KNOCKNAGAEL BESS

OUTLINE BATTERY SAFETY MANAGEMENT PLAN (OBSMP)

Virmati Energy Ltd, trading as Field

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Objective: This report is the Outline Battery Safety Management Plan for a proposed Battery Electric Storage System (BESS) located in Inverness, Scotland.

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1 EXECUTIVE SUMMARY

This report has been commissioned by Virmati Energy Ltd, trading as Field in relation to a planning application made to The Highland Council for the proposed construction of Knocknagael Battery Energy Storage System (BESS) ('the Proposed Development'). Field was established in December 2020 to build and operate energy storage systems. The company employs a team of highly qualified and experienced technical specialists including engineers, planners and project managers from across the energy industry.

The Proposed Development will comprise a 200 MW BESS for the purpose of importing, storing, and exporting electricity to the electricity network. The application will be submitted on behalf of Field Knocknagael Limited.

Large-scale battery systems are still an emerging technology in the UK, though the lithium-ion technology they use is a common feature of modern technologies including smartphones, laptops and electric cars. BESS play a crucial role in facilitating the integration of renewable energy into the electric grid by efficiently storing excess electricity generated during peak periods and releasing it during times of high demand, thus helping to stabilise and balance the grid.

The UK's Committee on Climate Change has signalled battery storage is a vital technology for the country's plans to reach net zero carbon emissions. In the case of The Highland Council area, the planned Knocknagael BESS development will install a system able to deliver 200 MW of power to support these aims. This is in line with The Highland Council's climate change response, as the Council is legally bound to contribute to Scotland's Net Zero target by 2045[1]. The Highlands Council will do this through their Net Zero Strategy[2] with the key area of alignment being the identification and development of opportunities arising from renewable energy generation.

Before submitting its planning application, Field commissioned DNV to review the company's plans for the Knocknagael project, the result of which are presented in this document. In particular, Field asked DNV to review the risks associated with a BESS alongside the proposed engineering controls that will be implemented by Field through the design, construction and operation of the Proposed Development to prevent, control and mitigate these risks.

This report assesses any key potential hazards the Proposed Development might present, even if considered very unlikely, and assesses these against the steps Field has, and will continue to implement throughout the development and construction of the Proposed Development to mitigate and manage risks associated with those hazards.

The safety mechanisms outlined in this plan aim to protect people, the surrounding environment and the BESS in the unlikely event of an incident occurring. The safety mechanisms will reduce the likelihood of accidents occurring and if they do occur reduce their potential impact.

The Proposed Development is currently in the planning application stage, and hence the final detailed design and specific technologies to be used have not yet been confirmed. Specific design and equipment supply will be confirmed as part of the detailed design and procurement phase which will take place after receiving planning consent. However, as part of the design contained within the planning application, Field has already committed to many safety requirements that will be implemented in the final detailed design. Furthermore, this document will be updated throughout the lifetime of the development to reflect advancements in the design. These key safeguarding measures include:

- **Adherence to UK and international standards:** The BESS will be designed in accordance with UK and international standards, recognised best practice guidance and codes of practice. These will be adhered to across all phases of the project's lifecycle.
    - Field requires any specific technology selected to demonstrate compliance to the industry standard NFPA 855 and the testing requirements of UL9540A.

[1] Climate change - gov.scot (www.gov.scot)

[2] Net Zero Strategy | Climate change | The Highland Council

- Standards and good practice for utility scale electrical infrastructure sites within the UK will be followed.

- **Minimising risk through equipment selection:** Field has sought to minimise the risk of fire, and in the unlikely event fire spread, by means of thorough equipment and technology selection, site design and implementing emergency plans on site. Any suppliers to the Proposed Development will also be required to have relevant quality certifications before being considered.
  - The battery chemistry selected will be lithium iron phosphate which has a higher thermal runaway temperature threshold compared to other commonly used chemistries.
  - The battery units will be installed with smoke and heat detectors.
  - Within the battery units, the safety features typically include internal electrical protection, separation layers, thermal monitoring, fire detection and suppression system and venting valves.
- **Agreeing a firefighting and emergency strategy:** To ensure that any potential incident is well planned for and understood by emergency services, Field will continue to liaise closely with the Local Fire and Rescue Service (LFRS) (in addition to the police and medical facilities). Field has already engaged with the LFRS in order to inform the initial design of the Proposed Development and will continue to do so throughout the detailed design, construction and operational phases.
  - Whilst the LFRS are non-statutory consultees in the planning process, Field recognises the importance of early engagement. Field has consulted and will continue to engage with LFRS throughout the project lifecycle to establish the emergency response plans.
  - The site design includes two access points. This aligns with the UK National Fire Chiefs Council guidance (published in November 2022) which recommends two separate access points to account for opposite wind conditions/directions. Secondary access allows some further means of access to maintenance crew and emergency services in addition to the primary access.
  - The site design includes an engineered drainage system and two attenuation basins to mitigate the risk of water contamination to the surrounding environment in the unlikely event of a fire. The drainage system collects surface water run-off which is attenuated in the basins. The basins will have a surface level filter drain on site which can capture the run-off and be tanked to be taken off site and treated.
  - The firefighting and emergency strategy will be developed in close collaboration with the LFRS, seeking adherence to UK National Fire Chiefs Council guidance and guidance from the Health and Safety Executive (HSE), which will ensure suitable strategies are in place, safeguarding the battery site itself, the public and the environment in the unlikely event an incident does occur.
- **Lack of flammable surroundings:** Within the compound, the areas between and around the equipment will be finished with gravel and are to be kept free of vegetation or other combustible material. This significantly reduces the risk of fire spreading.
- **Robust hazard identification:** Thorough risk management will be conducted by Field throughout the lifetime of the Proposed Development through the application of the HSE hierarchy of controls, as well as undertaking a number of risk reduction exercises through hazard identification and failure effects analysis.
  - Decisions made during the detailed design process will be recorded and used to form a project risk register, which will be continuously reviewed and updated throughout the lifetime of the Proposed Development.

- Quality, Health, Safety and Environment (QHSE) will be a major focus for the Proposed Development through supply chain management, manufacturing, post-manufacturing handling and testing with the aim of managing the risk of fire at source.
- Similar principles will apply to site testing and commissioning to manage risk through construction and integration of the equipment.

- **Decommissioning plan:** While the Proposed Development is intended to operate for up to 40 years, Field has outlined its plans for the eventual decommissioning of the site. This includes safe removal and disposal of the components, and a remediation plan to return the site to the landlord in the same or better condition than at present.

Once the Proposed Development has been constructed and enters its operational phase, safeguarding will continue by means of:

- Continuous, 24/7 monitoring of the BESS throughout the operational period by Supervisory Control & Data Acquisition (SCADA) and on site CCTV;
- An access control system, implemented to ensure it is always established, who, if anyone, is inside the site area and whether there is a need to evacuate;
- Periodic maintenance and testing of all major equipment and replacement before the end of its useful lifetime; and
- Regularly reviewing the emergency response plan in line with the latest industry and firefighting best practices. This will include an ongoing relationship with the LFRS.

By thoroughly examining the potential hazards associated with the Proposed Development in the planning application phase, this report demonstrates that Field has employed a pro-active risk aware approach to development, with many key safety mitigation measures embedded into the design. This report also sets out the principles and commitment by which Field will continue to manage safety risk throughout the lifetime of the Proposed Development, ensuring long-term dependable operation and maintaining the safety and protection of people, property and the environment.

2 INTRODUCTION

2.1 Proposed Development

The planning application for the Knocknagael BESS site has not yet been submitted, but it is expected that the planning consultant will submit an application to the Energy Consents Unit for the proposed construction of Knocknagael BESS (the 'Proposed Development') comprising a 200 MW/400 MWh BESS with associated infrastructure and ancillary works. [ECU Reference: ECU00005099/THC ref: 24/01337/PAN] The Proposed Development will be located on land at Knocknagael, Inverness, IV2 6AJ. Field will own and manage the operations of the facility. Figure 2-1 below shows the BESS site location where the site boundary (including the National Grid substation) is outlined in red. The area for the BESS site is currently an undeveloped greenfield site.

Figure 2-1: Site location

The BESS will provide grid stability and energy security to the electricity grid by importing, storing, and exporting electricity when required.

2.2 About Field

Field is the intended operator of the BESS, they will be responsible for the on-going asset management of the Proposed Development through operation. Therefore, this document reviews Field's safety processes and procedures.

Field is a renewable energy infrastructure and trading company dedicated to accelerating the build out of renewable energy infrastructure to reach net zero. Field was founded in December 2020 to build and operate energy storage systems. The company employs a team of highly qualified and experienced engineers, planners and project managers from across the energy industry. In the UK they have 40 MW of BESS assets in operation, 215 MW in or preparing for construction and 1,181 MW in their pipeline. By 2030 Field plan to have 3.1 GW of batteries, solar and emerging technologies in operation globally. Field aims to finance, build and operate their sites themselves, with an agile operation that has much lower overheads, and a much more comprehensive view of the energy market, than traditional infrastructure businesses.

Field provided input into the Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems guidance which was prepared for the Department for Energy Security and Net Zero. This document was produced to provide guidance to Electrical Energy Storage Systems (EESS) project developers to help navigate the H&S landscape and ensure relevant aspects of H&S are integrated into their processes.

2.3 Objectives of this Document

This document is the Outline Battery Safety Management Plan (OBSMP) for the proposed BESS.

The primary objective of the OBSMP is to provide an overview on the potential risks associated with a BESS, and engineering controls that will be implemented in the design and operation to prevent, control and mitigate these risks.

A. The OBSMP presents the reasonably foreseeable risks associated with BESS technology and outlines the measures that can be employed to mitigate the risks.

B. The OBSMP defines and proposes risk management measures to reduce risk to As Low As Reasonably Practicable (ALARP). These measures will be refined and further detailed (post planning consent) and when the specific technology – i.e. the equipment manufacturer and exact model – is selected for the Proposed Development.

C. Such mitigation measures in the OBSMP include the design, operation, and maintenance of the BESS in line with best practice and recognised international and national safety standards.

3 INTRODUCTION TO BATTERY ENERGY STORAGE SYSTEMS AND SAFETY CONSIDERATIONS

BESS are being widely deployed in the UK and worldwide to provide a range of electrical services to the electricity grid network. These systems are primarily lithium-ion (li-ion) rechargeable batteries housed in units fitted with electrical and safety management equipment. The battery units are connected in strings to Power Conversion Systems (PCS) and transformers; PCSs convert the electricity supply between the Direct Current (DC) from the battery and Alternating Current (AC) from the grid and the transformer would step-up or step-down the voltage of the supply as required for transmission (discharging)/storage (charging). A high-level system diagram is shown in Figure 3-1 below.

Figure 3-1 High-level BESS

This section provides an overview of a BESS, including a description of its key components, potential hazards and mitigation measures that may be implemented to reduce the likelihood and/or effects should a hazard materialise. The full extent of the committed mitigation measures to be implemented by Field is outlined in Section 4.

3.1 Li-ion batteries

Li-ion batteries are the most common category of rechargeable batteries and are used in a vast range of applications including portable electronics, battery electric vehicles, aerospace, and large-scale stationary applications. At its most basic level, a li-ion cell contains a cathode (positive electrode), an anode (negative electrode), and an electrolyte, all of which is held within a container (typically a pouch, prismatic or cylindrical cell). The chemical process by which energy is stored, involves lithium ions moving from the negative electrode to the positive electrode during discharge and back when charging – this reversible reduction-oxidation (redox) reaction chemically stores electrical energy for use later.

There are many possible combinations when choosing the materials for li-ion batteries. Therefore, a “li-ion battery” is the umbrella term referring to any electrochemical energy storage system which uses li-ions as the charge carrier between the cathode and anode during charging and discharging cycles. The types of li-ion batteries are usually differentiated by the chemical structures, cathode or anode materials. Changes in the chemistry of the cathode and anode gives rise to large variations in properties such as specific energy, peak power, cycle life, cost, safety and thermal stability.

Li-ion cells are integrated into battery modules, which are stacked in a shelving unit to form a rack as shown in Figure 3-2. A single rack or multiple racks can be housed in a unit; either a shipping container, a bespoke cabinet or a building. Units are fitted with electrical and safety management equipment. The batteries that will be used for the Proposed Development will be housed in bespoke cabinets, similar to the configuration shown in Figure 3-2.

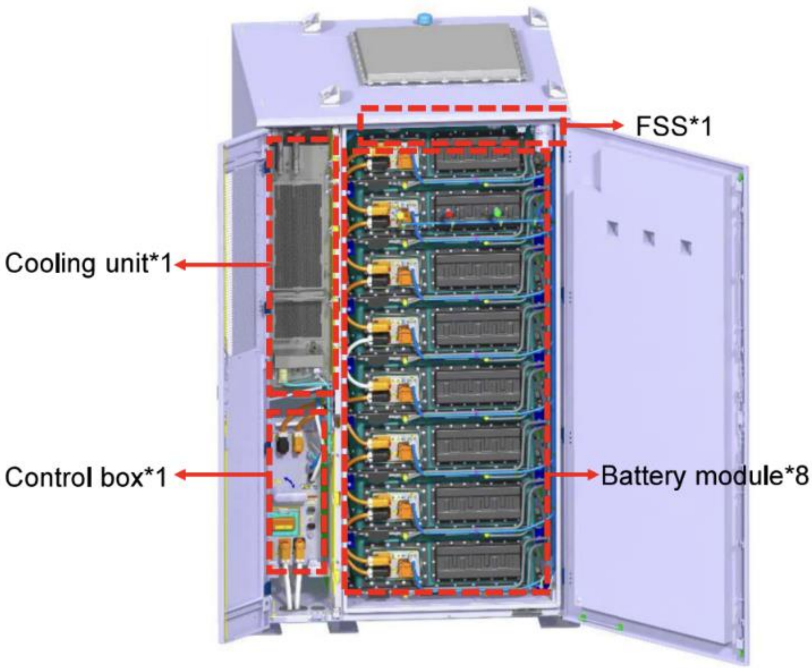

Figure 3-2 Display of a battery unit, containing a single rack with eight modules, a control box, a cooling unit and a fire suppression system (FSS)[3]

3.1.1 Safety considerations for li-ion batteries

A critical aspect of battery systems is safety. The battery's function is to store chemical energy; a failure can result in the uncontrolled release of said energy. A cell failure begins with an initial cause (such as an electrical short circuit or improper use), which often results in an increase of the cell temperature due to exothermic reaction(s) inside the cell. There is a risk that the increase in cell temperature may cause a thermal runaway event (increase of temperature in turn releasing energy, which further increases the temperature) which can lead to gas formation, pressure build-up, cell venting and/or rupture, and possibly fire and/or explosion. If one battery cell experiences thermal runaway, it can potentially rapidly spread to adjacent cells, potentially leading to a high heat release fire event. Thermal runaway risks can be mitigated through incorporating safety features such as cooling, ventilation and heat detectors to ensure that any fault is quickly detected, isolated, and managed. **Liquid cooling, monitoring systems and smoke and heat detectors will be considered as part of the unit design for the Proposed Development.**

Overheating can occur if the batteries are subject to external heating (perhaps because of nearby battery failure) or are mechanically damaged which can lead to a short circuit, generating localised high temperatures. In turn, the batteries can start to decompose rapidly and ignite in a process of thermal runaway. Overheating may also be caused by improper use, manufacturing defects, or poor design. **To mitigate these risks, quality assurance measures such as Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT) are carried out, ensuring no mechanical damage is present with the equipment that could lead to faults. Once the BESS is operational, further mitigations of maintenance at regular intervals and continuous monitoring will ensure the equipment is operating as expected.**

It should be noted that along with rapid technological advancement, safety and regulation has become a crucial element in battery technology, with a focus on producing batteries with a higher threshold for thermal runaway as well as higher scrutiny placed on battery thermal management fire detection systems and the battery monitoring systems. Thermal management and fire detection and suppression systems are discussed in Sections 3.2.4 and 3.2.5. Through constant monitoring and implementing emergency procedures, the risk of thermal runaway and its associated hazards is reduced.

[3] As provided by Field. The figure is of a CATL EnerOne cabinet, widely used in the industry, for illustration purposes.

The Proposed Development will be monitored and controlled 24/7, with alarms raised upon fault detection. Monitoring staff will be fully trained in the operations of the equipment.

3.1.2 Battery Management System (BMS)

The BMS is a crucial device to ensure the safe operating of the BESS, by monitoring battery performance parameters and ensuring that the battery voltage, temperature, and current is kept within safe operating limits. The BMS gathers status data from cell, module and rack, and exchanges information with other components. Some of the key functions of the BMS include controlling the charge and discharge of the battery system, monitoring the voltage, current and temperature, and calculating the state of charge and state of health. The BMS also provides fail-safe protections that ensure safe operation and integrity of the system. The BMS will raise an alarm in the case of any abnormal conditions in the BESS and if required will disconnect the battery from the wider system.

3.2 The wider energy storage system

To ensure that the BESS remains operating safely and efficiently, several auxiliary systems and equipment are integrated. The main auxiliaries within a BESS are the Power Conversion System (PCS), transformers, Energy Management System (EMS), Thermal Management System (TMS) and the fire suppression system. The role of these systems within a BESS are explained in the subsequent sections.

3.2.1 Power Conversion System (PCS)

The primary function of the PCS is to convert current from one form to another. Electricity grid systems (i.e. the electricity network to which the BESS is connected) tend to be of an Alternating Current (AC) form, whilst batteries charge or discharge energy in Direct Current (DC) form. In the case of BESS, the role of a PCS is to act as a bridge between the transmission grid system and the battery system by converting AC to DC for storage, and by inverting DC to AC for distribution. The PCS also provides many safety functions to the BESS which protect the battery from unsafe energy loads, promotes long-term health for the battery and reduces the risk of equipment failure.

3.2.2 Transformers

The primary function of transformers is to step-up and step-down voltages. Electricity network connected systems tend to operate at high voltage levels as this creates less electrical current in the power lines, which in turn reduces energy losses. Conversely, batteries are charged slowly at lower voltages to avoid damage and promote longevity. PCS transformers, also known as Medium Voltage (MV) transformers, allow for AC voltage to be stepped up or down between the electricity network and battery systems so that electrical power can be stored and transmitted effectively. Also present on a typical UK BESS site is an auxiliary transformer. This allows for step down from the high-voltage network to the low-voltage system required on site for the powering of the auxiliary systems; including the thermal management system, fire suppression system, communications, security and welfare systems.

3.2.3 Energy Management System (EMS)

An EMS is a control system that manages the charge and discharge of batteries on a system level by controlling the flow of energy between the electricity network and the battery system. The EMS interfaces with the electricity network and the BMS, logs the performance data, and monitors the state of charge and the state of health of the batteries. With this information the EMS optimises the BESS performance for safety, efficiency and longevity.

3.2.4 Thermal Management System (TMS)

The TMS monitors the temperatures via sensors within the BESS and uses liquid or forced air cooling to ensure the system remains within the defined operational range. It is important for the battery to be kept within a suitable operating temperature range to reduce degradation, malfunction and the risk of thermal runaway.

3.2.5 Fire detection and suppression system

The fire detection and suppression system consist of two main functions: firstly, detecting any fire hazard and secondly, suppressing that hazard if detected. Early off-gas detectors are recommended by some insurers to detect hazardous gases that are emitted under abuse conditions which may lead to thermal runaway. **Field will be procuring a BESS with smoke, heat and early off-gas detection.**

The two main forms of fire suppression that are deployed in UK BESS are water sprinklers and aerosol-based suppression systems. In both cases, the suppressant is triggered when a fire hazard is detected. The role of a water-based system is to cool the hazard, whilst an aerosol-based system seeks to suffocate the hazard.

In addition to robust fire detection and suppression, to further mitigate fire risk the BESS can send a system-level alarm signal upon detecting a hazardous condition. The 24/7 monitoring team will be alerted and will subsequently be able to alert the LFRS and initiate emergency procedures. **Field will employ an Asset Manager to continuously monitor the BESS and be ready to respond to any alarm signals. This will aid in ensuring that the response to potential incidents is escalated appropriately and safety procedures initiated.**

3.3 Receptors to risk

People and the environment are considered receptors in the event of an incident at a BESS site. Typically, an exclusion zone of 25 m to receptors is considered. The nearest residential building is 350 m west of the site and the closest body of water is approximately 250 m east of site.

3.3.1 Persons at risk

Those persons at risk in event of a fire at a BESS site are the following:

Staff and Contractors
Under normal circumstances, BESS sites are operated remotely and only accessed for maintenance and inspection activities.

Members of the Public
Nearby paths and/or roadways on which there is public right of way may be exposed to risk in an event of a fire onsite. This risk may extend to nearby properties and community spaces.

Emergency Responders
Fire and Rescue Service (FRS) responders, police and other emergency responders may be exposed to the risk of injury or death from fire, explosion and gas harmful to health in an emergency situation onsite, or when operating in close proximity.

This document presents Field's clearly defined procedures, that will be regularly reviewed and updated, for actions to be taken in the unlikely event that an emergency occurs to ensure that the risk to persons is lowered.

It should be noted that post-construction the site will be operated as an unoccupied facility, meaning that under normal operation there will not be any on site personnel (staff and/or contractors). This is typical for a BESS site and personnel will only access the site for maintenance purposes (1-2 times per month). The site remains under 24/7 remote monitoring, as discussed in Section 3.2.5.

3.3.2 The risk to the environment

In the unlikely event of a fire, the surrounding area could suffer from contamination from fire water run-off. Subsequently, clean-up work may be required in line with environmental legislation. Field is mitigating the risk of contamination to the surrounding environment by including attenuation basins with surface level filter drains on site which can capture the fire water run-off and be tanked to be taken off site and treated.

Thermal runaway may occur under certain circumstances, resulting in the release of hazardous and flammable gases. A 25 m exclusion zone is typically considered for a major incident on BESS sites, ensuring that the concentration of harmful gases outside of the exclusion zone is within acceptable limits. It should be noted that the nearest residential receptors are 350 m away from the site.

3.4 Applicable Regulations and Standards

The proposed BESS site is subject to the legislative requirements stated in the UK Statutory Instruments. Statutory Instruments (Sis) are secondary legislation of three main types: ‘Orders’, ‘Regulations’ and ‘Rules’. The instruments to which the Proposed Development is subject to are Regulations.

The relevant Regulations to which BESS developments must conform concern health and safety, fire safety, electrical safety, construction safety and battery safety. Thus, whilst not primary legislation, Regulations promote safety by imposing standards. Standards ensure that products and services meet a minimum requirement for safety, quality, and environmental impact.

The Proposed Development will be subject to the requirements of several international codes and standards. A large proportion of the work undertaken for the development, design, testing and installation requirements for BESS has been undertaken in the United States (US); therefore, it is common practice for such US standards to be applied to UK projects. The main standards applied to BESS projects include NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, and UL9540 and test method UL9540A Energy Storage Systems and Equipment**. An extended list of applicable standards is included in APPENDIX C to this document. Field will adhere to all relevant UK and international standards.**

A well-designed site layout that adheres to the relevant standards is an important factor in the implementation of a safe and efficient BESS project. While there is no requirement for a UK BESS system to be located indoors or outdoors, outdoor installations are preferable from a design, installation, maintenance, and safety perspective. For the latter, locating BESS systems outdoors allows gases or heat to escape in turn avoiding build-up of gas and heat that would occur in a building. **The Proposed Development is located outdoors.** The impact that a fire may have within a BESS system can be further mitigated by site spacing and sectioning. A good spacing and sectioning strategy can prevent overheating of units and prevent the spread of fire between units. UK regulations do not determine the minimum safety distances between BESS installations and other infrastructure; however, it is common for UK BESS projects to respect a separation distance of 3 metres. The Standard for the Installation of Stationary Energy Storage Systems (NFPA 855) specifies spacing requirements of 3 feet (0.9 m) between battery strings and 10 feet (3 m) between battery strings and other equipment and infrastructure such as roadways and buildings, which can be reduced as an exception to 3 feet (0.9 m) if fire walls are installed or if fire propagation mitigation is demonstrated by testing under UL 9540A. Separation distance from transformers is also specified in standard (BS EN 61936-1:2010) and is a function of the transformer oil volume. Commonly the separation distance between the battery group and the PCS transformer is 3 m or greater. The site layout should provide suitable mean of access to maintenance crew and emergency services. **Field requires any specific technology selected to demonstrate compliance to the standards specified in APPENDIX C which includes industry standard NFPA 855 and the testing requirements of UL9540A. Furthermore, Field has committed to a 3 m separation between the battery strings in its design of the Proposed Development (i.e. greater than the required minimum) to mitigate the propagation of fire to adjacent infrastructure. Field will be able to demonstrate the separation distances with a dimensioned site layout drawing.**

4 BESS RISKS AND SAFETY MANAGEMENT STRATEGY

4.1 Risk Management Overview

4.1.1 Health and Safety Policy

Field's Health and Safety Policy can be found in APPENDIX D.

4.1.2 ISO Accreditation

Although not a statutory requirement, Field has achieved certification in standards ISO 9001, 14001, 45001 and 45003. Achieving these certifications demonstrates that the organisation is run in accordance with internationally recognised quality and health and safety management standards.

Field is committed to (among others) principles of:

- Improving health and safety;
- Minimising environmental and social impact;
- Demonstrating social and ethical responsibility;
- Conforming to standards, statutory and regulatory requirements;
- Assuring performance and meeting/exceeding expectations of stakeholders; and
- Regularly reviewing and improving processes.

4.1.3 Battery Safety Strategy

Field's safety strategy for BESS sites comprises several elements which provides risk reduction at various stages of the project lifecycle. The primary components of the strategy are presented in Figure 4-1 and detailed within Sections 4.2 4.5.

Figure 4-1: Field BESS Project Safety Strategy

Field's safety and technical risk management incorporates:

- All relevant existing (and emerging) requirements for developing, designing, constructing, and operating the Proposed Development.
- Processes, protocols, and lessons learnt from other similar projects operated by Field and other organisations.

Field follows the risk management process which underpins technical risk management systems worldwide, to ensure safe development, design, construction and operation of its assets. Part of this includes application of the hierarchy of controls, a method of identifying and ranking safeguards to protect people from hazards.

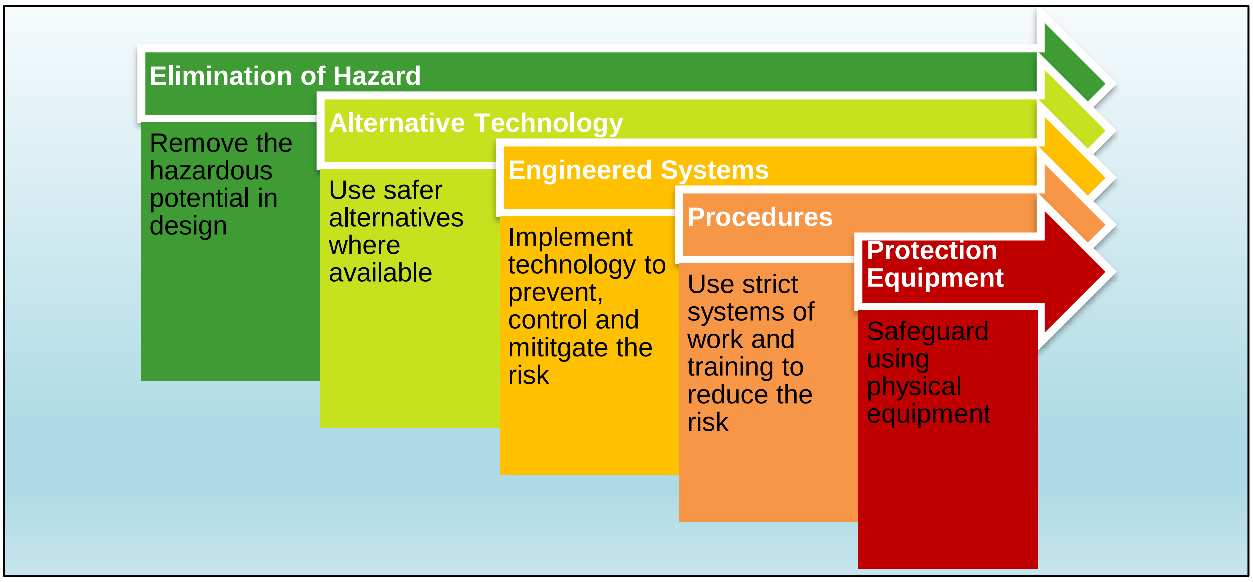

Figure 4-2: Hierarchy of Risk Management

4.2 Safety in Design Process

The key features of the safety in design process are as follows:

1. A Hazard Identification (HAZID), Hazard and Operability Analysis (HAZOP), Fire Risk Assessment (FRA) and a Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) Risk Assessment will be completed post receiving planning consent and ahead of the commencement works.

    a. HAZID – The purpose of this assessment is to identify hazards, causes, consequences, exiting prevention measures and recommendations for the Proposed Development. The process will involve Field alongside the: contractor; construction manager; independent third party and the LFRS.

    b. HAZOP – This assessment will cover the safety risks associated with site operation. All risks generated from the Proposed Development will be identified and the appropriate mitigations implemented to manage them. The risk identification and mitigation strategy creation will involve Field, the principal contractor, the principal designer and an independent third party.

    c. FRA – This assessment will cover all elements of fire risk generated by the Proposed Development. The assessment will be conducted by Field, an FRA specialist, the principal contractor, and the LFRS. The LFRS will cover the fire risk throughout all stages of the development of the Proposed Development and will conduct regular reviews.

    d. DSEAR – This procedure will assess the risks of fire and explosion of dangerous substances on site. The assessment will be conducted by a DSEAR specialist at the end of the construction phase, prior to the operation of the Proposed Development.

Furthermore, it should be noted that Field requires that the equipment manufacturer will carry out a Failure Mode and Effects Analysis (FMEA), a Layer of Protection Analysis (LOPA) and a Safety and Operability (SAFOP) study prior to the transport of the energy storage system to site to ensure the equipment is operating as expected.

2. Throughout the detailed design process, Field will continue to engage with the LFRS and other relevant stakeholders to identify any further relevant mitigation measures that may need to be considered as part of the process**. Field will engage with the LFRS in the pre-application phase. At the time of this report Field**

have shared initial site layout plans to the LFRS and are planning a meeting to discuss the layout further.

3. Decisions made during the detailed design process will be recorded and used to form a project risk register, which will be continuously reviewed and updated throughout the lifetime of the Proposed Development.

4. Fire safety provisions are reflected in the battery system design. Within the battery units, the safety features generally include internal electrical protection, separation layers, thermal monitoring, fire detection and suppression system and venting valves.

5. Field requires any system selected to comply to the industry standard NFPA 855[3] and the testing requirements of UL9540A[4], the tests results of which will inform the spacing of the battery units. In addition, standards and good practice for electrical sites within the UK are to be followed.

6. There are no residential properties within 25 m distance from the battery units, which is the distance typically used as an exclusion zone in a major incident on BESS sites.

4.3 Knocknagael site layout and adhering to standards

The Proposed Development will be subject to the requirements of several international codes and standards. An extended list of applicable standards is included in APPENDIX C to this document, of which Field has confirmed the Proposed Development and its BESS equipment will be compliant with.

The Knocknagael BESS will have equipment situated outdoors arranged as shown in the layout in Figure 4-3.

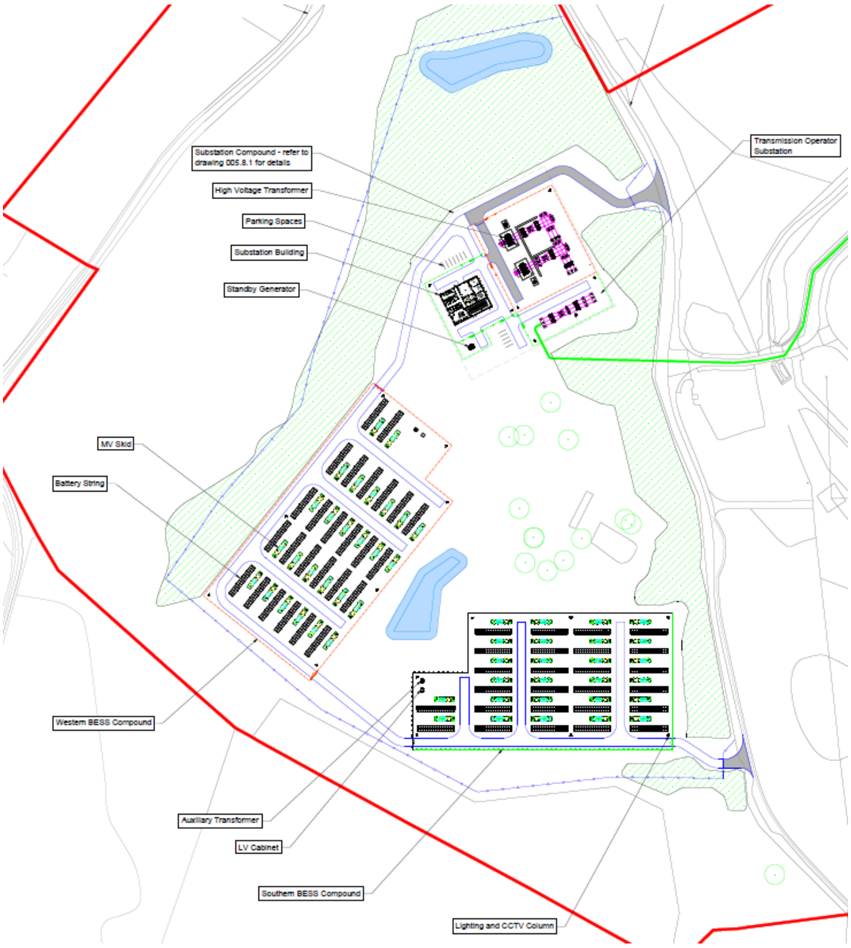

Figure 4-3: Knocknagael Site Layout

The Proposed Development is split into the Western BESS Compound, the Southern BESS Compound and the Substation Compound. Field has implemented a spacing and sectioning strategy to prevent the spread of fire between units. The Standard for the Installation of Stationary Energy Storage Systems (NFPA 855) specifies spacing requirements of 3 feet (0.9 m) between battery strings and 10 feet (3 m) between battery strings and other equipment and infrastructure such as roadways and buildings. Field has actively taken the decision to enforce a 3 m separation between battery strings and to other equipment for accessibility and to mitigate the propagation of fire to adjacent infrastructure. Maintaining the 3 m spacing will also aid with maintenance and construction processes.

In November 2022, UK National Fire Chiefs Council (NFCC) published their "Grid scale battery energy storage system planning guidance for FRS" [4], whilst not an industry standard, Field has considered this guidance and, where appropriate, has included the guidance within the project planning and design.

Area of NFCC Guidance	Compliance	Comments
Detection and monitoring	Compliant	Field have committed to install BESS units with Battery Management Systems which will monitor the system 24/7 and ensure the battery is kept within safe operating limits. At this stage of the development, the BESS supplier has not been selected. Field have committed to consider the monitoring and detection of gas and fires when selecting the BESS supplier.
Fire suppression	Compliant	Field have committed to installing suitable fire suppression systems across the site that will be compliant with all relevant fire safety standards. If a fire does occur, the facility will employ automatic fire detection and suppression systems. Field is working closely with the Scottish Fire and Rescue Service to ensure suitable emergency response procedures are in place, including a Battery Fire Safety Management Plan. Field is part of a working group reviewing and updating industry guidance regarding fire safety.
Access	Pending	The site has two access points which takes opposite wind direction into consideration. Field have provided evidence that the site has adequate spacing for emergency vehicles to access all areas of the site if required. Field have committed to providing the Scottish Fire and Rescue Service copies of the site access layouts. Turning circles or internal access loops will be implemented on site to allow adequate access. Only occasional visits are to be required for maintenance when the site is operational. During construction, the traffic will be suitably managed through a Construction Traffic Management Plan.
Spacing between battery units	Compliant, on the basis of updated standard	The initial site layout drawings show a minimum separation of 3 m between BESS units. A standard minimum spacing between units of 6 metres is not achieved and thus is not in line with the guidance. However, this guidance requirement references FM Global 5-33 (2017) which has since been updated (2024) to a separation distance of 1.5 m for LFP battery units. Therefore, the guidance is out of date and should be updated. Field is compliant to the updated standard.
Water supply	Pending	Field is currently in consultation with the LFRS, including in relation to their firefighting strategy for the site; it is currently assumed that the fire service will have sufficient water available via their fire engines in line with the perimeter cooling firefighting strategy to attend to the immediate situation. Field will continue to liaise with LFRS to finalise a suitable solution that meets the requirements of the firefighting strategy.
Explosion Mitigation and Control	Compliant	Field have committed to selecting BESS equipment that is fitted with deflagration venting which conforms to the standard NFPA 68 that will activate to safely direct energy externally from the BESS unit in the event that an explosive atmosphere is caused inside.
Surrounding Environment	Compliant, on the basis that Field are in the process of engaging with the fire service to ensure contaminated firewater does not escape into nearby water sources.	The guidance proposes a 25 m distance from BESS units to occupied buildings. There are no occupied buildings within 25 m of the site. The nearest residential building is 350 m west of the site. The areas around equipment are to be finished with gravel as a fire mitigation measure. Field is engaging with the local Fire and Rescue Service to identify the most suitable methods to ensure potential firewater does not contaminate water sources. Field is planning to implement a drainage system that will be able to collect and hold contaminated fire water run-off, which can be taken off site thus avoiding contamination entering the surrounding environment.

[4] Grid Scale Battery Energy Storage System planning – Guidance for FRS: https://www.ukfrs.com/sites/default/files/2023-04/Grid%20Scale%20Battery%20Energy%20Storage%20System%20planning%20Guidance%20for%20FRS.pdf

Area of NFCC Guidance	Compliance	Comments
		Field is committed to managing vegetation in and around the site to reduce the volume of combustible materials on site.
Emergency Response Plan	Compliant, on the basis that Field are in the process of producing an emergency response plan.	Field have committed to liaise with local fire and rescue service in the development of the emergency response plan. They will be kept fully informed of the Proposed Development and contribute to the development of an effective plan. The emergency response plan will be regularly reviewed and updated based on the latest industry best practices. The site emergency response plan will include procedures and mitigations in the event of a thermal runaway event.

4.4 BESS Hazards and Mitigation Measures

There are several risk mitigation measures that can be deployed for BESS and usually a combination of such measures will be adopted to reduce the potential impact and/or the likelihood of hazards. Depending on the specific technology chosen, some mitigation measures may be more applicable than others. It should be noted that Field has not yet procured a specific technology for the Proposed Development and as such the final combination of mitigation measures are yet to be determined. Although the specific technology has not yet been chosen, Field have stated their commitment to a number of embedded design elements as noted throughout this document. Field has also committed to implementing a comprehensive design risk management process which will commence post-consent as part of the initial site design. The process ensures that the detailed site design incorporates the prevailing industry standards and good engineering practice.

QHSE will be a major focus for the Proposed Development though supply chain management, manufacturing, post-manufacturing handling and testing with the aim of managing the risk of fire at source. Similar principles will apply to site testing and commissioning to manage risk through construction and integration of the equipment.

4.5 Fire Safety and Fire Fighting

The following measures will be implemented to ensure a safe approach to fire:

1. If a fire is detected, the battery system and the transformers in the BESS will be automatically electrically isolated. However, even an isolated battery will retain some energy depending on the state of charge, and thus will be considered as energised in the firefighting approach proposed in the emergency response plan.

2. The access has been designed such that emergency services will be able to access the site easily with site roads being clearly laid out. The dimensioned drawing will also detail the access route width, it is expected that this will be minimum 4 m to ensure the route is wide enough to allow emergency service access. A secondary access has been included in the site layout, this provides an alternative evacuation route and an additional access option for emergency services.

3. Field will continue to liaise with the LFRS and request their participation in fire safety planning once the Proposed Development has received planning permission. Field will consult them in matters regarding fire safety and mitigation, including bringing members of the Service to the Proposed Development to walk them through important features of the site, the site layout and to present the type of fire safety equipment that will be stored on site. Engaging with the LFRS post consent is considered standard practice. Field has already engaged with the LFRS in the pre-application phase and will maintain this relationship throughout the project delivery.

4. The firefighting strategy adopted will be discussed in detail with the local fire service. The firefighting strategy will likely be a "controlled burn", aiming not to douse with water to prevent fire water run-off but instead use perimeter cooling to avoid fire propagation. If a "controlled burn" approach is taken, it may be deemed necessary for a wet/water emergency response in a limited set of circumstances. For example, in case the fire service considers

there to be a life at risk inside the compound. Such an event shall be discussed with the fire service. Run-off from the BESS area will be contained by a surface level filter drain and an attenuation basin.

5. Based on the factors of distance to the nearest properties, and in the unlikely event, limited expected fire duration due to the sizing and layout of the facility, it is not anticipated that there will be adverse effects at the closest receptor locations as a result of a BESS fire incident. Whilst there is low risk of adverse effects at the closest receptors, the emergency response plan will incorporate the following mitigations to reduce the significance of the incident:

    a) A post event action plan will be drawn up that will determine any immediate and follow up actions required to an event.

    b) There are several factors which would inform the design of an investigation following an incident which account for the volume and concentration of the loss. In the case of a fire to a BESS unit, variables to be considered include:

        i) Extent of the fire: including duration, number of BESS units impacted, number of adjacent assets impacted;

        ii) Firefighting method: techniques may vary depending on the nature of the incident, with measures used (such as quantities of water) differing depending on the extent of the incident. Measures employed will be in accordance with emergency response plan, devised with input from the LFRS;

        iii) Location of the fire: adjacent to drainage or close to soft ground; and

        iv) Existing site conditions: recent weather and precipitation levels.

6. An emergency response plan will be developed using guidance from the HSE, consultation from the FRS and will include recommendations from the Fire Safety Order. Field will liaise with local medical facilities, police service and other emergency services in the development of the emergency response plan. The response will also incorporate a protocol on alerting the local residents near the site in the event of a fire including a statement of events and recommendations to mitigate risks proposed to them.

5 PROJECT LIFECYCLE RISK CONSIDERATIONS

There are three distinct phases of the development lifecycle; construction, operation and decommissioning. While the operational risks have been covered in detail within Section 4, the construction and decommissioning risks are described below.

5.1 Project Construction Risks

During the construction phase of the development, the BESS will be constructed in distinct phases. The civil works (e.g. site levelling) and installation of supporting equipment (e.g. foundations) and auxiliary equipment will be started first. At a suitable point the BESS equipment will be delivered to be installed on the foundations and connected to the supporting and auxiliary equipment.

- The installation will be undertaken in compliance with the Construction (Design and Management) Regulations 2015 and be subject to pre-requisites such as the contractor's own emergency protocol detailing the actions to be taken in an emergency, including the construction emergency response plan that would be coordinated with the relevant stakeholders and emergency services. A muster point shall be defined as part of the emergency response plan and will most likely be outside of the site access gate.
- The transportation of the equipment from the factory will be predominantly sea and land freight. The system will be certified for transportation in all potential environmental conditions. The batteries will have particular focus as they will carry energy during the transportation and thus any damage to these could cause faults or incidents. Following risk averse transportation procedures, transporting the batteries at a low state of charge and including shock sensors on each battery to give a visual indication of whether the batteries have been subject to physical impact during the transportation is an important part of ensuring that only batteries considered to be unaffected are installed.
- The concept design includes BESS units prepopulated with batteries which will have undergone FAT. By definition the FAT will be undertaken in the factory, thus reducing the risks during onsite construction with visual inspections and functional testing having been undertaken before any commissioning and SAT.
- The site installation will be supervised by the original equipment manufacturer and managed in a structured way to ensure that all necessary systems are available before the next step is required. The outline sequence is as follows (typically):
    - Inspect the items in the protective covers;
    - Unpack and inspect the items;
    - Install on the foundations;
    - Once stable inspect the internal components;
    - Mechanically anchor the unit to the foundations;
    - Connect any fire suppression equipment, strobe and siren;
    - Install the grounding;
    - Electrically interconnect the equipment DC, AC and communications cabling; and
    - Commissioning and testing the equipment.
- Comprehensive records of the installation works shall be produced and included within the As-built drawings.
- Inspection checklists shall be produced prior to inspection being undertaken and adhered to for the entire system. Electrical inspection and testing shall be performed as described in BS 7671 and supporting

documents, in particular Guidance Note 3 Inspection and Testing. These checklists will be used to record the completion of all steps in the inspection process.

- The commissioning procedures required by the electricity grid operator as set out in Engineering Recommendations G98/G99 will be followed.

5.2 Decommissioning Risks

5.2.1 Decommissioning

During the decommissioning phase of the development, the BESS will be subject to many of the same risks as during the construction phase, as described in Section 5.1.

- The decommissioning will be subject to pre-requisites such as a contractor emergency protocol detailing the actions to be taken in an emergency, including an emergency response plan that would be coordinated with the relevant stakeholders and emergency services. A muster point shall be defined as part of the emergency response plan and will most likely be outside of the site access gate.
- The transportation of the system components from the site to be re-used or disposed. This is detailed in Section 5.2.2.
- By following a logical sequence of works, with each step being built upon the preceding one, the system can be safely disassembled at low risk and all mitigations against issues can be in place before the next step occurs.
- Comprehensive records of the decommissioning works will be produced.
- Inspection checklists shall be produced and adhered to for the entire system.

5.2.2 Disposal of components

For decommissioning of the BESS, the requirements will be determined ahead of the decommissioning phase. At present, within the UK the responsibility to take back and suitably dispose of installed battery cells fall to the importer of the cells according to the 2009 Waste Batteries and Accumulators Regulations. It requires the party who introduces the batteries into the UK market for the first time, typically the Contractor, to take back waste industrial batteries and have them delivered to an approved treatment and recycling operator. Field will ensure that battery disposal shall follow the Waste Batteries and Accumulators Regulations 2009 (as amended) or such equivalent regulations in force at the time of decommissioning.

- All components replaced during the defects notification and warranty period will be taken back and recycled.
- Field will follow the hierarchy of waste management through the life of the scheme as follows:
  - Reduce – the lithium-ion batteries have finite life based on a number of factors, primarily the total number of cycles undertaken. The operation will attempt to manage the degradation by the selection of services and cycling that maximises the overall life. Consideration will be given to supplementation of the equipment or operation at a lower output.
  - Reuse – If the batteries are no longer suitable for use by the Field there may still be opportunities to use the batteries for second life applications.
  - Recycle – The battery supplier will have obligations under the Waste Batteries and Accumulators Regulations 2009 (as amended) (or such equivalent regulations in force at the time of decommissioning) and will be contractually obliged to offer a recycling service.
  - Recovery – The recycling will allow any useful materials to be recovered and re-enter the supply chain.

- Disposal – Any disposal of batteries shall be undertaken in compliance with all applicable laws and all regulatory requirements, product stewardship, registration disposal and recycling or take back requirement.

5.2.3 Site remediation

Field will remove the development at the end of the project life and deliver the property to the landlord in no worse state and condition as at the start of the project.

6 EMERGENCY RESPONSE PLAN

An Emergency Response Plan will be developed in collaboration with the local fire service and by following guidance from the Health and Safety Executive (HSE). The plan will be maintained and regularly reviewed throughout operation. The Emergency Response Plan will be readily available for operations and maintenance personnel. In the case of an emergency, critical alarms will likely be raised from the contracted 24/7 control room and emergency services contacted and the local O&M team will be notified. The Emergency Response Plan will be followed and the site will be isolated.

An Emergency Response Plan typically includes (inexhaustive list):

- Alarm information.
- Contact information: subject matter expert, system owner, first responders etc.
- Flow chart of emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire.
- Shut down/emergency stop sequence (sub and full system).
- Images of site and design, including access, emergency access, internal roads, firefighting facilities and evacuation routes.
- Highlights of hazards that are system and site specific.
- Setback and exclusion zones.
- Firefighting guidance and details of how the fire service will be alerted and incident communications and monitoring capabilities.

7 CONCLUSIONS

This document sets out the outline battery safety management plan. This outline plan will be developed further in consultation with relevant stakeholders and will be approved prior to the construction of the Proposed Development. The final plan will include the approach to be taken for the on-going design and operation of the Proposed Development.

Field is committed to developing a safe BESS that will provide long-term dependable operation.

This report demonstrates that safety must be inherent in the overall design, minimising the risk of a fire event occurring, and reducing the impact of such an event should it occur. By early assessment of safety and incorporation of embedded safety mitigation features by design, Field is demonstrating a risk aware approach to the Proposed Development, where the primary focus throughout the project lifecycle is safety and the protection of people, property and the environment.

APPENDIX A Glossary of Terms

Glossary

Term	Definition
As Low As Reasonably Practicable (ALARP)	"ALARP" is short for "as low as reasonably practicable". The term at its core is the concept of "reasonably practicable"; this involves weighing a risk against the trouble, time and money needed to control it. Thus, ALARP describes the level to which we expect to see workplace risks controlled. The concept of "reasonably practicable" lies at the heart of the British health and safety system. It is a key part of the general duties of the Health and Safety at Work etc. Act 1974. https://www.hse.gov.uk/managing/theory/alarpglance.htm
Battery Management System (BMS)	BMS is an electronic system that manages a rechargeable battery, such as by protecting the battery from operating outside its safe operating area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and balancing it.
Dangerous substance **(Scotland Regulations)**	A substance or preparation which meets the criteria in the approved classification and labelling guide for classification as a substance or preparation which is explosive, oxidising, extremely flammable, highly flammable or flammable, whether or not that substance or preparation is classified under the CHIP Regulations; A substance or preparation which because of its physico-chemical or chemical properties and the way it is used or is present in or on premises creates a risk; and Any dust, whether in the form of solid particles or fibrous materials or otherwise, which can form an explosive mixture with air or an explosive atmosphere.
Fire and Rescue Service (FRS)	A fire and rescue authority under the Fire and Rescue Services Act 2004.
Hazard and Operability Analysis (HAZOP)	A structured and systematic technique for system examination and risk management. In particular, HAZOP is often used as a technique for identifying potential hazards in a system and identifying operability problems.
Hazard Identification (HAZID)	A qualitative technique for the early identification of potential hazards and threats.
State of Charge (SoC)	The remaining quantity of electricity available in an electric battery relative to its capacity. SoC is usually expressed as percentage, where 0% = empty and 100% = fully charged.
State of Health (SoH)	The difference between a battery's capacity when it was manufactured (100%) to its current capacity due to battery degradation. SoH is usually expressed as percentage. A battery is typically retired from stationary energy storage applications when reaching 55-70% SoH.
Supervisory Control And Data Acquisition (SCADA)	A computerised system that is capable of gathering and processing data and applying operational controls over long distances.

Acronyms

Term	Description
AC	Alternating Current
ALARP	As Low As Reasonably Practicable
BESS	Battery Energy Storage System
BMS	Battery Management System
DC	Direct Current
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
FAT	Factory Acceptance Testing
FMEA	Failure Mode and Effects Analysis
FRA	Fire Risk Assessment
FRS	Fire and Rescue Service
HAZID	Hazard Identification
HAZOP	Operational Hazards
HSE	Health and Safety Executive
IEC	International Electrotechnical Commission
LFRS	Local Fire and Rescue Service
LOPA	Layer of Protection Analysis
MV	Medium Voltage
MW	Mega-Watt
NFCC	National Fire Chiefs Council (UK)
NFPA	National Fire Protection Association (USA)
O&M	Operations and Maintenance
OBSMP	Outline Battery Safety Management Plan
OEM	Original Equipment Manufacturer
PCS	Power Converter System
PSSR	Pressure Systems Safety Regulations
QHSE	Quality, Health, Safety and Environment
SAFOP	Operational Safety
SAT	Site Acceptance Testing
SCADA	Supervisory Control and Data Acquisition

APPENDIX B BESS hazards and mitigation measures

Potential hazard	Engineering and design mitigation measures	Quality assurance measures	Procedural mitigation measures and emergency planning
Thermal runaway	The battery chemistry selected will be LFP which has a higher thermal runaway temperature threshold compared to other commonly used chemistries. The system will be designed to monitor areas such as cell-level temperature and voltage, as well as other systems in the battery units to confirm the heath of the battery system. This monitoring along with other safety features within the BMS such as balancing of voltage levels between cells, short circuit detection, over current detection shall be used to help detect and prevent thermal runaway. On detection of an out of operating range condition, the BMS will disconnect and isolate the system. The battery units will be installed with smoke and heat detectors. Cooling, ventilation and monitoring systems will be incorporated into the units to ensure operational safety by maintaining the batteries at a stable operating temperature and removing excess heat in the event of overheating. The safety measures in place within the system to help mitigate and monitor for thermal runaway will be tested during both the FAT and site testing. The facility will be monitored and controlled by a SCADA safety system which is a 24/7 operation integrated with alarms to be raised upon fault detection. The monitoring staff will be fully trained in the operations of the equipment. Once the site is fully tested and operational, maintenance will be undertaken on the BESS equipment at intervals recommended by the Original Equipment Manufacturer (OEM). This will encompass all BESS equipment supplied by the OEM including the fire detection and suppression system.	Field will require that all vendors have relevant quality certifications before being considered as a potential supplier of equipment or services. The equipment will be tested at various stages of the project phase. The Contractors will produce a testing plan, to be approved by Field, which will detail the testing that will be carried out. FAT will be conducted prior to the transport of the energy storage system to site to ensure the equipment is operating as expected. The equipment will be transported to site ensuring employment of suitably qualified logistics and following environmental regulations. Once the equipment has been sited, installation checks and commissioning will be carried out to ensure the installation has been done in line with OEM requirements. Various tests will also be carried out both prior to and post site energisation, including testing of the fire safety detection, alarms, communication/monitoring and response measures. The purpose of this testing is to ensure that the system is installed properly, and that the battery management and protection systems are working properly. Following the installation and commissioning of the energy storage system, the system will only become operational following SAT, which tests the full site system to ensure it meets the expected system performance. SAT will be carried out on site in the presence of Field, the Contractors and an independent third party.	The site emergency response plan and both the operational and construction fire risk assessments will include procedures and mitigations in the event of a thermal runaway event considering hierarchy and prioritisation. The emergency response plan will be developed using guidance from the HSE, consultation from the FRS and will include recommendation of the Fire Safety Order. Field will also liaise with local medical facilities, police service and other emergency services in the development of the emergency response plan. They will be kept fully informed of the Proposed Development and contribute to the development of an effective plan. The emergency response plan will be regularly reviewed and updated based on the latest industry best practices. 24/7 monitoring of the Proposed Development via the control room and subsequent alert of the LFRS following an alarm signal will be implemented. Personnel will attend where required to support the emergency services and the control room will be able to direct the first responders to the source of the emergency. Site access will be designed such that emergency services are able to access the site easily with site roads being clearly laid out. Field will implement an access control system to ensure that it is always clear who, if anyone, is inside the site area and whether there is a need to evacuate someone from the site in case of an incident occurring. The BESS will not have emergency responders physically enter the battery units hence there is unlikely to be any immediate threat to life to the responders.

Potential hazard	Engineering and design mitigation measures	Quality assurance measures	Procedural mitigation measures and emergency planning
Fire propagation	The fire propagation risk will be considered as part of the system design. Field requires any specific technology selected to demonstrate compliance to the industry standard NFPA 855 and the testing requirements of UL9540A. NFPA 855 specifies spacing requirements of 3 feet (0.9 m) between battery units and 10 feet (3 m) between battery units and other equipment and infrastructure such as roadways and buildings. This can be reduced to 3 feet (0.9 m) based on the results of UL9540A testing, however, Field has actively taken the decision to enforce a 3 m separation for accessibility and to mitigate the propagation of fire to adjacent infrastructure. Maintaining the 3 m spacing will also aid with maintenance and construction processes. Standards and good practice for electrical sites within the UK will be followed with regards to site layout and separation distances for the transformers and power conversion systems. Where required, the BESS units will have a fire rating of 60 minutes. This means that a unit should resist the exposure of a fire for 60 minutes without failure. The battery safety units will include a fire detection and alarm system. If the alarm is triggered the information will be sent to the remote operator and the BESS operation will be stopped. The site will have access to a water supply. Field is currently exploring the various access options for water supply on site including nearby fire hydrants and storing water on site.	The BESS is divided in discrete strings comprising battery units, power converters and transformers. Each group is separated from the next. This allows emergency access in case of an intervention. The layout of the system provides separation between key components, and groups of key components. Field will conform to NFPA 855 and transformer spacing standard BS EN 61936-1:2010. Field will require that all vendors have relevant quality certifications before being considered as a potential supplier of equipment or services.	A response plan for the site will be developed in cooperation with LFRS based on the system design and fire services best practices. The site emergency response plan will be regularly reviewed and updated based on the latest industry best practices. Lessons learned from other fires involving battery storage has highlighted the need to ensure the attending emergency services are aware of the exact location of the fire without entering those battery units. This comprises the remote monitoring of battery units and thus reduces the risks of flame blow back and chemical risks to the attending fire services. The areas between and around the equipment will be finished with gravel and kept free of vegetation or other combustible material.
Flammable gas build-up	Flammable gas build-up will be considered as part of the system design safety standards such as NFPA 68 is considered industry best practice in this regard. NFPA 68 specifies passive explosion prevention through deflagration venting panels even in overpressure conditions.	Field will require that all vendors have relevant quality certifications before being considered as a potential supplier of equipment or services. Conformity to NFPA standards (68 and 855), including equipment spacing and active and passive gas build-up prevention systems. These systems will be tested during FAT and site commissioning to confirm the systems operating as expected.	Procedures will be developed for personnel attending site if a flammable gas build-up is suspected. The BESS will not have emergency responders physically enter the battery units hence there is unlikely to be any immediate threat to life to the responders.

Potential hazard	Engineering and design mitigation measures	Quality assurance measures	Procedural mitigation measures and emergency planning
Electric shock / Electrocution	Due to the stored energy inherent in battery systems, the risk of electric shock or electrocution is present onsite as soon the battery units arrive at the site. The system design will be in accordance with UK electrical regulations and the manufacturer's installation requirements to provide sufficient protections, isolations and procedures to minimise the risk of electric shock or electrocution during the construction and operational phases of the site. In addition, standards and good practice for electrical sites within the UK is to be followed with regards to site layout and separation distances for the transformers and power conversion systems. The system will have emergency-stop functionality on site and that can be remotely accessed. With regards to preventing unauthorised access, the site security profile will be assessed by the Field's dedicated security team and the output from this assessment will inform the level of security measures required. The Proposed Development will have an earthing grid installed. The battery containers will have redundant earth bonds.	Design reviews will be undertaken to confirm that the system has been designed in adherence with UK electrical regulations and the manufacture's installation requirements. Additionally, during commissioning, testing and inspections will be conducted to ensure safe installation of equipment. Whilst the site security assessment will be carried out at a later stage of the project, Field has confirmed that the BESS will have security fencing clearly signed in accordance with the relevant Electrical Regulations identifying the dangers within the site and the Control Room freephone telephone number for use in case of emergency. In addition, the site will also have high quality CCTV with video analytics to identify and prevent unauthorised access. This will enable the control room to undertake the correct response. The Proposed Development will complete arc flash assessment and fall of potential study (or similar).	This risk of electric shock and electrocution will be included in both the construction and operational site risk assessments. Procedures will be in place for handling the electrical equipment during installation, maintenance and decommissioning. Only suitably qualified professionals shall carry out such activities. Field will implement an access control system to ensure that it is always established who, if anyone, are inside the site area and whether there is a need to evacuate someone from the site in case of an incident occurring. To ensure this, access to the site will be by appointment only and for clear bodies of work usually undertaken by teams of people. There will be a log in and log out system so the operator always knows when someone is onsite. The BESS will automatically be electrically isolated when a fire is detected. However, even an isolated battery will retain some energy depending on the state of charge, and thus will be considered as energised in the firefighting approach proposed in the emergency response plan.

Potential hazard	Engineering and design mitigation measures	Quality assurance measures	Procedural mitigation measures and emergency planning
Mechanical Damage	Due to the stored energy inherent in battery systems, physical damage or irregular movements during transport or lifting operations may cause issues. The system design will be in accordance with UK electrical regulations and the manufacturer's installation requirements to provide sufficient protections, isolations and procedures to minimise the risk electric shock or electrocution during the construction and operational phases of the site.	Field will require that all vendors have relevant quality certifications before being considered as a potential supplier of equipment or services. The equipment will be transported to site ensuring employment of suitably qualified logistics and following environmental regulations. The batteries will have particular focus as they will carry energy during the transportation and thus any damage to these could cause faults or incidents. Following risk aware transportation procedures, transporting the batteries at a low state of charge and in line with manufacturer's specifications. On site inspections will be conducted to ensure the system is constructed in accordance with the manufacturer's installation requirements and industry best practices. The transportation of the system is within the BESS supplier's scope and it is their responsibility to comply with all laws and all requirements deemed necessary.	This risk will be included in both the construction and operational site risk assessments. Procedures of storing batteries will be followed according to manufacturer specifications. All equipment will be replaced before its respective useful lifetime, as specifies by the OEM. Throughout its useful lifetime, regular inspection and maintenance is to be carried out for equipment in accordance with the supplier's recommendations.
Failure of overcurrent protection	Failure of overcurrent or other protection equipment may damage equipment, leading to risk of thermal runaway, fire and electric shock. The BMS installed in the battery units will shut down and disconnect the battery if required. Additional protections will also be installed on the batteries such as fuses and disconnectors.	Batteries will be certified and have undergone abuse / failure testing. The PCS will also be certified in preventing overcurrent.	Battery and other systems will be maintained by competent personnel with the necessary training and certification. Personnel access will be controlled, to minimise risk to personnel if an incident occurs. Operating procedures approved by the maintenance provider and equipment manufacturers will be followed while carrying out activities onsite. Clear alarm response procedures will be developed, considering alarm hierarchy and prioritisation.
Loss of cooling system for the battery	Cooling, ventilation and monitoring systems will be incorporated into the units to ensure operational safety by maintaining the batteries at a stable operating temperature and removing excess heat in the event of overheating. Upon detection of a cooling system issue, the system will protect the affected parts of the BESS by disconnection or limiting the power available from that area to ensure the batteries remain in the acceptable temperature range.	The cooling system and the reporting of cooling system issues will be tested as part of site commissioning.	The system will alert a control room or the equipment supplier of cooling system issues and the appropriately qualified personnel will be dispatched to site to remedy the fault. Additionally, regular inspections and maintenance will be conducted in accordance with the supplier's recommendation and (if applicable) for liquid cooling systems, the UK Pressure Systems Safety Regulations 2000 (PSSR). Clear alarm response procedures to be developed, considering alarm hierarchy and prioritisation.

APPENDIX C Applicable Regulations and Standards

UK Primary Legislation and Statutory Instruments

The BESS is subject to the Health and Safety at Work etc. Act 1974. The Act imposes a wide range of duties on the employer, which in this case is Field, to protect the health, safety and welfare at work of all their employees, as well as others on their premises, including temporary staff, casual workers, the self-employed, clients, visitors and the general public.

The BESS site is subject to the legislative requirements stated in the UK Statutory Instruments under the Health and Safety at Work etc. Act 1974 in the following legislation:

Workplace Health and Safety

1. Management of Health and Safety at Work Regulations 1999
2. The Workplace (Health, Safety and Welfare) Regulations 1992
3. Provision and Use of Work Equipment Regulations

Fire Safety

4. The Fire Safety (Scotland) Regulations 2006
5. Dangerous Substances and Explosive Atmospheres Regulations 2002

Electrical Safety

6. Electricity at Work Regulations 1989
7. The Electricity Safety, Quality and Continuity Regulations 2002

Construction Safety

8. Construction (Design & Management) Regulations 2015

Battery-specific regulations applicable to the Proposed Development include:

1. Batteries and Accumulators (Placing on the Market) Regulations 2008
2. Batteries and Accumulators (Placing on the Market) (Amendment) Regulations 2012
3. Waste Batteries and Accumulators (Amendment) Regulations 2015

Other legislative requirements may also apply to the Proposed Development; the above lists are not to be considered as exhaustive.

Field will ensure that the Proposed Development is designed, constructed and operated in compliance with the enforced legislation in the United Kingdom, and additional or amended requirements in Scotland.

Engineering Standards and Guidance Documents

The Proposed Development shall incorporate the requirements and guidance in prevailing international standards and code of practices in the design, construction and operation of the BESS. A brief list of the standards, guidance documents and codes of practice applicable to the Proposed Development are:

1. NFPA 855, Standard for the Installation of Stationary Energy Storage Systems
2. NFPA 69, Standard on Explosion Prevention Systems
3. NFPA 68, Standard on Explosion Protection by Deflagration Venting

4. British Standard BS 7671 Requirements for Electrical Installations
5. Dangerous Substances and Explosive Atmospheres Regulations 2002 Approved Code of Practice and Guidance
6. Battery storage guidance note 2: Battery energy storage system fire planning and response
7. Code of Practice, Electrical Energy Storage Systems, 2nd Edition, IET
8. IEC 61508-1:2010, Functional safety of electrical/electronic/programmable electronic safety-related systems
9. IEC 61511-1:2016. Functional safety: Safety instrumented systems for the process industry sector
10. IEC 62619:2022, Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications
11. UL9540 and test method UL9540A Energy Storage Systems and Equipment.
12. IEC 62933-5-2 Electrical energy storage (EES) systems Part 5–2: Safety requirements for grid integrated EES systems electrochemical based systems.
13. IEC TS 62933-5-1 Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid-integrated EES systems - General specification
14. IEC 62485-5 Safety requirements for secondary batteries and battery installations - Part 5: Safe operation of stationary lithium ion batteries
15. BS EN 60079-10: 2003 Electrical apparatus for explosive gas atmospheres. Classification of hazardous areas British Standards Institution
16. Fire and Emergency Planning Directorate (1998), Fire Service Manual, Volume 2: Fire Service Operations, Electricity
17. Grid Scale Battery Energy Storage System planning – Guidance for FRS (2023), National Fire Chiefs Council.

Table 1 Overview of relevant BESS standards on fire safety

Standard	Summary/Overview
IEC 62933-5-2 **[Pub: Apr 2020]**	Electrical energy storage (EES) systems Part 5–2: Safety requirements for grid integrated EES systems electrochemical based systems. The IEC 62933-5-2 covers risk assessment, identification and mitigation of hazards, across 5 unique ESS classes based on electrochemistry. The standard focuses on a comprehensive risk assessment and corresponding risk mitigation measures in both design and operation. The standard requires that hazards such as flammable/explosive gases shall be mitigated. However, it does not prescribe solutions to do this. The risk assessment required and hazards and mitigations to consider are described in IEC 62933-5-1.
IEC TS 62933-5-1 **[Pub: Jul 2017]**	Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid-integrated EES systems - General specification Part 5-1 specifies safety considerations (e.g. hazards identification, risk assessment, risk mitigation) applicable to EES systems integrated with the electrical grid. This is a Technical Specification, so it does not contain mandatory parts. It is a guideline explaining how to set up the risk assessment for ESS.
IEC 62485-5 **[Pub: Nov 2020]**	Safety requirements for secondary batteries and battery installations - Part 5: Safe operation of stationary lithium ion batteries. This standard applies to installations of one or more stationary secondary batteries having a maximum aggregate voltage of 1,500 V_{DC}. It describes the principle measures for protection during normal operation or under any expected fault conditions (i.e. concerning electrical safety). The standard provides requirements on safety aspects associated with the installation, operation, inspection, maintenance and disposal of lithium ion batteries in stationary applications.
IEC 62619 **[Pub: Feb 2017]**	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications: Specifies requirements and tests for the safe operation of secondary lithium cells and batteries used in industrial applications including stationary applications. It should be noted that this standard focuses on safety at a cell and module level and does not include safety requirements for system integrated aspects.
NFPA 855 **[Pub: Sept 2019, latest amendment 2023]**	Standard for the Installation of Stationary Energy Storage Systems: This standard, developed by the National Fire Protection Association (NFPA) focuses on fire prevention, mitigation and suppression. NFPA 855 is often used by competent authorities as a guideline in permitting issues for BESS. This standard, along with UL 9540 is generally considered industry best practice for fire safety in stationary BESS installations in North America.
UL 9540 **[Pub: Feb 2020]**	Safety for Energy Storage Systems and Equipment 2nd Edition: This standard represents certification-based best practices for BESS development, testing, and safety. The UL 9540 is a general BESS safety standard and its requirements are closely aligned with IEC 62933. The UL 9540 scope covers a range of fire, electrical, mechanical and chemical hazards and requires that BESS shall be provided with a safety analysis such as failure modes and effects analysis (FMEA) or fault tree analysis (FTA). The 2nd edition of UL 9540 limits the maximum energy capacity of BESS to 50 kWh unless they comply with UL 9540A test criteria.
UL 9540A **[Pub: Nov 2019]**	Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems: This standard prescribes a test method for evaluating fire propagation in BESS during thermal runaway. Following this test method will provide data which confirms whether or not propagation of fire or thermal runaway conditions will occur at cell, module or unit level. The test results may be used to advise system design and help alleviate concerns that thermal runaway in one module could propagate to consume the full system and induce thermal runaway in adjacent units.

Table 2 High-level Comparison of NFPA 855, IEC 62933-5-2 and UL 9540 with respect to fire safety

NFPA 855	IEC 62933-5-2	UL 9540
• The Authority Having Jurisdiction (AHJ) shall be permitted to approve the hazard mitigation analysis of the safety of the ESS. • Where required, large-scale fire testing shall be conducted and witnessed on a representative ESS in accordance with UL 9540A or equivalent test standard. The test report shall be provided to the AHJ for review and approval. • For Li-ion batteries, an approved method shall be provided to preclude, detect[5], and minimise the impact of thermal runaway. • Electrical safety according to IEEE or NFPA 70E electrical code. • Outdoor walk-in containers or enclosures housing ESS[6] shall not exceed 53 ft × 8.5 ft × 9.5 ft. ESS located outdoors shall be separated by a minimum 10 ft (3048 mm) from exposures. • Smoke/fire detection and alarm[5] is prescribed. • Exhaust outlet(s) shall be directed into a safe direction. • Ventilation and gas detection[5] is prescribed. Also, explosion control is required (deflagration panels). • Water supply and/or fire hydrants are prescribed. • In response to an ESS incident, the owner shall provide trained fire mitigation personnel. • Commissioning plan and report are required. The commissioning results shall be provided to the AHJ prior to final inspection and approval. • An O&M manual, emergency plan and staff training shall be provided. • Security (access control) is required.	• Competent **authorities may be involved for** final approval of the system. • Fire-load calculations, or the experimental fire characteristics (e.g. according to UL 9540A), are applicable for the risk assessment • Li-ion batteries shall be validated in accordance with IEC 62619, 7.3.3: Propagation test (battery system). This test evaluates the ability of a battery system to withstand a single cell thermal runaway, so that this does not result in the battery system fire. This propagation test on system level must be passed. • Electrical safety according to IEC 60364. • Control of the size and separation distances is used to determine the suitability of the protection measures. (no exact values prescribed) • Smoke/fire detection and alarm[5] is prescribed. • Exhaust outlet(s) shall be directed into a safe direction. • Explosive atmospheres may not occur. Specific technical solutions are not prescribed. If ventilation is used, it shall be always on, or auto-start on a detection signal. • Water supply is not prescribed. • No requirement for owner's personnel on site. • Commissioning plan and report are required. At commissioning the competent authority *may* be involved for final approval. • An O&M manual, emergency plan and staff training shall be provided. • Security (access control) is required.	• The UL 9540 does not require a competent authority for approval. • Limits the maximum energy capacity of BESS to 50 kWh unless they comply with **UL 9540A test criteria.** • Electrical safety according to NFPA 70E & CSA Z462. • Assessment of size and separation distances is required in the risk assessment. However, exact values are not prescribed. • Well aligned with IEC62933 with respect to fire safety, detection[5] and suppression. However, IEC62933 provides some additional details on potential mitigation measures which UL does not comment on such as certification. • Ventilation prescribed, however, no details on the direction of exhaust gases. • Aligned with IEC62933 with respect to explosive atmospheres. UL9540 provides testing standards for container ventilation. If ventilation is used, it shall be always on, or auto-start on a detection signal. • Water supply is prescribed. • No requirement for owner's personnel on site. • References NFPA855 with respect to commissioning requirements. • An installation manual and O&M manual shall be provided. No requirement for emergency response manual. IEC 62933 goes to greater detail in outlining personnel training than UL9540 which points to normative reference of NFPA 70E (electrical safety) only. • Security (access control) is required.

5 Note DNV: Where detection and alarm is prescribed, this should also be communicated to the BMS (for rack or system shutdown) and to the remote operating centre (for proper follow-up).

6 Note DNV: This size/volume could also be used for the limit of a series of cube-sized housings (e.g. 5 x 10 ft against each other and then a distance to the next row).

APPENDIX D Field's Health and Safety Policy

Quality, Health, Safety & Environmental Policy

Our Mission at Field is to accelerate the transition to Net Zero. We are rapidly deploying grid-scale energy storage infrastructure which will help us create a more reliable, flexible, and greener electricity system. Ensuring the health, safety and welfare of all staff, stakeholders and the public is an integral part of us doing this effectively.

To ensure Field stays at the forefront of our sector, driving efficiency and supporting our ambitions in sustainability we set high standards in Quality, Health, Safety and Environment. We are committed to delivering for our stakeholders while also fulfilling our regulatory requirements. The implementation and continual improvement of an Integrated Management System (IMS) that covers the complete lifecycle of our projects can help us achieve this goal.

Having robust Quality, Health and Safety measures during the development, construction and operational life of projects makes good business sense.

We are committed to the prevention of pollution and strive to minimise waste, promote recycling, reduce energy consumption and harmful emissions. Where possible, we will work with our suppliers and contractors to protect the environment and establish practical environmental solutions.

The person with overall and final responsibility for issues relating to Quality, Health and Safety, Environment and Psychological health and wellbeing within Field is our CEO, Amit Gudka. The day to day responsibility for ensuring that this policy is put into practise lies with our Technical Director, QHSE Manager and Head of Construction. nonetheless, this responsibility will only be fully realised by a collective company effort.

Doc Name: QHSE Policy
Doc Number: FIELD-HSE-P-001
Doc Revision: 01

As part of our commitment we will:

Overall

- Empower all teams to communicate openly and honestly by providing forums to discuss actual and potential QHSE risks.
- Create specific QHSE objectives and KPIs that are reviewed across the company on a monthly basis
- Grow a culture of continuous improvement and feedback, where we learn from successes, failures, incidents and observations.
- Provide the necessary training, resources and equipment to support our employees in their development journey.
- Ensure that the integrity of the IMS is maintained at all times, particularly during periods of change.
- Report to the board on QHSE performance on at least a quarterly basis.

Quality

- Establish suitable monitoring and measuring techniques to ensure that we maintain and improve high standards of delivery and optimising efficiency.
- Ensure that our supply chain has Quality Management Systems in place appropriate to their activities. The performance of key suppliers is monitored.

Health, Safety and Wellbeing

- Create a safe and healthy workplace, including construction sites, operational projects and travel, for everyone.
- Assess, understand and manage our HSE risks and impacts during the development, pre-construction, construction and operational phases of our projects.
- Proactively seek ways to prevent work related ill health and injury by striving to eliminate hazards and reduce risk.
- Lead on HSE practices for businesses of our size / scale, not just accepting legal compliance as standard and commit to satisfy all applicable requirements to the business.
- Facilitate employees participation in a range of initiatives help to prevent mental ill health and provide support for those affected by issues relating to deterioration in their wellbeing.
- Strive to increase knowledge and awareness of mental health and wellbeing within our organisation and supply chain.
- Consult with our employees on health and safety and encourage participation in the decision making process with regards to risk reduction and continual improvement.
- Have zero tolerance for harassment of any kind.

Environment

- Comply with current and anticipated environmental legislation. In the absence of legislation, Field will implement cost effective best management practises to provide environmental protection and minimise risk.
- We incorporate biodiversity protection into our environmental management plans, aiming to achieve a net-positive impact in our project areas.
- Commit to rigorously measuring our impact, and make reasonably practicable steps to reduce it.

Amit Gudka
CEO Field

Signed.......[redacted]..................... Date: 19/03/24.......................................

Doc Name: QHSE Policy
Doc Number: FIELD-HSE-P-001
Doc Revision: 01

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analyzing sensor data from a gas pipeline or certifying a food company’s supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world’s most successful and forward-thinking companies.