REPORT

Planning Phase Battery Safety Management Plan – Fire Strategy

Document No.: O-LO-R70-039330

Client: Braxbess Limited

Document Notes

Confidentiality Notice and Disclaimer

This document is **confidential** and may contain proprietary information and intellectual property of Client and/or ABL.

The document has been produced by ABL through, their subsidiary OWC, for the exclusive use and benefit of Client and may not be relied on by any third party. ABL does not accept any liability or duty of care to any other person or entity other than Client.

The document should not be reproduced (in whole or in part), referred to or disclosed in any other document or made available to any third party (in any format) without the prior written consent of ABL.

Information

Project Name:	Braxbess Storage BESS
Document Title:	Planning Phase Battery Safety Management Plan – Fire Strategy
Document No.:	O-LO-R70-039330
Client Doc. No.:	N/A
Document Status:	Draft
Entity:	Offshore Wind Consultants Ltd, No. 07861245 in England, at 1st Floor, The Northern & Shell Building, 10 Lower Thames Street, London, England, EC3R 6EN

Document History

Rev	Date	Authored	Reviewed	Approved	Notes
A	2023-12-20	C. Maletti	S. Zhang	A. Besant	Draft for Client Comment
B	2024-01-17	C. Maletti	S. Zhang	A. Besant	Updated draft
C	2024-01-18	S. Zhang		A. Besant	Updated draft
D	2024-01-18	S. Zhang		A. Besant	Updated draft

Table of Contents

Document Notes **2**
Confidentiality Notice and Disclaimer 2
Information 2
Document History 2
Table of Contents **3**
Glossary **4**
1 Introduction **6**
1.1 Purpose of this report 6
1.2 ABL experience 6
1.3 General 6
2 Guidance **9**
2.1 Fire and Rescue Service Input 10
3 Outline fire management strategy **11**
3.1 Mitigation by design: Design Risk Management (DRM) 11
3.2 Quality control and quality assurance 12
3.3 Monitoring 12
3.4 Emergency Management 13
4 Fire Strategy **14**
4.1 Fire mitigants 14
4.1.1 Fire Suppression 14
4.1.2 Means of notifying the fire and rescue service 15
4.1.3 Fire Vehicle access to and around the site 15
4.1.4 Firefighting facilities & water supplies provided for the development 15
4.1.5 Fire event – Environmental impact mitigation 16
4.2 Fire incident response 18
4.3 Fire safety management 18
5 Battery Energy Storage System Design Recommendations **19**
6 Mitigations **23**
7 Conclusion **29**
Appendix A – NFCC Advice **30**
Appendix B – Engagement with the SFRS **40**

Glossary

Acronym	Definition
BESS	Battery Energy Storage System
BMS	Battery Management Systems
BMSP	Battery Management Safety Plan
CCTV	Closed-Circuit Television
CDM	Construction, Design Management
DRM	Design Risk Management
ECU	Energy Consents Unit
EPA	Environment Protection Authority
ESS	Energy Storage System
FAT	Factory Acceptance Testing
GW	Gigawatt
HAZID	Hazard identification
HAZOP	Hazard Operability Analysis
HSE	Health, Safety and Environment
HV	High Voltage
HVAC	Heating, Ventilation, and Air Conditioning
IFC	International Fire Code
kV	Kilovolts
LiFePO 4/ LFP	Lithium iron phosphate
LV	Low Voltage
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hour
NFCC	National Fire Chiefs Council
NMC	Nickel, Manganese, Cobalt
OEM	Original Equipment Manufacturer
PCS	Power Conversion System

Acronym	Definition
PPBMSP	Planning Phase Battery Management Safety Plan
PRMS	Pressure Reducing Metering Station
QHSE	Quality, Health, Safety, and Environment
SAP	Senior Authorised Person
SAT	Site Acceptance Testing
SCADA	Supervisory Control and Data Acquisition
SFRS	Scottish Fire and Rescue Service
SoC	State of Charge
VBB	Victoria Big Battery

1 Introduction

Braxbess Limited (the Applicant) is developing a Battery Energy Storage System (BESS) Project with a maximum power of up to 650 MW over a 2-hour period, located south of Barns Ness Terrace, Innerwick, East Lothian, EH42 1S (Project, Site).

1.1 Purpose of this report

This Planning Phase Battery Management Safety Plan (PPBMSP) has been prepared on behalf of the Applicant to support the submission to the Energy Consents Units (ECU) for the proposed development. The PPBMSP seeks to provide information as to how potential fire safety and related risks are identified, allocated and mitigated as far as reasonably practicable to protect people working on site, people living nearby and the local environment in the event of a fire incident. The plan is restricted to fire safety and does not represent a complete review of all safety concerns associated with BESS projects.

The PPBMSP identifies key entities that could potentially be impacted by a fire incident at the Project, including primarily those working on or around the Site and local residents, the local environment (including contamination or habitat destruction), and means of protecting these entities, local property, including the Project itself, and nearby businesses against the impact of fire.

It is expected that, prior to the commencement of construction, the PPBMSP will be updated and further developed in consultation with relevant stakeholders, including the Scottish Fire and Rescue Service (SFRS), the Environment Agency and the ECU to reflect the selected technology, construction process and the finalised construction level design.

1.2 ABL experience

ABL is a specialist and service-focused consultancy that helps develop and deliver bespoke renewable projects and investments for developers and investors in global markets. Our circa 1,500 staff are made up of experienced electrical, structural and civil engineers, renewable energy consultants and certified town planners. We have worked to deliver over 250 GW of renewable energy projects including about 3 GW of BESS experience. ABL and its associates have provided support on fire related topics for over 2 GWh of BESS projects and produced fire strategy reports for over 1 GW of BESS projects, for developers including Tag Energy, One Planet Developments and Ion Ventures. ABL are in regular contact with local fire services to ensure that the advice provided with respect to fire strategies is up to date and aligned with the most recent standards and industry best practice.

1.3 General

The Site will be composed of modular BESS with external Power Conversion System (PCS) and MV transformers and the associated grid connection infrastructure.

The proposed layout establishes the fundamental principles of the fire prevention and mitigation strategy that will be applied to the detailed design phase, as stated in Section 3.1. This PPBMSP is therefore based on designs and information provided by the Applicant and the assumption that the final product would be based on LFP (Lithium Iron Phosphate), cabinet-based battery products. The proposed layout for the Site is shown in Figure 1-1.

Figure 1-1 Proposed Layout

The development phase design consists of:

- 300 BESS containers
- 150 PCS units
- 75 medium voltage transformers
- 2 customer control rooms
- 6 switchrooms
- SPT 400 kV substation
- 2 132kV substations
- 4 630 kL water tanks (2 located on opposite sides of the Site)
- 38 fire hydrants located around the Site
- 2 auxiliary transformers
- Access tracks
- Fencing and access gates
- Associated infrastructure including underground pipes, power and communications cables
- Attenuation tanks and collection manholes to the south of the Site

The Supplier for the BESS and associated equipment has not yet been confirmed, however, the Applicant will ensure that the design, operation, and maintenance of the Site is in line with recognised safety standards and good industry practice. This is discussed further in Section 1 and Section 1.

The BESS containers will not exceed the dimensions of standard shipping containers; 16.2m long, 2.6m wide, 2.9m high.

As shown in Figure 1-1, the layout incorporates a main access point that provides two access roads into the Site to allow for access by the fire department to any BESS unit from multiple directions. There is a minimum separation of 88 m between the entry point to the access roads and the nearest BESS container, which seeks to allow firefighting vehicles to travel down either road in the event of an emergency. Access gates are proposed around both sections of the Site to allow access in multiple directions.

The Scottish Fire and Rescue Service (SFRS) have been consulted and will endeavour to provide feedback on this fire strategy throughout the determination process.

2 Guidance

The following list of includes the minimum UK Statutory Instruments that we consider relevant to BESS projects at the time of writing:

- Health and Safety at Work etc. Act 1974;
- Management of Health and Safety at Work Regulations 1999 Regulation 3;
- Electricity Safety, Quality and Continuity Regulations 2002;
- The Workplace (Health, Safety and Welfare) Regulations 1992
- Regulatory Reform (Fire Safety) Order 2005 for the fire safety management in buildings compliance;
- Construction, Design Management Regulations 2015 (CDM).
- IEC 62619:2022 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications;
- IFC 2021 International Fire Code (IFC).

The Applicant will appoint a suitably qualified Principal Contractor and Principal Designer to fulfil the respective roles under the CDM Regulations and discharge their Client duties. Following construction, ABL notes that there will be ongoing operational requirements relating to the design, selected technology, planning and statutory obligations, and various stakeholders which will require ongoing management.

The following guidance documentation has also been reviewed:

- Project technical documentation;
- Health and Safety Executive (HSE) Design standards;
- UK and EU (ADR Orange Book) HSE;
- Building Regulations 2010 – Approved Document B (volume 2 – 2019 edition);
- Regulatory reform (fire safety) order 2005;
- UL 9540, 2nd Edition, February 27, 2020 – UL Standard for Energy Storage Systems and Equipment;
- UL 1973, 3rd Edition, February 25, 2022 – UL Standard for Safety Batteries for Use in Stationary and Motive Auxiliary Power Applications;
- NFPA 855 (2023), Standard for the Installation of Stationary Energy Storage Systems;
- NFPA 69, Standard on Explosion Prevention Systems;
- UL 1642, 6th Edition, October 12, 2022 – UL Standard for Safety Lithium Batteries; and

- National Fire Chiefs Council Grid Scale Battery Energy Storage System Planning – Guidance for FRS.

2.1 Fire and Rescue Service Input

In addition to the extensive desktop research that has been conducted in order to ascertain the current state of the BESS guidance, ABL has engaged with the SFRS to request their input on the development phase design of the project and this fire strategy. A meeting with the SFRS was held on 8 January 2024 and the meeting minutes can be found in Appendix B – Engagement with the Fire Department.

In summary, the SFRS acknowledge that BESS development is an emerging practice and recommend that BESS are designed to meet the guidance laid out by the NFCC which ABL has taken into account in the drafting of this strategy. Updates to the layout and fire strategy were made following this initial SFRS engagement.

The SFRS will consider further this draft strategy and provide feedback as appropriate during the determination process.

3 Outline fire management strategy

The Applicant is committed to identifying the existing and emerging requirements of constructing and operating the proposed development. The requirements identified include processes and protocol and lessons learned from other similar projects, industry wide.

One of the key lessons learned from the BESS industry is to carefully involve the local fire service in the design and management strategies as a critical stakeholder.

3.1 Mitigation by design: Design Risk Management (DRM)

The initial design of the Site has been developed to reflect the statutory fire prevention strategies and good industry practice; as the design is progressed the concept of DRM will be implemented to ensure that risks that can be mitigated through the design of the Site will be eliminated where possible.

Throughout the detailed design process, key stakeholders will be engaged, including the SFRS and the local planning authority, to identify relevant design mitigations than can be enforced during the DRM process.

The advice issued by the National Fire Chiefs Council (NFCC) has been included in Appendix A – NFCC Advice. This guidance has been reviewed and applied to the greatest extent that is reasonably achievable for the project, including the items listed below:

- The detection and monitoring will be designed to the applicable industry standards, including EN 54;
- The suppression system for the BESS will be determined based on the selected design to comply with UL9540 as applicable;
- The installed BESS will include deflagration panels/venting as required by UL1970;
- The access to the site has been designed to provide a primary access point with two access roads in different directions ;
- The road network on site has been design to remove the requirement for turning or reversing;
- The spacing of the BESS containers has been designed to meet the requirements of NFPA 855 and provide at least 3m clearance between units and between units and other electrical components;
- The vegetation on site will be maintained to keep a 10m separation from the BESS containers;
- The proposed layout incorporates 4 630 kL water tanks, which can provide over 5 hours of fire-fighting per tank at a flow rate of 1,900 litres per minute;
- The signage installed at the site will adhere to health and safety regulations and meet the specification provided by the NFCC;
- As the Project progresses through the design phase into construction, an emergency response plan will be drawn up with the collaboration of the local fire authority.

As part of the development of the final BSMP and detailed construction design, the site will undergo the required Hazard Identification (HAZiD) and Hazard Operability Analysis (HAZOP) to identify any risks during the design, construction and operation phases. These will be attended by subject matter experts and key stakeholders to determine risks and the procedures required to mitigate them.

Decisions made and risks identified during the detailed design phase will be recorded in a design decision log and a risk register, with appropriate mitigation. This will be developed from throughout all design phases.

3.2 Quality control and quality assurance

The safety measures, testing and good industry practice standards, requirements of legislation and guidelines that are detailed throughout this report will be implemented as part of the design, construction, operation and maintenance of the proposed development, and integrated into the Employer's Requirements specification.

Manufacturing, post-manufacturing handling, testing and commissioning phases (and later the decommissioning of the Project) will be a major focus for Quality, Safety, Health and Environment (QHSE) Supply Chain Management, with the aim of managing the risk of fire at source by eliminating faulty cells from the design. These principles will be carried through the operation and decommissioning of the Site.

Factory Acceptance Testing (FAT) will be conducted prior to the transport of the energy storage system to site to aid the detection of any faults in the system and reduce the likelihood of defective materials entering the Site.

Following the installation of the energy storage system, the installation will only be accepted via Site Acceptance Testing and commissioning testing. The purpose of this testing is to identify any damage that may have been sustained during transportation, ensure that the system is installed properly, and that the battery management and protection systems are operating properly. This testing will be carried out in cooperation with the supplier.

3.3 Monitoring

The bespoke cabinets in which the battery modules will be housed will be designed to mitigate potential risks and hazards. This includes consideration of adequate separation (the initial design as shown in Figure 1-1 is based on 6m separation between rows of cabinets and surrounding plant, as recommended in the standard NFPA 855 and 2021 IFC) to minimise the spread of fire. Cooling, ventilation and monitoring systems will be incorporated to ensure operational safety by maintaining the batteries at a stable operating temperature and removing excess heat in the event of overheating.

Any system installed onsite will be compliant with the UL9540, UL1642 and UL1973 certification and UL9540a large scale fire testing requirements. This will ensure the installed containers contain cells and modules that have been tested against the propagation of thermal runaway or fire spread between cabinets. As walk-in cabinets are not proposed or expected to be used on this Project, no cabinets will need to be entered into for maintenance or (in the event of an incident) firefighting purposes.

During the operational phase of the proposed development, the whole battery storage facility will be monitored and controlled by a SCADA (Supervisory Control and Data Acquisition) safety system. Similarly, every individual cell will be constantly monitored by automated systems known as Battery Management Systems (BMS) that track current, voltage, temperature and other critical information. BMS are designed to ensure that the batteries are continually monitored and protected to prevent hazards occurring and to maintain the reliability of the batteries. Any cell that is detected by the BMS to be behaving abnormally will be automatically disconnected to remove the load and allow for the Heating, Ventilation and Air Conditioning (HVAC) to reduce the cell temperature, and an alarm will be raised to the asset manager.

To provide redundancy to the remote monitoring system, in the event of system downtime personnel will be deployed to Site.

3.4 Emergency Management

An Emergency Management Plan will be developed during detailed design phase of the project.

Although there has only been one occurrence of fire in relation to BESS in the UK (the Carnegie Road BESS, located in Liverpool, on 15 December 2020), lessons learned from the incident reports of this event highlight the need to ensure emergency services can have vision of what is taking place inside the battery storage units without entering those units. This comprises of practices such as the remote monitoring of battery rooms and avoiding key risks such as flame blow back and chemical risk. The BESS cabinets proposed for this development are not walk in units, as such there will be no need to access the cabinets in the event of a fire. The Applicant will continue to have ongoing conversations with the SFRS around all matters regarding fire safety and mitigation, including bringing members of the SFRS to the proposed development to walk them through important facets of the site, the detailed nature and specification of the chosen battery equipment and to confirm the on-site fire safety equipment is suitable and detail the storage arrangements of this equipment, and provide opportunities to ask questions. Access to the site will be made available to the SFRS for regular training exercises as required.

4 Fire Strategy

The development phase layout is presented in Figure 1-1. It can be seen in this figure that a clearance of 6 m has been maintained between all BESS units (comprising of 4 BESS cabinets), in excess of 10m separation between BESS cabinets and any surrounding buildings or vegetation, which is compliant with the standards set by NFPA 855 and 2021 IFC, and that access roads with 7 m width have been designed to enable fire engine access to all containers.

The layout has been designed with the requirements of fire fighting as a key principle. The perimeter roads and internal roads have been specified to allow for fire engine access and to remove the need for turning or reversing. Space has been included in the layout to allow for additional equipment that may be required by the fire service.

The proposed Project has been designed to be unoccupied during normal operation, however, during construction and maintenance activities, there will be presence on site and the storage or control buildings will be occupied for periods of time. The occupancy of these buildings will be limited in number of persons and occupancy time.

Prior to the beginning of construction, the updated fire strategy will be circulated to key stakeholders featuring the key contacts for the site and the contact details for these personnel. Key personnel include: the site manager, the asset manager, the Senior Authorised Person (SAP) and the asset owner. This will be maintained during the course of the build and updated as necessary to include key personnel for the Original Equipment Manufacturer (OEM) or BESS supplier with expert knowledge of the equipment being installed, in case of an incident.

The updated fire strategy will be stored onsite as a hard copy and in an online storage system as well as being circulated to key stakeholders.

The mitigants below include the safe design, monitoring and operation of the site to allow for redundancy in the fire safety design and include multiple layers of protection.

4.1 Fire mitigants

The following fire mitigants can be implemented in the design and operation of the Project to manage the risk of fire.

4.1.1 Fire Suppression

The BESS cabinets proposed for this development are not walk-in containers and are exempt from the requirement to have internal fire suppression as there is no risk of occupancy. The proposed BESS solution for the Project features bespoke cabinets with a modular design with liquid cooling systems and has achieved the UL9540A certification without the need for a fire suppression system.

Nevertheless, fire suppression systems will be employed with the aim of preventing a fire event of occurring in the first instance. Research by FM Global into fire suppression systems in BESS's[1] has identified that water suppression systems can extinguish a battery fire within a rack and, unlike gas suppression systems, are effective in preventing re-ignition and thermal

[1] FM Global, "Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems", June 2019 (revised October 2020)
Available: Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems

runaway as the water cools the batteries to below the self-ignition temperature due to its high heat absorption capacity.

4.1.2 Means of notifying the fire and rescue service

The Site will be monitored remotely through the SCADA system and the BMS, as is standard; these will provide real-time data and are able to raise alarms for any abnormal occurrences, allowing operatives to respond swiftly to any incidents. Details on the monitoring system for the Project are discussed earlier in Section3.3. In addition, the Site will have 24/7 remote security monitoring. In the event of a fire, SFRS will be immediately notified by the operation and maintenance provider. The response times and procedure will be a contractual obligation in the operation and maintenance agreement.

To address redundancy of and backup of the security team, the facility fire system could also utilise a 'Redcare' or equivalent fire alarm monitoring system connection subject to discussion with SFRS. This service can provide continuous monitoring of a telephone line that connects the fire alarm system installed on site to an alarm receiving centre (this is expected to be the nearest fire and rescue service station). This service will ensure continuous monitoring of the site all year round.

4.1.3 Fire Vehicle access to and around the site

The facility has been designed with the access of the fire and rescue services as a key design component, and the security access, road widths and turning arrangements have been designed to allow the fire service to access the site safely and efficiently. As required, the proposed facility will be provided with private hydrant fire mains. Vehicular access to and around the facility includes suitably dimensioned roads / tracks which will be 7 m in width, sufficient to accommodate fire and rescue service vehicles as presented in the layout shown in Figure 1-1. This will enable a pump appliance to be located adjacent to any site hydrant to serve the facility.

The main access to the Site is located approximately 50 m east of the Site and 88 m from the nearest BESS container. The main access point provides two main access roads running in different directions and access gates are provided around both sections of the Site to allow for access from multiple directions. In the unlikely case of a fire event (given the proposed fire suppression system):

- Wind blowing from an east to west, north to south or south to north direction is unlikely to cause fire smoke to impact fire vehicle access as the main site access point is located at least 88 m away and to the north-east of the containers;
- Wind blowing from a west to east direction may cause fire smoke to blow in the direction of the main site access, however, it is noted that containers are located between 88 m to 520 m away from the main site access point leading into the main site access roads.

Additionally, the roads are to be designed and built in order to accommodate emergency vehicles in all weather. The road layout has been designed to remove the requirement for reversing or turning and to provide fire engine access to every BESS cabinet.

4.1.4 Firefighting facilities & water supplies provided for the development

In order to facilitate firefighting, a premises information box (a Gerda Emergency Plan Box) will be located at the entrance near the main fire alarm panel. The content of the premises information will be devised with the collaboration of the fire department to ensure that the necessary information is included.

Private Hydrants will be provided and supported by the onsite water storage tanks.

All water supplies will be designed and installed in accordance with the requirements of the fire service. The sprinkler design (where appropriate) should be designed in accordance with the National Fire Prevention Association (NFPA) standards as described in Section 6. Emerging guidance from the National Fire Chief Council (NFCC) is recommending a fire-fighting supply of 32l/s for a duration of 2 hours. Water storage tanks have been incorporated sufficient to provide 2 hours' supply of water. There are 4 630 kL water storage tanks located across the site with hardstands and pumping stations located adjacent to each pair of water storage tanks, which can provide over 5 hours of fire-fighting water each and over 22 hours in total at the recommended flow rate.

4.1.5 Fire event – Environmental impact mitigation

In the event of a fire at a BESS site, there is a potential risk of environmental impact caused by the gasses produced during the fire and the potential for contaminated water runoff following firefighting activity.

Following the fire at the Victoria Big Battery (VBB), located in Victoria, Australia, on 30 July 2021, an environmental impact assessment was conducted to provide data-based evidence of the impact of the fire on the surrounding environment and to provide any lessons learnt in the design and firefighting process. The battery technology deployed for the VBB project and the Carnegie Rd, Liverpool site highlighted earlier (see Section3.4) utilised NMC cells, which have a higher propensity for thermal runaway than LFP cells which have been proposed for this Project. The report was produced by independent expert, Fisher Engineering Inc.[2]. The findings are discussed in the following sub-sections.

4.1.5.1 Contaminated water mitigation

In the event of any fire at a BESS unit, water could be used to extinguish the fire and keep the adjacent cabinets cool and prevent fire propagation. The resulting runoff water may be contaminated; therefore, it is necessary to implement pollution control measures to prevent potential environmental impacts as a result of contaminated water possibly entering the local water course or groundwater.

During the VBB fire, the water runoff from fire hoses was controlled by site personnel into a water catchment. Water samples were collected from the catchment and laboratory results from the samples indicated that the likelihood of the fire having a material impact on the water was minimal. Following the incident, as a precaution, the water was collected from the catchment and removed to a waste processing facility for safe disposal.

This is considered best practice and thus, it is generally recommended that the drainage system should be designed to allow for water used in firefighting to be collected in a suitably designed drainage swale with a penstock valve to allow the water to be trapped thus preventing any potential contamination to spread to the wider network. Following a fire event, the water within the swale would need to be tested and if necessary drained and the water disposed of appropriately based on testing results and environmental legislation. The Project layout incorporates attenuation tanks located to the south of the Site, which due to the natural

[2] Andy Blum, "Victoria Big Battery Fire: July 30, 2021 Report of Technical Findings" 25 January, 2022. Available: Victorian Big Battery Fire: July 30, 2021

grading of the land to the south, allows for contaminated water to be collected and subsequently treated in the collection manholes located to the south of each attenuation tank.

4.1.5.2 Gas dispersal

In the event of a BESS fire, the burning of the BESS materials can potentially produce hazardous gasses including carbon dioxide, carbon monoxide, hydrogen, and unburned hydrocarbons, and these gasses can be dispersed into the environment by the venting systems of the BESS units.

The results of the investigation into the VBB fire provide insight into the concentration of the gasses produced in a fire scenario.

The Environment Protection Authority Victoria (EPA) deployed two mobile air quality monitors within 2km of the VBB site in locations in which there was a potential impact on the local community. The samples, taken approximately 2 hours after the fire, confirmed *"good air quality in the local community"*. Whilst this data cannot be used to understand the airborne hazards during the actual fire event, it does demonstrate the fast dispersal rate of gases and that no long-lasting air quality concerns arose from this fire.

There is a risk of vapour cloud formation from the gasses dispersed by the venting systems concentrating which could result in an explosion if ignited and the fire propagating to other BESS units within the site. This risk is reduced provided the BESS units are separated as recommended in NFPA 855 and 2021 IFC; and the proposed layout is compliant with these separation distances. This risk will be included in the emergency response plan to ensure that appropriate clearance distances are observed by all personnel onsite during the firefighting activity.

The testing requirements to achieve UL 9540A involves module level fire testing; this measures the gaseous products of combustion of the battery modules. In order to pass the UL 9540A test, the level of flammable gases produced must be below the lower flammable limit. The selected BESS modules will be subject to UL 9540A testing and the flammable and non-flammable gases produced in the event of a fire will be included in the risk assessment.

4.1.5.3 Information availability – Lessons Learnt from the Liverpool BESS fire

In the event of a BESS fire, it is important to ensure that emergency responders are given the support they need. The 2020 Liverpool BESS fire, and its accompanying significant incident report from Merseyside Fire and Rescue Service (MFRS), have highlighted some key areas in which the design of BESS structure can be improved in order to aid emergency response.

The key lessons learned detailed within the significant incident report is that information should be onsite and accessible to emergency responders in the event of an incident. Clear warnings, Gerda Boxes containing site information, emergency contact numbers, and installation identification numbers are all recommended in order to help emergency responders.

The findings of the Liverpool report have been considered, and the Project will be designed with clear signage to identify the BESS. The signage shall include the following or equivalent: "BATTERY ENERGY STORAGE SYSTEM". Signage shall also feature current contact information, including phone number, for personnel authorised to service the equipment and for the local fire and rescue service.

4.2 Fire incident response

During the construction phase, appropriate firefighting and HSE equipment will be included in all welfare and storage buildings and personnel on site will be trained in the use of the equipment. An evacuation plan in the event of a fire accident will be produced for the Site. All personnel on site including visitors will be given a site induction which will include a safety brief on how to respond to a fire incident. Appropriate signage will be installed onsite to indicate evacuation routes; this signage will remain on site during its operation; an air horn procedure may also be implemented. A detailed Fire and Emergency Response Plan will be incorporated in the final version of the BMSP to be produced in consultation with SFRS and this will be enforced by the proposed planning condition.

4.3 Fire safety management

Fire safety will be at the forefront of the management procedures implemented during the construction and operation of the Site.

The fire safety management procedure will be informed by and compliant with the Regulatory reform (fire safety) order 2005.

In the event of fire on site or any near misses, an incident log will be maintained on site and in an online version to catalogue any events that lead to fire or had the potential to lead to fire. Following any fire event or near miss on site a review will take place to identify any possible improvements to fire safety procedure. All site personnel will be briefed on new procedures or lessons learnt. This log will be shared with SFRS and will act as a prompt to adopt any lessons learned from incidents on site.

5 Battery Energy Storage System Design Recommendations

ABL have consulted insurance requirements and lessons learned from similar projects to develop the following design recommendations. Table 5-1 highlights the risks associated with BESS projects and categorises them according to the risk posed following appropriate mitigation. Table 5-2 summarises the approach taken to risk rating in accordance with ABL SOP 13.

Table 5-1 Risk register

Component	Sub-element	Risk	Potential Impact	Notes and mitigants	Rating
Electrical connection	Switchgear	Explosion	Risk of harm to onsite personnel, environmental impact.	Substation design codes, ENA requirements	Low
	HV Transformer	Explosion, noise	Risk of harm to onsite personnel, environmental impact.	Substation design codes, ENA requirements, Location, Bunding Shielding	Low
	HV Transformer	Explosion, noise	Risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies).	Substation design codes, ENA requirements, Location, Bunding Shielding	Low
Power Conversion System	MV Transformer	Explosion, noise	Risk of harm to onsite personnel, environmental impact.	Location, separation distances	Low
	Controller	Data, communications failure	Inability to operate safely so the project will be disconnected	Risk increases if all one supplier, importance can be neglected by new entrances, experience. Experienced suppliers are recommended.	Low

Component	Sub-element	Risk	Potential Impact	Notes and mitigants	Rating
	PCS modules	Failure, e.g. short-circuit	Minor physical damage, outage	Experience and track record of supplier – Low if established	Low
Battery	Transport	Physical damage, hazardous chemicals, explosion	Increased risk of failure, risk of harm to onsite personnel, environmental impact, third party property impact.	Appropriate for technology type. In accordance with BESS transport legislation i.e., should have UN38.3 certification. SATs will be conducted following delivery to site to determine if any damage has occurred during transport.	Medium
	Off-loading	Physical damage, hazardous chemicals, explosion	Delay to commissioning, increased risk of failure, risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies).	Method statements for offloading and installation	Low
	Installation	Physical damage, hazardous chemicals, explosion	Delay to commissioning, increased risk of failure, risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies).	Design for access e.g. forklift replacement mechanism suitable for weight	Low
	Battery Management System (BMS)	Over / under charging, damage and fire	increased risk of failure, risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies)).	Supplier and experience of BMS designer – the importance can be overlooked by suppliers with less experience. Regular/scheduled recalibration of the State of Charge	Low

Component	Sub-element	Risk	Potential Impact	Notes and mitigants	Rating
				(SoC) will be conducted during operation.	
	Quality control	Defective cells resulting in increased fire risk.	Increased risk of thermal runaway.	A stringent quality control process will be implemented as part of the BESS supply contract. This will include Factory Acceptance Testing and Site Acceptance Testing.	Low
	Commissioning	Over / under charging damage and fire	Increased risk of failure, risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies).	Supplier experience – track record of successful projects. SATs commissioning witnessed by an experienced independent technical advisor.	Low
	Operation	Over / under charging, damage and fire, external physical damage	increased risk of failure, risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies).	Operator experience – track record of successful projects. Regular/scheduled recalibration of the State of Charge (SoC) will be conducted during operation.	Low
	Security	Vandalism	Increased risk of failure, risk of harm to onsite personnel, environmental impact (contamination of soils/nearby waterbodies).	Fencing and security measures taken will mitigate against any un-authorised persons entering the facility to commit vandalism.	Low
Ancillary controls	Environmental controls	Poor operating conditions such as high temperatures,	Reduced life, early replacement, increased risk of failure	Conditions will be set for the selected technology type during detailed	Low

Component	Sub-element	Risk	Potential Impact	Notes and mitigants	Rating
		exposure, or flooding		design, maintenance	
	Fire suppression (where appropriate)	Failure to operate	Physical damage to more than one unit	Effect on other units under operations, maintenance regime	Low
	Gas/thermal detection systems	Failure to operate	Physical damage to more than one unit	Regular verification of functioning and recalibration of sensors	Medium

Table 5-2: ABL SOP13 risk matrix

Impact ↓				
Critical	Medium risk	High risk	High risk	High risk
Major	Medium risk	Medium risk	High risk	High risk
Moderate	Low risk	Medium risk	Medium risk	High risk
Negligible	Low risk	Low risk	Medium risk	Medium risk
Likelihood →	Unlikely	Less Likely	More Likely	Certain / imminent

6 Mitigations

Table 6-1 below provides a summary of the recommendations following risks highlighted in Section 1 and outlines clear project responses based on standards that the Project will be constructed to and the mitigations that will be implemented to address the identified risks.

Table 6-1: Fire Safety Recommendations and Project Response

Recommendation	Project Response
Clearance to Exposures In accordance with NFPA 855, BESS located outdoors shall be separated by a minimum of 3m from the following exposures: • Property boundary • Public rights of way • Buildings • Stored combustible materials • Hazardous materials • High-piled stock • Other exposure hazards Clearances are permitted to be reduced to 914mm where a weatherproof enclosure constructed of non-combustible materials is provided over the BESS, and it has been demonstrated that a fire within the enclosure will not ignite combustible materials outside the enclosure based on large scale fire testing compliant with UL 9540A.	The Project layout has been designed to meet the separation requirements of NFPA 855 and 2021 FC; the layout design incorporates 6 m spacing between BESS units (comprising of 4 BESS cabinets) and there are no public rights of way, existing buildings, stored combustible materials, hazardous materials, or high-piled stock within or adjoining the site. The buildings proposed within the layout and surrounding vegetation have a separation distance greater than 10 m from the BESS cabinets. It is noted that there is currently a discrepancy between spacings recommended by NFPA and NFCC of 3m and 6m respectively, with the latter being the latest guidance available. The NFCC guidance states a 'standard minimum spacing between units of 6 metres is suggested unless suitable design features can be introduced to reduce that spacing'. The scheme's relevant design safety features include: • Design of the BESS to the UL9540A requirements • Provision of fire fighting water supplies and fire water storage. • Monitoring systems to measure cell voltage, currents and temperatures, where detection of potentially hazardous temperatures or other conditions shall result in the electrical disconnection of the affected BESS container to prevent, detect and minimize the risk of thermal runaway. • Inclusion of automatic thermal, gas, smoke and fire detection systems

	that have been certified to meet NFPA 72. • Inclusion of suitable fire suppression system, to be reached in agreement with the local FRS. • Inclusion of explosion control / deflagration venting in accordance with relevant standards. • Designing the layout to ensure that firefighting personnel could tackle a fire in any block of units from the internal access track. The proposed design and spacing is considered acceptable from a fire safety perspective. This will be confirmed during the detailed design phase by a fire engineer. As per the NFCC guidance, the Client has been engaging with the local fire service prior to the submission to the ECU. The Client will incorporate recommendations from the local fire service as appropriate.
Means of Egress The BESS installation shall be separated from the main route of egress as stated in NFPA 855.	The access and egress track for the Project has been designed with sufficient separation to allow unencumbered access to BESS equipment by the local fire service in the event of a fire on site. The SFRS have been consulted and will provide feedback as appropriate throughout the determination process.
Component/supplier selection The equipment selected for the BESS shall meet the below requirements: • Cell equipment will be listed in accordance with UL 9540. • Battery modules formed of cells separated by thermal barriers will be selected to meet the requirements of UL 9540A testing. • Chargers, inverters and energy management systems are listed in accordance with UL 9450. • Inverters will be listed and labelled in accordance with UL 1741. • The BESS shall feature an Energy Management System (EMS) that monitors and balances the cell	BESS will be procured from a reputable supplier with a track record in supplying UK BESS projects that have achieved the required certifications to demonstrate compliance with UL 9540 and UL 1973 (batteries) and UL 1741 (inverters).

voltage, currents and temperatures within the manufacturer's specifications. Detection of potentially hazardous temperatures or other conditions shall result in the electrical disconnection of the effected BESS container. The EMS must meet the test requirements of UL 1973. • ESS enclosure shall be of non-combustible construction and shall not exceed 16,154 mm x 2,438 mm x 2,896 mm, as stated in NFPA 855.	
Fire Detection An approved automatic gas/smoke detection system or radiant energy-sensing fire detection system shall be installed in accordance with the provisions of NFPA 72. This should be capable of detecting off-gases in low concentrations and provide early warnings of impending thermal runway.	The Project will feature automatic thermal, gas, smoke and fire detection systems that have been certified to meet NFPA 72. This will be developed in collaboration with the fire department.
Thermal Runaway Protection for thermal runaway will be provided by a Battery Management System (BMS) that has been evaluated, with the intended battery, in accordance with UL 1973. The BMS will meet the temperature monitoring and regulation requirements of UL 1973 to prevent, detect and minimize thermal runaway.	Evidence will be required from all tendering suppliers that the requirements of UL 1973 have been fully met to minimise the risk of thermal runaway. In addition, the lithium-ion technology ($LiFePO_4$ or LFP) selected for the Project has a significantly higher temperature (about 60 °C higher) for the initiation of thermal runaway in comparison to NMC batteries (Nickel, manganese, and cobalt) which were the battery technologies used in the Liverpool and Victoria fires mentioned earlier (see Sections 3.4and 4.1.5).
Fire Suppression BESS units that cannot be entered are exempt from the requirement to have fire suppression as there is no risk that the container will be occupied. ABL is aware that reputable BESS manufacturers include internal fire suppression system in their larger bespoke cabinet solutions (comparable size to container solutions) although not required.	All BESS designs will be approved by the fire department to ensure that they are satisfied with the choice of fire suppression system or the lack of requirement for fire suppression in cabinets that cannot be entered.
Ventilation and Temperature Control The BESS containers should be ventilated and temperature controlled in accordance with the manufacturer's instruction for the local conditions and environment.	All BESS enclosures will include adequate HVAC systems that have been provided by a reputable supplier with a strong track record of energy storage projects.

The testing of the HVAC system should be conducted in conditions that are representative of normal system operation. The HVAC system should be serviced and maintained as directed by the manufacturer to ensure optimum performance.	
Large Scale Fire test Large scale fire testing must have been completed on the proposed system in accordance with UL 9540A. The testing should have been conducted or witnessed and reported by an approved testing laboratory and show that a fire involving one BESS will not propagate to an adjacent BESS.	It will be specified in the project tender that all systems must be tested and approved by UL 9540A.
Explosion Control The BESS units will be designed to meet the requirements of NFPA 855, which details that energy storage systems must have either explosion control in accordance with NFPA 69 or deflagration venting in accordance with NFPA 68.	Evidence will be required from all tendering suppliers that the requirements of NFPA 855 have been met.
Provision for manual firefighting Adequate water supply should be provided on site to facilitate manual firefighting. In line with the recommendations provided by NFRS, an external hydrant should be located in close proximity to the BESS cabinets and the water supply should be capable of providing a minimum flow rate of 1900l/min for at least two hours. Additional hydrants should be strategically placed across the site sections; these should be regularly serviced and tested.	Private hydrants will be provided to within 90m of the accessible perimeter of the facility and the BESS units and within 90m of the facility buildings. Water storage tanks have been incorporated in the Project layout which will provide over 22 hours of firefighting water.
Electrical disconnects Where the BESS disconnector is not within sight of the main electrical service disconnector, signage shall be installed at the location of the main electrical service disconnector indicating the location of the BESS disconnector in accordance with NFPA 70.	Disconnectors will be clearly identified, and all personnel onsite will have been properly inducted. This induction will include the location of emergency disconnectors.
Signage Clear signage will be installed to identify the BESS, in accordance with NFPA 70. The signage shall include the following or equivalent: “BATTERY ENERGY STORAGE SYSTEM”. Signage shall also feature current contact information, including phone number, for personnel authorised to service the equipment and for fire mitigation personnel.	The BESS and auxiliary equipment will feature full signage in accordance with NFPA 70.

Vegetation Control Areas within 3m on each side of outdoor BESS shall be cleared of combustible vegetation or other combustible growth as stated in NFPA 855.	There is no existing vegetation within the proposed Site area where the compound will be located. A 10 m separation between the proposed battery units and any surrounding vegetation has been incorporated into the proposed layout, which is compliant with NFCC guidelines. As per the NFCC guidance, the Client has been engaging with the local fire service prior to the submission to the ECU. The Client will incorporate recommendations from the local fire service as appropriate.
Security BESS containers shall be secured against unauthorised access and tampering, in accordance with good industry practice. Security barriers, fencing and landscaping shall not interfere with the required air flow to the BESS.	The project will be comprised of locked BESS containers with 24 h remote security.
Auxiliary equipment Auxiliary equipment such as transformers and switch gear shall be installed in accordance with the relevant standards. • The transformers shall be separated from the BESS and installed with the clearances specified in IEC 61936-1: 2010. • Switchgear will be fire risk assessed in accordance with IEC 62271.	The selection and installation of auxiliary equipment for the project will be conducted by a reputable contractor in accordance with the relevant standards, including but not limited to IEC 61936-1: 2010 and IEC 62271.
Site Acceptance testing (SAT) Testing of equipment after they arrive on site to ensure that no damage was sustained from transporting them to the site and that equipment has been manufactured to the required standards.	A detailed SAT plan will be prepared for the Project to ensure that the equipment delivered to the site is free from damage, is functional and complies with the contractual obligations, design specifications, and applicable industry standards.
Commissioning Testing Testing of required thermal management, ventilation or exhaust systems should be conducted during project commissioning under conditions that are representative of normal operation.	A comprehensive commissioning test plan will be prepared for the project during the detailed design phase to ensure the installation meets the specification of the project and operates in accordance with the relevant standards.
Operation and Maintenance The installed BESS will be operated and maintained as specified by the supplier. • The monitoring systems will be routinely tested and inspected. • The HVAC systems will be routinely tested and inspected.	The operation and maintenance agreement for the project will be prepared with the input of the supplier to ensure the system is maintained in optimum condition.

• Repairs shall be conducted by qualified personnel. • Access and working space within any walk in BESS will be maintained in accordance with NFPA 70.	
Decommissioning Plan A decommissioning plan is required to state how the BESS will be safely removed from service. This plan shall include a list of contingencies from the removal of a BESS that has been damaged by fire.	A decommissioning plan will be developed during the detailed design phase with input from the selected supplier and the local fire department.

7 Conclusion

This document sets out the outline fire strategy and approach to be taken to ensure the safety of operators working onsite and local residents, and to provide protection for the local environment. ABL consider it feasible to execute the Project at minimal risk if the mitigations stated in this strategy are implemented.

In summary, the Project will minimise fire risks by:

- Incorporating Design Risk Management (DRM) through the design process to ensure that risks that can be mitigated through the design of the Site will be eliminated where possible. Instances of such design choices include: adequate separation between the batteries and other elements of the BESS and incorporating fire resistant materials.
- Ensuring that all equipment procured comply with all relevant legislation, industry standards and best practice guidance;
- Installation of thermal and gas detection sensors to ensure anomalies which may result in a fire event are prevented, where possible;
- Installation of Battery Management System (BMS) and Supervisory Control & Data Acquisition (SCADA) for automatic monitoring and control;
- Consulting and liaising with SFRS throughout all phases of the development i.e., the detailed design, construction, operation and decommissioning phases to develop and maintain an appropriate Fire and Emergency Response Plan to minimise risk and mitigate the impact in the event of a fire incident;
- Ensuring appropriate firefighting facilities are provided onsite in compliance with applicable regulations and advice to be provided by SFRS
- Ensuring fire suppression systems are designed in line with applicable standards and industry best practice;
- Inclusion of appropriate construction and transportation measures that comply with industry best practices, legislation and relevant standards;
- Including control and prevention measures against pollution which can result from fire incidents;
- Ensuring layout design is in line with all applicable standards for preventing the propagation of fire through the site and that the BESS units procured are designed with adequate ventilation systems to regulate the temperature of battery modules;
- Ensuring that multiple layers of protection are built into the design of the Site which will be reviewed by a fire safety engineer.

Provided the mitigations stated in this strategy are implemented, ABL considers it feasible to execute the Project at minimal risk. This outline plan will be developed further in consultation with relevant stakeholders and consultees, especially SFRS, and shall be approved by the ECU prior to the construction of the proposed development.

Appendix A – NFCC Advice

NFCC
National Fire
Chiefs Council

The professional voice of the UK Fire & Rescue Service

Grid Scale Battery Energy Storage System planning – Guidance for FRS

Grid scale Battery Energy Storage Systems (BESS) are a fundamental part of the UK's move toward a sustainable energy system. The installation of BESS systems both in the UK and around the globe is increasing at an exponential rate. A number of high profile incidents have taken place and learning from these incidents continues to emerge.

In the UK, approval for the majority of BESS installations takes place through the Local Authority planning process. Fire and Rescue Services (FRSs) may be engaged throughout the planning process, but this is not a statutory requirement. However, the National Fire Chiefs Council would encourage early engagement with the local FRS, continuing throughout the planning process.

The NFCC's expectation is that a comprehensive risk management process must be undertaken by operators to identify hazards and risks specific to the facility and develop, implement, maintain and review risk controls. From this process a robust Emergency Response Plan should be developed.

Given the rapidly developing nature of the technology, and ever evolving understanding of risks and mitigation measures, there is a need for guidance to support FRSs in providing consistent and evidence-based contributions to the planning process.

The guidance does not seek to provide a full specification or opinion on the entirety of a BESS system design. Instead, the aim is to limit the content to such matters that directly relate to facilitating a safe and effective response, by the fire and rescue service, to a fire or vapour cloud release involving a BESS installation. This includes factors such as facilities for the fire and rescue service, and design factors that contribute to reducing the escalation in the severity of an incident.

This guidance relates specifically to grid scale (typically 1 MW or larger) BESS in open air environments, using lithium-ion batteries.

The guidance is based upon a range of supporting materials including academic research, national and international standards, case studies, and industry guidance. The content of this document is the result of analysis of that supporting material with subsequent professional judgement applied. Every BESS installation will be different and fire and rescue services should not limit themselves to the content of this guidance. Particular reference has been made to the following:

- State of Victoria (County Fire Authority) (2022), *Design Guidelines and Model Requirements: Renewable Energy Facilities*
- FM Global (2017) *Property Loss Prevention Data Sheets: Electrical Energy Storage Systems Data Sheet 5-33*

- NFPA (2023) *Standard for the Installation of Stationary Energy Storage Systems*

Further advice and guidance can be obtained through the NFCC Alternative Fuels and Energy Systems lead officer.

This document contains guidance on:

1. Information requirements
2. System design, construction, testing and decommissioning
3. Detection and monitoring
4. Suppression systems
5. Site access
6. Water supplies
7. Emergency plans
8. Environmental impacts
9. Recovery

Principles

This guidance has been developed with the safety of the public and emergency responders in mind. It is based on trying to help reduce the risk as far as reasonably practicable, whilst recognising that ultimate responsibility for the safe design and running of these facilities rests with the operator.

The guidelines are a starting point and cannot cover every eventuality or type of design.

In developing these guidelines the hazards and risks from lithium-ion batteries, identified in National Operational Guidance, has been considered.

The following principles should be considered by Fire Services, when liaising with owners and operators, and form the basis of this guidance[3]:

1. Effective identification and management of hazards and risks specific to the siting, infrastructure, layout, and operations at the facility.
2. Impact on surrounding communities, buildings, and infrastructure.
3. Siting of renewable energy infrastructure so as to eliminate or reduce hazards to emergency responders.
4. Safe access for emergency responders in and around the facility, including to energy storage infrastructure and firefighting infrastructure.
5. Provision of adequate water supply and firefighting infrastructure to allow safe and effective emergency response.
6. Vegetation sited and managed so as to avoid increased bushfire and grassfire risk.
7. Prevention of fire ignition on-site.

[3] State of Victoria (County Fire Authority) (2022), Design Guidelines and Model Requirements: Renewable Energy
Facilities, p.4

8. Prevention of fire spread between site infrastructure (solar panel banks, wind turbines, battery containers/enclosures).
9. Prevention of external fire impacting and igniting site infrastructure.
10. Provision of accurate and current information for emergency responders during emergencies.
11. Effective emergency planning and management, specific to the site, infrastructure and operations.
12. Owner to have a comprehensive Emergency Response Plan, showing full understanding of hazards, risks, and consequences.

Information Requirements

Grid scale BESS should form part of FRS planning in accordance with arrangements required under section 7(2)(d) of the Fire and Rescue Services Act (2004). Site Specific Risk Information (SSRI) should be made available to crews in the form of an effective Emergency Response Plan.

Details of any site access arrangements, such as key codes, should be provided to the FRS.

System design, construction, testing and decommissioning

Information is required as early as possible from the applicant /developer/designer/manufacturer etc., to allow an initial appraisal of the BESS to be made. This information should be provided to the FRS (via the Local Authority Planners in the first instance), with appropriate evidence provided to support any claims made on performance, and with appropriate standards cited for installation.

Such information should also be made available to FRSs for inclusion in Site Specific

Risk Information (SSRI) records.

System design and construction

Information required:

1. The battery chemistries being proposed (e.g. Lithium-ion Phosphate (LFP), Lithium Nickel Manganese Cobalt Oxide (NMC)). Because:
    a. Battery chemistries will directly affect the heat released when a cell goes into thermal runaway[4]
    b. Battery chemistries will influence vapour cloud formation.
    c. An understanding of the battery chemistry is useful when requesting scientific advice during an incident.
2. The battery form factor (e.g. cylindrical, pouch, prismatic)
3. Type of BESS e.g. container or cabinet
4. Number of BESS containers/cabinets

4 https://www.nasa.gov/sites/default/files/atoms/files/nabw20_fire_gas_char_studies_liion_cells_batt_djuarezrobles.pdf

5. Size/capacity of each BESS unit (typically in MWh) 6. How the BESS units will be laid out relative to one another.
7. A diagram / plan of the site.
8. Evidence that site geography has been taken into account (e.g. prevailing wind conditions).
9. Access to, and within, the site for FRS assets 10. Details of any fire-resisting design features 11. Details of any:
    a. Fire suppression systems
    b. On site water supplies (e.g. hydrants, EWS etc)
    c. Smoke or fire detection systems (including how these are communicated)
    d. Gas and/or specific electrolyte vapour detection systems
    e. Temperature management systems
    f. Ventilation systems
    g. Exhaust systems
    h. Deflagration venting systems
12. Identification of any surrounding communities, sites, and infrastructure that may be impacted as a result of an incident.

Testing

Details of any evidence based testing of the system design should be requested, for example, results of UL 9540A testing.

Design

Design features should be made clear. These may include:

- Rack layout and setup
- Thermal barriers and insulation
- Container layout and access arrangements

Detection and monitoring

An 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. This may be achieved automatically through the provision of an effective Battery Management System (BMS) and/or a specific electrolyte vapour detection system.

Should thermal runaway conditions be detected then there should be the facility in place for the early alerting of emergency services.

Detection systems should also be in place for alerting to other fires that do not involve thermal runaway (for example, fires involving electrical wiring).

Continuous combustible gas monitoring within units should be provided. Gas detectors should alarm at the presence of flammable gas (yes/no), shut down the ESS, and cause the switchover to full exhaust of the ventilation system[5]. Sensor location should be appropriate for the type of gas detected e.g. hydrogen, carbon monoxide, volatile organic compounds.

[5] FM Global (2017) Property Loss Prevention Data Sheets: Electrical Energy Storage Systems, para. 2.5.5.2

External audible and visual warning devices (such as cabinet level strobing lights), as well as addressable identification at control and indicating equipment, should be to linked to:

1. Battery Management System (when a thermal runaway event is identified)
2. Detection and suppression system activation

This will enable first responders to understand what the warning is in relation to. This will aid in their decision-making.

Suppression systems

Suitable fixed suppression systems should be installed in units in order to help prevent or limit propagation between modules.

Where it is suggested that suppression systems are not required in the design, this choice should be supported by an evidence based justification and Emergency Response Plan that is designed with this approach in mind (for example, risk assessed controlled burn strategies, and external sprinkler systems).

Whilst gaseous suppression systems have been proposed previously, current research indicates the installation of water based suppression systems for fires involving cell modules is more effective.

The installation of gaseous suppression systems for electrical fires that do not involve cell modules may be appropriate but should be built into a wider suppression strategy.

FM Global cite the following reasons for not recommending gaseous protection systems[6]:

1. **Efficacy relative to the hazard**. As of 2019, there is no evidence that gaseous protection is effective in extinguishing or controlling a fire involving energy storage systems. Gaseous protection systems may inert or interrupt the chemical reaction of the fire, but only for the duration of the hold time. The hold time is generally ten minutes, not long enough to fully extinguish an ESS fire or to prevent thermal runaway from propagating to adjacent modules or racks.
2. **Cooling**. FM Global research has shown that cooling the surroundings is a critical factor to protecting the structure or surrounding occupancy because there is currently no way to extinguish an ESS fire with sprinklers. Gaseous protection systems do not provide cooling of the ESS or the surrounding occupancy.
3. **Limited Discharge**. FM Global research has shown that ESS fires can reignite hours after the initial event is believed to be extinguished. As gaseous protection systems can only be discharged once, the subsequent reignition would occur in an unprotected occupancy

The choice of a suppression system should be informed by liaison with a competent system designer who can relate the system choice to the risk identified and the duration of its required activation. Such a choice must be evidence based.[7]

[6] FM Global (2017) Property Loss Prevention Data Sheets: Electrical Energy Storage Systems, para. 3.3
[7] NFPA (2023) Standard for the Installation of Stationary Energy Storage Systems, para C.3

Any calculations for sufficient water supply for an appropriate suppression system will need to be completed by a competent person considering the appropriate risk and duration of any fire.

Water run-off and potential impact on the environment, along with mitigation measures, should be considered and detailed in the Emergency Response Plan.

Lack of sufficient water supplies at a particular site location should not be considered as the basis for a suppression system choice. Such an approach could result in potentially ineffective and/or dangerous system designs.

Deflagration Prevention and Venting

BESS containers should be fitted with deflagration venting and explosion protection appropriate to the hazard. Designs should be developed by competent persons, with design suitability able to be evidenced.[8] Exhaust systems designed to prevent deflagration should keep the environment below 25% of Lower Explosive Limit (LEL).

Flames and materials discharged as a result of any venting should be directed outside to a safe location and should not contribute to any further fire propagation beyond the unit involved or present further risk to persons. The likely path of any vented gasses or materials should be identified in Emergency Response Plans to reduce risk to responders.

Explosion/deflagration strategies should be built into the emergency plan such that responders are aware of their presence and the impact of their actions on these strategies.[9][10]

Where emergency ventilation is used to mitigate an explosion hazard, the disconnect for the ventilation system should be clearly marked to notify personnel or first responders to not disconnect the power supply to the ventilation system during an evolving incident.[11]

Access

Site access

Suitable facilities for safely accessing and egressing the site should be provided. Designs should be developed in close liaison with the local FRS as specific requirements may apply due to variations in vehicles and equipment.

This should include:

- At least 2 separate access points to the site to account for opposite wind conditions/direction.
- Roads/hard standing capable of accommodating fire service vehicles in all weather conditions. As such there should be no extremes of grade.
- A perimeter road or roads with passing places suitable for fire service vehicles.
- Road networks on sites must enable unobstructed access to all areas of the facility.
- Turning circles, passing places etc size to be advised by FRS depending on fleet.

[8] BS EN 16009:2011 Flameless Explosion Venting Devices; BS EN 14373:2021 Explosion Suppression Systems; BS EN 14797:2007 Explosion Venting Devices.

[9] UL FRSI (2020) Four Firefighters Injured in Lithium-ion Battery Energy Storage System Explosion – Arizona, pp.

[10] -49

[11] NFPA (2023) Standard for the Installation of Stationary Energy Storage Systems, para G.1.4.3.3

Access between BESS units and unit spacing

In the event of a fire involving a BESS unit, one of the primary tactics employed will be to prevent further unit to unit fire spread. Suitable access for firefighters to operate unimpeded between units will therefore be required. This should allow for the laying and movement of hose lines and, as such, access should be free of restrictions and obstacles. The presence of High Voltage DC Electrical Systems is a risk and their location should be identified. Exclusion zones should be identified.

A standard minimum spacing between units of 6 metres is suggested[12] unless suitable design features can be introduced to reduce that spacing. If reducing distances a clear, evidence based, case for the reduction should be shown.

Any reduction in this separation distance should be design based by a competent fire engineer.

There should be consideration for the fire separation internally and the total realistic load of fire. Proposed distances should be based on radiant heat flux (output) as an ignition source.

The NFCC does not support the stacking of containers/units on top of one another on the basis of the level of risk in relation to fire loading, potential fire spread, and restrictions on access.

Distance from BESS units to occupied buildings & site boundaries

Individual site designs will mean that distances between BESS units and occupied buildings/site boundaries will vary. Proposed distances should take into account risk and mitigation factors. However, an initial minimum distance of 25 metres is proposed prior to any mitigation such as blast walls. Reduction of distances may be possible in areas of lower risk (e.g. rural settings). Where possible buildings should be located upwind.

Site Conditions

Sites should be maintained in order that, in the event of fire, the risk of propagation between units is reduced. This will include ensuring that combustibles are not stored adjacent to units and access is clear and maintained. Areas within 10 metres of BESS units should be cleared of combustible vegetation and any other vegetation on site should be kept in a condition such that they do not increase the risk of fire on site. Areas with wildfire risk or vegetation that would result in significant size fires should be factored into this assessment and additional cleared distances maintained as required.

Water Supplies

Water supplies will depend on the size of the installation. In the majority of cases, initial firefighting intervention will focus on defensive firefighting measures to prevent fire spread to adjacent containers. As a result, proposals for water supplies on site should be developed following liaison with the local fire and rescue service taking into account the likely flow rates required to achieve tactical priorities. This should also take account of the ability of/anticipated time for the fire and rescue service to bring larger volumes of water to site (for example through the provision of High Volume Pumps).

[12] FM Global (2017) Property Loss Prevention Data Sheets: Electrical Energy Storage Systems, para. 2.3.2.2

IP ratings of units should be known so that risks associated with boundary cooling can be understood.

As a minimum, it is recommended that hydrant supplies for boundary cooling purposes should be located close to BESS containers (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. Fire and rescue services may wish to increase this requirement dependant on location and their ability to bring supplementary supplies to site in a timely fashion.

Water supply for any automatic suppression system will be covered by the relevant standard/design depending on which system chosen as appropriate for the risk. For manual water, amounts should come from performance based requirement rather than a reference to a code, unless it can be proven that the code specifically covers BESS. Regarding water storage tanks, volumes will again need to be informed on a performance-based need. Isolation points should be identified.

Any static water storage tanks designed to be used for firefighting must be located at least 10 metres away from any BESS container/cabinet. They must be clearly marked with appropriate signage. They must be easily accessible to FRS vehicles and their siting should be considered as part of a risk assessed approach that considers potential fire development/impacts. Outlets and connections should be agreed with the local FRS. Any outlets and hard suction points should be protected from mechanical damage (e.g. through use of bollards).

Consideration should be given, within the site design, to the management of water run-off (e.g. drainage systems, interceptors, bunded lagoons etc).

Signage

Signage should be installed in a suitable and visible location on the outside of BESS units identifying the presence of a BESS system. Signage should also include details of:

- Relevant hazards posed
- The type of technology associated with the BESS
- Any suppression system fitted
- 24/7 Emergency Contact Information

Signs on the exterior of a building or enclosure should be sized such that at least one sign is legible at night at a distance of 30 metres or from the site boundary, whichever is closer[13].

Adherence to the Dangerous Substances (Notification and Marking of Sites) Regulations 1990 (NAMOS) should be considered where the total quantity of dangerous substances exceeded 25 tonnes.

Emergency Plans

Site operators should develop emergency plans and share these with the Fire and Rescue Service. These include:

[13] NFPA (2023) Standard for the Installation of Stationary Energy Storage Systems, para G.1.4.2.1.1

A Risk Management Plan should be developed by the operator, which provides advice in relation to potential emergency response implications including:

- 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 site infrastructure and fire protection systems.
- The adequacy of proposed fire detection and suppression systems (e.g., water supply) on-site.
- Natural and built infrastructure and on-site processes that may impact or delay effective emergency response.

An Emergency Response Plan should be developed to facilitate effective and safe emergency response and should include:

- How the fire service will be alerted
- A facility description, including infrastructure details, operations, number of personnel, and operating hours.
- A site plan depicting key infrastructure: site access points and internal roads; firefighting facilities (water tanks, pumps, booster systems, fire hydrants, fire hose reels etc); drainage; and neighbouring properties.
- Details of emergency resources, including fire detection and suppression systems and equipment; gas detection; emergency eye-wash and shower facilities; spill containment systems and equipment; emergency warning systems; communication systems; personal protective equipment; first aid.
- Up-to-date contact details for facility personnel, and any relevant off-site personnel that could provide technical support during an emergency.
- A list of dangerous goods stored on site.
- Site evacuation procedures.
- Emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire, grassfire and bushfire

Environmental impacts

Suitable environmental protection measures should be provided. This should include systems for containing and managing water runoff. System capability/capacity should be based on anticipated water application rates, including the impact of water based fixed suppression systems.

Sites located in flood zones should have details of flood protection or mitigation measures.

Recovery

The operator should develop a post-incident recovery plan that addresses the potential for reignition of ESS and de-energizing the system, as well as removal and disposal of damaged equipment.[14]

[14] FM Global (2017) Property Loss Prevention Data Sheets: Electrical Energy Storage Systems, para. 2.8.2.3

Appendix B – Engagement with the SFRS

Date:	08 January 2024	**Ref:**	O-LO-R70-039330	**Meeting Started:**	11:00 hrs
Venue:	Online			**Meeting Adjourned:**	11:45 hrs
Attended by:	Three (3) attendees from OWC Four (4) attendees from the Scottish Fire and Rescue Service (SFRS)				
Apologies:	NA				
Subject:	Braxbess Storage BESS Fire Strategy				
Discussion:	**Braxbess Storage BESS Fire Strategy** OWC provided an overview of the proposed Braxbess BESS layout and the fire fighting strategies proposed. OWC noted that there a secondary access has not been proposed, noting that the site is very large. SFRS reiterated that the NFCC guidance stipulates a minimum of 2 entrances and noted that practically a single access point could be problematic for vehicle and convoy access. SFRS noted that there was a large fire at a landfill in Dunbar where the smoke plumb entered Dunbar causing great disruption. SFRS has a strong preference for a secondary access to mitigate risk of smoke preventing fire fighting efforts. OWC noted there are challenges with establishing a secondary access from a western direction, however, there is potential to establish a secondary access at the south-east corner of the site which given the large size may be feasible from a smoke perspective. SFRS noted that the primary access appears to be a small track road that may present logistical challenges. Pass-by areas may need to be included. SFRS to review the Braxbess Storage BESS Fire Strategy in more detail in the next few weeks and provide feedback, including consideration of the prevailing wind conditions of the area. OWC to notify the client of the SFRS's strong preference to incorporate a secondary access.				

Item #	Narrative	Action by:	Deadline
1.	SFRS to review the fire strategy and revert with feedback.	SFRS	20/01/2024
2.	OWC to provide initial SFRS feedback to the client.	OWC	10/01/2024