ENERGY

Australian Battery Performance Standard

Draft Standard and Industry Best Practice Guide

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12 December 2019

Project aim

- To produce a draft Performance Standard (Draft Standard), for Battery Storage Equipment (BSE) connected to domestic/small commercial PV systems

- The Draft Standard will comprise of a series of performance testing protocols & reporting methods for manufacturers and system integrators of battery storage equipment.

- This allows end-users to compare systems on a like-for-like basis, and will provide more relevant information regarding the expected performance of BSE for specific use-cases

Note

- This document is a draft to enable the project Consortium to get feedback from Industry and Stakeholders to assist with the drafting process

- What will be presented are our current thoughts – this will be further refined over the next 6 months

Draft Standard

- Layout:
  - First few sections contain general info
  - Later sections provide logic and overview of the:
    - Performance metrics
    - BSE use cases
    - Environmental profiles
  - Appendices proved the detailed steps to undertake each test
  - Two informative appendices included which will provide insight into the development of:
    - Temperature zones
    - BSE use cases

Draft Standard: Sections

- Section 1 Scope and general
- Section 2 Parameter measurement and tolerances
- Section 3 Performance metrics to be tested
- Section 4 BSE use cases
- Section 5 Test environmental conditions
- Section 6 General testing principles
- Section 7 Specific requirements and test methods
- Section 8 BSE performance reporting principles and requirements

Draft Standard: Appendices

- Appendix A Performance Metrics
- Appendix B BSE Use Case Profiles
- Appendix C Environmental Profiles
- Appendix D Manufacturer Data Sheet Recommendations
- Appendix E (informative) Development of temperature zones
- Appendix F (informative) Development of BSE use cases

Section 3: Performance metrics to be tested

- This section will provide an overview
- Test details and procedure will be in the appendix.
- Example:

Section 3

3.4.1 Maximum Power (kW)

"This is defined as the maximum power delivered or absorbed by the battery storage equipment over 10s under the relevant environmental test conditions. It is to be determined for both charge and discharge power."

Appendix A: Performance metrics

Appendix A.1 Maximum Power (kW)

"This is defined as the maximum power of the BSE over 10s under the environmental test conditions. It is to be determined for both charge and discharge power.

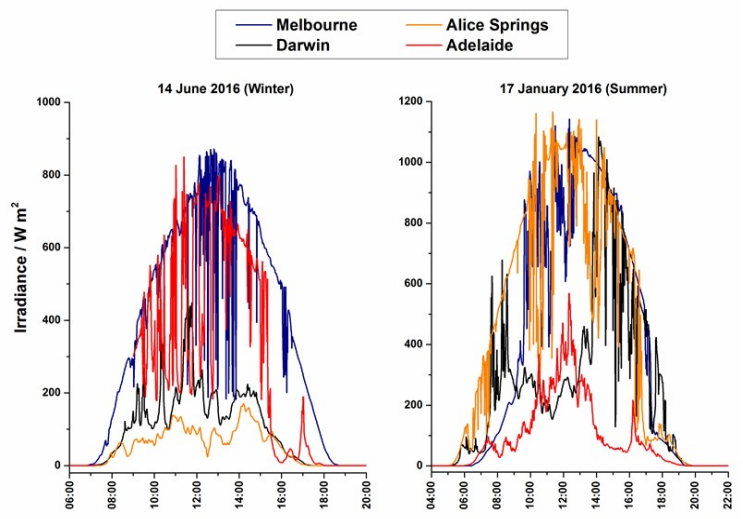
The power of a BSE shall be determined through the use of a series of high-rate pulse discharges and charges. The current employed in each case is either that stated by the manufacturer for determining power output, or it is the C_1 current.

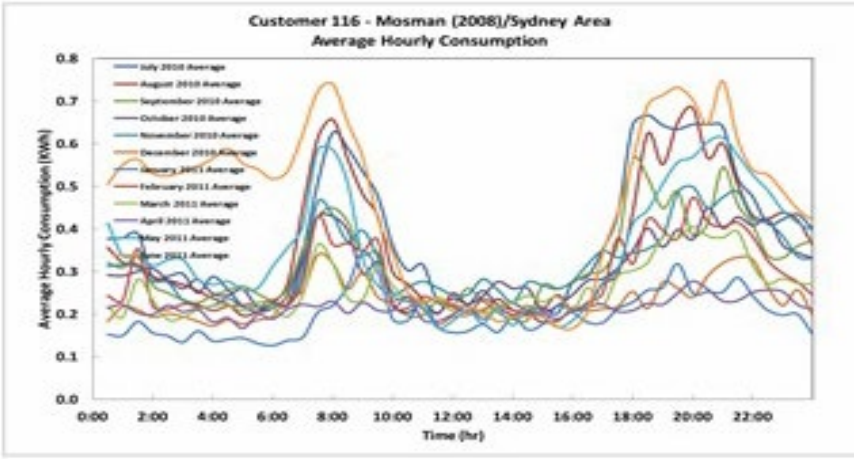
The test is applicable for either DC or AC systems."

Step number	Power Profile Procedure
1	Fully charge battery as per manufacturer specifications and allow to rest at open circuit voltage for 1 hour.
2	Discharge 10% state of charge at maximum rate stated by manufacturer
3	Rest for 1 hour
4	Discharge for 10s
5	Rest for 40s
6	Charge for 10s
7	Rest for 40s
8	Repeat steps 2 to 7, discharging by 10% state of charge each time, until 10% state of charge is reached
9	Fully charge the battery as per manufacturer specifications and allow to rest at open circuit voltage for 1 hour. This completes the power test and leaves the battery ready for the next testing as required.
10	Determine values of charging and discharging power at each step by calculating from the voltage drop that occurs during the current pulse. Power available for charging and discharging is calculated using: Charge Power: $P = \frac{V_{pulse}(V_{pulse}-V_{OC})}{R^{ch}}$ Discharge Power: $P = \frac{V_{pulse}(V_{OC}-V_{pulse})}{R^{dch}}$ where V_{pulse} is the voltage at the end of the pulse, V_{OC} is the open circuit voltage and R^{dch} is the discharging and R^{ch} is the charging resistance.
11	Record power at 90, 80, 70, 60, 50, 40, 30, 20 and 10% state of charge

Section 4: BSE use case profiles

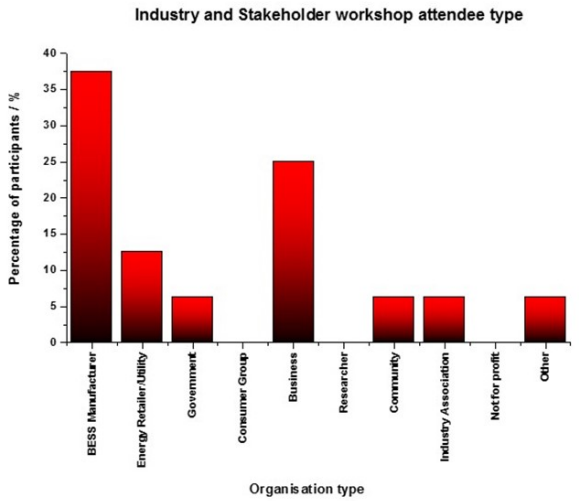
- Testing profile development
- Identify different applications in residential to light commercial space
- Use real life data (where available) to develop a simulated "application cycle"
- Identify performance metrics applicable to these cycles, for example:
  - Cycle life (charge/discharge based)
  - Energy throughput
  - Power
  - Depth of Discharge range
  - Temperature range
  - Etc.
- Propose performance metrics for each drive cycle/application
- Evaluate battery and ensure metrics are suitable for use

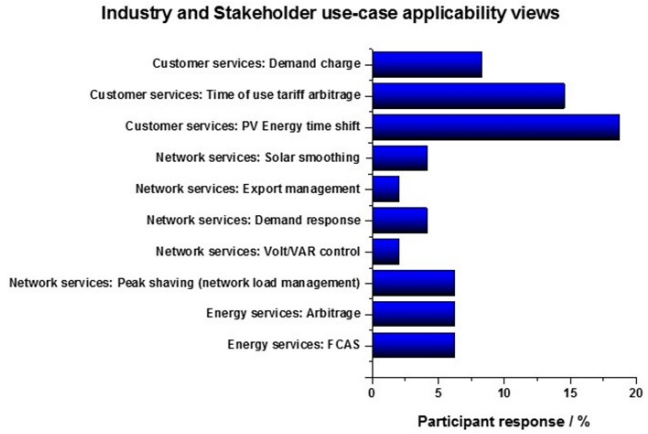




Section 4: BSE use case profiles

- Numerous potential applications of BESS in PV and grid connect modes
- Each application has different performance requirements
- Each application will use battery differently
- Survey of industry identified industry only wants 2 use cases for Performance Standard:
  - 1. Residential solar shift
  - 2. VPP profile





Section 4: BSE use case profiles

4.3 Solar energy shift load profile

4.3.1 Aim

The aim of this profile is to determine average values for particular performance metrics when the BSE is subject to a standardised daily charge / discharge cycle.

4.3.2 Description

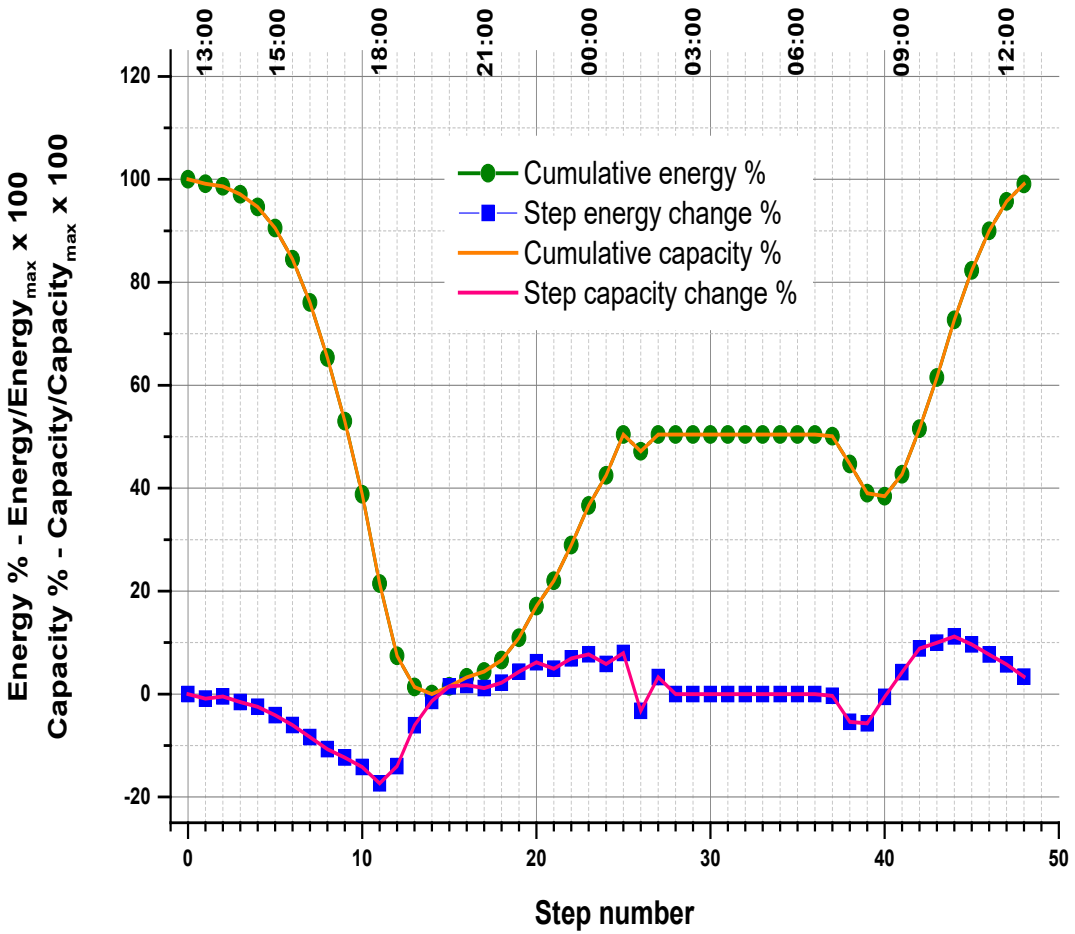
The BSE is to store the energy generated by solar PV during the day and discharge the stored energy during the peak demand period in the evening.

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

Each of the BSE use case profiles under which the relevant performance metrics are to be determined is provided in the following sections. Detailed information on each profile can be found in Appendix B.

4.3.3 Overview

A pictorial representation of the residential solar energy shift load profile is provided in the figure.



Appendix B: BSE use case profiles

B.1 Residential solar energy shift load profile

The table provides stepwise details of the electrical load profile. The profile is constructed… [description]

Equation 1: DC Mode…
Equation 2: AC Mode…

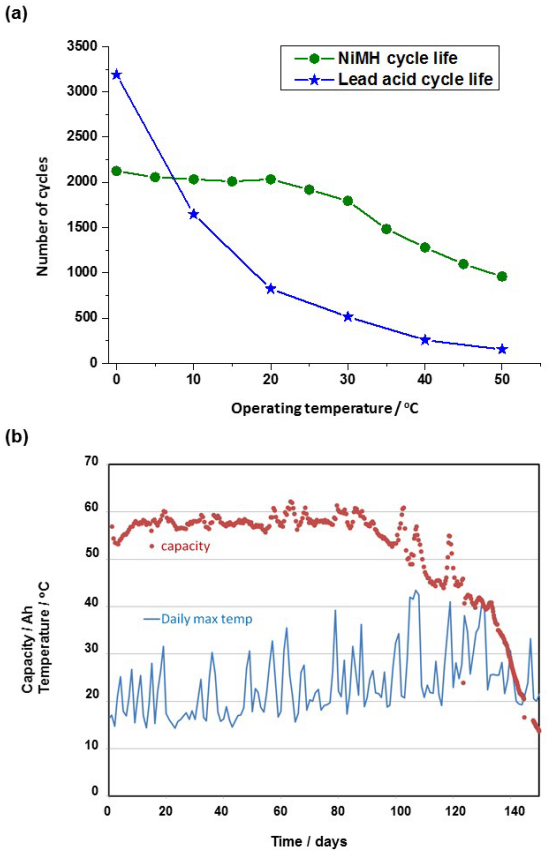
Where 0 < Partial State of Charge window (PSoC) < 1.

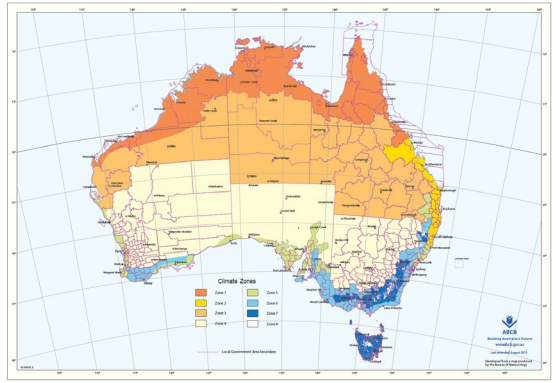
For an 80 to 25% SoC range PSoC window is 80% – 25% = 0.55

Step	Cumulative Capacity %	Step Capacity %	DC profile
1			Fully charge battery as per manufacturer specifications
2			Rest BESS for 30 minutes at open circuit voltage
3			Discharge battery to 80% state of charge as per manufacturer specifications or C3 current rate.
4			Rest battery for 5 minutes at open circuit voltage
5	99.1	-0.9	Discharge battery for 30mins using calculated current
6	98.6	-0.5	Discharge battery for 30mins using calculated current
7	97.1	-1.6	Discharge battery for 30mins using calculated current
8	94.6	-2.5	Discharge battery for 30mins using calculated current
9	90.5	-4.1	Discharge battery for 30mins using calculated current
10	84.5	-6.0	Discharge battery for 30mins using calculated current
11	76.1	-8.4	Discharge battery for 30mins using calculated current
12	…	…	…

Section 5: Test environmental conditions

- The Standard has to cover the entire range of environmental conditions in Australia
- There are 8 different climate zones in Australia
- Each has its own temperature and environmental conditions
- Temperature significantly affects battery performance and lifetimes
- To identify Australian environmental conditions:
  - Analyse historical environment data
  - 109 weather stations from Jan 1910 to Dec 2018
  - Cover all population centres at present and potential future areas





Section 5: Test environmental conditions

5.2 Extreme temperature profile

5.2.1 Aim

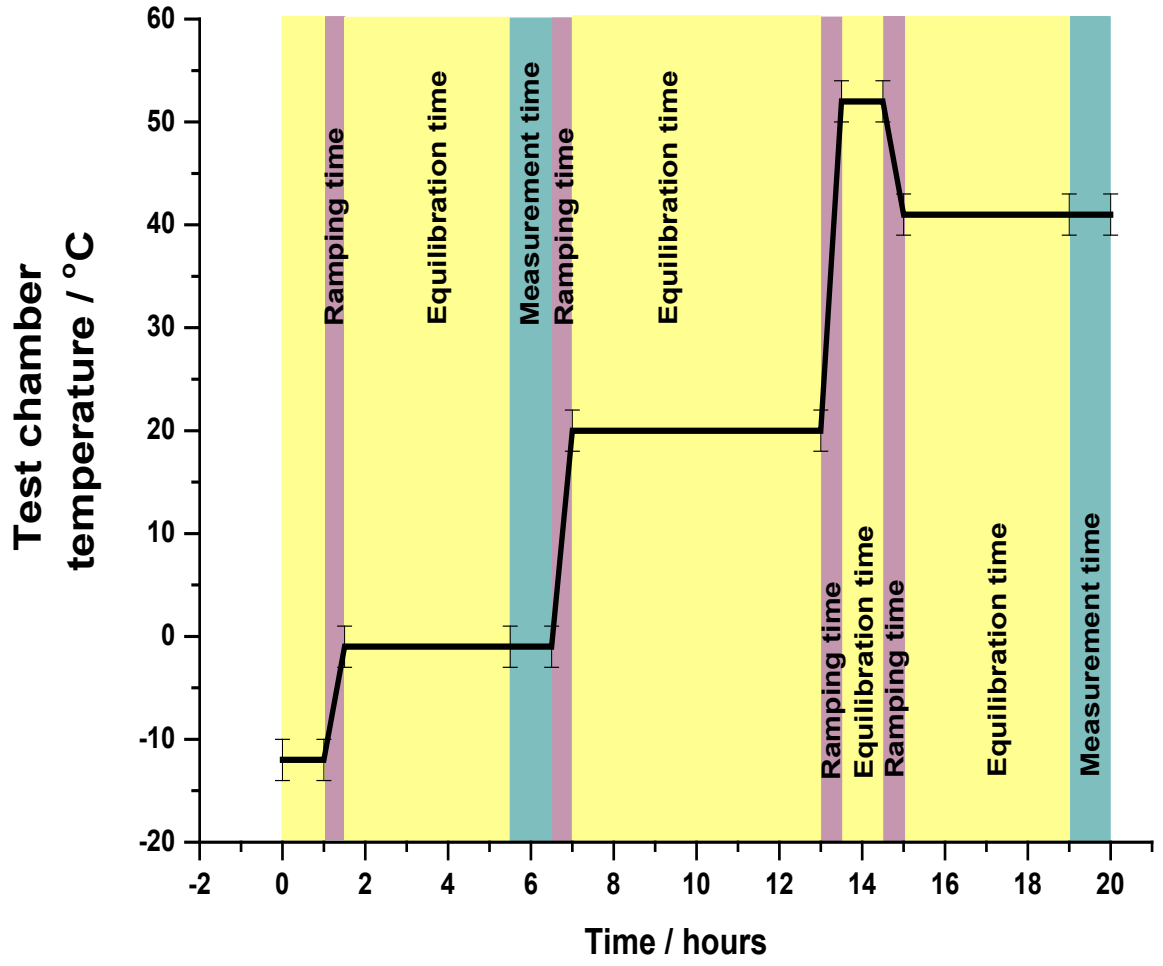
This aim of this profile is to verify that the DuT can withstand these extreme temperatures for short durations without suffering damage. It is not expected that the device operates at these temperatures.

5.2.2 Description

This temperature profile ranges from a low extreme value of -12 ±2°C to a high extreme value of 52 ±2°C. At these temperatures, the battery is not expected to charge or discharge, however after returning to within the standard temperature range, several performance metrics are to be determined.

5.2.3 Overview

A pictorial representation of the extreme temperature profile can be seen in the following figure.



Appendix C: Environmental profiles

C.1 Extreme temperature profile

The following test profile is to be repeated five (5) times. On completion of all tests, the average of the performance metrics measured for each test shall be reported.

Step	Description	Ambient temperature	Ambient humidity	Step time (hh:mm)	Performance metric to be measured
1	Place battery in test chamber	-12 ± 2°C	-	00:00	-
2	Hold battery at temperature	-12 ± 2°C	-	01:00	-
3	Linearly increase test chamber temperature	-1 ± 2°C	-	00:30	-
4	Equilibrate battery, perform relevant tests	-1 ± 2°C	-	04:00	Maximum Power (kW), Sustained Power (kW), Energy (kWh), Capacity (Ah)
5	Linearly increase test chamber temperature	20-25 ± 2°C	55 ± 5%	00:30	-
6	Equilibrate battery	20-25 ± 2°C	55 ± 5%	06:00	-
7	Linearly increase test chamber temperature	52 ± 2°C	55 ± 5%	00:30	-
8	Hold battery at temperature	52 ± 2°C	55 ± 5%	01:00	-
9	Linearly decrease test chamber temperature	41 ± 2°C	55 ± 5%	00:30	-
10	Equilibrate battery, perform relevant tests	41 ± 2°C	55 ± 5%	04:00	Maximum Power (kW), Sustained Power (kW), Energy (kWh), Capacity (Ah)
11	Repeat steps 1 – 10 for a total of 5 replicate tests. Determine average values of Maximum Power (kW), Sustained Power (kW), Energy (kWh), Capacity (Ah) and report				

Section 6: General testing principles

	Standard temperature profile	Extreme temperature profile	Seasonal temperature profile		Accelerated testing temperature profile	
			Solar energy shift profile	VPP with solar shift profile	Solar energy shift profile	VPP with solar shift profile
Maximum power test	X	X				
Sustained power test (2 min)	X					
Sustained power test (30 min)	X		X	X		
Discharge rate (C-rate)	X	X				
Discharge capacity	X	X	X	X		
Discharge energy	X	X	X	X		
Charge capacity			X	X		
Charge energy			X	X		
Round trip efficiency	X		X	X		
Voltage limits	X					
Maximum current	X					
Cycle number					X	X
Response time	X					

Appendix D: Manufacturer data sheet recommendations [Draft concept]

[State DC or AC] testing results - Manufacturer declared values																			
Residential Solar Shift performance (please provide an additional and separate table for VPP solar shift performance if required)																			
	Maximum range	Extreme temperature range Region A					Region B				Region C				Region D				Accelerated testing
Declared characteristics			Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	—
10s Maximum Power (kW) @ DoD%	kW to kW	kW to kW	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 min Sustained Power (kW) @DoD	kW to kW	kW to kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	—
30 min Sustained Power (kW) @ DoD	kW to kW	kW to kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	—
Useable C_5 Energy (kWh) and current used to determine	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	kWh and A	—
C_5 Capacity (Ah) and current used to determine capacity	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	Ah and A	—

Appendix D: Manufacturer data sheet recommendations [Draft concept]

[State DC or AC] testing results - Manufacturer declared values																					
Residential Solar Shift performance (please provide an additional and separate table for VPP solar shift performance if required)																					
	Maximum range	Extreme temperature range	Region A				Region B				Region C				Region D				Accelerated testing		
Minimum useable Voltage limit (V)	Vdc	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Maximum useable voltage limit (V)	Vdc																				
Maximum useable Current (A)	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
limitations																					
maximum useable discharge rate (C-rate)	c-rate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
limitations																					
Minimum useable discharge rate	c-rate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
DC coulombic efficiency (%)	% to %	—	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	—		
AC energy efficiency	% to %	—	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%			
AC coulombic efficiency	% to %	—	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%			
Cycle number	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	value		
Response time (s)	ms to ms	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		

Best practice guide

- To recap
  - Best practice guide will be released to the public at the same time that draft standard is submitted to SA
  - Intended to allow familiarisation and early adoption until official Standard is released

- The layout
  - Contains same information as standard
  - Also contains extra information about why / how & guidance
  - Most of the detailed information moved to the Appendix (relative to the Standard)

Industry best practise guide

- Part 1 Introduction
- Part 2 Using This Guide and Claiming Compliance
- Part 3 Definition of PV Connected Battery Storage Equipment for Residential to Small-Scale Commercial Applications
- Part 4 BSE Terms and Definitions
- Part 5 General Testing Principles
- Part 6 Operational Environmental Conditions
- Part 7 BSE Performance Reporting Principles and Requirements
- Part 8 Checklist of Information
- Appendix A General Terms & Definitions
- Appendix B Parameter Measurement and Tolerances
- Appendix C Performance Metrics Definitions
- Appendix D BSE Profiles
- Appendix E Test Environmental Conditions

Thank you for listening

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