Fire safety guideline

Technical information

D22/107002

Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations

1 Purpose

This technical information sheet outlines Fire and Rescue NSW (FRNSW) considerations relating to the assessment and determination of fire safety studies (FSS) for facilities containing large-scale lithium-ion battery energy storage systems (LiBESS).

2 Scope

This technical information sheet details agency considerations relating to:

- General requirements pertaining to the preparation of a FSS
- Assessment of potential consequences of credible incidents
- Defining of an appropriate fire safety strategy for the facility
- Electrical hazards posed to firefighters by LiBESS
- Fire brigade intervention
- Appropriateness and adequacy of installed fire safety systems and measures
- Separation of LiBESS
- Ventilation of compartments and/or containers containing LiBESS
- Management of environmental factors
- Clean-up and disposal of BESS involved in an incident, and
- Referencing of applicable codes and standards.

Large-scale LiBESS are a relatively new technology with a new risk profile that we have yet to fully understand. FRNSW continues to seek and consider the available knowledge and information on LiBESS to inform emergency services' preparedness and response to incidents involving these systems. In taking an evidence-based approach to further our understanding of risks associated with LiBESS, FRNSW has initiated the Safety of Alternative and Renewable Energy Technologies (SARET) collaborative research program. The findings of this and other research will be monitored to enable any findings to be incorporated into further revisions of this technical information sheet.

3 Application

This document applies to facilities containing large-scale LiBESS of greater than 200 kWh rated capacity located externally and not within a building. Such systems are typically associated with supporting and augmenting grid power supply (e.g., renewable energy installations, etc.)

4 Background

It has been the experience of FRNSW that large-scale LiBESS pose unique challenges to firefighters when responding to and managing an incident. Increasing uptake of this technology has led to a number of significant incidents at which firefighter injuries and fatalities have occurred. As a result, fire agencies internationally now recognise large-scale LiBESS as a hazardous electrical, chemical and fire risk with potential community

consequence that necessitates special consideration throughout the design, installation and lifetime management of the asset.

In New South Wales, this special consideration will often be by way of a requirement imposed by a consent authority to prepare a FSS for the facility containing the large-scale LiBESS. The preparation of a FSS enables the reviewing agency to determine the appropriateness and effectiveness of proposed fire safety strategies, systems and measures in meeting the extent of potential incidents for a facility and the surrounding area.

5 Developing the fire safety study

The development of a FSS for a facility containing the large-scale LiBESS should be undertaken in accordance with the *Hazardous Industry Planning Advisory Paper No 2 (HIPAP No. 2) Fire Safety Study Guidelines* (Department of Planning, Industry and Environment 2011). This guideline assists persons developing the FSS in undertaking a case-specific hazard-based approach to the design to ensure that the fire safety system is adequate to meet the extent of potential fires for the site and effective in minimising the potential for propagation and escalation of an incident.

5.1 Assessment of potential consequences of credible incidents

5.1.1 A fundamental objective of a FSS is that the hazard potential of a plant and/or operation is defined by a process of hazard identification and subsequent estimation of the potential consequences of credible incidents. Underestimation of the potential consequence of a credible incident is likely to result in failure of the fire safety system and subsequent propagation and escalation of an incident.

5.1.2 A failure event involving LiBESS may eventuate from a number of internal and external mechanisms including mechanical-, thermal- and electrical abuse or failure, and may result in the expulsion of chemical components, propagation of chemical vapours and/or a thermal runaway event and fire.

5.1.3 FRNSW consider a credible incident to be one in which a fire propagates within a LiBESS system or unit, with active fire safety systems disabled, and involves a full compartment or container.

5.1.4 When undertaking consequence analysis of an incident, both the direct impacts of an incident and the potential for propagation and secondary incidents should be addressed. This includes management of chemical components or by-products released during an incident and the environmental impacts of toxic water-run off that may be used to mitigate an incident.

5.1.5 Where a hazard analysis study (i.e., preliminary hazard analysis, final hazard analysis, or a hazard and operability study) has been undertaken for the site in question, this should be used to inform the FSS.

5.2 Defining the fire safety strategy

5.2.1 Within the context of a FSS, the fire safety strategy relates to the philosophy and approach that will be adopted to achieve the required level of safety and performance. An effective fire safety strategy aims to minimise the likelihood, severity, and extent of an incident.

5.2.2 Special consideration should be given to developing a fire safety strategy that is effective in minimising potential for propagation and escalation of an incident with reference to the credible incidents outlined in *Section 5.1 Assessment of potential consequences of credible incidents.* An example of an element of a fire safety strategy that may be adopted is the separation of BESS containers or racks by way of either appropriately fire-rated physical barriers or distance.

Where possible, preference should be given to the implementation of strategies that are supported by higher-order risk controls (i.e., elimination and/or engineering controls, etc.).

5.2.3 Supporting analysis and/or evidence should be provided within the FSS to justify the selection, appropriateness, and efficacy of the selected fire safety strategy.

5.2.4 FRNSW does not support the adoption of fire safety strategies that are either partially or wholly reliant on fire brigade intervention to achieve an acceptable level of safety, given that:

- Intervention of a fire brigade at an incident is considered to constitute application of a low-order administrative type risk control and is not in line with the *so far as is reasonably practicable* principle in managing risk, given higher-order controls are available and may be implemented in a reasonably practicable manner
- Large-scale LiBESS including supporting infrastructure may constitute a chemical or electrical hazard such that intervention activities and/or firefighting operations may pose unacceptable risks to the safety of attending firefighters
- The rapid intervention of a permanent full-time fire brigade cannot be relied upon as it is subject to resource availability and proximity to the incident.
- Potential for significant variation in the weight of response, capability, equipment, and level or training of attending fire brigade resources.

5.3 Electrical hazards posed to firefighters

5.3.1 Large-scale LiBESS including supporting infrastructure are considered to constitute an electrical hazard when involved in an incident, given that:

- It may not be possible to determine the state of charge of an affected unit.
- High voltages may still be present, even at low states of charge.
- There is potential for energy to be stranded within an affected unit.
- FRNSW currently does not have the equipment or capability to be able to detect live direct current (DC) power.
- It may not be possible to isolate the input to- or output from an affected unit, particularly where isolation controls (automated or otherwise) have been adversely affected by exposure to radiant heat.
- The affected and surrounding units may experience a degradation of the ingress protection (IP) rating as a result of exposure to radiant heat.

5.3.2 A FRNSW incident commander may determine that no intervention activities or firefighting operations will be undertaken where it is considered that there is unacceptable risk posed to the safety of firefighters.

5.3.3 Signage should be provided at appropriate locations including but not limited to the entrance to the respective compartment or container, warning of the potential electrical and chemical hazards present.

5.4 Fire brigade intervention

5.4.1 Section 5A *General functions of Commissioner* of the *Fire and Rescue NSW Act 1989* imposes specific statutory functions on the Commissioner of FRNSW, specifically that:

1) It is the duty of the Commissioner to take all practicable measures for preventing and extinguishing fires and protecting and saving life and property in case of fire in any fire district. (and)

2) It is the duty of the Commissioner to take all practicable measures—
   a) for protecting and saving life and property endangered by hazardous material incidents, and
   b) for confining or ending such an incident, and
   c) for rendering the site of such an incident safe.

In the event of a fire or hazardous material incident involving large-scale LiBESS, FRNSW may be required to undertake intervention activities and firefighting operations in order to fulfil statutory obligations, as such, consideration to the safety of first responders conducting intervention activities must be considered.

5.4.2 A potential incident at a BESS facility may be deemed a “hazardous material incident” in accordance with Section 3 of the *Fire and Rescue NSW Act 1989*. Substantial Hazardous Material response resources may be required to determine an appropriate intervention and mitigation strategy in the event of an incident.

5.4.3 Intervention activities and firefighting operations at an incident involving large-scale LiBESS will be undertaken in a manner similar to that for large-scale electrical infrastructure (e.g., substations, electrical switchyards, etc.). FRNSW personnel may not enter the affected BESS compound or compartment until an electrical company representative is in attendance on site and has confirmed power is isolated. The electrical company representative may also be required to provide safety and technical advice to a FRNSW incident commander to assist in determining what intervention activities and firefighting operations can be safely undertaken.

5.4.4 As previously noted, a FRNSW incident commander may determine that no intervention activities or firefighting operations will be undertaken where it is considered that there is unacceptable risk posed to the safety of firefighters.

5.4.5 An Emergency Response Plan (ERP) is to be developed for the site in accordance with *Hazardous Industry Planning Advisory Paper No 1* (HIPAP No. 1) *Emergency Planning*. The findings of the FSS should inform the development and content of the ERP. This should include, but not be limited to:

a. Details on how fire services are notified of an incident. This should be described as part of the fire safety strategy.

b. Detail effective communication strategy with remote operator representative for incident duration.

c. Suitable arrangements for attendance on site by an appropriately qualified representative during any incident.

d. Details on how battery status and information is relayed to emergency services.

5.4.6 The following FRNSW guidelines should also be utilised as part of the fire safety strategy and documentation requirements for the site:

a. FRNSW Fire safety guideline - Hazardous chemicals manifest - Version 04.01 dated 17 November 2020.

b. FRNSW Fire safety guideline - Emergency services information package and tactical fire plans - Version 02 dated 07/01/2019.

5.5 Implemented fire safety systems

5.5.1 The implementation of fire detection and protection measures may be required to ensure that the necessary level of safety and performance has been achieved for a site.

5.5.2 The analysis of requirements for fire detection and protection measures should be informed by the assessment of potential consequences of credible incidents for the site. This should also align with the objectives of the fire safety strategy for the site, particularly those relating to the management and mitigation of the severity of an incident, and prevention of propagation and escalation of an incident, including the potential off-site and environmental impacts.

5.5.3 Supporting analysis and evidence is required to be provided within the FSS to justify the suitability and efficacy of proposed fire detection and protection measures for the site. This evidence is required to demonstrate that the specified performance of individual measures and the collective system is adequate to satisfy the objectives of the fire safety strategy.

5.5.4 All fire detection and protection measures that are relied upon to satisfy the objectives of the fire safety strategy should be automatic in nature (i.e., not require manual operation by an operator or attending emergency service). Supporting evidence is required to be provided within the FSS to demonstrate that individual measures and the collective system have sufficient capacity to operate at the required level of performance for the full duration of an incident.

5.5.5 Adequate redundancy should be provided to all fire detection and protection measures that are relied upon to satisfy the objectives of the fire safety strategy. Supporting evidence is required to be provided within the FSS to demonstrate that there is no single point of failure within any of the systems (including comprising elements) relating to these measures.

5.5.6 Provision should be made for monitoring of the Alarm Signalling Equipment (ASE) where a fire detection system is provided as part of the fire safety system for a site and a readily available response from a permanent fire brigade is available.

5.6 BESS unit separation

5.6.1 As identified in Section 5.2 *Defining the fire safety strategy*, the separation of large-scale LiBESS containers or racks by way of either appropriately fire-rated physical barriers or distance may be adopted as a fire safety strategy for a site.

5.6.2 Where such a strategy is adopted, the FSS is required to contain supporting analyses or evidence to demonstrate that the objectives of the fire safety strategy have been satisfied, namely that the provided separation is adequate to prevent propagation and escalation of an incident. Where active and/or passive measures are provided to support the implementation of this strategy, evidence is required to be provided in the FSS that demonstrates their ability to maintain the required level of performance for the full duration of an incident.

5.6.3 Where separation is provided by way of a physical barrier that is constructed of a material with a fire resistance level as determined in accordance with AS1530.4:2014 *Methods for fire tests on building materials, components and structures - Fire-resistance tests for elements of construction*, an assessment is required to be undertaken to demonstrate that the fire severity associated with the design fire of the worst credible incident (i.e., the design fire severity) does not exceed that associated with the 'standard time versus temperature curve' as prescribed within Section 2.11 of AS1530.4:2014. Failure to accurately quantify the design fire severity such that it is underestimated or exceeds that associated with the standard fire curve may result in the fire resistance performance of materials relied upon for separation being exceeded and subsequent failure of the fire safety system.

5.6.4 Where separation is provided by way of distance, an assessment is required to be undertaken to demonstrate that propagation of the incident will not occur to adjacent and surrounding racks, containers, and/or associated infrastructure. The assessment is required to consider the combined effects of exposure to convective and radiant heat on a receiving body from the worst credible fire for the full duration of an incident.

5.6.5 The impacts of environmental conditions (e.g., wind effects) must also be assessed.

5.7 BESS unit ventilation and flammable and toxic gases

5.7.1 A LiBESS may produce large volumes of flammable, corrosive and toxic vapours and gases when involved in a thermal event as a result of: thermal decomposition of battery components and electrolytes, pyrolysis of combustible materials, and incomplete combustion of volatiles within smoke. Flammable vapours and gases when confined within a compartment or a container are deemed to have the potential to result in a hazardous atmosphere. Any person exposed to these vapours or gases is considered to be at risk of harm.

5.7.2 Ignition of the flammable gases produced during a thermal runaway event may result in a deflagration or explosion. This is noted to have caused or contributed to injury and death to attending emergency services at past incidents.

5.7.3 The design of the fire safety system for any facility containing large-scale LiBESS is required to demonstrate that consideration has been given to the management of flammable, corrosive and toxic vapours and gases that may be produced during a thermal runaway event.

5.7.4 Where a large-scale LiBESS is proposed to be located within a an enclosing container or compartment, a FSS must assume that there is potential for a hazardous atmosphere to be generated unless suitable evidence is provided that demonstrates otherwise. A subsequent analysis of potential consequences is required to be undertaken to inform the analysis of requirements for detection and protection such that suitable measures can be selected for implementation.

5.7.5 Where a large-scale LiBESS is proposed to be located within a an enclosing container or compartment and it is determined that there is potential for a flammable atmosphere to be generated from a thermal runaway incident, the consequence assessment is required to consider how an ignition of the atmosphere resulting in a deflagration or explosion will impact on surrounding racks or units, supporting infrastructure, and any other surrounding elements or structures.

5.7.6 Where a large-scale LiBESS is proposed to be located within an enclosing container or compartment that is occupiable by a person, signage should be provided at appropriate locations including but not limited to the entrance to the respective compartment or container, warning that in the event of an incident involving the LiBESS there is potential for a hazardous atmosphere to be present.

5.7.7 Where a large-scale LiBESS is proposed to be located within an enclosing container or compartment that is occupiable by a person, a visual warning device should be provided at the entrance to the compartment or container that is to activate upon the activation of any provided detection or protection measures, with associated signage provided stating that a fire safety measure has activated and warning that there is potential for a hazardous atmosphere to be present.

5.8 Environmental impacts

5.8.1 A LiBESS involved in a thermal runaway incident may produce combustion by-products that are hazardous to the environment.

5.8.2 When undertaking any consequence assessment relating to a thermal runaway incident, consideration must be given to the potential for the generation of a toxic smoke plume and its subsequent impact on the surrounding environment and communities.

5.8.3 Where a fire safety strategy is adopted that relies on the application of water (or water-based agents) to suppress a fire, provision must be made for the containment of all contaminated firefighting water for the entire expected duration of the incident. Any provided containment system must ensure that contaminated firefighting water is not able to enter local waterways or groundwater.

5.8.4 Where a containment system is proposed to be connected to a reticulated stormwater system, provision must be made for the isolation of the system by way of automatically operated valves that close upon activation of an associated fire safety measure.

5.8.5 Whilst not a requirement of a FSS, it is recommended that any Emergency Response Plan (ERP) developed for the site identify local catchment areas and drainage pathways such that appropriate measures may be implemented in the event that the capacity of the provided containment system is exceeded.

5.8.6 Appropriate consideration should also be given to *Planning for Bushfire Protection (2019)*.

5.9 Post-incident clean-up and disposal

5.9.1 Whilst not a requirement of a FSS, it is recommended that supporting management and procedures documentation for the site provide details of the following:

- Following an incident, how LiBESS will be handled and removed (including transportation) from site. It is noted that this is the responsibility of the facility owner and/or operator and that FRNSW is not responsible for aiding or facilitating such actions.
- A procedure for the removal and disposal of contaminated firefighting water.

5.10 Reference standards and codes

5.10.1 HIPAP No.2 states “The principle of a fire safety study is that the fire safety 'system' should be based on specific analysis of hazards and consequences and that the elements of the proposed or existing system should be tested against that analysis. This should always produce a better outcome than the application of generalised codes and standards alone” (DPIE 2011).

5.10.2 The provisions within applicable codes and standards may be adopted where it can be demonstrated that the requirements of HIPAP No.2 have been adequately satisfied.

6 Contact us

For further information contact the Fire Safety Branch on (02) 9742 7434 or email firesafety@fire.nsw.gov.au.