Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**
Building and Energy

Battery Energy Storage Systems

A guide for Electrical Contractors

Battery Energy Storage Systems (BESS) are being installed in increasing numbers in electricity distribution networks, homes, remote area power supplies and commercial/ industrial installations. Electrical contractors may be asked to recommend and quote for a BESS or install, commission and test a system designed or selected by others. The BESS may or may not form part of a solar PV installation. It is important they familiarise themselves with the systems and relevant safety requirements prior to doing work on BESS.

Over the last few years battery technology has undergone rapid change, with a range of new chemistries being developed. Current Australian Standards do not cover many critical aspects, creating potential safety hazards for installers, owners/ operators and the general public.

Standards Australia is developing a new standard (AS/NZS 5139) for battery installations but its release date is not yet clear.

For this reason, Building and Energy has prepared the following guidance to alert electrical contractors and electricians to the safety issues associated with BESS. The guiding principle is one of careful design and specification of equipment for each specific installation to achieve the highest practicable standard of "safety in design". This is the responsibility of all parties providing the equipment to the customer.

The Clean Energy Council's publication *Grid-Connected Energy Systems with Battery Storage* provides comprehensive requirements for its accredited installers (www.solaraccreditation.com.au/installers/compliance-and-standards/accreditation-guidelines.html). The Australian Energy Storage Council (ESC) also has produced a *Guide for Energy Storage Systems* (www.energystorage.org.au).

Network operator requirements

Network operators may have requirements affecting selection and installation if the BESS is to be grid-connected. Electrical contractors need to check with the relevant network operator to ascertain all compliance requirements.

Electrical contractors may have to submit a Preliminary Notice to the relevant network operator as a means of ensuring its requirements are known and understood. The network operator may require full technical details of the proposed BESS. Approval from the network operator is required before it will agree to connect. Battery storage may mask a customer's true demand which can be suddenly imposed on the network if the BESS ceases to operate.

BESS risks

Batteries can be a serious safety risk for occupants and installers if incorrectly installed and operated, potentially leading to electric shock, fire, flash burns, explosion or exposure to hazardous chemicals and released gases.

Various battery types will have different probability of failure and varying consequences of that failure (ie a different risk profile). Those responsible for the specification and/or supply of the BESS must ensure that an appropriate risk assessment is undertaken for the specific customer circumstances, location, the equipment proposed and its installation.

Any business installing a BESS must ensure the safety of workers and customers. The BESS must be installed, commissioned and maintained correctly to ensure this. Electrical contractors may need to train customers so they can operate and shut down their BESS safely. Some customers may have technically competent staff on site but most will not.

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Battery types

Many different battery technologies are available for use as a BESS. Some of these have been in use for many years while others have only recently been developed. Some of the common battery technologies on the market are:

- lead-acid;
- nickel cadmium;
- lithium ion;
- nickel metal hydride;
- sodium ion;
- sodium sulphur; and
- vanadium Redox Flow.

Each of these has different performance characteristics which must be considered when selecting a BESS to suit a customer's needs.

Manufacturers also offer a few options for BESS, including:

- a pre-packaged battery module (enclosed factory-connected batteries);
- a pre-packaged system (enclosed factory connected batteries with other components such as a charger control or inverter); or
- a custom-made battery bank (individual batteries installed with other components and interconnected).

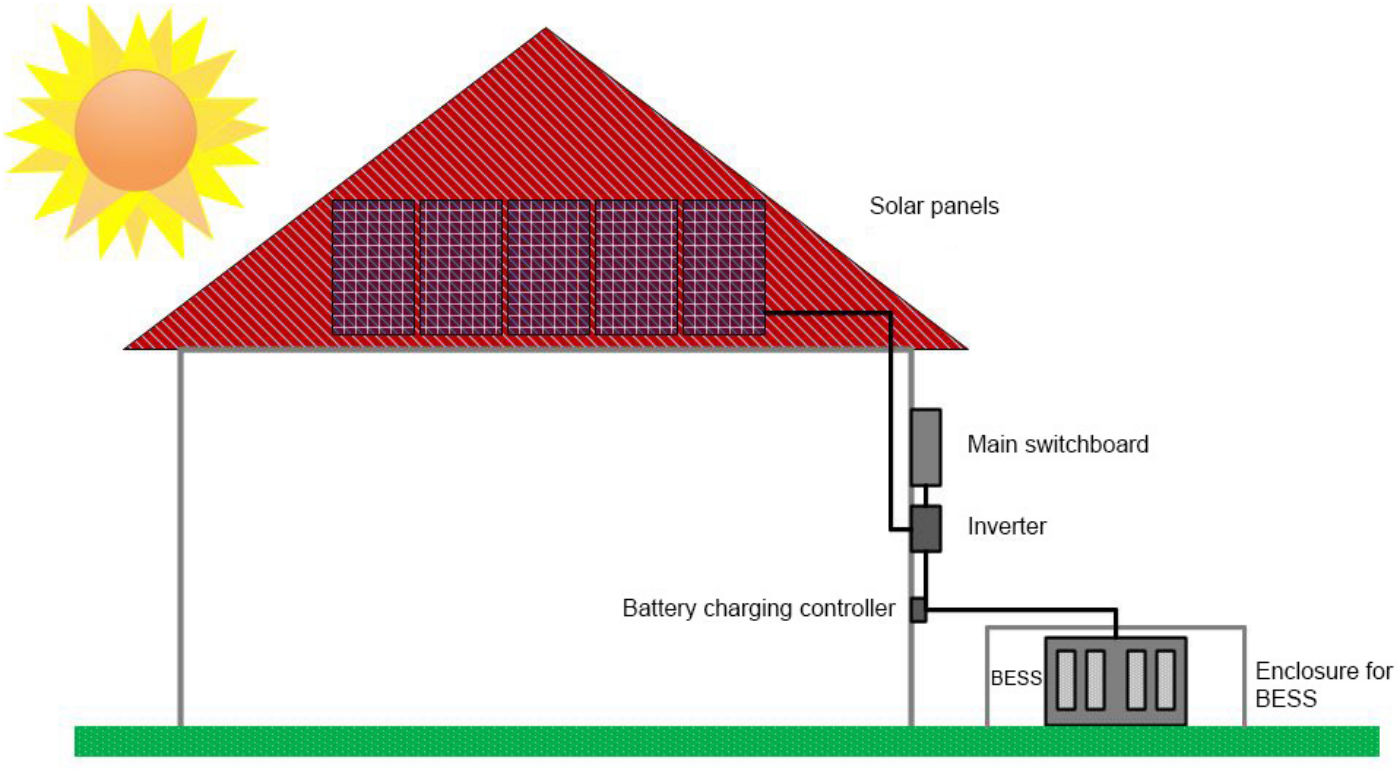
BESS selection

A BESS needs to suit a customer's electricity demand profile. Customer installations connected to network operator distribution systems are designed to export power into the grid, while remote area supplies are not. BESS in remote installations may have to be integrated with wind and/or diesel generators as well as solar PV panels.

Competency requirements

Electrical contractors must ensure their employed electricians have been trained and are familiar with the particular BESS they are asked to install or maintain. BESS designers must be competent in electro-technology and be familiar with such systems, including risk assessment methodologies.

The following sketch depicts one typical example of a solar photo-voltaic installation with battery storage for a domestic dwelling. Many other designs and installations are possible to reflect site-specific circumstances.



Domestic installation with solar panels and battery storage

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Hazards associated with BESS

Installers and owners must be aware of hazards associated with the chosen technology and know how to handle, install and operate the system safely.

Electric shock

Banks of battery cells can deliver a severe electrical shock. There are likely to be 230 volt-rated parts or other system components operating at hazardous voltages.

The battery bank must be electrically isolated while any work is being performed on it or upstream or downstream parts of the system. Battery terminals must be isolated with secure insulating barriers.

Before proceeding, a risk assessment is to be carried out, a Safe Work Management Procedure is to be prepared and suitable protective equipment and insulation barriers must be used.

A drawing showing any remote battery bank locations must appear on the main switchboard. Minimum labelling for grid-connected inverter systems are set out in AS 4777.1:2016, which includes requirements for battery storage.

Arc flash

A battery has sufficient energy to cause an arc flash if it suffers a short circuit or fault. An arc flash can have temperatures above 12,000°C, capable of melting metal or causing fires and explosions. Generally higher battery energy storage capacities have a higher risk of arc flash. Arcing faults may cause catastrophic failure of battery cell enclosures unless the fault currents are removed quickly by correctly rated electrical protective devices.

Fire and explosion

Most lead-acid batteries generate hydrogen and oxygen when charging. Other battery types also emit flammable gases and need adequate ventilation to avoid an explosion, fire or risk to occupants.

Lithium-ion batteries do not produce any exhaust gases during normal operation, but they can produce flammable and toxic gases if there is a fault.

Fire and explosions can result from component failure, a short circuit or loose connections. The chemistry of lithium-ion batteries makes them prone to 'thermal runaway' if they are damaged or overheated by overcharging. Elevated ambient temperatures should be considered by the installer when locating a BESS on a customer premise. Some brands of lithium-ion batteries have superior features intended to prevent the uncontrolled rupture of cells under runaway conditions making them inherently safer.

Hazardous chemicals

Battery casings can degrade or be damaged by impacts. They can also rupture as a result of excessive temperatures and excessive pressure generated from a change in chemical reaction from over-charging or following a short circuit. Electrolyte (fluid or gel) can leak from a ruptured casing, resulting in toxic fumes, burns, corrosion or explosion.

Some compounds produced during the failure of a cell can be extremely toxic. The clean-up, decontamination and disposal of damaged equipment may require specialised equipment and skills. Disposal of contaminated items or batteries at the end of their service life usually will require treatment as a hazardous waste.

Electrical safety requirements in Western Australia

BESS installations in WA must comply with applicable regulatory requirements, including:

- *Electricity Act 1945*;
- AS/NZS 3000:2007;
- The Australian Building Code;
- WA Electrical Requirements (WAER);
- The network operator's technical rules;
- The network operator's consumer connection agreement; and
- AS 4777 - Grid connection of energy systems via inverters - Installation requirements and, where applicable, AS 5033 – Installation and safety requirements for photovoltaic (PV) arrays.

Depending on the battery technology used, the following Australian Standards may be applicable:

- AS 3011-1992, Electrical installations — secondary batteries installed in buildings;
- AS/NZS 2676.1-1992: Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings - Vented cells;
- AS/NZS 4509.1:2009;
- AS/NZS 4509.2:2010: Stand-alone power systems – System Design; and
- AS 4086.2—1997: Secondary batteries for use with stand-alone power systems – Installation and Maintenance.

Minimum installation requirements

As a reminder, the following key requirements from the Wiring Rules apply:

- All components of the electrical installation must be properly selected and installed for the application (Clause 1.7 of AS/NZS 3000:2007).
- All components of the electrical installation

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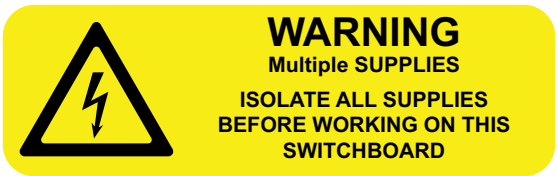
must be installed in accordance with the BESS's manufacturer's instructions.

- Installation work practices must be in accordance with the Wiring Rules.
- Wiring systems and cables must be selected and installed in accordance with the Wiring Rules and be adequately protected against external influences i.e. mechanical impact, UV and environmental damage.
- The short circuit circuit/fault current ratings of BESS are specified by the manufacturer. It is imperative that the overcurrent protection device (fuse/circuit breaker) is adequately sized to cope with such currents.
- Battery Isolation - Correctly-sized DC switch/ isolators must be installed to completely isolate a battery from all circuits connected to it during maintenance.
- AC and DC circuits must be properly segregated from each other with the DC circuit labelled.
- All switches must be clearly labelled.
- Adequate signage should be provided with the BESS, including:
  - Signage for Grid-connected BESS shall be provided according to AS/NZS 4777.1:2016.
  - Signs for stand-alone power systems incorporating BESS shall be according to AS/NZS 4509.
  - For all other systems as a minimum the following sign must be provided
  - A sign must be provided indicating that the switchboard has alternative energy sources and showing the BESS location on the premise.



  - A sign indicating "Danger of battery explosion from open flames, sparks and smoking".

  - A sign explaining the shutdown procedures for the BESS.
- Main Battery Fuses – A battery's fault current is limited only by its internal resistance. If short-circuited, a battery can deliver an extremely high current in a short space of time, in the order of 100 to 1,000 times the typical discharge current normally used. This will cause explosive failure of the battery unless circuit protection operates very quickly.

A protection device should be located as close as practicable to the main output terminals of the battery. Any cabling to the location of protective fuses or circuit breakers should be double insulated.

Location

Given their particular risks, some BESS batteries are not suitable for installation in habitable parts of homes or an attached building, while others may be specifically designed for indoor locations such as laundries or garages.

Prior to the selection of the installation location, a risk assessment should be conducted by a competent person familiar with the chosen technology, with due consideration for the consequences of a contingency event. Where batteries are sensitive to operating temperature, particular consideration should be given to this matter in the risk assessment. A copy of this risk assessment should be provided to the customer as part of the equipment documentation.

Manufacturer's guidelines should be strictly followed.

A BESS may be mounted on a suitable outside wall (with an appropriate IP rating) or installed in a fire and weatherproof enclosure. The fire rating of an enclosure is particularly important if the BESS is to be indoors. Installers must pay due regard to the manufacturer's recommendations about operating temperature limits, exposure to direct sunlight and avoidance of impact risks. Pre-packaged BESS may include weatherproof enclosures for outdoor mounting and may not need any additional protection.

Enclosures should prevent access by untrained people, children, pets or vermin.

The following should be considered when selecting a suitable location:

- Building codes applicable to batteries (national and local) and changes to floor loadings. The National Construction Code (NCC) also has specific requirements for battery installations. Please refer to the NCC for more details;
- if located in an electrical switch room, the room complies with Wiring Rules requirements;
- the location complies with the manufacturer's recommendations to protect the system from weather and extreme heat, light and temperature, which may reduce performance, the life span of the

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system or trigger one of the hazards mentioned above. Most batteries have an optimal operating temperature range to achieve their design life and maintain safety. In Western Australia, locations exposed to north and west-facing aspects are undesirable for BESS installations for reasons of high solar radiation;

- the room or enclosure must be suitably ventilated for the location and the type of BESS;
- the enclosure must be capable of containing any electrolyte spills (if applicable);
- adequately fire-rated walls are used to avoid or delay the spread of fire, should it occur, giving fire authorities time to attend the scene;
- suitable means of access/egress to the area is provided during installation and for maintenance work; and
- the enclosure provides adequate mechanical protection to the BESS.

Testing, verification and commissioning

The BESS must be tested and commissioned in accordance with the network operator's requirements, manufacturer's instructions and relevant standards, including the Wiring Rules.

When the BESS installation is complete, the electrical contractor must submit a Notice of Completion to the relevant network operator or to Building and Energy for non-grid connected or remote installations. In either case, the installation may be subject to a safety inspection by an Inspector (Electricity), who may require access to the BESS owner's documentation package, including the risk assessment. In addition, the electrical contractor is also required to provide an Electrical Safety Certificate to the customer/owner of the electrical installation in accordance with the Electricity (Licensing) Regulations 1991.

Hand-over must include owner and user training on:

- how to operate the BESS safely and shut it down in an emergency;
- the purpose of various safety warnings and lights; and
- safety data sheets.

Maintenance

The BESS owner's documents must include the maintenance requirements specified by the manufacturer, which should be followed. They must be performed by a licensed electrical contractor unless operating at ELV.

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