Grid-Scale Battery Energy Storage Systems – General Considerations

The use of Grid-Scale Battery Energy Storage Systems is becoming increasingly common as organisations seek to maximize energy efficiency, cost savings, and meet their Environmental, Sustainability and Governance goals.

This Loss Prevention Standard provides an overview of Grid-Scale Battery Energy Storage Systems, and risk management guidance to help reduce the potential for loss or damage from the use of such Systems.

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Introduction

Grid-Scale Battery Energy Storage Systems (BESS) are a means of capturing and storing energy. They can also be used to maximise the generation of energy from renewable energy sources, such as onshore or offshore wind turbines and photovoltaic solar panel systems. Primarily, the energy stored in BESS is used to provide grid services such as frequency regulation, peak shaving, voltage support and congestion relief.

Whilst these systems have a proven track record of safe operation, a number of battery energy storage fires have been reported over recent years. The most significant being a thermal runaway event at a large BESS facility in the US in 2019 which resulted in a blast that seriously injured four firefighters. More recently, there have been thermal runway related battery energy storage fires at a number of locations in the US and Australia resulting in the loss of at least one battery energy storage system and impacting energy production at the site.

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This document provides an overview of outdoor grid-scale BESS, outlining the main areas of concern, and provides useful guidance on minimising the associated risks. It excludes any type of indoor BESS and any outdoor systems that are not used for grid services, which are discussed in Aviva Loss Prevention Standard **Small-Scale Battery Energy Storage Systems.** Guidance on constructing grid-scale BESS can be found in Aviva Loss Prevention Standard **Grid-Scale Battery Energy Storage Systems – Construction**, and inspection and maintenance in **Grid-Scale Battery Energy Storage Systems – Ongoing Care**.

Note: This document is focussed on property loss prevention in relation to liquid electrolyte battery BESS installations and related risk management guidance. It is not intended to address Liability exposures. The presumption is that all regulatory requirements, Fire Risk Assessments, and compliance with requirements placed by the local authority having jurisdiction which would include licencing, building permissions, regulations, codes, or standards, have or will be met.

Background

Modern BESS are a type of energy storage technology, and dispatchable source of power. They provide more flexibility to grid infrastructure, whilst also enabling cost efficient decarbonisation of energy systems. The rise of lithium-ion batteries has helped the deployment of BESS at scale and the proportion of energy supplied by BESS installations within the UK is expected to grow to 10GWh by 2030, with global installed capacity forecasted to reach close to 2 TWh at the same time.

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BESS installations come in a range of different types of enclosures including containers, cabinets, segmented systems, and modular systems. They comprise a number of key components, namely:

- **Batteries.** The system features a number of battery racks, which will vary based upon the manufacturing design and size of the enclosure, with each rack containing a number of individual modules containing liquid electrolyte battery cells. The BESS unit energy density depends on its size, internal arrangement, and chemistry, and ranges between a few hundred kWh to several MWh.

  Battery cells are available in three types:
  - ✓ **Pouch** – Typically composed of aluminium pouches housing the electrolyte, anodes and cathodes, and separating material. Whilst providing some flexibility of packing, these types are more vulnerable to rupture, impact damage and swelling, which potentially impacts other cells and do not support extensive deep cycle functions. As such they are considered less favourable for use in grid-scale BESS.
  - ✓ **Prismatic** – Typically housed in an aluminium and polymer case, this cell type supports regular deep discharge, provides longer life and increased power storing capability. The aluminium may however be vulnerable to corrosion in some environments. These are the most common and favourable type for BESS.
  - ✓ **Cylindrical Cells** – Traditional battery type, typically arranged in parallel to achieve the required power capability. These cell types have a shorter life compared to prismatic cells, but longer than pouch cells, and are less efficient in cell packing, matching and cell balancing.

    Note: Other battery technologies can be used, however lithium-ion is currently the most prevalent. In terms of lithium-ion battery chemistry, Lithium Iron Phosphate (LFP) batteries are considered more favourable to other lithium-ion battery chemistries such as Lithium Nickle Manganese Cobalt Oxide (NMC). This is because LFP batteries are more stable, less prone to thermal runaway and have a lower risk of catching fire or exploding than other liquid electrolyte chemistry types.

- **Enclosure.** The battery racks are connected in series and parallel configurations within an enclosure. Common enclosure types include:
  - ✓ Modular/segmented – The key components are housed together within smaller individual metal cabinets, including several cabinets housing batteries, often in back-to-back configurations. The barriers between the modules may be beneficial in reducing the potential for fire spread between modules.
  - ✓ Cabinets – Ranging from small cabinets to larger units, these are narrower than traditional container type enclosures, allowing back to back configurations and are less energy dense per module.
  - ✓ Container - The container type enclosures range in size, typically between 6 and 12 metres and the number provided in the installation will depend on the energy generating capacity and storage requirements.

  Other design features within the enclosure include environmental control via air conditioning; fire barriers; fire protection and fire detection devices; venting for explosion/deflagration and accessibility for ease of inspection and maintenance (more modern BESS enclosure designs are external access only).

  Note: Enclosures with large/multiple openings are preferred for accessibility and safety purposes. Single entry/egress units are not recommended.

Power Conversion Systems (PCS). The batteries generate and charge with DC current, whereas the grid or load will use AC current. The Power Conversion System uses inverters and rectifiers to act as a bridge between the two types of current to change it into a usable form depending on the direction of electric flow. The PCS can be integrated within the BESS unit or located separately, and occasionally also includes the voltage transformer.

- **Battery Management System.** The Battery Management System (BMS) helps ensure the batteries operate within safe and appropriate charging and discharging parameters, as well as managing state of charge; measuring performance against stated Key Performance Indicators (KPI's); temperature output; cell balancing etc., to help maximise performance and minimise the risks of overheating and other safety concerns.

- **System Controller.** The controller performs a similar role to BMS, however it monitors, controls, and protects the whole BESS and its key components. It also communicates performance data to the monitoring system.

- **Cooling system.** The ability to maintain stable working temperatures within the BESS according to manufacturer's guidance is imperative and automated cooling systems linked to the BMS are essential. Methods of cooling currently comprise:
  - ✓ **Air cooling** - Open systems where air is drawn into the enclosure, chilled and circulated to cool the enclosures or closed systems where cool air is drawn from the outside into a heat exchanger to cool the internal enclosure air temperature. Some systems can result in increased moisture levels within the BESS, a potential fire and decomposition risk. Air cooling is also less able to cool evenly within the BESS. It is worth noting that individual battery modules within the enclosure also have additional localised air cooling to provide better heat dissipation. Locations near corrosive environments, such as coastlines, are particularly exposed to advanced corrosion if they use air cooling. Liquid cooling is preferable for these locations and will typically increase the lifespan of the enclosure.
  - ✓ **Liquid cooling** – Used most commonly to cool batteries locally, closed loop liquid refrigerant systems, which circulate through the enclosure are generally preferred over air cooled systems due to the lack of moisture and other contaminants generated. In some systems the design allows even cooling of individual modules. Localised liquid cooling can be used in addition to air cooling for the internal BESS enclosure in some designs.

- **Deflagration Ventilation.** During a thermal runaway event, the battery enclosure should have methods of venting off-gases comprising of volatile organic compounds (VOC) to prevent their buildup inside an enclosed space. These comprise:
  - ✓ **Passive ventilation -** Use of pressure relief panels that open once pressure inside the enclosure reaches a certain level.
  - ✓ **Active ventilation -** Use of ATEX rated fans to circulate gases out of the enclosure.
  - ✓ **Adherence to NFPA 68 - Passive Explosion Mitigation** and/or **NFPA 69 - Standard on Explosion Prevention Systems** which provides guidance on enclosure ventilation.

- **Monitoring System.** These communicate the system outputs and other relevant data, allowing the system to be supervised.

- **Transformer Equipment.** The inverters in the PCS will connect to an adjacent Medium Voltage (MV) transformer, which steps up the voltage to reduce transmission losses. This in turn connects to the offtake point via switchgear, and may be stepped up to a higher voltage through a grid transformer.

Understanding the Risks

The lithium-ion batteries used in BESS are generally safe and reliable to use. If the battery packs are manufactured to acknowledged quality standards, transported correctly and once in use, are charged/discharged, cooled, and monitored appropriately, the risks of fire and explosion are low. The consequences of a fire or explosion involving liquid-electrolyte batteries within a BESS can however be significant and concerns include:

- ✓ **Smoke/off gassing.** Combustion products are highly damaging, corrosive, and can damage buildings and assets. They are also toxic and can lead to long term health impacts and fatalities to workers.
- ✓ **Vapour Cloud Explosion.** The initial off-gassing associated with battery failure contains a number of highly flammable gases or VOCs, which can accumulate within the enclosure and if ignited can lead to deflagration/explosion incidents, particularly if venting systems are not functioning or oxygen levels increase significantly, such as when the door to the BESS enclosure is opened.
- ✓ **Fire.** Following the initial off-gassing event, the batteries may enter thermal runaway and ignition. Lithium-ion battery fires often feature volatile and widely dispersed flaming; a 'chain reaction' effect as fire spreads between individual cells within the battery, or batteries, prolonging the burn time; and the potential for reignition from ongoing chemical battery decomposition after the initial fire.

When the temperature of lithium-ion battery cells increases in excess of safe working parameters, batteries can become unstable and enter a condition known as **thermal runaway**. Thermal runaway typically occurs as a result of external damage, manufacturing defects, controller and charging issues, insufficient climate controls, or internal short circuiting including dendrite formation.

A thermal runaway event is characterised by:

- An increase in internal battery temperature.
- The creation of flammable gases, that are readily ignitable.
- An intense fire event.
- Production of hydrogen and combustible hydrocarbons.
- Potential for explosions (this is particularly prevalent in large scale battery systems where the production of flammable gases is very significant).
- Self-sustaining fire. Thermal runaway events in BESS can typically last several days, or longer dependant on site/layout characteristics, and can re-ignite even after full extinguishment.

A liquid-electrolyte battery fire normally emits significant quantities of dense and combustible hydrocarbons, which resemble smoke, and which can be prolonged in the BESS by the continued cascade of thermal runaway across the battery cells within modules and the battery rack. Any fire within a BESS enclosure is extremely difficult to extinguish and can reignite in some cases due to ongoing chemical decomposition.

Depending on water supplies, the fire size and potential for fire spread, the most favourable firefighting response is to focus on preventing spread of fire to other valuable assets in proximity via cooling of the external areas around the BESS, rather than direct extinguishment of the fire, which is generally largely ineffective.

The amount of firefighting water used in tackling a BESS fire incident can be significant, with contaminated run off water presenting environmental risks requiring careful management.

In summary, a fire within a BESS enclosure presents a number of concerns, including:

- Fire and smoke spread to other enclosures and adjacent assets, potentially leading to a catastrophic loss event.
- Prolonged and expensive clean-up operations.
- Loss of profits from energy sales or increased energy costs due to the loss of on-site energy storage capability.
- Impacts to trading during repairs and/or rebuilding works.
- Impacts to Environmental, Social and Governance (ESG) programmes and associated exposure.

General Design Considerations

Assessing the likely risk exposures during the design stage can help with planning a safe and efficient BESS and help mitigate the main risk related concerns.

- Ensure competent and experienced installers are utilised.
  - ✓ Companies, and any third party contractors, should be reputable and experienced in BESS design and installation projects.
  - ✓ Electrical engineers should be qualified to install and maintain electrical systems in compliance with national regulations, standards, or codes. In the United Kingdom, this is **BS 7671: 2018 Requirements for Electrical Installations IET Wiring Regulations (18th Edition)**.
    - ▪ Specific electrical energy storage systems training courses are available to qualified electrical engineers, and any electrical engineer installing a BESS should have undergone such training and be able to provide certification upon request.
- Systems and components should be reputable and suited for the type and size of the installation.
  - ✓ The BESS should be manufactured by a reputable and experienced company and tested to be compliant with safety standard **UL 9540: Energy Storage Systems**.
  - ✓ Lithium Iron Phosphate chemistry battery systems are recommended in preference to other lithium-ion battery chemistries due to their higher thermal tolerance.
- The system should also be tested using test standard **UL 9540A: Evaluating Thermal Runaway Response**, and the results incorporated into the system design.
  - ✓ UL9540A tests do have variability - Developers should satisfy themselves that cell/module performance is repeatable under a best endeavours basis.
  - ✓ The Developer should obtain copy of the full UL9540A test results, carried out at cell, module, rack, and unit level.

- The system should be installed in accordance with national or international regulations, standards, or codes, such as:
  - ✓ **NFPA 855 - Standard for the Installation of Energy Storage Systems.** This standard describes the requirements for large-scale fire testing and determining appropriate mitigation strategies for stationary storage systems.
  - ✓ **NFPA 68 - Passive Explosion Mitigation -** This standard outlines passive methods for mitigating against explosion within enclosures, such as containerised BESS.
  - ✓ **NFPA 69 - Standard on Explosion Prevention Systems.** This standard discusses deflagration prevention and control for enclosures.
  - ✓ **UL9540 - Energy Storage System (ESS) Requirements.** This standard defines electrical; mechanical; fluid containment; environmental performance; and system safety tests for energy storage systems. It is a system-level standard, meaning that all components that make up a BESS must be tested together.
- All BESS enclosures should be of non-combustible construction with any insulation materials also rated as non-combustible and achieve a fire resisting rating (insulation and integrity) of 120 minutes. In the United Kingdom and Europe, this would be materials classified as A1 or A2 under **BS EN 13501-1 - Fire classification of construction products and building elements - Classification using data from reaction to fire tests** and REI 90 to REI 120 under **BS EN 13501-2 Fire classification of construction products and building elements - Classification using data from fire resistance and/or smoke control tests, excluding ventilation services**.
- BESS enclosures should be located on foundations which have been designed by a competent person and deemed suitable for the specific location, factoring in site ground and water conditions.
- The BESS installation should be managed through a formal Management of Change process to help ensure all stages of the change are progressed with minimal exposure to the existing arrangements e.g. changes to layout to accommodate the facility/facilities, and any necessary risk management controls.
  - ✓ Refer to the Aviva Loss Prevention Standard **Managing Change** for further guidance.
- Housekeeping arrangements are important, particularly maintaining sterile areas between the enclosures and other buildings, plant etc., which should be kept clear of vehicles, combustible items etc., to prevent the risk of fire bridging.
- Your BESS Insurer and Broker can provide guidance on further reducing the potential for large losses and should be consulted during the early design stages.

Specific Design Considerations

Cooling Systems

Batteries are vulnerable to damage when operating outside of their safe operating window. Batteries operating at high temperatures can start to decompose leading to an increased risk of thermal runaway, and subsequent fire or deflagration incidents.

BESS installations feature cooling systems in respect of the enclosure and the battery racks and the types in use may vary across different manufacturers.

- The optimal operating temperature within a BESS enclosure is maintained by the battery management system.
  - ✓ The battery management system should be configured to alarm and isolate the BESS if temperatures exceed specified temperature thresholds.

- The whole enclosure and all battery racks should be cooled evenly to help prevent hot spots developing.
  - ✓ The use of thermographic cameras can help identify cooling issues within the enclosure.
- The cooling systems should not be powered by the BESS system.
- Closed loop liquid cooling systems should be utilised where possible.
  - ✓ Closed loop systems help prevent external contaminants entering the enclosure.
  - ✓ Liquid cooling is extremely effective at dissipating large amounts of heat and maintaining uniform temperatures within the enclosures.
- If any air cooled systems are utilised, ensure:
  - ✓ Such a system is appropriate for the anticipated ambient air temperatures in the region. In colder climates this make take the form of an environmental temperature control system, which may provide heating and cooling as required to maintain a stable temperature in accordance with the BESS manufacturers recommendations.
  - ✓ The batteries are adequately cooled.
  - ✓ A formal housekeeping regime is in place to clean and replace air filters regularly.
  - ✓ The BESS enclosure is regularly inspected to ensure moisture levels are appropriate and no wear or corrosion is developing.
    - ▪ If moisture levels are higher than anticipated, the installers should undertake a cause and effect analysis and rectify the issue promptly.
    - ▪ Replace any moisture damaged components promptly.
- Dust levels/accumulations should be monitored and BESS enclosures cleaned as necessary to ensure a sterile environment is maintained.

Note: If the BESS installation is sited in an environment at the upper or lower bounds of environmental tolerance, additional climate control measures may be necessary. The BESS OEM should be consulted to provide appropriate guidance.

Battery Management Systems

The battery management system, or BMS, is provided within the battery systems and is responsible for monitoring, managing, and optimizing the performance of the batteries, as well as balancing cell performance, current/energy flow, and operating temperatures.

- Ensure a reliable, proven BMS is utilised. Whilst monitoring systems offer a range of features, the following are deemed critical:
  - ✓ **Real-time Monitoring**. The main parameters such as voltage, current, and temperature of the battery cells via module fan speed, ensuring optimal performance is achieved.
  - ✓ **Charging/discharging.** The BMS manages the charging and discharging cycles helping to improve battery life and performance.
  - ✓ **Charge balancing.** The BMS ensures the battery cells are charging uniformly, improving battery performance, and ensuring uniform battery balancing within the enclosure.
  - ✓ **Safety Protections.** These include overcharge and discharge issues, overcurrent, and thermal management. Upon detection the BMS can implement corrections or protection controls.
  - ✓ **Data Sharing.** The BMS will share performance data with the monitoring systems to ensure appropriate supervision and logging of issues.

- The BMS should be configured to safely isolate the BESS if prescribed high temperature thresholds are achieved, or other hazardous performance characteristics are indicated that could lead to a thermal runaway event, e.g. increased resistance.
  - ✓ Analysis of BMS data through the use of analytics can provide useful data which when incorporated with preventive O&M measures can reduce the likelihood of failure whilst improving performance.

System Controller and Monitoring

The system controller oversees the entire BESS, controlling and protecting the key components and communicating performance data to the monitoring system. The monitoring system is responsible for communicating data to key users/managers etc.

- The BESS should be monitored and configured to alert key personnel in the event of any reported performance discrepancies or deviations.
- Ensure adequate communications redundancy.
  - ✓ Dual transmission systems should be considered where provided or available.

Ventilation

The safe management of smoke and gas emissions resulting from battery off gassing, thermal runaway and combustion should be considered. The off gassing/thermal runaway of lithium-ion batteries produces flammable vapours and gases which result in deflagration/explosion potential. In addition, flammable gases including hydrogen can be released upon the application of firefighting water, further increasing the likelihood of a deflagration event.

BESS enclosures will feature either active or passive forms of ventilation:

Active Ventilation. Active ventilation is linked to the BMS and gas detection equipment.

- BESS enclosures that feature active ventilation should be rated as suitable for use in explosive atmospheres as appropriate and interlocked to the BMS and/or gas detection to activate upon detection of early gas release or potential faults identified by the monitoring equipment.
  - ✓ This should be powered independently of the BESS enclosure, and additional back-up power should be considered to ensure autonomous operation in the event of an off gassing event.
  - ✓ This is of additional concern given the production of hydrogen gas that can be generated when firefighting water is applied to lithium-ion battery fires.
- The ventilation system should be continuous and not actuated or stopped by performance of any fire protections.

Passive Ventilation. Deflagration venting, typically in the form of vent panels that open in the event of an over pressure event such as an explosion, thus relieving the pressure within the enclosure and directing the pressure and any flaming to a safe area, should be installed.

- Such systems should be designed, tested, installed and maintained by a competent and experienced company in accordance with appropriate testing standards such as **NFPA 68 - Passive Explosion Mitigation, NFPA 69 - Standard on Explosion Prevention Systems, BS EN 14797:2006 - Explosion venting devices or FM7730 Examination Standard for Explosion Venting Devices**.

- The exhaust point of both active and passive ventilation systems' venting should be to a safe area in the open, and not located in an area where any exhausted smoke could compromise the air intake of other enclosures or buildings in proximity.

Power Conversion Systems

- The inverters should be located at least 1.5m from BESS enclosures and at least 10m from buildings, other valuable assets and/or waste stores, pallets, or other combustible goods.
- Ensure the inverters are adequately IP rated for external use and not unduly exposed to harsh weather conditions or impact damage from vehicles and other moving plant.
- **UL1741 Safety of Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources** sets out the manufacturing (including software) and product testing requirements for inverters used for grid connection applications.

Customer Substation Building

These standalone structures are critical to the safe management and distribution of electricity from the site to and from the power grid, as well as often housing monitoring and control equipment.

- Ensure switchgear buildings are of non-combustible construction.
- Switchgear buildings should feature good quality climate controls to remove any moisture and control humidity, and ideally be of double-skinned construction.
  - ✓ Aviva has witnessed failure of switchgear due to wear and tear accelerated by insufficient climate controls, which voided manufacturers' warranty.
- Cable pits beneath switchgear buildings should be maintained clear of water, which not only degrades the insulation but also contributes to increased humidity within the enclosure, accelerating equipment deterioration and increasing the potential for major faults.
  - ✓ Sealing cable entry points is recommended.
  - ✓ Installing an automatically operating sump pump can also help clear water accumulations promptly.
- Do not install office equipment, document storage etc., in the same room as switchgear cabinets. As live high voltage areas, these environments must be maintained as sterile environments.
  - ✓ Access should also be limited to designated persons only, as sanctioned by the Senior Authorised Person.

Transformers

- The BESS installation will feature Medium Voltage (MV) transformers allocated to their respective PCS systems, and in some cases High Voltage (HV) grid transformers if a higher voltage is required at the point of interconnection.

  Note: The term 'Medium Voltage' refers to the location of the transformers relative to the site, generally ranging from 1kV to 33kV. All Medium Voltage is still technically classed as High Voltage as it is above 1000Vac or 1500Vdc, where HV standards and regulations apply.

- The HV transformer(s) may be owned by either the BESS site or the District Network Operator (DNO).
- An auxiliary transformer will often also be present to take power from the grid to power certain equipment within the BESS, for example the BMS, cooling equipment, security, and fire protections etc.

- All transformers should be manufactured, tested and installed to BS EN IEC 60076 - Power Transformers and be subject to a formal maintenance programme which includes condition inspection; dissolved gas analysis and insulation resistance testing.
- Synthetic insulation oils are preferred over mineral oil due to the lower ignition risk. Modern on-line monitoring including partial discharge (PD) monitoring is recommended for HV transformers.

Risk Protections

Fire Detection

Early detection of fire is essential.

- Ensure automatic fire detection equipment is installed with enclosures and any other site buildings including switchgear buildings.
  - ✓ In the United Kingdom such systems should be compliant with **BS 5839-1:2017 - Fire detection and fire alarm systems for buildings - Code of practice for design, installation, commissioning, and maintenance of systems in non-domestic premises,** and be installed by an accredited installer e.g. approved to BAFE scheme **SP203-1 Fire Detection and Fire Alarm Systems** or Loss Prevention Certification Board Loss Prevention Standard **LPS 1014 - Requirements for Certificated Fire Detection and Alarm Systems Firms**.
  - ✓ These systems should ideally be monitored via an accredited Alarm Receiving Centre (ARC) to help ensure any incidents are reported promptly to responsible appointed persons.
  - ✓ Linear heat detection may be appropriate for such environments, and can be configured to detect early changes in heat levels within BESS enclosures, potentially allowing intervention and risk control.

Off-Gassing Detection

These systems provide sensor and gas detection for Battery Energy Storage Systems and work by detecting gases released in the early stages of battery failure, commonly known as 'off gassing'.

- An automatic gas detection system, designed for the detection of lithium-ion battery off gassing, should be installed within all BESS enclosures.
  - ✓ These detection systems should be interlocked to the power supply to interrupt power to the batteries, whilst maintaining power to cooling and protection systems upon the immediate detection of gases and prior to thermal runaway.
  - ✓ The detection system should be suitably rated for use in potentially explosive atmospheres.
  - ✓ The gas detection systems should be subject to formal testing, servicing/calibration, and maintenance arrangements with a competent and experienced company, and this should be undertaken in accordance with the manufacturer's instructions, supplemented by regular self-inspections as part of a planned preventive maintenance regime to check for damage, faults etc.
  - ✓ An accredited fire protection installer can provide further guidance and assistance if required.

Automatic Fire Protections

- Automatically operating gaseous fire suppression systems are often installed within BESS enclosures, however, are designed to only suppress fire starting within electrical components/switchgear etc., and are not effective in suppressing lithium-ion battery fires.
    - ✓ They may also cause damage to the batteries through surface contamination of the gaseous deposits when released.
- Activation of such a protection may also increase the pressure within the enclosure and accelerate the internal enclosure environment reaching its lower explosive limit, potentially increasing the risk of early deflagration.
- Gaseous fire suppression systems are not recommended within BESS enclosures.
- Installing an automatic fire suppression systems can however help reduce the potential for fire damage within any switchgear buildings.
    - ✓ Such systems should be designed by an experienced and competent company.
    - ✓ Ensure any automatic suppression systems are interlocked to power supplies to isolate all power automatically upon activation.
        - ▪ This will help prevent reignition once the suppression agents have been exhausted.
- Activation of active fire suppression systems should result in an alarm alerting the site teams.

Note: Any plans to install fire protection systems should be discussed with your BESS Insurer and Broker, who can provide guidance and advice.

Automatic Sprinklers

- The installation of automatic sprinklers within BESS enclosures is also not recommended.
    - ✓ Water reacts violently with lithium and can produce hydrogen gases, increasing the deflagration/explosion potential within the BESS enclosure. Damaged batteries are more susceptible to facilitating the reaction.
    - ✓ Water demand is significant, and the sprinkler system would not be able to store/deploy enough water to effectively control the battery fire.
    - ✓ The modules and racks are also confined, potentially limiting water access to the seat of the fire.
- Further guidance on the suitability of such systems, should be obtained from your BESS Insurer and Insurance Broker.

Interlocks

- The use of interlocks may help reduce the potential for an overheating lithium-ion battery or cell to enter thermal runaway. As such, the actuation of any gas detection systems and other alarms should be interlocked to de-energise the power supplies and isolate charging equipment. The interlocks should be tested at least annually and restored following any impairment to the fire protection and alarm systems.

Lightning Protection

- The BESS should be protected against the risks of lightning damage including surge and transient surge.
- A lightning risk assessment should be completed by a competent person or company, preferably a member of a recognised quality scheme or body such as the Association of Technical Lightning and Access Specialists (ATLAS), and any lightning protection systems should be installed in accordance relevant standards, such as BS EN 62305

pts 1 to 4 – Protection Against Lightning to determine the direct and secondary effect protection.

Refer Aviva Loss Prevention Standard **Lightning Protection** for further guidance.

Fire and Rescue Service

Early liaison with the local Fire and Rescue Service can aid with fire response planning and containment plans for contaminated firefighting water runoff. Accordingly, you should invite the local Fire and Rescue Service to inspect the BESS installation, and surrounding area, to evaluate fire risk and contamination exposures, as well as determine access and egress routes to all high hazard onsite equipment, including BESS enclosures.

One of the most effective means of limiting the potential for fire spread between enclosures is to deploy firefighting hoses to create a 'water curtain', effectively cooling the area between enclosures to help prevent radiated heat transfer, and this should be discussed during the Fire and Rescue Service visit.

To support firefighting the water supplies available for Fire and Rescue Service use should be understood. Site management should therefore establish:

- What fire water is available.
- Static pressure flows and residual pressure test results.
- Whether additional resources, such as a private hydrant system or water storage tanks are necessary.
- The location and number of fire hydrants in the proximity of the BESS installation should be documented in an emergency response plan or shown on appropriate drawings.

Further guidance for United Kingdom operators can be found in the document Grid-Scale Battery Energy Storage System planning – Guidance for FRS, published by the National Fire Chiefs Council.

Fire Extinguishers

- Fire extinguishers specified for use in tackling lithium-ion battery fires are available, however whilst potentially providing some benefit require very early application and, may not fully extinguish a developing fire involving larger lithium-ion battery arrangements or prevent the batteries reigniting. The volatility of lithium-ion battery fires and their explosive characteristics also presents significant injury risks to persons tackling such a fire in proximity, and as such their use is not recommended within BESS enclosures.
  - ✓ Fire extinguishers should only be used to aid escape/evacuation.
  - ✓ Further Guidance on fire extinguishers is provided in Aviva Loss Prevention Standard **Fire Extinguishers**.

Emergency Response

Given the risks associated with BESS/liquid-electrolyte battery fires, an Emergency Response Plan should be produced specifically developed to outline key responsibilities and actions in an emergency event.

The emergency response rules should be formally documented, and appropriate training provided.

Note: The explosive potential of lithium-ion batteries is increased when enclosed within compartments, particularly when oxygen levels increase suddenly, such as when compartment doors are opened. Access into such compartments during a fire event should ideally be limited to appropriately trained persons.

Refer to Aviva Loss Prevention Standard **Emergency Response Teams** for further guidance.

Impairments

Ensure any impairments relating to gas detection and protection systems including interlocks are reported to your Insurer and Insurance Broker. Temporary changes may be necessary to some arrangements whilst impairments are ongoing.

Refer to Aviva Loss Prevention Standard **Impairment Management** for further guidance.

Business Continuity

Every business should have a formal Business Continuity Plan in place. This should be reviewed to ensure disaster recovery and continuity arrangements remain adequate following the installation of the BESS. Any actions generated should be addressed promptly.
Refer to Aviva Loss Prevention Standard **Business Continuity** for further guidance.

Security

Perimeter Security

- As part of the construction works and to protect the finished site, three metre proprietary security fencing should be installed, certificated to a recognised standard, such as **LPS 1175: Issue 8.1 Requirements and Testing Procedures for the LPCB Certification and Listing of Intruder Resistant Building Components, Strongpoints, Security Enclosures and Free-Standing Barriers** in the United Kingdom, and achieving a security rating of at least B3.
- Entrance gates and gate posts should be of similar construction to the security fencing and be secured with good quality padlocks and heavy-duty chains. In the United Kingdom and Europe, padlocks should be in compliance with **BS EN 12320:2012 Building Hardware. Padlocks and Padlock Fittings. Requirements and Test Methods** and achieve a CEN grade 4 or 5 rating. If possible, a steel protective lock housing of at least 4mm thickness should be fabricated to access gates to help prevent lock tampering. Keys for entrance gate padlocks should not be kept on site and any padlock combination codes changed regularly. Digital combination type key safes are vulnerable to attack and are not recommended.
- Perimeter security not achieving appropriate certification, whilst not providing a defined security resistance, may be suitable for some lower risk sites.

  Refer to your Property Insurer and Broker for further guidance on the suitability of proposed perimeter security systems.

Video Surveillance Security Systems

- A detector activated Video Surveillance System (VSS) should be installed at the location.
  - ✓ The VSS should be monitored by an accredited Remote Video Response Centre (RVRC) and where available, a police response should be considered.
    - In the United Kingdom, a Level 1 Police Response is recommended.
    - To achieve a Level 1 Police Response, the system will need to be installed, maintained, and monitored to the requirements of **BS8418: Design, Installation, Commissioning and Maintenance of Detection-Activated Video Surveillance Systems (VSS). Code of Practice**.
  - ✓ The VSS should be positioned to cover all points of the site perimeter, site entrance, BESS enclosures and the associated key equipment and buildings.
  - ✓ To ensure the best quality of service, the Installer and RVRC should be members of a recognised third-party accreditation/approval scheme, such as those provided by the National Security Inspectorate (NSI), or the Security Systems and Alarms Inspection Board (SSAIB). In the United Kingdom this is required for police response.
  - ✓ The incorporation of an audio challenge facility, which would allow the RVRC to issue warnings to any unauthorised persons attempting to access the site or behaving suspiciously, should be considered.
  - ✓ Should there be anticipated delays in police response in some localities, it may be more appropriate to utilise a security company to provide keyholder and VSS detection response services, rather than rely on police response.
  - ✓ Regular security patrols of the site by the security company can also provide a significant deterrent to intruders.
  - ✓ Any such providers should also be members of a recognised accreditation scheme, such as those provided by the National Security Inspectorate (NSI), or the Security Systems and Alarms Inspection Board (SSAIB) in the United Kingdom.
  - ✓ Additionally in the United Kingdom, they should also be members the Security Industry Authority, and provide their services in accordance with the requirements of **BS 7984-3:2020 Keyholding and Response Services - Provision of Mobile Security Services. Code of Practice.**

    Note: Staff keyholding and site response to VSS detection alerts is not recommended, unless in accompaniment of approved security guarding or the police.

- Specifications for any proposed detection security systems should be submitted to your BESS Insurer and Broker for review.

Refer to Aviva Loss Prevention Standard **Video Surveillance Systems - Introduction** for further guidance.

Protection of Key Assets

Forensic or DNA marking is the application of a discreet agent, with a unique forensic signature, to mark valuable and/or easily removable items. Such marking can be applied to cabling including buried cables, and other valuable equipment onsite. Therefore, any recovered stolen equipment can be returned. Pairing with appropriate warning signage can also act as a valuable deterrent to thieves.

Any such protection should be applied by a competent and experienced company, and preferably members of the British Security Industry Associations (BSIA) Asset and Property Marking Section.

Spare modules, copper cables and other theft attractive components should not be stored on site. If this is unavoidable, storage should be limited to essential spares only and kept within a secured and robust building. The physical security recommendations pertaining to higher risk buildings above should be followed. The use of shipping containers for storage of theft attractive spares is not generally recommended.

Backfilling underground cable runs or ducts with cement can reduce the risks of cable theft. A depth of at least 300mm is recommended.

Diesel for back-up generators should be limited to essential supplies only and secured within a secured building or security compound.

Cyber Security

- Cyber security exposures should be risk assessed to ensure appropriate protections and procedures are incorporated including data access approval management.

Refer Aviva Loss Prevention Standard **Cyber Security - Top 12 Tips to Protect Against Cyber Attacks** for further guidance.

Other Security

All outdoor equipment cabinets for inverters etc., should be securely locked, and any switch/control panels also secured to prevent malicious interference.

Checklist

A separate Battery Energy Storage Systems - Checklist is available which can be tailored to your own organisation.

Specialist Partner Solutions

Aviva Risk Management Solutions can offer access to a wide range of risk management products and services at preferential rates via our network of Specialist Partners.

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- Automatic fire detection and portable extinguishers: SECOM
- Business continuity: Horizonscan

For more information please visit: Aviva Risk Management Solutions - Specialist Partners

Sources and Useful Links

- EPRI BESS Failure Incident Database
- BS EN 62305 - Protection against lightning.
- BS 7430:2011+A1:2015 Code of Practice for protective Earthing of Electrical Installations.
- LPS 1204 : Issue 3.2 Requirements for Firms Engaged in the Design, Installation, Commissioning and Servicing of Gas Extinguishing and Condensed Aerosol Systems.
- BAFE SP203-3 Fixed Gaseous Fire Extinguishing Systems
- BS EN 15004 - Fixed firefighting systems. Gas extinguishing systems
- BS ISO 14520-1 Gaseous fire-extinguishing systems – Physical properties and system design – Part 1: General requirements.
- MIS 3012 – The Battery Standard.
- BS 7671: 2018 Requirements for Electrical Installations IET Wiring Regulations (18th Edition).
- UL 9540 Energy Storage Systems and Equipment.
- UL 9540A Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
- BS EN 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.
- BS EN IEC 63056:2020 Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems
- BS EN 62620:2015+A1:2023 Secondary cells and batteries containing alkaline or other non-acid electrolytes. Secondary lithium cells and batteries for use in industrial applications
- NFPA 855 – Standard for the Installation of Energy Storage Systems.
- NFPA 68 Standard on Explosion Protection by Deflagration Venting
- NFPA 69 Standard on Explosion Prevention Systems
- FM Property Loss Prevention Data Sheets 5-33 lithium-ion Battery Energy Storage Systems
- EN 13501-1 Fire classification of Construction Products and Building Elements - Classification Using Data from Reaction to Fire Tests.
- BS EN 14797:2006 Explosion Venting Devices
- FM 7730 Examination Standard for Explosion Venting Devices

Note: Whilst UK standards and legislation are referenced in this document, other international standards and legislation should be referenced where applicable.

Additional Information

Relevant Loss Prevention Standards include:

- **Grid-Scale Battery Energy Storage Systems - Construction**
- **Grid-Scale Battery Energy Storage Systems - Ongoing Care**
- **Battery Energy Storage Systems Checklist**
- **Small-Scale Battery Energy Storage Systems**
- **Business Continuity**
- **Contamination Following a Fire**
- **External Building Areas - Usage and Safety**
- **Self-Inspections**
- **Heat and Smoke Venting Systems**
- **Managing Change - Property**
- **Smoke Contamination**
- **Emergency Response Team**
- **Thermographic Surveys**
- **Video Surveillance Systems - Introduction.**
- **Cyber Security - Top 12 Tips to Protect Against Cyber Attacks**
- **Cyber Security - Ransomware**

To find out more, please visit Aviva Risk Management Solutions or speak to one of our advisors.

Email us at riskadvice@aviva.com or call 0345 366 6666.*

*The cost of calls to 03 prefixed numbers are charged at national call rates (charges may vary dependent on your network provider) and are usually included in inclusive minute plans from landlines and mobiles. For our joint protection telephone calls may be recorded and/or monitored.

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Please Note

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