West Springfield Solar & BESS – Outline Battery Storage Safety Management Plan

Technical Report

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Making Sustainability Happen

Revision Record

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Basis of Report

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Acronyms and Abbreviations

Acronym	Explanation
BESS	Battery Energy Storage System
EPC	Engineering, Procurement, and Construction
HSE	Health, Safety, and Environment
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
SWMS	Safe Work Method Statement
SDS	Safety Data Sheet
JSA	Job Safety Analysis
EMS	Environmental Management System
ERP	Emergency Response Plan
MSDS	Material Safety Data Sheet
WHS	Workplace Health and Safety
LOTO	Lockout/Tagout
FAT	Factory Acceptance Testing
SAT	Site Acceptance Testing
NFPA	National Fire Protection Association
ANSI	American National Standards Institute
IEEE	Institute of Electrical and Electronics Engineers
NESC	National Electrical Safety Code
NEC	National Electrical Code
EPA	Environmental Protection Agency
DOT	Department of Transportation
NIOSH	National Institute for Occupational Safety and Health
AHJ	Authority Having Jurisdiction
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedure
RAMS	Risk Assessment and Method Statement
RCD	Residual Current Device
GFCI	Ground Fault Circuit Interrupter
HV	High Voltage
LV	Low Voltage
EHS	Environmental, Health, and Safety

1.0 Introduction

1.1 Scope

The purpose of this document, the West Springfield Outline Battery Storage Safety Management Plan (OBSMP), is to describe the guidelines and best practice for safe operation of a large-scale Battery Electric Storage System (BESS). The purpose of this document is to identify, assess, and mitigate fire safety risks associated with the installation and operation of the BESS.

It should be noted that when detailed design will be undertaken and prior to commencement of the BESS project construction, a Battery Storage Safety Management Plan (BSMP) will need to be developed with the latest good practices for battery fire detection and prevention including an emergency response plan. The planned operational date for the BESS is 2027. The BSMP would need to be developed in line with the most up to date standards, guidelines and good practices described in the OBSMP. Early engagement with the local planning authorities and relevant regulatory bodies will be crucial.

1.2 Site Description

The Proposed Development is located at the Rankeilour Estate, West Springfield, Fife. The Proposed Development will comprise of a ground-mounted solar photovoltaic (PV) array and associated infrastructure with an installed capacity of circa 65MW. The PV array will comprise of PV modules arranged in rows with a maximum height of 2.67m Above Ground Level (AGL).

The Proposed Development also includes a Battery Energy Storage System (BESS) with a capacity of 35MW and a storage capacity of 70MWh. The BESS will store excess energy generated by the solar PV array and release it during periods of high demand or low generation. The infrastructure associated with the Proposed Development will include:

- PV module mounting frames;
- Battery units housed in containers;
- Inverters;
- Transformers;
- High Voltage (HV) switchgear and control equipment;
- Cabling and interconnectors;
- Onsite substations and control building;
- Communications container; spares containers;
- Site access and tracks;
- Security fencing and CCTV; and
- Temporary construction compound

The design has been conservatively sized for a power capacity of 49.9MW, although the planned capacity has been reduced to 35MW with 2 hour storage capacity. There will be approximately 24 Battery Energy Storage System (BESS) containers in the Proposed Development measuring approximately 8.3m in length by 3.1m in width, with indicative height of 2.6m (including platform height). The six associated Power Conversion System (PCS) stations will be located adjacent to the BESS containers, to allow the batteries to switch between inverter and charger modes. They measure approximately 9.2m in length by

5.4m width with an indicative height of 2.3m. The BESS and PCS units will be in a compound within the north land parcel – in field 8 (see **Figure 1-1** West Springfield Site Layout).

Figure 1-1 West Springfield Site Layout

1.2.1 National Policy Alignment

NPF4 is the Scottish Government's long-term spatial planning framework, integrating national policy on land use and sustainable development. According to the NPF4, BESS projects play a crucial role in realising the UK's objective of transition towards a more sustainable energy system. Policy 9 supports the re-use of brownfield land and policy 11[1] explicitly support all forms of renewable energy generation and emphasise the importance of energy storage; specifically:

- Policy 9: supports the sustainable reuse of brownfield land including vacant, derelict land and empty buildings.
- Policy 11 (Energy): confirms that development proposals for all forms of renewable, low carbon and zero emissions technologies will be supported. The policy requires development proposals to maximise net economic impact, including local and community socio-economic benefits.

[1] h*ttps://www.gov.scot/publications/national-planning-framework-4/pages/3/*

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 will describe the fundamentals of BESS, the cell technology, main system components that typically compromise a BESS system (battery container, PCS, cooling system, fire suppression system and control), and listing of standards.

Prior to commencement of construction of the BESS, a BSMP (in accordance with this Outline BSMP) is required to be prepared and submitted to the relevant local planning authority and approved, in consultation with the HSE and Scottish Fire and Rescue.

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 a Li-ion cell 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 2022.

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.
- 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 as well for the safe functioning of the battery. The BMS maintains each 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 includes 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.

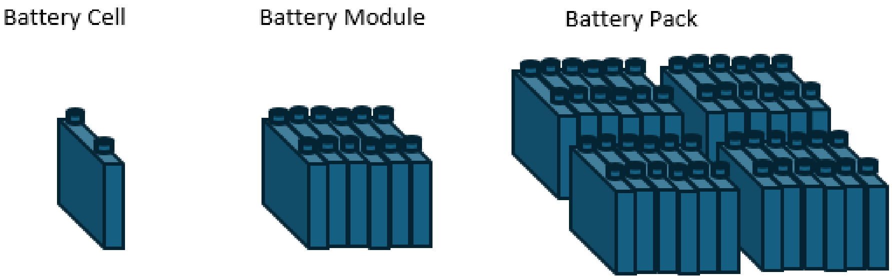

Figure 2-1 Battery

2.1.3 Safety Systems

This section provides a description of the safety systems required and integrated in a large-scale battery project. The BESS does require a comprehensive safety system that contributes to safe operational conditions and minimises potential risks such as thermal runaway[2], 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 derive 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.
- State of Charge (SOC) and Health (SOH) monitoring: The monitoring and control of the SOC and SOH to ensure long battery life and prevent potential deep discharges or overcharging.

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

- 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.
- 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 BESS 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 on the BESS of high external temperatures.

2.1.3.2 Fire Suppression System (FSS)

The FSS must be integrated into BESS enclosures and is designed to 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:

- 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) or/and 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.

2.1.3.3 Gas Detection and Ventilation System

The system is required 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.

2.1.3.4 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 event that vapours, gases, dust, or other flammable substances are ignited; and
- Security System: This includes controls, alarm and surveillance to protect the system from tampering or unauthorised access.

2.1.3.5 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 West Springfield BESS development must comply with several standards and certifications for safe and resilient operation. The current design standard for BESS facility is the latest edition of UL 9540, currently from 2023. It should be noted that currently the NFPA 855 (2023) represents a guideline for the design and installation of BESS. The Grid Scale Battery Energy Storage System planning - Guidance for FRS[3] (2023) was also considered.

Compliance with relevant safety standards at component level is essential for mitigating risks such as electrical faults, thermal runaway, fire and explosion. A summary list of safety standards for the main components of BESS has been produced.

Please note that the standards described in this section and 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:

[3] FRS stands for Fire Rescue Service

- 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.
- IEC 62619: International standard for rechargeable battery safety in industrial applications, focusing on preventing thermal runaway, overcharging, and electrical safety.
- 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 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 AC and DC, and ensuring seamless interaction between the storage system and the grid or end users. The PCS 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.
- 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.

- 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

The 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 shall demonstrate compliance with following standards:

- 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) 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 will need to be considered:

- Involvement of Fire Protection Engineer (FPE) who has experience in fire suppression systems, particularly for large scale BESS as is the case in Port Dundas.
- 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. It shall be noted that the lack of sufficient water supplies at a particular site location should not be considered as the basis for a suppression system choice. The consideration of alternative solutions would need to be investigated.
- The water run-off management from the suppression system and its impact on the surrounding environment such as water sources, soil and nearby ecosystems. The investigation of measures to minimize potential environmental impacts would need to be assessed, e.g. containment basins or filtration systems. This must be detailed in the Emergency Response Plan.

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 handle 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 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 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 Port Dundas the BESS will be deployed outdoors and enclosures need to be highly protective.
- 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:

- **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 proposed 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

Preventative maintenance for BESS requires scheduled, proactive actions 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 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 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.
- Alarn 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 tot eh 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 on the 18th March 2025 (see email sent under Appendix A) for the West Springfield project to ensure that their recommendations have been taken into consideration in the design layout of the proposed development.

Based on recent correspondence on other BESS projects, the recommendation is to apply , NFCC Best Practice guidance on BESS. The official responses state that the recommendations will in future be provided once the relevant working group have been established, to ensure consistency in the responses at national level to all applications. Until then, it is clearly stated that the NFCC guidance shall be followed which has already been considered in this document.

6.0 BESS Design Layout

6.1 Description

The proposed layout for the West Springfield PV and BESS development is shown in **Figure 6-1**: West Springfield BESS Layout, the BESS area is indicated by a pink rectangle located to the north. A layout only showing the BESS area has also been included in **Figure 6-2.**

Figure 6-2 shows a back-to-back design composed of 192 x 0.3727MWh Lithium ∞ Container Block with 1.3m by1.3m containers block and a total of eight Freemaq PCSK Power Electronics battery inverters with a combined power of 35MW. For each pair of containers (4.47MWh), an inverter has been assigned with a power rating of 4.39MW and a total of eight Power Electronics Twin Skid and two Single Skid transformers for the connection to the 33kV switchgear. The drawing allows for some spare space for future augmentation to mitigate, battery degradation. The BESS design has been conservatively based on a 35MW BESS power capacity however the final design capacity will involve a 35MW design with 2 hours storage capacity, it will also include space for augmentation of the batteries.

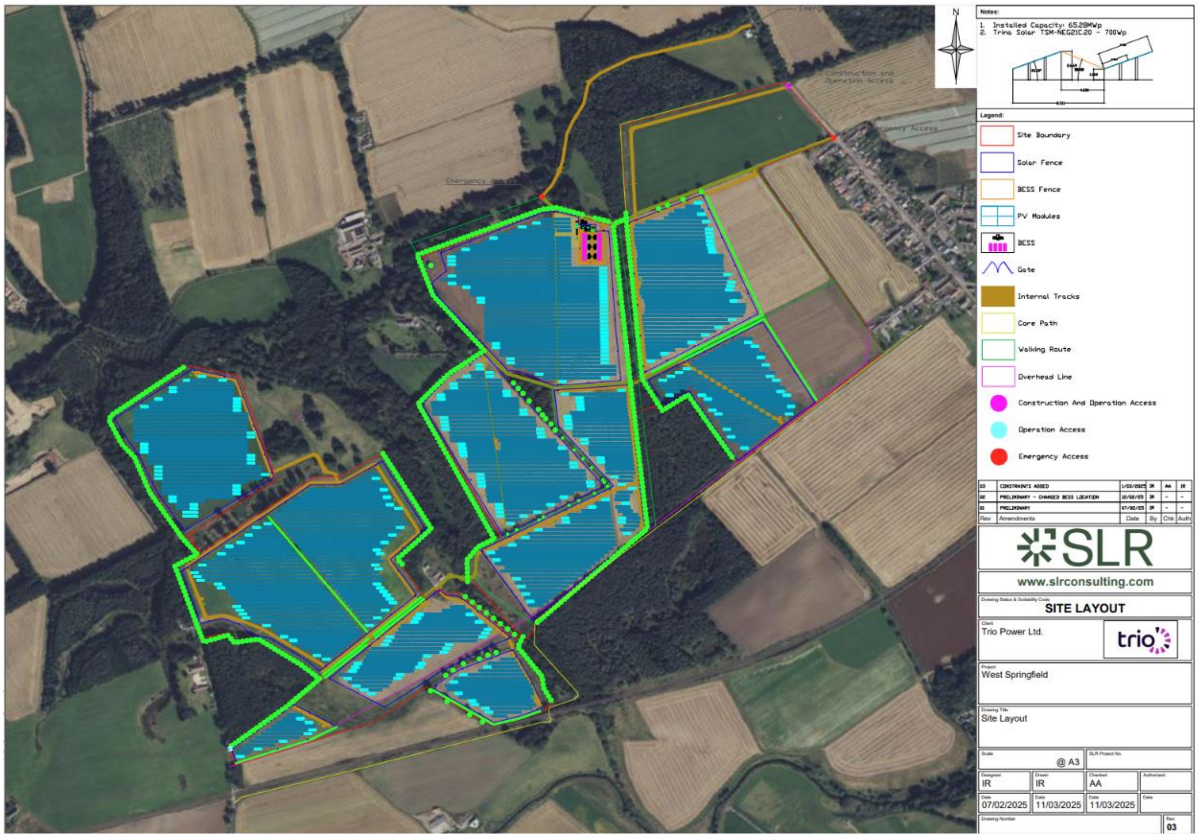

Figure 6-1 West Springfield Layout

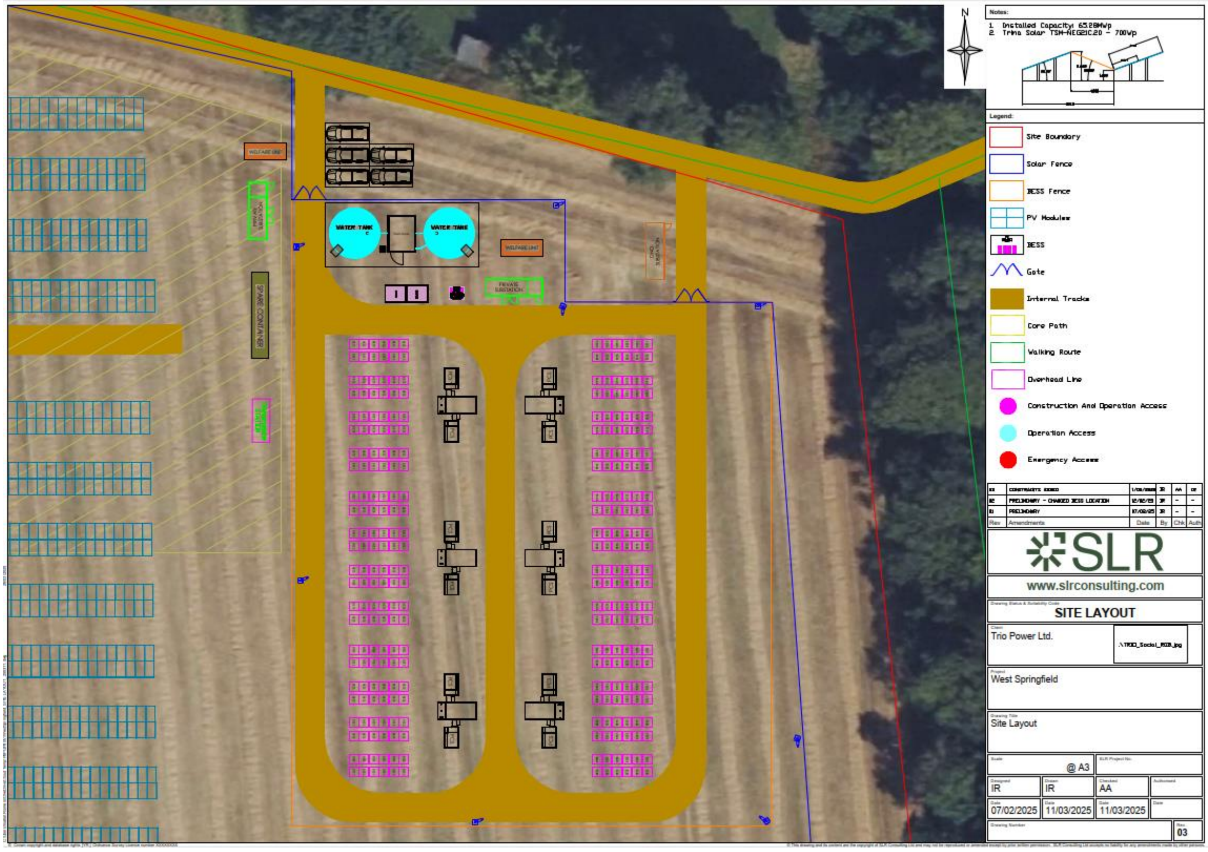

Figure 6-2 - BESS Layout

There is also a Private Substation to the north, as well as a transformer/switchgear located to the west of the Private Substation.

In addition to the electrical components the BESS area includes a welfare unit, spares container, communications room and two water tanks, which are supported by a pump room.

6.2 Design Guidelines

Table 6-1 lists the main BESS fire safety design guidelines and how the proposed development adheres to these.

Table 6-1: Listing of design requirements

Design Requirement	Adherence of the proposed design layout
As per NFPA (2023), the space separation between enclosures is required to be at least 6 metres, if it is not 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	The current design shows a 3m 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.

Design Requirement	Adherence of the proposed design layout
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.	
NFPA (2023) advises that the potential impact radius and therefore separation distance between a BESS and occupied buildings in case of a potential explosion event is at least 23 metres. Nevertheless, recommends increasing the clearance to 30.5 m. The Grid Scale Battery Energy Storage System planning - Guidance for FRS (2023)[5] 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 buildings (the farmhouse to the west and residential properties to the east) confirms it is greater than 30m. The closest property is the farmhouse to the west which is over 400m away.
The layout design shall consider the Grid Scale Battery Energy Storage System planning - Guidance for FRS (2023) which states that areas within 10 metres of the BESS units should be cleared of vegetation to minimise the risk of fire spreading.	The proposed development is located within farmland which is bordered by some trees. The BESS containers are roughly 20m from the closest tree. Therefore, the distance from the trees is in line with the guidance. It is recommended that any landscaping to deliver biodiversity enhancement is kept to the site permitter or away from the BESS area.
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 Grid Scale Battery Energy Storage System planning - Guidance for FRS (2023). Nevertheless, the 2024 FRS Draft Guidance that still needs to be released as a final version indicates it is preferable to have an alternative access point taking account of the likely wind direction.	The design has access at three separate points from Main Street which runs parallel the eastern border of the site, Main Street can be access from the north via the A91 or from the south via the A914. **Figure 6.1** shows there are two Emergency Access points and one Construction and Operation Access points. Although the access points are all on the eastern side of the site, the choice of three allows the emergency services to avoid any smoke plumes upon entry to the site. Additionally, an email has been sent to the SFRS to consult them on the design, which is currently awaiting response. As the SFRS is currently in the process of forming a working group (see email

Design Requirement	Adherence of the proposed design layout
	correspondence in Appendix 1). The Applicant is committed to explore all potential access options and to continue to seek to engage with SFRS on this matter.
The Grid Scale Battery Energy Storage System planning - Guidance for FRS (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.	The site layout shows that there will be two large water tanks capable of holding the volume of water required for delivering 228,000 litres of water for two hours, which is in line with the FRS Guidance from 2023. The Applicant will investigate this point and ensure that a connection is pursued and that it can fill the water tanks that will be installed on site.
The design shall integrate fire hydrants and/or static water tanks depending on the site conditions and presence of a fire main. The placement of water access points near to the BESS is critical for ensuring both effective firefighting and the safety of personnel. The distance requirement between water access point and BESS typically between 10 to 30 metres, though this can vary depending on site-specific conditions, the outcome of risk assessments and recommendations from the FRS.	As shown in **Figure 6-2** the static water tanks are located to the north of the BESS containers. The water tanks have been appropriately distanced from the BESS containers, they are currently 30m away.

6.3 Design Review of Proposed Development layout from Fire Safety Perspective

The BESS design layout provided by SLR has been reviewed, Table 6-2 shows adherence with best practice and industry standards.

Table 6-2: Design Review of Proposed Development from Fire Safety Perspective

Design Review	Design Compliance
Connectivity to the public water supply.	The current planning design[4] includes two static water tanks. It is currently unknown how the site is connected to the public water supply. It is recommended that a connection is confirmed to guarantee that the water tank can be filled.
Provision of on-site drainage system to manage water runoff from a potential thermal runaway event to protect the environment and prevent contamination of water sources.	A Drainage Impact Assessment has been prepared and is submitted in support of the application. This details that a SuDs attenuation basin will be provided on-site to manage surface water run-off. The Drainage Impact Assessment sets out that the basis will be fitted with a valve system that can be closed in the unlikely event of a thermal runaway event. This will allow the run-off water to be contained and assessed and if necessary treated.
Space for a Welfare Unit would be recommended to be provided on site, if required for operational purposes	A welfare unit has been included within the design and confirmed to be within the site boundary.
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	The inclusion of a spares container in the site boundary has been confirmed.

[4] Drawing File "Port Dundas BESS Layout-BESS Layout.pdf"

Design Review	Design Compliance
rapidly address potential system failures.	
The allowance of a space for service vehicle parking would be recommended.	Service vehicles attending the site for planned or reactive maintenance can be parked in the parking spaces that are shown to the north of the BESS site.
CCTV covering the BESS development area is strongly recommended to enhance site security.	CCTV will be provided at the site for security purposes and remote monitoring.

Appendix A

David Fernandez

From:	David Fernandez
Sent:	Tuesday, March 18, 2025 11:57 AM
To:	'SFRS Water Planning'
Cc:	Hugh Smith
Subject:	West Springfield BESS Project 50MW and 100MWh

To whom it may concern, an application for Battery Energy Storage System (BESS) scheme in Rankeilour Estate, west of Springfield (Fife) with a planned capacity of 50 MW and 100MWh is been developed and supported by us SLR Consulting.
We SLR are developing the Outline Battery Safety Management Plan and we would like to engage the local FRS at an early stage so that any requirements or recommendations that are considered will be included in the document.
Please note that we are already following the FRS guidance (2023) and draft version from 2024 but it may occur that based on site specifics or local knowledge the BESS design may have specific additional requirements. For this reason, we are contacting FRS.

If preferred happy to have a call to discuss.

Regards,

David

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