global Loss and Prevention Datasheet 5-33 (as cited in the NFCC Report) [Ref. 3].
- Root Power BESS Fire Strategy and Emergency Response [Ref. 4].

It also provides the basis for the safety management processes and procedures required to satisfy the identified safety requirements for a BESS system capability.

The preliminary safety hazard identification and analysis, based on like for like energy storage systems of this type, namely Lithium-Ion Battery technology, has determined the likely causes and hazards associated with such BESS technology 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 concluded that, as far as reasonably practicable and for this planning stage of this BESS installation, that the currently foreseeable hazards associated with the technology proposed 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 programme the selection of the BESS technology to be positioned at Luzlow has yet to be decided.

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 undertaking to strive to reduce the potential for accidents to the lowest practicable level by being a 'risk aware'. Promoting a supportive safety and environmental culture at all stages of the development. This OBSMP is the starting point from which the project will progress.

It will be essential that the design process is subject to a Design Risk Analysis by a competent person in compliance with the Construction Design and Management (CDM) Regulations 2015 [Ref. 5].

Abbreviations

ALARP	As Low As Reasonably Practicable
ARC	Abbott Risk Consulting Ltd
BESS	Battery Energy Storage System
BMS	Battery Management System
CCTV	Closed Circuit Television
CDM	Construction Design and Management
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
DBSMP	Detailed Battery Safety Management Plan
ECU	Environmental Control Unit
ERP	Emergency Response Plan
FAQs	Frequently Asked Questions
FDSS	Fire Detection and Suppression System
FH	Fire Hydrant
FM	Factory Mutual
fph	failures per hour
FRS	Fire and Rescue Service
H ₂	Hydrogen
HF	Hydrogen Fluoride
HSWA	Health and Safety at Work Act
HSE	Health and Safety Executive
LFP	Lithium Ferrous Phosphate
NFCC	National Fire Chiefs Council
NFPA	National Fire Prevention Association
NMC	Nickel Manganese Cobalt
OBSMP	Outline Battery Safety Management Plan
PCIP	Pre-construction Information Plan
PPG	Planning Practice Guidance
SFRS	Staffordshire Fire and Rescue Service
TR	Thermal Runaway
UK	United Kingdom
UL	Underwriters Laboratory

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1.0 Outline Battery Safety Management Plan (OBSMP) Purpose

1.1 Aim

The aim of this report is to outline the safety management approach that will be adopted. Furthermore, the overall Battery Energy Storage System (BESS) 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 mitigated and managed as far as possible through diligent development, design, construction, and operation. In accordance with the Health and Safety Executive (HSE) Reducing Risk, Protecting People - Guidance [Ref. 6], the BESS development should aim to reduce risks to 'As Low As Reasonably Practicable' (ALARP).

1.2 Scope

The scope of this report is for the proposed Luzlow BESS development (the project) and capability and covers the physical and functional aspects of the equipment. The BESS safety management will cover design, validation, siting, operation, fire strategy and emergency response, and removal from site (post use). It will also include any remote monitoring and control, maintenance, storage / transportation, and calibration.

1.3 Context

This OBSMP has been developed by Abbott Risk Consulting Ltd (ARC) in the role of the Safety Subject Matter Expert and aims to identify the safety requirements (and any additional derived safety requirements) such that the proposed Luzlow BESS development can be assessed against a common benchmark, criteria set and safety targets.

This BESS OBSMP has been developed at this early planning stage with the client Root Power to identify and assess the potential risks associated with the BESS 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 (Planning)** – this report. The OBSMP informs on how safety management is to be conducted. It outlines:
 - a. 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.
 - b. It provides the criteria and targets against which the installation will be assessed.
 - c. It provides the initial the compliance status against key requirements contained in the Planning Practice Guidance (PPG) (and referenced guidance).
 - d. It identifies the common hazards associated with BESS installations of this type.

2. **Detailed Battery Safety Management Plan (DBSMP) (Installation and Implementation)** – The DBSMP will be produced post planning consent and will build upon the OBSMP and reflect the maturity of the project and availability of detailed information and evidence to support safety claims. The DBSMP will:
 - a. Assess the level of residual risk posed by the BESS design to individuals (both those directly involved in the operation and 3rd parties), the immediate environment, the asset (i.e. the BESS), interfacing / interdependent assets and property / equipment that could be affected by the operation of the BESS (noise, radiated emissions etc.).
 - b. Contains the Emergency Response and Contingency Plans.
 - c. References to supporting evidence.
 - d. Details any recommendations for improvement.
3. **Site Safety Audit (Operation)** – Validates the BESS installation against the safety requirements and identified control measures in the DBSMP. It also validates that the safety processes and procedures required to ensure that the risk posed by the design remains within the bounds established and associated requirements have been implemented i.e., training, provision of Personal Protective Equipment, calibration, scheduled maintenance etc. Appropriate reports by the manufacturers and installers will be included in the Site Safety Audit to validate competency and technical due diligence. This will be further validated independently via input from the Client's Owner's Engineering Consultants.

The incumbent technology at the time of writing is primarily based on Lithium-Ion batteries. Due to the pace at which battery technology is developing, the precise battery chemistry will not be selected, and the solution confirmed until the detailed design phase of the development. As such, this report is written leaning on the subject matter expertise that ARC have considering this technological domain, industry good practice and regulation. Selection of equipment will be based on proven and evidential technical and safety performance.

A section of BESS Frequently Asked Questions (FAQs) is provided at Appendix A to this OBSMP.

2.0 Project Overview

2.1 The Project

Luzlow Energy Storage project is a 99MW BESS under development on land adjoining New House Farm, Luzlow, to the west of Luzlow Lane. The project will connect into the adjacent National Grid substation. See Figure 2-1 for the BESS site location.

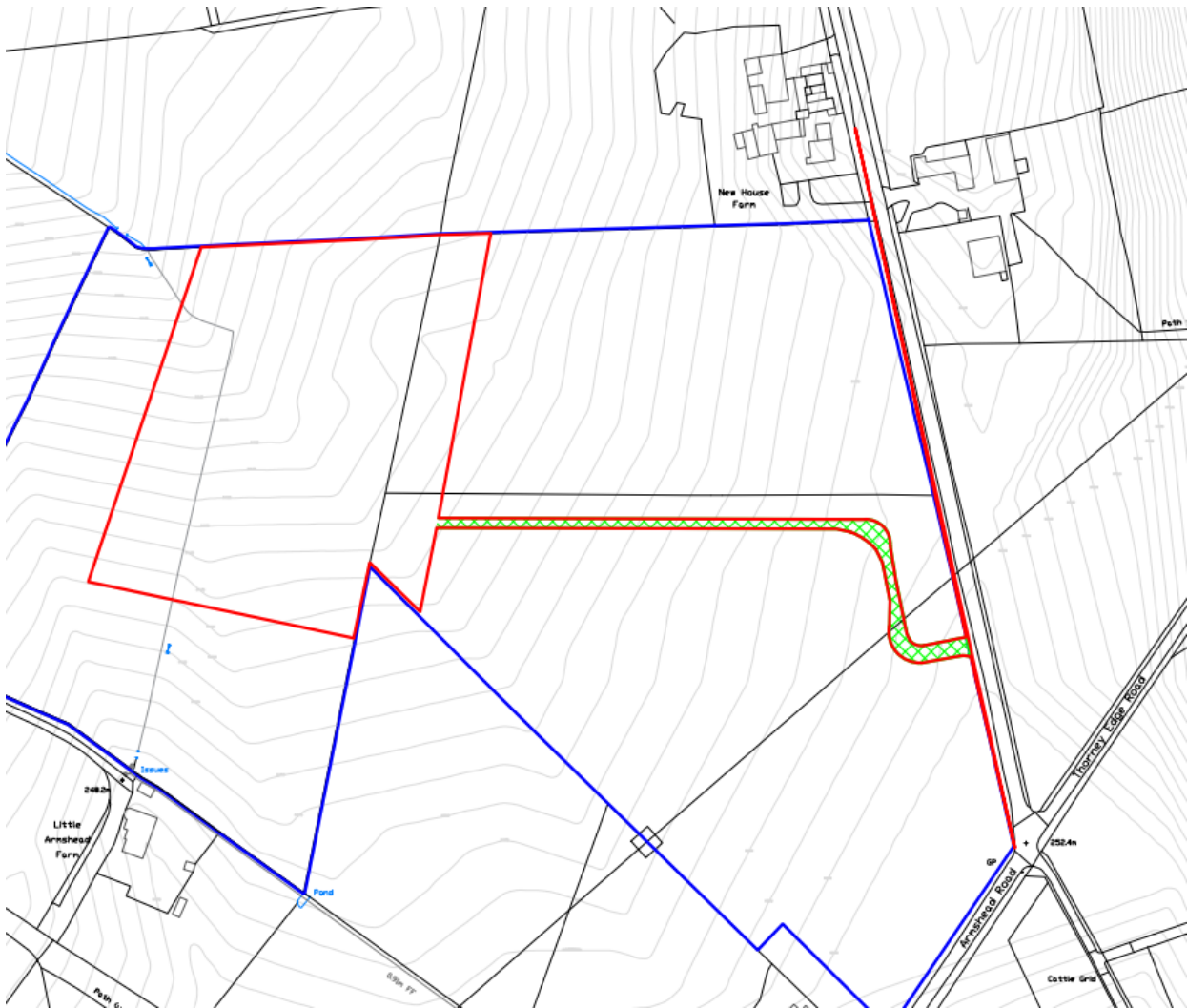


Figure 2-1 - Luzlow Site Location and Boundary

3.0 Safety Objectives

3.1 High Level Safety Objective

The primary safety objective across the BESS Project is to minimise risk to health and safety of the public, employees, property, and the environment by complying with applicable legal requirements and relevant emerging good practice for grid scale connected BESS. These will be distilled into safety requirements that will be included in the requirements for prospective suppliers during the tendering and contracting stage.

Compliance with these safety requirements (by the potential suppliers) will be used as part of the safety argument, 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' as directed by the HSE. Compliance with the Construction Design and Management (CDM) Regulations 2015 [Ref. 5] will require the following documentation:

- Pre-Construction Information Plan (PCIP).

- Review of Contractor Competency and Prequalification.
- Review of Contractor Construction Phase Plan.
- Registration of the project on a HSE UK F10 form, under Regulation 6 of CDM 2015 [Ref. 5].
- On completion of the BESS installation a competent Health and Safety File is to be produced by the Principal Contractor for the BESS which clearly identifies all Residual Risks.
- A comprehensive set of Operational Manuals and “As Built” Plans including all Single Line Diagrams and Schematics.
- A Fire Strategy and Emergency Response Plan (ERP).

These derived safety requirements will be fundamental to the BESS development and will be used to ensure that all direct and indirect safety requirements for BESS are met and the supplier(s) and installers are safety competent and compliant.

4.0 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 current 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 – UKSI 2005/1093.
5. Electrical Equipment (Safety) Regulations SI 1994/3260.
6. Electro-magnetic Compatibility Regulations SI 2006/3418.
7. Fire Safety (Employees’ Capabilities) (England) Regulations SI 2010/471.
8. Fire Safety Order 2023 SI 2005/1541.
9. Fire Safety (England) Regulations SI 2022/547.
10. Lifting Operations and Lifting Equipment Regulations 1998 – UKSI1998/2307.
11. Management of health and safety at Work Regulations 1999 – UKSI1999/3242.
12. Manual Handling Operations Regulations 1992 – UKSI1992/2793.
13. Personal Protective Equipment Regulations 2002 – UKSI2002/1144.
14. Provision and Use of Work Equipment Regulations 1998 – UKSI1998/2306.
15. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations SI2013/1471.
16. Supply of Machinery (Safety) Regulations 2008 – UKSI2008/1597.
17. Workplace (Health, Safety and Welfare) Regulations 1992 – UKSI1992/3004.

18. Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations – 1907/2006.
19. Restriction of Hazardous Substances Directive – 2011/65/EU.
20. Dangerous Substances and Explosive Substances Regulations 2002 - SI 2002/2776.
21. Construction (Design and Management) Regulations - SI 2015/51.
22. Health and Safety - Safety Signs and Signals Regulations 1996.
23. Waste Batteries and Accumulators Regulations 2009.

4.1 Relevant Regulation and Industry Benchmarks

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 [Ref. 1], which refers out to.
 - a. National Fire Chiefs Council (NFCC) Grid Scale BESS Planning – Guidance for Fire and Rescue Services (FRS) [Ref. 2].
 - b. Factory Mutual (FM) Global Property Loss Datasheet 5-33 – Lithium-Ion BESS [Ref. 3].
2. National Fire Protection Association (NFPA) 855 [Ref. 7] – Energy Storage Systems and Solar Safety, which refers out to:
 - a. Underwriters Laboratory (UL)1973 [Ref. 8] – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications.
 - b. UL9540A – BESS Test Methods [Ref. 9].
 - c. UN38.3 – Standard Requirements for Lithium-Ion Battery Production [Ref. 10].
3. International Electrotechnical Commission (IEC) 61508 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related systems [Ref.11].

4.2 NFCC Guidance

The NFCC Report Grid Scale BESS Planning – Guidance for FRS [Ref. 2] details the FRS requirements anticipated at BESS installations. The alignment of the proposed project with these guidelines are outlined in Table 6-1 based on the site layout detailed in Figure 6-1.

5.0 Safety Controls and Good Practice

5.1 BESS Procurement

Root Power operates a stringent prequalification process that leverages the global technological capabilities of the company in the selection of all components. The Applicant is therefore experienced in conducting thorough tendering processes for procuring battery storage equipment and services, working with Tier 1, bankable, suppliers of battery cell manufacturers, inverters, and transformers.

This limits the selection of manufacturers to only those which are approved by YLEM Energy. The Root Power procurement processes look to inspect manufacturing facilities and periodically monitor production lines. The inspections evaluate production quality documentation and production line process, against pre-defined documentation to verify that the quality requirement is correctly respected and implemented. The following aspects are specifically checked:

- Material management.
- Procurement and supplier management.
- Manufacturing processes.
- Quality system.
- Reliability program.
- Training.
- Corrective action and non-confirming process and process improvements.
- Corporate social responsibility, environmental, health and safety.

Root Power employs a robust quality process at the development and procurement stages that ensures safe and continuous operation. These require the designs to incorporate the most advanced fire detection and suppression systems, including adhering to the UL9540 [Ref. 9] and NFPA855 [Ref. 7] standards, as well as conform to local and industry standards.

5.2 Design Safety

As a minimum it is anticipated that the BESS 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 module 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) and a layered protection system in accordance with UL1973 [Ref. 8] guidelines.
4. Safety certification and qualification to UL9540A [Ref. 9] 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. Battery chemistry bespoke Fire Detection and Suppression System (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 national and international guidance detailed in this report.

- b. The landscaping of land adjacent to and between BESS containers and 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 and water sources.
- e. Drainage Study and other groundwater studies, soil investigations, ground resistivity, hydrology, roads/bridges access assessment. environmental impact assessments, existing buildings/services, (all to be included in the PCIP) for contractors.

5.3 Testing

Once chosen, the battery system will be tested in accordance with UL9450A [Ref. 9] or its successor. UL9540A was developed to address safety concerns identified by the building codes and the fire service in the United States and is considered the global standard for evaluating the propensity of BESS to suffer from thermal propagation at cell, module, rack and enclosure level. The results of all four tests at each level will be made available on request.

5.4 Decommissioning

Disposal activities will be considered at the procurement contract stage and will be included within the BESS safety management process and detailed in the DBSMP. As the programme matures the hazard log will be expanded to cover each phase of product development and installation.

The chosen BESS supplier will be designated as the producer of the battery components and the party placing the battery components on the UK market, and as such has certain obligations in respect of battery disposal pursuant to the Waste Batteries and Accumulators Regulations 2009 (or such equivalent regulations in force at the time of decommissioning).

It is assumed that all components replaced during the defects notification and warranty period will be returned to the manufacturer and recycled.

The BESS development will be subject to a decommissioning plan for submission to the Local Authority on request. (Note this is essentially a reverse engineering exercise with a large component on safe disposal of the batteries) to comply with the Waste Batteries and Accumulators Regulations 2009.

Root Power will follow the hierarchy of waste management throughout the life of the Scheme and during construction (subject to monthly reports) as follows:

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

- Recycle – The supplying manufacturer will have obligations under the Waste Batteries and Accumulators Regulations 2009 (as amended) (or such equivalent regulations in force at the time of decommissioning) and will be contractually obliged to offer a recycling service.
- Recovery – The recycling should allow any useful materials to be recovered and re-enter the supply chain.
- Disposal – Any disposal of batteries shall be undertaken in compliance with all applicable Laws and all regulatory requirements, product stewardship, registration disposal and recycling or take back requirement.

5.5 Maintenance

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. The register is used to highlight the hazardous materials contained within BESS 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 BESS Hazardous Materials Register will be made available to the local emergency services.

The compound will be regularly kept free of vegetation, litter, and any combustible materials.

All internal roads will be maintained to a standard suitable for use during usual operation and emergency response.

All required hazard signage, contact information for emergency response and security will be attached to main gates and boundary fencing. (compliant with the health and safety (Safety Signs and Signals Regulations 1996)).

5.6 Emergency Response Plans

Prior to construction of the BESS, ERP and Risk Assessment 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. An on-site fire containment strategy will be incorporated into the overall site drainage design at the detailed design stage.

The ERP 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.

It is important to note that current guidance states that Lithium battery fires will not be tackled with water other than for the purpose of cooling down and fire prevention to other assets local to the fire.

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

1. The 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 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 will be developed and include:
- a. How the FRS are to be alerted.
 - b. The site layout including infrastructure details, operations, number of personnel, and operating hours. Key points on-site such as entrances and availability of hydrants and shut of isolations as identified by “What 3 Words Codes” for the Local FRS. This will require consultation and site visits by the regional FRS.
 - c. A site plan depicting key infrastructure, site access points and internal roads.
 - d. Details of emergency resources, including FDSSs and equipment; gas detection; emergency eyewash and shower facilities; 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.

6.0 Site Specific Safety

6.1 Siting

The site has been selected due to its minimal environmental constraints, screening from nearby residences and proximity to a viable grid connection. There are no residential properties within 25m of the BESS units.

There are no public footpaths or rights of way within the site boundary.

Figure 6-1 illustrates the site layout for the Luzlow BESS installation with dimensions.

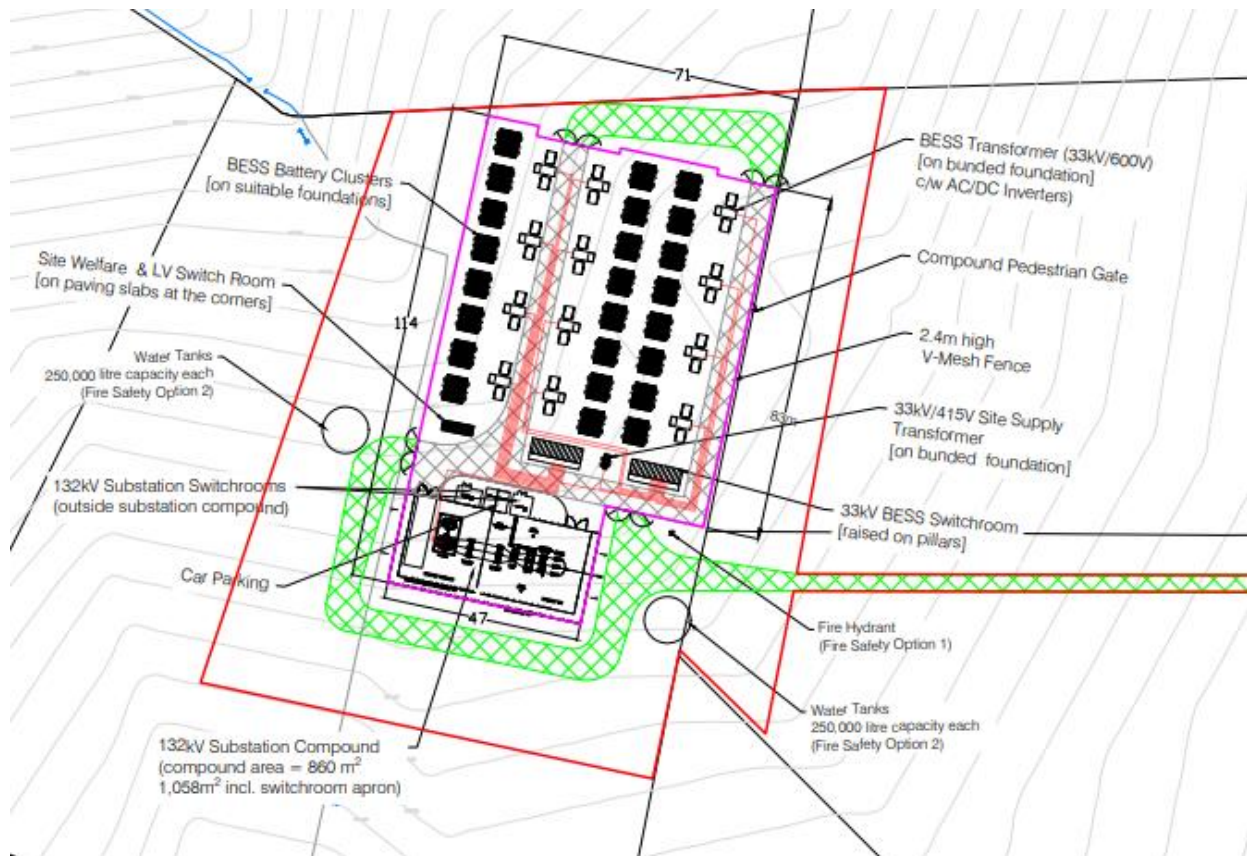


Figure 6-1 – Luzlow Energy Storage Site Layout

6.2 Security

During construction, the site will be secured with temporary fencing, Closed Circuit Television (CCTV) and in-person security. During operation, a security fence and security cameras will be in place that are remotely monitored 24/7.

6.3 FRS

The Staffordshire Fire and Rescue Service (SFRS) is the regional FRS for the Luzlow site:

1. **Consultation.** Consultation with the SFRS is envisaged during the planning stages of the project.
2. **Water Supply.** The Applicant has analysed and discussed the NFCC recommendations with several regional FRS and concluded that the options, and that which will be explored by the Applicant, are:
 - a. The identification of a Fire Hydrant (FH), with sufficient capacity and pressure, within a range of 60-80m of the BESS compound. Noting that the route from the FH to the site must consider topological obstacles such as rivers, canals, railway lines, major roads, and other infrastructure.
 - b. As above, the identification of a Water Access point with 60-80m of the BESS compound that has, subject to discussion with the owning Water Utility Provider, capability to be converted to a FH. Noting that the route

from the FH to the site must consider topological obstacles such as rivers, canals, railway lines, major roads, and other infrastructure.

- c. Identification of a FH or a suitable water source, reservoir, lake, large river, etc. within 100-150m of the BESS compound – enabling connection and maintenance of pressure using in-line pumps. Noting that the route from the FH to the site must consider topological obstacles such as rivers, canals, railway lines, major roads, and other infrastructure.
 - d. Siting of a Water Storage Tank or multiple tanks at the site with a capacity of 228m³ or greater.
 - e. The identification of FHs within 1- 2km of the site, such that the FRS can replenish at the closest point to the site. These FH are to be identified in the ERP.
3. Pending identification of the options at 2a-e above, the Applicant has tentatively included two Water Tanks, each with 250m³ capacity, at the site as an element of the design. These Water Tanks are for emergency fire-fighting use only, they are not designed to accommodate human consumption and do not serve that purpose. The tanks are self-contained and will be filled by tanker prior to site commissioning and topped-up periodically by tanker to accommodate any losses.
4. **NFCC Guidance Compliance.** The NFCC has provided guidance to regional FRS regarding grid scale BESS and planning. This NFCC Guidance [Ref. 2] has been distilled into the 14 key salient points arising from the guidance and is presented at Table 6-1, this details the site layout and compliance status reflecting the NFCC guidance.

Ser	NFCC Recommendations	Site Status	Options / Comments
1	Access - Minimum of two separate access points to the site	Compliant	There are two points of access into the BESS compound, emanating from Luzlow Road, Figure 6-1 refers. There is also a pedestrian point of entry on the eastern security fence should both vehicular points of entry be obstructed.
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 compound is a metaled surface and lends itself well for the positioning of FRS vehicles in attendance. There is no extreme of grade at the site. The site access road is suitable for Heavy Goods Vehicle traffic – asphalt in construction.
3	A perimeter road or roads with passing places suitable for fire service vehicles	Compliant	The site service road loops in the site allowing for drive in, drive out using the two points of site access. Given the compact nature of the site access to all BESS is possible from this looped route.
4	Road networks on sites must enable unobstructed access to all areas of the facility	Compliant	Access to all BESS units is afforded from the service road in the BESS compound.
5	Turning circles, passing places etc. size to be advised by FRS depending on fleet	Compliant	There is hard standing within the BESS compound which can serve a passing point or manoeuvring area.
6	Distance from BESS units to occupied buildings & site boundaries. Initial min distance of 25m	Compliant	There are no occupied buildings within 25m of the BESS units, the nearest occupied buildings being to the northeast at some 180m distance.
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 LIB-ESS comprised of Lithium Ferrous Phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors, or deflagration vents. - For containerized LIB-ESS comprised of Lithium Nickel Manganese Cobalt (NMC) cells where wall construction is unknown or has an 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 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. Following this revision to the Datasheet, the BESS containers on-site are 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. The distance between BESS container pairs is approx. 3.0m for sides that contain access panels or doors, Figure 6-1 refers.
8	Site Conditions – areas within 10m of BESS units should be cleared of combustible vegetation	Compliant	The BESS units will sit on concrete slabs or supporting feet. Internal access tracks will comprise crushed stone and the access road for the abnormal load will be asphalt. Within fence line and between BESS containers units the surface is laid over to gravel.

Ser	NFCC Recommendations	Site Status	Options / Comments
9	Water Supplies	Compliant	Within the current design there are two separate options subject to FRS consultation, these being Option 1 – A site specific FH connected to the mains supply. Option 2 - Two 250,000L water storage tanks located to the west of the site and within a maximum of 60m of the furthest BESS units. These tanks will be self-contained and not connected to the water system, the provision of the water is for fire-fighting purposes only.
10	Signage	Compliant	Signage to be positioned at the entrance to the site. Signage to be confirmed through design process and will be detailed in the ERP.
11	Emergency Plans	Compliant	Future iteration of the OBSMP to DBSMP will roll up the ERP outlining who and how FRS will be alerted, facility description, number of operatives, detailed site plan etc.
12	Environmental Impacts	Compliant	Consultation with the Environment Agency will be conducted in accordance with Planning process requirements.
13	System design, construction, testing and decommissioning	Compliant	Several of the elements under this aspect of the NFCC Guidance are contained in this plan, however details of the construction, testing and decommissioning will only be available in later stages of the programme and be contained in the DBSMP. Compliant at this juncture in the planning procedure.
14	Deflagration Prevention and venting	Compliant	Elements of this requirement are contained in this plan, but the actual technique to be adopted will not be apparent up to the point 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, as such deflecting blast upwards and away from FRS personnel. Compliant at this juncture in the planning procedure.

Table 6-1 – NFCC FRS Requirements X-Ref to Luzlow BESS

7.0 Conclusions and Recommendations

7.1 Conclusions

This is the initial OBSMP for the Project 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 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 in use and other associated products using Lithium-Ion electrical storage technology or similar. 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.

It is concluded that, as far as reasonably practicable and for this planning stage of the project, that currently foreseeable hazards associated with the equipment have been identified, and these will be developed and managed with prospective suppliers during the tendering, contracting and construction stages. These hazards will be actively managed throughout the life of the installation and added to as necessary as the BESS Project develops and will be reported on regularly.

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.

7.2 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.

It is recommended that to maintain an acceptable level of residual risk, that all the identified control measures are assessed as the design matures to elicit; applicability, feasibility and the potential amelioration afforded. At this juncture of the programme, 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 arguments and supporting evidence to make such a claim.

8.0 References

1. Planning Practice Guidance – Low Carbon and Renewable Energy, [Renewable and low carbon energy - GOV.UK \(www.gov.uk\)](https://www.gov.uk/guidance/renewable-and-low-carbon-energy) dated 14 Aug 2023.
2. NFCC Grid Scale BESS Planning – Guidance for FRS dated Nov 2022.
3. FM Property Loss Prevention Datasheet 5-33 dated Jan 2024 (Interim Revision).
4. Root Power HSE Management System.
5. Construction Design and Management (CDM) Regulations 2015 – SI2015/51 dated Dec 2017 (as revised).
6. Reducing Risk, Protecting People (HSE Publications) - <https://www.hse.gov.uk/risk/theory/r2p2.pdf> first published 2001, ISBN 0717621510.
7. NFPA 855 Standard for the Installation of Stationary Energy Storage Systems dated Aug 2023
8. UL1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications.
9. UL9540A – BESS Test Methods.
10. UN38.3 Standard Requirements for Lithium Battery Production - 4th Revision.
11. IEC 61508:2010 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems dated 2010.

Appendix A - FAQs

Ser	Question	Answer
1	How does a BESS work?	A BESS generally employs Li-Ion technology, but other technologies are available, 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 Photo Voltaic Solar Farm and store energy throughout the day for release in the evening and in this mode of operation is a green renewable energy. 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 variation on the National Grid. This mode of operation allows energy suppliers to operate their power station in a more economical manner and assists in reducing the carbon-footprint of the power suppliers. Two different primary Lithium-Ion Battery chemistries (the elements that form the energy storage parts of the batteries) are used in BESSs, these being: ○ Lithium Ferrous Phosphate (LFP) - LFP batteries are possibly the best types of batteries for BESSs. 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. ○ Lithium NMC - NMC batteries feature both strong energy and power density, and they are relatively safe compared to other types of Lithium-Ion batteries when it comes to thermal runaways. However, they offer a significantly lower number of life cycles compared to LFP batteries, generally between 1,000 and 2,000 cycles. NMC batteries also require cobalt and nickel, which are more expensive and harmful to the environment. There is also significant concern about shortages in these minerals, which can significantly impact both cost and availability.
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 July 2023 and published 8 August 2023) the data has been filtered for BESS installations in the UK and the following salient points are deduced:

Ser	Question	Answer
		1. As of July 2023, there are 100 BESS sites in operation across the UK. 2. The total energy capable of being stored is estimated at 1580MW (1.58GW). 3. Since 2006 BESS have operated for approximately 4.8 million hours (data details 4,729,560 hours) which is equivalent to 540 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. 5. This equates to 2.11E-07 (0.000000211) failures per hour (fph) for BESS fires in the UK. 6. Given the HSE R2P2 Guidance [Ref. 1] of 1.0E-06 fph as being a ‘societally acceptable’ safety rate, the level achieved by UK BESS is 10 times better than HSE guidance. Noting that to date nobody in the UK has been killed in a BESS incident. BESS are designed to industry specific guidelines and subject to UK legislation.
3	How is the BESS temperature controlled?	The Lithium-Ion batteries are housing in an ISO type 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 Lithium-Ion 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 to 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 and emerging battery chemistries. 3. Over-temperature in the cell because of:

Ser	Question	Answer
		a. Over-charging (which is controlled by two separate BMS – battery and rack). b. High ambient temperature – controlled by the ECU.
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. 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. 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 (Lithium-Ion like other batteries do not perform well in low temperature conditions).
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 suppress 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. 5. Various FDSS aerosols (also known as aqueous) and gaseous systems are available, and they use a variety of aerosol solutions.

Ser	Question	Answer
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. 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. 2. 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. 3. The application of water on a BESS fire increases the generation of gases such as Carbon Monoxide (CO), Hydrogen (H₂) and Hydrogen Fluoride (HF). Applying water causes incomplete combustion of organic substances inside the battery resulting in production of CO rather than Carbon Dioxide (CO₂); when water is applied, H₂ is released that, without combustion, can react with phosphorus pentafluoride, if present in free form, to produce gaseous HF. 4. 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.
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 refer to as the vapour cloud) is dependent on the chemistry in use, the design and components of the BESS and the magnitude of the fire. Amongst the general gases released are CO, HF, Oxygen and H ₂ . The only UK BESS fire (Carnegie Road, Liverpool – Sept 2020) was monitored and the resultant composition of the plume determined as being negligible in toxic gas concentration.
9	How is the BESS site secured?	BESS Site are secured through fences / walls and are monitored remotely via CCTV. Warning signs along the fence indicate 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 centralise 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 several times in the 40-year life of the site.