

AS 5374:2023



Energy storage system performance



AS 5374:2023

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Preface

This Standard was prepared by the Standards Australia Committee EL-005, Secondary Batteries.

The objective of this document is to provide manufacturers and test houses with a standardised format for the testing and reporting of the performance of battery energy storage systems to enable end users to compare different product performance metrics that have been determined in the same manner.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

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NOTES

Australian Standard®

Energy storage system performance

Section 1 Scope and application

1.1 Scope

This document specifies technology agnostic practices for measurement and reporting of the performance characteristics of Battery Storage Equipment (BSE) designed to be used within residential or small-scale-commercial applications in conjunction with solar photovoltaic (PV) systems.

The document is applicable to battery cells, modules, pre-assembled and integrated systems. It is intended to provide standardised testing and reporting requirements for the performance of BSE. This document is also applicable to BSE designed and constructed using previously used batteries such as second life or refurbished battery systems.

This document is directly applicable to solar PV-connected BSE for use in residential and small-scale commercial customers in Australia. Sections of the document may, however, be applicable for other BSE or BSE subcomponent types and applications for which no specific standard exists.

This document defines the following as they relate to BSE performance:

- (a) Performance indicators/metrics.
- (b) Standardised testing protocols to determine performance metrics.
- (c) Standardised reporting requirements for performance metrics.

This document is applicable to battery systems —

- (i) using secondary or rechargeable cells;
- (ii) with a nominal power equal to, or less than 100 kW; and
- (iii) with a rated capacity equal to or greater than 1 kWh and no more than 200 kWh at the C5 rate.

Where an installation includes multiple battery energy storage systems (BESS), this document applies to each individual BESS if each individual BESS is no more than 200 kWh.

This document is applicable to battery storage equipment connected to residential and small commercial applications with solar PV electricity generation on the consumer network side of the utility meter in a low voltage Alternating Current (AC) connection (i.e. behind the meter).

This document does not intend to cover —

- (A) design, installation;
- (B) safety;
- (C) grid integration and demand response management;
- (D) operational control and communication;
- (E) recycling;
- (F) handling and transport;
- (G) solar PV installation; and
- (H) training requirements.

NOTE 1: While this document does not apply to systems with a nominal power greater than 100 kW or a capacity greater than 200 kWh, the principles and general requirements can be applied to these systems.

NOTE 2: This document primarily considers BSE applications installed behind the meter however the testing principles and results may prove useful for other low voltage applications.

NOTE 3: Off-grid applications are not covered by this standard, however the principles herein for determining performance at various temperatures may be relevant to this application.

The document provides guidance for both required and optional performance metrics by —

- (1) defining how tests are to be undertaken to determine each performance metric, including the environmental conditions;
- (2) defining the results from the testing that are to be reported; and
- (3) defining the method of presentation of test results for both the overview and detailed parameters.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 3731.2, *Stationary batteries—Nickel-cadmium, Part 2: Valve-regulated type*

AS/NZS 3100, *Approval and test specification – General requirements for electrical equipment*

AS/NZS 5139, *Electrical installations — Safety of battery systems for use with power conversion equipment*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61427-2, *Secondary cells and batteries for renewable energy storage – General requirements and methods of test – Part 2: On-grid applications*

IEC 62133-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems*

IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

IEC 62281, *Safety of primary and secondary lithium cells and batteries during transport*

1.3 Terms and definitions

For the purposes of this document, the following terms and definitions and those given in AS/NZS 5139 apply.

NOTE ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

1.3.1 assembled

separate component parts of battery storage equipment (BSE) connected together

1.3.2

auxiliary equipment battery equipment

equipment required for supporting different battery technologies and associated battery infrastructure

Note 1 to entry: May include pumps, storage tanks, fire suppression, communications equipment, and any other equipment required for the battery system to operate, excluding BMM and BMS.

1.3.3

battery

unit consisting of one or more energy storage cells connected in series, parallel or series-parallel arrangement

1.3.4

battery energy storage system

BESS

system consisting of PCE, battery system(s), and isolation and protection devices

Note 1 to entry: Where provided, it also includes auxiliary battery equipment, battery cables, battery management module(s), and battery management system.

1.3.5

battery management system

BMS

electronic system that monitors and manages a battery or battery system's electric and thermal states enabling it to operate within the safe operating region of the particular battery

Note 1 to entry: The BMS provides communications between the battery or battery system and the PCE and potentially other connected devices (e.g. vents or cooling).

Note 2 to entry: The BMS monitors cells, battery or battery modules to provide protective actions for the battery system in the case of overcharge, overcurrent, over discharge, overheating, overvoltage and other possible hazards that may occur. Additional BMS functions may include active or passive charge management, battery equalization, thermal management, specific messaging or communications to the PCE regarding charge rates and availability.

1.3.6

battery module

one or more cells linked together

Note 1 to entry: May also have incorporated electronics for monitoring, charge management and/or protection.

1.3.7

battery storage equipment

BSE

equipment to provide energy from batteries

Note 1 to entry: It is used to describe both systems with and without integrated power conversion equipment, including:

- (a) *DC BSE* — acronym used to describe BSE without integrated power conversion equipment.
- (b) *AC BSE* — acronym used to describe BSE with integrated power conversion equipment.

Note 2 to entry: See [Appendix F](#) for more detail regarding BSE.

1.3.8

battery system

system comprising one or more cells, modules or batteries, which may include one or multiple battery management system/s and auxiliary supporting or protective equipment depending on the type of technology

Note 1 to entry: This does not include the PCE.

1.3.9**battery system enclosure**

dedicated enclosure containing the battery system, including associated battery system components, and which is compatible with the installation location

Note 1 to entry: Pre-assembled battery systems may already include a suitable enclosure.

1.3.10**capacity****C**

electric charge that a cell or battery can deliver at a specified constant current and end voltage

Note 1 to entry: Measurand is Ampere-Hours (Ah).

1.3.11**cell**

basic functional unit that is a source of electric energy obtained by direct conversion of chemical energy

Note 1 to entry: This unit typically comprises an assembly of electrodes, electrolyte, container, terminals and usually separators.

1.3.12**charging**

operation during which a secondary cell or battery is supplied with electric energy from an external circuit which results in chemical changes within the cell and thus the storage of energy as chemical energy

1.3.13**c-rate**

reference current derived by dividing the manufacturers declared rated capacity (Ah) by the time (h) for which the rated capacity is declared

1.3.14**dedicated room**

room exclusively assigned for the use of equipment specified as part of the battery system, BSE or power system (including energy source connections)

1.3.15**discharging**

battery delivering current to an external circuit by the conversion of chemical energy to electric energy

1.3.16**device under test****DuT**

BSE which will be subjected to the tests outlined in this document

1.3.17**end user**

person(s) who will use the battery storage equipment once installed

1.3.18**energy**

scalar quantity which may be increased or decreased in a system when it receives or produces work, respectively

Note 1 to entry: The coherent SI unit of energy is joule.

1.3.19**hazard**

potential source of harm

1.3.20**lithium-ion technologies**

secondary battery technology containing a lithium salt electrolyte

Note 1 to entry: Different battery types may have different material compositions for each of the anode, cathode and electrolyte.

1.3.21**may**

indicates the existence of an option

1.3.22**nominal cell voltage** **V_n**

manufacturer's stated voltage between the terminals of an electrochemical cell

1.3.23**nominal system voltage** **V_{sys}**

manufacturer's stated voltage between the terminals of a battery

Note 1 to entry: This is calculated from the cell nominal voltage (V_n) and the number of cells in series (n) as follows —

$$V_{sys \text{ nominal}} = V_n \times n$$

1.3.24**partial state of charge operation**

operation whereby batteries do not typically cycle between full SOC and depletion and are then fully recharged

1.3.25**power conversion equipment****PCE**

electrical device converting and/or manipulating one kind of electrical power from a voltage or current source into another kind of electrical power with respect to voltage, current and/or frequency

Note 1 to entry: Examples include but are not limited to d.c./a.c., inverters, d.c./d.c. converters and charge controllers.

Note 2 to entry: Battery management systems are not considered to be PCEs for the purpose of this document.

1.3.26**pre-assembled battery system**

system comprising one or more cells, modules or battery systems, and/or auxiliary supporting equipment

Note 1 to entry: Depending on the type of technology, the battery system may include a battery management system. Pre-assembled battery systems may come in a dedicated battery system enclosure.

Note 2 to entry: Pre-assembled lithium-based battery systems that comprise pre-assembled battery system equipment that conforms to the Best Practice Guide — battery storage equipment — Electrical Safety Requirements and include a battery management system and a dedicated enclosure as integral parts of the equipment.

1.3.27**pre-assembled integrated BESS**

battery energy storage system equipment that is manufactured as a complete, pre-assembled integrated package

Note 1 to entry: The equipment is supplied in an enclosure with the PCE, battery system, battery management system, protection device and any other required components as determined by the equipment manufacturer.

Note 2 to entry: A pre-assembled BESS may be delivered in separate modular parts and assembled on site.

Note 3 to entry: Pre-assembled lithium-based battery energy storage system (BESS) equipment that conform to the Best Practice Guide — battery storage equipment — Electrical Safety Requirements are a pre-assembled integrated BESS when installed.

1.3.28

response time

difference between the time a specified change of the DuT is initiated and time the DUT reaches a steady-state value within the limits specified

1.3.29

shall

indicates that a statement is mandatory

1.3.30

should

indicates a recommendation

1.3.31

state of charge

SOC

charge available in a battery or battery system expressed as a percentage of the rated capacity of the battery or battery system

1.3.32

system integrator

person or entity which integrates various individual parts of battery storage equipment to form a single battery storage device

1.3.33

terminal

terminal post

part provided for the connection of a cell or a battery to external conductors

1.3.34

use-case

specific situation in which the BSE can be used with a specific type of electrical load profile dependent on the application

1.3.35

virtual power plant

VPP

group of distributed energy resources which combine to function as a dispatchable unit

Note 1 to entry: A virtual power plant may be used for the purpose of participating in the electricity market or aggregating ancillary services.

Note 2 to entry: The VPP definitions are defined by the Australian Energy Market Operator (AEMO) from “NEM Virtual Power Plant (VPP) Demonstrations Program”, July 2019 and “AEMO Virtual Power Plant Demonstration Knowledge Sharing Report #1”, March 2020.

1.3.36

warrantied

given rights through voluntary promise offered on a product

Note 1 to entry: Once the product has been purchased, the promise becomes a right that can be enforced under the Australian consumer law.

1.3.37

warrantied calendar life

lifetime in years of operation of the BSE which is warrantied by the manufacturer or retailer

1.3.37.1**personal use**

<warranties> for the purposes of meeting typical domestic load elements in a system with solar PV and storage

Note 1 to entry: The warranted calendar life value is to be based on the profile which is defined in [Clause 5.3](#) as the “Residential solar energy shift profile”.

1.3.37.2**personal use with VPP**

<warranties> for the purposes of meeting typical domestic load elements in a system with solar PV and storage as well as participation in a virtual power plant operation

Note 1 to entry: The warranted calendar life value is to be based on the profile which is defined in [Clause 5.4](#) as the “Virtual power plant (VPP) mode incorporating a solar energy shift profile”.

1.4 New designs and innovations

This document does not prevent the use of materials, methods of assembly, procedures and the like that do not conform with the specific requirements of this document, or are not mentioned in it, provided the minimum dimensional and performance requirements specified herein are met.

While best endeavours have been made to include all current and near operation chemistries and applications for domestic and small-scale commercial battery storage equipment coupled with a solar PV system in the Australian market context, future services will inevitably develop that may not be fully covered by the current version of the document. These may be addressed by future revisions.

Section 2 Parameter measurement and tolerances

2.1 Application

This section outlines the minimum accuracy requirements of instruments used in the testing of BSE to this document.

2.2 General

The instruments used during the test shall enable an accurate measurement of the relevant reportable parameters to be made. The test instruments used shall be chosen to fulfil the accuracy requirements outlined in the following sections. The required accuracy shall include all possible errors associated with the measurements, including accuracies of the measuring instruments, measuring methods and analysis, but excluding operator errors.

All test equipment for measuring AC voltage, current and impedance values shall be of the true RMS type.

2.3 Electrical measurements

2.3.1 Measurement accuracy

The electrical measurement and calculation accuracy shall conform to the requirements specified in Table 2.1.

Table 2.1 — Specification of measurement and calculation accuracy

Quantity	Measurement accuracy	Reference standard
Voltage	±1 %	IEC 62133-1 and IEC 62281
Current (AC and DC)	±1 %	IEC 62133-1 and IEC 62281
Power	±1 %	IEC 62133-1 and IEC 62281
Resistance	±1 %	
Energy	±1 %	
Capacity	±1 %	IEC 62133-1 and IEC 62133-2
NOTE For the purposes of AC measurement accuracy Vnom refers to 230 V of AS 60038.		

2.4 Temperature and humidity measurements

Temperature measurements shall have an absolute accuracy of at least 0.5 °C in accordance with AS 3731.2. For all test temperatures above 10 °C, the ambient relative humidity of the test environment shall have a measurement accuracy of ± 5 %.

2.5 Time measurements

2.5.1 Tolerances

Time measurements shall have an absolute accuracy of at least 0.1 % relative to the specified or actual measurement in accordance with IEC 62281.

2.5.2 Sampling periods

The sampling period shall be chosen appropriate to the resolution requirements of the performance metric being determined.

Section 3 General testing principles

3.1 Application

This section provides an overview of the tests required and specifies the general testing principles to be observed while performing the tests.

The tests have been designed to be applied to both Alternating Current (AC) and Direct Current (DC) BSE. For AC BSE this shall be the PCE output and for DC BSE this shall be the output of the BSE.

3.2 Conformance testing

3.2.1 General

To declare conformance to this document, suppliers of battery systems or system components shall state the performance of the system in accordance with the testing and reporting requirements outlined within this document.

To claim conformance to this document, all systems less test uncertainty shall meet or exceed the claimed performance.

3.2.2 Type testing

Type testing should be completed at least once for each variant or configuration of BSE by suppliers conforming to the ISO 9000 or ISO 14000 family of quality management systems.

For suppliers that do not have ISO 9000 certification, multiple systems should be tested. DC vs AC testing

For BSE without integrated PCE, testing at the DC output of the system is to be undertaken, with all pre-conditions as defined in [Section 3.5](#) fulfilled.

The tests defined herein have been designed such that they can be applied at the DC output of BSE without PCE, or at the AC point of coupling for systems with PCE of the battery energy storage equipment. Where appropriate and required, equations to determine the current or power required for both DC and AC systems can be found in [Sections B.1.1](#) and [B.1.3](#).

3.3 BSE temperature range

BSE installations shall meet the requirements of AS/NZS 5139. In accordance with this document, BSE shall not be installed in locations where the temperatures exceed the range of allowable temperatures as defined by the system manufacturer.

This document delineates temperature testing for BSE into two classes:

- (a) *Class A Temperature-controlled profile* — Class A applies to BSE intended only for locations where the ambient temperature remains in the range 25 ± 5 °C.
- (b) *Class B Standard temperature profile* — Class B applies to BSE intended for locations where ambient temperature can vary outside of the range of 25 ± 5 °C.

The testing requirements for both Class A and Class B BSE are described in more detail in [Section 5](#) and [Section 6](#).

3.4 Reporting of test results

This section provides an overview of the reporting of test results required to conform with this document.

[Table 3.1](#) provides a summary of the test reporting requirements according to the class and intended usage for required and optional profile tests.

Table 3.1 — Overview of test report requirements

	BSE type	BSE without VPP capability	BSE with VPP capability
Class A	Temperature controlled profile (25 °C ± 5 °C)	A	A
Class B	Standard Temperature profile (-1 °C to 41 °C)	B	B
Seasonal temperature profile	Extended temperature profile (Section 6.5)	B	B
	Solar energy shift profile	A/B	A/B
Accelerated testing temperature profile	VPP with solar shift profile	O	A/B
	Solar energy shift profile	O	O
If requested	VPP with solar shift profile	O	O
	Temperature rise test profile	O	O
Test reporting: A = Required for Class A, B = Required for Class B, O = Optional for Class A and B			

Class A BSE are required to report:

- (a) Performance metrics at 25 °C in the temperature-controlled profile ([Section 6.4](#)).
- (b) Solar energy shift profile ([Section 5.3](#))

BSE designated for operation outside of 25 °C (± 5 °C) shall follow Class B requirements for reporting.

Class B BSE are required to report:

- (i) Performance metrics at -1 °C and 41 °C in the standard temperature profile ([Section 6.4](#)).
- (ii) The extended temperature profile test ([Section 6.5](#)).
- (iii) Solar energy shift profile ([Section 5.3](#))

For BSE that is not designated for operation within a virtual power plant (VPP), the profile “Virtual power plant (VPP) mode incorporating a solar energy shift profile” within the seasonal and accelerated testing temperature profiles is not required to be tested ([Section 6](#)).

The temperature rise test is optional and intended for systems greater than 50 kW. This test is to be performed if requested by end users.

3.5 Test pre-conditions

The device under test (DuT) shall operate under the following conditions:

- (a) All programmable parameters within the BSE have their respective default values according to the manufacturers instructions for the BSE configuration under test.
- (b) All thermal management systems are enabled and operating in accordance with manufacture specifications.
- (c) All auxiliary systems as would be expected to be required under standard operating conditions are enabled.

- (d) If the BSE is designated for installation in a dedicated enclosure as defined by the manufacturer, the BSE including the enclosure is the device under test.
- (e) For AC BSE, the power factor set point shall be 1.0.

All reporting of performance metrics shall be inclusive of the impact of all thermal management system and auxiliary system loads, unless specified otherwise in the test protocol.

Section 4 Performance metrics to be tested

4.1 General

This section specifies the performance metrics that are to be measured and reported to achieve conformance to this document.

4.2 Application

The performance metrics outlined in this section shall be measured with reference to the measurement accuracies outlined in [Section 2](#), under the temperature profiles specified in [Section 6](#), and where the battery energy storage equipment is subject to the use case profiles defined in [Section 5](#).

An overview of when each performance metric is to be measured relative to the temperature and use case profile is detailed in [Section 7](#).

4.3 Parameters to be measured

The following parameters shall be directly measured during testing of each performance metric, with a minimum accuracy as outlined in [Section 2](#):

- (a) Voltage (both AC and DC).
- (b) Current (both AC and DC).
- (c) *For maximum power and sustained power test* — Internal resistance, both for charge and discharge conditions.
- (d) Ambient temperature within the test chamber. The test chamber shall be able to measure and control the ambient temperature to the required set point and be able to maintain that ambient temperature given the heat output of the DuT.
- (e) Ambient humidity within the test chamber.
- (f) Time.

4.4 Performance metrics

4.4.1 General

The following sections provide a description of each of the performance metrics to be determined under this document. Details on how to derive these performance metrics are provided in [Appendix A](#).

4.4.2 Maximum power (kW)

This is defined as the maximum power delivered or absorbed by the battery storage equipment over a 10 s period under the relevant environmental test conditions. It is to be determined for both charge and discharge power. The power determined through this testing shall include any derating effects due to system design or hardware components. Details on how to derive these performance metrics are provided in [A.1](#).

4.4.3 Sustained power (kW)

This is the useable power output of the battery storage equipment under specific operating conditions. The sustained power is dependent on the operating conditions. The sustained power shall be measured and reported for durations of both 2 min and 30 min. The power determined through this testing shall include any derating effects due to system design or hardware components.

4.4.4 Energy (kWh)

Energy is defined as the amount of energy storage capacity of the battery storage equipment in kilowatt hours (kWh) at a stated discharge rate. For the purposes of this document, specified currents or rates will be defined for different applications in the following sections. The energy shall be calculated via the multiplication of the current capacity (4.4.4) with the nominal system voltage. Alternatively, the system energy shall be determined via the multiplication of the current and voltage for each sampling period throughout a testing step and then normalized to a 1-h time period.

4.4.5 Capacity (Ah)

Capacity is defined as the amount of charge that can be withdrawn from fully charged battery storage equipment in Ampere-Hours (Ah) at a constant current rate within the allowable Voltage limits (see 4.4.6). For the purposes of this document, specified currents or rates will be defined for different applications in the following sections.

4.4.6 Voltage limits (DC operating voltage window) (V)

4.4.6.1 General

The voltage limits, also known as the operating voltage window, define the voltage range in Volts of the battery storage equipment at the DC connection point. The limit specified by the manufacturer shall be the maximum limit at which the BSE shall be operated. The minimum limit is the lowest voltage the BSE can sustain as specified by the manufacturer. Notably, under certain circumstances, these limits may be more restrictive than the limits the battery chemistry is capable of operating between. Typically, such restrictions are managed by the auxiliary components of the BSE, such as BMS, EMS, PCE or other limitations imposed by the manufacturer.

This performance metric is not directly measured under this standard but shall be the value reported by the manufacturer in accordance with the requirements in Clause A.3 and Section 8.

4.4.6.2 Open circuit voltage (OCV) (V)

The nominal system voltage measured at open circuit on fully charged battery storage equipment at the DC connection point.

4.4.7 Maximum current (A)

The maximum current limit is defined as the highest current at which the BSE can be safely operated as defined by the manufacturer. The maximum allowable current is set by the auxiliary components of the BSE such as BMS, EMS, PCE or other limitations imposed by the manufacturer. The operating current range is defined as the current in Amperes of the BSE at the DC connection point or the AC connection point for BSE with PCE under normal operating conditions (not fault conditions). The maximum allowable current shall include any reductions due to internal battery resistance or hardware limitations.

This performance metric is not directly measured under this document but shall be the manufacturer stated value reported in accordance with the requirements in Clause A.4 and Section 8.

4.4.8 Discharge and charge rate range allowed (C-rate)

The discharge and charge rates under which the BSE can operate is called the C-rate. The charge rate is expressed as the reference current $I_t = C_r/n$ where C_r is the rated capacity declared by the manufacturer and n is the time base in hours for which the rated capacity is declared. It is alternatively written as x C, where the inverse of x represents the time base. E.g. 0.2C represents a 5 h discharge time ($1/0.2 = 5$ h) as does C5 or C₅, while 5C represents a 12 min discharge time ($1/5 = 0.2$ h).

The “C-rate” is the constant value of current (A) that is drawn from the battery during the determination of C. The manufacturer of BSE shall report the allowable minimum and maximum C-rate for the system.

C-rate shall be reported as xC (where x is defined as 0.1C, 0.2C, 1, 10C, etc., as appropriate for the BSE). In the event that a battery system requires a variable rate during the charge or discharge process due to cell balancing, equalization or for any other reason, then the average discharge rate should be stated with a clear indication that this may vary during actual system operation. Where a battery system C-rate is limited or de-rated due to BMS, EMS, PCE or under limitations imposed by the manufacturer, the de-rated C-rate shall be reported.

This performance metric is not directly measured under this document, but is a manufacturer stated value that is to be reported in accordance with the requirements in Clause [A.5](#) and [Section 8](#).

4.4.9 Round trip efficiency (%)

Round-trip efficiency represents the fraction of energy put into a BSE that can be retrieved and is given as a percentage value:

- (a) DC-to-storage-to-DC energy efficiency.
- (b) AC-to-storage-to-AC energy efficiency, including the BSE.

Both Energy and Coulombic (DC BSE only) efficiency shall be calculated based on the manufacturer’s maximum ratings as follows —

$$\text{Energy efficiency \%} = \frac{0.2C \text{ discharge energy output [Wh]}}{0.2C \text{ charge energy input [Wh]}} \times 100$$

$$\text{Coulombic efficiency \%} = \frac{0.2C \text{ discharge capacity output [Wh]}}{0.2C \text{ discharge energy input [Ah]}} \times 100$$

Where the BSE configuration is DC to storage to AC, the BSE shall be considered as an AC type and tested as per (b) above.

4.4.10 Cycle number

The cycle number is a measure of how many cycles a battery storage equipment is anticipated to achieve throughout its warrantied life. Critical to cycle lifetime is the choice of duty cycle (that is charge and discharge rates) since the duty cycle will strongly affect the number of cycles available. Standardised duty cycles for use cases (i.e. Residential solar energy shift profile and virtual power plant (VPP) mode incorporating a solar energy shift profile) are stated in this document and are defined to enable standardised reporting.

4.4.11 Response time (ms)

The response time of the BSE is the time taken to deliver the power or energy requested upon receiving an external command, and shall be the duration between the instant of initiating a change and that when the BSE attains a steady-state within $\pm 5\%$ of the required change.

This performance metric is not directly measured under this document, but is a manufacturer stated value that is to be reported in accordance with the requirements in Clause [A.7](#) and [Section 8](#).

4.4.12 State of charge window (%)

State of charge (SoC) window is the range of charge levels within which the BSE can be operated. The maximum SoC of 100 % refers to a fully charged battery and the SoC of 0 % refers to a fully discharged battery.

It should be noted that the SoC range is always in the 0-100 % range, irrespective of a new BSE with full capacity or aged BSE. The optimal or working SoC range for a BSE shall be defined and stated by the manufacturer.

This performance metric is not directly measured under this document, but is a manufacturer stated value that is to be reported in accordance with the requirements in Clause [A.8](#) and [Section 8](#).

4.4.13 Energy throughput

Energy throughput is the total amount of energy a BSE can be expected to deliver over the warrantied period.

4.4.14 Surface touch temperature

The surface touch temperature shall not exceed the limits in accordance with AS/NZS 3100.

Section 5 BSE use case profiles

5.1 Application

This section specifies the applications (use-cases) applicable to solar PV connected residential/small-scale commercial BSE for which several performance metrics shall be tested. Two specific use-case profiles shall be used to determine the various metrics related to BSE performance in this document, which are defined following.

[Section 7](#) provides further detail on the specific performance metric to be measured under each use case, as well as the required test sequences.

5.2 General

Some performance metrics of a BSE are highly dependent on the charge/discharge cycles to which it is subject to. Two battery use case profiles are defined in this document which represent those that a BSE connected to a typical Australian residential household may experience —

- (a) residential solar energy shift profile; and
- (b) virtual power plant (VPP) mode incorporating a solar energy shift profile.

Both profiles define a standard daily cycle for the purposes of this document, averaged over regions and seasons.

Each profile has been normalized, and should be scaled for the size of the device under test (DuT) as defined in [Appendix B](#).

5.3 Residential solar energy shift profile

5.3.1 Aim

The aim of this profile is to determine values for particular performance metrics when the BSE is subject to a standardised daily charge/discharge cycle under cyclical temperature conditions. The solar energy shift profile is assumed to be invariant with season but shall be used in conjunction with the seasonal temperature profile and the (optional) accelerated testing temperature profile.

5.3.2 Application

This profile is to be tested for all BSE for which conformance to this document is claimed.

5.3.3 Description

The BSE is assumed to generally store the energy generated by solar PV during the day and discharge the stored energy during the demand period in the evening.

The profile defined in this section forms the basis of a single daily net energy use cycle of the average Australian household with connected solar PV.

NOTE The single daily net energy use cycle is the sum of the energy generated minus the domestic consumption of a typical Australian household with PV.

The use case profile under which the relevant performance metrics of BSE are to be determined is provided in the following sections. Detailed information on the profile can be found in [Appendix B](#).

5.3.4 Overview

A pictorial representation of the residential solar energy shift profile is provided in [Figure 5.1](#) for energy content of AC BSE and [Figure 5.2](#) for the capacity of DC BSE.

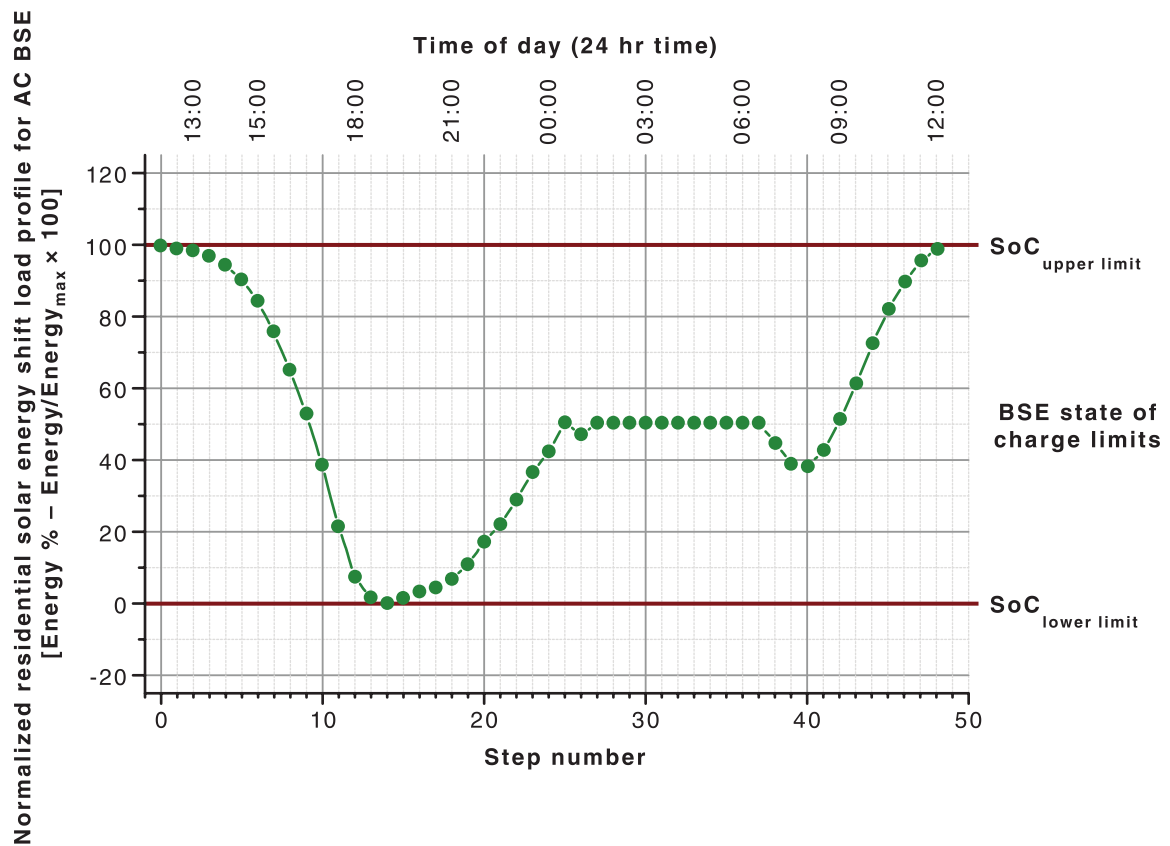


Figure 5.1 — Normalized residential solar energy shift profile for AC BSE

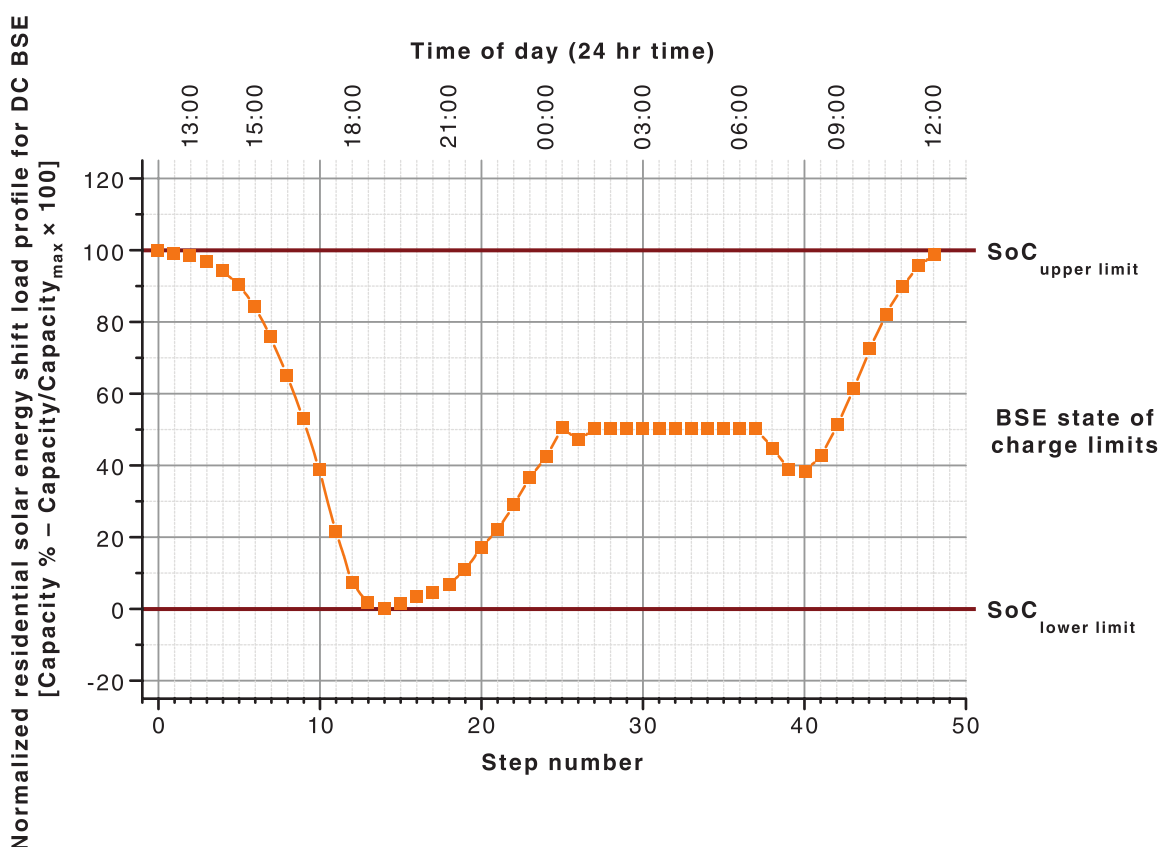


Figure 5.2 — Normalized residential solar energy shift profile for DC BSE

NOTE The left y-axis represents the percentage of the defined partial state of charge (PSoC) range. E.g. For BSE with a PSoC of 80 %–25 %, 100 % on the plot represents 80 % of actual SoC, while 0 % on the plot represents 25 % of SoC for that particular BSE.

5.3.5 Test properties

5.3.5.1 Number of test cycles

The DuT shall be subjected to no less than 5 cycles of the residential solar energy shift profile and average overall performance metrics shall be reported.

5.3.5.2 Performance metrics to be measured

In accordance with the test details outlined in [Appendix B](#) and [Appendix C](#), for each test cycle, the following parameters shall be determined using measurement equipment conforming to the requirements ([Section 2](#)):

- Discharge capacity (Ah).
- Charge capacity (Ah).
- Discharge energy (kWh).
- Charge energy (kWh).
- Sustained power (kW).
- Coulombic efficiency for DC BSE only (%).

- (g) Round trip efficiency (%).

5.3.5.3 Performance metrics to be reported

The arithmetic average of all cycles tested (a minimum of five [5] shall be undertaken) of the parameters outlined in [Clause 5.3.5.2](#) shall be calculated and reported in accordance with the requirements defined in [Section 8](#) and [Appendix B](#). These are to be reported together with several manufacturer stated values as described following —

- (a) DC BSE without PCE —
 - (i) DC 24h discharge capacity (Ah).
 - (ii) DC 24h useable discharge energy (kWh).
 - (iii) DC 24h 2 min and 30-min sustained power (kW).
 - (iv) DC 24h coulombic efficiency (%) (calculated as defined in [Clause 4.4.8](#)).
- (b) AC BSE with PCE —
 - (i) AC 24h discharge capacity (Ah).
 - (ii) AC 24h useable discharge energy (kWh).
 - (iii) AC 24h 2 min and 30-min sustained power (kW).
 - (iv) AC 24h round trip efficiency (%) (calculated as defined in [Clause 4.4.8](#)).

5.4 Virtual power plant (VPP) mode incorporating a solar energy shift profile

5.4.1 Aim

The aim of this profile is to determine average values for particular performance metrics when the BSE is subject to a virtual power plant operation incorporating a standardised daily charge/discharge cycle under cyclical temperature conditions. The VPP mode incorporating a solar energy shift profile shall be used in conjunction with the seasonal temperature profile and the (optional) accelerated testing temperature profile.

5.4.2 Application

This profile is for BSE wishing to claim conformance to this document for virtual power plant operation. For systems not designated for use with VPPs, conformance to this profile is optional.

5.4.3 Description

The BSE is assumed to generally store the energy generated by solar PV during the day and discharge the stored energy during the peak demand period in the evening. When the BSE is not performing this duty, it is expected to discharge during periods of high market spot prices in the morning and late afternoon/early evening periods. This additional discharge load is assumed to be replenished with a charge sourced from the external grid during the overnight period when there is no solar PV input, and the market spot prices are low.

The profile defined in this section forms the basis of a single daily net energy use cycle of the average Australian household with connected solar PV and operating as part of a VPP participating in the spot price arbitrage market.

An overview of the BSE use case profile and the relevant performance metrics that are to be determined is provided in the following sections. Detailed information on the profile can be found in [Appendix B](#).

5.4.4 Overview

A pictorial representation of the residential VPP mode incorporating a solar energy shift load profile is provided in [Figure 5.3](#) for energy content of AC BSE and [Figure 5.4](#) for energy content of DC BSE.

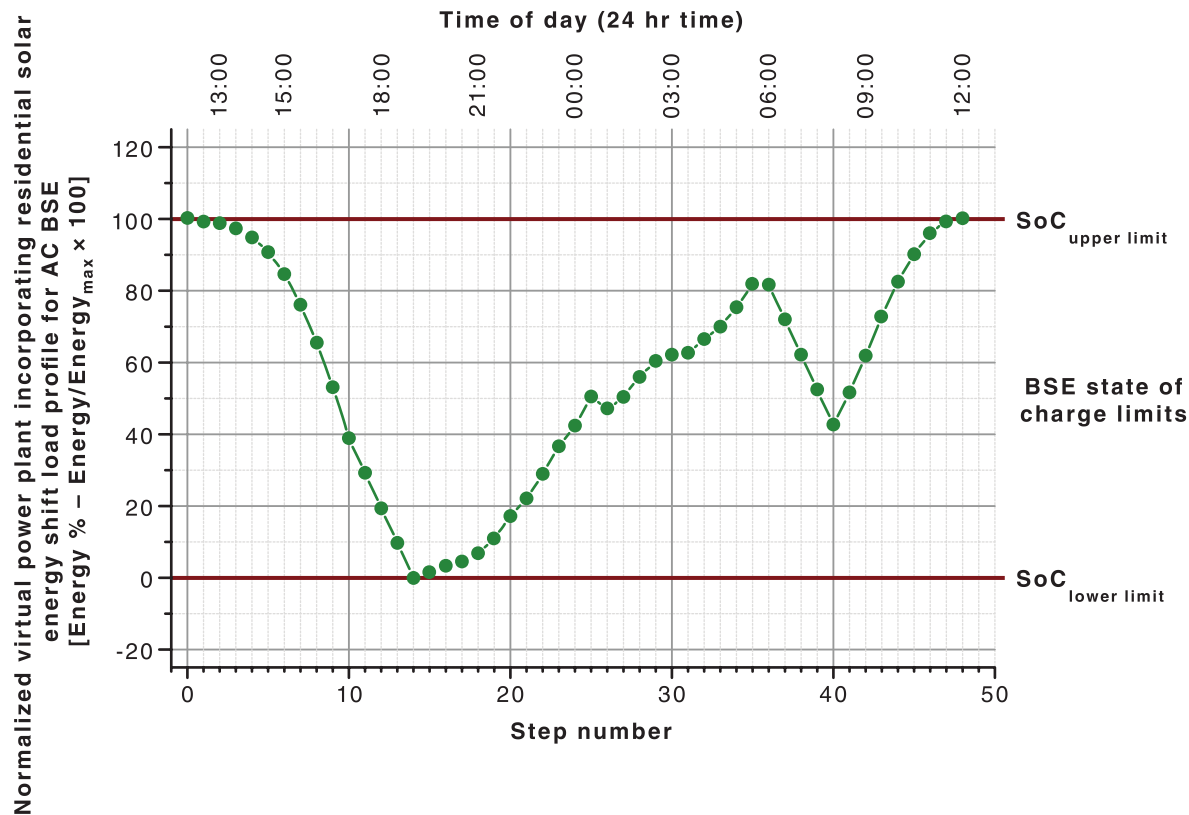


Figure 5.3 — Normalized virtual power plant incorporating residential solar energy shift profile at AC for BSE