Technical Appendix 2.2: Outline Battery Safety Management Plan

Kirknewton Solar & BESS EIA Report

Trio Power Ltd

Prepared by:

SLR Consulting Limited

The Tun, 4 Jackson's Entry, Edinburgh, EH8 8PJ

SLR Project No.: 405.065786.00001

9 December 2025

Revision: 02

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
01	3 October 2025	I Romero	D Fernandez	G Spowage
02	9 December 2025	I Romero	D Fernandez	S Cockell

Table of Contents

List of Tables

List of Graphics

1.0 Introduction

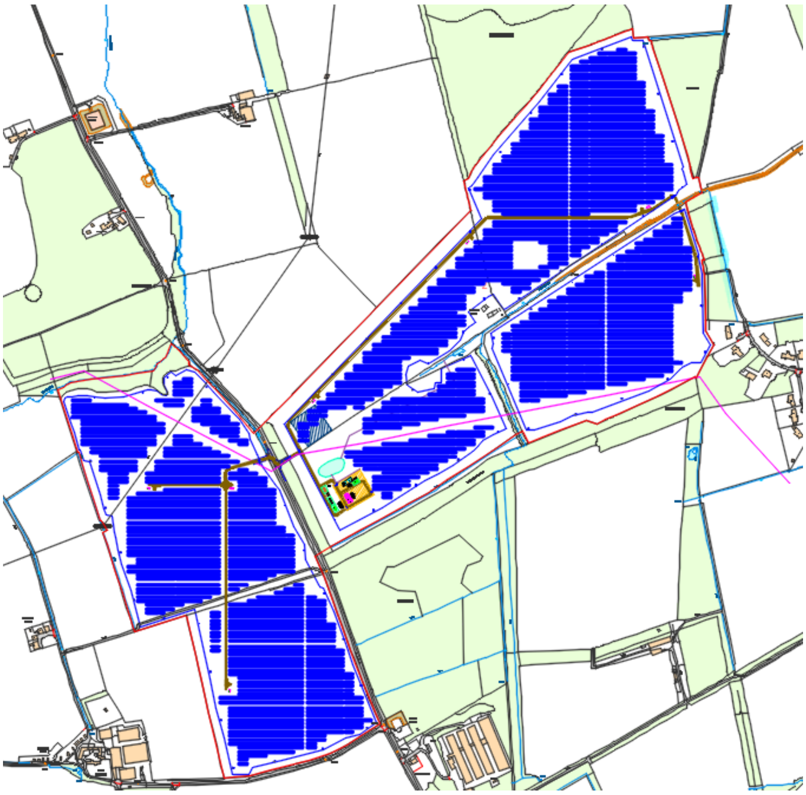
1.1 Scope

The purpose of this Outline Battery Storage Safety Management Plan (OBSMP) is to describe the guidelines and best practice for safe operation of the BESS component of the Proposed Solar and BESS Development at Kirknewton, and to identify, assess, and mitigate fire safety risks associated with the installation and operation of the BESS.

A detailed Battery Safety Management Plan (BSMP) will be required post-consent, prior to the commencement of the BESS project construction, once detailed design has been completed. The BSMP should incorporate the latest good practices in battery fire detection and prevention and include a comprehensive emergency response plan. The Applicant has secured a grid offer with a connection date of 2030 and, therefore, construction is likely to commence in 2029. Once the final technology, supplier and layout have been confirmed, the BSMP will be developed in line with the most up-to-date standards, guidelines, and good practices described initially in this OBSMP. Early engagement with West Lothian Council and other relevant regulatory bodies will be essential to ensure compliance and approval.

1.2 Site Description

The proposed BESS will be located on land approximately 1.5 km south of Kirknewton, near Leyden Rd, West Lothian EH27 8DQ (see **Graphic 1-1).** The Site is situated within predominantly agricultural land and is surrounded by open countryside. The closest built features are farm buildings and associated infrastructure, along with Newlands, a small estate of residential properties, the nearest of which is located more than 500 m from the BESS area.



Graphic 1-1: Proposed Development Site

1.3 Proposed BESS Development

The BESS will be deployed alongside solar PV as part of a co-developed asset which includes the following infrastructure:

- Battery containers;
- On-site substation;
- Battery Inverter cabins to convert direct current (DC) electricity into usable alternating current (AC) power;
- Transformers;
- Underground cabling;
- Internal access tracks;
- Temporary construction compound;
- Underground cabling;
- Spares container;
- CCTV cameras mounted on posts;
- Perimeter fencing;
- Site drainage; and
- Biodiversity and landscaping enhancements.

The proposed BESS layout, including the battery containers, Power Conversion Systems (PCS), access road, and switchgear is illustrated in **Graphic 1-2**. The proposed scheme comprises a BESS with an export capacity of 9 MW. Further details on the design are provided in **Section 6.0**.

The design is currently at an early stage and is likely to evolve prior to construction. At this stage, the battery cells are expected to be prismatic lithium iron phosphate (LFP) cells, a lithium-ion battery technology recognised for its stability, safety, and long cycle life. Additional information on the BESS technology and associated infrastructure is provided in **Section 2.1.**

1.4 National Policy Alignment

National Planning Framework 4 (NPF4) sets out the Scottish Government's national planning policies. It states that local planning authorities:

"*…should seek to realise their area's full potential for electricity and heat from renewable, low carbon and zero emission sources by identifying a range of opportunities for energy development."*

Policy 11 stresses the government's commitment to encouraging, promoting and facilitating all forms of renewable energy development, and expanding renewable, low-carbon and zero emissions technologies. It states that "*Development Proposals for all forms of renewable, low-carbon and zero emission technologies will be supported. These include … Energy storage, such as battery storage..."*[1]

[1] Scottish Government (2023) *National Planning Framework 4*

Graphic 1-2: BESS Layout

2.0 Project Requirements

For the development of a utility scale BESS project, it is essential to specify project requirements to ensure successful planning, design, construction, and operation. This section describes the fundamentals of BESS, the cell technology, main system components that will comprise the BESS system at Kirknewton (battery container, PCS, cooling system, fire suppression system and control) and listing of standards.

Prior to commencement of construction of the Kirknewton BESS, a BSMP (in accordance with this Outline BSMP) will be prepared and submitted to the West Lothian Council for approval, in consultation with the Health and Safety Executive (HSE) and the Scottish Fire and Rescue Service.

2.1 BESS Technology

2.1.1 Fundamentals

Lithium-ion (Li-ion) batteries have become a dominant rechargeable energy storage technology due to their high energy density, long lifespan, and lightweight nature. They are widely used in consumer electronics and electric vehicles as well as larger scale stationary energy storage applications.

Li-ion batteries function by moving lithium ions through an electrolyte between an anode and cathode during charging and discharging. The anode is typically made from graphite, and the cathode is composed of a lithium-based material. During discharge, lithium ions move from the anode to the cathode, releasing energy. The key components of Li-ion cells are:

- Anode: Typically graphite or silicon;
- Cathode: Composed of various materials, in this case lithium iron phosphate ($LiFePO_4$);
- Separator: Avoids direct contact between anode and cathode, allowing only ions to pass through; and

Electrolyte: A lithium salt dissolved in an organic solvent. LFP is less susceptible to thermal runaway than chemistries like Nickel Manganese Cobalt (NMC) and has better thermal and chemical stability and does not decompose at higher temperatures. LFP represented about 60% of the UK BESS market share in 2023[2].

2.1.2 System Components

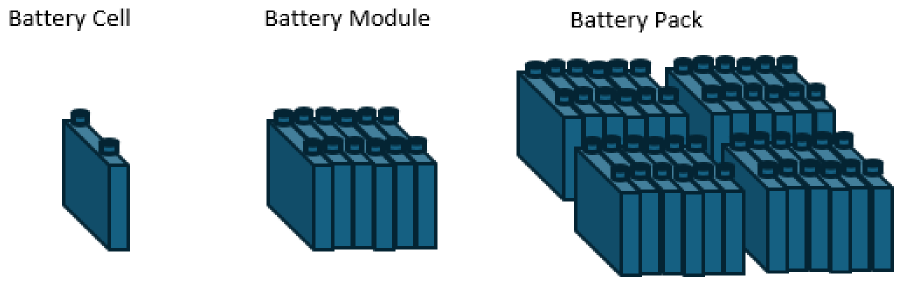
The main components typically found in a BESS are as follows:

- Batteries: The battery is composed of single cells, which can be arranged e.g. into battery modules or battery packs (**Graphic 2-1**).
- Power Conversion System (PCS): The PCS is a bi-directional inverter that converts direct current (DC) stored by the batteries to alternating current (AC) for the grid, or AC from the grid to DC for charging the batteries. It is a critical system component that controls battery charge and discharge based on internal communication protocols.
- Battery Management System (BMS): This component is responsible not only for the correct operation but also for the safe functioning of the battery. The BMS maintains each

[2] Market and Technology Assessment of Grid-Scale Energy Storage required to Deliver Net Zero and the Implications for Battery Research in the UK, Rho Motion, 2023

battery cell within the required operational voltage, current and temperature range. The BMS also estimates the State of Charge (SoC) and State of Health (SoH) of the battery.

- Energy Management System (EMS): The EMS is responsible for the control of the BESS and plays a crucial role in managing the charging and discharging process with the purposes of optimising system performance and BESS longevity, amongst others.
- Safety Systems: These include systems such as cooling and heating, air conditioning, fire suppression, smoke detection, etc. A monitoring and control system will be responsible for the safe operation of the BESS and prevent fire or other hazardous events. The BESS will also normally include a CCTV system. This has been included for the Kirknewton BESS.



Graphic 2-1: Battery Cells, Modules and Packs

2.1.3 Safety Systems

This section provides a description of the safety systems that will be integrated in the Proposed Kirknewton BESS Development. The BESS will require a comprehensive safety system that contributes to safe operational conditions and minimises potential risks such as thermal runaway[3], fires or system failures.

2.1.3.1 Battery Management System (BMS)

The BMS is the primary safety and control mechanism in a BESS. The BMS is required to monitor and manage the battery cells to ensure optimal operation and safety. By controlling the battery's key parameters in real-time, the BMS protects the system from dangerous conditions such as overvoltage, undervoltage, and overheating. The parameters controlled by the BMS include the following:

- Temperature monitoring: The continuous measurement of cell temperatures to prevent potential overheating issues that could lead to thermal runaway.
- Voltage and current monitoring: This ensures each battery cell operates within a safe voltage range but also monitors current to avoid potential overcharging or discharging.

[3] Thermal runaway definition: A condition where the heat generated inside a battery exceeds the ability of the BESS cooling system to dissipate that heat.

- State of Charge and State of Health monitoring: The monitoring and control of the SoC and SoH to ensure long battery life and prevent potential deep discharges or overcharging.
- Cell Balancing: The aim is to ensure uniform performance across all cells, thus minimising risks of premature degradation of weak cells or other system imbalances that may occur.

2.1.3.2 Thermal Management System (TMS)

The TMS is responsible for controlling the temperature of the battery at pack level. This system is required to prevent overheating issues and ensure the battery pack operates in a safe temperature range to minimise thermal runaway risks. The Proposed Kirknewton BESS Development's TMS shall include:

- Active cooling: This involves air or liquid cooling systems to dissipate heat during charging and discharging cycles. Liquid cooling for BESS is becoming the established technique due to advantages in cooling efficiency, enhanced thermal management, improved safety, etc.
- Passive cooling: Includes heat sinks, ventilated enclosures, and other passive mechanisms to distribute heat naturally.
- Temperature sensors: Located throughout the BESS to detect local temperature spikes.
- Thermal insulation: This reduces the effect of high external temperatures on the BESS.

2.1.3.3 Fire Suppression System (FSS)

An FSS would detect, control, and extinguish fires before they propagate, especially under a potential thermal runaway scenario. A rapid response from the suppression system helps prevent fire spreading to other cells or modules. The FSS shall provide the Kirknewton BESS with:

- Smoke and Fire Detection: This will allow the early detection of smoke, temperature spikes, and gas emissions to trigger alarms or suppression mechanisms.
- Fire Suppression: This involves an automatic fire suppression system employing chemical extinguishing agents (e.g. Novec 1230) and/or water mist systems designed to suppress Li-ion battery fires. The system shall be designed to act quickly and be compatible with the operation of electronic equipment within the BESS container.
- Gas Ventilation: The BESS may be equipped with a gas exhaust system to remove hazardous gases that may have been generated in a thermal runaway event which generally include hydrogen. This will reduce the risk of potential explosions.

2.1.3.4 Gas Detection and Ventilation System

The Kirknewton BESS will have a gas detection and ventilation system to detect hazardous gases that could be emitted during a thermal runaway event or other potential system failures. The system will safely extract the generated gases from the BESS enclosure to outside air. This will avoid the buildup of potentially flammable or toxic gases in the BESS container, reducing the risk of explosion or harm to personnel. The system features shall be as follows:

- Gas Detection System: These are installed to detect various gases including hydrogen, carbon monoxide, or toxic electrolytes released when battery cells fail.

- Ventilation System: The system is automatically activated and ventilates dangerous gases to ensure that a hazardous environment does not develop within the container.
- Pressure Relief System: If excessive pressures are reached within the battery enclosure, the pressure relief system is activated to reduce the risk of a potential explosion.

2.1.3.5 Battery Enclosure

The BESS enclosure is designed to protect the battery system against mechanical damage, from external environmental hazards and unauthorised access. The enclosure features shall include:

- Weatherproof and Fireproof Enclosures: The protection of the BESS from external environmental factors such as wind, fire, rain and extreme temperatures.
- Explosion-Proof Enclosure: The enclosure must be able to contain potential explosions that occur within its enclosure in the unlikely event that vapours, gases, dust, or other flammable substances are ignited.
- Security System: This includes controls, alarm and surveillance to protect the system from tampering or unauthorised access.

2.1.3.6 Alarm and Emergency Shutdown System (AESS)

The AESS is required for automatic system shutdown under critical failure or hazard. The principle is to prevent further damage or potential hazard in the event of an emergency by stopping the system operations, thus mitigating the risk to personnel and equipment. The system shall be equipped with the following:

- Manual Emergency Shutdown System: Provides a manual shutdown mechanism for operators to safely power down the system in an emergency.
- Shutdown System: The system can automatically shut down if it detects critical issues identified by the real time monitoring, such as overheating, overvoltage, or fire.
- Alarms System: Immediate alerts are sent to operators and emergency responders when a failure or dangerous condition is detected.

3.0 Safety Standards for Li Ion Battery Technology

The Proposed Kirknewton BESS Development must comply with several standards and certifications for safe and resilient operation. The following guidance and standards have been considered within this OBSMP:

- National Fire Chiefs Council (NFCC), Grid Scale Battery Energy Storage System planning – Guidance for Fire and Rescue Services (FRS), Version 1.0, Published April 2023;
- NFCC, Draft Guidance on Grid Scale Battery Energy Storage Systems (BESS), 2024, final version to be published in 2025.
- Underwriter Laboratories (UL) 9540 Standard for Energy Storage Systems and Equipment, Published April 2023.
- NFPA 855 Standard for the Installation of Stationary Energy Storage Systems, Published May 2023.

Compliance with relevant safety standards at component level is essential for minimising and mitigating risks such as electrical faults, thermal runaway, fire and explosion. A summary list of safety standards for the main components of the BESS has been compiled. This includes key regulatory and industry standards relevant to the design of the BESS in order to make sure compliance with both national and international safety requirements.

Please note that the standards described in this section and elsewhere in this document may be superseded by future standards and versions.

3.1 Battery Cells and Modules

The battery modules shall demonstrate compliance with following standards:

- UL 9540A: This involves tests for thermal runaway propagation to ensure that the fire risk within a module or between battery cells is minimised and contained. This standard demonstrates that thermal runaway propagation does not spread between modules generating potentially explosive gases, such as hydrogen for Li-ion cells. This would otherwise result in a potential hazard for the battery container's integrity.
- UL 1973: This covers safety for stationary battery systems, testing for mechanical integrity, electrical faults (overvoltage, overcurrent), and thermal fatigue in Li-ion cells.
- International Electrotechnical Commission (IEC) 62619: International standard for rechargeable battery safety in industrial applications, focusing on preventing thermal runaway, overcharging, and electrical safety.
- United Nations (UN) 38.3: Transportation safety standard, ensuring that Li-ion batteries can safely withstand mechanical shocks, pressure, and temperature extremes during transit.

3.2 Battery Management System

The Battery Management System (BMS) shall demonstrate compliance with following standards:

- UL 991: Safety standard for BMS electronics, ensuring reliable fault detection and protection features such as voltage, current, and temperature monitoring.
- UL 1998: Software reliability standard, ensuring that BMS software handles charging and discharging functions and operates safely under all conditions.

- IEC 61508: Functional safety of electrical, electronic, and programmable systems, ensuring that the BMS follows safety protocols for fault tolerance and system shutdown in critical situations.
- IEC 62040: Addresses safety and performance of power systems, ensuring BMS integration with power conversion equipment.

3.3 PCS/Battery Inverters

The PCS is a fundamental component managing the energy flow between the battery, the electrical grid, and the connected loads. The PCS enables efficient charging and discharging of the batteries, converting power between alternating current (AC) and direct current (DC), and ensuring seamless interaction between the storage system and the grid or end users. The PCS at Kirknewton BESS shall demonstrate compliance with key standards including:

- UL 1741: Governs the safety of inverters for distributed energy resources, including BESS. It focuses on preventing electrical faults, such as overvoltage and ground faults.
- IEC 62109: Ensures the safety of inverters by addressing electrical shock prevention, thermal management, and insulation resistance.
- Institute of Electrical and Electronics Engineers (IEEE) 1547: Specifies the requirements for connecting the BESS to the utility grid, ensuring the inverter safely synchronizes with and disconnects from the grid during faults or outages.
- IEC 62116: This standard refers to anti-islanding protection methods to ensure PCS disconnect from the grid in case of a power outage, preventing unintentional islanding.
- IEC 61000: This standard refers to electromagnetic compatibility (EMC), covering emission and immunity requirements.
- International Organization for Standardisation (ISO)/IEC 27001: This standard is not specific to PCS but outlines best practices for information security management systems (ISMS). With increasing digital control and remote operation of BESS systems, PCS components need to be secured against cyber threats. Compliance with cybersecurity protocols ensures data integrity and protects the system from unauthorised access.
- IEC 61850: This standard defines communication protocols for substation automation systems and is widely adopted for smart grid applications. It ensures secure and standardised communication between the PCS and other grid components.

3.4 Energy Management System (EMS)

The Kirknewton BESS EMS shall demonstrate compliance with following standards:

- IEC 62443: Ensures cybersecurity for industrial automation systems, including EMS, to prevent cyberattacks that could disrupt BESS operations.
- ISO 27001: Focuses on information security management, ensuring that the EMS can protect critical operational data.
- IEC 61508: Functional safety for EMS systems to ensure that safety-critical processes within the BESS, such as dispatching power and controlling inverters, are reliable.

3.5 Fire Detection and Suppression Systems

The fire detection systems at Kirknewton BESS shall demonstrate compliance with following standards:

- National Fire Protection Association (NFPA) 855: Provides fire safety requirements for the installation of energy storage systems, including Li-ion BESS, such as fire separation distances, suppression system requirements, and emergency planning.
- UL 9540: Focuses on system-level safety for energy storage systems, including fire protection measures for electrical components and enclosures.
- UL 9540A: Tests the system's ability to handle thermal runaway and limit fire propagation within and between battery modules.
- FM Global Datasheet 5-33: Offers guidelines for fire protection and hazard mitigation specific to Li- ion battery systems, including guidance on suppression systems for large battery arrays.
- Grid Scale Battery Energy Storage System planning - Guidance for FRS (2023) (NFCC, 2023) states that gaseous suppression systems have been proposed in the past. However, it indicates that based on research studies the installation of water-based suppression systems for fires involving cell modules are more effective.
- FM Global Research: States that cooling of the surroundings under a fire event is critical to protect the surrounding infrastructure but as well because it is currently not possible to extinguish a BESS fire with sprinklers. Furthermore, gaseous protection systems do not provide cooling of the ESS or the surrounding occupancy.

For the selection of the fire suppression system, in addition to the standards and compliance requirements, it is essential to base the choice on thorough risk assessments, environmental considerations, and the specific operational needs of the facility. The following aspects have been considered:

- Involvement of a Fire Protection Engineer (FPE) who has experience in fire suppression systems, particularly for large scale BESS as is the case at the Proposed Development.
- Calculation of the water supply requirements to ensure the flow rates and volumes needed for the type of suppression system selected and the potential for fire spread and the required coverage area. For Kirknewton BESS this would be a minimum of 1,900 litres per minute and for at least 120 minutes of sustained supply. The tanks in Kirknewton BESS development can hold a volume of 230,000 litres. More details regarding the guidance can be found in **Section 6.2**.
- The water run-off management from the suppression system and its impact on the surrounding environment such as water sources, soil and nearby ecosystems. Measures to minimise potential environmental impacts, e.g. a containment basin and a firewater outflow cut-off valve, will be detailed in an Emergency Response Plan for the development. Kirknewton BESS has a Sustainable Drainage System (SuDS) designed to safely capture any firewater run-off from the BESS compound. More details in **Section 6.2**.

3.5.1 Note on BESS without Fire Suppression System

Contemporary thinking on fire suppression strategies focuses on controlling and containing fire risks without necessarily relying on automatic fire suppression systems inside the BESS cabinets. The principle is to allow a controlled burn-out of the battery cells or modules. This minimises the risk related to live battery modules that could still hold energy after a fire event, known as “stranded energy”. This facilitates the handling and disposal of the damaged battery cells or modules after the fire incident. For this design approach, the decommissioning process is simplified because there is no need to dispose of water or chemical suppression agents that might have been deployed during the fire suppression process.

Instead of an automatic suppression system, the BESS cabinets would operate what is effectively a dry pipe sprinkler system. This type of system does not fill pipes with water unless activated, which makes it less prone to accidental discharge and water damage. Firefighters or emergency responders can then manually activate the dry pipe sprinkler system if they assess that internal suppression is necessary during a thermal runaway or fire event. This strategy allows human intervention, ensuring that suppression systems will only be deployed if judged to be required.

3.6 Battery Enclosures

The enclosures shall demonstrate compliance with following standards:

- UL 9540: Governs the system-level safety of the entire energy storage system, ensuring enclosures protect components from environmental hazards and electrical faults.
- NFPA 68: This refers to the "Standard on Explosion Protection by Deflagration Venting," which focuses on designing systems to protect against explosions, specifically by allowing deflagration to vent safely without catastrophic damage to equipment or facilities.
- IEC 60529: Provides ingress protection (IP) ratings for electrical enclosures, determining resistance to water, dust, and accidental contact. For Proposed Development the BESS will be deployed outdoors and enclosures need to be highly protective.
- British Standards (BS) EN 13501-2: European standard for the fire resistance of building materials, ensuring BESS enclosures and partitions provide adequate containment during fire events.
- NFPA 855 requirement states that fire-rated barriers be established between the BESS units and adjacent areas:
  - 1-hour fire resistance rating for barriers within BESS installations or between individual BESS compartments; and
  - 2-hour fire resistance rating for walls separating BESS from other occupancies or critical infrastructure.

3.7 Cabling and Electrical Connections

The cabling and electrical connections shall demonstrate compliance with following standards:

- UL 6141: Safety standard for wiring and connections in energy storage and photovoltaic systems, ensuring proper insulation, grounding, and fault protection.
- NFPA 70 (NEC Article 690): The National Electrical Code (NEC) specifies installation standards for electrical systems, including battery connections and grounding, to prevent electrical fires and shock hazards.
- IEC 60502: International standard for medium-voltage power cables, addressing their performance and safety in energy systems.

3.8 Cooling and Ventilation Systems

The cooling and ventilation systems shall demonstrate compliance with following standards:

- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 90.1: Standards for the energy-efficient design of buildings, including proper cooling and ventilation for energy storage systems to manage heat generated by Li-ion batteries.
- NFPA 69: Provides guidelines for prevention of explosion, focusing on managing gas buildup (e.g., hydrogen release from faulty Li-ion batteries) through proper ventilation and explosion venting systems. This standard focuses on preventing the explosion through methods like suppression, containment, inerting, or control of ignition sources.
- UL 9540A: Includes testing for heat and gas management in energy storage systems to prevent explosions or fires caused by thermal runaway.

4.0 Operation and Maintenance Requirements

The Operation and Maintenance (O&M) for a BESS is crucial for both plant performance and safety. Methods and procedures impacting project safety must comply with up-to-date standards and regulations. Furthermore, O&M must contribute to optimal system performance and lifecycle; and maximise system availability through the minimisation of potential plant downtime.

4.1 Operational Requirements

The system operation shall be monitored to ensure optimal performance and identify any potential issues at an early stage. For the Kirknewton BESS, the system shall monitor at least the following:

- Battery Management System (BMS) Operational Monitoring:
  - Ensure that battery cells and modules track the State of Charge (SoC), State of Health (SoH) and operating battery cell temperatures.
  - Ensure the system operates within safe voltage and current limits.
- Energy Management System (EMS) Operational Monitoring:
  - Monitoring the charge-discharge cycling to optimise system efficiency and revenue (e.g. energy arbitrage, frequency regulation, peak shaving).
  - Monitoring and control of the interaction between the BESS and the grid to ensure that the BESS provides the contracted grid services without compromising battery health.
- Remote Monitoring and Alerts: Provision of remote monitoring capabilities so that operators receive real-time alerts and can monitor plant status. This shall include an automatic monitoring system of key safety parameters such as cell / module overheating warnings, deep charge/discharges of the battery or system failures (e.g. the cooling system).

4.2 Maintenance Requirements

4.2.1 Preventive Maintenance

The Proposed Kirknewton BESS Development will have regular, scheduled maintenance to minimise the potential risk of plant failures, extension of system lifetime and contribute to system performance. This will result in a reduction of unplanned downtime, reactive repair needs, less frequent component replacements, and improve plant reliability and system efficiency. The preventative maintenance regime shall regularly require at least the following:

- Battery System:
  - Visual examination: Periodical visual checks to identify potential damage, leakages or corrosion.
  - Thermal Inspection: Use of infrared thermography to identify potential hotspots, e.g. poor electrical connections.
  - Capacity Testing: This involves regular discharge tests to check the battery capacity and actual performance, ensuring the system still meets the expected

energy output. The BS EN 62620 standard specifies the requirements for large scale Li-ion BESS in terms of capacity testing, safety, and battery performance. As an example, if a BESS system participates in the UK's Capacity Market, it is a typical requirement to provide yearly capacity tests and performance tests to demonstrate that the system can deliver the capacity for which it has been contracted.

  - Regular cleaning: This is to ensure that battery terminals and general connections are clean to avoid poor connections.

- PCS
  - Battery inverter testing: The regular testing and recalibration of the inverters to guarantee the system efficiency and operational safety.
  - Firmware Updates: Regular software updates to ensure new releases or bug fixes are applied.
  - Visual examination: Undertake inspections to identify potential damage to connectors, cables, connectors, etc.
- Cooling and Heating, Ventilation and Air Condition (HVAC) System Maintenance
  - Air filters maintenance: Ensure filters are regularly cleaned or replaced to guarantee optimal cooling performance.
  - Fans and Ventilation System Inspection: Inspect ventilation fans and airflow paths for blockages and ensure proper air circulation.
  - Coolant Levels: For liquid cooling systems, verify coolant levels and test for potential system leaks.
- Fire Suppression System Maintenance
  - Functional System Testing: This involves periodical fire tests to verify that the system performs as expected.
  - Smoke and Gas Detectors Testing: This involves periodical tests to verify early detection of any hazardous situations.
  - Alarm system testing: This involves periodical tests to confirm the alarm notification is triggered under a potential fire event.

4.2.2 Corrective Maintenance

This refers to the activities that are undertaken to rectify or address system failures or faults that have been identified. This may include:

- Battery Replacement or Reparation
  - Cell Replacement: Over time, batteries can degrade for several reasons such as usage, defects, environmental factors, etc. and therefore require repair or replacement.
  - Battery Rebalancing: This process ensures that individual cells within a battery pack have an equal voltage level, otherwise the discharging process is not uniform resulting in higher degradation of some cells compared to other and imbalances,

thus reducing overall BESS capacity.

- Cooling System Repair
  - HVAC Unit Reparation: The repair or replacement of a failing HVAC to ensure that the BESS operates in the expected temperature range.
  - Leak Reparation: For liquid cooling systems, it is critical to resolve potential leaks that could result in overheating issues and electrical faults.
- PCS/Inverter Reparation
  - Electrical Faults: Correct any detected electrical faults, such as short circuits, ground faults, or voltage imbalances, in order to prevent damage to the BESS.
  - Fault Diagnosis: If the inverter is underperforming or failing then the inspection is required; causes may include firmware or hardware malfunctions. This may necessitate repairs or replacement of the faulty component.
- Compliance with Standards: The standards compliance contributes to the BESS safety, performance, and reliability:
  - Regulatory Inspections: This is to ensure that the BESS meets safety regulations, such as NFPA 855, UL 9540/9540A (for system safety testing), and IEC standards.
  - Environmental Compliance: This is to ensure the system meets environmental regulations regarding noise levels, system efficiency and materials disposal amongst others.
- Battery End-of-Life (EoL) Management: Determining the retirement of a BESS at EoL involves assessing several factors, including performance, safety, etc. Considerations include:
  - Monitoring of the BESS: As battery cells degrade over time this will track the capacity reductions and thus estimate when they should be potentially retired or replaced depending on the SoH.
  - Recycling Program: A proper recycling and disposal program should be developed in line with environmental regulations, this will contribute to the safe disposal of hazardous materials.
- Component Lifecycle Planning: Within a BESS each component has its own lifecycle, therefore it is fundamental to undertake careful component replacement planning. This will ensure that the full system operates optimally with minimal disruptions. The aim is to contribute to plant performance but also safety and plant reliability, e.g. inverter typically require replacement every 10-15 years, auxiliary systems like sensors, fuses, etc. may have different life expectancies.

5.0 Fire and Rescue Services Consultation

The Scottish Fire and Rescue Service (SFRS) has been consulted for the Proposed Development to ensure that their recommendations have been taken into consideration in the design layout of the Proposed Kirknewton BESS Development. Their official response has been included, and full correspondence can be found in **Annex 1**.

In their response, the SFRS confirmed that a dedicated working group is currently reviewing all BESS applications to provide unified guidance across departments. Until this process is completed, they recommend that the development follows the NFCC Best Practice Guidance on Battery Energy Storage Systems[4], which has already been considered in this document.

[4] Grid Scale Battery Energy Storage System planning - Guidance for FRS (2023)

6.0 BESS Design Layout

6.1 Description

The layout for the Proposed Kirknewton BESS Development is shown in **Graphic 6-1**. The Graphic shows a design composed of 48 x 0.3727MWh CATL 0.5P EnerOne+ Outdoor Liquid Cooling Rack containers, with a total capacity of approximately 17.88 MWh.

For every group of 24 battery racks (equivalent to approximately 8.95 MWh), a dedicated inverter with a rated power output of 4.39 MW is allocated. In total, the system is supported by four Power Electronics Twin Skid transformers, which facilitate connection to the 33 kV switchgear.

The current layout allows sufficient space for future augmentation. This provides the potential to offset battery degradation over time and to expand capacity, supporting ongoing eligibility for future capacity market services.

Graphic 6-1: BESS Layout

6.2 Design Guidelines

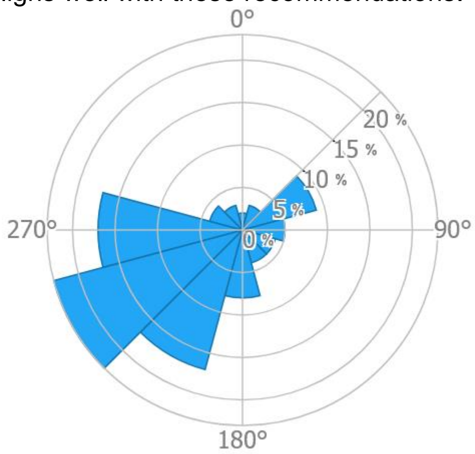
Table 6-1 lists the main BESS fire safety design guidelines, best practice and industry standards; and how the Proposed Kirknewton BESS Development adheres to these.

Table 6-1 Listing of design requirements

Design Requirement	Adherence of the proposed design layout
The proposed layout involves a side-by-side layout design. As per NFPA 855 (2023), if the space separation between enclosures is less than 6 metres then a thermal barrier rated at a minimum of 1 hour should be provided on the inside or outside of the enclosure. The NFPA (2023) also states that the clearance to other structures than buildings may be reduced to 0.9 metres. However, the fire and explosion testing in accordance with UL9540A would then need to demonstrate that a fire within the BESS enclosure will not generate radiant heat flux sufficient to ignite stored materials in the surroundings or otherwise threaten the exposure.	The Proposed Development design shows a 3 m separation between pairs of containers, therefore the 1-hour thermal resistance barrier requirement (e.g., from the enclosure) will need to be included and it will be adhered to within the Proposed Development.
The NFPA (2023) advises a minimum separation distance of 23 m between a BESS and occupied buildings to mitigate risks associated with a potential explosion event, with a recommendation to increase the clearance to 30.5 meters for added safety. The 30.5m clearance is a conservative safety measure designed to provide an extra margin of protection. It accounts for differences in battery chemistries, site-specific conditions such as ventilation and containment but as well considers the potential for cascading effects or larger than expected blast effects for high storage capacity systems. The NFCC (2023) recommends an initial minimum separation distance of 25m prior to any mitigation measure such as blast walls.	For the current BESS layout, the distance from the battery containers to the nearest occupied building is more than 500 m, therefore much greater than 30.5m.
The layout design shall consider the NFCC (2023) which states that areas within 10 metres of the BESS units should be cleared of vegetation to minimise the risk of fire spreading.	For the proposed planting as part of the Proposed Development's Landscape Mitigation Plan, the BESS design layout has maintained a minimum distance of 10 m separation of battery units from vegetation.
The provision of two separate access points to the site is recommended, with the intention that at least one is upwind of the prevailing wind direction as per NFCC (2023). The 2024 FRS Draft Guidance that still needs to be	The proposed development design features two access points to the BESS area. This is in line with NFCC (2023). In this case, the positioning of the access points has been driven by various considerations such as ease of entry, land

<table>
<tr><th>Design Requirement</th><th>Adherence of the proposed design layout</th></tr>
<tr><td>released as a final version also indicates it is preferable to have an alternative access point taking account of the likely wind direction.</td><td>availability, and wider site constraints and main wind direction.

The Global Wind Atlas[5] shows that the prevailing wind directions are from the west-southwest (approximately 240°–270°) and southwest (210°–240°), as shown by the longest segments on the wind rose. The current design, which includes an access point on the southwest corner, aligns well with these recommendations.




</td></tr>
<tr><td>The NFCC (2023) recommends that hydrant supplies for boundary cooling purposes should be located close to BESS containers and be able to deliver no less than 1,900 litres per minute for at least two hours.</td><td>The BESS compound would incorporate two water tanks, which represents good practice. In case of fire, reference should be made to the Grid Scale Battery Energy Storage System Planning Guidance. The 2023 guidance recommends a minimum supply of 1,900 litres per minute for at least two hours (i.e. 228,000 litres), while the 2024 guidance, which is still under review, reduces this to at least 1,500 litres per minute.

The layout indicates that each tank can hold a volume of 115,000 litres, having a total of 230,000 litres. This complies with both versions of the guidance.</td></tr>
</table>

[5] https://globalwindatlas.info/en/

Design Requirement	Adherence of the proposed design layout
	The relatively small size of the BESS compound means that fire appliances would be able to connect directly to the water tanks rather than requiring hydrants elsewhere in the compound.
Connectivity to water supply as indicated in the NFCC (2023).	There is a water source approximately 300 m northeast of the BESS. This is recommended to have in addition to the water tanks.
Water run-off, NFCC (2023)	The layout includes a Sustainable Drainage System (SuDS) connected to the water source.
Space for a Welfare Unit would be recommended to be provided on site, if required for operational purposes	The layout includes a designated on-site welfare unit.
A spares container is not strictly required for a BESS site but recommended for larger sites. This is not stipulated in NFPA 855 but the document does state the requirement to maintain high standards of safety, performance, and reliability. Critical components for fire safety, thermal management, electrical integrity, and operational efficiency should be determined and be available on site to rapidly address potential system failures.	The inclusion of one 20ft spares container within the BESS compound.
The allowance of a space for service vehicle parking is recommended.	Service vehicles designated for planned or reactive maintenance may be parked on the internal access road or at the BESS compound entrance.
CCTV covering the BESS compound is strongly recommended to enhance site security.	CCTV camera locations are indicated on the Proposed Development layout. These will provide security and remote monitoring for the BESS compound.

Annex 1 Email Correspondance

To SFRS.WaterPlanning@firescotland.gov.uk
Cc

Thu 18/09/2025 10:53

Hi,

I am writing regarding a proposed Battery Energy Storage System (BESS) development located approximately 2.5 km south of East Calder and Kirknewton, at Leyden Road, West Lothian EH27 8DQ. The BESS is designed with a planned capacity of 17.56 MW.

SLR Consulting is preparing the Outline Battery Safety Management Plan (OBSMP) for the scheme. We would like to engage with the Scottish Fire and Rescue Service (SFRS) at this early stage to ensure that any requirements or recommendations specific to the site are appropriately captured within the plan.

Please note that the OBSMP is being prepared in line with the Fire and Rescue Service (FRS) guidance published in 2023, as well as the draft 2024 update. However, we recognise that local knowledge and site-specific considerations may introduce additional requirements, and we would greatly value your input.

We would be happy to arrange a call to discuss this further if necessary.

For reference, please find the site location below:

Kind regards,

FW: Kirknewton - BESS Development

SW SFRS Water Planning <SFRS.WaterPlanning@firescotland.gov.uk>
To

Reply | Reply All | Forward

Thu 18/09/2025 12:25

This sender SFRS.WaterPlanning@firescotland.gov.uk is from outside your organization.

Start your reply all with: Thank you for the update. | Thank you very much for your response. | Thank you very much for the update. | Feedback

Good Afternoon, please see the standard response from our Watch Commander regarding all BESS sites.

SFRS are assessing all BESS site applications at the moment and there has been a working group established to consolidate all our departments and provide unified responses to all applications. Until this group completes its work, NFCC Best Practice guidance on BESS should be followed.

Regards

Kind Regards

| Support Assistant - Hydrants & Water Planning Department | Operational Planning – Preparedness Function | Prevention Directorate | 4 Barr Street | Ardrossan | KA22 8HD |
|Email

Making Sustainability Happen