One Earth Solar Farm

Volume 7.0: Other Documents [EN010159]

Outline Battery Safety Management Plan

December 2025

Document Reference: EN010159/APP/7.11.5

Revision Number 06

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Reg 5 (2) (q)

Table of Contents

Abbreviations and Acronyms

Term	Meaning
AC	Alternating Current
BESS	Battery Energy Storage System
BMS	Battery Management System
BS	British Standards
BS EN	British Standards European Norm
BSMP	Battery Safety Management Plan
CCTV	Closed-Circuit Television
CFD	Computational Fluid Dynamics
CO2	Carbon Dioxide
COSHH	Control of Substances Hazardous to Health
DC	Direct Current
DNO	Distribution Network Operator
DNV	Det Norske Veritas
DRA	Design Risk Assessment
EA	Environment Agency
EMS	Energy Management System
EN	European Norm
E-Stop	Emergency Stop
ESS	Energy Storage System
FAT	Factory Acceptance Testing
FACP	Fire Alarm Control Panel
FRS	Fire and Rescue Service
HAZID	Hazard Identification Study
HMA	Hazard Mitigation Analysis
HMI	Human Machine Interface
HV	High Voltage
HVAC	Heating, Ventilation, and Air Conditioning
IEC	International Electrotechnical Commission

Term	Meaning
ITP	Inspection Test Plan
LFP	Lithium Iron Phosphate
Li-Ion	Lithium-Ion
LPS	Loss Prevention Standard
MSDS	Material Safety Data Sheets
MW	Mega Watt
MWh	Mega Watt hour
NFCC	National Fire Chiefs Council
NFPA	National Fire Protection Agency
NG	National Grid
ODEMP	Outline Decommissioning Environmental Management Plan
OEM	Original Equipment Manufacturer
PCS	Power Conversion System
PHAST	Process Hazards Analysis Software Tool
PPE	Personal Protective Equipment
PTW	Permit To Work
RRO	Regulatory Reform Order
SAT	Site Acceptance Testing
SoC	State of Charge
SoH	State of Health
SuDS	Sustainable Urban Drainage System
T&D	Transmission and Distribution
TSO	Transmission System Operator
UL	Underwriters Laboratories
VESDA	Very Early Smoke Detection by Aspiration

1. Executive Summary

1.1.1 Please note that the document references within this Revised Outline Battery Safety Management Plan have not been updated from those used in the original submission. Please refer to the Guide to the Application [EN010159/APP/1.3.2] for the list of current versions of documents.

1.1.2 This Outline Battery Safety Management Plan (oBSMP) identifies the fire safety risks for the One Earth Solar Farm Battery Energy Storage Systems (BESS) and explains the measures included in the Proposed Development to mitigate those risks. The Proposed Development is located in the vicinity of the High Marnham substation, primarily in Nottinghamshire, but partly in Lincolnshire. BESS are proposed at two locations, one in the west and one in the east of the Proposed Development, and the safety measures outlined in this report shall be applicable to both locations. For the purpose of this report, the two BESS locations will be referred to as 'BESS Sites'.

1.1.3 The BESS Sites are at an early design stage and the BESS supplier and associated equipment is currently unconfirmed. However, the technology information will be updated as the design progresses to reflect the selected solution, including detailed safety considerations, mitigations and specifications, to ensure the fire service can undertake a meaningful review.

1.1.4 At this stage, two parcels of land have been identified, within which BESS will be located. One BESS Site on the east of the River Trent and one BESS Site on the west shown on Work No. 2 of the **Works Plan [EN010159/APP/2.3]**. This oBSMP has been developed to support the Development Consent Order (DCO) application for the Proposed Development and will outline the safety objectives, BESS failure modes, relevant guidance (standards), BESS safety requirements, firefighting consultation and guidance, and preconstruction information requirements planned for the two BESS Sites. Guidance documents and standards considered by the Applicant in the design and selection of these systems have been used to inform the design of the Proposed Development.

1.1.5 The event of a fire is extremely unlikely. In the United Kingdom, only a single BESS fire incident has occurred to date. There are significant advancements in the technology for these proposed BESS compared to the equipment that caused the fire, with various technologies offering distinct features and capabilities. This document will outline the layered security approach taken in regards to fire safety.

1.1.6 To ensure the safety of the overall system, various levels of detection and suppression mechanisms have been thoughtfully incorporated. These mechanisms have been designed to promptly identify and mitigate any potential risk of thermal runaway and the conditions that may lead up to it. In the unlikely event that a fire does occur, the spacing and location of the units will be carefully considered to eliminate any possibility of fire spreading between units, ensuring the situation does not escalate. BESS units shall be selected that are designed to self-contain fire risks. The emphasis of fire prevention and mitigation in design underpins One Earth Solar Farm Ltd's ('the Applicant's') commitment to maintaining the highest safety standards.

1.1.7 Although unlikely, should a fire occur, the BESS Sites shall incorporate appropriate and robust fire and gas detection and suppression systems validated through designers risk assessments (DRA) and proven by testing at component level. This shall be carried out at detailed design and shall be separate to the BSMP. It shall effectively contain the fire, off gassing and minimise the possibility of thermal runaway and reignition. Exhaust and ventilation shall purge heat, gas and smoke during an emergency. The Fire Alarm Control Panel (FACP) located at each battery unit or group of units, will be connected to the Main/Central FACP within the control room, shall direct attending fire service personnel to the affected location should the local Fire Service require this. Network-connected closed-circuit television (CCTV) shall also be utilised to monitor each battery enclosure via a control room. Information and guidance will be provided to assist the responses of Lincolnshire Fire and Rescue Service (FRS) and Nottinghamshire FRS and minimise any potential damage.

1.1.8 Early discussions with the FRSs have taken place to introduce them to the Proposed Development and inform them that we will comply with the National Fire Chiefs Council (NFCC) guidance. The FRSs have been invited to review the Outline BSMP. The FRSs shall be involved and informed on the final BESS design, means of containment, BESS system layout and will be notified of any changes that impact fire safety as appropriate. Site access points, internal site roads, water sources, onsite water storage for fire service use, fire hydrant location and any other information that may assist the fire service to assess the site fire risk shall be elaborated in the detailed BSMP, the FRSs (and EA) will be consulted on the content of the detailed BSMP. The BESS Sites will each have four 120,000 l water storage tanks with a combined capacity of 480,000 l of water (1900 l/min for 2 hours). This will feed the fire hydrants and the water supply will be available for use by the FRSs. The water tanks are not intended to feed any automated sprinkler system.

1.1.9 The risk of rapid combustion and explosion of cells will be mitigated by selecting BESS units that are designed to self-contain fire risks as proven by testing at a component level. If an alarm is raised the alternating current (AC) power will be automatically disconnected however emergency responders should be aware of the risk of electric shock when using water to contain the fire. Exposed cables should be treated as "live". Appropriate personal protective equipment (PPE) should be worn to prevent exposure to any hazards present.

1.1.10 The BESS Sites will be unmanned at all times during normal operation. The BESS Sites will be remotely monitored 24 hours, 7 days a week. An emergency information pack, where material has been agreed with the local fire service, shall be accessible to fire responders at BESS site emergency access points. The BESS sites will be easily accessible for emergency vehicles via access routes verified by a swept path analysis. There are no dead-end access routes within the BESS compounds.

1.1.11 Should water be used for firefighting, the firefighting water shall be collected by an appropriate drainage design for the units to prevent the release of polluted water.

1.1.12 The illustrative layout in **Figure 2.1** and **Figure 2.2** of this oBSMP are based on proven battery technology and adheres to the latest available safety guidance and relevant standards. In the event that the DCO is granted, a competitive tendering exercise will be undertaken to select a battery technology that includes rigorous fire safety protection and standards. Once the technology has been selected, the BESS Sites will undergo further refinement to accommodate the specific technology, which is referred to as the detailed design stage. The draft DCO includes a requirement for the submission of a detailed BSMP which will be prepared in accordance with the oBSMP and will be approved by the relevant county authorities. The detailed BSMP will be implemented as approved.

1.1.13 Separate to the oBSMP, the Emergency Response Plan will provide information that supports operators and the FRSs in effectively responding to an incident at the BESS Sites. It shall include information such as BESS site plans, contact information, infrastructure details and emergency procedures and is required by National Fire Chiefs Council guidance. The plan will be shared for the construction, operation and decommissioning.

1.1.14 This oBSMP and Emergency Response Plan will be reviewed regularly both prior to commencement of development and during the operational period, and the FRSs and Environment Agency (EA) will be consulted on the detailed BSMP prior to its formal submission. The FRSs will be notified should there be any changes that would impact their response.

1.1.15 **Table 1.1** details how the Applicant will adhere to the guidance in the NFCC Grid Scale Battery Energy Storage System planning – Guidance for FRS (2022) or alternative guidance where modified. These will be secured in the **Outline Design Parameters [EN010159/APP/5.9]** and/or the Height Parameter Plan found in **Site Layout Plans [EN010159/APP/2.5]**.

Table 1.1: Battery Fire Safety Compliance Checklist for the Proposed Development

Ref	Required by	Description	How this BSMP adheres to guidance	Adheres to
1	Industry best practice	The separation distance between the BESS and transformer will be a minimum of 6 m unless sufficient 3rd Party data demonstrates less is safe (as agreed with the FRS)	The illustrative design shows at least 6 m spacing. It should be noted that NFPA 855[1] and Factory Mutual (FM) Global 5-33[2] allows a smaller distance of 3 m and 1.5 m respectively.	Adheres to industry best practice using mitigations.
2	National Fire Chiefs Council (NFCC) NFPA 855 (2023)	Each group of battery enclosures, inverters and transformers will be separated from the next by a minimum of 6 m, unless sufficient UL 9540A testing and/or 3rd Party Fire and Explosion testing heat flux data can be provided, and it is agreed with the FRS. Each BESS group shall be spaced a minimum 0.9 m from other groups unless evidence from relevant testing approves smaller group spacing and LPA permits it	NFCC guidance references FM Global 5-33 (2017)[3]. The 2024 revision of this document provides an updated recommended separation distance of 1.5 m for Lithium Iron Phosphate (LFP) ESS. This is stricter than the NFPA 855 requirement. The design shows 6 m separation between each group of BESS which is compliant with the standards. The separation between BESS units installed back-to-back currently is 0.15 m. • UL 9540A compliant equipment • 1 hour fire rated BESS enclosures • 8m spacings implemented between larger battery islands. • Appropriate fire suppression systems shall be installed. Additional information and justification to be provided by a competent fire engineer at later project stages.	Mitigations to NFCC provided. Compliant with latest international standard FM Global 5-33 (2024)
3	NFCC NFPA 855 (2023)	The separation distance between the BESS enclosures and a hedge or tree will be a minimum of 10 m from the edge of the canopy.	There shall be no vegetation within 10 m of the proposed BESS enclosures. To mitigate fire risk, vegetation shall be trimmed so that it is at least 3 m away from the closest enclosure around the perimeter as per the min. requirements of NFPA 855 (2023)[1].	Compliant with NFCC. Mitigations proposed. Compliant with latest international standard NFPA 855 (2023)

[1] N. F. P. Agency, "NFPA 855 - Standard for the Installation of Stationary Energy Storage Systems," 2023.

[2] F. Global, "5-33 Lithium-Ion Battery Energy Storage Systems," October 2024. [Online]. Available: https://www.fm.com/resources/fm-data-sheets#rbdatasheetssearch_datasheets%20product%20type=05.%20Electrical&rbdatasheetssearch_o=Datasheets%20Name%2CAscending.

[3] F. Global, "FM Global 5-33 - Lithium-Ion Battery Energy Storage Systems," 2017

Ref	Required by	Description	How this BSMP adheres to guidance	Adheres to
		Areas within 3m on each side of outdoor energy storage system (ESS) shall be cleared of combustible vegetation and other combustible growth.		
4	NFCC NFPA 855 (2023)	BESS will be separated from the site boundaries by a minimum of 25 m prior to any mitigations. ESS located outdoors shall be separated by a minimum 3 m from lot lines prior to any mitigations	The distance of BESS from the compound Site red line boundaries shall satisfy the minimum requirement of the current NFCC document or any future revisions. The minimum distance of BESS to the Site red line boundaries will satisfy the requirement as it will be within the Proposed Development. To mitigate any risks the following will be implemented: • UL 9540a compliant equipment • 1 hour fire rated BESS enclosures • Appropriate fire suppression systems shall be installed • Fire hydrants located around the BESS Sites NFPA 855 (2023)[1].states that separation may be reduced up to 0.9 m with a 1-hour fire barrier.	Compliant with NFCC. Mitigations proposed. Compliant with latest international standard NFPA 855 (2023)
5	NFPA 855 (2023)	BESS will be separated from any public rights of way by a minimum of 3 m (10 ft).	The closest Public Right of Way is located approximately 70 m south of the nearest BESS unit at the West BESS Site and over 100 m west from the nearest BESS unit at the East BESS Site, exceeding NFPA 855 (2023)[1] minimum requirements. The BESS Sites shall adhere to NFPA 855.	Compliant with latest international standard NFPA 855 (2023)
6	NFCC NFPA 855 (2023) NFPA 855 (2023)	BESS will be separated from any occupied buildings by 25 m prior to any mitigations. ESS located outdoors shall be separated by a minimum 3 m from buildings prior to any mitigations.	All buildings on the BESS Sites including the control building are greater than 10 m from any BESS unit. There is a farm located over 25 m away from the East BESS Site. The BESS Sites shall comply with NFPA 855[1] and ensure there are appropriate mitigations. The following additional mitigations are proposed: • Battery units shall have a 1-hour fire rated enclosure. • Control building is not normally occupied. The control building will only be occupied for maintenance activities by	Compliant with NFCC / NFPA 855

Ref	Required by	Description	How this BSMP adheres to guidance	Adheres to
		ESS installed in remote area is defined to be located more than 30.5 m from buildings, lot lines that can be built upon, public ways, stored combustible materials, hazardous materials, high piled stock, and other exposure hazards not associated with electrical infrastructure grid.	personnel trained in BESS safety and fire protocols and full safety precautions will be implemented.	
7	NFPA 855 (2023)	BESS will be separated from stored combustible materials by a minimum of 3 m (10ft).	A minimum 3 m will be adhered to.	Compliant with NFPA 855 (2023)
8	NFPA 855 (2023)	BESS will be separated from hazardous materials by a minimum of 3 m (10 ft).	A minimum 3 m will be adhered to.	Compliant with NFPA 855 (2023)
9	NFPA 855 (2023)	BESS will be separated from high-piled stock by a minimum of 3 m (10 ft).	A minimum 3 m will be adhered to.	Compliant with NFPA 855 (2023)
10	NFCC	Mains water supply	Will be addressed in detailed BSMP. Provision for minimum firewater is described below in row 11 and 12 as well as in **Section 4.4**.	Will be addressed in detailed BSMP
11	NFCC	Fire-fighting water tanks will be located a minimum distance of 10 m from the nearest BESS enclosure (ideally upwind from the prevailing wind direction).	Fire water tanks are located at more than 10 m away from BESS enclosure.	Compliant with NFCC
12	NFCC	Hydrant supplies for boundary cooling purposes should be located close to BESS enclosures (but considering safe access in the event of a fire) and should be capable of delivering no less than 1,900 litres per minute for at least 2 hours.	Hydrants are located close to BESS enclosures and shall deliver the required amount of water of at least 1,900 l/min for at least 2 hours.	Compliant with NFCC
13	NFCC (Undefined - Dead end access)	Vehicle turning facilities will be provided in any dead-end access route that is longer than 20 m.	There are no dead-end access routes longer than 20 m onsite. Passing places shall be provided onsite, where required.	Compliant with NFCC
14	NFCC (Undefined - Min. access road width)	The minimum access road width to reach a BESS facility will be 4 m, with two access points.	The design will consider two access points. The access roads shall be 6 m in width respectively. This shall be verified by a swept path analysis.	Compliant with NFCC

Ref	Required by	Description	How this BSMP adheres to guidance	Adheres to
15	NFCC	Consideration given to management of water runoff (e.g. drainage systems, interceptors, bunded lagoons etc) and suitable environmental protection measures should be provided.	Appropriate drainage design to collect possible firewater runoff detailed in **Section 5.1**.	Compliant with NFCC
16	NFCC	Signage installed in suitable and visible location on the outside of BESS units identifying the presence of BESS system	Signage requirements will be adhered to.	Compliant with NFCC
17	Industry best practice	All installation, maintenance and access to battery enclosures is from the outside. No personnel will ever be able to be inside a battery enclosure due to enclosure design.	No personnel access to battery enclosure at all times.	Compliant with industry best practice
18	NFCC	Details of any evidence-based testing of the system design should be requested, for example, results of UL 9540a testing.	Units will be UL 9540a compliant. Specific testing details including UL 9540a shall be provided at a later stage once battery supplier has been selected.	NFCC
19	NFCC	Effective and appropriate method of early detection of a fault within the batteries should be in place, with immediate disconnection of the affected battery/batteries	Automatic temperature, gas, fire and smoke detection systems within enclosures to identify fire as early as possible and activate external audible and visual warnings and activate the appropriate suppression mechanisms. Battery Management System (BMS) shall automatically shutdown or disconnect affected cell. Fire Alarm Control Panel (FACP) to identify type and location of fire. Further detailed in **Section 3.5**.	NFCC
20	NFCC	Suitable suppression systems shall be installed in units to prevent or limit propagation between modules. They shall be designed by a competent system designer	Appropriate fire suppression systems shall be installed. A design risk assessment shall be carried out to ensure the fire suppression system will effectively contain the fire, off gassing and reduce the potential of thermal runaway and reignition. Further detailed in **Section 3.5**.	NFCC
21	NFCC	BESS enclosures shall be fitted with deflagration and explosion protection and venting.	Adequate ventilation systems to prevent the build-up of gases shall be provided and shall vent away from access, escape routes and personnel. Deflagration and explosion protection may be fitted onto enclosures.	NFCC

Ref	Required by	Description	How this BSMP adheres to guidance	Adheres to
22	NFCC	Emergency Plans including Risk Management and Emergency Response Plans (ERP) shared with the FRS.	An ERP shall be developed in consultation with the local FRSs and include information to assist operators and firefighters in an effective fire response. These shall be reviewed and updated regularly. A risk management plan shall be developed, see **Section 4.7** for details.	NFCC
23	NFCC	Post-incident hazards and mitigations should be addressed in post-incident recovery Plan.	Post-incident recovery plan and mitigations are detailed in **Section 4.8**.	NFCC

2. Introduction

2.1 Scope of this Document

2.1.1 One Earth Solar Farm Ltd (hereafter referred to as the 'Applicant') has prepared this Outline Battery Safety Management Plan (oBSMP) in relation to an application for a Development Consent Order (DCO) for the construction, operation and maintenance, and decommissioning of the One Earth Solar Farm (hereafter referred to as the 'Proposed Development'). The terminology used in this document is defined in the **Glossary of Terms and Abbreviations [EN010159/APP/7.17].**

2.1.2 A DCO would provide the necessary authorisations and consents for the Proposed Development which comprises comprises the construction, operation and maintenance, and decommissioning of a solar photovoltaic (PV) array electricity generating facility. The project includes solar PV panels, Battery Energy Storage Systems (BESS), onsite substations and associated grid connection infrastructure which will allow for the generation and export of electricity to the proposed National Grid High Marnham Substation.

2.1.3 This document specifically examines the fire safety risks associated with the two BESS installations at One Earth Solar Farm located in Nottinghamshire. In particular, it considers risks which will occur during the operation and maintenance phase and **Table 1.1** explains the measures included to mitigate those risks. It considers the National Fire Chiefs Council (NFCC) guidance document[4] on fire safety for grid-scale BESS projects and other best practice fire safety standards and recommendations.

2.1.4 The illustrative layout has used proven battery concepts which comply with current applicable safety guidance and relevant standards. In the event that the DCO is granted, a competitive bidding process will be conducted to select a battery technology that includes rigorous fire and battery safety requirements. Subsequently the BESS Sites will undergo adjustments to accommodate the technology in what is referred to as the detailed design stage, which will be within the parameters approved in the **Outline Design Parameters [EN010159/APP/5.9]** and/or Height Parameter Plan found in **Site Layout Plans [EN010159/APP/2.5]** of the DCO application.

2.1.5 Risks during construction are considered to be standard for a construction project and will be addressed elsewhere using construction industry standard techniques. These risks will be detailed in the **Outline Construction Environmental Management Plan [EN010159/APP/7.5]**.

[4] NFCC, "Grid Scale Battery Energy Storage System Planning - Guidance for FRS," 2022.

2.1.6 Risks associated with ancillary equipment required to connect the BESS to the electrical network are considered to be standard for transmission and distribution (T&D) equipment and shall be addressed in Employer's Requirements and covered in relevant BS/IEC standards.

2.1.7 This document summarises the safety considerations already accounted for in the development of these BESS Sites, inviting the local Fire and Rescue Service (FRS) to review and comment. Initial discussions with the FRSs have taken place to introduce them to the Proposed Development and inform them that the Applicant will comply with NFCC guidance and relevant legislation in **Section 2.5**. The FRSs have been invited to review the Outline BSMP. A detailed Battery Safety Management Plan (BSMP) for the Proposed Development will be produced following grant of the DCO, appointment of contractor(s), and prior to the start of construction of the Proposed Development. The detailed BSMP will be prepared in accordance with this Outline BSMP as a requirement of the DCO. The detailed BSMP will be approved by the relevant local planning authorities following consultation with the Lincolnshire FRS, the Nottinghamshire FRS and the Environment Agency, prior to the commencement of works for the BESS.

2.2 Description of Proposed BESS

2.2.1 The proposed BESS installation has been sized in order to take the full generation capacity from the solar PV. It comprises the BESS installation itself, plus associated plant and equipment required to store and connect the system to the electrical supply network and other ancillary infrastructure. BESS are proposed in two locations within the Proposed Development, one either side of the River Trent. For the purposes of this report, the two locations where BESS are proposed are referred to as the West BESS Site and East BESS Site.

2.2.2 The proposed locations are in the vicinity of the existing High Marnham substation, primarily in Nottinghamshire, but partly in Lincolnshire. The closest public right of way to the East BESS Site is approximately 100 m west of nearest battery unit at the East BESS Site. The closest public right of way to the West BESS Site is approximately 70 m away. Although the BESS is split between two areas of the Proposed Development, the safety measures outlined in this report shall be implemented across both locations to maintain consistent safety standards throughout the project.

2.2.3 Associated equipment on the BESS Sites includes electrical cables, electrical metering, substations, transformers, circuit breakers, current and voltage transformers etc. The associated equipment can be considered as mature and closely similar to equipment which has been in use for many years in the UK electrical transmission and distribution network. All such associated equipment will be installed, operated and maintained in strict accordance with established electricity industry standards and guidelines including, but not limited to, IEC 61936-1[5].

2.2.4 The BESS installation will use lithium-ion (li-ion) battery techonolgy or a similarly stable chemistry, with alternatives considered during procurement if deemed more suitable. Illustrative layouts for the West and East BESS Sites are provided in **Figure 2.1** and **Figure 2.2**, respectively, although it should be noted that for the purposes of the Enviromental Impact Assessment, a parameters-based approach has been adopted as described in **ES Volume 2, Chapter 5: Description of the Proposed Development [EN010159/APP/6.5]**. The illustrative layouts are also included in **Appendix A** – **West Bess Illustrative Layout** and **Appendix B – East Bess Illustrative Layout**. This is subject to change as the detailed battery technology is identified, and the design is finalised.

[5] IEC, "IEC 61936 - Power installations exceeding 1 kV AC and 1.5 kV DC," 2021.

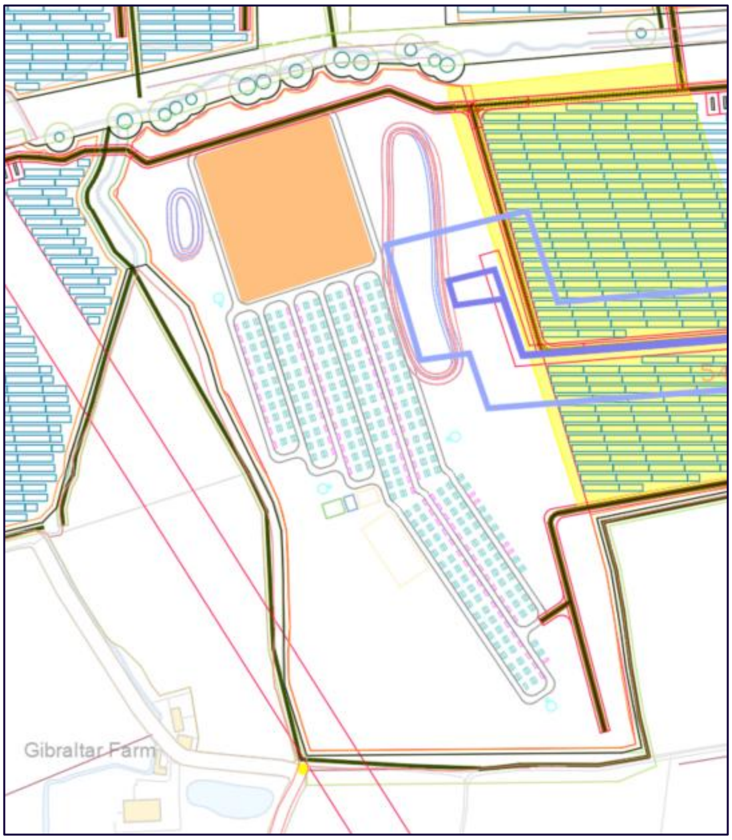


Figure 2.1: Illustrative Layout West BESS Site

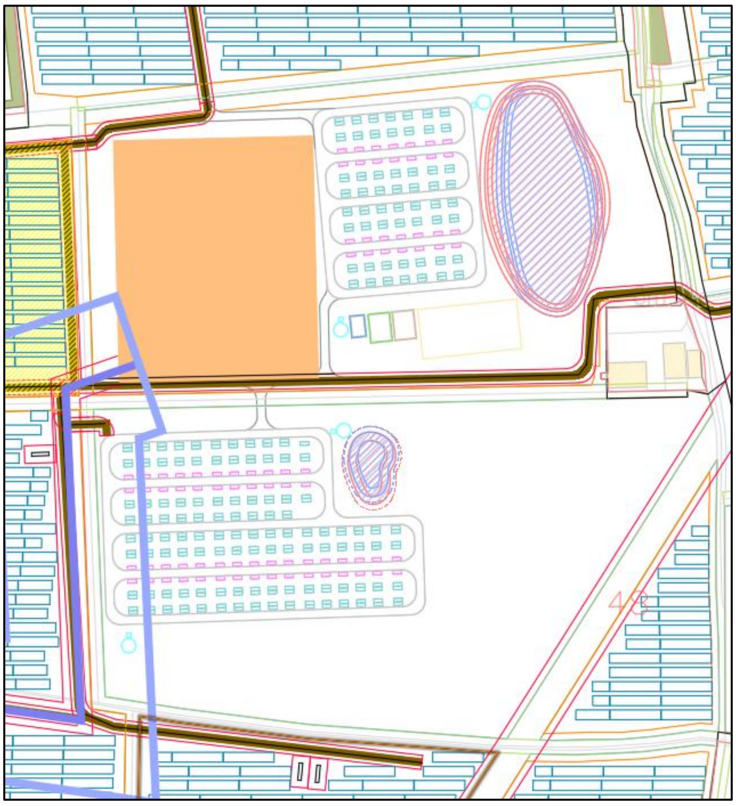


Figure 2.2: Illustrative Layout East BESS Site

2.3 Potential BESS Failure

2.3.1 The main failure modes of li-ion batteries and the methods of mitigation to reduce the risk are detailed in **Table 2.1** below.

Table 2.1: Failure Modes and Mitigation

Failure Mode	Description	Mitigation
Electrical Failure	An electrical failure can occur if the battery is overcharged, over-discharged, undercharged or charged too rapidly. Insulation faults, short circuit or power surge can also cause damage to the battery. These conditions can cause internal overheating and lead to thermal runaway and eventually fire.	Control systems in the BMS will continuously monitor battery conditions and utilise automatic circuit breakers to protect equipment during a fault condition. The control systems will also be set to keep the BESS within safe parameters of operation as dictated by the Original Equipment Manufacturers (OEMs) operation manuals/guidance. Refer to BMS section in **Section 3.5**.
Mechanical Failure	Mechanical abuse of the battery can be caused by compression and deformation of the battery container, including collision or vibration during transportation or movements around the battery enclosures.	Quality checks on equipment at point of manufacture ensure that components and systems are not damaged prior to shipping. Damage to the battery will be prevented by protecting the internal systems through the robust design of the enclosures. Care must be taken when transporting and installing battery units. Packing and handling shall be in accordance with the manufacturer's guidance. Upon arrival to the BESS Sites, units will be inspected to ensure there is no damage prior to further handling and installation. Impact protection barriers will be implemented on the BESS Sites in key locations where there is a risk of accidental collision or other potential impacts that could compromise safety Permit to Work (PTW) procedures, which will mitigate the risk of accidental damage during installation and maintenance, shall be established at the BESS Sites. A regular maintenance schedule in accordance with manufacturer/supplier requirements will be developed to identify any damage or defect at the BESS Sites and will be performed by experienced personnel.
Thermal Failure	Thermal failure occurs when the BESS is subjected to or is operating at temperatures outside its specified operating range. This can lead to premature ageing of the battery or even complete failure and result in a fire event. This issue can occur if exposed to external heat sources, overheated adjacent cells and high environmental temperatures.	Chemistry selected shall be LFP technology, with a higher thermal runaway temperature which makes it more thermally stable and less prone to thermal runaway. Thermal safety measures such as ventilation and cooling of the batteries will be in place to ensure efficient heat dissipation to manage the temperature of the system. Redundant systems ensure cooling system availability is protected in the event of cooling system primary power failure.

Failure Mode	Description	Mitigation
Environmental Impacts	Seismic events, extreme ambient temperatures, high wind speeds and high levels of solid or water ingress and damage caused by debris.	The Applicant's approved suppliers list shall be rigorous in this regard and will only adopt robust technologies for the expected environmental conditions of the area. The units will be ingress protection rated to IP55. They shall withstand high-wind speeds and seismic forces however seismic events are very unlikely in the Nottinghamshire area. The ambient temperatures of the BESS Sites will be within the design temperature range. The BESS and substations will be sited outside of flood zones 2 and 3.
System Faults	Manufacturing defects or failure of the control and instrumentation systems can lead to failure in monitoring the operating environment of the BESS.	Manufacturing faults will be protected by quality processes (Factory Acceptance Tests (FAT), Site Acceptance Tests (SAT) and Inspection and Test Plans (ITP)) as the first line of defence. Faults shall be detected and managed by the BMS and the Energy Management System (EMS). The BMS continuously monitors the individual cell condition, measuring its operating parameters and states, such as such as state-of-charge (SoC) and state-of-health (SoH), it also regulates the charge and discharge of batteries and ensures that the battery is within safe operational limits. EMS provides stability, resilience and reliability by communicating with the Power Conversion System (PCS) and BMS to monitor and control the flow of energy within the BESS. It optimises the charge-discharge cycles to guarantee safe operation while flagging any issues to the operators.

2.4 BESS Safety/Hazards

2.4.1 The safety objectives for the design of the BESS are:

- To minimise the likelihood of an event. This is the overriding priority.
- To minimise the consequences should an event occur.
- To restrict any event to the BESS Sites and minimise any impact on the surrounding areas.
- To automatically detect and begin to fight a fire as soon as possible.
- To ensure any personnel onsite are able to escape safely away from the BESS Sites.
- To ensure that firefighters can operate in reasonable safety where necessary.
- To ensure that fire, smoke, and the spread of gasses do not significantly affect occupants in surrounding buildings and areas.

2.4.2 The following sections set out the design responses that will be incorporated into the Proposed Development in order to achieve these safety objectives in **Section 2.4.1**.

2.4.3 Should the unlikely event of BESS failure occur, hazards associated with the installation are outlined below. Hazard Mitigation Analysis (HMA) will be conducted to provide a record of the decision-making process for fire prevention.

2.4.4 **Figure 2.3** shows the bow-tie diagram of the potential conditions and control measures and the potential outcomes and their mitigation. The diagram shall be detailed further during the detailed design stage once a battery manufacturer is selected in a specific HMA and will be included in the detailed BMSP.

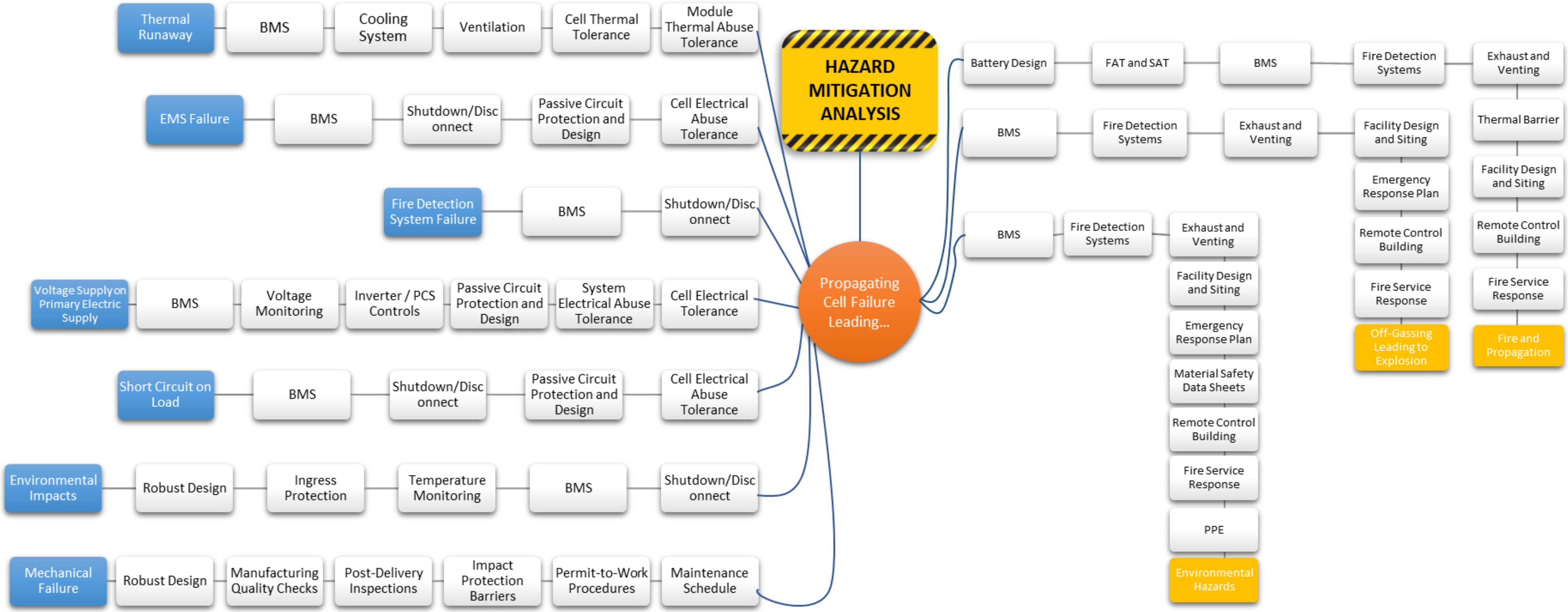


Figure 2.3: Bow-tie Diagram for BESS

Thermal Runaway

2.4.5 Lithium-ion batteries have the risk of catching on fire if they overheat or are subject to physical damage or any of the issues as highlighted in **Section 2.3**. If damage occurs, it can result in a short circuit, the battery will heat up to very high temperatures in a process called thermal runaway. As the battery cells rapidly degrade, they can produce significant amounts of heat, off-gassing, smoke and eventually cause it to ignite. If not detected and controlled, it can lead to a fire. If the cell explodes it may affect adjacent cells, damaging them and in turn causing the fire to propagate between cells. The rapid overheating occurring during thermal runaway may not be visible compared to conventional fires however is still detectable by robust temperature and gas detection systems and BMS. The rapid overheating can be detected by temperature detection systems and consequently the affected cell can be shutdown before thermal runaway actually occurs to the extent that it would lead to ignition.

2.4.6 LFP batteries are less prone to thermal runaway due to being more chemically stable compared to other lithium-ion chemistries. The risk of thermal runaway propagation between batteries can be mitigated by good battery design and ensuring there is adequate spacing between units. UL 9540A[9] details the test method for evaluating thermal runaway fire propagation in BESS. All BESS installed on site shall be tested to this standard and demonstrate that unit level performance criteria are met.

2.4.7 In the event of a fire, toxic and flammable gases such as carbon monoxide and hydrogen may be released. While smoke and temperature sensors are standard in battery units, it is considered industry best practice to include a gas detection system that can shut down the units upon detection of combustible gas. The potential for the release of dangerous gases is low, however the risk must be properly mitigated by design and operational controls.

Combustion Products

Solids

2.4.8 Solid, corrosive and toxic post-combustion products may be present following a fire event. To minimise the likelihood of firefighters encountering these harmful substances, appropriate personal protective equipment (PPE) should be worn. Details on hazardous battery compounds, decomposition by-products and material safety data sheets (MSDS) shall be provided by cell manufacturers.

Gases and Smoke

2.4.9 A plume assessment assessment has been conducted to assess the potential impact to air quality in the unlikely event of unplanned emissions to the air from the BESS , found in **Appendix C – Unplanned Emissions Assessment**. This shall be re-run at detailed design to confirm the effects will not be worse than the original assessment.

2.4.10 **Figure 2.4** shows the wind rose for North Clifton which is between both BESS Site locations. The prevailing wind direction for North Clifton is from the west-southwest to the northeast, this factor shall be taken into account in the design of the access points for the BESS Sites. The prevailing wind direction for the BESS Sites and surrounding towns of South Clifton, Fledborough and Ragnall are also from the west-southwest to the northeast.

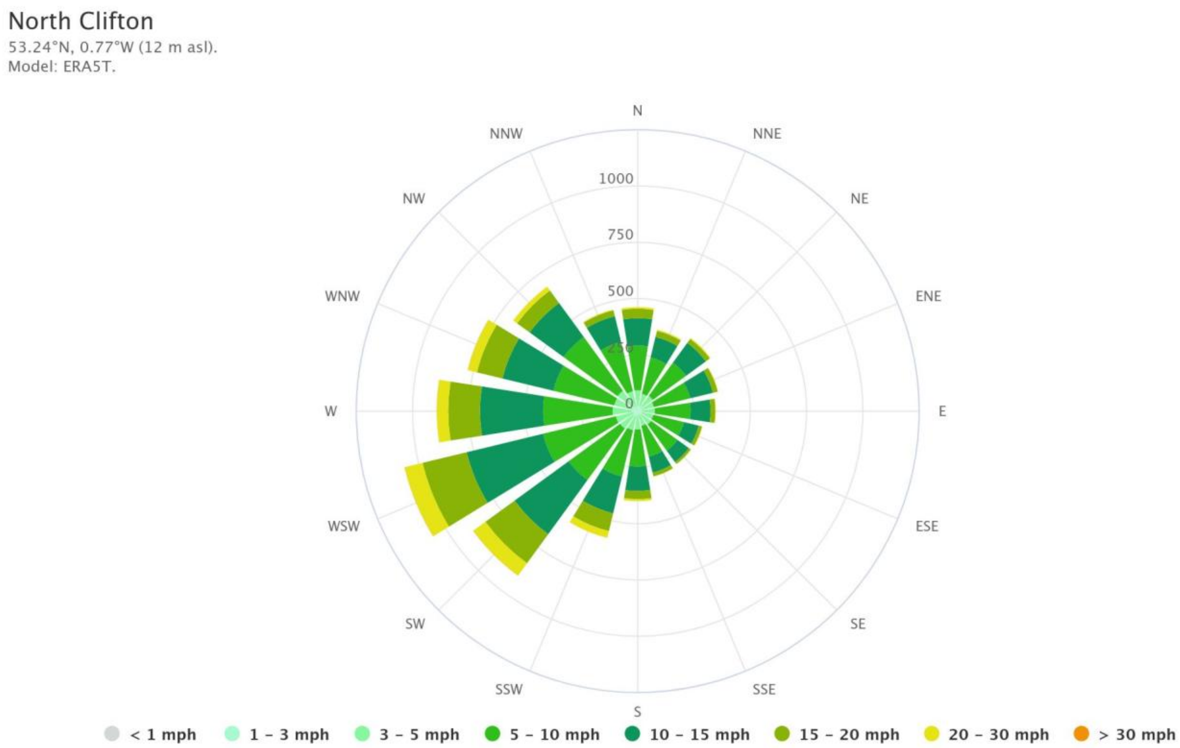


Figure 2.4: Wind Rose for North Clifton, Nottinghamshire

2.4.11 There shall be two points of access for each BESS Site as described in **Section 4.3** providing an alternative access route for fire service personal so that there is a lower probability of smoke precluding firefighting access.

2.4.12 Dispersion modelling and a risk assessment (Process Hazards Analysis Software Tool (PHAST) or similar) can be carried out once more information on specific suppliers is known, if required. This would be able to provide more detailed information around the potential risks. Modelling from similar projects suggest that the distance to the nearest residential area is sufficient to minimise risk[6] [7].

---

[6] C.C.G. Ltd., AIR QUALITY DISPERSION MODELLING AND RISK ASSESSMENT FOR TRANSALTA CORPORATION WATERCHARGER PROJECT, 2022.

[7] T.T. Limited, *Environmental Statement Addendum: Air Quality Impact Assessment of Battery Energy Storage Systems (BESS)* Fire, 2024.

2.4.13 According to the 2017 DNV report OAPUS301WIKO(PP151894)[8], studying the risks when installed inside a building, the levels of toxicity were found to be similar to that of a plastics fire. The toxicity of the battery fires was found to be mitigated with ventilation rates common to many occupied spaces. Harmful smoke and gas emissions shall dissipate in the outdoor environment.

Electric Shock

2.4.14 When an alarm is raised, the battery will be automatically disconnected and isolated from the grid. Should there be damage to any electrical protection equipment, there is a risk of electric shock as the batteries may still hold a residual charge. Responders should confirm if the BESS has been disconnected and treat any exposed cables or equipment as "live". A controlled burn strategy is expected to be adopted as detailed in **Section 4.2** so it is expected that firefighters will only point water jets at battery units adjacent to the fire to prevent propagation, thus reducing the risk of electrocution. Residual charge should not pose an electrical shock risk when firefighting with water but if fire has damaged electrical protection may be a risk if firefighters touch exposed cables.

2.5 Relevant Guidance

2.5.1 Guidance documents and standards considered by the Applicant in the design and selection of these systems have been used to inform the design of the BESS Sites.

2.5.2 There is currently limited UK specific guidance for BESS installations, however the Applicant operates globally and incorporates good practice from around the world.

2.5.3 The Applicant will develop the BESS in accordance with all relevant legislation and good practice, such as NFCC guidance. Where any variation occurs, this will be agreed with Lincolnshire and Nottinghamshire Fire and Rescue Services through justified evidence.

2.5.4 This document takes into account, and the detailed BSMP will take into account, the recommendations of the following good practice documentation used in the UK for similar sites, including but not limited to **Table 2.2**.

[8] D. GL, "Considerations for ESS Fire Safety, Report No. OAPUS301WIKO(PP151894), Rev. 4," 2017

Table 2.2: Relevant Guidance and Legislation

Standard Identifier	Title	Issued By	Applicability
Grid Scale Battery Energy Storage System planning – Guidance for FRS[4]	Grid Scale Battery Energy Storage System planning – Guidance for FRS	National Fire Chiefs Council. UK	Provides guidance for the fire service on assessing the risk management process of BESS installations and supporting the FRSs in providing consistent and evidence-based contributions to the planning process. It should be noted that NFCC guidelines have been revised and published for consultation. As these are not yet enforceable this document references the 2022 version. However, the following changes to the guidance shall also be considered in the future design stages, some of these changes include: • Reduction in recommended spacing without heat flux / Computational Fluid Dynamics (CFD) analysis. • Reduction in water supply requirements 180000 l of water (1500 l/m for 2 hours). • Consideration for firefighting tactics “defensively fire fight and boundary cool whilst allowing the BESS to consume itself” which may reduce firewater capture requirements. • More clear turning / access requirements.
FM Global DS 05-33 July 2024[2]	Property Loss Prevention Data Sheets	FM Global	FM Global is an American mutual insurance company with an Engineering specialism. This data sheet describes loss prevention recommendations for the design, operation, protection, inspection, maintenance, and testing of electrical energy storage systems (ESS) that use lithium-ion batteries. FM Global have identified thermal runaway, electrical fire, and potential for explosion due to insufficient venting as the principal risks for property loss for a BESS system.
NFPA 855[1]	Standard for the Installation of Stationary Energy Storage Systems	National Fire Prevention Association. USA	A new standard was developed by a United States (US) organisation to define the design, construction, installation, commissioning, operation, maintenance and decommissioning of stationary ESS. Provides a general reference for this document and its safety principles are applicable worldwide.

Standard Identifier	Title	Issued By	Applicability
UL 9540A[9]	Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems	Underwriter's Laboratory. USA	Guidance document applicable to BESS facilities and used to aid the manufacturing and testing process for BESS.
IEC 62619[10]	Safety requirements for secondary lithium cells and batteries	International Electrotechnical Committee. Europe	Specifies requirements and tests for the safe operation of BESS including general safety considerations such as ventilation and temperature management, impact tests and the prevention of over-charging.
IEC 61936[5]	Power installations exceeding 1 kV AC and 1,5 kV DC – AC	International Electrotechnical Committee. Europe	Provides guidance on for inverters and transformers and other equipment associated with BESS.
BS 5839[11]	Fire Detection and Fire Alarm Systems for Buildings	British Standards Committee. UK	Provides guidance on fire detection and alarm systems that will be designed and installed on the BESS Sites.
IEC 62281[12]	Safety of primary and secondary lithium cells and batteries during transport	International Electrotechnical Committee. Europe	Provides guidance on the testing and requirements to ensure the safety of BESS during transport as well as the packaging used.
BS EN 15004[13]	Fixed firefighting systems. Gas extinguishing systems	British Standards European Norm. UK	Provides guidance on extinguishing systems.
BS 6266[14]	Fire protection for electronic equipment installations – Code of practice	British Standards Committee. UK	

[9]U. Laboratory, "UL 9540a - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems," 2019

[10] IEC, "IEC 62619 - Safety Requirements for Secondary Lithium Cells and Batteries," 2022

[11] B. Standards, "BS 5839 - Fire Detection and fire alarm systems for buildings," 2023

[12] IEC, "IEC 62281 - Safety of primary and secondary lithium cells and batteries during transport," 2019

[13] B. Standards, "BS EN 15004 - Fixed Firefighting Systems. Gas Extinguishing Systems," 2024

[14] B. Standards, "BS 6266 - Fire protection for electronic equipment installations. Code of practice.," 2011

Standard Identifier	Title	Issued By	Applicability
BS 5306-8[15]	Fire extinguishing installations and equipment on premises – selection and positioning of portable fire extinguishers	British Standards Committee. UK	Provides guidance on type, quantity and location of fire extinguishers.
BS EN 60079-29-2[16]	Explosive atmospheres. Gas detectors. Selection, installation, use and maintenance of detectors for flammable gases and oxygen	British Standards European Norm. UK	Provides guidance on fire and gas detection and alarms
BS EN 12101[17]	Smoke and heat control systems	British Standards European Norm. UK	Provides guidance on some and heat venting.
NFPA 204[18]	Smoke and Heat Venting	National Fire Prevention Association. USA	Provides guidance on calculating vent areas for fire safety.
NFPA 68[19]	Explosion protection by deflagration venting	National Fire Prevention Association. USA	Provides guidance on design, installation and maintenance of deflagration vents.
NFPA 69[20]	Explosion prevention systems	National Fire Prevention Association. USA	Covers the minimum requirements for installing systems for the preventions of explosions.
	The Regulatory Reform (Fire Safety) Order (RRO) 2005[21]	UK Government. UK	Governs the fire safety in England and Wales. Applies to almost all non-domestic premises, including commercial buildings and workplaces, ensuring fire safety and reducing the risk of fire.

[15] B. Standards, "BS 5306-8 - Fire extinguishing installations and equipment on premises. Selection and positioning of portable fire extinguishers," 2023

[16] B. Standards, "BS EN 60079-29-2 - Explosive atmospheres. Gas detectors. Selection, installation, use and maintenance of detectors for flammable gases and oxygen," 2015

[17] B. Standards, "BS EN 12101-6 - Smoke and heat control systems," 2022

[18] N. F. P. Agency, "NFPA 204 - Standard for Smoke and Heat Venting," 2024

[19] N. F. P. Agency, "NFPA 68 - Standard on Explosion Protection by Deflagration Venting," 2023

[20] N. F. P. Agency, "NFPA 69 - Standard on Explosion Prevention Systems," 2024

[21] U. Government, "The Regulatory Reform (Fire Safety) Order 2005," October 2024. [Online]. Available: https://www.legislation.gov.uk/uksi/2005/1541/contents

3. BESS Safety Requirements

3.1 BESS Safety Introduction

3.1.1 This document outlines the safety considerations that will underpin the BESS Site designs and equipment, aiming to minimise the fire risk and reduce propagation pathways as far as reasonably practicable. By reviewing a range of best practice, parameters adopted in the application, applicable guidance and lessons learnt from previous projects, the design methodology will be specifically selected to reduce the risk of fire spread.

3.1.2 Firstly, equipment selection reduces the likelihood of fire propagation and equipment separation further reduces the risk of fire spread within the BESS Sites. If fire does propagate, two BESS Site entrances at each BESS Site allow for unimpeded access to the BESS Sites and the network of firewater across the BESS Sites ensure that the FRS are within a suitable distance of water, fed by static tanks. The BESS Sites satisfy the NFCC guidance and industry leading standards, as detailed later in **Table 3.2**.

3.1.3 A fire risk assessment will be developed at a later design stage, this will be underpinned by an HMA. This shall be separate to the BSMP and include BESS-specific emergency response, shut down procedures, etc. A clear fire response strategy will be developed with the local FRSs and copies kept on the BESS Sites at suitable locations and all access points.

3.2 BESS Components

3.2.1 The following section describes the BESS technologies and the components which make up the BESS, **Table 3.1** outlines the description of each.

Table 3.1: BESS Components

Term	Description
Battery Cells	Contains the electrodes, electrolyte and separator / membrane which allow the battery to store energy when submitted to an electrical current. Can have a range of battery chemistries such as lithium-ion.
Battery Module	Consists of several cells connected together in series or parallel.
Battery Rack	A collection of battery modules which are combined to create a rack. These racks tend to be modular so one could be used on its own or multiple racks could be combined to create a larger capacity battery.
Battery Unit	Containerised unit comprising of multiple battery cells, modules, racks, battery management system combining to produce a MWh storage capacity. All Battery Units considered for the BESS Sites shall be air or liquid cooled.
BESS	A containerised utility scale battery system, using lithium-ion technology, for the storage and release of electrical energy to aid in grid scale demand matching operations
BMS	Battery Management System (BMS) provides the control, monitoring and communications for the batteries as well as controlling any individual module cooling systems.
EMS	Energy Management System (EMS) monitors and controls the flow of energy within the BESS for efficient operation.

Term	Description
PCS	Power Conversion System (PCS) converts Direct Current (DC) battery power to AC power for connection to the surrounding electrical network. It consists of inverter and associated control systems. Depending on the manufacturer, some PCS units include the inverter transformers within their enclosures, while others are external, located nearby. Some PCS are integrated within the battery unit.

3.2.2 The BESS will use li-ion battery cells. There are multiple variants of li-ion batteries differentiated by the additives to the material of the cathode. The preferred chemistry for this BESS installation is Lithium Iron Phosphate (LFP). LFP is currently one of the most common chemistries used in grid scale BESS installations, it has a lower energy density but is considered to be safer compared to other chemistries. LFP is a more stable chemistry that is less prone to thermal runaway and overheating issues[22] [23].

3.2.3 If a demonstrably similar stable chemistry or a more stable chemistry is commercially available, then this will be considered during procurement. A plume assessment has been conducted to assess the potential air quality impacts associated with unplanned emissions to the air from the BESS, found in **Appendix C – Unplanned Emissions Assessment**. This assessment shall be re-evaluated during the detailed design stage to ensure that any emissions from potential fires do not exceed those identified in the original plume assessment. The final battery chemistry will be confirmed as part of the detailed design stage process before construction begins.

3.3 BESS Units

3.3.1 The BESS will be designed to be both operated and maintained remotely. During operation, the BESS Sites will be remotely managed and visited only for maintenance, inspections, and ongoing land and habitat monitoring and mangement. Access for operations and maintenance shall be conducted externally and will not require entry into either cubicles or containers.

3.3.2 The final technology has not been selected however, it is to be externally accessed and resemble a shipping container sized enclosure. The techonology selected shall prioritise safety and engineering performance.

3.3.3 The illustrative layout currently includes a high-density unit that combines the PCS and battery units within one enclosure, the MV station includes the RMU and transformer however this may be changed at a later stage of design. The BESS will consist of circa 110 MV stations at the West BESS Site and 82 MV stations at the East BESS Site. Next to each MV station unit there will be a footprint that can accommodate the required number of battery units. The final

[22] P. C. A. G. J. S. M. P. K. S. K. Zaghib, “LiFePO4 safe Li-ion polymer batteries for clean environment,” *Journal of Power Sources,* Vols. Volume 146, Issues 1–2, no. 0378-7753, pp. Pages 380-385, 2005

[23] J. N. D. D. J. C. S. F. B. Peter J. Bugryniec, “Pursuing safer batteries: Thermal abuse of LiFePO4 cells,” *Journal of Power Sources,* vol. 414, no. 0378-7753, pp. 557-568, 2019

number is subject to detailed design. The precise number and configuration of units is subject to change as battery technologies are rapidly evolving, however, an illustrative layout is shown in **Appendix A** – **West BESS Illustrative Layout** and **Appendix B – East BESS Illustrative Layout**. The battery units may have a distance less than described in **Table 3.2**, however, they will have appropriate an fire rating.

3.3.4 The illustrative design includes 764 battery / PCS units (439 units at the West BESS Site and 325 units at the East BESS Site); however, this is subject to detailed design. It should be noted that the overall footprint and heights will not vary greatly between suppliers however, the number and therefore capacity of each battery unit can vary.

3.3.5 The batteries will be compliant with testing requirements of UL 9540A Testing the fire safety hazards associated with propagating thermal runaway within battery systems[9] and demonstrate that fire will not propagate between cells, racks, and modules. The Original Equipment Manufacturer (OEM) shall provide the certification and evidence that confirms the adherence to the requirements and that testing will be undertaken by an approved testing laboratory. Analysis of test results shall be performed by an accredited testing laboratory.

3.3.6 The BESS must be designed, commissioned, and installed onsite in full accordance with the criteria given in the test. No deviations are permitted.

3.4 System Layout

3.4.1 The BESS system layout will provide adequate separation between key components or groups of key components. The BESS will be separated into discrete groupings of battery / PCS units and RMU / transformer containers.

3.4.2 Each group will be separated from other groups in order to contain any fire to the affected group and to allow access for emergency services in the event of an incident. Battery groups will be separated by adequate spacing and there will be no less than 3 m between groups. Larger separations will be used at strategic points across the BESS Sites to provide robust firebreaks and further reduce the probability of fire spreading.

3.4.3 Furthermore, compliance with the battery suppliers' BESS installation manual is deemed of high importance and should be followed regarding separation distances.

3.4.4 Separation of inverters and transformers will be dictated by the final technology and materials used and will comply with NFPA 855[1] and/or IEC 61936[5], whichever is the most onerous.

3.4.5 Areas between groupings and equipment shall be finished with gravel and shall be kept free of vegetation or any other material which could act to spread a fire.

3.4.6 According to NFPA 855[1], a minimum separation of 3 m (10 feet) will be maintained between BESS groupings and the following site features:

- Public rights of way
- Site boundaries
- Buildings
- Stored combustible materials
- High piled stock
- Any other exposure hazards not associated with electrical grid infrastructure.

3.4.7 The above noted limits may be reduced to 0.9 m where testing to UL 9540A has been successfully undertaken.

3.4.8 The separation between BESS enclosures and perimeter fence shall be a minimum of 1.5 m (5 feet) according to NFPA 855[1].

3.4.9 Comparing three standards, as summarised in **Table 3.2**, the BESS Sites have adopted the largest distance in each scenario.

Table 3.2: System Layout Standard Comparison

Item	NFPA 855 2023 (section)	FM Global 5-33 Jan 2024 (section)	NFCC Guidance November 2022	Adopted Distance
Battery unit to Battery unit	0.914 m (9.4.2.2)	1.5 m (2.3.2.2)	6.0 m	6.0 m
Battery unit to MV Station	NA	NA	NA	6.0 m
MV Station to MV Station	NA	NA	NA	≥6.0 m
Island to island: Battery unit	NA	NA	NA	8.0 m
Island to island: MV Station	NA	NA	NA	≥7.0 m

3.4.10 The layout groups rows of MV Station and BESS / PCS units into islands. Islands are separated by the internal access roads and have a separation of at least 8 m, further reducing the risk of fire propagation between units and allowing a wide space for operation, maintenance and if required firefighting.

3.4.11 NFCC guidance suggests a separation distance of 6 m between units unless suitable design features present an evidence-based case for reducing distances. The document refers to FM Global 5-33 (2017)[3], Section 2.3.2.2 which allows the separation of less than 6 m (20 ft) if a thermal barrier rated at 1 hour is provided. However, the NFCC guidance is outdated, as per FM Global 5-33 (2024)[2], the recommended separation distance for LFP ESS has been revised to 1.5 m.

Despite the updated recommendation, the BESS unit and MV Station installation adopts a separation of 6 m, incorporating all the relevant mitigations. The International standards from which the NFCC guidance was derived have since been updated in light of worldwide experience, battery chemistry developments and improved mitigation measures and standards required by lenders and insurers. It should be noted that the NFCC guidelines have been revised and published for consultation. For further information on the updated guidelines, please refer to **Table 2.2**.

3.4.12 If back-to-back units are used, this configuration will be supported by technical evidence and risk assessment to demonstrate that effective fire response and adjacent unit protection can be maintained.

3.4.13 All manufacturers' enclosures have a Fire Rating of a minimum 1 hour.

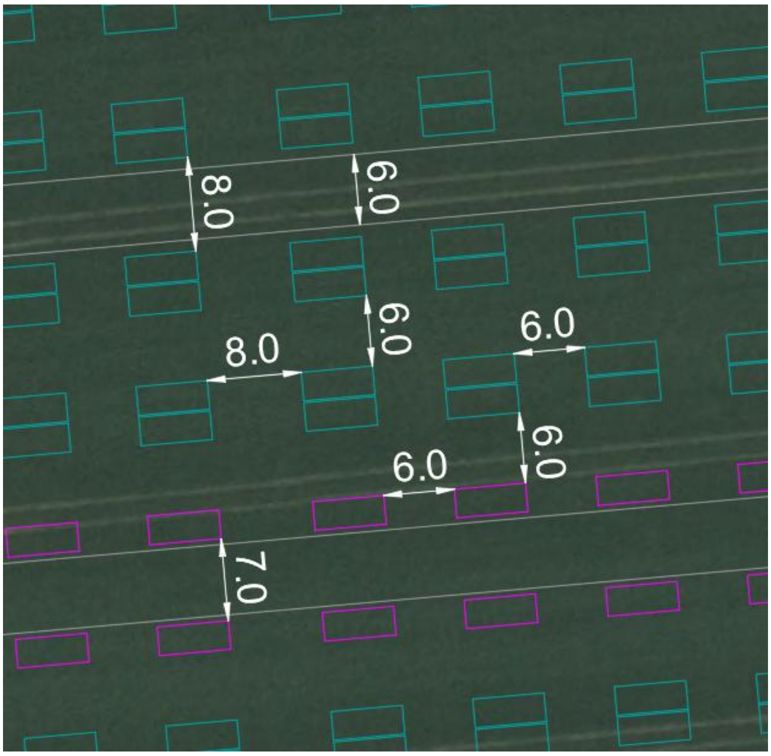


Figure 3.1.1 - BESS and MV Station Unit Spacing

3.4.14 The separation distance between vegetation and battery enclosures shall be 10 m as stated by the NFCC guidance and at minimum 3 m (10 feet) as stated by NFPA 8551. Vegetation shall be trimmed regularly to ensure they do not grow within the minimum of 3 m from the batteries.

3.4.15 Please refer to **Appendix A – West Bess Illustrative Layout** and **Appendix B – East Bess Illustrative Layout** for the illustrative BESS Site layouts which show one way in which the above layout commitments could be achieved.

Combustible Materials

3.4.16 Combustible materials shall not be stored in proximity to BESS equipment and storage of such material shall be covered in the Site Hazard Identification Study (HAZID) review process.

3.4.17 Combustible materials shall be stored at a distance greater than 0.9 m from the BESS equipment should they be required to be in close proximity, stated by NFPA 855[1]. Suitable storage facilities shall be provided for consumables, maintenance tools and other equipment at the BESS Sites.

3.5 Safety Design Features

3.5.1 The BESS and all associated equipment shall be designed to comply with all applicable standards and good engineering practice at the time of design and implementation. This is considered to be:

- NFPA 855[1]
- UL 9540[24]
- UL 9540A[9]
- IEC 61936[5]

3.5.2 Associated equipment, MV station, substations, transformers, switchgear, metering etc. and components such as cables shall be designed in accordance with established standards appropriate to the equipment type. Small transformers associated with the MV station will be MIDEL filled or filled with some similar low flammability ester and will adhere to IEC 61936 guidelines[5].

3.5.3 The PCS shall allow the system to dynamically control active and reactive power and meet all necessary operational requirements, grid connection and applications. All necessary self-protective and self-diagnostic features shall be included in the design of the PCS to enable it to monitor and react to internal and external failure or damage such as sensors, alarms and protection systems.

3.5.4 The BESS system design will incorporate appropriate provision for fire safety. These may vary slightly between manufacturers, but would typically include:

- Internal fuses
- Rack, string and bank level contactors
- Overcharge prevention safety device
- Internal separation layers

[24] U. Laboratory, "UL 9540 - Energy Storage Systems and Equipment," 2023.

- Fire and smoke detection with local and remote indication
- Automatic disconnection of AC power in the event of a fire or other major incident

3.5.5 The Applicant will provide certification and evidence that confirms the adherence of the BESS units to the requirements and that testing was undertaken by an approved testing facility. Where applicable, the BESS must be designed, commissioned and installed onsite in full accordance with the test criteria with no deviations permitted.

3.5.6 The final design will have a fire risk assessment produced in accordance with the Regulatory Reform (Fire Strategy) Order 2005[21].

3.5.7 In addition to fire suppression and detection systems and other systems of detecting fire, general fire prevention measures will be employed where applicable. Each BESS enclosure will have a fire rating of 1 hour. The specific system details will be determined in the detailed design stage.

Battery Management System

3.5.8 The BMS, along with fire suppression system(s) must possess robust detection capabilities to identify potential fire risks allowing the appropriate fire suppression mechanisms to be activated effectively, limiting fire damage and preserving the BESS.

3.5.9 It shall ensure that the battery is operating within safe limits by monitoring the following main conditions as a minimum:

- Overcharging/overvoltage – monitor and control voltage during charging so that they do not exceed voltage limits.
- Over discharging – discharging at a low state of charge (SoC) can lead to a short circuit so BMS will monitor and control discharging such that overcurrent limits are not exceeded.
- Extreme temperatures – BMS will monitor and stop operating if the cell temperature exceeds temperature limits and controls the rate of charge at specific low temperatures to prevent failure. Indoor and outdoor humidity will also be regulated.
- Imbalance – The BMS will monitor and regulate the cell during resting periods to balance SoC and state of health (SoH).

3.5.10 The BMS will monitor a minimum of 24 hours of pre and post-event data which shall be recorded and stored for long term data storage and retrieval.

3.5.11 The conditions will be monitored 24/7, 365 days a year by trained, experienced personnel from a remote control centre. Should any deviations be identified, the affected battery rack, or full enclosure shall be shut down automatically. Control centre personnel shall have the ability to remotely shut down enclosures if human intervention is required.

3.5.12 Operators shall be given clear guidance on how to respond through methods such as on screen or written procedures should any deviations to normal operating limits be identified.

3.5.13 Fire detection and suppression systems shall remain active via the Auxiliary supply should the mains supply fail.

Emergency Stop Switches

3.5.14 Emergency stop switches shall be provided at each grouping of batteries and shall trip all associated BESS inverters, isolate AC and DC breakers, and send a signal to the Fire Alarm Control Panel (FACP). Containerised BESS systems shall incorporate Emergency stops (E-stops) into the inverter control panel or local Human Machine Interface (HMI) and shall shut down only the affected BESS equipment train.

Temperature Management Systems

3.5.15 High ambient and cell temperatures can result in overheating of the batteries. This can eventually lead to thermal runaway if not identified and mitigated effectively. Temperature shall be monitored in each BESS dedicated-use room, cabinet or container. Battery cell temperature will be kept within limits by the BMS and displayed at the control facility where it will be continuously monitored. An air or liquid cooling system will ensure the internal temperature of the BESS enclosure is maintained.

3.5.16 Should temperatures exceed normal operating conditions a high temperature alarm will be raised, and heat diffusion mechanisms will be activated, mainly to suppress thermal runaway and reduce heat within the cell, module and container.

3.5.17 Experienced technicians and engineers will perform required checks in accordance with the BESS manufacturer’s instructions on a regular basis. This will be incorporated into the maintenance schedule of the BESS Sites.

3.5.18 Cell temperature readings can be reviewed to identify the source of the initial battery fire and the number of affected cells.

Fire and Gas Detection Systems

3.5.19 Battery units will include automatic fire and smoke detection systems within the enclosures above the batteries to identify fire as early as possible and activate appropriate suppression mechanisms. All BESS manufacturers have multiple layers of detection system, including gas, heat and smoke monitoring.

3.5.20 Very Early Smoke Detection by Aspiration (VESDA) systems detect minute smoke particles by continuously sampling the air within the enclosure. These will be installed to detect fire at an early stage. Fire detection systems will be employed at welfare areas to detect causes of fire that do not involve thermal runaway.

3.5.21 Fire Detection Systems shall comply with the following standards:

- BS EN 54
- BS EN 5839
- BS EN 12094

3.5.22 Gas detection systems will also be in place in all BESS enclosures to monitor the presence of flammable gases and instigate an emergency shutdown response should threshold limits be exceeded. Li-ion batteries will release combustible gas in the early stage of combustion and so gas detection systems will be key to identifying the early thermal runaway conditions. Specific gas detection systems can be installed to identify gases such as carbon monoxide and hydrogen.

3.5.23 Should any identifiers of fire be detected, or any components become offline or in a failed state, visual and audible alarms will be raised and displayed on the HMI. All detected systems shall be connected to a FACP for a battery or group of battery units. The FACPs will be connected to a Main FACP, this will be easily accessible to fire responders allowing them to identify the type and exact location of the fire.

3.5.24 After smoke, gas and temperature sensors detect a fire, an alarm will be raised, fire suppression systems will be activated, and the affected unit shall be shut down and isolated. The ventilation shall consequently exhaust any flammable gas, or smoke and allow thermal dissipation. Details of the fire suppression system and the following mechanisms are detailed in the following sections.

3.5.25 Should thermal runaway conditions i.e., overheating, off gassing etc, be detected, the fire service will be notified immediately, BESS Site operators will also attend to the BESS Sites to provide guidance as necessary.

3.5.26 Fire alarms shall be designed and commissioned by an LPS 1014[25] certified firm.

[25] BRE, “LPS 1014 - Requirements for certificated fire detection and alarm systems firm,” 2023

3.5.27 Gaseous systems shall be designed and commissioned by an LPS 1204[26] certified firm.

3.5.28 In case of fire alarms causing plant shutdown and similar actions, there will be a test performed to demonstrate this.

Fire Suppression Systems

3.5.29 Automatic fire suppression systems, along with the BMS shall identify potential fire risks and activate the appropriate fire suppression mechanisms.

3.5.30 If fire or extreme temperatures are detected the suppressant will be automatically released into the environment actively targeting the flame and providing rapid cooling preventing reignition and cutting off the battery chain reaction.

3.5.31 Each manufacturer allows for an aerosol suppression system within the BESS enclosures. Depending on the manufacturer's specification 'Clean agent' extinguishing systems will be utilised. Clean agent extinguishing systems will comply with NFPA 2010[27]. CO2 systems are not acceptable as they work by displacing the oxygen and do not directly cool the fuel source. Thermal runaway produces oxygen and so there is a chance of reignition once the CO2 is removed. Non-occupiable container solutions shall include a clean agent fire suppression system as required by NFPA 855[1]. Material Safety Data Sheets (MSDS) will be provided once the system has been selected to ensure approriate control measures are implimented in case of fire.

3.5.32 If automatic sprinklers are required, they shall be designed and tested by an LPS 1014[25] certified firm. They shall be installed to LPS 1048-1[28] approval level 4 with supporting certificate on BESS Site acceptance. BESS enclosures shall have an inlet to allow for connection to water pipes.

3.5.33 A design risk assessment shall be carried out to ensure the fire suppression system will effectively contain the fire, off gassing and reduce the potential of thermal runaway and reignition.

Ventilation and Exhaust Systems

3.5.34 Combined with the temperature management, ventilation systems shall ensure the battery unit will not overheat and ensure efficient heat dissipation or provide thermal insulation if extreme cold temperatures are experienced.

---

[26] BRE, "LPS 1204 - Requirements for firms engaged in the design, installation and commissioning of fixed fire systems," 2021.

[27] N. F. P. Agency, "NFPA 2010 - Standard for Fixed Aerosol Fire-Extinguishing Systems," 2020

[28] BRE, "Requirements for the approval of sprinkler system contractors in the UK and Ireland," 2015

3.5.35 The ventilation systems shall comply with NFPA 69. Flammable gas concentration shall be maintained below 25% of the lower flammability limit (LFL). This preventative approach aims to prevent explosion.

3.5.36 Should the suppression agent discharge, pressure relief vents shall prevent structural damage of the protected enclosure.

3.5.37 Ventilation systems shall purge the BESS enclosure should the presence of smoke or flammable battery off gas be detected.

3.5.38 Ventilation exhaust vents, releasing any product other than ventilation air (e.g., smoke or combustible gases), shall be designed to be facing away from any ventilation air intakes, windows or doors. Exhaust vents shall be directed away from access, pedestrian or escape routes to prevent exposure to personnel.

3.5.39 Smoke and heat venting shall be provided in areas identified by the fire risk assessment and shall aid safe access of firefighters and safe egress of personnel.

3.5.40 Information on the ventilation air flow rate shall be provided by the manufacturer however the ventilation and exhaust system design shall meet the requirements of NFPA 8551.

Deflagration Venting Systems

3.5.41 A deflagration event can occur with the build-up of pressure as smoke and gas build up within the enclosure. To relieve pressure and prevent the build-up of an explosive atmosphere deflagration panels may be fitted on each enclosure. Any venting shall be to a safe location away from access, pedestrian or escape routes to prevent exposure to personnel. The deflagration venting system shall comply with NFPA 68.

Testing

3.5.42 The BESS will be compliant with testing requirements of UL 9540A Testing the fire safety hazards associated with propagating thermal runaway within battery systems[9] and demonstrate that fire will not propagate at a cell, module and rack level with preference for full system testing. The OEM shall provide the certification and evidence that confirms the adherence to the requirements and that testing was undertaken by an approved testing laboratory. The BESS shall be designed, commissioned, and installed onsite in full accordance with the criteria given in the test. No deviations are permitted.

CCTV

3.5.43 A network-connected closed-circuit television (CCTV) system shall be installed on the BESS Sites which can be utilised to assist with identifying issues and checking the battery enclosures status. These shall be monitored via an operational control room.

4. General Fire Safety

4.1 Consultation with Local Fire Service

4.1.1 As the design of the BESS Sites progress through the DCO application and detailed design, the Applicant will continue to engage with the local FRSs to provide input into the design. Following the selection of a battery supplier, the Applicant shall provide information relating to the BESS makeup. This includes but is not limited to chemistry, component design layout and means of containment (shipping containers, dedicated building, specially designed housing). The technology information will be updated as the design progresses to reflect the selected solution, including detailed safety considerations, mitigations, and specifications, to ensure the local fire services can undertake a meaningful review. Following consultation with the local fire services and the Environment Agency, the detailed BSMP (including details in relation to the BESS layout) will be approved by the relevant county authorities pursuant to a requirement [7] of the draft DCO. The Applicant will engage with the Lincolnshire and Nottinghamshire FRSs throughout development of the BESS Sites.

4.1.2 The final layout shall confirm BESS configuration, detailing internal BESS Site roads, water sources, water storage (if applicable), fire hydrant location and any other information that may assist the FRSs' understanding of the BESS Sites.

4.1.3 A summary of the main materials used on the BESS Sites will be prepared and be provided to the FRSs.

4.1.4 It is probable that, as the installation project progresses, additional information may become available. Detailed design elements will be reflected in the detailed BSMP, which the local FRSs will be consulted on. Any site information such as contact details, changes to equipment after the finalisation of the detailed BSMP which impact the fire safety of the BESS Sites should be communicated to the FRSs at the earliest opportunity.

4.2 Fire Service Guidance

4.2.1 It is anticipated that, in the unlikely event of a fire, a controlled burn strategy will be implemented. However, the final approach will be determined in consultation with the Environment Agency. The Applicant will continue to engage with the Environment Agency, Environmental Health, and the UK Health Security Agency to agree on the method of site control. The Applicant is providing water to allow adjacent units to be cooled, if necessary, in accordance with decisions confirmed within the Fire Response Plan which will be developed at a future design stage. As a unit burns, the surrounding units will be doused with water to dissipate heat and prevent ignition of the adjacent units. Should there be a fire incident, the appropriate fire fighting method shall be determined by the FRSs at the time of the incident based on the information provided and their judgment.

4.2.2 The risk of propagation is considered to be low due to the design decisions covered within Section 3.

4.2.3 The main risk to firefighters is the potential for rapid combustion and explosion of the cells affected by the fire or close enough to the fire to be affected. To mitigate this, exhaust systems and, depending on the selected supplier, deflagration panels may be in place to prevent explosion. Rapid combustion will be mitigated by minimising thermal runaway conditions through fire suppression systems. Although the BESS design will be specifically designed to self-contain fire risk, the risk is not reduced to zero.

4.2.4 Discussions with Lincolnshire FRS have identified the need for a programme of operational monitoring and risk assessment following commissioning of the BESS. This process will support safe operation, fire crew familiarisation, emergency preparedness, and reassurance to local communities. The Applicant will engage with Lincolshire FRS to discuss appropriate protective provisions to support this approach.

4.3 Site Access

4.3.1 Site access will be designed such that emergency vehicles are able to access the BESS Sites easily. For each BESS Site, two access points shall be provided should one be obstructed during an emergency (e.g. by smoke). The location of the access points will be confirmed at a later design stage.

4.3.2 For the West BESS Site:

- An access route from the north of the West BESS Site from the adjacent internal solar access road.
- A second access route from the internal solar farm access road either at the south or east of the West BESS Site.

4.3.3 For the East BESS Site:

- An access point west or north of the East BESS Site from the A1133, Collingham Road.
- An access point from the solar access road in the east through the middle of the East BESS Site.

4.3.4 An emergency responder information pack will be located at or near access points and the BESS Site roads shall incorporate suitable signage to assist FRS personnel.

4.3.5 A swept path analysis shall be conducted for emergency vehicles and roads within the BESS Sites to ensure they shall be suitable for fire tender and emergency vehicle access.

4.3.6 There are no dead-end access routes within the BESS compound planned at this time. Should this change during the detailed design phase, any such access route longer than 20 m will have turning facilities or passing places.

4.3.7 All BESS Site access roads will be a minimum of 6m in width.

4.3.8 Emergency lighting, including external BESS Site lighting, shall be available along escape routes at all times and in the event of power failure and shall direct personnel to a place of safety.

4.4 Water Supply

4.4.1 The illustrative design includes four (4) 120,000 litre static water tanks at each BESS Site however the final capacity will be detemined at detailed design stage. These will be connected to a network of fire hydrants. All water supply points, and fire hydrant locations shall be clearly identified with appropriate signage and shown on the BESS Site plans. The delivery rate of water will be a minimum of approximately 1,900 litres/min for 2 hours, subject to discussion with the local FRSs.

4.4.2 This will feed the fire hydrants and the water supply will be available for use by the FRS. The water tanks are not intended to feed any automated sprinkler system.

4.4.3 The final sizing, number and location of tanks is subject to detailed design, which will involve a risk review to ensure that the fire water response is appropriate. The water tanks shall be located a minimum of 10 m away from the nearest battery enclosure.

4.5 Pre-Fire Planning

4.5.1 A pre-fire plan will be prepared by the Applicant following the detailed design stage a separate document for use on site. It does not need to be submitted with the DCO for approval and will contain the following information as a minimum:

- The battery type and chemistry;
- The number of batteries, capacities and the overall capacity of the BESS installation;
- A BESS Site plan layout which clearly shows which units contain batteries, and which contain associated equipment;
- Notable construction features of the BESS installation. To include muster points, emergency stop locations, fire water supply points and hydrants etc;
- Material Safety Data Sheets (MSDS);

- Control of Substances Hazardous to Health (COSHH) assessment;
- Details of installed incident detections systems, including fire and gas detection, with type and speed of response noted;
- Details of any passive fire protection measures in place;
- Details of any active fire protection measures in place e.g., water spray/mist systems, dry agent systems;
- Consider reasonably practical containment measures for battery waste and electrolyte;

Consider reasonably practical containment measures for firewater retention.

- Arrangements for alerting any impacted off-Site parties;
- Arrangements for air quality monitoring in the event of a prolonged fire event; and
- Considerations for post incident monitoring, clean-up and disposal of both fire damaged and undamaged battery cells.

4.5.2 A concise emergency information pack will be provided to the emergency responders at or near emergency access points. The contents of the pack are to be agreed with the local fire services.

4.5.3 The pre-fire plan shall be reviewed annually at a minimum. Any changes to the BESS Sites, equipment or changes in industry best practice shall be reflected in the pre-fire plan at the earliest opportunity.

4.6 Signage

4.6.1 Appropriate signage shall be available onsite marking access and escape routes, water supply points and hydrants, safety signage, and emergency response guidance. The Main FACP shall also show directional signage to guide firefighters to the affected location as required.

4.6.2 Signage for the BESS units shall detail the type of BESS technology, suppression system fitted, hazards associated, and 24/7 emergency contact information.

4.6.3 Signs on at least one of the enclosures should be visible at night from a distance of 30 m.

4.7 Emergency Response Plans

4.7.1 An Emergency Response Plan detailing the construction, operation and decommissioning phases will be developed in consultation with the local FRSs during the detailed design phase and prior to the construction of the BESS Sites.

The plan shall include information that can support operators and firefighters in effectively responding to a fire incident at the BESS Sites. The Emergency Response Plan is not part of the DCO or the BSMP; however, it is a requirement under the NFCC guidance.

4.7.2 While the response plan is still to be developed, some indicative content topics which will be covered are as follows:

- Information on alerting fire service;
- Facility infrastructure details;
- BESS Site plans;
- Emergency and evacuation resources;
- Dangerous goods stored list;
- Contact details of relevant stakeholders;
- Procedure for safe shutdown, de-energisation, or isolation of equipment and systems;
- Procedures for inspection and testing of associated alarms, interlocks, and controls;
- Procedures to be followed in response to notification of system alarms;
- Emergency procedures to be followed in case of fire, explosion, or other dangerous conditions; and
- Procedures for dealing with BESS equipment damaged in a fire or other emergency event.

4.7.3 Local storage of this document on the BESS Sites will be at both access points to ensure in the event of a fire the FRS is able to safely access the information.

4.7.4 A clear firefighting strategy shall be communicated, and information shall be available onsite, including contact information, until a qualified attendant is present.

4.7.5 A risk management plan shall also be developed by the Applicant to identify potential hazards and risks of the BESS Sites and provide advice to the fire service on how to manage these issues when dealing with an emergency incident. This document shall be separete to the detailed BSMP and DCO; however, it is a requirement under the NFCC guidance and will incorpoate the following:

- The hazards and risks at and to the facility and their proposed management;
- Any safety issues for firefighters responding to emergencies at the facility;

- Safe access to and within the facility for emergency vehicles and responders, including to key BESS Site infrastructure and fire protection systems;
- The adequacy of proposed fire detection and suppression systems (e.g., water supply) onsite; and

Natural and built infrastructure and onsite processes that may impact or delay effective emergency response.

4.8 Post-incident Recovery and End of Life Management

4.8.1 The pre and post incident data will be monitored and recorded by the BMS. This data, along with any relevant details, shall be available to share to the United Kingdom Association of Fire Investigators and NFCC for learning and information should any cell, system failure or recall occur.

4.8.2 A post-incident recovery plan shall be developed by the operator to safely deal with the removal and disposal of any damaged batteries and equipment.

4.8.3 Safe lifting, removal of battery containers and end-of-life management shall be accounted for during the planning phase. For more details on decommissioning and end-of-life management, please refer to **Section 7.1.4**.

4.8.4 Following a battery fire there are potential issues that must be considered once the initial combustion has subsided. Prior to disposal, damaged batteries shall be stored separate to unreacted cells, in small quantities in an open-air environment at least 15 m away from other parts of the installation or structures.

4.8.5 Residual heat and stranded energy in the batteries can cause reignition and cause affect adjacent batteries long after initial extinguishment. Reignition can occur within minutes, hours or even days after the initial fire event. Appropriate heat detection systems can be used to identify persistent heat spots and mitigate the risk of reignition.

4.8.6 Battery waste that is burnt or unburnt contain corrosive and toxic substances and should be removed appropriately. PPE should be worn by personnel to prevent coming into contact with these hazardous substances.

4.8.7 At the time of writing there is no clear consensus on the type or quantity of potentially harmful combustion products, as this depends on the type of battery energy storage selected, and the way in which the system is manufactured. Engagement with industry research and statutory bodies will continue through detailed design, to support in making sure controls suggested remain suitably effective in case of fire for the proposed Development.

4.8.8 According to the 2017 DNV report OAPUS301WIKO(PP151894)[8], studying the risks when BESS units are installed inside a building, the levels of toxic fumes were found to be similar that of a plastics fire. This could be mitigated by ensuring enough distance between residential areas and providing sufficient ventilation. Harmful smoke and gas emissions shall dissipate in the outdoor environment. Fire responders shall maintain safe distances to the smoke plume until it is certain that they do not pose a hazard. This can be determined by flammable gas detection at key points around the facility and local air quality monitoring.

4.8.9 If any contaminants are identified within the firewater used in a fire event, all detention basins, SuDS basins, and swales will be drained and cleaned. Testing will be undertaken to ensure no residual contamination remains in the substate prior to the penstock valve being reopened.

4.8.10 Post-incident hazards shall be addressed in the pre-fire planning and post-incident recovery plan, including consideration of contaminants remaining within the substrate of with the BESS compound of the fire water storage areas.

5. Conceptual Drainage Design

5.1 Firewater Runoff

5.1.1 Should water be used as the suppressant for the fire system, contaminated water will be contained within the BESS Sites as part of the BESS Site drainage design to prevent the release of polluted water.

5.1.2 In the event of a fire, activation of the fire suppression system will automatically trigger a penstock valve located downstream of the attenuation basins to isolate any potentially contaminated runoff and preventing its discharge to surrounding watercourses.

5.1.3 A backup manual penstock valve will be included within the final drainage design that can be closed manually in the event of the automatic penstock valve failing.

5.1.4 Firewater used to cool the adjacent units shall also be collected by an appropriate drainage design with an impermeable lining in areas under the units and prevent infiltration of potential contaminants to the ground and groundwater.

5.1.5 The firewater shall be gathered into the water containment area adjacent to the BESS Sites, which will hold capacity for all the firewater. There shall be no firewater runoff released to the environment before appropriate testing has been carried out. Any polluted runoff will be removed from Site for treatment.

5.1.6 The Applicant commits to the in-situ cleaning, or removal and replacement (if required) of any substrate within the BESS and Substation areas, to allow for thorough cleaning and replacement as required.

5.1.7 To determine what gravel needs to be removed, and if the drainage system is suitable to be reopened, samples would be taken, when safe to do so by the FRS. These would be sent to a UKAS accredited laboratory for analysis by UKAS. MCERTS accredited methods would be used where applicable. The water samples would be checked against the list of surface water specific substances in the surface water pollution risk assessment guide.

5.1.8 Furthermore, the potential for concurrent fire and rainfall events has been considered. The attenuation basins have been sized to accommodate the volume of runoff generated by a 1 in 10 year rainfall in addition to 228 m^3 of firewater (based on a firefighting rate of 1,900 l/minute over a duration of two hours), with no resultant discharge to surrounding environments.

5.1.9 The **Flood Risk Assessment and Outline Drainage Strategy [EN010159/APP/6.21]** sets the above out in further detail.

5.1.10 The BESS Site-specific fire risk assessment shall inform the final design and level of protection of this system.

5.1.11 This site specific assessment will inform the detailed design, in the event that the site specific assessment recommends ground monitoring equipment to enable early detection and management of spills, the Applicant commits to providing this monitoring in line with the recommendations.

6. Remaining Infrastructure

6.1 Infrastructure Introduction

6.1.1 Outlined within **Section 3**, the BESS Site designs will comprehensively mitigate the risk of fire as far as reasonably practicable across all areas. The following section outlines key infrastructure and equipment which will be present on the BESS Sites.

6.1.2 The measures below are not all encompassing and aim to provide the reader with an overview of items considered. All details regarding the final design will be outlined within the fire risk assessment and underpinned by a Hazard Mitigation Analysis. This will need to be completed at the start of the detailed design phase.

6.2 Buildings

6.2.1 The final number, location and purpose of all buildings will be confirmed at the detailed design stage.

6.2.2 Fire detection and alarm systems throughout all buildings and plant shall be in accordance with BS 5839-1[11]. Gas detection shall be provided where flammable gas may collect and shall be in accordance with BS EN 60079-29-2[16].

6.2.3 Portable fire extinguishers will be provided at key locations on the BESS Sites in accordance with BS 5306-8[15]. The details and location of the portable fire extinguishers shall be recorded in the fire risk assessment.

6.2.4 Buildings shall incorporate smoke and heat venting in accordance with BS EN 12101[17], and vent area calculated with NFPA 20418 [1]. According to DNV report OAPUS301WIKO(PP151894)[8], smoke levels when BESS installations were inside a building were mitigated with adequate ventilation and had similar levels of toxicity to a plastics fire, as detailed in **Section 2.4 – Gases and Smoke**.

6.2.5 Emergency lighting shall be available throughout the BESS Sites, including external BESS Site lighting to ensure safe movement along escape routes.

6.2.6 Buildings will be separated to reduce the spread of fire and allow for complete exterior access.

6.3 Power Transformers

6.3.1 Each transformer shall be protected against incipient and electrical faults. Monitoring and protection shall be provided for all electrical faults, high winding and oil temperatures, low oil level, gas in oil and over-pressure, as a minimum, through suitable devices locally and alarms provided to the control system.

6.3.2 Transformer spacing will be based on the calculated fire damage zone which mitigates any interaction between two adjacent transformers. Each transformer may also be surrounded by an acoustic wall to adhere to the required noise attenuation.

6.3.3 Transformer bunds shall be adequately designed and installed to capture and retain any fire-fighting water as well as any oil spillage or rainwater.

6.3.4 Transformers will be oil-filled. All oil will be contained in accordance with the Environment Agency's requirements and interceptors provided as required by the Sustainable Drainage System (SuDS).

6.3.5 All transformer enclosures and coatings shall be specified to ensure the Operational life is achieved and any ventilation system shall be appropriate for the application.

6.3.6 Transformers shall be designed, installed, tested and maintained according to the Applicant Requirements.

6.3.7 A fire risk assessment of the transformer compound shall be performed as required by guidance and Applicant requirements. It shall take into consideration the location, nearby substation, switchgear, and battery assets based on relevant standards.

7. Pre-Construction Information Requirements

7.1.1 This OBSMP is required to be supplemented and revised at the detailed design stage once a battery supplier has been identified. The detailed BSMP will be submitted pursuant to requirement [7] of the DCO, if granted, to the local planning authority prior to the commencement of construction of the BESS Sites.

7.1.2 The detailed BSMP shall include:

- Detailed design drawings of the BESS;
- Details of the BESS specifications, including fire detection and suppression systems;
- A statement outlining operational procedures, training requirements and emergency operations;
- A statement confirming overall compliance of the system with applicable legislation;
- An environmental risk assessment to ensure that the potential for indirect risks e.g., leakage and/or other emissions, is understood and mitigated against.
- A re-evaluation of the plume assessment.

7.1.3 Provision of the above information will demonstrate prior to construction that all of the considerations and requirements in this document have been addressed and the BESS installation is safe.

7.1.4 Safe decommissioning of the BESS will be addressed prior to decommissioning of the Proposed Development in the detailed version of the Decommissioning Environmental Management Plan (DEMP) approved in accordance with the **Outline Decommissioning Environmental Management Plan [EN010159/APP/7.6]**.

8. Conclusion

8.1.1 This document summarises the fire safety risks associated with the BESS and associated infrastructure installation at One Earth Solar Farm BESS and the measures to mitigate them within this document. It addresses the requirements set out in the NFCC and other best practice fire safety guidance documents. It demonstrates how the Applicant aims to mitigate the identified risks and hazards and will aid discussion with local Fire and Rescue Services. To this end, the Applicant will be able to provide more information on the specifics of any relevant design parameter or technology as the detailed design process begins in an effort to build a design which satisfies all requirements.

8.1.2 The Applicant is committed to ensuring safety on all sites and will engage with the local Fire and Rescue Service to satisfy the safety requirements of their staff, the local residents, and the surrounding area in the unlikely event of a fire taking place at the BESS Sites. **Table 1.1** details how the Applicant will adhere to the guidance in Grid Scale Battery Energy Storage System planning – Guidance for FRS (2022) or alternative guidance where requirements are modified.

Appendix A West BESS Site Illustrative Layout

one earth
solar farm

Client: One Earth Solar Farm Ltd	Drawing Title: OE-ACM-R0-S3-DR-EE-4004 APPENDIX A - WEST BESS SITE ILLUSTRATIVE LAYOUT
Project: One Earth Solar Farm	Project: EN010159/APP/7.11 — Rev. 01
	Drawn: AL — Designed: AL — Approved: PJ
Planning Inspectorate Scheme Ref:EN010159	Drawing Date: 2025-02-06 — Scale: 0 50 100 m
Environmental Statement Volume 7	

Legend

- PV MODULES
- PV ARRAY AREA
- BATTERY UNIT
- MV STATION UNIT
- OHL CLEARANCE
- EXISTING WOODLAND
- EXISTING HEDGEROW
- EXISTING TREES & TREE BELTS
- EXISTING WATERCOURSE
- SUBSTATION
- DRAINAGE POND
- PARKING
- CONTROL BUILDING
- STORAGE
- ACCESS ROAD
- LAYDOWN AREA
- WATER TANK

Notes

1. DRAWING IS FOR INDICATIVE PURPOSES ONLY
2. EMERGENCY WATER STORAGE TANK FOR FULL EMERGENCY SERVICE USE. 120,000L x 4 WATER TANKS.
3. 439 BATTERY UNITS AND 110 MV STATION UNITS
4. DRAINAGE POND REQUIREMENT IS SHOWN INDICATIVELY. REQUIREMENT AND SIZING IS TO BE DETERMINED AT THE NEXT STAGE OF DESIGN.

Appendix B East BESS Site Illustrative Layout

one earth solar farm

Client:
One Earth Solar Farm Ltd

Project:
One Earth Solar Farm

Planning Inspectorate Scheme Ref:EN010159

Environmental Statement Volume 7

Drawing Title:
OE-ACM-R0-S3-DR-EE-4005
APPENDIX B - EAST BESS SITE ILLUSTRATIVE LAYOUT

Project: EN010159/APP/7.11

Rev. 01

Drawn: AL | Designed: AL | Approved: PJ

Drawing Date: 2025-02-06

Scale: 0 50 100 m

Legend

- PV MODULES
- PV ARRAY AREA
- BATTERY UNIT
- MV STATION UNIT
- OHL CLEARANCE
- EXISTING WOODLAND
- EXISTING HEDGEROW
- EXISTING TREES & TREE BELTS
- EXISTING WATERCOURSE
- SUBSTATION
- DRAINAGE POND
- PARKING
- CONTROL BUILDING
- STORAGE
- ACCESS ROAD
- LAYDOWN AREA
- WATER TANK

Notes

1. DRAWING IS FOR INDICATIVE PURPOSES ONLY
2. EMERGENCY WATER STORAGE TANK FOR FULL EMERGENCY SERVICE USE. 120,000L x 4 WATER TANKS.
3. 325 BATTERY UNITS AND 82 MV STATION UNITS
4. DRAINAGE POND REQUIREMENT IS SHOWN INDICATIVELY. REQUIREMENT AND SIZING IS TO BE DETERMINED AT THE NEXT STAGE OF DESIGN.

Appendix C Unplanned Emissions Assessment

C.1 Introduction

C.1.1.1. This report describes an assessment of the potential air quality impacts associated with unplanned emissions to air from the Battery Energy Storage Systems (BESS) at the proposed One Earth Solar Farm (the 'Proposed Development'). It has been written by Logika.

C.1.1.2. The Proposed Development will include two BESS compounds – one to the east and one to the west of the River Trent (illustrated in **Figures 5.1 and 5.2**). The exact details (for example, the final quantities, configurations of the infrastructure within the work order limits and the technical specifications) are not currently known, however the following has been provided by the project team:

> Individual battery cells will be 280 Ah lithium iron phosphate (LFP) batteries;

> Sixty-four cells will make up each battery pack/module, each rack will contain eight packs and there will be six racks per cabinet;

> Cabinets (likely to be made of steel) will be 9.34 m (length) x 2.6 m (width) x 1.73 m (height) in size and will be located in an array within each of the eastern and western sites; and

> The eastern site will contain 656 cabinets and the western site will contain 880 cabinets, with a minimum separation distance of 3 m.

C.1.1.3. BESS are used as part of solar developments to store excess electrical power generated during times of lower demand so it can be supplied to the national grid at times of higher demand, thus providing a degree of energy security. Specifically, in the case of the Proposed Development, excess power generated during the day may be utilised during at in the evening when production is low and demand is higher.

C.1.1.4. There are numerous safeguards included in the BESS design to prevent and control potential fires. These include the use of factory sealed batteries which do not vent when in normal use and have no free electrolyte. Each battery pack will contain cells separated by a thermal barrier to prevent one cell affecting the temperature of the adjacent one, with the packs themselves also separated by a thermal barrier. The batteries will be controlled by charging management systems that will detect if a cell or battery is not operating correctly and the whole BESS will be fitted with a fire monitoring system, so if one cell or module were to catch fire the fire suppression system will automatically be triggered to reduce the temperature and ensure that the overheating cell or pack does not affect the others in the BESS. These design features are set out in the Safety Management Plan, an **Outline Battery**

Safety Management Plan [EN010159/APP/7.11] is included within the DCO Application.

C.1.1.5. Despite the above design measures and management systems that ensure the risk of fire in the BESS is minimised, an assessment of the potential impacts that a fire could have on air quality at nearby existing sensitive receptors has been carried out in line with the Planning Inspectorate Scoping Opinion[29]. The following sections set out the criteria, methdology and results of the assessment.

C.2 Context

C.2.1.1. As set out above, the technology used in the BESS at the Proposed Development does not routinely result in emissions to air, but the Scoping Opinion requires the potential effects of unplanned emissions during a fire to be considered. If the battery cells become damaged in a fire affecting one or more of the modules or cabinets, then combustible materials could burn to release various pollutants.

C.2.1.2. A number of previous solar DCO applications in the UK have been required to undertake a similar assessment and, as part of these, a review was undertaken of existing studies into the potential types and quantities of pollutants that may be emitted during a fire at a BESS. Two studies were found to be of relevance:

‘Hazard Assessment of Lithium Ion Battery Energy Storage Systems’ published by the Fire Protection Research Foundation (FPRF)[30]; and

- ‘Investigation of Fire Emissions from Li-Ion Batteries’ by Anderson et al[31].

C.2.1.3. The former study investigated the emissions from ignition tests of BESS modules up to 100 kWh in size, whilst the latter conducted similar laboratory tests on smaller laptop battery packs. The key findings of the studies of relevance to this assessment were:

- Hydrogen fluoride (HF) was identified as a key pollutant, regularly emitted from the fires;
- Chlorine and methane were not detected;

[29] The Planning Inspectorate (2023) Scoping Opinion: Proposed One Earth Solar Farm.

[30] Fire Protection Research Foundation (2016) Hazard Assessment of Lithium Ion Battery Energy Storage Systems.

[31] Anderson et al (2013) Investigation of Fire Emissions from Li-Ion Batteries.

> Carbon monoxide was detected during the first 30 minutes but this decreased to near zero during the main, self-sustaining period of the fire (as is often the case in fires); and

> A combined battery of the scale found in plugin hybrid electric vehicles (i.e. 432 cells) could emit 400 – 1,200 g of HF if combusted.

C.2.1.4. Overall, only HF emissions appear to be of potential concern in the case of a fire at the BESS, although the quantities are unclear and are likely to vary based on the exact battery technology, scale and duration of any potential fire.

C.3 Assessment Criteria

C.3.1.1. The UK Health Security Agency have published Incident Management guidance for hydrogen fluoride (HF)[32], which is the main pollutant of concern from fires at BESS. The guidance includes information on exposure and health effects from a number of published sources, including the Acute Exposure Guideline Levels (AEGLs) from the US Environmental Protection Agency, which are considered to be an appropriate for use as assessment criteria in this assessment. The AEGLs are described in **Table C.1**.

Table C.1: Acute Exposure Guideline Levels

	Definition	1-hour mean Concentration (ppm)	1-hour mean Concentration (µg/m^3)
AEGL-1	Level in air at which the general population could experience notable discomfort	1	0.82
AEGL-2	Level in air at which there may be irreversible or other serious long-lasting effects or impaired ability to escape	24	19.68
AEGL-3	Level in air at which the general population could experience life-threatening health effects or death	44	36.08

C.3.1.2. In order to ensure the most conservative assessment approach is undertaken, the assessment level adopted for this assessment is AEGL-1, which is currently set at 1 part per million (ppm) (0.82 µg/m^3).

[32] UK Health Security Agency (2024) Hydrogen fluoride and hydrofluoric acid: incident management. Available: https://assets.publishing.service.gov.uk/media/6717bd07d94d2c219a540591/Hydrogen_Fluoride_UKHSA_IM_.pdf

C.4 Methodology

C.4.1 Model Inputs

C.4.1.1. The impacts of unplanned emissions have been predicted using the ADMS-6 dispersion model. ADMS-6 is a new generation model that incorporates a state-of-the-art understanding of the dispersion processes within the atmospheric boundary layer.

C.4.1.2. The model has been run to predict the process contribution (i.e. the impact) of emissions of a potential BESS fire on 1-hour mean concentrations of HF in 90% of meteorological conditions (90th percentile). Model input selections are summarised in **Table C.2**, and, where considered necessary, discussed further below. Input emission parameters are presented in **Table C.3**.

Table C.2: Summary of Model Inputs

Model Parameter	Value Used
Terrain Effects Modelled?	No
Variable Surface Roughness File Used?	Yes – 12km x 12km Cartesian grid at 50m resolution
Urban Canopy Flow Used?	No
Building Downwash Effects Modelled?	No
Meteorological Monitoring Site	Waddington
Meteorological Data Years	2019 – 2023
Dispersion Site MO Length (m)	1
Met Site Surface Roughness (m)	0.3
Met Site MO Length (m)	1

Table C.3: Modelled Emissions and Release Conditions

Parameter	Value
Height (m)	1
Width Depth (m)	1.73
Temperature (°C)	15 (ambient)
Source Dimensions (m)	9.34 x 2.60 x 1.73
HF Emission Rate ($g/m^3/s$)	1

Exit Velocity (m/s)	0

C.4.1.3. A number of conservative assumptions have been made to ensure a robust assessment of the potential impacts. The Proposed Development will include two BESS sites. As it is not known where on either site the unplanned emissions would originate (i.e. where a fire would start), four potential source locations on each site have been modelled (one at each corner) and the worst case process contributions used for each receptor across these four scenarios.

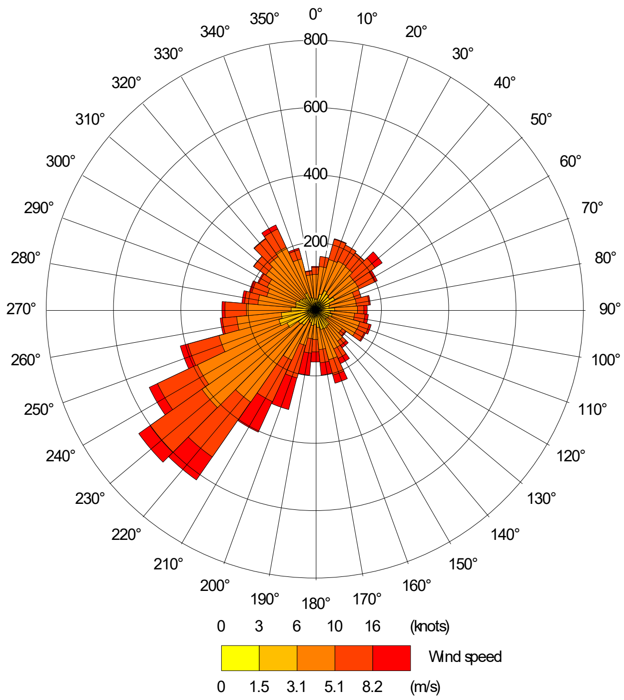
C.4.1.4. The emission sources were modelled at 15 ^{o}C (ambient temperature), as opposed to the high temperatures that would be expected in a fire at the BESS. This results in the emissions having much lower buoyancy than would actually be expected, and therefore modelled near-ground level concentrations are likely to overpredict those experienced in real world conditions.

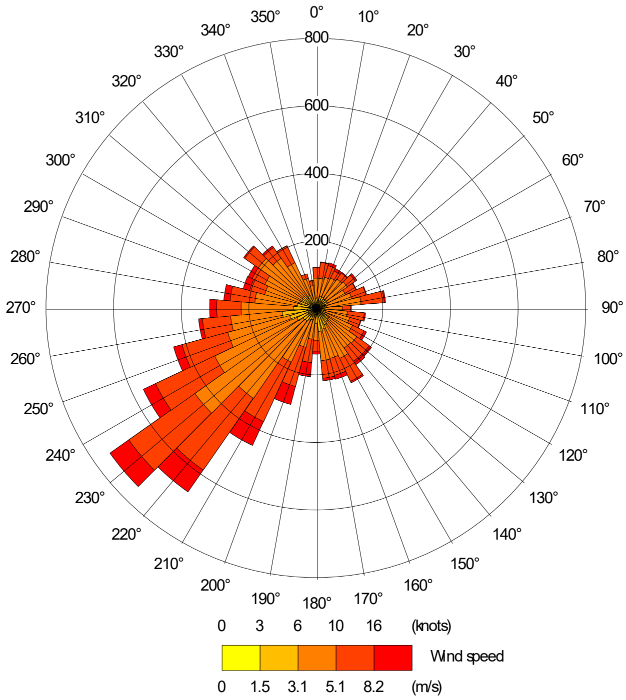
C.4.1.5. As the exact BESS specification will not be known until later in the detailed design stage, and therefore an exact emission rate of pollutants is not currently known, a nominal emission rate (1 $g/m^3/s$) has been modelled to allow future inferance of the pollutant concentrations at sensitive receptor locations under different emission rate scenarios.

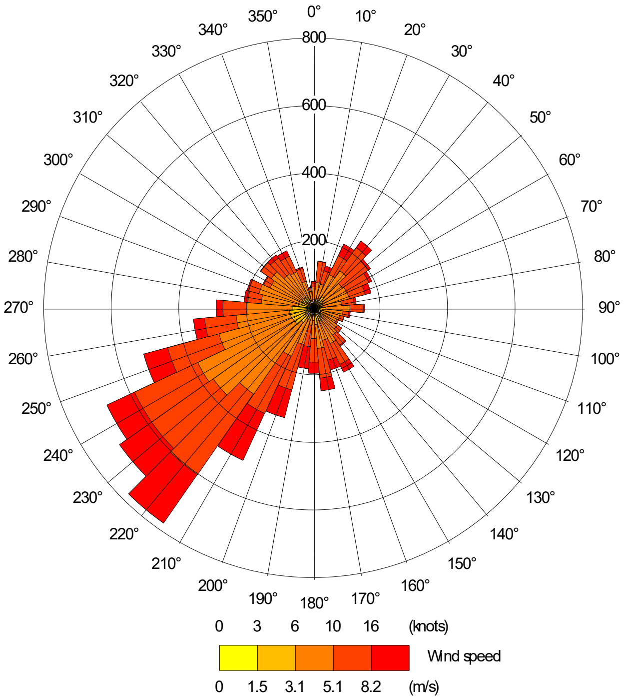
C.4.2 Meteorological Data

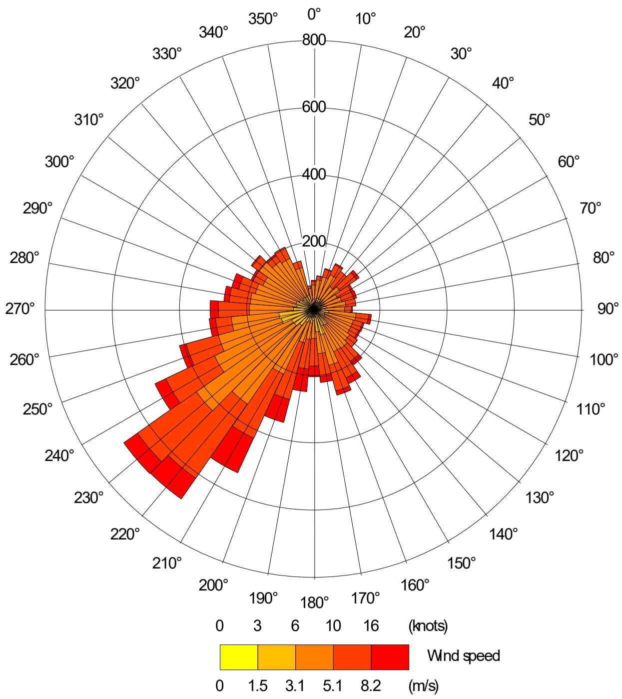
C.4.2.1. Hourly sequential meteorological data in sectors of 10 degrees from Waddington for 2019 – 2023 have been used in the model. The meteorological monitoring station is located at RAF Waddington, approximately 15 km to the east of the Proposed Development, which is the closest (and most recent) data to the Site available. Both the application site and the meteorological monitoring station are located in the east of England where they will be influenced by the effects of inland meteorology in flat-lying topography. The topography of the model domain is similar to that around the meteorological monitoring station and measurements from this site are considered to provide the most robust basis to predict meteorology within the model domain. Wind roses for the site for the years 2019 – 2023 are provided in **Figure C.1**. Raw data were provided by the Met Office and processed by AQC for use in ADMS.

C.4.2.2. Of the five meteorological years modelled, the worst case year (2021) was identified by the highest annual average process contribution and the results for this year have been reported to ensure a conservative approach.


0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
800
600
400
200
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
800
600
400
200
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
800
600
400
200
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
800
600
400
200
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)

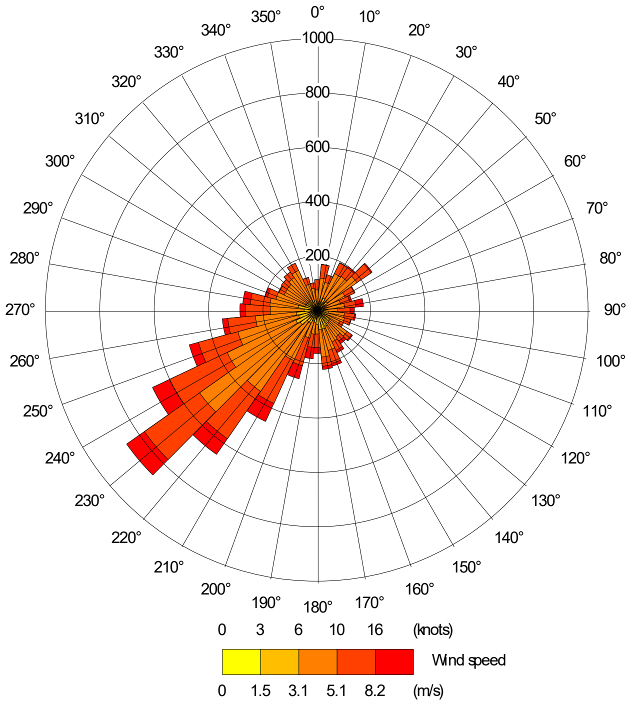


Figure C.1: Wind Rose for Waddington 2019 – 2023

C.4.3 Post-processing

C.4.3.1. In line with the approach undertaken in other studies of unplanned BESS emissions, and the results of the studies summarised in **Section C.2**, a number of potential pollutant emission scenarios were considered as the exact specification (and therefore pollutant content) of the BESS is not yet known. Different hypothetical pollutant quantities within each BESS cabinet were considered along with different fire durations to determine a range of possible emission rates, which are set out below in **Table C.4**.

Table C.4: Pollutant Emission Scenarios [a]

Scenario	Pollutant Mass (kg)	Duration of Fire (hrs)	Emission Rate (µg/m^3/s)
1	**1**	**3**	**2.2**
2	1	6	1.1
3	**2**	**3**	**4.4**
4	2	6	2.2
5	**3**	**3**	**6.6**
6	3	6	3.3

[a] Emission rates used in the assessment are in **bold**.

C.4.3.2. Of the scenarios set out in **Table C.4**, scenario 5 would result in the highest pollutant emission rate from an individual cabinet fire (6.6 μg/m^3/s). This emission rate, along with a mid-range scenario and a lower level scenario, have been used to assess the impacts on the surrounding environment. Given all of the other conservative assumptions adopted in the assessment methodology, this range of emission scenarios is still considered to be robust.

C.4.3.3. The emission rates were applied to the results of the dispersion modelling to calculate the pollutant concentrations at the modelled receptors. Contours were then plotted to illustrate where the assessment level of 0.82 μg/m^3 (AEGL-1) would be exceeded in case of fire at either the eastern or western BESS site. These contours are presented in **Figures C.1** and **C.2**.

C.4.4 Results and Conclusions

C.4.4.1. As illustrated in **Figure C.2**, at the eastern BESS site, in all emission rate scenarios there are no sensitive receptors located within the area where the assessment level may be exceeded in 90% of meteorological conditions. Thus, it can be concluded that a fire at the eastern BESS site would not result in any significant adverse health effects.

C.4.4.2. **Figure C.3** presents the contours for the western BESS site. There are a small number of existing residences within the outermost contour (representing the highest emission rate tested), one residence within the mid-range scenario contour and none within the lower level scenario. Given the conservative assumptions made in the assessment methodology, as discussed previously, it is still considered unlikely that there would be any significant adverse health effects should a fire occur at the western BESS site.

C.4.4.3. It should be noted that in the unlikely event that a fire were to break out in a single cell or module it is very unlikely, given the control measures, that the fire would spread to the rest of the BESS. Even should all the systems fail and a large scale fire break out within one of the BESS containers (as has been assessed) then the resultant HF concentration at the closest receptors would be below the level that PHE has identified as resulting in notable discomfort to members of the general population.

C.4.4.4. As set out in **Volume 1, Chapter 5: Description of the Proposed Development [EN010159/APP/6.5]**, the BESS will be designed in accordance with the latest guidance and policy, including guidance from National Fire Chiefs Council (NFCC), NFPA 855[33] and FM Global 5-33[34]. An **Outline**

[33] NFPA 855, Standard for the Installation of Stationary Energy Storage Systems (2023).

[34] FM Global (2020) Property Loss Prevention Data Sheets. Available: https://liiontamer.com/wp-content/uploads/Property-loss-prevention-data-sheet-5-33-ESS.pdf

Battery Safety Management Plan [EN010159/APP/7.11] is also included within the DCO Application.

C.4.4.5. As the detailed design progresses, the expected HF content of the BESS will be considered in the context of the assumptions in this assessment and, if necessary, further modelling will be undertaken to demonstrate that the impacts associated with an unplanned fire would not cause any significance adverse health effects to the local community.

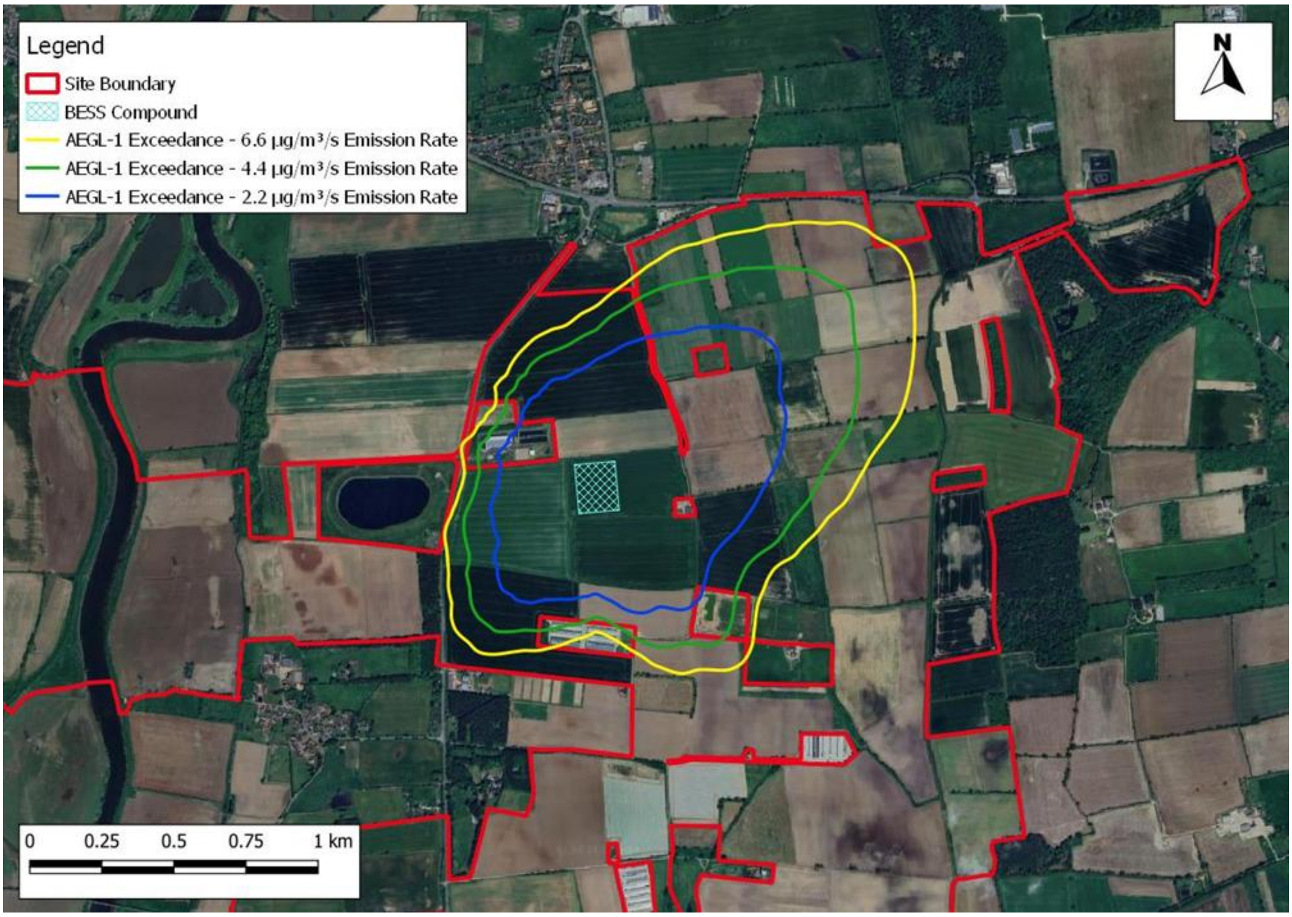


Figure C.2: Impacts from Unplanned Emissions at Eastern BESS Compound

Imagery ©2024 Google, Imagery ©2024 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies, Map data ©2024.

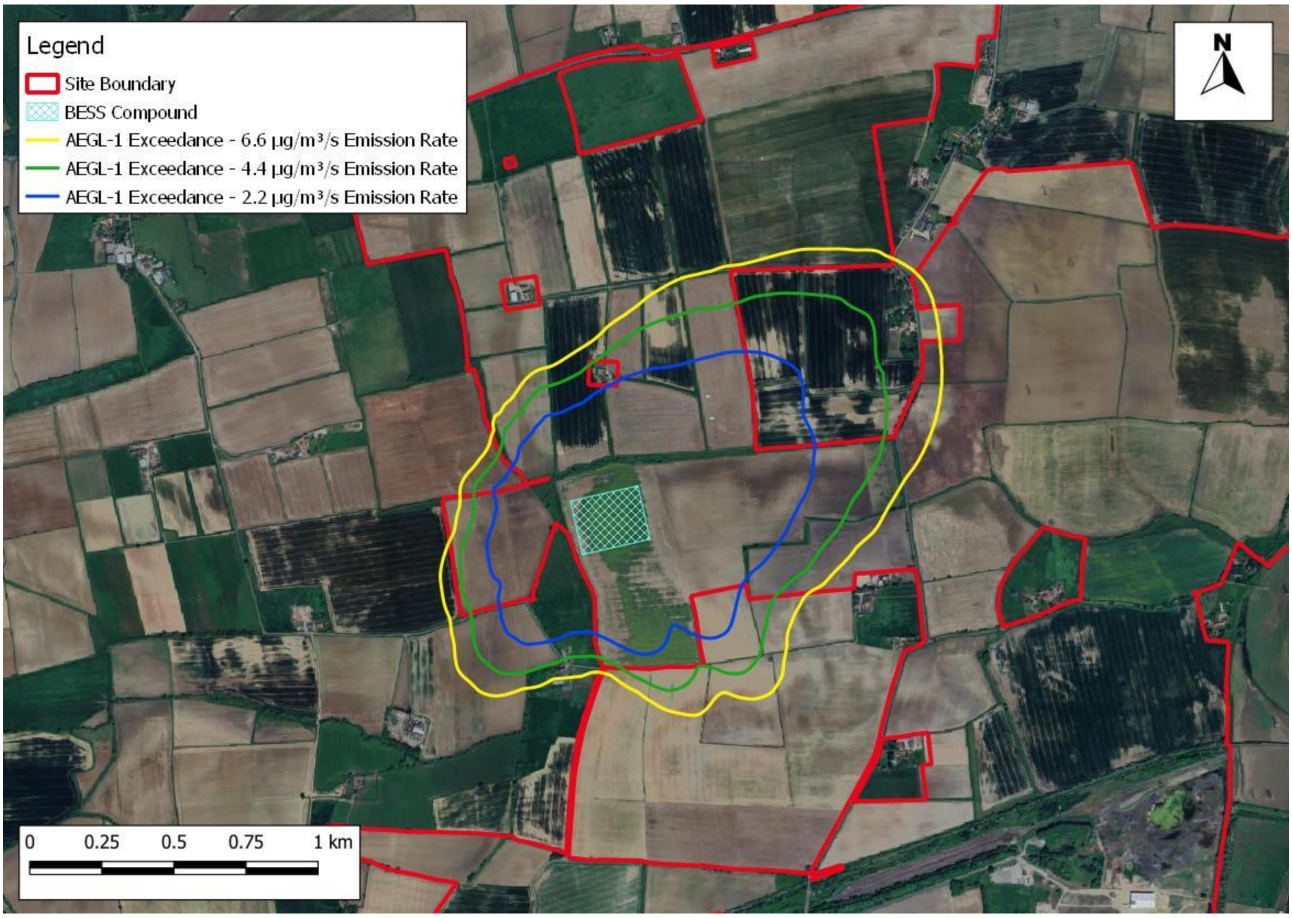


Figure C.3: Impacts from Unplanned Emissions at Western BESS Compound

Imagery ©2024 Google, Imagery ©2024 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies, Map data ©2024.

one earth
solar farm