Large-scale battery energy storage system installations

PROCEDURAL

GUIDELINE
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Review period

This AFAC guideline should be reviewed by the doctrine owner by October 2029.

Contents

About AFAC and AFAC Doctrine

AFAC

The Australasian Fire and Emergency Service Authorities Council (AFAC) is the Australian and New Zealand National Council for fire, emergency services and land management. It is a collaborative network of fire, emergency services and land management agencies that supports the sector to make communities safer and more resilient.

AFAC Doctrine

AFAC develops doctrine to support the practice of emergency management. The information in doctrine publications is evidence-based and drawn from academic research and the collective expert knowledge of member agencies. Doctrine is regularly reviewed and represents the official AFAC view on a range of topics.

Doctrine does not mandate action; rather, it sets aspirational measures. Publishing nationally agreed views, shared approaches and common terminology enhances cooperation and collaboration within and between agencies and jurisdictions.

Types of AFAC Doctrine

AFAC Doctrine is classified as follows:

Capstone doctrine – includes publications, such as 'strategic intents', that are high-level accounts of the concepts of emergency management operations and service delivery. They describe the principles of what is practical, realistic and possible in terms of protecting life, property and the environment.

Fundamental doctrine – includes 'positions', which AFAC members are expected to support, as well as 'approaches' and some 'frameworks'. Fundamental doctrine may become agency or jurisdictional policy on a matter if adopted by individual services or jurisdictions.

Procedural doctrine – includes 'guidelines', some 'frameworks', and 'specifications'. AFAC members are expected to be aware of procedural doctrine. A guideline is an advisable course of action; a framework provides a linking of elements to create a supporting structure to a system, and specifications are a detailed description of a precise requirement to do something or build something.

Technical doctrine – includes 'technical notes', 'training material' and the *Australasian Inter-Service Incident Management System* (AIIMS). Technical doctrine provides guidance of a technical nature: the how to do something, or the technical meaning relative to a situation.

About this document

This publication is a procedural guideline.

Acknowledgements

AFAC acknowledges the work of the ARET and BE Technical Groups for authoring this guideline.

Source of authority

AFAC Council approved this doctrine in October 2024.

Purpose

This is AFAC guidance to industry stakeholders for the development of an overall strategy for fire safety at a Battery Energy Storage System (BESS) Power Grid Connected Installation. AFAC recommends the development of a fire safety strategy for the installation.

A fire safety strategy is a set of measures that deliver the overall objectives for fire safety, including designing for adequate response to potential fire and/or water inundation. Thus, the strategy must be developed with consideration to the emergency response capabilities through engagement with the jurisdictional fire and emergency service.

The rapid advancement of new and emerging renewable energy technology has outpaced the development of fire and emergency management standards and guidance.

To bridge this gap, AFAC has collaborated with stakeholders nationally and internationally to develop guidelines for designing a new facility or modifying and operating existing ones.

The AFAC guideline advocates for a holistic approach to fire and emergency risk management.

Scope

This AFAC guideline applies to large-scale BESS installations with a capacity of 2MWh or greater, situated externally and not housed within a building. BESS installed within a building pose additional hazards that are outside the scope of this guideline due to their elevated risk profile.

BESS installed within cabinets or containers of any size for the purpose of housing the BESS outside a building with another/mixed purpose is deemed to be external.

Large scale BESS may be installed in association with augmented grid power supply infrastructure, such as solar facilities, wind facilities, and at substations, but increasingly are being installed in rural areas, commercial buildings, small towns, and in proximity to the urban environment.

Statement of engagement

This guideline has been authored by the AFAC Alternative and Renewable Energy Technologies (ARET) Technical Group and the Built Environment Technical Group (BETG).

Audience

This guideline is intended for AFAC member agencies and all public and private stakeholder groups, such as property owners, operators, developers, designers, engineers, planners, legislative and regulatory consent authorities, and the insurance industry.

Definitions, acronyms and key terms

AEP	Annual exceedance probability
ARET	AFAC Alternative and Renewable Energy Technologies Technical Group
AS	Australian Standard
BESS	Battery Energy Storage System
BETG	AFAC Built Environment Technical Group
FSS	Fire safety study
Large Scale BESS	a large-scale BESS facility is typically 2MWh or larger.
Thermal runaway	is a term used for the rapid uncontrolled release of heat energy from a battery cell; it is a condition when a battery creates more heat than it can effectively dissipate. Thermal runaway in a single cell can result in a chain reaction that heats up neighbouring cells. As this process continues, it can result in a battery fire or explosion. This can often be the ignition source for larger battery fires. (NFPA, 2022)

Background

BESS installation rates across Australia and New Zealand are increasing. There are several government rebate and stimulus initiatives that are making energy storage systems accessible, resulting in an increased rate of both residential and commercial installations.

Competition in the BESS market centres on the intellectual property related to battery chemistries, particularly the electrolytes and materials used for the anodes and cathodes. Manufacturers use a variety of chemistries, with lithium-ion (or Li-ion) batteries being the most common. A well-designed Li-ion battery can operate safely if the battery controls maintain the battery cells within a specified safe operating region. However, the battery may be subject to abuse such that the control system may not be able to maintain battery cells with the safe operating region, resulting in thermal runaway.

Causes of such abuse include, but are not limited to:

- Thermal abuse (i.e. very high or very low external temperatures)
- Overcharge
- Short circuit
- Over-discharge
- Mechanical impact.

Such failure events within a BESS that have the potential to lead to a thermal runaway event which may pose significant challenges for emergency service personnels in the management of the incident.

In incidents involving large batteries or large quantities of batteries, emergency responders may encounter problems such as:

- stranded electrical energy within large battery packs and installations that present significant fire and electric shock risks.
- complex, resource intensive and protracted extinguishment and cooling.
- combustible and toxic fire emissions and the accumulation of combustible gases in enclosed spaces, leading to flammable atmospheres and potential explosion.
- effluents, including the containment of large amounts of contaminated fire water that may pollute soil, groundwater and nearby waterways, which present a possible health risk to emergency service personnel, the local community near a fire, and to the environment.
- secondary ignitions, that may occur without warning some time after the initial event, potentially during recovery, transport, storage, and disposal.

Whilst failure events are currently reported to be occurring at a low frequency, the potential risks that can eventuate from a thermal runaway event may be of high consequence.

There is concern not only for the fire risk and directional delivery of heat from the pressure relief mechanisms, but also the risk presented by rapid onset vapour cloud explosions. Where a BESS has entered thermal runaway and an ignition source is not present, combustible gases can rapidly build up in an enclosed area, presenting an explosion risk.

The above issues represent an increase in risk faced by first responders and emergency service personnel when attending incidents involving BESS.

In the absence of a specific Australian Standard for large-scale BESS facilities, the current versions of the following should be used in the design and operation of battery energy storage systems, except where varied by this guideline.

- NFPA 855: Standard for the Installation of Stationary Energy Storage Systems
- UL 9540: Energy Storage System Requirements
- UL 9540A: Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
- FM Global Property Loss Prevention Data Sheet 5-33 Electrical Energy Storage Systems

Doctrine concepts

This AFAC guideline provides general guidance on the minimum considerations for fire safety in design for BESS installed as off grid energy sources or as augmented energy storage facilities.

AFAC recommends that regional fire, land management and emergency management agencies are engaged with and consulted in the planning and implementation of all energy infrastructure installations such as large-scale BESS.

AFAC recommends that where BESS installations are proposed to be installed on public land, the relevant land management authority is engaged with, and that any increase in requirement for asset protection and risk mitigation activity including planned burning resulting from the installation of infrastructure is subsidised appropriately.

AFAC recommends that appropriate monitoring for facility infrastructure must be provided to ensure that equipment failures with the potential to ignite or propagate fire are rapidly identified and controlled. Any fire must be notified to Triple Zero (000) in Australia or 111 in New Zealand immediately.

A fire safety study (FSS) is a site-specific fire and explosion hazard analysis and the specification of fire safety systems and mitigation strategies to address the hazards. AFAC recommends the development of a FSS for all large-scale BESS facilities to inform the design of the fire detection and protection systems for the site installation.

Role of fire and emergency services in statutory planning

Fire and emergency services may maintain a statutory role in planning legislation in each jurisdiction, as a referral authority. During the statutory planning phase of a project, these agencies will be engaged to provide consent to proposed plans.

Where fire and emergency services do not hold this statutory responsibility, they may make voluntary submissions as interested parties.

Role of fire and emergency services during an emergency

The fire and emergency services have a specific role during an emergency event at a BESS facility. Their responsibilities include:

- responding to an emergency call or alarm notification
- conducting defensive firefighting to limit fire spread
- hazardous substance control and mitigation during an emergency
- community safety
- emergency service personnel safety.

Fire and emergency services will not:

- open or assess whether the BESS pod, unit or enclosure is safe; this responsibility falls to the operators, not the fire and emergency services.

Fire risk management principles

While this guideline has been developed based on the latest information available, it has not been possible to capture every possible renewable energy facility configuration or battery chemistry due to the rapid evolution of the technology. There are many different battery chemistries available and developing within the BESS market.

Wherever possible, the fire safety study must be based on the specific equipment proposed to be used within the installation and/or facility. Where the specific equipment is replaced or modified, the fire safety study should be updated to reflect the changes.

The following principles for the overall strategy should be applied to all installations:

- Identification of onsite hazards and operations at the facility.
- Provision for firefighting infrastructure.
- Prevention of fire spread within onsite infrastructure and across the site boundary.
- Site access in and around the facility.
- Bushfire exposure risk evaluation.
- Water inundation mitigation evaluations for the site.
- Management of firefighting run-off water.
- Communication and monitoring strategies.
- Clear intervention signage and action plans.
- For installations proposed for a location within 200 meters of human occupancy or existing facilities, a preliminary hazard analysis should be completed.

Fire safety strategy development

A site wide risk assessment, which would include the consideration of fire risks, should be produced as the first step in development of the fire safety strategy for the site. The identification of fire hazards and assessment of potential fire incident consequences should be undertaken. This includes analysis of fire detection and suppression requirements, and identification of the specific measures to be implemented specific to the hazards.

To identify all hazards and assess risks to fire fighters, which include but are not limited to fire, explosion, electrical hazard and toxic gas effects, AFAC recommend a risk assessment is conducted in accordance with AS/NZ ISO 31000:2018 *Risk Management Principles and Guidelines* and associated tools, or a similar process. Jurisdictions may have their own specific guidance.

Further assessment of large-scale BESS installations should then follow a well-recognised methodology for conducting a FSS. Methodologies can be found in such publications as:

- the FRV fire safety guideline GL54 – Fire Safety Study
- New South Wales Department of Planning Hazardous Industry Planning Advisory Paper No 2 Fire Safety Study (2011)
- Country Fire Authority Design Guidelines and Model Requirements for Renewable Energy Facilities (2023).

Installation operators or designers may have developed bespoke approaches for such studies.

A fire safety study should include but is not limited to:

- identification of fire, explosion and toxicity hazards at the facility, including hazards to the emergency responders.
- analysis of on-site and off-site consequences of incidents.
- fire prevention strategies/measures.
- analysis of requirements for fire detection and protection.
- detection and protection measures to be implemented.
- firefighting water demand and supply.
- containment of contaminated firefighting water.

Reporting of BESS and other site hazards and exposures

Hazard identification to support a risk assessment requires knowledge of the site and equipment. This should include as a minimum:

- general site description and layout of site infrastructure.
- quantity of BESS units installed.
- BESS manufacturer and model/variant name.
- manufacturer's data, which will include cell chemistry, energy capacity, cell/module/unit test reports relating to hazards resulting from thermal runaway and/or fire at cell, module and unit level.
- installation scale – total capacity MWh/kWh.
- on-site BESS container configuration and other ancillary equipment location. (e.g. control room, substation).
- bushfire attack level assessment report.
- fire and explosion suppression system details if installed. (e.g. as cooling systems, automatic fire fighting system, gas suppression systems, hydrants).
- installation design and location of water supply and hydrants.
- containment systems for contaminated firefighting water.
- in-built fire safety systems (e.g. battery management system, electrical fault protection, deflagration control).
- transformers, inverters, electrical infrastructure on-site or connected to the BESS.
- connectivity to grid network (overhead or underground cables).
- connectivity to other infrastructure (e.g. solar, wind farms, hydro and/or pumped hydro supplying electrical energy).
- register of materials and quantities stored or in process on-site, including storage of hazardous materials and spare/defect BESS units. Include class of material and hazard type (HAZCHEM UN).

Fire risk assessment

The FSS should include an assessment of credible fire scenarios.

- AFAC recommends the assessment of potential fire scenarios includes credible escalation, to inform on what operational challenges may be presented where fire and emergency service intervention is available. Fire types to consider are construction-initiated fire, BESS fire, transformer fire, buildings, and bushfires.
- Assessment of the consequence of fire and explosion events, if there is failure of active fire protection measures, should be included in the FSS.
- When considering the consequences, this should include consideration of the following exposures:
  - other structures on-site
  - distance to nearest neighbours/receivers, waterways/catchments
  - hazardous vegetation in the context of bushfire and designated areas for managed vegetation, firebreaks/fire management lines.

Design and fire prevention measures

Bushfire exposure measures

The FSS should report on whether a bushfire attack level assessment has been conducted for the site.

- AFAC recommends a suitable fire trail/perimeter access and asset protection zone (APZ)[1] are maintained around the installation. Confirm if clearing approvals are required and seek guidance from the relevant authority.
- The distance (in metres) of the site from hazardous vegetation (vegetation hazard classes) should be developed in accordance with the methodology in AS 3959-2018 *Construction of Buildings in Bushfire Prone Areas* for the site bushfire hazard assessment.
- Potential bushfire exposure thresholds (radiant heat flux, direct flame contact and ember attack) to BESS units/modules and other structures should be considered. AFAC request confirmation that the APZ widths do achieve attenuation such that exposure from bushfire does not cause ignition, glazing breakage or degradation of the BESS module structure and battery cells, leading to thermal runaway and battery fire. Exposure thresholds may be guided by a regional jurisdiction and are to be justified based on the subject installation. It should be noted that criteria

1 Requirements for APZ should be determined in consultation with regional jurisdictions.

for prevention of degradation of BESS units, modules and cells should be available from the bespoke testing conducted for the subject installation.

- The fire safety strategy, which would consider the APZ, should also be designed such that a fire on-site can be managed to prevent escalation off-site.
- An on-site management plan for the maintenance of fuel loads including grasses or vegetation within the installation perimeter should be detailed and implemented.
- AFAC recommends the installation developer and designer must consult with jurisdictional fire and emergency services for construction of safe access and egress as they may have minimum design specifications.

Flood mitigation evaluation

The FSS should report on whether a flood mitigation survey has been conducted for the site.

The FSS should:

- report on the mitigation strategies designed or implemented for the site.
- inform on the flood management strategy for the site, where it may be inundated with floodwater for short or prolonged time periods. BESS systems should be positioned sufficiently to prevent the incursion of flood water into multiple BESS systems from a single flood event. Specific AEP flood level thresholds should be determined as per regional planning regulations.
- refer to jurisdictional planning requirements if site is located in a flood prone area.
- inform on what actions are to be taken following a flood.

Separation of equipment onsite

The FSS should report on the installations strategy to avoid the spread of fire between on-site equipment.

- AFAC recommends a deterministic analysis of credible fire scenarios is provided, demonstrating that fire will not propagate from the initiating module or unit leading to thermal runaway or fire to other exposures. This is supported by bespoke fire testing and/or fire engineering evaluation.
- Where controlled burn out is proposed for the site, separation distances between equipment are required to be quantitatively validated to mitigate potential for fire spread between equipment onsite. The calculated total heat release rate and time to total burn out for a BESS unit fire event are also to be provided in this analysis.
- Separation distances between equipment and other exposures e.g. lot boundary, buildings, storage of hazardous materials, access tracks for emergency services and so on are be substantiated.
- Transformer fires inducing thermal runaway on neighbouring BESS units should be considered (N.B. the separation distances in AS 2067:2018 '*Substations and high voltage installations exceeding 1 kV a.c.*' do not consider this).

Provision of emergency information and notification

The FSS should report on the detection and notification strategy for the system and site, including:

- details of hazard control measures provided within the BESS, including the BMS, to mitigate risks of:
  - thermal runaway
  - fire
  - explosion

  at cell, module, and unit level.
- details of site monitoring to be implemented (remotely or on-site, 24 hours monitoring or business hours only and so on).
- information regarding how the jurisdictional fire and emergency services will be notified of a fire incident occurring on the site.
- site familiarisation should be conducted with emergency services in the response area.
- AFAC recommends that emergency information is provided in a secured location at the site perimeter. The specific content and location of emergency information should be agreed with the jurisdictional fire and emergency service. Suggested content includes:
  - emergency contact numbers for BESS specialist support.
  - location and layout diagram of the room or area in which the BESS is to be installed.
  - quantities and types of BESS units present.
  - manufacturer's specifications including battery chemistry and product SDS.
  - description of energy storage management system (ESMS) and operation details.
  - details on installed fire suppression, smoke or fire detection, gas detection, thermal management, ventilation, exhaust, and deflagration venting systems.
  - procedures for safe shutdown, de-energising, or isolation of equipment and systems under emergency conditions to reduce the risk of fire, electric shock, and personal injuries and for safe start up following cessation of emergency conditions.

- emergency procedures to be followed in case of fire, explosion, release of liquid or vapours, damage to critical moving parts, or other potentially dangerous conditions.
- procedures for dealing with BESS equipment damaged in a fire or other emergency event including contact information for personnel qualified to safely remove damaged BESS equipment from the facility.
- other hazard mitigation procedures as determined necessary to provide for the safety of occupants and emergency responders. Consider:
  - thermal runway condition in a single module, array or unit.
  - failure of an ESMS.
  - failure of a required ventilation or exhaust system.
  - failure of a required smoke detection, fire detection, fire suppression or gas detection system.

- provision of appropriate warning signs.

Provisions for firefighting

The FSS should report on the installation's strategy to provide firefighting infrastructure, such as firefighting equipment, reticulated water supply or boosted hydrants systems or onsite tank supply.

AFAC recommends the installation developer and designer consults with the jurisdictional fire and emergency service regarding fire risk management in facility during the facility design phase.

Firefighting water

Firefighting water requirements vary across jurisdictions due to a range of influences. AFAC recommends engaging with the jurisdictional fire and emergency service early to understand what the requirements are for each specific site.

AFAC recommends:

- the provision of a minimum of a hydrant system complying with requirements of AS 2419.1: 2021, noting that BESS installations are considered special hazard areas to be considered under Appendix E.
- assessment of adequacy of supply mains or static supply.

Any deviation from providing a hydrant system or primary source of firewater at a BESS facility should be decided upon in conjunction with the appropriate jurisdictional fire and emergency service with justification based on a thorough risk assessment.

Where the installation developer or designer does not propose to install firefighting infrastructure, or the nominated site does not have reliable water resources within practical proximity, the FSS should assess and demonstrate that in the case of a fire event, without fire and emergency service intervention, the fire will be contained within the site boundaries.

Containment of contaminated firefighting water

The containment of firefighting water varies between jurisdictions in Australia and New Zealand due to differing environmental protection agency requirements. AFAC recommends engaging with the jurisdictional fire and emergency service to understand the requirements at each site.

Site access in and around the facility

AFAC recommends site access is provided around the full perimeter of the installation with the provision of a least two points of access throughout the facility. AFAC recommends that the number of access points must be informed through a risk management process, developed in consultation with jurisdictional fire and emergency services.

AFAC recommends the installation developer and designer must consult with jurisdictional fire and emergency services for site access requirements as they may have minimum design specifications, such as fire response vehicle type and dimensions that are likely to arrive at the site for incident response.

Supporting References

1. Energy Safe Victoria, *Draft Victorian neighbourhood battery safety guideline,* Melbourne, 2024 www.energysafe.vic.gov.au/victorian-neighbourhood-battery-safety-guideline
2. Country Fire Authority, *Design Guidelines and Model Requirements for Renewable Energy Facilities V4*, Melbourne, 2023 www.cfa.vic.gov.au/plan-prepare/building-planning-regulations/renewable-energy-fire-safety
3. Fire and Rescue New South Wales, *Fire Safety Guideline Large Scale external lithium-ion battery energy storage systems*, Sydney, 2023 www.fire.nsw.gov.au/page.php?id=9166
4. NSW Government, *Hazardous Industry Planning Advisory Paper No. 2 – Fire Safety Study Guidelines,* Sydney, 2011 www.planning.nsw.gov.au/policy-and-legislation/hazards
5. National Fire Protection Association, *NFPA 855 – Standard for the installation of Stationary Energy Storage Systems*, Quincy, 2023, www.nfpa.org/codes-and-standards/nfpa-855-standard-development/855