OAKLANDS FARM SOLAR PARK

Applicant: Oaklands Farm Solar Ltd

Environmental Statement

Appendix 4.6 – Outline Battery Safety Management Plan

January 2024

Document Ref: EN010122/APP/6.1/Appx 4.6

Revision: -

Planning Act 2008
Infrastructure Planning (Application: Prescribed Forms and Procedure) Regulations 2009 - 5(2)(a)

Oaklands Farm Solar Park - Environmental Statement Volume 3

Appendix 4.6: Outline Battery Storage Safety Management Plan

Final report
Prepared by LUC
January 2024

Client: Oaklands Farm Solar Limited
Document No: 0073-R-01
Version: 2.0
Date: 3 January 2024

OAKLANDS FARM SOLAR PARK

Outline Battery Safety Management Plan

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DOCUMENT INFORMATION

Project Title:	Oaklands Farm Solar Park
Document Title:	Outline Battery Safety Management Plan
Cairn Number:	0073
Document Number:	0073-R-01
Client:	Oaklands Farm Solar Limited
Document Status:	Final for Issue
Version:	2.0
Date:	3 January 2024

REVISION HISTORY

No	Description	Issue Date	Author	Reviewed	Approved	Notes
0.1	First Draft	22/09/23	M. Urquhart	M. Clouting	G. Ellor	Draft version issued for project internal review
1.0	Final for issue	09/11/23	M. Urquhart	M. Clouting	G. Ellor	Draft version updated following project stakeholder review
1.1	Final for issue	17/11/23	M. Urquhart	M. Clouting	G. Ellor	Version 1.0 updated following project stakeholder review
2.0	Final for issue	03/01/24	M. Urquhart	J. Moorse	M. Urquhart	Version 1.1 updated following further project stakeholder review

ACRONYMS & ABBREVIATIONS

AC	Alternating Current
ALARP	As Low As Reasonably Practicable
ATEX	EXplosive ATmospheres
BayWa	BayWa-r.e. UK Ltd
BESS	Battery Energy Storage System
BMS	Battery Management System
BSMP	Battery Safety Management Plan
CCTV	Closed Circuit Television
CDM	Construction (Design & Management) Regulations 2015
CTMP	Construction Traffic Management Plan
DC	Direct Current
DCO	Development Consent Order
DSEAR	Dangerous Substances And Explosive Atmospheres
e-HAZID	Electrical Hazard Identification (Study)
ES	Environmental Statement
ERP	Emergency Response Plan
FMEA	Failure Modes & Effects Analysis
F&R	Fire & Rescue
HAZID	Hazard Identification (Study)
HAZOP	Hazard and Operability (Study)
HGV	Heavy Goods Vehicle
HSE	Health & Safety Executive
LEL	Lower Explosive Limit
LFP	Lithium Iron Phosphate
Li-ion	Lithium-ion
LOPA	Layers Of Protection Analysis
MAD	Major Accidents & Disasters
NFPA	National Fire Protection Association
NMC	Nickel Manganese Cobalt
OBSMP	Outline Battery Safety Management Plan
OEMP	Operational Environmental Management Plan
OFSP	Oaklands Farm Solar Park
OFSL	Oaklands Farm Solar Limited
PCI	Pre-Construction Information
PCS	Power Conversion System
PEIR	Preliminary Environmental Information Report
PRoW	Public Right of Way
PV	Photovoltaic
RAM	Risk Assessment Matrix
SAP	Safety Assurance Process
SAT	Site Acceptance Testing
SF6	Sulphur Hexaflouride
SIF	Safety Instrumented Function
SIMOPs	Simultaneous Operations
SuDS	Sustainable Drainage System

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1 INTRODUCTION

1.1 Background

The Oaklands Farm Solar Park (OFSP) project is a proposed solar and associated battery development with a generating capacity of over 50 MW.

The development is owned by Oaklands Farm Solar Ltd (OFSL), a wholly owned subsidiary of BayWa-r.e. UK Ltd (BayWa). OFSP is a 'Nationally Significant Infrastructure Project' under the Planning Act 2008, and therefore an application for Development Consent (a Development Consent Order (DCO)) is required.

1.2 Purpose

This Outline Battery Safety Management Plan (OBSMP) has been prepared to supplement Chapter 4 (Site Description and Proposed Development) of the Environmental Statement (ES).

The purpose of this OBSMP is to:

- Demonstrate that the safety and environmental hazards associated with BESS are understood;
- Describe the risk reduction measures that have been incorporated in the preliminary design and those that are likely to be included in the final detailed design; and
- Outline the approach that will be taken in progressing and optimising the BESS design in line with relevant codes, standards, legislation and good practice guidance and in consultation with relevant bodies.

A finalised Battery Safety Management Plan (BSMP) must be prepared by OFSL prior to construction of the Proposed Development, which must be in accordance with the principles of this OBSMP.

1.3 Project Description

1.3.1 Oaklands Farm Solar Project

The Oaklands Farm Solar Park Project, as displayed in **Figure 1**, comprises a proposed solar farm with an associated Battery Energy Storage System ('the Proposed Development'). The Proposed Development would have a generating capacity of over 50MW and would be situated on 191 hectares of land at Oaklands Farm to the south-east of Walton-on-Trent and to the west of Rosliston in south Derbyshire. The solar farm itself, comprising photovoltaic panel arrays, a central electricity substation and Battery Energy Storage System together with access, landscaping and other works would be located on 135 hectares of agricultural land currently in use for arable production and grazing. A high voltage underground electricity cable would then run through land at Fairfields Farm and Park Farm to the north to connect the solar farm to the national grid via an electricity substation located at the former Drakelow Power Station which sits south of Burton-upon-Trent. As the Proposed Development would be an onshore generating station with a generating capacity of over 50MW an application for a Development Consent Order is being made under the Planning Act 2008 to the Planning Inspectorate, for determination by the Secretary of State for Energy Security and Net Zero.

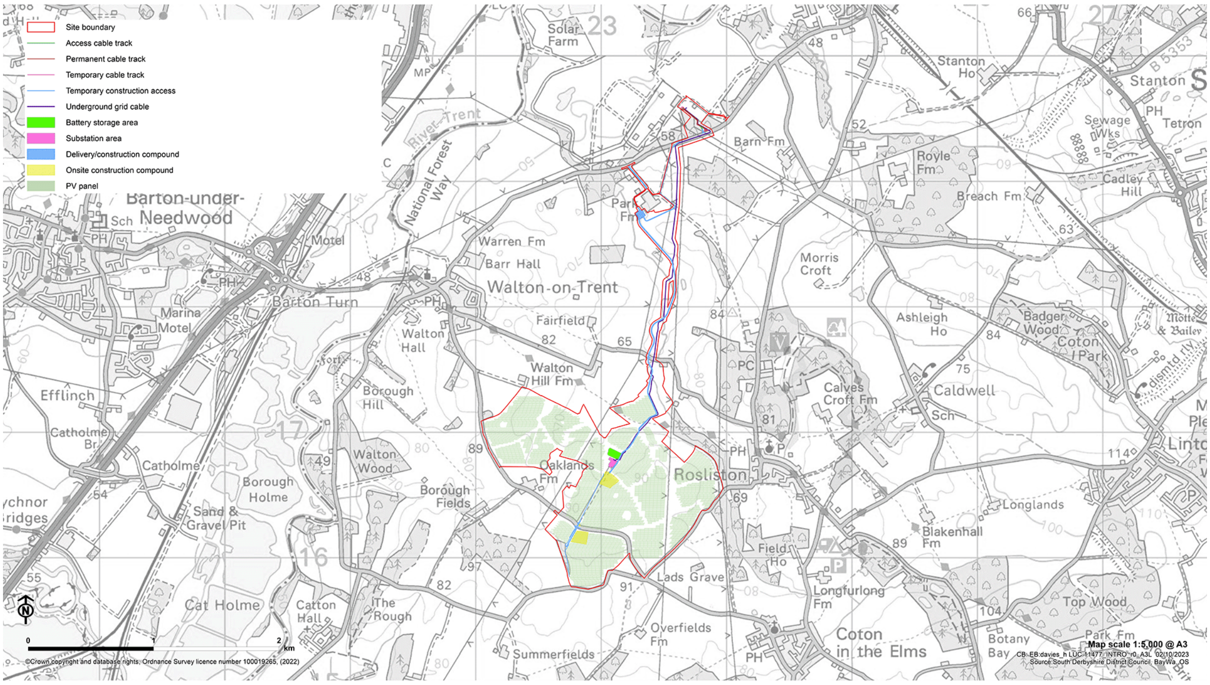

Figure 1: Oaklands Farm Solar Park Layout

1.3.2 BESS Compound

The BESS will be located centrally in the south of the site boundary, adjacent to the substation as displayed in **Figure 2**. A more detailed view is shown in **Figure 3**. The proposed BESS comprises:

- 78x Battery containers (see **Section 4.2.2**. This is the maximum number of battery containers that the BESS compound will contain. The number of battery containers may reduce, depending on commercial, construction and operational factors, and the required separation between containers for fire safety);
- 13x Power Conversion System (PCS) & transformer containers; and
- 1x 33 kV switch station.

The separation distances between the electrical assets are:

- Battery-battery, horizontal edge – 3 m (see **Section 4.2.2**. This is the minimum allowable spacing between pairs of battery containers and can be increased if required to minimise the risk of fire propagation between battery containers).
- Battery-battery, vertical edge – 3 m
- Battery-PCS, horizontal edge – 3 m
- Battery-33 kV switch station, horizontal edge – 2.5 m

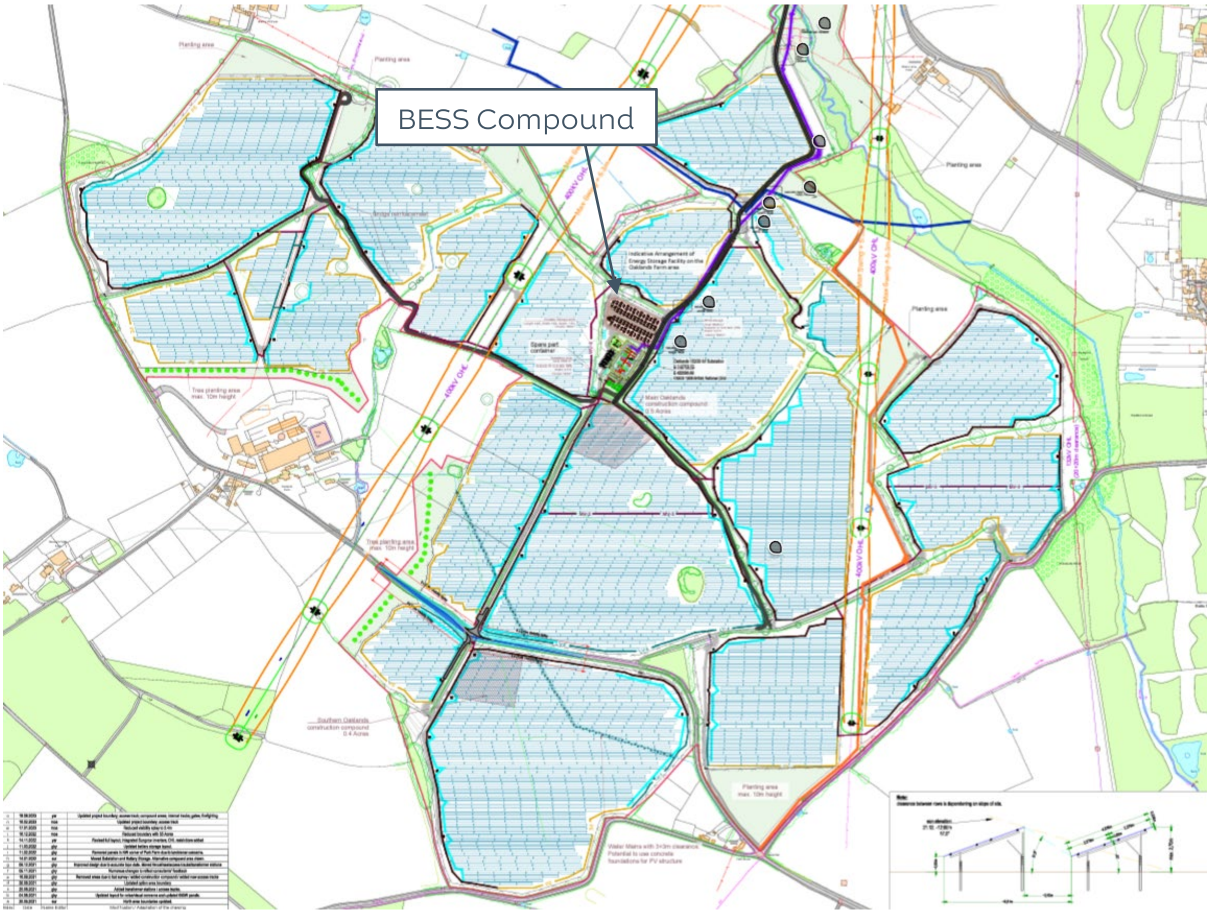

Figure 2: BESS Compound Location

Figure 3: BESS Compound Layout

1.4 BESS Specification

As battery technology is rapidly evolving, the specific battery models that will be available when the design is finalised prior to construction are currently unknown. Therefore, an assumed battery design has been specified based on current available technology suitable for this application. The detailed design of the BESS compound will be completed following identification of the battery supplier and model and will be in accordance with the parameters set out in the DCO application.

It has been assumed that batteries will be Lithium-ion (Li-ion) type. The two main types of Li-ion batteries are Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP), both named after the components which their cathode are composed of.

NMC batteries have a higher energy density compared to LFP batteries, which make them attractive for applications where space and weight are constrained, such as in electric vehicles. NMC batteries require replacement after significantly less cycles than LFP batteries – between roughly 1,000-2,000 cycles, compared to 2,000-5,000 cycles for LFP. Therefore, using NMC batteries would increase the risk of heavy lifting during battery exchange. NMC batteries are less favourable in terms of safety compared to LFP batteries, as they are more prone to thermal runaway if they are damaged or subjected to high temperature due to having a less stable chemical make-up. Additionally, NMC batteries are generally more expensive than LFP type.

As LFP batteries are more favourable in terms of lifecycle length and safety and are being installed on other sites being developed by BayWa, it has been assumed for the purposes of this document that the BESS will be made up of LFP type battery containers.

The assumed design parameters and specifications used for the components of the BESS compound are shown in **Table 1**, as presented in Chapter 4 of the ES (Project Description) [4].

A final decision will be made on the BESS equipment specification following a final decision on the project's DCO application.

Table 1: BESS Specification

Scheme Component	Parameter Type	Applicable Design Parameter
Battery Energy Storage System (BESS) compound – 0.8ha		
BESS Compound (compound to house the BESS components and the containers)	Maximum area	0.8ha
Battery Energy Storage System (BESS) Battery Containers	Maximum number	78
	Dimensions (in metres)	9.34 x 1.73 x 2.52 (length, width, height)
	Colour	Dark Green or Recessive Grey
	Foundation	Containers will sit on concrete piles or blocks, raised to a maximum of 0.6 metres above ground level. For drainage and fire-fighting water control, a drainage and containment system will be implemented into the sub-base of the BESS compound. The worst case would be an impermeable area of concrete hardstanding covering the whole BESS compound.
BESS Power Conversion System (PCS) Units	Maximum number	13
	Dimensions (in metres)	6.1 x 2.44 x 2.90 (length, width, height)
	Colour	Dark Green or Recessive Grey
	Foundation	Containers will sit on concrete piles or blocks, raised to a maximum of 0.6 metres above ground level. For drainage and fire-fighting water control, a drainage and containment system will be implemented into the sub-base of the BESS compound. The worst case would be an impermeable area of concrete hardstanding covering the whole BESS compound.
BESS Auxiliary Transformer	Number	1 up to 5 MVA
	Dimensions (in metres)	8.5 x 4.9 x 3 (length, width, height)
	Colour	Dark Green or Recessive Grey
	Foundation	Sits on concrete pad up to 50mm thick, with suitable bund around the base for containment of oil. The worst case would be an impermeable area of concrete hardstanding covering the whole BESS compound.
Internal BESS Unit Fire Suppression System	Type	Built into interior of battery container units with detection and automatic initiation. Water-based (sprinkler or mist system), or inert gas delivery system. Associated storage of water or inert gas with infrastructure for deliveries/removal, or connection to existing piped agricultural water supply. "Dry Risers Pipes" may be utilised on units which allow for injection of water into burning containers without personnel having to access.

Scheme Component	Parameter Type	Applicable Design Parameter
External BESS Fire Suppression	Type	Provision for controlled burn of units is a potential option to manage fires, with fire-fighting strategy consisting of cooling surrounding components and units to prevent spread of fire (managed by spacing of units to prevent runaway/spread, containment of emissions/residues, and automatic shut-down of BESS compound). Water is to be used to 'dowse' and cool surrounding battery units to prevent spread of fire, allowing a burning battery unit to extinguish itself. Deluge system consists of water supply (tanks or piped supply), piping, nozzle/delivery components, containment of used water and contaminants via mitigation measures (bunding and/or containment ponds/tanks with shut-off and separating capabilities to test water before discharging to environment).
	Number and dimensions of water storage tanks (in metres)	Up to 3 water storage tanks capable of storing c.300m^3. Water tank = 6 metre diameter, 4 metre height to achieve c.100m^3
BESS Compound Access gates and palisade fencing	Type	Steel palisade security fencing with lockable double-leaf access gates
	Height	Up to 3m

1.5 Relevant Guidance

Currently, there is very limited UK-specific guidance for the design of BESS. However, there are globally recognised good practice recommendations that will be followed in the design of the BESS of the Proposed Development, as well as all applicable UK legislation.

Relevant guidance and good practice documentation that will be followed in the development of the BESS includes, but not is limited to:

1. UL 9540, Standard for Energy Storage Systems and Equipment
2. UL 1973, Batteries for Use in Stationary and Motive Auxiliary Power Applications, Edition 3 (2022)
3. IET, Code of Practice for Electrical Energy Storage Systems, 2nd Edition
4. Energy Institute, Battery Storage Guidance Note 1: Battery Storage Planning
5. Energy Institute, Battery Storage Guidance Note 2: Fire Planning and Response
6. Energy Institute, Battery Storage Guidance Note 3: Design, Construction & Maintenance
7. IEC 62933-5-2:2020, Safety requirements for grid-integrated EES systems — Electrochemical based systems
8. Energy Storage Operators Forum - A Good Practice Guide on Electrical Energy Storage (2014)
9. National Fire Protection Agency (NFPA) 855 (United States of America), Standard for the Installation of Stationary Energy Storage Systems, 2023 Edition
10. United Kingdom Power Networks (UKPN) Engineering Design Standard 07-0116: Fire Protection Standard for UK Power Networks Operational Sites, 2016
11. DNV GL-Recommended Practice-0043: Safety, Operation and Performance of Grid-Connected Energy Storage Systems, 2017

12. Scottish and Southern Energy TG-PS-777: Limitation of Fire Risk in Substations, Technical Guide, 2019
13. BS 5839 Part 1 2017: Fire Detection and Fire Alarm Systems for Buildings
14. The Regulatory Reform (Fire Safety) Order (RRO) 2005
15. IEC 61936, Power installations exceeding 1 kV AC and 1,5 kV DC – AC
16. IEC 62443, Industrial communication networks - Network and system security
17. The Waste Batteries and Accumulators Regulations 2009
18. National Fire Chiefs Council, Grid Scale Battery Energy Storage System planning – Guidance for FRS
19. IEC 61508 Functional Safety of electrical/electronic/programmable electronic safety-related systems
20. NFPA 68, Standard on Explosion Protection by Deflagration Venting, 2023 Edition
21. NFPA 69, Standard on Explosion Prevention Systems, 2019 Edition

2 BESS SAFETY ASSURANCE PROCESS

2.1 BESS Hazards

The main fire hazards introduced by BESS are associated with **thermal runaway**. Thermal runaway occurs in a cell due to abuse (e.g. overcharge, heating): the abuse triggers exothermic reactions, producing large volumes of gas and heat. Eventually, the heat is produced faster than it can dissipate and the exothermic reactions become self-sustaining and the cell is in uncontrolled positive thermal feedback-"thermal runaway". The gases typically include up to 50% hydrogen, c.a. 20% carbon monoxide, carbon dioxide, methane and propene, as well as toxic chemicals. The cell can then heat up adjacent cells and send them into thermal runaway – a cascade effect called "thermal propagation". The gases inside the cells will vent to the outside taking with them droplets of the organic electrolyte to form a "vapour cloud", with the following consequences:

- **Fire**. If the vapour cloud ignites immediately, the flames will initiate further thermal runaway and gases, and fire can spread across all cells within battery cells, modules, units and containers and lead to catastrophic damage, environmental impact and impact to people (on-site personnel situated nearby and emergency response personnel). If the fire spreads to engulf an entire battery unit or container, there is the risk of the resultant thermal radiation impacting upon adjacent assets, potentially resulting in a domino effect (i.e. fire propagating along a row of battery containers).

  Unfortunately, the cells in BESS are usually inaccessible to water and any suppression system that simply kills fire (water, aerosols, inert gas) but does not stop thermal propagation switches the hazard from fire to explosion, as the cascade of cells producing the vapour cloud continues. Hydrogen in particular has a very low minimum ignition energy and a wide flammability range and in the aftermath of a battery fire, there are many potential ignition sources.

  Fire can also spread across surrounding vegetation if it is not well managed, especially in dry conditions.

- **Explosion**. The vapour cloud is produced by all lithium-ion batteries under abuse conditions, including LFP batteries, varying only in volume and relative composition. If there is insufficient ventilation of a battery container during a thermal runaway incident and immediate ignition does not occur, the vapour cloud can accumulate which, when ignited, can deflagrate and produce overpressures that may severely impact upon nearby people, assets and the environment. Projectiles can be produced from such overpressure and adjacent battery cells, modules and units can be damaged, further escalating a thermal runaway incident.

- **Environmental Release**. There are two main causes of environmental releases:
  - **Gaseous**. Gases produced as a result of thermal runaway and battery fires can be toxic or poisonous in nature, such as hydrogen fluoride and carbon monoxide. Migration of these gases can impact upon local communities or other environmental receptors (e.g. livestock), on-site personnel or emergency response personnel attending an incident. Toxic gases such as carbon monoxide will continue to be produced until the battery cells are cooled to their core. If a fire spreads to a neighbouring transformer, Sulphur Hexafluoride (SF_6) gas may also be released, which is both harmful to people and an extremely potent greenhouse gas.
  - **Liquid**. If firewater is used to cool batteries in the event of thermal runaway or a fire, the produced wastewater will be hazardous to the environment if not collected, treated and disposed of properly. This will be of particular concern if

the water drains into nearby water courses relied upon for fresh water supply by people and livestock in the area. A sample of firewater should be taken in order to test the level of contaminants in the water.

The main mechanisms that will likely lead to the above hazards from manifesting are:

- **Thermal instability**. The battery cells must be maintained at a temperature which will not accelerate the chemical reaction to the point that it is uncontrollable and may result in thermal runaway. This can be achieved through ventilation and/or forced cooling, either using air or a liquid cooling system.
- **Electrical fault**. Electrical faults may arise from manufacturing defects, incorrect/inadequate maintenance, loose terminal connections or operating errors (e.g. overcharging, over-discharging).
- **Mechanical damage**. Mechanical impact, as a result of human error during maintenance, error during construction or internal faults (i.e. projectiles being created).
- **Chemical**. Chemical instability in the battery cells, potentially caused by operating the batteries outside of their intended parameters (i.e. charging, discharging rates) and general degradation.

The other clear hazard associated with batteries is electrocution. This can be caused by the same issues highlighted against Electrical Fault above, as well as factors such as improper isolation prior to working on equipment and access to BESS containers by unauthorised personnel. Appropriate security and interlock/isolation procedures are essential in preventing people from being exposed to live high voltage equipment.

2.2 Safety Assurance Approach

2.2.1 Objectives

The primary objective of the safe operation of the BESS is to prevent any hazardous scenarios from occurring. **Figure 4** displays a "Bowtie" diagram, which provides a useful visual representation of hazardous events.

There are many initiating causes/events which may lead to a hazard manifesting – for example, those highlighted in **Section 2.1** above (thermal instability, electrical fault, mechanical damage, chemical). A thorough understanding of the causes that can lead to a hazardous scenario arising, and the means of reliably controlling or preventing these causes from occurring ("Preventative Barriers" shown in **Figure 4**), is the most effective means of ensuring safe operation of potentially hazardous assets.

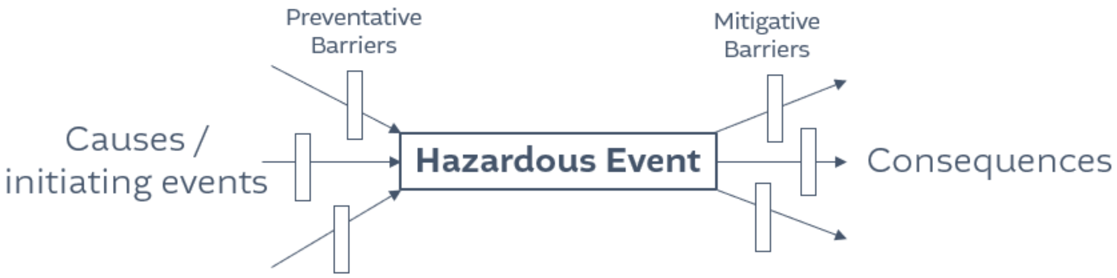

Figure 4: Bowtie Diagram

The secondary goal is then to understand all of the consequences that could arise from the identified hazardous scenarios and ensure that there are effective measures in place to prevent these consequences from being realised, or mitigate the severity of these consequences to protect people, assets and the environment from harm ("Mitigative Barriers" shown in **Figure 4**).

Preventative and mitigative barriers can be both passive and active. If the hazardous event is thermal runaway (and therefore the consequences being fire, explosion and environmental release), then example barriers are:

- Appropriate, regular maintenance by competent personnel to identify faults/early signs of degradation;
- Gas, smoke and/or heat detectors that will automatically shut down and isolate a battery and trigger inert gas to suppress a fire and water mist to reduce and maintain the the battery temperature at a safe level;
- Location of the BESS to prevent fire, smoke and toxic gases impacting off-site receptors and constrain the consequences to a localised area;
- Design of site to allow ease for access to emergency response personnel and ease of egress for on-site personnel;
- Provision of a sufficient volume of firewater to allow the fire service to extinguish a fire and prevent the spread to adjacent assets.

2.2.2 Risk Reduction

In considering the most effective means of reducing risk through design, OFSL has followed the hierarchy of risk controls (see **Figure 5**), which is enshrined in UK Health & Safety legislation [1]. The hierarchy of risk controls is a framework for implementing the methods of risk reduction shown in **Figure 5** in order, from most to least effective.

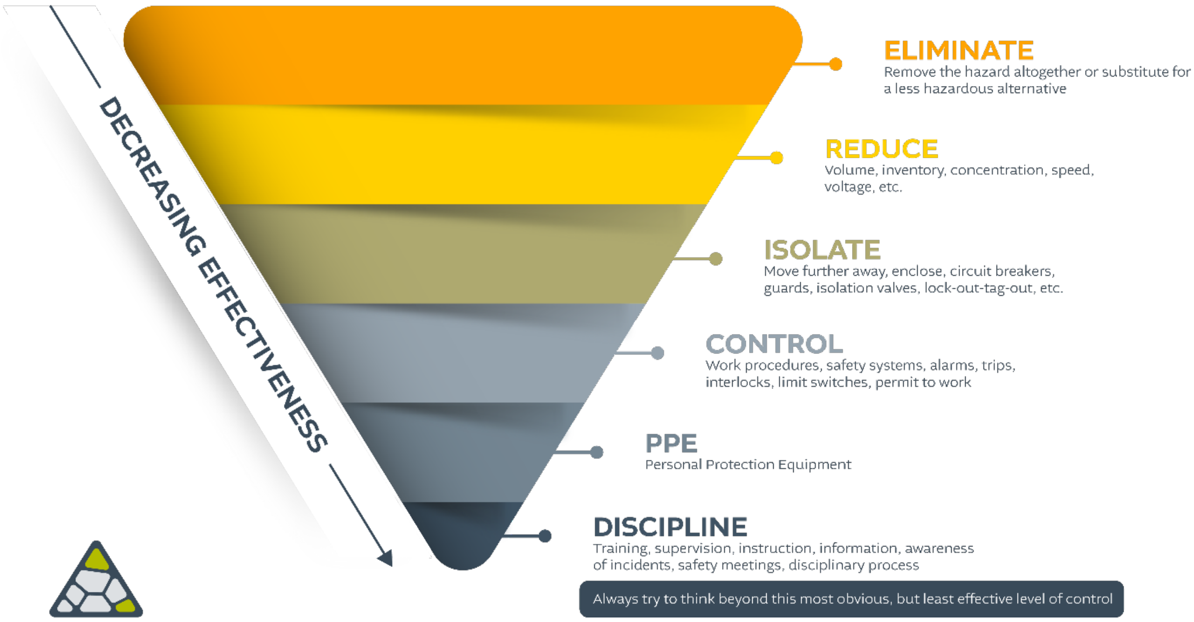

Figure 5: Hierarchy of Risk Controls

Beginning the Safety Assurance Process (SAP) in the early stages of design has provided OFSL with the greatest opportunity to implement design changes based on the top half of the hierarchy. As the design progresses, it is more difficult and more costly to implement as effective risk reduction measures, particularly when design changes are constrained following acceptance of a DCO application, for example.

2.2.3 Primary and Secondary Safety Issues

During the early design stages, a project Risk Register was developed with a structure to differentiate between "Primary" and "Secondary" safety issues, which are outlined in **Figure 6**.

Primary safety issues are those which are fundamental to demonstrating that the proposed facility will be safe in its planned location. They require specific risk management attention in the pre-consent phase to demonstrate that there are no "show-stoppers" (i.e. hazards that cannot be eliminated or their risk reduced to a tolerable level through design changes, which would deem the safe development of the project unfeasible at the proposed location). Post-consent, design updates relating to Primary safety issues must not fundamentally alter the risk profile, such as relocating batteries nearer to nearby properties.

Secondary safety issues are not fundamental to the safety justification of the project and there is no need to resolve them to inform a consenting decision. However, there is an action plan for these issues to be addressed through the detailed design phase as part of the ongoing Safety Assurance Process (SAP).

Primary and Secondary issues were identified relating specifically to the BESS compound of the Proposed Development, providing a prioritised action plan for issues to address through the development of the project.

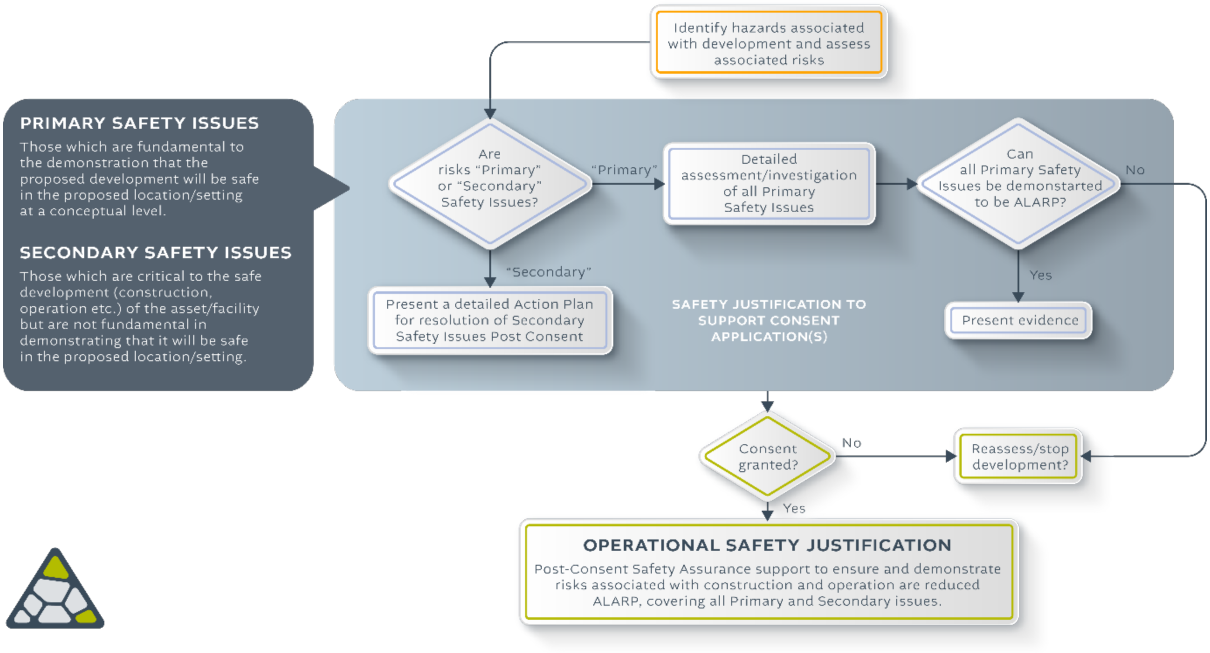

Figure 6: Safety Assurance Approach for Development Projects

2.3 Safety Assurance Activities

2.3.1 Hazard Identification

Two major Hazard Identification (HAZID) activities were undertaken to inform the preliminary design:

- A HAZID workshop [2], which identified the hazards that may be introduced by the construction, operation, maintenance and decommissioning of the Proposed Development; and
- An Electrical HAZID (e-HAZID) [2], which focused on the hazards associated with the electrical infrastructure. The BESS compound was a specific area of study in this workshop.

Following a similar approach to that outlined in **Figure 4**, for each hazard identified during the HAZID exercises, the following were recorded:

- Threats/Causes which could lead the hazard being realised;
- Consequences of the hazard being realised (worst case consequences, assuming no

mitigative barriers are in place);

- Preventative and mitigative barriers which are incorporated in the design;
- The risk associated with the hazard, to assess the effectiveness and suitability of barriers in place. Risk was determined as a combination of; the likelihood of the hazardous scenario occurring, and the severity of the consequences. Criteria for likelihood and severity were specified on a Risk Assessment Matrix (RAM).
- Whether it is a Primary or Secondary issue, as **per Section 2.2.3**.

Where further investigation was required on the identified hazards, actions were raised to inform the progression of the design and implement further risk reduction measures, as appropriate.

2.3.1.1 Primary Safety Issues

The Primary safety issues specifically relating to the BESS that were identified during the project HAZID workshops [2] are listed in **Table 2**. The early identification of these issues created an action plan of the matters needing addressed to demonstrate that the BESS can exist safely, at a conceptual level, in its proposed location/layout. Controls & mitigations have been included or assumed in the conceptual design to demonstrate how the risks will be managed. The controls & mitigations shall be reviewed and optimised, if necessary, as the design progresses.

Table 2: OFSP BESS Primary Safety Issues

Hazard	Threat	Issue	Consequences (unmitigated)	Controls/Mitigations
Extreme weather	Rain, groundwater level rising	Water ingress into battery/transformer/substation units	Electrical fault and/or fire, potential failure of substation/transformer/battery units	Battery and substation units raised above ground level on concrete substructures. Drainage system in BESS compound. Substation and BESS compound located away from water courses.
Fire/smoke	Battery fire	Potential for fire at battery unit to block emergency escape routes	Personnel unable to escape in vehicles in the case of a battery fire	Built-in fire suppression (e.g. inert gas) is standard on containerised battery units Substation no longer isolated with only access route to the south, which could have been blocked by a battery fire. There are multiple escape routes to/from the site. Vegetation around BESS compound and substation will be well managed.
Battery composition	Unknown battery composition - technology is rapidly changing so there may be more favourable options available by the time the batteries are procured	Potentially flammable fluids contained within batteries	Fire/explosion Equipment damage and potential injury/fatality	Containerised batteries as standard have individual fire suppression systems (e.g. inert gas for fire suppression, water mist as a coolant). Firewater tanks for firefighting and associated drainage/firewater containment to minimise environmental impact.

Hazard	Threat	Issue	Consequences (unmitigated)	Controls/Mitigations
Cooling system	Potential for liquid cooling system for batteries (e.g. glycol solution)	Leakage of liquid, environmental concern, drainage issues from battery area	Environmental release Equipment damage and potential injury/fatality	BESS compound has containment for contaminated firewater which will be treated prior to disposal. Firewater containment can be utilised to contain glycol solution leakages. Note: Ethylene glycol in water and in soil will breakdown within several days to a few weeks. Unlikely to seriously affect health unless ingested in large quantities.
Separation distance between battery units	Battery fire	Potential for heat transfer between battery units in the event of a fire	Escalation of fire (i.e. domino effect), leading to extensive equipment damage and potential injury/fatality	3 m separation between battery containers in line with NFPA 855 guidance. Firefighting strategy is to cool battery containers adjacent to container which is on fire to prevent propagation of fire. Containerised batteries as standard have individual fire suppression systems (e.g. inert gas for fire suppression, water mist as a coolant).
Separation distance between battery units	Lifting operations (e.g. removal of batteries for maintenance/change-out)	Potential for one or more battery units being impacted by a dropped object due to the close proximity of battery units	Damage to/failure of battery units	3 m separation between battery containers.
Access to battery containers	Emergency escape from battery containers in the event of a major incident	Location of access/egress doors on battery containers Close proximity of battery containers	Personnel unable to escape in the event of a major incident, leading to injury/fatality	Requirement for 2 means of egress from battery containers, if walk-in units are opted for. Sufficient space between battery containers to allow emergency escape from multiple egress points (3 m spacing allowed, in line with NFPA 855 guidance on access/egress routes). Potential to use battery container design which does not allow personnel access into the containers (cabinet-style containers).

Hazard	Threat	Issue	Consequences (unmitigated)	Controls/Mitigations
				Maintenance can be conducted by staying outside the container and accessing components from shutters/doors that open on both sides.
Inverters	Arc flash / arc blast	Potential for insufficient clearance from other equipment and access ways	Injury/fatality due to exposure to arc flash/arc blast	Standard design of inverter containers is that the arc flash boundary is contained within the enclosure
24 hour battery operation	Potential for operational issues outside of working hours	Operational issues which cannot be dealt with remotely	Equipment damage/failure	24 hour supervision of facility

2.3.2 Design Reviews

The design of the Proposed Development and the BESS compound has undergone multiple iterations. Each iteration impacting the BESS compound underwent a thorough review considering the safety and environmental risks associated with the design of the BESS compound. Such design reviews have considered:

- The relocation of the substation to be adjacent to the BESS compound. It was ensured that there was sufficient clearance between the assets for:
  - Accessibility;
  - Electrical interference;
  - Fire effects (i.e. thermal radiation impacting upon adjacent equipment); and
  - Bending radii of associated cables.
- The layout of the BESS compound, considering aspects such as:
  - Clearance between BESS containers, inverters and transformers (for accessibility, electrical interference and fire effects);
  - Orientation of BESS containers and the redundancy of means of access/egress;
  - Access road design, regarding ease of access for emergency response vehicles and cranes (for construction and if any additional lifting activities, such as change-out of batteries, are required).

Such reviews have allowed a preliminary design to be finalised which has addressed significant hazards through the most effective means, as per the Hierarchy of Risk Controls (e.g. isolating BESS compound from nearby environmental receptors and maintaining a safe distance between hazardous electrical assets to prevent escalation of a hazardous incident). Once the specific battery model is known, residual risk can be minimised through measures such as engineering controls (e.g. gas detection, fire suppression, etc.) – the further risk reduction measures will be part of the BESS design have been assumed based on current industry standard battery container products (see **Table 1**).

2.3.3 Future Safety Assurance Activities

2.3.3.1 Expected Safety Assurance Activities

The Safety Assurance Activities undertaken to date have been proportionate to the level of detail required for the concept design of the BESS compound and the wider project, focusing on the Primary Safety Issues listed in **Table 2**. As the project moves beyond planning/development and into the Detailed Design phase and the design is further refined, it is envisaged that at least some of the following activities will be performed to inform the design development in such a way that reduces risks ALARP and addresses the Secondary Safety Issues detailed in **Table 3**:

- **A follow-up HAZID**, building upon the "Coarse" HAZID described in **Section 2.3.1**. HAZIDs performed during detailed design often study discrete sections of a project in greater detail, so there may be a dedicated HAZID conducted on the BESS compound. Follow-up HAZIDs will act as an ongoing validation of the Risk Register and identify further hazards, threats and controls/safeguards that will reveal themselves as the design develops;
- **Consequence modelling (fire/explosion/gas dispersion)**. This will inform the area that would be impacted in the event of a BESS fire/explosion by thermal radiation, explosion overpressure or toxic gas migration and identify whether any further mitigations are required;
- **Hazardous Area Assessment (e.g. ATEX, DSEAR)**. Based on the outcome of flammable gas dispersion modelling, it may be required to define hazardous areas within which there

is a risk of a flammable atmosphere forming. Equipment within these zones must be compliant (i.e. will not act as an ignition source) and people will not be allowed within these zones unless equipped with the appropriate PPE and equipment;

- **Hazard & Operability (HAZOP) study**. Once a detailed electrical design has been developed, a HAZOP study can be used to assess whether the design is adequate in protecting against upsets/deviations from intended operating conditions which could lead to operability issues or hazardous conditions. HAZOPs are used to identify changes to optimise the design in terms of safety;
- **Layers Of Protection Analysis (LOPA)**. For potential hazardous events (e.g. BESS fire) – often those identified during a HAZOP – a LOPA will be used to determine the likelihood of such an event occurring based on the safeguards included in the current design. The risk of this hazardous event can then be compared against tolerability criteria to determine whether additional protection layers are required and if so, the level of risk reduction they must provide (quite often in the form of Safety Instrumented Functions (SIL); and
- **Failure Modes & Effects Analysis (FMEA)**. This study will assess the detailed electrical design to identify all the modes in which the system can fail and for each failure mode, identify all causes and effects. This can be used to identify changes in the design to both prevent these modes of failure from occurring and mitigate the consequences.

2.3.3.2 Secondary Safety Issues

Table 3 details the Secondary safety issues identified during the project HAZID workshops [2]. Addressing these issues and the associated actions, where these exist, will form part of future activities in ensuring that the detailed design of the BESS is developed with safety and environmental risks reduced ALARP.

Table 3: OFSP BESS Secondary Safety Issues

Hazard	Threat	Issue	Consequences (unmitigated)	Controls/Mitigations
Discharges to the environment (liquids/gases/ particulates)	Transformers & batteries	Potential release of harmful chemicals to the environment, such as SF6. Large volume of water held in deluge system, potential for oily water release	Contamination of land. Environmental impact (SF6 is potent greenhouse gas)	Concrete bund around equipment containing harmful chemicals Minimised SF6 volumes in design
Electrical fault/failure	Batteries, cables, inverters, transformers	Short circuit of electrical equipment	Fire/explosion and damage to/failure of electrical equipment	Access provision has been allowed around substation & batteries. Asset integrity through maintenance and inspection. Competence and training of installation and maintenance personnel. Water ingress protection.
Fire/smoke	Underground cables, inverter units, batteries, transformers Chemicals/fertilisers used by land owners igniting Vegetation on site causing fire to spread	Electrical equipment catching fire potentially spreading across OFSP	Injury/fatality Damage to/failure of OFSP equipment	Sheep grazing on Oakland Farm reduces vegetation growth - unlikely to be vegetation surrounding substations Routine checks & landscaping procedures to maintain vegetation at safe level Major equipment located away from site edges, reduces impact on neighbouring sites Fire clearance around transformers sized by quantity of oil. Clearance around BESS compound itself, to fence line ensure no propagation outside compound.

Hazard	Threat	Issue	Consequences (unmitigated)	Controls/Mitigations
Extreme weather	Rain, groundwater level rising	Water ingress into substation and battery concrete substructures	Cracking of concrete substructures, leading to structural failure and damage to/failure of battery or substation equipment	Substation and battery compounds located away from water courses
Loss of containment (liquids/gases/ particulates)	Fluids/gases from batteries/switchgear (e.g. SF6)	Site personnel come into contact with fluids/gases from batteries/switchgear during maintenance/inspection activities	Asphyxiation/intoxication/fatality	Asset integrity through maintenance and inspection routines. Potential use of switchgear which utilises "green gas" rather than SF6. Personnel training and competency.
Fire/smoke	Underground cables, inverter units, batteries, transformers Chemicals/fertilisers used by land owners igniting Vegetation on site causing fire to spread Personnel smoking	Electrical equipment catching fire potentially spreading across OFSP Cigarette causing fire, potentially spreading across OFSP	Injury/fatality Damage to/failure of OFSP equipment	Sheep grazing on Oakland Farm reduces vegetation growth Routine checks & landscaping procedures to maintain vegetation at safe level No smoking rules on site
Out of specification release/ discharge	Replacement of battery modules	Disposal or recycling of battery modules	Environmental impact of battery module disposal Potential for old batteries being stored on site if no recycling facilities available at the end of battery life	No storage of spent modules onsite. Battery recycling/disposal method to be agreed with battery manufacturer as part of procurement contract. It is expected that the manufacturer will undertake this task. Battery recycling methods likely to have progressed by the time batteries on the Oaklands site require change-out. To comply with the Waste Electrical and Electronic Equipment (WEEE) regulations.
Lifting/ handling	Removal and replacement of containers (i.e. batteries, welfare and storage containers)	Access/egress for lifting equipment, including turning heads	If turning heads are not included in design, there is potential for collisions during future lifting activities	Access road runs around the perimeter of the BESS compound with turning circles sufficient for foreseeable vehicles (i.e. vehicles used for lifting activities). Crane pads included in BESS compound design to allow lifting of battery containers.

Hazard	Threat	Issue	Consequences (unmitigated)	Controls/Mitigations
Fire/smoke	Battery fire	Potential for fire at battery unit to block emergency escape routes	Personnel unable to escape in vehicles in the case of a battery fire	Built-in fire suppression (e.g. inert gas) is standard on containerised battery units There are multiple escape routes to the site which must remain clear (Substation no longer isolated with only access route to the south, which could have been blocked by a battery fire.)
Battery containers	Live high voltage electrical equipment	Potential for batteries still being live when personnel enter for maintenance activities	Injury/fatality due to electrocution	Containerised battery solutions can be individually isolated with interlocks de-energising on door entry.

3 CONSULTATION

3.1 Derbyshire Fire and Rescue

Engagement with the local Fire and Rescue (F&R) Service is essential in the development of large-scale projects involving BESS. This engagement is for the benefit of both parties and has the objectives of:

- Ensuring that OFSL understands the provisions Derbyshire F&R requires to fight a BESS fire and these have been incorporated in the design. This includes but is not limited to:
  - Volume of firewater stored in water tanks provided to fight BESS fire and the location of the hose tie-in point relative to the BESS compound;
  - Additional firefighting provisions and water supplies, e.g. hydrants, mains water supply points;
  - Access roads and routes suitable for fire engines.
- Ensuring that Derbyshire F&R are familiar with BESS fires and that they are comfortable and competent in how to safely fight a BESS fire;
- Agreeing the spacing between battery containers is sufficient in preventing propagation of fire and allowing access/egress in the even of a fire.
- Agree a firefighting strategy in consideration of Emergency Response Plans to be agreed prior to construction.

Derbyshire F&R have been contacted and are aware of the Proposed Development. They have provided advice in the following areas:

- Access requirements for emergency vehicles, following Approved Document B [5] – a guidance document under The Building Regulations 2010.
- The most effective means of extinguishing battery fires is to submerge the batteries, although this comes with the risk of producing hazardous waste. It is noted that this advice differs from the latest guidance from the National Fire Chiefs Council (NFCC) [8], who recommend to focus on defensive firefighting measures such as using firewater to cool adjacent containers and prevent spread of fire – this approach is the current firefighting strategy of the Proposed Development.

As part of a DCO Requirement, this OBSMP will be developed in cooperation with Derbyshire F&R post-consent. Derbyshire F&R shall confirm the objectives listed above have been achieved and to inform any necessary amendments to on-site firefighting provisions and/or the firefighting strategy in advance of construction of the BESS.

3.2 Other Consultees

This OBSMP and the wider DCO application will be reviewed by the Emergency Planning Officer at the Local Planning Authority and the Health & Safety Executive, among others.

Of the consultee responses received on the Scoping ES in 2021, only one was in relation to battery safety (received from the Planning Inspectorate):

> "Advised the ES should include a description and assessment (where relevant) of the likely significant effects resulting from accidents and disasters applicable to the Proposed Development, such as battery storage fire hazards. The Applicant should make use of appropriate guidance (e.g. that referenced in the Health and Safety Executives (HSE) Annex to the Inspectorate's Advice Note 11) to better understand the likelihood of an occurrence and the Proposed Development's susceptibility to potential major accidents and hazards. The description and assessment should consider the vulnerability of the Proposed

> Development to a potential accident or disaster and also the Proposed Development's potential to cause an accident or disaster. The assessment should specifically assess significant effects resulting from the risks to human health, cultural heritage or the environment. Any measures that will be employed to prevent and control significant effects should be presented in the ES."

This response has been sufficiently covered between this document and the Major Accidents & Disasters (MAD) section within Chapter 16 of the ES [3]. This OBSMP provides an assessment of the likely significant effects of BESS fires, whilst the MAD chapter within the PEIR provides an assessment of the wider accidents and disasters which the Proposed Development may be vulnerable to.

4 BESS LIFECYCLE RISK REDUCTION

The following section describes what has been done and what will be done in ensuring the BESS is developed to reduce safety and environmental risks to a tolerable level. **Table 4** outlines the main safety requirements and recommendations identified in the preparation of this OBSMP that the BESS shall be designed in accordance with.

The requirements and recommendations referred to in **Table 4** are those which were identified as relevant at the time of preparing this OBSMP. It is acknowledged that applicable and up-to-date requirements and recommendations are subject to change in the time prior to procurement and construction of the BESS. The final BSMP will be prepared in accordance with the relevant and up-to-date guidance at the time it is written.

Table 4: BESS Safety Requirements & Recommendations

No	Safety Requirement / Recommendation	Reference	OBSMP Section
1	BESS Manufacturer Quality Management	ISO 9001 – Quality Management	**4.1.1**
2	Lithium Battery Certification	UN38.3 – Certification for Lithium Batteries	**4.1.1**
3	Testing for Thermal Runaway Propagation	UL9450 A – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems	**4.1.1**
4	BESS separation distance from vulnerable exposures (at least 3 m)	NFPA 855 (§9.4.2)	**4.2.2**
5	BESS separation from combustible vegetation (at least 3 m)	NFPA 855 (§9.5.2.2)	**4.2.2**
6	BESS separation from means of egress (at least 3 m)	NFPA 855 (§9.5.2.6.1.7)	**4.2.2**
7	Protection of personnel against live HV equipment	IEC 61936, Power installations exceeding 1 kV AC and 1,5 kV DC – AC	**4.2.4**
8	Provision of automatic fire control and suppression systems	NFPA 855 (§9.6.2)	**4.2.4**
9	Implementation of safety shutdown, isolation and interlock systems	IEC 61508	**4.2.4**
10	Provision of fire & gas detection systems	National Fire Chiefs Council – Grid Scale Battery Energy Storage System planning – Guidance for FRS	**4.2.4, 4.2.5**
11	Provision of adequate ventilation	NFPA 855 (§9.6.5.1.5); National Fire Chiefs Council – Grid Scale Battery Energy Storage System planning – Guidance for FRS	**4.2.3, 4.2.5**
12	Protection against cyber attacks	IEC 62443	**4.4.2**
13	Correct disposal or recycling of batteries	Waste Batteries and Accumulators Regulations 2009 (as amended)	**4.5**
14	Safe transportation and handling of BESS	UN Recommendations on the Transport of Dangerous Goods; IATA Dangerous Goods Regulations	**4.1.1**
15	Engagement and planning with local Fire & Rescue Service	The Fire Service Manual Volume 2 Fire Service Operations – Electricity	**5.1**

No	Safety Requirement / Recommendation	Reference	OBSMP Section
16	Access requirements for Fire & Rescue Service vehicles	The Building Regulations 2010, Fire safety, Approved Document B	**5.2**
17	Adequate firewater provision (in agreement with local Fire & Rescue Service)	National Fire Chiefs Council – Grid Scale Battery Energy Storage System planning – Guidance for FRS	**5.3**
18	Adequate firefighting equipment (in agreement with local Fire & Rescue Service)	N/A – to be advised by Derbyshire F&R Service	**5.4**
19	Production of Emergency Response Plan	NFPA 855; National Fire Chiefs Council – Grid Scale Battery Energy Storage System planning – Guidance for FRS	**5.5**

4.1 BESS Procurement and Testing

4.1.1 Procurement

OFSL will work with BESS system integrators which have a good, proven track record of projects and experience in relevant markets (i.e. UK-based projects) and whom are well aware – and will therefore comply with – grid codes and UK-specific regulations and standards.

OFSL intends to procure batteries from Tier 1 suppliers compliant with:

- ISO 9001 (Quality Management);
- UN38.3 (Certification for Lithium Batteries); and
- UL9450 A ('Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems').

As part of supplier qualification, due diligence on visiting production facility, quality & technical documentation will be performed.

4.1.2 Testing

The battery manufacturer's test protocols will be checked by OFSL and OFSL personnel shall oversee Site Acceptance Testing (SAT).

4.2 BESS Compound Design

4.2.1 Location

The central location of the BESS within the site of the Proposed Development is favourable because it is a considerable distance from any neighbouring properties. Under normal operating conditions, this minimises the impact on nearby properties from noise and the visual presence of the BESS. Additionally, if an incident such as BESS fire were to occur, the degree of separation significantly reduces the likelihood of nearby properties being impacted by the event.

The substation was relocated from its original position to the north of Oaklands Farm to be adjacent to the BESS compound. This relocation was assessed and it was confirmed that there is sufficient clearance between the assets for:

- Accessibility;
- Electrical interference;

- Fire effects (i.e. thermal radiation impacting upon adjacent equipment); and
- Bending radii of associated cables.

4.2.2 Layout

The indicative layout of the BESS compound is shown in **Figure 3** above. It comprises 4 rows of battery containers and transformer/PCS units. Access roads run around the perimeter of the compound and between every second row of battery containers and transformer/PCS units.

NFPA 855 (§9.5.2.6.1) [5] recommends that batteries located outdoors should be separated by a minimum 10 ft (3 m) from the following exposures:

- **Site boundaries**. The minimum distance between a battery container and the nearest site boundary is greater than 90 m.
- **Publics ways**. The minimum distance between a battery container and the nearest Public Right of Way (PRoW) is greater than 250 m.
- **Buildings**. There are no buildings within the BESS compound. The closest building to the BESS compound is the central substation building, which is much greater than 3 m from the nearest battery containers.
- **Stored combustible materials**. The nearest combustible material to the batteries is the transformer oil within the transformer/PCS units, which are 3.4 m from the batteries.
- **Hazardous Materials**. There are no other hazardous materials planned to be stored within the vicinity of the BESS compound.
- **High-piled stock**. There are spare parts containers located south of the substation, which are much greater than 3 m from the nearest battery containers. There are no plans for high-piled stock to be stored in the vicinity of the BESS compound. A waste management plan will be produced for the project, which will ensure that waste disposal locations are a safe distance from flammable hazards such as batteries.
- **Other exposure hazards not associated with electrical grid infrastructure**. No other hazards have been identified in the vicinity of the BESS compound.

As noted above, the recommended separation between batteries and other hazardous/flammable materials (e.g. other battery containers) is 3 m, which has been provided between the battery containers in the current design. NFPA 855 (§9.5.2.6.1) [5] states that, where approved, clearances to exposures other than buildings shall be permitted to be reduced to 3 ft (914 mm) where large-scale testing of the battery demonstrates that a fire within the battery container will not generate radiant heat flux sufficient to ignite stored materials or otherwise threaten the exposure. Therefore, in the procurement of the BESS equipment, OFSL will need to ensure that for the batteries chosen:

- Large-scale testing has been undertaken which includes fire testing (in accordance with UL 9540A test method, or equivalent);
- The radiant heat flux generated from a battery fire is known (e.g. from UL 9540A testing), particularly at the distances at which other assets are to be set back from the batteries;
- The fire rating of the battery containers (i.e. how long the container can withstand a fire, particularly a fire producing the radiant heat flux measured during the fire testing);
- The ability of the battery containers to maintain the internal temperature at a safe level, even during the event of a fire external to the container, such that thermal runaway of neighbouring batteries can be prevented during a fire.

In addition to the NFPA recommendation, National Fire Chiefs Council (NFCC) recommends a separation distance of 6 m between adjacent battery containers [8]. The current BESS compound design includes firewater inventory in line with the NFCC recommendation (see **Section 5.3**). If there is a significant fire in one battery container, the firefighting strategy is to douse adjacent containers in water to maintain a low temperature and prevent the fire spreading between containers (see **Section 5.6**), while the battery on fire will undergo a controlled burn. It is believed that this would be sufficient in preventing the spread of fire between containers with the current separation distance of 3 m. If review of testing of the chosen battery model (i.e. UL 9540A testing) or other evidence concludes that 3 m is insufficient, then the BESS compound layout will be adjusted, increasing the separation between battery containers by reducing the number of battery containers installed on the site.

Increasing the separation distance between adjacent battery containers to 6 m may allow for the controlled burn of a single battery container without the requirement for firewater to cool adjacent units, which in turn would remove – or significantly reduce – the likelihood of contaminated firewater being produced. The current design has oversized battery containers by 5% and included additional battery containers and PCS units which may be redundant, providing flexibility to adjust the layout or remove assets if required on the grounds of safety. If the separation distance is increased, firewater requirements would be reviewed in consultation with a competent fire safety engineer and the Derbyshire Fire & Rescue Service.

NFPA 855 (§9.5.2.2) [5] recommends that areas with 10 ft (3 m) on each side of outdoor BESS should be cleared of combustible vegetation and other combustible growth. The battery containers will sit on concrete piles or blocks, raised to a maximum of 0.6 metres above ground level. The containers will sit on impermeable hard standing, which will be surrounded by access roads with a width of at least 4 m, so the batteries will be more than 4 m from any vegetation. Strict vegetation management on the site will be detailed in the Operational Environmental Management Plan (OEMP). The OEMP shall state the requirement to clear any combustible vegetation from the BESS compound – should it grow there – and maintain all other vegetation on site so that it is not overgrown (particularly in dry summer conditions).

NFPA 855 (§9.5.2.6.1.7) [5] recommends that BESS located outdoors are separated from means of egress by no less than 10 ft (3 m) to ensure safe egress under fire conditions. In the BESS compound there are multiple routes of egress, meaning that personnel can escape from any location within the compound whilst maintaining more than 3 m distance from a battery container which is on fire.

4.2.3 BESS Container Design

The battery containers shall be constructed by the manufacturer in compliance with the most up to date good practice – for example, NFPA 855 & UL 1973, unless any UK-specific guidance is available at the time.

As mentioned in **Section 4.2.2**, the containers shall have a fire rating which allows them to withstand a fire long enough that the local F&R service can intervene and mitigate the effects of a fire.

The containers shall be designed to prevent and mitigate explosions in line with NFPA 69 and NFPA 68, respectively.

The BESS containers shall also be designed to prevent personnel from being exposed to high voltage, live electrical equipment. It shall be ensured that there is a robust isolation/interlocking procedure which does not allow personnel to open the door of any battery container without the battery having first been discharged and isolated from the rest of the system. There shall be lights on the containers indicating when batteries are charging/discharging to warn personnel when they are in a particularly dangerous state. Around the BESS compound, there will be steel palisade security fencing with lockable double-leaf access gates and the site will monitored remotely 24 hours a day, with the ability to shut-down the BESS equipment remotely should conditions become unsafe for operatives within the BESS compound.

Adequate cooling and ventilation of the containers is key to maintain the batteries to a safe temperature to prevent thermal runaway and to vent flammable/toxic gases which could lead to an explosion or adversely impact personnel accessing the containers. The manufacturer shall demonstrate that the air change rate within the container is sufficient in maintaining the concentration of foreseeable flammable/toxic gases to a safe level. The manufacturer shall also demonstrate that the cooling system is sufficient in preventing a thermal runaway incident and in maintaining the batteries at a temperature which will not induce premature degradation of the cells.

There shall be means of indicating to personnel when hazardous conditions have been detected (e.g. fire or gas detection, thermal runaway), such as visual warning devices (e.g. strobing lights) and alarms.

4.2.4 Fire Detection and Suppression

Each battery container will be equipped with a fire detection and suppression system. This shall be built into the interior of each individual unit, with the detection of fire automatically initiating the suppression systems. It shall be ensured that there are minimum of two types of fire detection (e.g. heat, chemical, optical) that are truly independent of each other to provide redundancy.

The temperature of the battery containers will be continuously monitored. The internal cooling system should control the temperature within safe operating parameters. If the temperature rises beyond this limit, the fire suppression system will be initiated. Site shutdown and disconnection of the battery from adjacent electrical assets will be automatically initiated upon detection of a battery fire – manual shutdown will be possible both locally and remotely if a fire has started but has not been detected.

Inert gas (e.g. NOVEC 1230) will be used to extinguish a fire and a water-based sprinkler or mist system will be used to reduce the temperature – and maintain a low temperature – of the battery to prevent reignition. "Dry Risers Pipes" may be utilised on units which allow for injection of water into burning containers without personnel having to access.

The expected operation of this system is based upon currently available BESS designs. It shall be confirmed with the final battery manufacturer that the safety objectives relating to fire detection and suppression will be met in line with these expectations. Implementation of reliable mechanisms for the shutdown, isolation and interlocking of BESS in the case of emergency scenarios should follow IEC 61508.

4.2.5 Gas Detection and Ventilation

Gas detection systems expected to be installed in the battery containers include those for carbon monoxide, hydrogen, volatile organic compounds and specific electrolyte vapour. Detection of any of these gases shall initiate automatic shutdown of the BESS and switch over to full exhaust of the ventilation system. As recommended by the National Fire Chiefs Council, to prevent an explosive atmosphere from forming, the detection and exhaust systems should be designed to maintain the concentration of any flammable gas below 25% of its Lower Explosive Limit (LEL). Gases should be detected prior to a fire starting – with a focus on preventing incidents rather than mitigating the consequences of them, such detection systems are key in the Battery Management System (BMS).

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

If any hazardous gases are detected, the battery is expected to be automatically disconnected from adjacent electrical assets.

4.3 Safe BESS Construction

The anticipated sequence of construction of the BESS Compound is:

- Land preparation (civil engineering works);
- Construction of access routes;
- Erection of fencing;
- Foundations installation;
- Delivery and installation of BESS units and associated equipment; and
- Electrical cable trenching and connections made prior to testing/commissioning.

The BESS compound has been designed with construction in mind, allowing sufficient space for the delivery and lifting of the battery containers. The roads are designed for Heavy Goods Vehicles (HGV) and crane access and crane pads have been provided.

Being located adjacent to the substation, there is the potential for Simultaneous Operations (SIMOPs) between the construction/installation of the BESS compound and substation area. The risks associated with this will be assessed in a SIMOPs study and reflected in Works Plans and the Construction Traffic Management Plan (CTMP).

The construction phase Emergency Response Plan will review the risks associated with the construction of the BESS compound. Access for emergency response vehicles to the BESS compound area during the construction phase will also be ensured in the construction phase TMP.

The Pre-Construction Information (PCI) provided to the Principal Contactor (as defined in the Construction (Design & Management) (CDM) Regulations 2015) appointed to oversee the construction of the BESS compound will allow them to manage the specific risks associated with this activity.

The batteries will be transported to the site as part of a preassembled unit, which will have certification for road transport in place (UN38.3 (Certification for Lithium Batteries)).

4.4 Safe BESS Operation

4.4.1 Control Philosophy

Although it will be located adjacent to the substation – where personnel on site will most often be located – the BESS compound will generally be an unoccupied area. However, the batteries will be monitored 24 hours a day, 7 days a week from both the central control room adjacent to the substation and a remote control room facility. If there is an incident (e.g. fire) detected in any battery container, a site shutdown will automatically be initiated. It will then be the responsibility of the control room personnel to initiate the emergency response plan and act as the main point of contact with emergency response personnel (e.g. F&R Service). The Emergency Response Plan (ERP) will include the contact details for emergency services and other key responders.

Control room personnel will have the authority to initiate site shutdown, if this is not automatically done through detection of hazardous conditions.

In case other on-site personnel or a member of the public are the first to identify an incident, the fencing around BESS compound will display signage in accordance with relevant Electrical Regulations and an emergency contact number for the control room, so that they can raise the alarm.

4.4.2 Security

The BESS compound will be equipped with the following security features to restrict access only to authorised personnel:

- Palisade fencing;
- CCTV;
- Security gates; and
- 24/7 remote monitoring.

There will be signage around the perimeter of the BESS compound in accordance with relevant Electrical Regulations to warn unauthorised people of the dangers.

Given the important role the facility will play in energy generation and grid stability, the site will be designed with the threat of cyber attacks in mind through compliance with IEC 62443.

4.4.3 Maintenance

The philosophy for maintenance, inspection and testing for the BESS will follow recommendations of the selected BESS manufacturer. Proportionate maintenance will confirm the batteries can continue to be operated safely and can also be used to gauge cell degradation. The internal resistance of the cells should be measured periodically as this tends to increase as the cells near the end of their life, so can indicate if cells require change-out.

Key activities regarding BESS safety include:

- Checking for fluid leakage – leakages can result in toxic fumes, burns, corrosion or fires/explosions; and
- Torquing of electrical terminal connections, which will maintain connection integrity. Loose connections may experience thermal runaway, leading to elevated temperatures and subsequently fire.

All maintenance will be performed following site safety rules and will be controlled under safe systems of work. Each task will be individually risk assessed to confirm that adequate provisions are in place to protect the individual carrying out the work.

Lone working on site will only be allowed if strictly necessary and if personnel have to work alone, this will be communicated with the control room so that control room personnel can make regular contact to confirm the lone worker has not encountered any issues.

4.5 Decommissioning / End of Life Disposal

The method of decommissioning of the BESS will be agreed with the supplier of the batteries. At the end of the equipment life, the equipment will be returned to the supplier for recycling, repurposing, or disposal.

The planned life of the facility is 40 years, which is partially determined by the expected life of the equipment being installed. The methods of recycling/disposing of such equipment at this point in the future are currently unknown, but the main focus will be on reducing waste as much as possible through operating the batteries in such a way that they do not encounter early life degradation. If practicable, the batteries should be reused at the end of the life of the Proposed Development and if not, as many of the materials should be recycled as possible, in line with the Waste Batteries and Accumulators Regulations 2009 (as amended) and/or other relevant regulations in future.

5 FIREFIGHTING

5.1 Fire Service Guidance

The Fire Service Manual Volume 2 Fire Service Operations – Electricity [6] provides guidance for fighting fires involving electricity, including on power generation sites. Engagement and planning between OFSL with the Derbyshire F&R Service will follow recommendations provided in this document. Two key recommendations are:

- **Liaison**. There should be close liaison both before and during an incident. Pre-planning visits on on-site training exercises should be arranged to ensure that proper risk assessments are carried out and personnel are familiar with plant and processes before an incident occurs. OFSL shall arrange for site visits and training exercises to be held for the Derbyshire F&R Service to ensure familiarity with the site, equipment, access routes and firefighting provisions.
- **Equipment Isolation**. In all cases involving electrical apparatus the first essential is to ensure that the apparatus is electrically isolated and safe to approach. In large installations (such as the BESS compound of the Proposed Development) this will be carried out by an "Authorised Person". The site Emergency Response Plan shall state the requirement for a Suitably Authorised Person to isolate the batteries before any firefighting can begin. It must be noted that while the batteries can be isolated, they will still hold a residual charge. The F&R Service must be made aware of this and not use any extinguishing media which could exacerbate the fire and put themselves in danger. This will be made clear in the site's firefighting strategy.

5.2 Fire Service Access

There is no specific guidance for access requirements for F&R Services to sites such as the Proposed Development. However, Approved Document B [7] – a guidance document under The Building Regulations 2010 – provides typical access requirements for UK F&R Services vehicles, as displayed in **Table 5**. Derbyshire F&R Service advised to follow this guidance to ensure there is adequate access on the site for emergency vehicles.

Table 5: Typical fire and rescue service vehicle access route specification

Appliance type	Minimum width of road between kerbs (m)	Minimum width of gateways (m)	Minimum turning circle between kerbs (m)	Minimum turning circle between walls (m)	Minimum clearance height (m)	Minimum carrying capacity (tonnes)
Pump	3.7	3.1	16.8	19.2	3.7	12.5
High reach	3.7	3.1	26.0	29.0	4.0	17.0

The minimum road width at the BESS compound and other access roads on site is approx. 4 m, which is compliant

Access tracks at the BESS compound are currently designed to allow large cranes in for installation, so will have sufficient carrying capacity for F&R Service vehicles.

Other side access roads are designed for both HGVs and cranes, so the carrying capacity of all roads leading to the BESS compound will be capable of supporting F&R Service vehicles.

Turning circles are only required on dead-end access routes longer than 20 m, so these requirements are not applicable to the BESS compound.

Derbyshire F&R Services will be consulted on the final detailed design of BESS compound to ensure location of water supplies and access/parking requirements are sufficient.

5.3 Firewater Provisions

Provision has been made for 3 firewater storage tanks situated directly adjacent to the BESS compound (whilst allowing space for safe access in the event of a fire), each with a capacity of 100 m^3, providing a total of 300 m^3 firefighting water. The National Fire Chiefs Council [8] recommends that firewater provisions shall allow the flow of 1.9 m^3/min for at least 2 hours. The firewater tanks provided would therefore allow for approx. 2.63 hours of firefighting time, which aligns with this recommendation. However, it is noted that F&R services may wish to increase this requirement dependent on location and their ability to bring supplementary supplies to site in a timely fashion.

Firewater capacity will be reviewed with the Derbyshire F&R Service and advice will be sought from the manufacturer of the BESS on the recommended volume of water required for a facility of this magnitude. Further firewater (e.g. via a hydrant or mains water supply) may be provided as required. It may also be concluded from consultation with the Derbyshire F&R Service and fire safety expert(s) that increased spacing between battery containers is sufficient in preventing the spread of fire between adjacent battery containers and as such, significant firewater storage may not be deemed necessary.

5.4 Firefighting Equipment

There will be weather stations installed at site to provide the F&R Service with an indication of the weather at site (i.e. wind speed and direction). This will allow them to approach an incident from a direction that will reduce the likelihood of being impacted by a toxic plume. If requested by Derbyshire F&R or other relevant authority, a plume assessment may be undertaken using a wind rose for the site (i.e. taking into account the prevailing wind direction) to inform the F&R Service of the likely direction of approach. This plume assessment would consider migration of gases in the event of a battery fire and migration of gases from the battery container exhaust following detection of a flammable/toxic gas.

Provision of additional firefighting equipment will be based on the recommendations of the Derbyshire F&R Service. This could include, but not be limited to, fire extinguishers, fire hose reels and other spare firefighting parts.

5.5 Emergency Planning

A detailed Emergency Response Plan (ERP) will be developed for the BESS. Derbyshire F&R will be consulted in preparation of this document to ensure it is robust and that they would be comfortable in following the plan as emergency responders.

The ERP will include, as a minimum:

- Indication of primary and secondary escape routes;
- The key points (e.g. muster points, emergency shutdown locations) that should be known by all personnel;
- Procedure for the isolation of BESS equipment (note this must be undertaken by suitably qualified personnel);
- Specification of the batteries, so that first responders and emergency services are aware of the risks (e.g. potential presence of toxic/flammable gases) and the correct firefighting medium to use;
- Location of firefighting equipment; and
- Firefighting strategy.

5.6 Firefighting Strategy

The strategy for the local F&R Service to fight a BESS fire is to leave the BESS container(s) already on fire to undergo a "controlled burn" whilst focusing on cooling surrounding equipment (adjacent battery containers, transformers, PCS units) by dowsing them in water to prevent further spread of the fire. Separation of the equipment, as described in **Section 4.2.2**, should prevent the fire from spreading between units, but cooling of adjacent equipment will act as a further preventative measure.

In using firewater, there is an additional risk of causing environmental harm from discharge of contaminated water. To prevent this, there be a drainage system installed around the BESS compound and substation area that will either drain to an underground tank or Sustainable Drainage System (SuDS) pond with shut-off and separating capabilities for containment and testing of water prior to discharge or removal [9].

6 PRE-CONSTRUCTION INFORMATION REQUIREMENTS

A detailed BSMP (that will follow the format of this document) shall be issued to the Local Planning Authority in advance of the construction of the Proposed Development. The following details, which will be determined as a detailed design of the project is defined, shall be included in the detailed BSMP:

- **Battery Specification**. The specific battery container units that will be installed at the Proposed Development – this will detail (at a minimum):
  - Model/manufacturer;
  - Battery chemistry type;
  - Cell size and format;
  - Battery container dimensions;
  - Access/egress points;
  - Battery container fire rating;
  - Fire detection systems; and
  - Fire suppression systems.
- **Applicable Legislation**. The legislation that must be met by the design of BESS compound and a statement/demonstration of how this has been achieved.
- **Detailed BESS Compound Design**. A detailed layout of the BESS compound, indicating how the following factors have been accounted for:
  - Adequate separation between the battery containers and other exposures (inclusive of other equipment items, access/egress routes and combustible vegetation);
  - Design of roads to allow safe construction and maintenance of the BESS, and to provide safe access to emergency response vehicles;
  - Location of firefighting equipment is suitable for fighting a BESS fire;
  - Security arrangements to prevent access to unauthorised personnel.
- **Detailed Description of Firefighting Provisions**. An overview of the location and specification of firefighting provisions at the BESS compound.
- **Firefighting strategy agreed between OFSL and Derbyshire F&R**. A demonstration that the Derbyshire F&R Service are satisfied that the firefighting provisions at the BESS compound and details of the firefighting strategy that has been agreed between the two parties.
- **Maintenance Philosophy and Safe Systems of Work**. Outlining the intended maintenance/inspection/testing schedule to ensure the ongoing safe operation of the BESS and to detect early life failures. An overview of how maintenance personnel will be protected from harm will be provided, including specific competencies of personnel required to perform maintenance tasks and additional mitigations (isolation/interlock, PPE requirements, etc.).
- **Emergency Response Plans**. How incidents involving the BESS will be dealt with, including escape of personnel to a safe place, contacting of emergency response personnel and first responders, and follow-up investigation of incidents. ERPs shall be provided for all operational phases (construction, operation and decommissioning) and will be agreed with Derbyshire F&R.

- **Battery Transportation Plan**. A demonstration of how batteries will be transported to and from the site safely in accordance with the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) 2019 and the UK "moving dangerous goods" guidance web page.
- **Environmental Risk Assessments**. Details of any risk assessments required to assess the risk to environmental receptors (e.g. plume assessment) to confirm that these effects have been mitigated through design. Environmental Risk Assessments will be performed as required and will proportionate to the risks posed by the BESS.
- **Safety Risk Assessments**. Details of any risk assessments performed to assess the risk to people (e.g. fire/explosion modelling) to confirm that these effects have been mitigated through design. Safety Risk Assessments will be performed as required and will proportionate to the risks posed by the BESS.

The inclusion of the above information in the detailed BSMP shall demonstrate that all measures necessary have been taken to understand the risks introduced by the BESS and that these have been reduced ALARP through the design and provision of further risk reduction measures.

7 CONCLUSIONS

This OBSMP demonstrates the commitment of OFSL in developing a BESS that can be constructed, operated and decommissioning as safely as possible. This has been done through a thorough identification of the hazards posed by the BESS, consideration of these hazards in the development of the design and referring to applicable legislation, codes, standards and guidance. The focus of OFSL is to firstly prevent an incident involving the BESS from arising and then to provide means of mitigating the consequences of such an incident to protect people and the environment from harm.

This OBSMP outlines the preliminary BESS design and demonstrates how the Primary Safety Issues – those which are fundamental to demonstrating that the proposed facility will be safe in its planned location – have been addressed in the development of the design. It is necessary to address such issues prior to submission of the project's DCO application because once a DCO application has been accepted, there is limited scope for modifying the design in a way that materially alters safety or environmental risks. As such, the OBSMP provides a roadmap that will be followed through the detailed design of the BESS compound to address the residual risk through managing the Secondary Safety Issues and enable a final consenting decision.

Through the detailed design of the BESS, OFSL shall engage with relevant stakeholders – including Derbyshire F&R – to ensure there is a mutual agreement that the BESS has been designed with risks adequately addressed.

Section 6 and **Section 2.3.3** provide a clear path for what must be done to further define the BESS design and understand the associated risks such that a detailed BSMP can be prepared that demonstrates how the BESS will be constructed, operated and decommissioned safely.

8 REFERENCES

[1] The Management of Health and Safety at Work Regulations 1999, Schedule 1 – General Principles of Prevention

[2] 0003-01 Oaklands Farm Solar Project, HAZID Studies, Cairn Risk Consulting, 19 July 2022

[3] Oaklands Farm Solar Park Environmental Statement (November 2023)

[4] Oaklands Farm Solar Park Environmental Statement, Chapter 4 – Project Description (November 2023)

[5] National Fire Protection Agency (NFPA) 855 (United States of America), Standard for the Installation of Stationary Energy Storage Systems, 2023 Edition

[6] The Fire Service Manual Volume 2 Fire Service Operations – Electricity

[7] The Building Regulations 2010, Fire safety, Approved Document B (2019 edition incorporating 2020 and 2022 amendments – for use in England)

[8] National Fire Chiefs Council, Grid Scale Battery Energy Storage System planning – Guidance for FRS

[9] Oaklands Farm Solar Park Environmental Statement, Chapter 8 – Water Resources and Flood Risk

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