OPERATIONS BULLETIN 2024-02

Incidents involving large lithium-ion batteries

Issue

Incidents involving large lithium-ion batteries can be highly complex and protracted. Incident Commanders (ICs) need to consider all potential risks and hazards to ensure safe and effective management during and following such incidents. This bulletin provides guidance for ICs and firefighters attending incidents involving large lithium-ion batteries.

Background

Large lithium-ion batteries are a type of battery energy storage system (BESS). BESS have a number of battery cells, a battery management system (BMS), and a cooling system. Unlike smaller lithium-ion batteries in portable devices (phones, computers, toys) or mobility devices (e-scooters, e-bikes, e-skateboards), large batteries cannot be moved from their location during operations.

Large lithium-ion batteries can be:

- Installed on or within a structure – providing electrical energy to a residence, or to a commercial or industrial building.
- Freestanding – forming part of transmission or distribution networks operated by electrical authorities, including community batteries, or installed by private operators to supply premises or facilities.
- Operating within a vehicle or craft – powering an electric vehicle such as a car, bus, truck, light rail vehicle, or boat.
- In storage, transit, or disposal – in vehicles, warehouses, yards, or waste facilities.

There are different operational tactics required depending on the device in which the large battery is used and the location of the device.

Lithium-ion batteries vary in chemical composition – eg lithium metal polymer batteries, lithium cobalt oxide, lithium iron phosphate – and require varying operational tactics.

All rechargeable lithium-ion batteries, no matter the chemical composition, are collectively known as **lithium-ion batteries**.

The guidance in this bulletin can also be applied to incidents where there are a number of small batteries located together.

Hazards

When lithium-ion batteries fail, energy is rapidly released, presenting new hazards to the community and to emergency responders. These hazards include:

Electrical	• Electrical hazards from connected electrical supply and stored energy. • Stranded electrical energy presenting fire and electric shock risks.
Chemical	• Toxic products from leaked electrolyte or coolant. • Highly toxic and corrosive emissions and fire effluents.
Thermal or explosive	• Fire from thermal runaway, which may present as intense, directional, jet-like flames. • Explosive atmosphere from flammable vapours released from battery cells. • Secondary ignitions, which may occur sometime after the initial event.
Mechanical	• Projectiles as battery contents are released under pressure.

Lithium-ion batteries are transported (stored) at up to 30% state of charge and can pose similar risks to batteries installed in equipment or buildings. Damaged batteries are at an unknown state of charge.

Thermal runaway

When lithium-ion battery cells undergo thermal runaway, the exothermic chemical reaction produces **heat**, and the decomposition of the electrolytes and electrodes provides **oxygen** and **fuel** to generate a self-sustaining fire. This means that lithium-ion battery cell fires:

- Cannot be smothered or starved.
- Need to be cooled to stop further propagation within the battery pack.

Products such as fire blankets, foams, and vermiculite products operate on the smothering principle and are not conducive to cooling.

Where possible, large lithium-ion batteries should be allowed to burn and self-consume. Where this is not practicable, the best available medium for battery cooling is *water.* Note that:

- Water must not be used on batteries connected to the electrical network including charging equipment.
- Some battery chemistries contain components that may react violently with water – where possible, identify battery chemistry prior to water application. If water is applied and a violent reaction occurs, stop water application and continue exposure protection.

Battery cells, modules, or adjacent battery packs exposed to heat or damage from thermal runaway pose a risk of secondary ignition. Undertake a thermal check and ensure that these products are stored in a safe location away from other exposures.

Indicators of a battery in thermal runaway include:

- Discolouration, blistering, bulging, or swelling of the casing.
- Pungent odours or leaking electrolyte.
- Abnormal popping, hissing, or crackling sounds.
- Rising temperature of battery exterior, smoke, vapour or jet like flames.

Thermal check

A thermal check may be used to monitor a damaged battery pack.

Where cooling is adopted as the firefighting strategy, cooling sprays should be applied until the battery maintains ambient temperature for 60 minutes. An increasing temperature is a sign that thermal runaway may be occurring within the battery.

When monitoring temperature with a thermal imaging camera (TIC), be aware that the TIC may not be able to accurate readings through battery enclosures. Consider the use of RPAS to assist with temperature monitoring.

General principles – all incidents

- Identify if a large lithium-ion battery is present or involved in fire.
- Review any onsite emergency services information package (ESIP), pre-incident plans, or emergency response guides (ERG).
- Use multi-head gas detector to determine safe approach distances.
- Establish the three zone system in accordance with SOG10.1 *Guidelines for all hazardous materials incidents*.
- Assess whether the equipment is connected to an external electricity supply.
- Confirm battery chemistry and firefighting measures as per ERG or Safety Data Sheet (SDS).
- Consider fire location including exposures and available water supply.
- Anticipate rapid incident escalation due to vapour cloud ignition.
- Consider potential contaminated water run-off, smoke, or vapour clouds.
- Request hazmat support including scientific advisor, for intervention, decontamination, and handover advice.
- Call emergency contact numbers for any additional product guidance.

Personal protective equipment

Life-at-risk or expanding incident phases

Due to the nature of products released and the risk of rapid onset fire or explosion from the battery, firefighters must wear Level 1 PPE (structural firefighting) including donned SCBA when undertaking operations, including during salvage and overhaul. Crews should operate outside of any smoke or vapour cloud to minimise firefighter exposure and PPE contamination.

Contained phase

During the contained phase, the IC may specify alternative PPE (eg chemical protective PPE), subject to the risk management plan.

Operations – Grid scale BESS

Grid scale BESS are found across NSW within new or existing electrical infrastructure sites. They will be installed alongside other hazardous electrical equipment including transformers and high voltage powerlines.

Pre-incident planning

Undertake pre-incident planning of grid scale BESS in and around your station area. Each grid scale BESS facility should have an emergency plan and an ESIP.

Principles

External fire (eg bushfire)

Undertake operations to prevent fire impacting on grid scale BESS. Sites should have adequate clearance from vegetation. Firefighting water should be used to ensure that heat does not impact on BESS units and lead to thermal runaway.

Internal fire

Where a fire occurs within a grid scale BESS site, undertake defensive operations in accordance with SOG 14.5 *Substations* while waiting for onsite experts to arrive for further guidance.

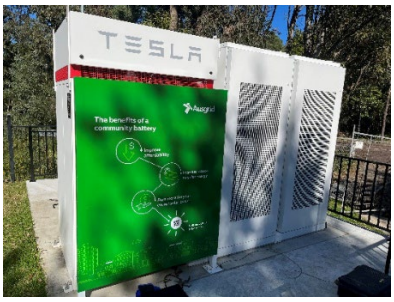
When BESS units are involved in fire:

- Limit FRNSW operations to protecting exposures. Grid scale BESS are designed to not propagate fire to adjacent BESS modules. Water sprayed directly onto grid scale BESS will be largely ineffective due to the enclosed structure of BESS, and water ingress may lead to additional battery modules entering thermal runaway.
- Remain outside of any smoke or vapour cloud. Request hazmat support for advice on atmospheric monitoring and plume modelling.

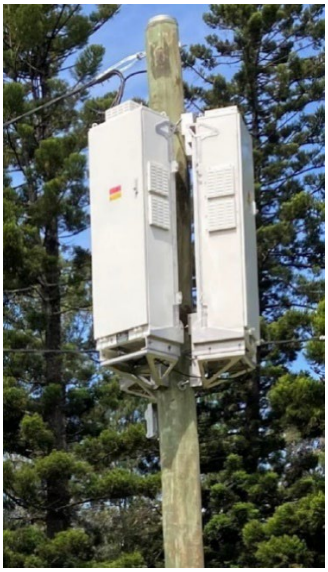
Operations – Network batteries

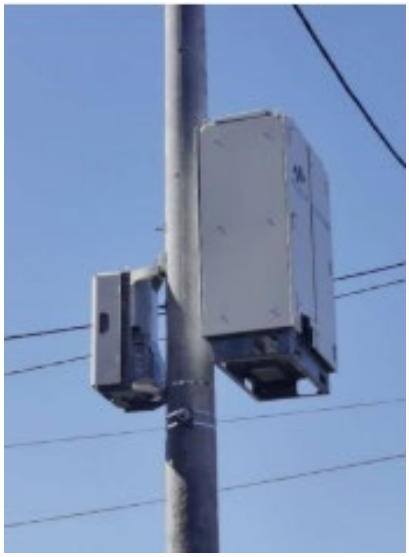
There are large lithium-ion batteries in devices throughout the electrical network deployed by the electrical network service providers (Ausgrid, Endeavour Energy, and Essential Energy). These devices can be mounted on the ground or on poles.

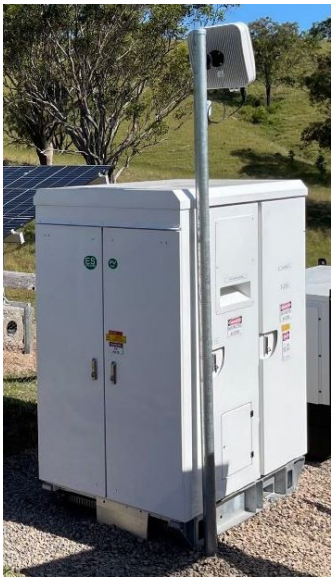
Community batteries incorporate a range of designs and may look similar to traditional electrical kiosks.



Pole mounted network batteries can weigh more than 1 tonne and may look similar to transformers or switching cabinets. They will usually be installed on a dedicated pole away from other overhead wiring.







Stand-alone power systems (SAPS) are replacing large sections of electrical infrastructure. They supply a small number of properties and are coupled with a renewable energy source (eg solar) and a backup energy source such as diesel or hydrogen.

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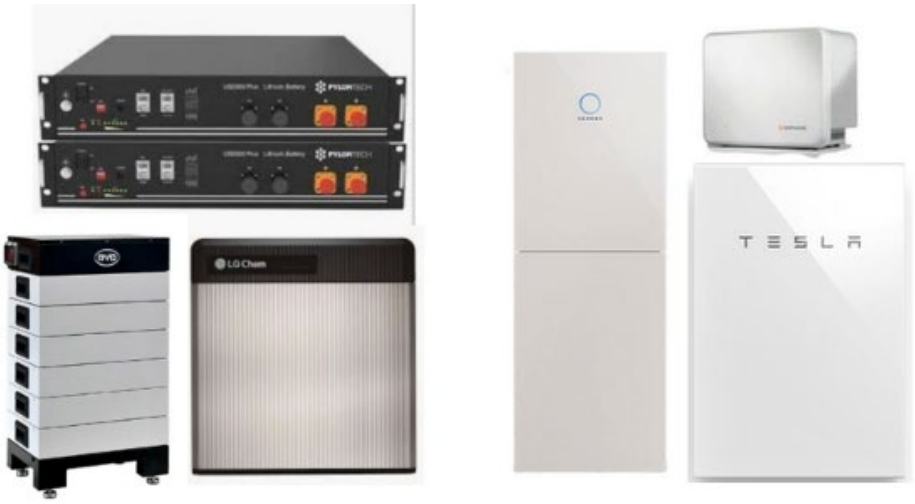
When a network battery is involved in an incident, undertake defensive operations in accordance with SOG 14.6 *Poles, kiosks, pillar boxes and street fixtures*. Wait for onsite experts (electrical network operator) and establish an 8 metre (minimum) exclusion zone.

If the battery is involved in fire:

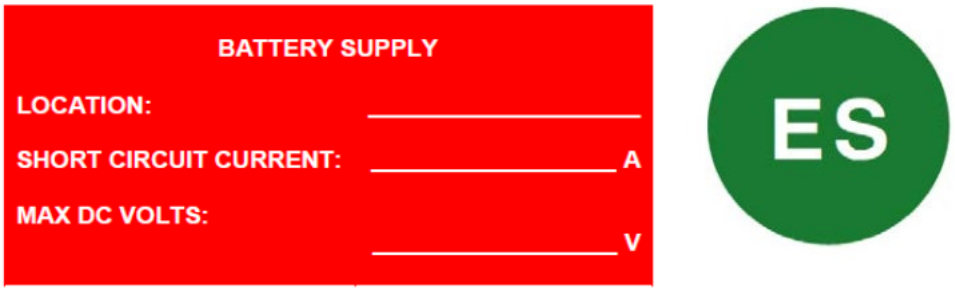
- Limit FRNSW operations to protecting exposures. This includes extinguishing any spot fires started by molten projectiles. Do not spray water directly onto the battery.
- Remain outside of any smoke or vapour cloud. Request hazmat support for advice on atmospheric monitoring and plume modelling.

Operations – Residential, commercial, and electric vehicle batteries

Homeowners and businesses install large lithium-ion batteries on their premises to store electrical energy, often in conjunction with solar PV array systems. These batteries may be floor or wall-mounted in houses and unit complexes, in dedicated battery rooms in commercial buildings, or in containerised solutions. These batteries vary in appearance, depending on type and manufacturer.



An indication that a battery is installed is an ‘ES’ sticker or battery label or warnings in the switchboard or at entry to rooms or compartments containing batteries.



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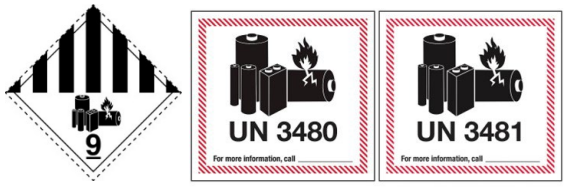
There are large lithium-ion batteries in electric vehicles – passenger vehicles, buses, trucks, and light rail vehicles. These vehicles may be located outdoors or within structures such as garages, carparks, and tunnels.

Large batteries may also be found in storage locations such as waste disposal, workshops, or warehouses. There may be UN labels present to indicate that they are lithium-ion batteries (UN 3480 or UN 3481).



Outdoor firefighting

Where a battery is installed externally to a building (including within a container), or within a vehicle (outdoors):

- Focus firefighting operations on protecting exposures and allowing the battery to self-consume. Do not open doors, hatches, or covers of the batteries.
- Switch off power in accordance with instructions displayed at the main switchboard.
  - For electric vehicle battery fires ensure that charging equipment is disconnected or isolated prior to commencing firefighting operations (refer Operations Bulletin 2021-01 *Electric vehicle fires*).
  - For light rail vehicles, liaise with onsite representatives to confirm that overhead wiring and the third rail (where installed) are both de-energised.
- Contact the site representative and/or product manufacturer for advice on the safe removal of the damaged product.

Indoor firefighting

Where a battery (including an electric vehicle or stored batteries) is situated within a structure such as within a garage, enclosed carpark, or battery room additional precautions are required, if undertaking offensive operations:

- Establish exclusion zones in front of potential vent points including doors and windows.
- Switch off the electricity supply to the structure in accordance with SOG 14.2 *Isolating Power*.
- Do not use spark creating equipment such as power saw to force entry into a compartment where combustible vapours may be present.
- Conduct atmospheric monitoring of lower explosive limits prior to and during entry to compartments.
- Undertake compartment entry in strict accordance with door entry techniques (see STP-8B Station Training Program).
- Conduct thermal checks of battery to identify whether it is in thermal runaway and protect internal exposures.

Decontamination

Leaking batteries and batteries undergoing thermal runaway release toxic products into the smoke and water runoff. Decontaminate in accordance with SOG 10.4 *Decontamination* and with advice from hazmat and scientific advisor.

Handover

Conduct handover when the battery is no longer producing vapours, smoke, or flame and is maintaining ambient temperature for 1 hour without cooling sprays being applied.

During handover to the owner or other responsible person, advise the following:

- There is a risk of re-ignition (secondary ignition), which could occur at any time until the battery is made safe by a qualified person. (Including adjacent battery packs).
- Electrical circuits be checked by a suitably qualified electrician, before restoring power.
- There is an electrocution risk from the hazardous DC electricity in damaged batteries known as stranded energy.
- There may be hazardous materials, including electrolyte products on the surfaces of batteries or on equipment, which can have acidic or alkaline corrosive properties.
- There may be site contamination from smoke or run-off.
- Product manufacturer, NSW EPA, or local council should be contacted for advice re safe disposal of damaged lithium-ion batteries.

If you attend an incident involving a lithium-ion device, you must complete a FRNSW Lithium-ion battery incident notification form on return to your station and forward to firu@fire.nsw.gov.au.

Contact Officer

Station Officer Daniel O'Dea, Capability Management, ARET@fire.nsw.gov.au