

# BATTERY ENERGY STORAGE SYSTEM FIRE SAFETY OVERVIEW

## Unit 3, Chosen Park, Baglan Bay Energy Park

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# Contents

1.0 Introduction .....1

2.0 The Technology .....1

3.0 Standards .....1

4.0 Fire Risk.....2

5.0 Mitigation .....3

6.0 Proposal.....4

7.0 Risk Management Plan & Emergency Response Plan .....6

8.0 Conclusion .....8

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## **1.0 Introduction**

- 1.1 GTH has prepared this Fire Safety Overview on behalf of Aldustria Limited. It supports the submission of a planning application for the installation of a 30MW battery energy storage system (BESS) on land adjacent to Unit 3, Chosen Industrial Park, Baglan Energy Park, SA11 2HZ.
- 1.2 This document explains the technology, the standards it must comply with and assesses the potential for fire risk. Good management of fire safety is essential to ensure that, in the first place, fires are unlikely to occur; and if they do occur, they are controlled or contained quickly, effectively and safely.
- 1.3 As the industry develops, the safety standards and expectations are constantly evolving to be specific to BESS. Planning Practice Guidance (PPG) has recently been updated which identifies the need to consider the fire safety as part of BESS planning applications.

## **2.0 The Technology**

- 2.1 A lithium-ion or Li-ion battery is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy.
- 2.2 Li-ion is the predominant battery type used in portable consumer electronics and electric vehicles. It also sees significant use for grid-scale energy storage and military and aerospace applications. Compared to other rechargeable battery technologies, Li-ion batteries have high energy density, low self-discharge, and no memory effect (although a small memory effect reported in lithium iron phosphate batteries has been traced to poorly made cells).
- 2.3 Lithium-ion batteries can be a safety hazard if not properly engineered and manufactured, because cells have flammable electrolytes and if damaged or incorrectly charged, can lead to explosions and fires. Much progress has been made in the development and manufacturing of safe lithium-ion batteries. Lithium ion all solid state batteries are being developed to eliminate the flammable electrolyte.

## **3.0 Standards**

- 3.1 BESS is regulated through various legislation and standards, which include measures regarding safety. The battery system technology and installation, its connectivity of the system to the outside network, as well as the conditions in which the battery is kept through operation and maintenance, are all important.
- 3.2 Battery safety standards are typically separated out into subsections of the battery system, such as:
  - System;
  - Enclosure;
  - Energy Bays;
  - Modules;

- Cells.

### 3.3 BESS safety standards for different levels of the system are given below.

| BESS Safety Standards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                |                                                                                   |                                                                                                                 |                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------------------|
| System Level                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Safety Consideration                                                                                                                                           |                                                                                   |                                                                                                                 |                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Safety                                                                                                                                                         | Electromagnetic Compatibility                                                     | Seismic and Enclosure Integrity                                                                                 | Grid Interconnection             |
| System                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | UL 9540<br>NFPA 70 and 70E<br>UN38.3<br>IEC 60529,<br>IEC60950-1<br>(Controls), IEC<br>62040-1 IEEE C-2<br>(National Electrical<br>Safety Code) IEC<br>62040-1 | FCC 47 CFR Part<br>15 Subpart B Class<br>A IEC 61000-6-2, 4,<br>and 5 EN 55011    | CBC/IBC and IEEE<br>693 IEC 60529<br>AMERICAN<br>BUREAU OF<br>SHIPPING<br>Certificate of<br>CARGO<br>CONTAINERS | UL 1741 SA IEEE<br>519 IEEE 1547 |
| Battery Racks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | UL 1973, NFPA 70<br>and 70E UN38.3<br>IEC 61508(BMS),<br>IEC 62619                                                                                             | FCC 47 CFR Part<br>15 Subpart B Class<br>A IEC 61000-6-2, 4,<br>5, and 7 EN 55011 | CBC/IBC and IEEE<br>693                                                                                         |                                  |
| Modules                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | UL 1973 UN 38.3<br>IEC 62619                                                                                                                                   |                                                                                   |                                                                                                                 |                                  |
| Cells                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | UL 1642 UN 38.3<br>IEC 62619                                                                                                                                   |                                                                                   |                                                                                                                 |                                  |
| <p>The relevant standards can be found on their relevant website databases:</p> <p>UL: <a href="https://standardscatalog.ul.com/">https://standardscatalog.ul.com/</a></p> <p>IEEE: <a href="https://standards.ieee.org/standard/1547-2018.html">https://standards.ieee.org/standard/1547-2018.html</a></p> <p>UN 28.3: <a href="http://www.unece.org/trans/areas-of-work/dangerous-goods/legal-instruments-and-recommendations/un-manual-of-tests-and-criteria/rev6-files.html">http://www.unece.org/trans/areas-of-work/dangerous-goods/legal-instruments-and-recommendations/un-manual-of-tests-and-criteria/rev6-files.html</a></p> <p>IEC: <a href="https://www.iecee.org/dyn/www/f?p=106:48:0">https://www.iecee.org/dyn/www/f?p=106:48:0</a></p> <p>NFPA: <a href="https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards">https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards</a></p> <p>FCC 47: <a href="https://www.fcc.gov/wireless/bureau-divisions/technologies-systems-and-innovation-division/rules-regulations-title-47">https://www.fcc.gov/wireless/bureau-divisions/technologies-systems-and-innovation-division/rules-regulations-title-47</a></p> <p>CBC: <a href="https://up.codes/codes/california">https://up.codes/codes/california</a></p> <p>IBC: <a href="https://www.iccsafe.org/products-and-services/i-codes/2018-i-codes/ibc/">https://www.iccsafe.org/products-and-services/i-codes/2018-i-codes/ibc/</a></p> <p>EN: <a href="https://www.en-standard.eu/">https://www.en-standard.eu/</a></p> |                                                                                                                                                                |                                                                                   |                                                                                                                 |                                  |

- 3.4 These standards offer an overview of the safety of the system itself, and are usually in aid of preventing system damage and faults. Many of the battery safety standards include fire safety requirements to be fulfilled, and are frequently updated to ensure lockstep with an evolving industry.

## 4.0 Fire Risk

- 4.1 The overall biggest risk from a battery system is a thermal event that is severe enough to cause a fire, leading to thermal runaway. The overheating of lithium-ion cells can result in a self-accelerating reaction called thermal runaway, where internal temperature and pressure rise at a quicker rate than can be dissipated. Resultantly, the cell produces a significant amount of heat, and can ignite, which flames and can affect adjacent cells.

- 4.2 The primary causes of BESS related fires are suspected to be as follows:
- Lack of battery protection against electric shocks;
  - Insufficient oversight in the battery's environment;
  - Inattention to installation details;
  - Missing BESS integration controls and protection systems.
- 4.3 These same causes have been found to be the case for battery fires that have occurred, and the vast majority of these causes are the result of avoidable errors in the development process.
- 4.4 Considerations to aid with reducing potential fire risk are as follows:
- Purchasing batteries from quality manufacturers;
  - The battery system integration, both from the point of view of hardware, as well as from software;
  - Product design and post-operation maintenance are key to the safe operation of a battery system.
- 4.5 The risk of a fire in a battery system can be dramatically reduced by exercising care and caution in its design and construction, and using experienced suppliers and workers to build, operate, and maintain the system.

## **5.0 Mitigation**

- 5.1 Most BESS manufacturers and system suppliers offer a fire detection and suppression system. Such systems are built into the BESS's housing, and operate through the release of an inert gas / fire suppressing agent as the result of smoke/thermal detection or other fire detection system.
- 5.2 Additionally, most systems include an audio/visual response (siren/flashing light) as well as remote indicators for the system operator. For example, once either smoke or a high level of thermal energy is detected, an alarm is raised both onsite and to the remote control centre, whereafter the system container is sealed to prevent airflow, and an inert gas is released to smother any fire before it causes excessive damage leading to a larger fire.
- 5.3 Alongside this, there are preventive measures such as shutting down a particular battery rack/module to stop the increased risk of thermal runaway spreading from one cell to its neighbouring cells, which is monitored remotely by a battery management system (BMS).
- 5.4 Another key fire safety consideration that a battery system owner and/or operator can do to ensure a low risk through the battery system's life is to ensure its maintenance. Frequent monitoring (at least twice per year is often recommended) and routine cleaning and thorough inspection of the hardware are the best way to ensure the safety of the system.

- 5.5 Furthermore, a well-implemented system with comprehensive and ongoing operation and maintenance should have a checklist of specific criteria to check that may indicate a risk that could lead to a thermal event.
- 5.6 Additionally, the connection to the grid network should be considered by both the battery system supplier as well as the network operator to consider any potential safety considerations that may be applicable.

## **6.0 Proposal**

### **Layout**

- 6.1 The proposed system is a ground mounted, utility scale and grid connected development based on a modular system and does not include placing any BESS equipment within or in proximity to other buildings. The site would be secure and only accessible to those authorised to be in attendance and only for purposes associated with the BESS. The security measures include 2.4m high metal palisade fencing, CCTV monitoring and motion activated security lighting.
- 6.2 The proposed development has been designed by accredited and experienced electrical designers to conform with current standards and to the satisfaction of investors, insurance and independent third-party technical advisor due diligence. The proposed BESS is compliant with the test results of UL9540A and NFPA 855 instructions, standards highlighted in paragraph 3.3, which are the strictest fire safety regulations for battery systems at this time. The plans show a separation distance of at least 2m between battery system skids, limiting the number of modular units that will be grouped together.

### **Management**

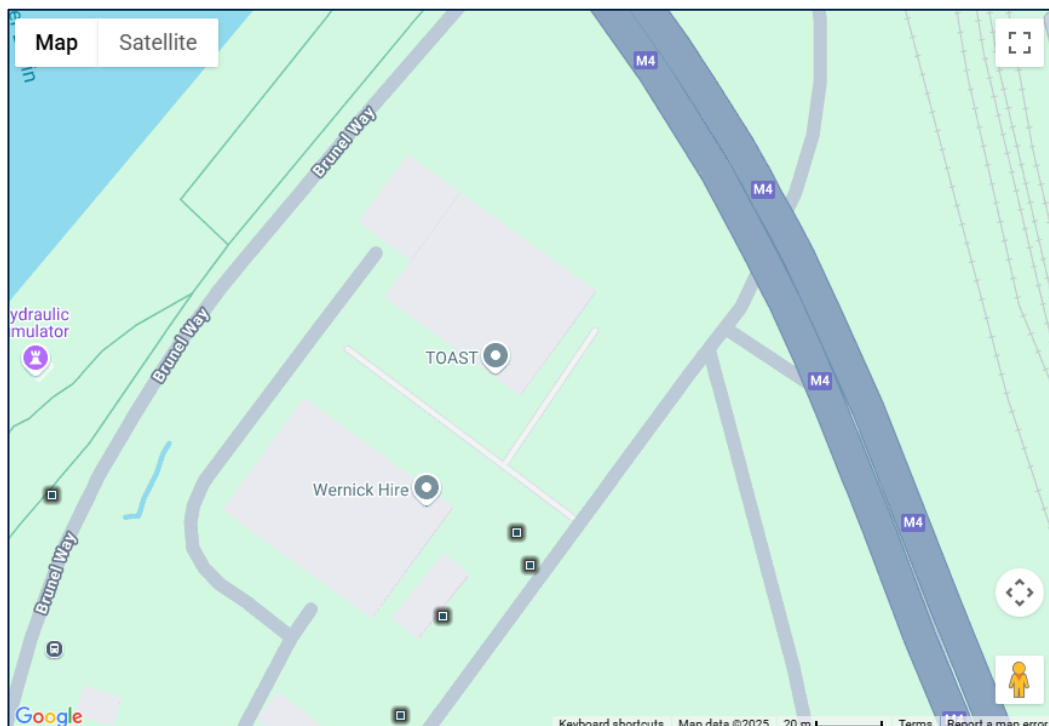
- 6.3 The proposed development will be operated to a strict management schedule and will be monitored 24 hours per day 365 days per year. Given the proposed modular system, it is more controllable and early, targeted shutdown is more effective in the event of a fire.
- 6.4 Smoke detectors are fitted within the modules, and at a cell, module and rack level there is continuous heat monitoring and data collection via the BMS, primarily to optimise performance, regulate temperature via the inbuilt liquid cooling system and detect degradation. The BMS provides an effective means of identifying any thermal event and for this identification to be at the earliest possible moment, since any cell, module or rack can be shut down before any significant overheating occurs, thus avoiding smoke or other off-gassing or electrolyte vapour.
- 6.5 Should the system solely rely on smoke detection, it would mean a thermal event could only be identified when thermal runaway had commenced, as evidenced by the issuing of smoke. Therefore, the detection system deployed in this development is far more effective than just smoke detection and provides a far higher level of risk mitigation.

6.6 All modules are fitted with an aerosol fire suppression equipment, meaning modules can be isolated and aerosol released to cut off oxygen and tackle any identified thermal event. Sprinkler protection as an extinguishing mechanism would not be effective and is not relevant to this type of electrical development.

#### 6.7 Local Fire and Rescue Service

6.8 Should a fire occur when the site is unmanned or emergency service require access then the site could be accessed via the main entrance which would have an electronic coded entry, to be provided to Mid and West Wales Fire and Rescue Service. In addition, a 24 hour key holder would be available, with a contact number being provided to the Mid and West Wales Fire and Rescue Service and clearly displayed at the entrance to the site.

6.9 Due to the fire risks of BESSs, if one was to occur it would likely be an electrical fire and although the site would be remotely isolated from water mains, water from a hydrant would not be the appropriate medium to tackle these types of fires. This example highlights that the site does not need a fire hydrant due to the likely nature of the fire, however, the NFCC guidance requires the provision of firefighting infrastructure including an adequate water supply. There are a number of hydrants in close proximity to the site, as shown in the image below. Furthermore, each battery container is fitted out with five sprinkler heads for connection to a hydrant if required.



Map showing location of hydrants near application site.  
Source: <https://dataservices.riscauthority.co.uk/map/index>

6.10 A plan showing vehicle tracking for a fire engine to access the site is submitted as part of the planning application supporting documents.

## **7.0 Risk Management Plan & Emergency Response Plan**

### **Fire Risk Assessment**

- 7.1 Guidance published by the National Fire Chiefs Council (NFCC) advises that in order to comply with the Regulatory Reform (Fire Safety) Order 2005, the responsible person for a premises must carry out a fire risk assessment, prior to operation.
- 7.2 This guidance advises that a fire risk assessment should consider:
- Emergency routes and exits;
  - Fire detection and warning systems;
  - Firefighting equipment;
  - The removal or safe storage of dangerous substances;
  - An emergency fire evacuation plan;
  - The needs of vulnerable people, eg the elderly, young children or those with disabilities;
  - Providing information to employees and other people on the premises;
  - Staff fire safety training.
- 7.3 Most of the above considerations can be demonstrated through the information presented within this document.
- 7.4 The site is not publicly accessible with only authorised and trained personnel being present on the site. Staff would receive required fire safety training on site as necessary under legislation, with accommodations for accessibility being provided as needed.
- 7.5 Throughout the site, appropriate signage regarding fire safety would be installed, providing required information to staff to ensure their safety in the event of a fire.

### **Risk Management Plan**

- 7.6 Following guidance from the NFCC, Fire and Rescue Services are expecting specific information about the site to ensure the safety of the public and responders in the event of a fire. The guidelines set out in the Grid Scale Battery Energy Storage System Planning supplementary document, require the following information:
- Effective identification and management of hazards and risks specific to the siting, infrastructure, layout, and operations at the facility;
  - Impact on surrounding communities, buildings, and infrastructure;

- Siting of renewable energy infrastructure so as to eliminate or reduce hazards to emergency responders;
- Safe access for emergency responders in and around the facility, including to energy storage infrastructure and firefighting infrastructure;
- Provision of adequate water supply and firefighting infrastructure to allow safe and effective emergency response;
- Vegetation sited and managed so as to avoid increased bushfire and grassfire risk;
- Prevention of fire ignition on-site;
- Prevention of fire spread between site infrastructure (solar panel banks, wind turbines, battery containers/enclosures);
- Prevention of external fire impacting and igniting site infrastructure;
- Provision of accurate and current information for emergency responders during emergencies;
- Effective emergency planning and management, specific to the site, infrastructure and operations;
- Owner to have a comprehensive Emergency Response Plan, showing full understanding of hazards, risks, and consequences.

7.7 Details required for this document have been stated previously within this overview, and together with the information gathered from the Fire Risk Assessment, forms a comprehensive Risk Management Plan.

### **Emergency Response Plan**

7.8 Following requirements under section 7(2) (d) of the Fire and Rescue Service Act (2004), Site Specific Risk Information (SSRI) should be provided to the local FRS to allow for the initial appraisal of the BESS site. The NFCC requires planning applications for BESS sites to submit the following information;

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

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

7.9 These details have been stated previously within this document, planning statement and site plans. Together they inform Emergency Response Plan, which under The Civil Contingencies Act places responsibility on Category 1 responders to produce, to ensure that any event of a fire could be tackled safely.

## 8.0 Conclusion

8.1 Overall, this document establishes the BESS layout and management in regard to fire mitigation, stating the integrated monitoring and suppression systems and lays out the ongoing maintenance to ensure continued compliance with fire safety requirements.

8.2 This overview supports the planning application through demonstrating compliance with the necessary legislation, guidance and safety regulations set out by the NFCC, providing all the required information for the development of various fire safety reports and plans, which ensure the safety of the public and responders in the event of a fire at this site.