Grid-Scale Battery Energy Storage Systems – Construction

Grid-Scale Battery Energy Storage Systems (BESS) are exposed to a number of hazards during the planning and construction phase.

This Loss Prevention Standard outlines the main risks and provides useful guidance on reducing the risks of loss or damage during these phases, helping to ensure the BESS installation is resilient and constructed to a good standard.

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Introduction

Grid-Scale Battery Energy Storage Systems (BESS) are a means of storing electrical energy, typically to provide grid services such as frequency regulation, peak shaving, voltage support and congestion relief, and are often paired with renewable energy generation systems such as solar photovoltaic systems or wind turbines.

Given the reliance of such systems to store and manage energy efficiently, it is critical Grid-Scale BESS are planned, designed, installed, tested and commissioned to a high standard and as resilient as possible.

This document provides useful guidance on constructing Grid-Scale BESS to a standard that helps reduce the potential for loss or damage. Refer to Aviva Loss Prevention Standard **Grid-Scale Battery Energy Storage Systems – General Considerations** for an overview of grid-scale BESS, key components, manufacturing and installation standards, and **Grid-Scale Battery Energy Storage Systems – Ongoing Care** for guidance on inspection and maintenance.

Note: This document is not intended to address Small Scale BESS (below 1 MW power output, and/or not directly connected to transmission or distribution networks. Refer **Small-Scale Battery Energy Storage Systems**), nor 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.

Understanding the Risks

The risks of damage to Grid-Scale BESS in relation to the construction phase include:

- **Fire**. Potential causes of fire damage include:
  - ✓ **Battery Fire**. Most BESS utilise battery chemistries which, when damaged or faulty, can release toxic and explosive gases and eventually ignite.
  - ✓ **Electrical**. Damaged and/or faulty electrical components and equipment and overloaded systems can lead to ignition during installation, testing and commissioning stages.
  - ✓ **Hot Works**. Poorly managed hot works within or in proximity to BESS enclosures during the system installation can result in fire damage to combustible components, ignition of combustible materials, vegetation etc.
  - ✓ **Smoking**. Discarded smoking waste can ignite contractors waste, stored materials, dry vegetation, etc.
  - ✓ **Malicious**. Deliberate ignition/arson including but not limited to civil unrest events from opportunist trespassers.

- **Windstorm**. Systems in the course of construction, temporary work and poorly installed systems are more vulnerable to high wind conditions. Unsecured items, stored materials and equipment, etc., can also become windblown and cause damage to BESS enclosures and associated balance of plant equipment.
- **Flooding**. Excessive rainfall or rising groundwater can damage temporary works; infiltrate substation and transformer cable pits; breach underground cable conduits and more severe incidents can lead to structural damage to the installation, access roads and other infrastructure.
- **Security**. Construction sites are vulnerable to theft and Grid-Scale BESS locations are potentially more exposed given the often remote and isolated locations; reduced security outside of working hours; theft attractive equipment, e.g., battery modules, cabling, tools, etc.

Managing the Risks

General Planning and Design Considerations

- Ensure competent and experienced installers are utilised.
  - ✓ Companies, and any third party contractors, should be reputable and experienced in BESS design and installation projects.
- Ensure compliance with any national or local regulations and accreditation requirements.
- The design specification should take into consideration the site conditions for existing, temporary and permanent drainage requirements, temporary loading for any foundation and erection works.
- Pre-qualification design assessment procedures should be in place to ensure the planned works align with the agreed design specifications.
- Procedures should also be agreed in relation to quality control, materials verification, site acceptance and testing of equipment, collating and verifying certificates of conformity etc.
- Ensure appropriate smoking, setting down and storage locations are provided, at least 10 metres from the works and other valuable assets.
- The project should be managed in accordance with **Fire Prevention on Construction Sites - The Joint Code of Practice on the Protection from Fire of Construction Sites and Buildings** issued by the Fire Protection Association.
- The battery modules' state of charge (SOC) must remain within the Original Equipment Manufacturers (OEM) recommended depth of charge (DOC) range to ensure system longevity. BESS units should be connected and commissioned on a rolling basis to reduce idle time without a safe grid connection, ensuring safety, and heating/cooling systems can operate without depleting the battery. Where this cannot be done, a mobile generator should be used to ensure adequate SOC pending a permanent connection.
- Hot works should be controlled in accordance with Aviva Loss Prevention Standard **Hot Work Operations.**
  - ✓ Thermographic cameras should be incorporated into fire watch procedures to help identify hot spots, heat transfer etc.
  - ✓ Refer to Aviva Loss Prevention Standard **Thermographic Surveys** and **Thermographic Cameras - 10 Top Tips** for further guidance.

Ground Conditions

The quality of the ground conditions at the site are integral to the structural resilience of the BESS.

- **Ground Investigative Report.** A detailed interpretative ground investigation report is critical to support the foundation design, construction of access roads, any temporary works including piling or lifting mats and mitigate environmental risk factors including surface water and groundwater flooding.
- **Foundation.** Foundations should be designed by a competent person and deemed suitable for the specific location, factoring in site ground and water conditions.
- **Flood Risk Assessment.** A Flood Risk Assessment should be completed, and based on the findings, appropriate temporary and permanent drainage and flood control mitigations put in place.

  Note: BESS should not be in close proximity to watercourses or areas of environmental importance. In the event of fire, run off products from firefighting can contaminate waterways and protected land. If this is unavoidable, consider the risks of contamination within a specific risk assessment and ensure adequate protections such as bunding, etc., are put in place.

Separation

- 4.5 metres separation should be maintained between BESS enclosures in an installation to help reduce the threat of propagation in the event of thermal runaway.
- At least 10 metres separation should be maintained between BESS enclosures and switchgear rooms; High Voltage (HV) Transformers; back-up generators; fuel tanks; electrical vehicle charging facilities; sprinkler tanks and sprinkler equipment; waste management enclosures; waste receptacles; compactors; pallet stores; or areas that workers or visitors may congregate such as smoking shelters, etc.
- At least 1.5 metres separation should be maintained between BESS enclosures and power conversion equipment, including inverters and Medium Voltage (MW) transformers.

  Note: Fire and/or explosion events within a BESS enclosure can damage property in proximity. This may have significant impacts to trading depending on the criticality of the damaged equipment.
  - ✓ There have been recorded events where the scale of fire damage has been worsened due to wind propagation. As such, average wind speeds should be checked, and separation distances extended if there is a risk of strong winds that may support fire spread.
- If adequate separation cannot be achieved:
  - ✓ Review the planned configuration and consider removal of some enclosures to increase the fire separation.
  - ✓ Consider adjusting the site layout by grouping the BESS enclosures with smaller separation distances and separate these groups by the recommended spatial distance.
- Alternatively, where the configuration of the site layout cannot be changed, fire barriers should be installed between the BESS and the adjacent asset.
  - ✓ Any barriers used should have a fire resistance rating (insulation and integrity) of at least 120 minutes and extending at least 1m over the height and sides of the BESS enclosures.

- ✓ **NFPA 221 - Standard for High Challenge Fire walls, fire walls, and fire barrier walls** and **BS EN 1364-1 - fire resistance tests for non-load bearing elements - walls** provide guidance on fire barrier walls.
- ✓ The installation of fire barriers should be completed by a reputable and accredited company, such as those certificated to LPCB Loss Prevention Standard **LPS 1271: Requirements for the LPCB Approval and Listing of Companies Installing Fire or Security Doors, Door-sets, Shutters and Active Smoke/Fire Barriers** in the United Kingdom and Ireland.

- Any critical heating and ventilation system inlets on buildings sited within 10m proximity to the BESS installation should be relocated to avoid contamination and damage to the building services.
- BESS installations should not be installed in close proximity to critical overhead electrical or telecommunications lines, equipment, or poles.

Electrical Risks

- Electrical engineers should be qualified to install electrical systems in compliance with national regulations, standards, or codes. In the United Kingdom this is BS 7671: Requirements for Electrical Installations IET Wiring Regulations.
  - ✓ 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.
- Cabling and other services will need to be installed between the various components and equipment. These should be located underground in back filled cable ducting to help avoid wear and tear, impact, or weather-related damage, etc.
  - ✓ Where this is not achievable, appropriate cable trunking/trays should be utilised and located in areas where the risks of damage are minimised and suitably protected.

Customer Substation Buildings

Customer substation buildings may be planned as part of the construction works and are critical to the safe management and distribution of electricity from the site to the power grid, as well as often housing monitoring and control equipment.

- Ensure switchgear buildings are of non-combustible construction.
- Switchgear buildings should feature appropriate ventilation or climate controls.
- Cable pits beneath switchgear buildings should be designed to minimise water ingress.
  - ✓ Sealing cable entry points is recommended.
  - ✓ Installing an automatically operating sump pump can also help clear water accumulations promptly.

Testing and Commissioning

The BESS installation, including mechanical and electrical connections should be thoroughly inspected prior to commissioning to ensure compliance with design specifications and installation standards.

- A commissioning report will be provided to confirm compliance with design specifications.

Risk Protections

Full guidance on fire and gas detection systems and fire protections, including recommended standards, can be found in Aviva Loss Prevention Standard **Grid-Scale Battery Energy Storage Systems - General Considerations,** however in summary:

- Automatic fire detection equipment should be installed within enclosures and any other site buildings including substation/switchgear buildings.
- An automatic gas detection system, designed for the detection of lithium-ion battery off gassing, could be installed within all BESS enclosures.
- Gas detection systems and other alarms should be interlocked to de-energise the power supplies and isolate battery charging equipment.
- Gaseous fire suppression systems are not recommended within BESS enclosures.
  - ✓ Such systems are not effective in suppressing lithium-ion battery fires, and the agents can also cause damage to the batteries when activated.
- The installation of automatic sprinklers within BESS enclosures is also not currently recommended.
  - ✓ 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.
  - ✓ Water can react with lithium and can produce hydrogen gases, increasing the deflagration/explosion potential within the BESS enclosure.

Fire and Rescue Service

The water supplies required to tackle fires involving lithium-ion fires and cool adjacent enclosures are significant and need to be carefully considered during the design and construction phases, ensuring:

- Adequate firefighting water is available.
  - ✓ If not, 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 are documented in an emergency response plan or shown on appropriate drawings.
- Containment plans for firefighting water run-off have been documented.
- Static pressure flows and residual pressure test results have been assessed.
- Early liaison with the local Fire and Rescue Service is recommended.

Note: Minimum water supplies in excess of 1900 litres per minute for at least two hours are typically specified by Fire and Rescue Services in the United Kingdom, however this may not be sufficient, and consideration should be given to increasing the volume of stored water to supplement firefighting efforts if required.

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 and **Fire Prevention on Construction Sites - The Joint Code of Practice on the Protection from Fire of Construction Sites and Buildings**.

Security Arrangements

Full guidance on securing BESS locations, including recommended standards, can be found in Aviva Loss Prevention Standard **Grid-Scale Battery Energy Storage Systems – General Considerations,** however in summary:

- The construction site should be secured/fenced during works to prevent unauthorised access.
  - ✓ Security hoarding is recommended. This helps limit the view of the construction site.
- Security guarding should be considered during the construction phase, if high volumes of theft attractive components are to be held at the site prior to installation, or in the event of security incidents or concerns.
- External compounds, used to house any transformer and/or generator equipment etc., should be of robust palisade or 'V-Mesh' type fencing to a height of at least 2.5 metres and secured with good quality padlocks. A steel protective lock shroud of at least 4mm thickness should be fabricated to compound gates to help prevent lock tampering.
- Replacing theft attractive copper cabling with aluminium cabling can help reduce the scale of any theft losses.
- Backfilling underground cable runs or ducts with concrete can aid in reducing the risks of cable theft. A depth of at least 300mm is recommended.
- Cabling and other valuable components etc. should not be stored in large quantities at the site during the construction process, and instead delivered to the site 'as needed', and installed immediately to prevent stored accumulations of theft attractive equipment.
- As part of the construction works, and to protect the finished BESS location:
  - ✓ 3 metre security fencing and gates should be installed.
  - ✓ Gates should be secured with heavy duty chain and good quality padlocks.
  - ✓ A detector activated, remotely monitored Video Surveillance System (VSS) should be installed to the site perimeter and within enclosures and critical buildings.
    - The installation of VSS can allow remote investigations and checks to made without the need to travel to site, however more significant exposures, or security breaches, should result in site attendance by an approved security company or contractor.
- Forensic or DNA marking should be applied to plant equipment, storage containers, cable reels etc. 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.
- Proposals and security system specifications should be submitted to your BESS Insurer and Broker for review.

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

Sources and Useful Links

- BS EN 62305 - Protection against lightning.
- BS 7430:2011+A1:2015 Code of Practice for protective Earthing of Electrical Installations.
- BS 7671: 2018 Requirements for Electrical Installations IET Wiring Regulations (18th Edition).
- 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.
- Fire Prevention on Construction Sites - The Joint Code of Practice on the Protection from Fire of Construction Sites and Buildings Undergoing Renovation

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

Additional Information

Relevant Aviva Loss Prevention Standards include:

- **Grid-Scale Battery Energy Storage Systems - General Considerations**
- **Grid-Scale Battery Energy Storage Systems - Ongoing Care**
- **Battery Energy Storage Systems Checklist**
- **Small-Scale Battery Energy Storage Systems**
- **Hot Work Operations**
- **Thermographic Surveys**
- **Video Surveillance Systems - Introduction.**

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.***

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