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Battery Storage Systems for Grid-Connected PV Systems

Revisions to the Battery Storage Systems for Grid-Connected PV Systems Australian Edition Version 2.3 Publication

GSES
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Following is the summary of changes to the information within Battery Storage Systems for Grid-Connected PV Systems Australian Edition Version 2.3, April 2021. Please note that the changes in this document are subject to alterations in newer editions. While all care has been taken to ensure this document is free from omission and error, no responsibility can be taken for the use of this information in the design or installation of any grid-connected PV system.

Keywords

Addition: *Adding an additional paragraph.*

Replacement: *To entirely replace something.*

Extension: *To add an additional sentence/s onto the end of a sentence or paragraph.*

Amendment: *To modify sections of a paragraph or sentence either by quote or by reviewing the referenced text.*

Removal: *To remove something altogether.*

Chapter 4: Power Conversion Equipment

1. **Section 4.2 - Decisive Voltage Classification**

   Amendment:

   > ***AUSTRALIAN STANDARDS***
   >
   > DVC classification of PCE ports is provided by manufacturers as part of ***IEC 62109-1***, referenced by ***AS/NZS 4777.2:2020.***

2. **Section 4.3.1 - Grid-connect, Stand-alone and Multimode Inverters**

   Amendment:

   > **IMPORTANT**
   >
   > Stand-alone inverters that do not comply with local grid-connection standards or regulations, e.g. ***AS/NZS 4777.2:2020*** in Australia, must not be directly connected to the main grid at any time.

3. **Section 4.3.3 - Demand Response Management (DRM)**

   Amendment:

   > ***AUSTRALIAN STANDARDS***
   >
   > ***AS/NZS 4755*** series of standards provides full details on the various Demand Response Modes for various equipment. ***AS/NZS 4755.3*** in particular deals with Energy Storage Systems and DR AS/ NZS 4755.6 covers the requirements for Demand Response Enabling Devices. ***AS/NZS 4777.2:2020*** Section 3 covers the operational mode requirements for grid-connected inverters or the grid-connected port of multimode inverters.

4. Section 4.3.3 - Demand Response Management (DRM)

Amendment:

Table 4.3: *Demand Response Modes. (Source:* ***AS/NZS 4777.2:2020 Table 3.1****)*

Mode	Requirement
DRM 0	Operate the disconnection device
DRM 1	Do not consume power
DRM 2	Do not consume at more than 50% of rated power
DRM 3	Do not consume at more than 75% of rated power AND supply reactive power if capable
DRM 4	Increase power consumption (subject to constraints from other active DRMs)
DRM 5	Do not generate power
DRM 6	Do not generate at more than 50% of rated power
DRM 7	Do not generate at more than 75% of rated power AND absorb reactive power if capable
DRM 8	Increase power generation (subject to constraints from other active DRMs)

Chapter 5: Preliminary System Design

5. Section 5.6.1 - Hierarchy of Controls

Replacement:

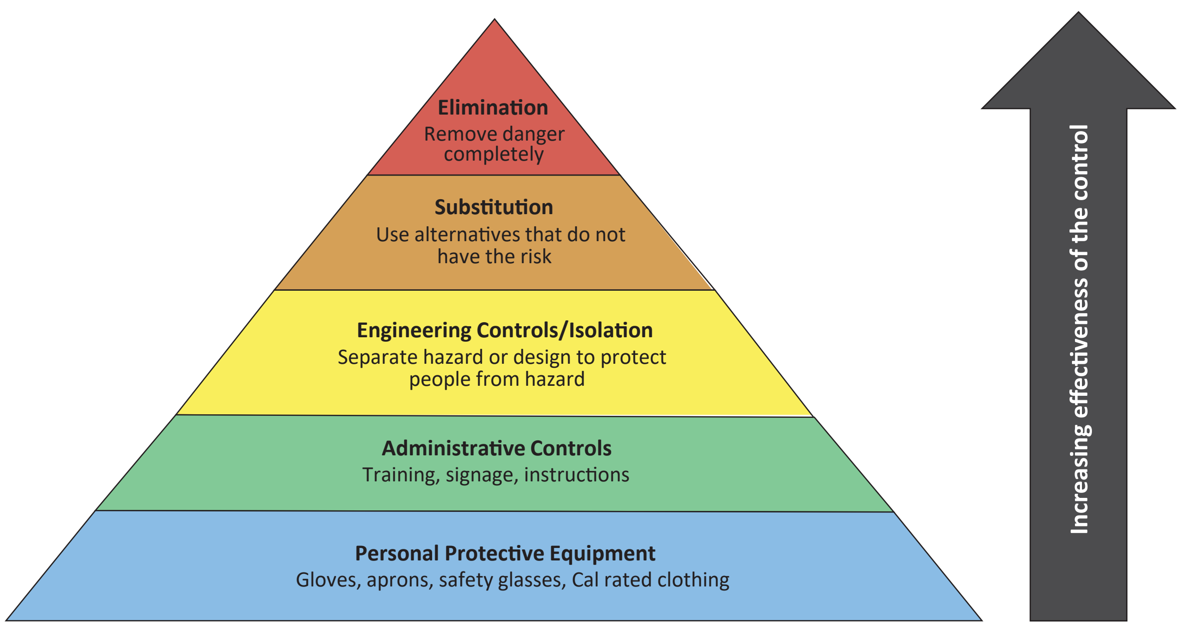


Figure 5.26: Hierarchy of controls as described by AS/NZS 5139:2019

6. Section 5.7.5 - Explosive Gas Hazard

Amendment :

- I = Charging rate (in A)

7. Section 5.7.5 - Explosive Gas Hazard

Amendment :

For flooded lead acid battery systems, the charging rate is the combined maximum charge current possible from all sources. If the battery system comprises parallel strings then the charging rate for each battery cell is only a portion of the maximum charge current for the full battery system. For example, if there are two parallel strings and the maximum charge current is 100 A then the charging rate for each battery system cell will be 50 A.

$$I = \frac{maximum\ (system)\ charge\ current\ (in\ A)}{number\ of\ battery\ strings}$$

Where:

- I = Charging rate (in A) for each battery cell

For valve regulated lead acid battery systems the charging rate is either:

8. Section 5.7.5 - Explosive Gas Hazard

Amendment:

- A = minimum area of vents (cm^2)

9. Section 5.7.5 - Explosive Gas Hazard

Removal:

In general, natural ventilation will have ventilation on opposite sides, however if the ventilation vents are all on one side, adequate airflow can be achieved if the internal roof slopes up to the outlet vent. Chemical hazards

10. Section 5.7.5 - Explosive Gas Hazard

Addition:

EXAMPLE

A 48V valve regulated lead acid (VRLA) battery is made up of 2V cells, and is charged with a smart controller that includes an automatic over voltage cut-off. Assume the battery has a capacity of 820Ah at the 3-hour discharge rate, and the enclosure has ventilation holes. What is the minimum vent area required to allow adequate ventilation?

Since the controller has an automatic over voltage cut-off, the charging rate is:

$$I = \frac{0.5\ A}{100\ Ah} \times 820\ Ah$$
$$= 4.1\ A$$

The minimum area required for each vent is:

$$A = 0.6 \times n \times I$$
$$= 0.6 \times 24 \times 4.1\ A$$
$$= 59.04\ cm^2$$

Chapter 6: Equipment Sizing and Selection

11. Section 6.3.2 - Sizing the Capacity of the Battery Bank

Amendment:

- H_{CABLE} = efficiency of the cables from the battery to the specified load/s, dimensionless (see Section 6.6.2 for information on calculating cable efficiencies).
- η_{TEMP} = derated capacity of battery, (see Figure 2.18 and Figure 2.19)

12. Section 6.5.2 - Customer Objectives

Replacement:

EXAMPLE 1

A BESS is being designed to provide backup due to frequent grid outages. The battery has been sized with a reserve capacity such that if a grid outage occurs at night time, they will not be without power. They are not concerned with meeting daytime loads as they are rarely home during the day. They would like the system to be sized for winter months so the system will function even during low irradiation.

In this example, the PV array should be sized to be able to at minimum recharge the batteries back up to the reserve capacity.

Assume:

- De-rated module output = 234 W
- Worst case PSH = 2.6
- Usable battery capacity = 5.5 kWh
- Reserve capacity = 45%
- PV inverter efficiency = 96%
- Multimode inverter efficiency = 95%
- Cable efficiency = 97%

The system will consist of a multimode inverter connected to the battery, and a PV inverter connected to such that PV can charge the battery when disconnected from the grid.

$$\text{Energy required to charge the battery} = 0.45 \times 5.5 = 2.5 \text{ kWh}$$

$$\text{Energy to be provided by the PV array} = \frac{2.5}{(0.96 \times 0.95 \times 0.97)} = 2.8 \text{ kWh}$$

$$\text{Number of modules required} = \frac{2.8}{(0.234 \times 2.6)} = 4.6\text{, round up to 5}$$

Therefore, a minimum of 5 modules are required to charge the batteries up to reserve capacity during winter.

13. Section 6.5.2 - Customer Objectives

Replacement:

System components must also meet safety requirements as set out in AS/NZS 5139:2019, in particular the requirements based around the Decisive Voltage Classifications (DVC).

14. Section 6.6.2 - Cable Sizing

Amendment:

EXAMPLE

Using Table 6.2, determine the minimum cable size required for an array where:

- Route length = 20 m,
- Maximum current = 15 A,
- System voltage = 24 V, and
- Maximum allowable voltage drop = 5%.

$$\text{Maximum } V_C = \frac{1{,}000 \times 0.05 \times 24\ V}{20\ m \times 15\ A}$$

$$= 4\ mV/Am\ (DC)$$

Converting to three-phase:

$$\frac{4\ mV/Am}{1.155} = 3.46\ mV/Am\ (\text{three-phase AC})$$

Assuming the selected cable may operate up to its rated insulation temperature of 90°C, the minimum conductor CSA that meets the calculated V_C requirement is a 16 mm^2 cable.

Cable manufacturers may also provide voltage drop figures using a range of alternative methods.

15. Section 6.6.2 - Cable Sizing (Fault Current Cable Sizing)

Addition:

AUSTRALIAN STANDARDS

Battery manufacturers are required to provide the short circuit current (or fault current) of their battery systems as per ***AS/NZS 5139:2019*** Clause 3.2.3.3. If no information is available, the battery system should not be installed.

Chapter 7: Determining the System Layout

16. Section 7.2.2 - PCE Design Functions

Amendment:

DID YOU KNOW?

Some multimode inverters can use DRM modes as set out in ***AS/NZS 4777.2:2020*** to ramp a PV inverter output up or down during stand-alone mode.

Chapter 8: System Performance, Economics and Documentation

17. Section 8.2.3 - DC-Coupled System Example: Efficiency and Yield for a Configuration with a Single Inverter with Separate Solar Controller

Amendment:

3. Efficiency of charging battery bank:

   i. from PV array:

$$\eta_{BATTERY\text{-}CHARGE(PV)} = \eta_{CC} \times \eta_{BATTERY} \times \eta_{CABLE}$$

   ii. from grid (if permitted):

$$\eta_{BATTERY\text{-}CHARGE(GRID)} = \eta_{MM} \times \eta_{BATTERY} \times \eta_{CABLE}$$

Chapter 9: Installation Work Health and Safety

18. Section 9.1 - Introduction

Replacement:

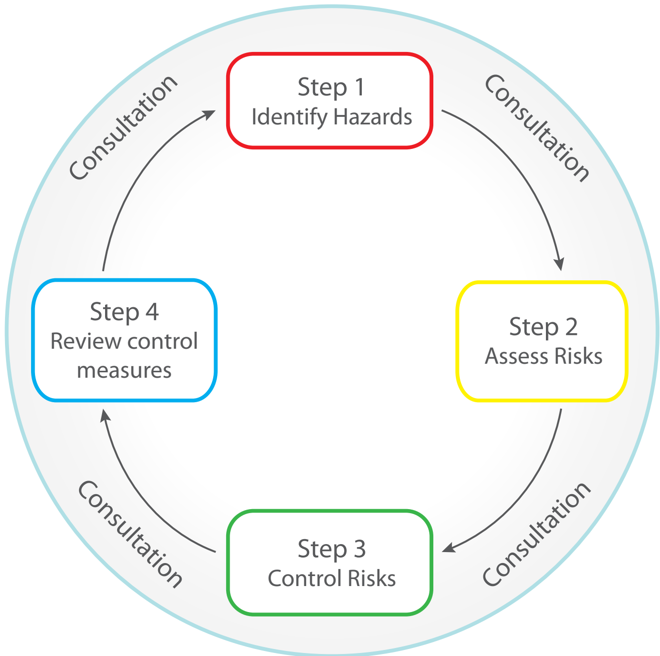


Figure 9.1: The Risk Management Cycle.

Chapter 10: Installation

19. Section 10.5.2 - Residual Current Devices (RCD)

Amendment:

> ***AUSTRALIAN STANDARDS***
>
> ***AS/NZS 4777.2:2020*** Clause 3.4.1 states the type of RCD compatible with and for use on the stand-alone function outputs shall be declared, and ***AS/NZS 4777.2:2020*** Clause 7.2.5 states where an external RCD is required, the inverter shall be marked with a warning along with the rating and type of RCD required.

20. Section 10.5.2 - Residual Current Devices (RCD)

Amendment:

> ***AUSTRALIAN STANDARDS***
>
> ***AS/NZS 4777.2:2020*** Clause 2.10 limits the D.C. current injection at any a.c. port (grid-interactive and/or stand-alone) to no greater than 0.5% of the inverters rated current or 5mA, whichever is greater.

21. Section 10.10 - Signage

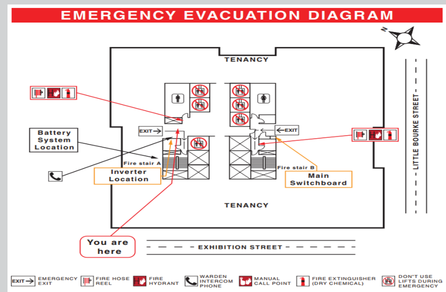
Amendment:

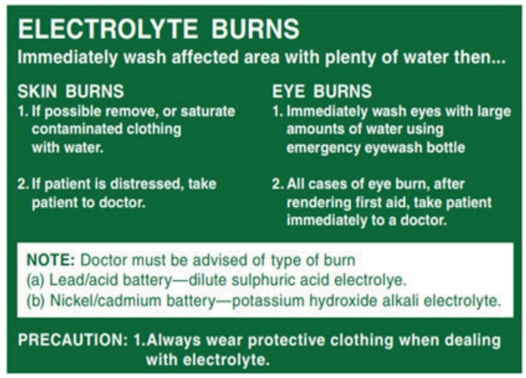
> **REMEMBER**
>
> Typical examples of signs relating to the battery system or BESS can be found in ***AS/NZS 5139:2019*** Appendix B.

22. Section 10.10 - Signage

Amendment:

***Table 10.2**: Example warning signs for a grid-connected PV system with battery storage.*

<table>
<tr><td>Main switchboard and main metering panel
Example of battery location signage
AS/NZS 5139:2019 Clause 7.4</td><td>
</td></tr>
<tr><td>Adjacent to the battery enclosure or on all doors to the battery room
Typical sign for restricted access
AS/NZS 5139:2019 Clause 7.5</td><td>
</td></tr>
<tr><td>Adjacent to the restricted access sign
Typical sign for specific PPE requirements
AS/NZS 5139:2019 Clause 7.5</td><td>
</td></tr>
<tr><td>Adjacent to the battery enclosure or on all doors to the battery room
Typical sign for battery system voltage
AS/NZS 5139:2019 Clause 7.6</td><td>BATTERY SUPPLY
SHORT CIRCUIT CURRENT ________A
MAX D.C. VOLTS ____________V</td></tr>
<tr><td>Adjacent to the battery enclosure or on all doors to the battery room
Typical sign for battery system with voltage greater than DVC-A
AS/NZS 5139:2019 Clause 7.6</td><td>BATTERY SYSTEM (specify location)
SHORT CIRCUIT CURRENT (specify)______A
MAX D.C. VOLTS (specify)
HAZARDOUS D.C. VOLTAGE</td></tr>
<tr><td>Adjacent to the battery enclosure or on all doors to the battery room
Example sign for explosion hazard
AS/NZS 5139:2019 Clause 7.8</td><td>
</td></tr>
</table>

Adjacent to the battery enclosure or on all doors to the battery room Example sign for toxic fume hazard ***AS/NZS 5139:2019*** Clause 7.9	
Adjacent to the battery enclosure or on all doors to the battery room Example sign for toxic fume hazard ***AS/NZS 5139:2019*** Clause 7.9	
Adjacent to the battery enclosure or on all doors to the battery room Example sign for arc flash hazards ***AS/NZS 5139:2019*** Clause 7.11	
Adjacent to the battery system Spill safety signage labelling ***AS/NZS 5139:2019*** Clause 7.19	IN THE EVENT OF LIQUID DETECTED IN THE BUND, USE LABELLED SPILL KIT AND PPE TO REMOVE LIQUID. REPORT FAILURE IMMEDIATELY TO SUPPLIER UN: _____
Adjacent to each BESS Example battery enclosure source label where there are multiple battery supplies. To be located on individual battery enclosures. ***AS/NZS 5139:2019*** Clause 7.6	MULTIPLE BESS SUPPLIES BESS # 1/4 SHORT CIRCUIT CURRENT _____A MAXIMUM D.C. VOLTS _____V

Main switchboard and main metering panel

Example of energy storage label required for emergency workers, including the UN number.

Ensure the UN number of battery chemical type displayed is indicative of the battery chemistry installed. The table displays the UN number for common battery types.

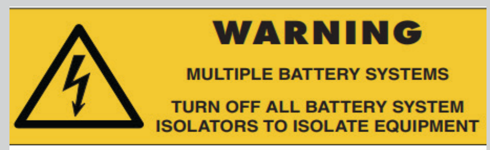
AS/NZS 5139:2019 Clause 7.3

UN number	Battery chemical type
UN 3480	Lithium ion (including ion polymer)
UN 3090	Lithium metal batteries
UN 2794	Flooded lead acid battery
UN 2800	Valve regulated lead acid battery
UN 3496	Nickel-metal hydride battery
UN 2795	Nickel cadmium battery
UN 3292	Sodium ion batteries

Adjacent to PCE connected to the multiple battery systems

Typical warning sign for inverters connected to multiple battery systems

AS/NZS 5139:2019 Clause 7.12.3



Adjacent to each disconnector for DVC-B and DVC-C systems

Typical warning sign for isolation switches for battery systems above DVC-A

AS/NZS 5139:2019 Clause 7.12.4

Adjacent to the PCE and visible from the equipment to be operated in the event of a shutdown

Battery safe isolation procedure located at the battery system isolation point

AS/NZS 5139:2019 Clause 7.16

Isolation devices

Battery isolator signage in a prominent location

AS/NZS 5139:2019 Clause 7.12.2 and 7.13.1

BATTERY SYSTEM
D.C. ISOLATOR

23. Section 10.10 - Signage

Removal:

Adjacent to the battery enclosure or on all doors to the battery room

Example sign for arc flash hazards

AS/NZS 5139:2019 Clause 7.11

BATTERY SYSTEM
CIRCUIT BREAKER

Chapter 12: Worked Examples

24. Section 12.2.1 - Load Assessment

Amendment:

Table 12.1: *Consumption over 3-day blackout*

Appliance Description	Power (W)	Usage (Hours x Number of Days)	Energy (Wh)	Power Factor	Max Demand (VA)
Cash Register 1	260W	22.5 (7.5 × 3)	5850Wh	1	260VA
Cash Register 2	260W	22.5 (7.5 × 3)	5850Wh	1	260VA
Lighting	100W	22.5 (7.5 × 3)	2250Wh	1	100VA
Refrigeration	801W	24kWh over 3 days		0.9	801 W ÷ 0.9 = 890 VA
		Total Energy (Wh)	37950Wh		
				Maximum Power Required at any one time (VA)	1510VA

Note: A 24V system does appear to be a low voltage for a total energy of 37,950Wh. However, with only 1510 VA demand, the current demand will be less than 100A, which means that using a 24V system should be acceptable. In Section 12.2.3, it will be determined whether a battery bank with a single string (always the preferred option) is able to provide enough current to supply the load using a 24V as the system voltage.

Table 12.2: *Loads to be supplied by additional PV generation when available*

Appliance Description	Power (W)	Usage (Hours)	Energy (Wh)	Power Factor	Max Demand (VA)
Lighting	100W	7.5	750Wh	1	100 VA
Refrigeration	801W	3200Wh during daylight hours		0.9	801 W ÷ 0.9 = 890 VA
		Total Energy (Wh)	3950Wh		
				Maximum Power Required at any one time (VA)	990VA