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Specification – LV connected Energy Storage Systems (ESS)

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* Shall be the Process Owner and is the person assigned authority and responsibility for managing the whole process, end-to-end, which may extend across more than one division and/or functions, in order to deliver agreed business results.

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1	04/05/22	Updated to apply to all Energy Storage Mediums, updated OT requirements, updated Commissioning requirements and Appendix A4 Technical Rules Compliance Tests

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1 INTRODUCTION AND SCOPE

1.1 Scope of this Document

This specification defines the minimum requirements for an Energy Storage System (ESS) Package which has Low Voltage (LV) primary output and is to be connected to a Horizon Power (HP) network or power station. This specification is relevant to the following ESS Packages:

- 1) The Energy Storage System which is comprised of:
 - A Battery System or Energy Storage Medium.
 - Power Conversion Equipment (PCE).
 - ESS Enclosures.
 - ESS Controller.
 - All other equipment specific to the ESS.
- 2) Low Voltage (LV) Connection Board.
- 3) Civil and structural works.
- 4) OT Network and SCADA works.
- 5) Testing and Commissioning

This specification shall be read in conjunction with the Scope of Works, which defines the Project specific requirements that are not contained within this document.

Project specific requirements shall **only supersede** the requirements of this specification when those requirements exceed the minimum set forth in this document.

1.2 Scope Boundary Limits and Interfaces

The ESS Package shall include all equipment and services within the specified Scope boundary limits in Table 1, including the interface and Connection Points at the boundary limits required to connect the ESS Package to existing Horizon Power infrastructure.

Table 1: Scope boundary limits

Scope	Requirement
Civil	
Equipment footings and hardstand	All required footings, hardstands, excavations and earthworks for the ESS Package shall be included.
Buried Services	All buried services required for the ESS Package shall be included. Buried services associated with the connection of the ESS Package to the network are not included.

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Electrical	
ESS Package Connection Point	All equipment up to the Connection Point is included within the ESS Package.
Earthing	A buried copper earth system in the immediate vicinity of the ESS Package is included.
Fire Detection and Protection	The supply, installation and commissioning of all required fire detection, protection and suppression is included.
Protection and interlocking	The supply and installation of all protection equipment is included. Final settings of protection equipment are to be performed by others.
Metering	The supply and installation of all metering equipment and cabling is included, noting that some equipment shall be supplied by Horizon Power as per Section 1.3.
Instrumentation, Control, Communications and SCADA	
Hardware and Physical Connections:	The supply and installation of all instrumentation, control equipment, communication equipment, and cabling shall be included, noting that some equipment shall be supplied by Horizon Power as per Section 1.3.
Network interface	The configuration of the ESS Controller to interface with the MGC, Network Switch, RTU, and/or Horizon Power SCADA network is included. Configuration of the MGC, Network Switch, RTU, and Horizon Power SCADA is to be carried out by others.

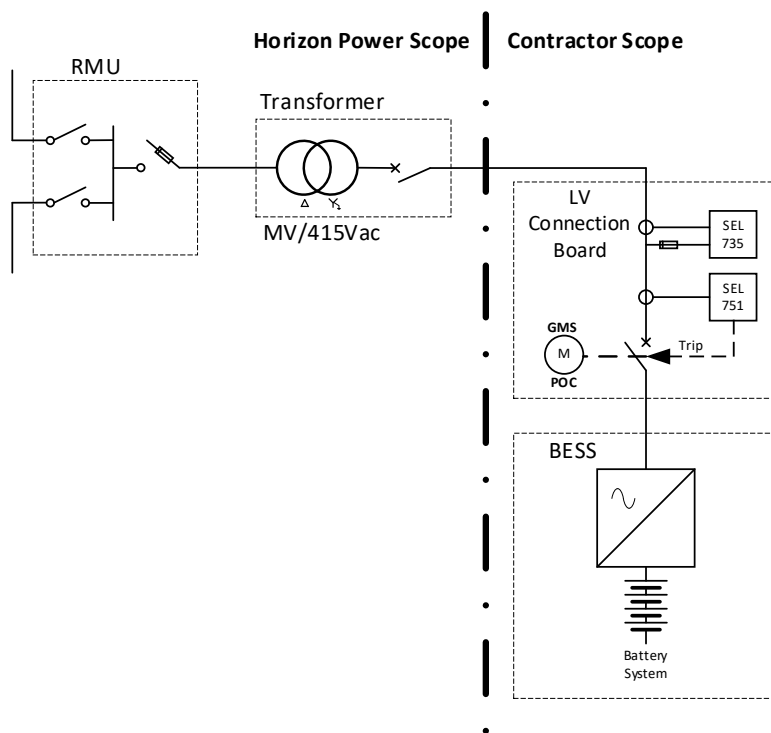


Figure 1: Boundary Limits

1.3 Free Issued Materials

1.3.1 Tariff and Non-Tariff Meter

A SEL-735 meter shall be free issued by Horizon Power, to be installed in the LV Connection Board as a part of the tariff class metering system.

1.3.2 MGC

If the ESS is to be controlled by a Microgrid Controller (MGC), an MGC from the latest approved version of the *HPC-9NC-21-0008-2020 OT Standard Equipment List* shall be free issued by Horizon Power for installation in the System Control and Data Acquisition (SCADA)/control enclosure within the LV Connection Board.

1.3.3 Network Switch

A network switch from the latest approved version of the *HPC-9NC-21-0008-2020 OT Standard Equipment List* shall be free-issued by Horizon Power for installation in the SCADA/control cubicle within the LV Connection Board.

1.3.4 Fibre Media Converter

If the ESS is to be connected to any existing fibre-optic network on-site, a fibre media converter from the latest approved version of the *HPC-9NC-21-0008-2020 OT Standard Equipment List* shall be free-issued by Horizon Power for installation in the SCADA/control cubicle within the LV Connection Board.

1.3.5 Router or Modem

If the ESS is to communicate to Horizon Power SCADA via a 4G connection, a router or modem from the latest approved version of the *HPC-9NC-21-0008-2020 OT Standard Equipment List* shall be free-issued by Horizon Power for installation in the control cubicle.

An external antenna, coaxial cabling and fittings from the latest approved version of the *HPC-9NC-21-0008-2020 OT Standard Equipment List* shall also be free-issued by Horizon Power.

2 NORMATIVE REFERENCES

Except as modified herein, the ESS Package, shall be designed, manufactured, and tested in compliance with the latest revision of the applicable laws, statutes, orders, decrees, licences, permits, approvals, agreements, regulations, directions and directives or any re-enactments thereof of any Commonwealth of Australia, the Western Australia Parliament, ministry, department, agency, corporation, local authority or commission under the direct or indirect control of any provincial or municipal authority in those jurisdictions affecting the construction and/or operation of the Work.

At the time of publication, the editions indicated were valid. All standards and specifications are subject to revision, and parties to agreements based on this specification shall apply the latest editions of the documents listed below. Information on currently valid national and international standards and specifications can be obtained from SAI Global – Standards On-Line data base or equivalent standards database.

2.1 Legislative Requirements

The ESS Package shall comply with all Legislative Requirements, including the ones listed in Table 2 (without limitation).

Table 2: Legislative Requirements

LEGISLATIVE REQUIREMENTS
Electricity Act 1945 (WA) and associated Regulations, including: <ul style="list-style-type: none"> a) Electricity Act 1945 (WA) b) Electricity (Licensing) Regulations 1991 (WA)
Australian Dangerous Goods (ADG) Code
Construction Safety Regulations
Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations
Electricity (Supply Standards and System Safety) Regulations 2001 (WA)
Electricity Industry (Network Quality and Reliability of Supply) Code

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LEGISLATIVE REQUIREMENTS
Electricity Industry Metering Code
Energy Network Australia (ENA) Guidelines including EG1 (Substation Earthing Guide)
Energy Supply Association of Australia (ESAA) Guidelines, including HB LLM 02-2000 (Guidelines for Live Line Stick Work) and Safety Assurance Guideline" dated 20 May 1999
Environmental Protection (Clearing of Native Vegetation) Regulations
Environmental Protection (Noise) Regulations
Environmental Protection (Unauthorised discharges) Regulations
Environmental Protection Act
Occupational Safety and Health Act 1984 (WA)
Occupational Safety and Health Regulations 1996 (WA)
WA Electrical Network Safety Regulations
WA Office of Energy Safety Guidelines
WA Work Safe Commission for Occupational Safety and Health Codes of Practice and Guidelines, including: a) Managing Noise at Workplaces; and b) Prevention of Falls at Workplaces

2.2 Government Agencies

The ESS Package shall comply with the requirements of all Government Agencies having jurisdiction over the installation.

The installation shall satisfy the following Government Agencies:

- 1) Department of Fire and Emergency Services.
- 2) Energy Safety Division, Department of Commerce.
- 3) WA Planning Commission.
- 4) WorkSafe WA.
- 5) Clean Energy Regulator.
- 6) Department of Environment Regulation.
- 7) Environmental Protection Authority.

2.3 Priority of Technical Standards

The order of precedence of design codes and standards shall be:

- 1) Western Australia Laws.
- 2) Australian Laws.
- 3) Horizon Power Technical Rules: (HPC-9DJ-01-0001-2012).
- 4) Horizon Power Design Standards.
- 5) Non-statutory Australia/NZ Codes and Standards.
- 6) International Electrotechnical Commission (IEC) Codes and Standards.
- 7) ASME/ANSI/NFPA Codes and Standards.
- 8) Other International Standards and Codes of Practice.

Note:

Where conflict exists between any of the statutory regulations, standards, reference documents, and/or the requirements on drawings, data sheets and this specification, the most stringent requirement shall apply.

2.4 Standards Compliance

When relevant to the ESS technology then the works shall comply with the latest revision, including amendments, of the relevant Australian Standards, Codes of Practice and Guidelines or, in the absence of appropriate Australian Standards, with the relevant ISO, IEC, US, British or European (DIN or similar) Standards, including but not limited to Table 3, Table 4 and Table 5.

2.4.1 Applicable Australian and New Zealand Standards

Table 3: Applicable Australian and New Zealand Standards

Standard	Title
AS 1307.2:1996 (R2015)	Surge arresters – Metal-oxide surge arresters without gaps for a.c. systems
AS 1345:1995 (R2018)	Identification of the contents of piping, conduits and ducts
AS 1603 (Series)	Automatic fire detection and alarm systems
AS 1670 (Series)	Fire detection, warning, control and intercom systems – System design, installation and commissioning
AS 2067:2016	Substations and high voltage installations exceeding 1 kV a.c.
AS 2312 (Series)	Guide to the protection of structural steel against atmospheric corrosion using protective coatings
AS 2380 (Series)	Electrical equipment for explosive atmospheres

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Standard	Title
AS 2444:2001	Portable Fire Extinguishers and Fire Blankets – Selection and Location
AS 2676.1:199 AS 2676.2:1992	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings -Part 1-Vented cells -Part 2 -Sealed cells
AS 4044:1992	Battery chargers for stationary batteries
AS 4070:1992 (R2015)	Recommended practices for protection of low-voltage electrical installations and equipment in MEN systems from transient overvoltage's
AS 4086.1:1993	Secondary batteries for use with stand-alone power systems (Series)
AS 4100:1998 (R2016)	Steel structures
AS 4214:2018	Gaseous Fire-Extinguishing Systems
AS IEC 60038:2022	Standard Voltages
AS 60044 (Series)	Instrument transformers
AS 60099.4:2022	Surge Arresters Part 4: Metal oxide surge arresters without gaps for a.c. systems
AS 60529:2004 (R2018)	Degrees of Protection Provided by Enclosures (IP Code)
AS 61508 (Series)	Functional Safety of electrical/electronic/programmable electronic safety-related systems
AS IEC 61131 (Series)	Programmable controllers
AS IEC 62477.1:2016	Safety requirements for power electronic converter systems and equipment – General
AS IEC 62619:2017	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications
AS/NZS 1020:1995	Control of Undesirable Static Electricity
AS/NZS 1125:2001 (R2017)	Conductors in Insulated Electrical Cables and Flexible Cords

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Standard	Title
AS/NZS 1170 (Series)	Structural Design Actions
AS/NZS 1554 (Series)	Welding of steel structures
AS/NZS 1680.5:2012	Interior and workplace lighting – Outdoor workplace lighting.
AS/NZS 1768:2007	Lightning protection
AS/NZS 2053 (Series)	Conduits and fittings for electrical installations (Series)
AS/NZS 2967:2014	Optical fibre communication cabling systems safety
AS/NZS 3000:2018	Electrical Installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008 (Series)	Electrical Installations – Selection of Cables
AS/NZS 3012:2019	Electrical installations – Construction and demolition sites
AS/NZS 3013:2005	Electrical installations – Classification of the fire and mechanical performance of wiring systems
AS/NZS 3835 (Series)	Earth potential rise – Protection of telecommunications network users, personnel and plant
AS/NZS 4296:1995 (R2016)	Cable trucking systems
AS/NZS 4509.1:2009 (R2017)	Stand-alone power systems – System Design
AS/NZS 4509.2:2010 (R2017)	Stand-alone power systems – Safety and Installation
AS/NZS 4600:2018	Cold-Formed Steel Structures
AS/NZS 4755 (Series)	Demand response capabilities and supporting technologies for electrical products
AS/NZS 4777.1:2016	Grid connection of energy systems via inverters- Installation requirements
AS/NZS 4777.2:2015	Grid connection of energy systems via inverters- Inverter requirements
AS/NZS 5000 (Series)	Electric cables – Polymeric insulated

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Standard	Title
AS/NZS 5139:2019	Electrical installations – Safety of battery systems for use with power conversion equipment
AS/NZS 5601 (Series)	Gas installations
AS/NZS 60076 (Series)	Power transformers
AS/NZS 60331 (Series)	Tests for electric cables under fire conditions
AS/NZS 60947 (Series)	Low-voltage switchgear and control gear
AS/NZS 61000 (Series)	Electromagnetic compatibility (EMC)
AS/NZS 61386 (Series)	Conduit systems for cable management
AS/NZS 61439 (Series)	Low Voltage Switchgear and Control gear Assemblies
AS/NZS 60079	Explosive Atmospheres
ENA EG0 DOC 025:2015	Power System Earthing Guide
ENA EG1:2006	Substation Earthing Guide

2.4.2 Applicable International Standards

Table 4: Applicable International Standards

Standard	Description
BS 6739:2009	Code of practice for instrumentation in process control systems: installation, design and practice
BS EN 13601:2013	Copper and copper alloys – copper rod, bar and wire for general electrical purposes
BS EN 50178:1998	Electronic equipment for use in power installations
BS EN 50288-7:2005	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for instrumentation and control cables
DNVGL-RP-0043:2017	Safety, operation and performance of grid-connected energy storage systems
DIN EN 55011:2018	Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement

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Standard	Description
ENA TS 41-24:2017	Guidelines for the Design, Installation, Testing and Maintenance of Main Earthing Systems in Substations
FGW TG 3	Grid connection allowance and electrical characteristics
IEC 60068 (Series)	Environmental testing
IEC 60071 (Series)	Insulation co-ordination
IEC 60189 (Series)	Low-frequency cables and wires with PVC insulation and PVC sheath
IEC 60228	Conductors of insulated cables
IEC 60255 (Series)	Electrical relays
IEC 60297 (Series)	Mechanical structures for electronic equipment – Dimensions of mechanical structures of the 482,6 mm (19 in)
IEC 60364 (Series)	Low-voltage electrical installations
IEC 60654 (Series)	Operating conditions for industrial-process measurement and control equipment
IEC 60664 (Series)	Insulation coordination for equipment within low-voltage systems
IEC 60721 (Series)	Classification of environmental conditions
IEC 60794 (Series)	Optical fibre cables
IEC 60870 (Series)	Telecontrol equipment and systems
IEC 60898 (Series)	Electrical accessories
IEC 60909 (Series)	Short-circuit currents in three-phase a.c. systems. Calculation of currents
IEC 61084 (Series)	Cable trunking and ducting systems for electrical installations
IEC 61386 (Series)	Conduit systems for cable management
IEC 61427 (Series)	Secondary cells and batteries for renewable energy storage

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Standard	Description
IEC 61508 (Series)	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61810 (Series)	Electromechanical elementary relays
IEC 61850 (Series)	Communication networks and systems for power utility automation
IEC 61950:2019	Cable management systems – Specifications for conduit fittings and accessories for cable installations for extra heavy-duty electrical steel conduit
IEC 62133 (Series)	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications
IEC 62305 (Series)	Protection against lightning
IEC 62351 (Series)	Power systems management and associated information exchange – Data and communications security
IEC 62443 (Series)	Industrial communication networks
IEC 62485 (Series)	Safety requirements for secondary batteries and battery installations
IEC 62909 (Series)	Bi-directional grid connected power converters
IEC 62930:2017	Electric cables for photovoltaic systems with a voltage rating of 1,5 kV d.c.
IEC 62933 (Series)	Electrical energy storage (EES) systems
IEEE 1547 (Series)	IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE 1584:2018	Guide for Performing ARC-Flash Hazard Calculations
ISO 10721 (Series)	Steel structures
ISO 13033:2013	Bases for design of structures – Loads, forces and other actions
ISO 14520 (Series)	Gaseous fire-extinguishing systems – Physical properties and system design

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Standard	Description
ISO 15673:2016	Guidelines for the simplified design of structural reinforced concrete for buildings
ISO 7010:2019	Graphical symbols – Safety colours and safety signs – Registered safety signs
ISO 15630 (Series)	Steels for the reinforcement of concrete
ISO/IEC 27000:2018	Information technology – Security techniques – Information security management systems – Overview and vocabulary
ISO/IEC 27001:2013	Information technology – Security techniques – Information security management systems – Requirements
ISO/IEC 27005:2018	Information technology – Security techniques – Information security risk management
ISO/IEC 27019:2017	Information technology – Security techniques – Information security controls for the energy utility industry
UL 1741:2019	Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
UL 1642 (Series)	Standard for Lithium Batteries
UL 1973 (Series)	Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications

2.4.3 Horizon Power Technical Codes and Standards

Table 5: Applicable Horizon Power Technical Codes and Standards

Code	Title
HPC-9DJ-01-0001-2012	Horizon Power Technical Rules NWIS & NIS
HPC-9AJ-01-0001-2014	Horizon Power Standard for Coating and Colour Coding
HPC-9EJ-01-0001-2013	Horizon Power Environmental Conditions
HPC-8DJ-03-0003-2012	Technical Requirements of LV Power Cables with Rated Voltages

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Code	Title
HPC-9AF-07-0001-2011	General Template Labelling Standard for Distribution Equipment
HPC-9DJ-23-0001-2016	Panel Wiring and Terminals
HPC-9CA-01-0001-2012	Engineering Drawings, General Requirements, Practices and Preparation of Drawings / CAD Specification
HPC-9CA-01-0002-2012	Numbering and Titling Specification
HPC-9OJ-13-0001-2012	Transfer of Customer Load between Embedded Generators and the Distribution Network
HPC-9PJ-17-0001-2014	Network Access Points and Relays
HPC-9NC-21-0002-2020	OT Data Sets Standard
HPC-9NC-21-0004-2020	OT Naming Standard
HPC-9NC-21-0006-2020	OT RTU and PLC Architecture Standard
HPC-9NC-21-0007-2019	OT Design Considerations
HPC-9NC-21-0008-2020	OT Standard Equipment List
HPC-9NC-21-0011-2020	OT System Network IP Addressing Standard

3 DEFINITIONS & ABBREVIATIONS

Table 6: Table of Definitions

Definition	Meaning
Battery Management System (BMS) (when relevant) / Energy Storage Management System (when relevant)	The proprietary control system that comes with the Battery or Energy Storage System.
Battery Rack (when relevant)	A single rack housing a number of battery modules connected in series. All battery modules are contained within Battery Racks.

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Definition	Meaning
Battery System (when applicable)	The Battery System is a component of the ESS and is defined as the system within the ESS containing all cells, battery modules, Battery Racks, and Battery Management System (BMS). Depending on the design of the ESS, the Battery System may be contained within one or more ESS enclosures. The Battery System does not include the PCE.
Beginning of Life (BOL)	The date on which the ESS begins commercial operation.
Bumpless Transfer	Transitioning between control modes such as Grid Forming Droop Mode (Section 5.2.1) and Grid Following Mode (Section 5.2.2), or turning control responses on and off, with continuity of supply and no supply interruption.
Charge Power	The Charge Power of the ESS, measured at the Connection Point, accounting for all efficiency losses and parasitic loads.
Connection Point	The point at which the ESS Package connects to the Horizon Power network or power system where electrical system compliance and performance of the ESS Package is expected.
Connection Point Circuit Breaker	The main circuit breaker that isolates the ESS Package at the Connection Point.
Design Life	The period that the designers of the system expect the system to work in its specified parameters. The Design Life of the Battery System / Energy Storage Medium is the difference between the Beginning of Life (BOL) and the End of Life (EOL) of the Battery System.
Discharge Power	The Discharge Power of the ESS, measured at the Connection Point, accounting for all efficiency losses and parasitic loads.
End of Life (EOL)	The EOL is specific to the Battery System and is defined as the date where the Battery System / Energy Storage Medium Usable Energy Capacity has degraded to below the Usable Energy Capacity required by this specification. The difference between BOL and EOL is the Design Life of the Battery System / Energy Storage Medium.

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Definition	Meaning
Energy Storage Medium	The Battery System or any other medium of electrical energy storage in the ESS.
Energy Storage System (ESS)	<p>ESS is a device or group of devices that is to convert electrical energy from power systems and store energy for later use when needed.</p> <p>An ESS is comprised of an Energy Storage Medium, a PCE, one or more enclosures housing the Energy Storage Medium and PCE, and an ESS Controller. The ESS Controller may be housed in an enclosure separate to the ESS.</p> <p>The ESS does not include the LV Connection Board unless the LV Connection Board is contained within the same enclosure as the PCE.</p>
ESS Controller	<p>Charge or Dispatch.</p> <p>The controller that controls the ESS, which may be comprised of one or more devices.</p>
ESS Controller	The controller that controls the ESS, which may be comprised of one or more devices.
ESS Circuit Breaker	An ESS Circuit Breaker is the primary circuit breaker for any ESS enclosure that houses a PCE. Each ESS enclosure that houses a PCE shall be equipped with an ESS Circuit Breaker.
ESS Package	The ESS Package contains the ESS, the LV Connection Board, and any other equipment contained within the scope boundary limits of this specification.
Grid Forming Droop Mode	In Grid Forming Droop Mode the ESS forms, or contributes to forming, the power system or network frequency and voltage, and is capable of generating power without additional grid forming elements (such as diesel generators or electrical grid power). In this mode the ESS shall also have a primary frequency watt droop response, as defined in Section 5.2.1.
Grid Following Mode	Grid Following Mode is an operating mode where the ESS is not setting the frequency and voltage of the power system or network. When in this mode, the ESS shall have PQ and Droop Response capability, as defined in Section 5.2.2.
Islanding	Islanding is the condition in which a distributed generator continues to power a location even though electrical grid power is no longer present.

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Definition	Meaning
LV Connection Board	The switchboard that connects all PCE units in the ESS Package to the network or power station. The LV Connection Board (MSB or SMSB) contains the Connection Point Circuit Breaker.
Maximum Normal SOC (when relevant)	The Maximum Normal SOC is the maximum SOC at which the full rated charging power can be absorbed by the BESS. It is the <u>upper limit</u> for determining Useable Energy Capacity. Battery systems can still be charged to 100% SOC. Note: for some Battery chemistries, the maximum charge rate needs to be reduced as the SOC approaches 100%
Minimum Normal SOC (when relevant)	The Minimum Normal SOC is the minimum SOC at which there are no adverse effects on BESS component Design Life, and the full rated discharging power can be output by the BESS. It is the <u>lower limit</u> for determining Useable Energy Capacity.
Operational Handover	The point during commissioning and testing at which the operation of the ESS Package is handed over to Horizon Power Operations.
Power Conversion Equipment (PCE)	The Power Conversion Equipment is a component of the ESS and is defined as the system within the ESS containing all inverters, transformers, and associated hardware required to charge and discharge the Battery System or Energy Storage Medium, excluding the BMS. Depending on the size and design of the ESS, the PCE may be contained within one or more ESS enclosures.
Scope of Works	Supporting Scope of Works and other documents and drawings, separate to this specification which further articulate specific requirements for the installation of the ESS Package for the project.
Site Conditions	The physical, ambient and environmental conditions and characteristics of the Site and the Environment under which the ESS Package shall be designed to reliably operate as specified in the Scope of Works.
State of Health (SOH) (when relevant)	The State of Health is a measurement that reports the general condition of the Battery System and its ability to deliver the specified performance compared with the BOL condition. It takes into account such factors as charge acceptance, internal resistance, voltage and self-discharge.

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Definition	Meaning
Useable Energy Capacity (when relevant)	Useable Energy Capacity is the energy in the BESS available from the Maximum Normal SOC and the Minimum Normal SOC.

3.1

Abbreviations

ABBREVIATION	MEANING
AC	Alternating Current
AS	Australian Standard
AVR	Automatic Voltage Regulator
BESS	Battery Energy Storage System
BMS	Battery Management System
CB	Circuit Breaker
CT	Current Transducer
DC	Direct Current
ESS	Energy Storage System
ESM	Energy Storage Medium
FAT	Factory Acceptance Testing
FIP	Fire Indication Panel
HAZOP	Hazard and Operability Study
HMI	Human Machine Interface
HP	Horizon Power
HV	High Voltage
I/O	Input/Output
ITP	Inspection and Test Plan
ITR	Inspection and Test Report
kV	kilo Volt
kVA	kilo Volt Ampere

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kVAr	kilo Volt Ampere (reactive)
kW	kilo Watt
kWh	kilo Watt hour
LV	Low Voltage, <1,000 volts AC
MDR	Manufacturer's Data Report
MGC	Microgrid Controller
MVA	Mega Volt Ampere
MVAr	Mega Volt Ampere (reactive)
MW	Mega Watt
MWh	Mega Watt Hour
NTP	Network Time Protocol
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OT	Operational Technology
P	Real Power (W or kW or MW)
PC	Power Capacity
PCE	Power Conversion Equipment
PID	Proportional, Integral, Derivative
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PV	Photovoltaic
Q	Reactive Power (Var or kVAr or MVAr)
QA	Quality Assurance
QC	Quality Control
RTU	Remote Terminal Unit
SAT	Site Acceptance Testing

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SCADA	Supervisory Control and Data Acquisition
SLD	Single Line Diagram
SOC	State of Charge
SOH	State of Health
SOW	Scope of Work
UPS	Uninterruptable Power Supply
VT	Voltage Transformer

4 PERFORMANCE REQUIREMENTS

The ESS Package equipment site specific performance requirements shall consist of the following parameters below which may be detailed in the Scope of Works.

Appendix A1 details all performance requirements.

4.1 Intended Use Case

The ESS Package shall be required to:

4.1.1 Peak Shifting

Mitigate overloading on conventional generation either by:

- 1) Altering the local load profile, i.e. shifting the peak, by absorbing energy during periods of high generation and releasing energy at other times, or
- 2) Utilising energy storage as an alternative energy source to meet the increased demand.

4.1.2 Renewable Energy Smoothing

Supply loads in situations of reduced PV supply either by:

- 1) A dynamic discharge from the ESS when the frequency drops due to a rapid reduction in a renewable output, or
- 2) A controlled discharge from the ESS to coincide with the reduction in renewable energy output, at a ramp rate that enables the conventional generators to respond to the event adequately.

4.1.3 Spinning Reserve

Provide generator/power station spinning reserve support either by:

- 1) Instant discharge during under frequency events (virtual spinning reserve), and
- 2) Instant output power for a generator trip (reduced spinning reserve).

4.1.4 Renewable Curtailment Reduction

Absorb excess power generated from the high PV generation, in instances of high PV and low load conditions, reducing the risk of reverse power situations to generators and ensuring that PV generation curtailment is not necessary by:

- 1) In cases of managed PV, be able to charge from excess PV generation where otherwise PV generation would have to be curtailed, and
- 2) In cases of unmanaged PV, the MGC or Horizon Power SCADA charges the ESS if the load falls below a defined set point.

4.1.5 Voltage Support

Have the ESS PCE provide voltage control for over and under voltage scenarios by:

- 1) Injecting or absorbing reactive power, and or
- 2) Providing a local primary response to voltage variations or a secondary response to managing voltages and reactive power flows across the network.

4.1.6 Frequency Support

Have the ESS PCE to provide frequency control by:

- 1) Injecting or absorbing real power,
- 2) Providing a local primary response to frequency variations, and/or a secondary response to managing frequency and real power flows across the network.

4.1.7 Power Quality Response

Address periods of low power quality specifically voltage flicker and harmonics by providing dynamic voltage control to balance out the effect of the disturbance. This may include direct voltage control to manage local voltages to within suitable tolerances, or harmonic filtering to balance out the effect of harmonics injected into the network.

4.1.8 Reactive Power Compensation

Inject or absorb reactive power in accordance with the required reactive power loading at any point in the network, or at the power station, to ensure that the generators at the connected power station operate optimally. Generators require the power system to be loaded in a certain capability range in regard to the reactive power component.

4.1.9 Dispatch Optimisation

Minimise the generator running costs incurred by running generators sub optimally and in poor scheduling by:

- 1) Providing power to the connected power system in substitution of connected generators to assist with scheduling.

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- 2) Enable start up or have a communication connection to the generators to start up and schedule generators, so that short increases of load do not require a ramp up from the generators.

4.1.10 Hydrocarbons Off

Be the source of voltage and frequency during periods of high renewable output. Hydrocarbon based generators will be used in conjunction with the ESS system, and the ESS system will have a source of renewable power.

The Intended Use Cases outline typical cycle scenarios and can be listed as per Table 14 in Appendix A2.

4.2 Design Life

The Design Life of the ESS Package components are defined in Table 7, with reference to Equipment Warranties (Section 4.19).

Table 7: Design Life of ESS Package Components

ESS Package Component	Design Life	Comments
Battery System / Energy Storage Medium	10 Years	Equipment shall not require replacement or upgrade during the Design Life. The Energy Storage Medium shall maintain the minimum Useable Energy Capacity over the Battery System Design Life. The Energy Storage Medium shall be capable of supplying the Annual Energy Throughput for the Energy Storage Medium Design Life, for any pattern of charge and discharge that can reasonably be expected for the Intended Use Cases (Section 4.1), over the Energy Storage Medium Design Life.
PCE	10 Years	Equipment shall not require replacement or upgrade during the Design Life.
ESS Enclosure	20 Years	Equipment shall not require replacement or upgrade during the Design Life.
LV Connection Board	20 Years	Equipment shall not require replacement or upgrade during the Design Life.
Controls and instruments	15 Years	Equipment may require replacement or upgrade during the Design Life.
Control Software	6-8 Years	Software may require replacement or upgrade during the Design Life.

ESS Package Component	Design Life	Comments
Other electrical systems	15 Years	Equipment shall not require replacement or upgrade during the Design Life.
Cables and wiring	25 Years	Equipment shall not require replacement or upgrade during the Design Life.
Civil works	40 Years	Equipment shall not require replacement or upgrade during the Design Life.

4.3 Power Capacity

The Power Capacity shall account for all thermal derating, efficiency, and parasitic losses, and be available at the Connection Point as specified in the Site Conditions in the Scope of Works.

The Charge Power (kW) and Discharge Power (kW) of the ESS shall be at least equal to the specified Power Capacity.

4.4 Useable Energy Capacity

The Useable Energy Capacity shall not be adversely affected or degraded by site temperature specified in the Scope of Works, or any pattern of charge and discharge that can reasonably be expected for the Intended Use Cases (Section 4.1).

The Useable Energy Capacity shall be available for the Power Capacity (Section 4.3) Discharge Power, for the Design Life (Section 4.2) of the Battery System, assuming the ESS discharges the Annual Energy Throughput (Section 4.5).

4.5 Annual Energy Throughput

The Annual Energy Throughput is the amount of energy that shall be able to be discharged by the ESS Package annually while still satisfying the Useable Energy Capacity (Section 4.4) for the Design Life (Section 4.2) of the Battery System for the Intended Use Cases (Section 4.1).

The Annual Energy Throughput is measured at the Connection Point.

4.6 Reactive Power Capacity

The ESS Package shall provide fully rated, four quadrant P-Q Power Capacity output as specified in Appendix A1 (i.e. 100% reactive power rated output Leading/Lagging) at maximum ambient temperature conditions, at the Connection Point.

The Reactive Power Capacity shall account for all thermal derating, efficiency, and parasitic losses, and be available at the Connection Point (including the Coupling transformer, if installed).

4.7 **Fault Current Contribution and Fault Duration**

The ESS Package shall be capable of providing the minimum Fault Current Contribution for all balanced and unbalanced fault types (includes phase to earth faults), regardless of pre-load conditions and shall consider thermal derating as specified in the Site Conditions in the Scope of Works.

The ESS Package shall 'ride through' for the duration of the fault current contribution, so that it does not trip before the fault current duration time, refer to Voltage Ride Through Capability (Section 4.14) & Frequency Ride Through Capability (Section 4.15).

The ESS Package shall deliver the minimum fault current contribution and duration over the entire Design Life (Section 4.2).

4.8 **Overload Capability**

The ESS Package shall be capable of providing the Overload Capability for all balanced and unbalanced fault types, regardless of pre-load conditions and maximum ambient temperature conditions, at the Connection Point.

Note: The Vendor shall declare Overload Capability values and characteristics if the requirements of Appendix A1 are not met.

4.9 **Minimum Availability**

The ESS Package shall be designed for a Minimum Availability of 95% over a 365 day period where maintenance procedures, e.g. cell balancing, string equalisation and State of Charge (SOC) calibration, shall not reduce the Minimum Availability to more than the specified minimum level of availability.

4.10 **Power Swing Capability**

The ESS Package shall have Power Swing Capability across the full range of the specified Charge and Discharge Power Capacity (Section 4.3) & Reactive Power Capacity (Section 4.6) without any limitations on the Response Times (Section 4.13).

4.11 **PQ Set-point Accuracy Tolerance**

The ESS shall be capable of accepting a full analogue range of P (kW) and Q (kVAr) set-points with a tolerance of $\pm 1.0\%$.

When the ESS is in Grid-Following mode, the ESS PCE shall be capable of slaving to real and reactive set-points provided by the MGC and/or Horizon Power SCADA.

When given specific P and Q values, assuming no droop response is acting in parallel with the PQ command, the PCE shall deliver these P and Q values within the PQ Set-point Accuracy Tolerance in both transient and steady state conditions.

4.12 Grid Forming Droop Mode Set-point Tolerance

When the ESS is in Grid Forming Droop Mode, the ESS shall be capable of maintaining the frequency and voltage of the Power Station or Network based on pre-programmed set-points within the ESS Controller. The ESS shall deliver these values compliant with the Steady and Transient State Quality of Supply Requirements (Section 4.18).

4.13 Response Times

The ESS Package shall perform its Power Swing Capability (Section 4.10) within the minimum required Primary and Secondary Control Response Times of <100 ms and <750 ms respectively.

4.14 Voltage Ride Through Capability

The ESS Package shall provide low and high voltage ride through with customisable voltage thresholds and duration characteristics. This shall ensure that the ESS can be customised not to trip and to keep providing active and reactive power for voltage sags and spikes as specified in Table 10 (Section 7.1.2), Table 11 (Section 7.2) and Fault Current Contribution and Fault Duration (Section 4.7).

- Continuous operation: 90-110% of V_{nom}
- A period of 10 seconds: 75 – 110 % of V_{nom}
- Fault Duration time plus 30 ms Safety margin: 0% of V_{nom}

4.15 Frequency Ride Through Capability

The ESS Package shall provide high and low frequency ride through with customisable frequency threshold and duration characteristics. This shall ensure that the ESS can be customised not to trip and to keep providing active and reactive power for frequency deviations up to the limits specified in Table 10 (Section 7.1.2), Table 11 (Section 7.2) and Fault Current Contribution and Fault Duration (Section 4.7).

- Minimum Over Frequency Ride Through Capability: 55 Hz continuous.
- Minimum Under Frequency Ride Through Capability: 45 Hz continuous.

4.16 Round Trip Efficiency

The Round Trip Efficiency (AC_{in} / AC_{out}) shall be measured at the Connection Point for a 100% Useable Energy Capacity (Section 4.4) charge and discharge (i.e. one full cycle), which shall be inclusive of all DC and AC auxiliary loads including Thermal Management System (Section 8.1) and parasitic losses.

- Minimum Round Trip Efficiency: 85%.

4.17 Noise Limits

Unless a more stringent requirement specified in the Scope of Work, the minimum Noise Limits (< 85 dBA for the inside of any enclosure and < 65 dBA outdoors) set out in the Occupational Safety and Health Act 1984 and the WA noise regulations shall apply.

4.18 Quality of Supply

Quality of Supply for nominal voltage and frequency at the Connection Point shall comply with:

- 1) AS IEC 60038.
- 2) Section 10 of the WASIR; and
- 3) Clause 3.2.1 of HP Technical Rules (HPC-9DJ-01-0001-2012).

This includes for Voltage Ride Through Capability (Section 4.14) and Frequency Ride Through Capability (Section 4.15), where the Network's voltage and frequency undergo transient fluctuations.

- 3ph, 415 V_{L-L} (+/- 6% settable), 50 Hz

4.18.1 Voltage Flicker

Comply to Section 3.2.1(b) of the HP Technical Rules (HPC-9DJ-01-0001-2012).

4.18.2 Harmonics

- 1) Comply to Section 3.2.1(c) of the HP Technical Rules (HPC-9DJ-01-0001-2012).
- 2) Remain connected under continuous zero sequence harmonic voltage below the limits specified in Table 2.5 of HP Technical Rules (HPC-9DJ-01-0001-2012).
- 3) The measurement of harmonics must be carried out according to AS/NZS 61000.4.7 and Horizon Power's Power Quality Testing and Reporting Requirements Standard HPC-2DJ-13-0003-2020. The measurement shall be carried out at the nominal rating of the ESS.
- 4) System tests for harmonics shall include but are not limited to:
 - a) Energisation of AC harmonic filter (if fitted) to check that no protection alarms or trips occur, and visual inspection indicates no equipment damage.
 - b) Operational tests to check the operation, control, and protective actions of the ESS both at site and remotely.
 - c) Harmonic performance measurements at various levels of output to determine compliance with the design specification.
- 5) The Vendor shall specify the harmonic current emission values using frequency dependent Norton equivalents with attention to the following parameters:
 - a) Harmonic current emissions per phase in amps at voltage level of 415 V.
 - b) Harmonic of the fundamental up to the 50th order.
 - c) Inter-harmonics up to the 50th order.
 - d) Harmonic current emission values when the ESS Facility is supplying Nominal rated power to the network at the full range of power factor possibilities, or at the 'worst case' power factor.

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- e) Reference to harmonic current emission values also includes reference to inter-harmonic current emission values.
- f) If greater magnitude harmonic current emissions occur at intermediate operating point between zero power output and maximum power output, then the Vendor shall also specify the harmonic current emission values at the relevant intermediate operating points.

4.18.3 Unbalance

Individual phase shall be balanced to produce a three-phase supply output within the limits as outlined in Section 3.2.1(d) of the HP Technical Rules (HPC-9DJ-01-0001-2012).

4.19 Equipment Warranties

The equipment shall be warranted for a **minimum of 3 years** unless greater as stated in Scope of Work. The required Equipment Warranties for the components of the ESS Package are listed in Table 8 below.

Table 8: Minimum Warranty Periods for ESS components

Component	Comments
Battery System / Energy Storage Medium	The warranty shall be supplied by the Original Equipment Manufacturer (OEM) to Horizon Power.
Battery System / Energy Storage Medium Annual Energy Throughput (Section 4.5) Design Life (Section 4.2) Useable Energy Capacity (Section 4.4)	A product performance warranty shall be supplied by the OEM to Horizon Power. The Energy Storage Medium shall be capable of supplying the (Annual Energy Throughput x Energy Storage Medium Design Life) over the Energy Storage Medium Design Life, while still maintaining the minimum Useable Energy Capacity over the Energy Storage Medium Design Life.
PCE	The warranty shall be supplied by the OEM to Horizon Power.
OT/SCADA equipment	The warranty shall be supplied by the OEM to Horizon Power.

Note: Horizon Power shall be listed as the end-user for all warranties and guarantees.

5 CONTROL REQUIREMENTS

5.1 General

The ESS control system shall be capable of performing all control functions in accordance with this section in order to be correctly controlled by the Horizon Power programmed MGC and/or Horizon Power SCADA.

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The ESS control systems shall ensure that the ESS is fully able to start, synchronise with the network or power station, shut down and operate safely for all operating conditions. The integration of the ESS Package shall not adversely affect the general control and operation of the Power system and/or Network.

The ESS shall be capable of fully automated (unmanned) operation. All operating modes and control functionality shall be able to be selected and enabled/disabled via commands from the MGC, Horizon Power SCADA, the ESS browser interface (Section 11.8), or any ESS local HMI.

Appendix A1 details all control requirements.

5.2 Standard Operating Modes

The ESS Package shall be able to operate in two (2) distinct Standard Operating Modes, under which several Responses can be enabled or disabled, in order to be correctly controlled by the Horizon Power programmed MGC and/or Horizon Power SCADA.

- 1) **Grid Forming Droop Mode** (Section 5.2.1). This shall be the default operating mode for the ESS Package.
- 2) **Grid Following Mode** (Section 5.2.2).

The ESS Controller shall provide a Bumpless Transfer (Refer to HPC-90J-13-0001-2012) when changing between Grid Forming Droop Mode and Grid Following Mode.

5.2.1 Grid Forming Droop Mode

The ESS Package forms, or contributes to forming, the power system or network frequency and voltage, and is capable of generating power without additional grid forming elements (such as diesel generators or electrical grid power).

The ESS Controller shall be capable forming a grid at the nominal frequency and voltage within the Quality of Supply Requirements (Section 4.18) and may be activated via a command from the MGC or Horizon Power SCADA.

The ESS shall maintain the voltage and frequency of the system according to pre-programmed set-points within the required Set-point Tolerance (Section 4.12).

This mode of operation shall include a primary Grid Forming Droop Response that automatically acts to output active and reactive power based on the measured frequency and voltage at the ESS.

The ESS is operated in a voltage source, grid forming mode, with the real and reactive power output determined solely by the following droop responses:

- 1) Power-frequency droop response (injecting or absorbing power in response to measured frequency). The ESS's nominal frequency can be shifted up and down by an external controller (such as the MGC) in order to cause the ESS to charge or discharge real power at the desired rate. In some cases, the ESS Controller completes this functionality internally and only requires a P command to be sent from the MGC.
 - Frequency-Watt Droop Curve Slope of 4%

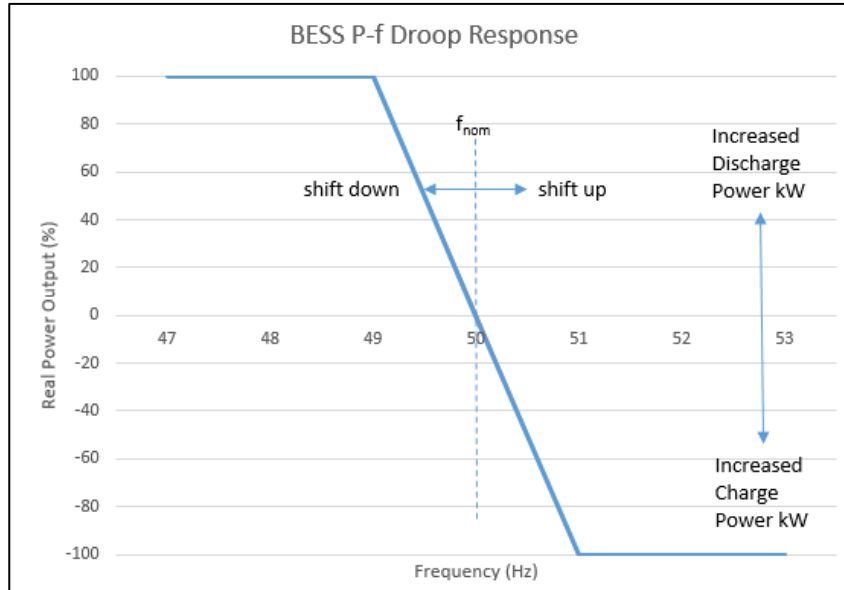


Figure 2: ESS P/f Droop Response (example - 2% droop)

- 2) Reactive power-voltage droop response (injecting or absorbing VAr in response to measured voltage). The nominal voltage setpoint can be shifted up and down to cause the battery to inject or absorb reactive power at the desired rate. In some cases, the ESS Controller completes this functionality internally and only requires a Q command to be sent from the MGC.
 - Volt/VAr Droop Curve Slope of 17%

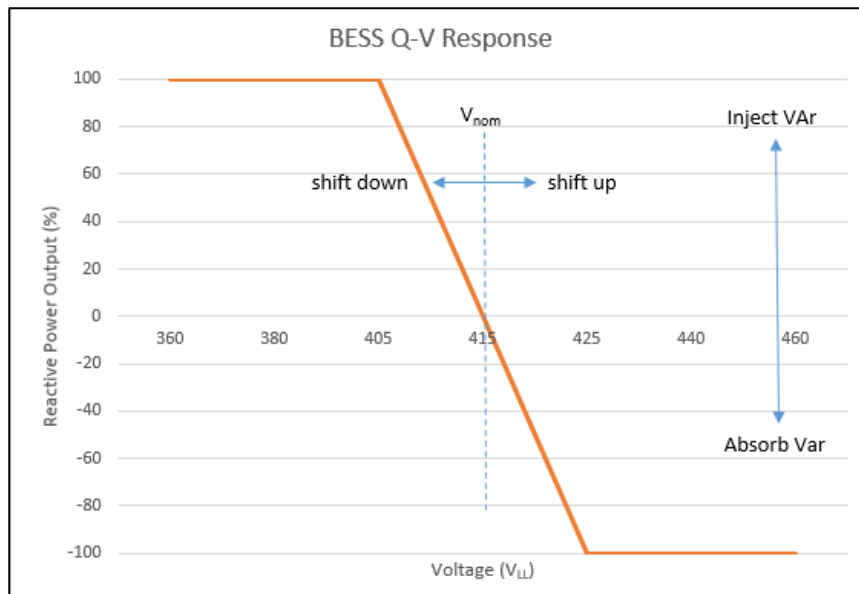


Figure 3: ESS Q/V Response (example - 2% droop)

The active and reactive power droop response characteristics shall include proportional, integral, and derivative (PID) components that are able to be altered locally via the ESS browser interface, in order to tune the primary ESS response to the power system response. The droop response characteristics shall also contain a configurable dead band in order to allow the droop response to only act outside the dead band limits.

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The transition in and out of Grid Forming Droop Mode shall be a Bumpless Transfer, for Intended Use Cases that require Unplanned Islanding function refer to Section 5.8 below.

Horizon Power may require changes to these setpoints at commissioning.

5.2.2 Grid Following Mode

The ESS shall enter Grid Following Mode when commanded to by the Horizon Power MGC or Horizon Power SCADA. When the ESS is operating in Grid Following Mode, the following Response functions shall be available:

- 1) PQ Response (Section 5.2.2.1)
- 2) Frequency-Watt Droop Response (Section 5.2.2.2)
- 3) Volt-Var Droop Response (Section 5.2.2.3)

5.2.2.1 PQ Response

The ESS Controller shall be able to receive and respond to P (W) and Q (VAr) set-points sent to the ESS Controller from the MGC or Horizon Power SCADA, and maintain those set-points through Primary Control functions inherent to the ESS within the required PQ Set-point Accuracy Tolerance (Section 4.11) & Response Times (Section 4.13).

The following parameters shall be configurable by the MGC and/or Horizon Power SCADA:

- 1) Positive power limits (P and Q).
- 2) Negative power limits (-P and -Q).
- 3) Positive ramp rate limit (dP / dt or dQ / dt respectively).
- 4) Negative ramp rate limit ($-dP / dt$ or $-dQ / dt$ respectively).

5.2.2.2 Frequency-Watt Droop¹ Response

The ESS Controller shall have an inbuilt Frequency-Watt Droop Response that automatically acts to output or absorb active power based on the measured frequency at the Connection Point. The droop response shall be capable of operating simultaneously with the PQ Response (Section 5.2.2.1), so that the power output of the ESS is equal to the P set-point + frequency-watt response.

The 0% or centre point of the droop curve shall continuously update to be equal to the requested P setpoint command, and not to zero Watts and the Response can be individually disabled while not affecting the other control schemes.

¹ Where frequency-watt droop is defined as the percentage change in frequency from zero to full real power output.

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The droop response characteristics shall include proportional, integral, and derivative (PID) components that are able to be altered locally via the ESS browser interface, in order to tune the primary ESS response to the power system response. The droop response shall also contain a configurable dead band in order to allow the droop response to only act outside the dead band limits.

- Droop of 4%
- Dead Band of ± 0.6 Hz

Horizon Power may require changes to these setpoints at commissioning.

5.2.2.3 Volt-Var Droop² Response

The ESS Controller shall have an inbuilt Volt-Var Droop Response that automatically varies the dispatch of Reactive power based on the measured voltage at the Connection Point. The response shall be capable of operating simultaneously with the PQ Response (Section 5.2.2.1), so that the power output of the ESS is equal to the Q set-point + Volt/VAr response.

The 0% or centre point of the droop curve shall continuously update to be equal to the requested Q setpoint command, and not to zero (0) Var.

- Droop of 17%
- Dead Band of ± 5 V

Horizon Power may require changes to these setpoints at commissioning.

5.3 Failsafe Mode

The ESS Controller shall be capable of entering a failsafe mode that overrides all other operating modes. When this mode is activated, the ESS shall ramp, following a configurable time delay, at a configurable ramp rate to a configurable set-point that ensures the ESS is not capable of adversely affecting the Power station or Network. The default ESS set-points shall be able to be altered by the MGC and Horizon Power SCADA.

This contingency measure shall be set up to occur automatically when the following is identified by the ESS:

- 1) MGC Failure.
- 2) Communications with the MGC or Horizon Power SCADA is lost.
- 3) An MGC failsafe command.
- 4) A Horizon Power SCADA failsafe command.

² Where volt-var droop is defined as the percentage change in voltage from zero to full reactive power output.

5.4 Manual Mode

In manual mode, the operator shall be able to fully control the ESS with no external inputs from the MGC or Horizon Power SCADA, including selecting and enabling/disabling all operating modes and control responses, modifying set points, modifying ramp rates, modifying limits, and fully dispatching (i.e.: adjust P and Q setpoints) of the ESS within the operational parameters of the equipment.

Manual mode shall be selectable via:

- 1) Any local ESS HMI.
- 2) An ESS browser interface (when made available by Horizon Power).
- 3) A signal received from Horizon Power SCADA or the MGC.

Note: Where operational settings are applied via a keypad or switches, adequate security shall be employed to prevent tampering or inadvertent/unauthorised changes to these settings. A suitable lock or password system shall be used. The Network Service Provider shall approve changes to settings prior to implementation.

5.5 State of Charge Limitations (as applicable to any medium)

The ESS shall have configurable minimum and maximum SOC setpoints as applicable to the medium.

Where the ESS is unable to charge at the requested Charge Power due to a high SOC, the ESS shall charge as close as possible to the requested set point and provide a “maximum available Charge Power” value to the MGC and/or Horizon Power SCADA.

Where the ESS is unable to discharge at the requested Discharge Power due to low SOC, the ESS shall discharge as close as possible to the requested set point and provide a “maximum available Discharge Power” value to the MGC and/or Horizon Power SCADA.

5.6 Controllable Set Points and States

The following minimum set points and states of the ESS shall be controllable via:

- 1) The Modbus TCP interface from the MGC and/or Horizon Power SCADA to the ESS Controller:
 - a) Active Power Set Point (P slaving).
 - b) Reactive Power Set Point (Q slaving).
 - c) Operating mode selection.
 - d) Maximum and minimum SOC Set-points.
- 2) The ESS browser interface (when made available by Horizon Power) or any ESS HMI (not necessarily by the MGC or Horizon Power SCADA interface):
 - a) Droop response PID and deadband settings;
 - b) P and Q ramp rate limits;
 - c) Over/under frequency and voltage protection thresholds and delays;

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- d) Anti-islanding enabled/disabled; and
- e) Nominal frequency and voltage set-points.

5.7 **Unplanned Islanding**

If this capability is required, when operating in Grid Following Mode the ESS shall be capable of preventing the power system or network from blackout in the event of an unintended loss of power from generators or the network, and the load being within the capability of the Power Capacity (Section 4.3).

When unplanned Islanding capability is enabled and the power station or network loses power, the ESS shall:

- 1) Provide immediate voltage and frequency support to the power station or network through the primary frequency-watt and volt-var responses.
- 2) Transition to Grid Forming Droop Mode before any form of protection inherent to the ESS Package trips the ESS or the Connection Point Circuit Breaker. This transfer shall be a Bumpless Transfer.

5.8 **Active Anti-islanding**

All active anti-islanding protection functions shall be capable of being enabled/disabled for all operating modes.

Active anti-islanding shall be disabled by default.

6 **ELECTRICAL REQUIREMENTS**

6.1 **General**

The ESS Package shall comply with all relevant Australian standards, including AS/NZS 3000, AS/NZS 5139, and AS/NZS 61439.

All electrical materials and equipment shall be selected to ensure safe, reliable and satisfactory operation. The equipment shall be configured to facilitate ongoing maintenance including inspection, cleaning and repairs.

All conductors, electrical connections and contacts shall be of ample cross-sectional area to continuously carry the maximum load currents without undue heating or voltage drop and carry fault currents until cleared by protective devices.

All apparatus, connections and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.

All terminals and internal equipment shall be shrouded, insulated or suitably designed such that a person's finger cannot contact any live parts of the equipment.

6.2 Energy Storage Medium

The Energy Storage Medium shall be intrinsically safe, i.e. a credible misuse such as a short circuit between Battery Racks or battery modules shall not result in a safety hazard. Access to the Energy Storage Medium for routine operations including inspections shall not expose operations and/or maintenance personnel to arc flash exclusion zones.

Selection of the Energy Storage Medium or its subsets shall take into account (but not be limited to) the following:

- A compatible PCE,
- Expected operation characteristics (maximum charge and discharge currents; rated capacity and timeframe for typical charge and discharge events; potential for partial SOC operation),
- Expected service life, Available installation location including environmental factors, maximum acceptable nominal system voltage, additional hazard issues and service provisions and ability to replace components.

6.2.1 Battery Modules (where applicable)

This section is only applicable to Battery Energy Storage Systems.

All battery cells, modules and racks are to be selected from a manufacturer's range that has been proven in similar Site Conditions. The battery OEM shall have a technical support service in Australia.

All battery module terminals, DC power cables/links between battery modules, communications cables, and any other live parts of the Battery System, shall be shrouded or insulated to be at least IP2X, with no live parts exposed.

The length and location of all cabling between battery modules, the positioning of the battery module terminals, and the positioning of the cable termination points on the Battery System shall be optimised to reduce the risk of cables being accidentally pulled out or the terminals being pulled/distorted during standard operation and maintenance procedures.

The Battery System shall be designed for ease of maintenance and replacement of battery modules.

6.2.2 Exchange of Battery Modules (where applicable)

This section is only applicable to Battery Energy Storage Systems.

Battery modules shall be able to be easily and quickly exchangeable in a short time without specialised tools. No difficult control cabling, handling of hazardous substances or other complex operative procedures shall be required.

If special tools are required for the exchanging of battery modules, all special tools and equipment such as battery lift devices and insulated hand tools required to replace battery modules shall be supplied to Horizon Power prior to Operational Handover.

6.2.3 Energy Storage Management System (ESMS) / Battery Management System (BMS) (where applicable)

The ESS shall include a ESMS or BMS that protects, monitors and controls the System. The minimum functions the ESMS or BMS shall have are:

- 1) Comply with all SCADA and communication requirements.
- 2) Prevent thermal overload and ensure charge and Discharge Power is within OEM acceptable limits.
- 3) Over voltage and under voltage protection.
- 4) Over current protection.
- 5) Over and under temperature protection.
- 6) Battery module charge balancing (when relevant).
- 7) Battery module, Battery Rack and Battery System charge and discharge control (when relevant).

In the case of faulty battery modules, the BMS shall be able to isolate the least amount of faulty equipment whilst maintaining nominal DC voltage limits, so that the remaining unaffected battery modules can continue to operate.

The BMS shall have a proven SOC algorithm, which is calibrated based on kWh throughput, cell voltage, and self-consumption. The SOC uncertainty shall be less than 5%, and at the SOC calibration points the uncertainty should be less than 2%.

The BMS shall balance or equalise the SOC of the battery modules, and the SOC between Battery Racks.

The BMS shall have a degree of redundancy to ensure battery safety is maintained under BMS fault conditions.

6.3 Power Conversion Equipment

The ESS Package shall include Power Conversion Equipment (PCE). The PCE may be comprised of the following:

- 1) One or more Battery inverters capable of charging and discharging the ESS.
- 2) Transformer(s) if required, if the PCE is not capable of outputting the Connection Point voltage.

The PCE shall be designed, installed and commissioned in accordance with good electricity practice and relevant Australian standards fit-for-purpose for the specific conditions of the installation, and shall be submitted to Horizon Power for acceptance prior to procurement.

The PCE shall comply with the following requirements:

- 1) The PCE shall be certified to be compliant with AS 4777.2 by an accredited testing laboratory, with an accreditation number.

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- 2) The PCE shall be capable of meeting all Performance (Section 4), Control (Section 5), Protection (Section 7) and SCADA/comms requirements (Section 11).
- 3) The PCE OEM shall have a technical support service to Australia.
- 4) The PCE shall be manufactured by an organisation who has been supplying significant quantities of PCEs into Australia for no less than three years.
- 5) The PCE shall be from a manufacturer's range that has been proven in similar Site Conditions specified in the Scope of Works.
- 6) The PCE shall have been in operation in at least two (2) commercial projects (not demonstration projects) of at least 2 MW nominal power total, for at least 12 months, in Australia. The OEM shall certify that the PCE has achieved a technical availability of at least 95% for 12 consecutive months of operation;
- 7) The location and installation of the PCE shall comply with site restrictions for appropriate and safe access.
- 8) The ventilation and air requirements of the PCE shall be met in accordance with the OEM requirements and Site Conditions.
- 9) The PCE shall be able to be controlled by the ESS Controller.
- 10) Be compatible with the Battery System.
- 11) Each inverter shall be able to be fully isolated within the relevant PCE enclosure.
- 12) All active anti-islanding settings and algorithms shall be able to be completely disabled.
- 13) All protection setpoints shall be programmable, with adjustable voltage and frequency thresholds and duration.
- 14) The PCE shall have the capability of not disconnecting due to frequency or voltage within the limits specified in Sections 4.14 and 4.15. These settings shall be configurable, and Horizon Power may request changes to the settings prior to energisation.
- 15) Control of each PCE shall be coordinated via the ESS Controller, so that no direct control of the PCE by the MGC or Horizon Power SCADA is required during normal operation.
- 16) When the PCE is disconnected from the Energy Storage Medium, the PCE shall be able to reconnect to the Energy Storage Medium, for all situations, without any adverse effects such as current or voltage spikes on the PCE, Energy Storage Medium, or any other equipment within the ESS Enclosure. If DC bus equalisation is required to achieve this, the PCE shall control the DC bus equalisation function; and
- 17) If the PCE output voltage is less than the Connection Point voltage, the PCE shall contain a coupling transformer. The coupling transformer shall be of a dry type installed internal to an ESS enclosure with no live parts accessible during operation and maintenance.

6.4 Switchgear

6.4.1 General

All AC and DC Switchgear within the ESS Package shall satisfy the following requirements:

- 1) All switchgear shall be manufactured by an organisation who has been supplying significant quantities of switchgear into Australia for no less than five years.
- 2) All switchgear is to be selected from a manufacturer's range that has been proven in similar Site Conditions.
- 3) All circuit breakers, disconnectors and isolators shall be able to be locked in accordance with the Horizon Power Generation Permit to Work Standards.
- 4) All switchgear shall have appropriate voltage, fault and load current ratings appropriate for the operating voltage type i.e. AC or DC ratings.
- 5) All switchgear shall be designed and type tested to IEC AS 60947.
- 6) All circuit breakers shall have a curve type that ensures full discrimination and coordination throughout the ESS Package.

6.4.2 ESS Circuit Breaker

Every ESS enclosure that contains a PCE shall have a controllable main circuit breaker that shall:

- 1) Be capable of disconnecting and isolating the PCE within the ESS Enclosure from the LV Connection Board.
- 2) Provide for remote alarming and indication.
- 3) Be fitted with a shunt trip coil or equivalent for inter-tripping.
- 4) Be fitted with an auxiliary contact.
- 5) Have visibility as to whether the circuit breaker has operated either due to an inter-trip command or due to overcurrent/earth-fault protection inherent to the circuit breaker.

The location of this circuit breaker may be in either the LV Connection Board or the ESS enclosure(s) housing the PCE.

6.4.3 Connection Point Circuit Breaker

The ESS Package shall have a single Connection Point Circuit Breaker, which acts to isolate the entire ESS Package from the Horizon Power network or power station. This circuit breaker shall be contained within the LV Connection Board, and shall satisfy the following requirements:

- 1) Be capable of complying with all central protection features in accordance with Section 7.1.
- 2) Be capable of disconnecting and isolating the ESS Package from the network or power station.
- 3) Be motorised to provide for remote operation (both open and close) with automated spring charging and override manual charging capability.

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- 4) Provide for remote alarming and indication.
- 5) Be fitted with an auxiliary contacts.
- 6) Be fitted with a shunt trip coil or equivalent for inter-tripping.
- 7) Have visibility as to whether the circuit breaker has operated either due to an inter-trip command or due to overcurrent/earth-fault protection inherent to the circuit breaker.

6.4.4 Battery Rack DC Disconnectors (where applicable)

This section is only applicable to Battery Energy Storage Systems.

Each Battery Rack shall have provision of a DC disconnection device at the electrical output of the Battery System in accordance with clause 6.3.1.3 of AS/NZS 5139. The Battery Rack DC disconnector shall meet the requirements of clause 2.3.2.2 of AS/NZS 3000 for an Isolating device. The Battery Rack DC Disconnector shall be located as close as possible to the positive and negative output terminals of each Battery Rack.

Note: The Electrical output is defined at the point where the voltage is that of the DC operating voltage of the complete Battery System.

The Battery Rack DC disconnection devices shall satisfy the following requirements:

- 1) Be non-polarized and DC rated for the appropriate voltage and current.
- 2) Have a utilisation category of at least DC21B as defined by the requirements of AS 60947.3
- 3) Include an overcurrent protection device either with or in line with each disconnector (e.g. a high rupturing capacity fuse or a moulded case circuit breaker).
- 4) Provide for remote alarming and indication.
- 5) Be mounted as close as practicable to the output terminals of the Battery Racks.

6.5 LV Connection Board

The ESS Package shall contain an LV Connection Board that shall:

- 1) House the Connection Point Circuit Breaker and all ESS Circuit Breakers.
- 2) Have a segregated metering and protection section that houses all protection and metering equipment, with all relays, meters, and test blocks mounted on a 19-inch swing-frame rack.
- 3) Have a segregated control and communications section that houses all communications, SCADA and control equipment that can be accessed without operations personnel having to isolate the AC/DC supply, and prevents personnel from being exposed to voltages above 50 V_{AC} and 110 V_{DC}.

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Note: If any equipment contained within this enclosure requires temperature to be controlled in order to operate within the OEM's minimum and maximum temperature envelope, a system shall be installed that can be shown to provide the required cooling and/or heating for all internal components. This may include thermoelectric coolers that use the Peltier effect.

- 4) Contain all other electrical, protection, and communication equipment not housed within the ESS enclosure(s).
- 5) Have a minimum fault current rating as per Section 6.7.
- 6) Comply with AS/NZS 61439 and AS/NZS 3000.
- 7) Achieve an indoor IP rating of IP54.
- 8) Be extensible (extendable busbars and sides to accommodate future expansion).
- 9) Be type tested to satisfy all relevant Australian Standards.
- 10) Have hinged escutcheons panels for access to any compartments containing operational equipment (such as circuit breakers).
- 11) Have escutcheon panels fixed with bolts for all compartments not containing operational equipment (such as busbar and termination enclosures).
- 12) Have hinged doors with handles and locks keyed to Horizon Power requirements.
- 13) Be vermin proof.
- 14) Have all busbars shrouded and insulated.
- 15) Have an emergency stop pushbutton as per Section 6.6.
- 16) Have all terminals and wiring labelled with a unique identifier and wires shall be identified at each end.
- 17) Have all switchgear sections fitted with an engraved label stating the circuit name and reference.
- 18) Have a fixed table for operational staff and maintain egress requirements.
- 19) Have 2 x GPO's, and an RJ45 socket for connection to the network switch, accessible with the escutcheon doors closed.
- 20) If located outdoors:
 - a. Be free standing and floor mounted.
 - b. Have integrated sunshades on all sides, the roof, and doors or alternatively have insulation properties which restrict significant heat transfer from the sun and condensation.
 - c. Be rated to a minimum of IP65.
 - d. Be oriented so that the doors are on the southern side.
 - e. Be painted to have an external appearance of Parchment White.
- 21) Have a minimum 20% spare capacity for:
 - a. Cable gland and cable transport systems.
 - b. Small power circuits.

- c. Communications equipment; and
- d. Communications, control, and protection terminations, wiring and equipment.

6.6 Emergency Stop

An emergency stop push button shall be fitted in an easily accessible place inside the LV Connection Board. The pushbutton shall initiate the following response:

- 1) Open the Connection Point Circuit Breaker.
- 2) Open all ESS Circuit Breakers.
- 3) Open all Battery System DC disconnection devices to reduce as far as practicable the coupling of batteries.

6.7 Fault Current Rating

The minimum fault current withstand of all electrical equipment and materials shall be as per clause 2.5.6 of Horizon Power Technical Rules (HPC-9DJ-01-0001-2012) which are shown in Table 9, unless otherwise advised by the Scope of Works.

Table 9: Equipment minimum fault current rating

Equipment voltage	Minimum fault current rating
415 Vac	31.5 kA / 1 sec where supplied from one transformer, or 63 kA where supplied from two transformers in parallel

6.8 Electrical Cables and Wiring

6.8.1 Cabling and Wiring

All cabling and wiring shall comply HPC-9DJ-23-0001-2016 Standard – Panel Wiring and Terminals and with the following:

- 1) Be installed in a neat and tidy manner in accordance with best industry practice which allows for easy circuit identification and rectification works.
- 2) Comply with AS/NZS 3000 and AS/NZS 3008.
- 3) All primary current path terminations shall be cleaned and have suitable jointing compound applied between the lug, cable and the clamp to prevent the ingress of moisture.
- 4) Be appropriately specified based on current rating, fault current, voltage drop, ease of installation and mechanical protection.
- 5) All cables installed underground shall be installed in conduits and be protected from termites.
- 6) AC and DC circuits shall be segregated be separated as specified in AS/NZS 3000 and AS/ACIF S009.

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- 7) Be supplied by a cable manufacturer that has been producing cables for the last five (5) years.
- 8) Shall be fire-resistant (flame retardant and non-propagating) and self-extinguishing, with XLPE insulation where required; and
- 9) Not be exposed to UV light.

6.8.2 AC Power Cabling

AC power cabling shall be rated for a nominal use of no less than 90 degrees Celsius, and have red, white, and blue phase colouring.

6.8.3 DC Power Cabling

DC cabling shall be of the flexible type, double insulated with red and blue colouring. DC cables shall comply with AS/NZS 5000.1 & 2 and for Battery Systems with a system voltage greater than 0.6 kV to 1.5 kV shall be IEC 62930.

DC cabling lengths shall have equal resistance, except if the BMS provides managed voltage and current charge/discharge control to each separate Battery Rack.

Maximum allowable voltage drop between the electrical output of the Battery System and PCE should be no more than 2% based on the rated DC battery port current of the PCE and shall be no more than 5% under any operating condition.

6.8.4 Instrument and Control Cable

All communication, SCADA, instrumentation, metering and control cable shall be shielded/screened.

Pull down resistors, capacitors and termination resistors shall be supplied and installed as required to prevent any interference.

6.8.5 Fibre Optic Cables

All fibre optic cable shall be single mode 12 core 9/125.

6.8.6 Wiring and Cabling Identification

All cabling and wiring shall have permanent identification.

All control and instrumentation cables shall have ferruling on both ends.

Wiring naming, colouring and identification shall be as per the Horizon Power standard HPC-9DJ-23-0001-2016: Panel Wiring and Terminals.

6.8.7 Cable Management

All cables and cable management methods shall comply with the following:

- 1) Have mechanical protection and support along their entire length.
- 2) Have adequate segregation between power and instrumentation cables.
- 3) Be arranged neatly, be bundled if appropriate, and be cleated or tied to cableways using materials specifically designed for this purpose; and

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- 4) Not have conductive cable ties used on single insulated cables.
- 5) Have PVC-coated stainless-steel tie wraps or banding used for fixing cables outside.
- 6) Above ground cabling systems shall not impede or restrict access for necessary operation and maintenance activities.
- 7) Suitable screened bedding and backfill materials shall be provided for all direct buried services. All buried cabling shall be installed in conduits with ample room for additional cabling. All conduits entries shall be sealed.

6.9 Earthing

Unless otherwise excluded by the Scope of Works, the following requirements shall apply:

- 1) The Vendor shall supply an NER certified earthing design package and reports for the proposed design incorporating site earthing designs, EPR/Step/Touch Voltage assessment under all Operating modes.
- 2) The Vendor shall plan to obtain or make use of existing soil resistivity measurements to establish the earthing soil model of the site.
- 3) Derivation of step and touch voltage criteria from the associated HV/MV installations connected to the ESS Package as per AS 2067 and ENA EG1.
- 4) Model the proposed earth system and assess the maximum touch and step voltages at the site including detailed investigation of EPR related hazards under varying operation scenarios. Fault level data and protection settings/clearing times shall be provided on a per project basis.
- 5) Conduct an EPR contour assessment to determine the hazards for instrument earthing.
- 6) Undertake conductor ampacity calculations to determine the minimum required earth conductor sizes for the installation.
- 7) Preparation of earthing design report to document studies carried and modelling software calculation output clearly showing SFAIRP/ALARP compliance of the earthing design in accordance with AS 2067, ENA EG-0, and ENA EG1.
- 8) Provide information showing depth and location of earth electrodes and buried prepare earthing layout drawings. Buried earth grid shall follow the site trenching routes where possible as common trenching. Equipotential bonding of all site structures will be installed in accordance with AS/NZS 3000.
- 9) Preparation of material lists for the proposed design. Buried earth grid connections shall be compression crimp style, certified to IEEE 837.
- 10) Post-earthing installation, the Vendor shall verify the earthing design through injection testing to AS 2067 requirements.
- 11) Preparation of final current injection testing report describing the final EPR for the facility.

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6.9.1 Installation Requirements

Earthing of the Battery System shall be "Floating / Separated" and all metallic equipment enclosures associated with the ESS installation, shall be equipotential bonded together and connected to the earthing system of the electrical installation to prevent a shock hazard occurring.

The minimum bonding conductor size shall be as per AS/NZS 3000 and AS/NZS 61439. An earth fault alarm shall be provided with an audible signal activated in a location where and authorized persons will be aware of the signal refer to Battery System DC Protection (Section 7.5).

An earthing system shall be provided as part of the ESS Package, which shall include:

- 1) Suitable labelling of earthing conductors and components.
- 2) A buried Bare Copper Earth (BCE) grading ring around the ESS Package enclosures.
- 3) Earth electrodes of sufficient depth to ensure that the hazardous step and touch voltage limits are met and installed with trafficable inspection pits.
- 4) All BCE conductors shall be minimum 70 mm².
- 5) The ESS Package enclosures shall be bonded to earth at a minimum of two (2) points. All outdoor and underground earthing joint connections shall be certified to IEEE 837 with preference for compression crimp or swage connections. Exothermic connections are not acceptable.
- 6) Provision for the inter-connection to an existing Substation earthing grid (if required in the Scope of Works).
- 7) Connection of all Main earth bars in the ESS Package to the earth grading ring, via two separate 70 mm² PVC earths connected at each end of the Main earth bar for redundancy.
- 8) The earth electrodes and resistances shall be compliant with AS/NZS 3000 and AS 2067.
- 9) Earth bars shall be sufficiently sized for connection of equipment and external earth grid with allowance of additional 20% spare.
- 10) All earthing connections shall be cleaned and have suitable jointing compound applied between the lug, cable and the clamp to prevent the ingress of moisture.

6.10 Lightning and Surge Protection

6.10.1 Lightning Protection

Unless otherwise excluded by the Scope of Works, the following requirements apply.

- 1) A Lightning Risk assessment shall be performed and provided as part of the documentation in accordance with AS/NZS 1768.

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- 2) The Vendor shall provide a Lightning protection study which shall report all key Risk management calculation inputs and any assumptions that were made such as:
 - Structure dimensions and attributes
 - Environment parameters, i.e. the ground flash density ($\text{km}^{-2}\text{y}^{-1}$) and service line density.
 - Assumed service lines and justifications.
 - Statement of Acceptable Risk of Loss Summary.
 - Values for Damage categories 1, 2, 3 & 4.
 - Assumed number, location and type or Surge Protection Devices (SPD).
- 3) The results shall be in a table to summarise the calculated, acceptable and risk category and a statement confirming pass /fail.
- 4) Where the results of an LPS study determine the need for an LPS. The LPS shall be designed and installed at per AS/NZS 1768 and shall be included in the Earthing design package of Section 6.9.

6.10.2 Surge Protection

Surge protection devices in accordance with AS 60099.4, shall be installed on all cables that may be adversely affected by lightning, as close as possible to the entry of the cable to the relevant enclosure. This is applicable for the following circuits:

- 1) All DC circuits.
- 2) All AC circuits.
- 3) All communications circuits.

6.11 Lighting System

- 1) lighting done in accordance with AS/NZS 1680.5.
- 2) All enclosures shall have LED lighting providing a minimum illumination of 300 lux in any areas required to be accessed by operations personnel.
- 3) There shall be external bunker lights above access paths and stairwells.
- 4) Lighting shall be switched on and off with a limit switch activated by the door to that section of the enclosure.
- 5) All lighting shall be in accordance with AS standards, fitted with RCD protection and provided complete with all necessary installations.

6.12 Auxiliary AC Supply

The ESS shall include an AC auxiliary supply network and shall be designed and installed in accordance with AS/NZS 3000. The Auxiliary AC supply shall be metered refer to Section 6.14. The Vendor shall declare the estimated AC Auxiliary power demand and any supply requirements.

6.13 Uninterruptible Power Supply

- 1) The ESS Package shall have a DC emergency Uninterruptible Power Supply (UPS) that automatically powers all critical Protection & Control systems, including breaker operation, metering systems and instrumentation systems, for a minimum of 8 hours if the AC auxiliary supply is unavailable.
- 2) The ESS Package shall have adequate redundancy to ensure failure of an AC or DC auxiliary system does not result in reliability issues or introduce an unsafe situation.
- 3) The UPS shall be capable of being tested for routine capacity and functionality checks.
- 4) The UPS System shall provide a means to signal loss of supply or internal faults to the HP SCADA that may reduce the reliability of the DC supply. This can be supplied in the form of a dry-type contact or a Modbus TCP link.

6.14 Metering

A metering system shall be installed as part of the ESS Package, and shall:

- 1) Comply with all relevant codes and standards.
- 2) Be able to accurately control the ESS as per the requirements defined in this specification.
- 3) Have all required meters and test blocks installed in a segregated compartment of the LV Connection Board alongside the protection equipment, and be mounted on a 19 inch swing frame rack that is hinged on one side to accommodate meter and protection rack mounting systems as per Section LV Connection Board (Section 6.5).
- 4) Include all ancillary equipment.
- 5) Have all power supplies to meters backed up by the ESS Package UPS (Section 6.13).
- 6) The metering system that measures the total output of the ESS Package shall:
 - Be an Import / Export tariff class metering system.
 - Include the Horizon Power free-issued SEL-735 meter.
 - Include CT's of minimum metering class 0.5 S, extended range 200%, that are either separate to the protection system CT's or use a separate core if the CT's are dual core.
 - Include a test block of model RMS 2RMLB-S1, Reyrolle 2RMLG 01, or similar.
 - Interface with the Horizon Power free-issued network switch.
- 7) Where possible, the ESS Package shall use the SEL-735 meter for any required control purposes.
- 8) A Power meter shall be installed to monitor the AC auxiliary supply usage for the ESS Package. The Power meter shall be supplied and installed by the Vendor, the specification, accuracy and configuration of the meter shall be subject to HP approval.

7 PROTECTION REQUIREMENTS

7.1 Central Protection

The ESS Package shall have a central protection system that shall:

- 1) Comply with:
 - HPs Technical Rules (HPC-9DJ-01-0001-2012).
 - All other relevant codes and standards.
- 2) Control the Connection Point Circuit Breaker.
- 3) Operate independently from protection functions integrated with the PCE.
- 4) Have one IEC 60255 compliant external protection relay to control the Connection Point Circuit Breaker containing all necessary protection functions where the ESS Package has a Power Capacity <1 MVA.
- 5) Have duplicate IEC 60255 compliant external protection relays of fully independent protection schemes of differing principle with complete secondary system redundancy where the ESS Package has a Power Capacity ≥ 1 MVA in accordance with protection requirements of HP Technical Rules (HPC-9DJ-01-0001-2012).
- 6) Include a test block of model RMS 2RMLB-S1, Reyrolle 2RMLG 01, or similar.
- 7) Have the central protection relay(s) and test block(s) installed in a segregated compartment of the LV Connection Board alongside the metering equipment, and be mounted on a 19 inch swing frame rack that is hinged on one side to accommodate meter and protection rack mounting systems as per Section 6.4.4.
- 8) Include CT's and VT's that meter the LV output on the network/power station side of the Connection Point Circuit Breaker. The CT's shall be either separate to the metering system CT's or use a separate core if the CT's are dual core.
- 9) Interfaces with the Horizon Power free-issued network switch.
- 10) Have the power to the protection relay(s) backed up by the ESS Package UPS (Section 6.13).
- 11) Have labels with Horizon Power's flag numbers/descriptions applied to the protection relay.
- 12) Be configurable to accommodate inter-trip functions with remote protection devices.
- 13) Allow for the addition of sensitive earth fault and neutral voltage displacement protection to the central protection system, without requiring any additional terminals or equipment to be installed within the LV Connection Board.

7.1.1 Central Protection Functions

Central Protection requirements shall be as per AS/NZS 4777 and HP Technical Rules (HPC-9DJ-01-0001-2012). The minimum required protection functionality of the central protection shall be:

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- 1) Overcurrent facility fault, grid fault and earth fault protection (50/51).
- 2) Voltage, frequency, and ROCOF protection (59U/O, 27U/O, 81U/O, 81R).
- 3) Earth fault protection for earth faults (this protection scheme may be earth fault or neutral voltage displacement); and
- 4) Circuit Breaker (CB) Fail, Trip circuit supervision (TCS), including the capability to trip the circuit breaker in the event of an E-Stop or inter-trip.

All settings shall be programmable and alterable only by personnel with appropriate training and authorisation, through the use of user permissions.

Horizon Power may request additional protection settings prior to energisation.

7.1.2 Central Protection Voltage and Frequency Settings

The default settings for the central protection shall be as per Table 10, with variations to AS 4777.2 (Australia Region C settings) marked with (*). Horizon Power may request changes to these settings prior to energisation.

Table 10: Central Protection Voltage and Frequency Protection Set Points

Setting Parameter	Trip Delay Time (Ride through)	Maximum Disconnection Time	Setting
Sustained over voltage (V>) (based on average value over a period of 10 min)	10 minutes	10 minutes, 15 seconds	258 V
Over voltage (V>)	2 seconds*	2 seconds	265 V
Under voltage (V<)	11 seconds	11 seconds	180 V
Over frequency (F>)	6 seconds*	6 seconds*	55 Hz
Under frequency (F<)	6 seconds*	6 seconds	45 Hz

7.2 PCE Passive Anti-islanding

The PCE shall be capable of meeting the passive anti-islanding requirements and settings defined by AS/NZS 4777.2 (Australia Region C settings).

The voltage and frequency disconnection setpoints and trip delay times for the PCE shall be configurable. The default values for the PCE passive anti-islanding requirements are shown in Table 11, with variations to AS 4777.2 (Australia Region C settings) marked with (*). Horizon Power may request changes to these settings prior to energisation.

Table 11: Default Passive Anti-Islanding Settings

Protective Function	Protective Function Limit	Trip Delay Time (Ride through)	Maximum Disconnection Time
Undervoltage (V<)	180 V _{L-N}	10 seconds	11 seconds
Overvoltage 1 (V>)	265 V _{L-N}	1 seconds	2 seconds
Overvoltage 2 (V>>)	340 V _{L-N*}	0 seconds	0.2 seconds
Under-frequency (F<)	45 Hz	5 seconds	6 seconds
Over frequency (F>)	55 Hz	5 seconds*	5.2 seconds*

7.3 PCE Active Anti-islanding

Active anti-islanding protection requirements for the PCE shall be as per AS/NZS 4777.2 and IEC 62116.

The active anti-islanding settings shall be configurable, with the capability to completely de-active all active anti-islanding protection.

Note: Active anti-islanding will be deactivated by default.

7.4 PCE DC Disconnection and Protection Device

Each inverter shall have overcurrent protection and able to be isolated on both the positive and negative circuits of the incoming DC cables. These devices shall be located in the same enclosure as the inverters.

7.5 Battery System DC Protection (where applicable)

This section is only applicable to Battery Energy Storage Systems.

The BESS shall have an appropriate DC overcurrent protection scheme as per the requirements of AS/NZS 5139 that ensures that the arc-flash requirements defined in Section 7.9 are complied with.

The positive and negative DC output from each Battery Rack shall have a means of automatic disconnection that acts in the event of:

- 1) Overcurrent of the positive and/or negative output from each Battery Rack.
- 2) BESS emergency stop.
- 3) Any inter-trip; and
- 4) Any DC fault.
- 5) Earth fault indicating breakdown in resistance of the DC system to earth.

7.5.1 Insulation Monitoring

All Battery Systems shall contain insulation monitoring system that can detect a breakdown in insulation resistance on any the Battery System DC circuits. Upon detection of an insulation breakdown, the BESS shall be capable of providing an audible alarm and automatic shut-down of the affected system(s), raising an alarm locally via the HMI and/or remote vendor monitoring, and raising an alarm to Horizon Power SCADA.

7.6 Battery Module DC Protection

This section is only applicable to Battery Energy Storage Systems.

Each battery module shall be monitored by the BMS to detect any fault internal to the module, including temperature and charging differences between modules.

Upon detection of a fault in a module, the BMS shall be capable of shutting down either the individual module or the Battery Rack, without affecting the operation of the other Battery Racks.

7.7 Synchronisation

Synchronisation is required from the Connection Point Circuit Breaker. The ESS Package shall confirm the supply voltage and frequency is within limits for no less than one (1) minute prior to synchronisation. The synchronisation functions shall ensure that:

- 1) The ESS Package cannot attempt to connect with the network or power station while the ESS Package is out of synchronisation.
- 2) The ESS Package can synchronise and connect to the network or power station within two (2) minutes of receiving the signal to synchronise.

The ESS Package shall be capable of bumpless reconnection to the network from islanded operation by having provision to synchronise the ESS Package output to a network voltage and frequency.

7.8 ESS Enclosure Doors

All doors in each ESS enclosure that allow personnel direct access to the Energy Storage Medium or PCE units within the ESS Package shall be fitted with limit switches. These limit switches shall be incorporated into an inter-trip scheme that acts to shut the system down and isolate ESS Circuit Breaker relevant to that section of the ESS.

7.9 Arc-flash Mitigation

Arc-flash hazard calculation and analysis shall be performed in accordance with clause 3.2.4 of AS/NZS 5139. This shall assess the incident energy related to arc-flash associated with the Energy Storage Medium, with the calculations and results supplied to Horizon Power in the form of a detailed Arc Flash Report.

Any areas within an arc flash boundary of 1.2 cal/cm² shall have restricted access and be physically separated to ensure that no personnel can be exposed to an arc flash risk without the appropriate PPE as described in Table 3.3 of AS/NZS 5139.

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The maximum allowable incident energy associated with the worst-case arc-flash at a working distance of 45 cm is 8 cal/cm².

After calculation and analysis, the following aspects of arc flash hazard prevention shall be provided to Horizon Power, including:

- 1) Proper equipment labelling.
- 2) Defined maintenance procedures including the level of PPE required for each activity.
- 3) Arc flash resistant switchgear if required.
- 4) Form of Separation to prevent arc initiation.
- 5) Mitigation techniques that can be implemented during the design phase to reduce arc flash hazard.

8 MECHANICAL REQUIREMENTS

8.1 Thermal Management System

A thermal management system shall be supplied as part of the ESS Package that maintains the temperature of the Energy Storage Medium and all other temperature sensitive equipment to levels acceptable to the normal operating and warranty conditions for all Site Conditions over the Design Life of all ESS components.

Evidence of the supplied thermal management system's capability to maintain equipment temperatures within allowable operating envelopes during worst-case conditions (e.g. Full power discharge on the hottest day of the year) shall be supplied through either thermal loading calculations/modelling or ESS OEM documentation.

If the thermal management system is a HVAC system, it shall have N+1 redundancy on the ESS and shall have humidity control functionality.

If the thermal management system uses coolant, evidence shall be supplied to Horizon Power verifying that the thermal management system's availability while operating at the Site Conditions will not have an adverse effect on the ESS's required availability.

The thermal management system shall make the following data available to Horizon Power SCADA:

- 1) Ambient Temperature.
- 2) Set Point Temperature.
- 3) Faults/alarm status.
- 4) Operational status.

8.2 Fire Detection and Protection (where applicable)

A fire detection and protection system shall be included within the ESS Package for Energy Storage Mediums that have the potential for thermal runaway. Energy Storage Medium technologies that are demonstrated to not have potential for thermal runaway will be exempt from Section 8.2 and Section 8.3.

The ESS design shall inherently contain fire spread and prevent thermal runaway between ESS enclosures without requiring any form of fire suppression.

The following are minimum requirements for the ESS Package fire detection and protection:

- 1) A proven fire and smoke detection system shall be contained within each ESS enclosure.
- 2) In the event of a fire in any ESS enclosure, fire shall not be able to propagate to another ESS enclosure, or other equipment or enclosures in the vicinity of the ESS Package, including in the event of battery module thermal runaway.
- 3) The battery modules used in the ESS shall be type tested to ensure that they do not explode or combust when exposed to any credible mechanical damage, heat, or fault that cannot be safely contained by the ESS enclosure.
- 4) Appropriate fire separation distances are maintained between all enclosures within the ESS Package, and any structures external to the ESS Package.
- 5) The fire detection system shall be integrated with any existing Fire Indication Panel (FIP).
- 6) All accessible enclosures that contain battery cells shall be appropriately fire rated.
- 7) The Fire Detection and Protection system shall shut down the Thermal Management System and isolate the Battery System, PCE, and open the Connection Point Circuit Breaker upon fire detection.
- 8) A signal shall be sent to Horizon Power SCADA upon fire detection.
- 9) Required testing of the fire detection system shall be able to be completed by Horizon Power Operations personnel.
- 10) 5 kg Class E fire extinguishers shall be installed at all entry points to ESS Enclosures if Emergency exit signs are required by the BCA they shall be self-illuminating.

8.3 Fire Suppression (where applicable)

If the ESS fire detection and protection system cannot be demonstrated to adequately reduce the risk of fire to a level acceptable by Horizon Power, the ESS shall include an active fire suppression system.

The minimum requirements of any active fire suppression system are:

- 1) The system shall be designed and certified to meet all applicable Australian Standards.
- 2) The suppression agent shall be widely used and an industry standard.
- 3) The system shall not require testing more than once every six (6) months.

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- 4) Two (2) separate triggers (such as heat and smoke) shall be activated in order for the fire suppression to be deployed.
- 5) The suppression agent shall be reliably and automatically released upon detection of both heat and smoke.
- 6) Appropriately sized pressure relief vent(s) shall be installed.
- 7) The fire suppression system shall have the ability to be isolated or deactivated to facilitate testing of the system.
- 8) Required testing of the fire suppression system shall be able to be carried out by Horizon Power Operations personnel.

9 STRUCTURAL REQUIREMENTS

9.1 Equipment Layout and General Arrangement

The overall layout of the ESS Package shall:

- 1) Be a layout type as defined in the “allowable layout types” in Appendix A1. Description of the layout types are defined in Table 12, and drawings of the layout types are shown in Appendix 3.

Table 12: ESS Package layout types

ESS Package Layout	Battery System location	PCE location	LV Connection Board location
Type 1	One or more separate enclosure(s)	One or more separate enclosure(s)	Separate enclosure
Type 2	One or more separate enclosure(s)	LV Connection Board contained in a single PCE enclosure. PCE may be contained within multiple enclosures.	
Type 3	Energy Storage Medium and PCE combined in a single enclosure. Additional combined PCE/ Energy Storage Medium enclosures permitted.		Separate enclosure
Type 4	Energy Storage Medium, PCE and LV Connection Board contained in a single enclosure. Additional combined PCE/ Energy Storage Medium enclosures permitted if required for capacity.		

- 2) Have the Energy Storage Medium contained in a segregated section to any equipment not associated with the Energy Storage Medium (such as the PCE). This may be achieved by using separate enclosures or having segregated compartments within the same structure.
- 3) Not restrict access to any existing or planned equipment outside of the ESS Package outlined in the Scope of Works.

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- 4) Allow a separation distance of no less than four metres between the ESS Package and any other existing or planned equipment noted in the Scope of Works.
- 5) Allow for access for any inspection, cleaning, maintenance, repair and equipment replacement in accordance with all equipment OEM requirements, including allowing for any required crane or lifting device access.
- 6) Allow for adequate ventilation of all equipment and materials.
- 7) Have the overall layout optimised to reduce electrical losses; and
- 8) Be optimised for transportability, ease of offloading, and ease of installation.

9.2 ESS Enclosure (where applicable)

All enclosures within the ESS Package shall comply with the following requirements:

- 1) All ESS enclosures shall comply with the Building Code of Australia.
- 2) All ESS enclosures shall have outward opening doors, providing access to all equipment without personnel needing to be inside the enclosure.
- 3) All ESS enclosures shall withstand expected thermal cycling without permanent distortion for the Site Conditions in the Scope of Works.
- 4) The design of the ESS enclosures shall physically separate the Battery System from all other equipment.
- 5) All ESS enclosures shall be designed to allow the removal and replacement of all enclosed equipment.
- 6) All ESS enclosures shall be vermin proof.
- 7) The minimum degree of ingress protection for all ESS enclosures shall be IP55 or greater.
- 8) All enclosures shall be designed and built to be transportable over unsealed roads and withstand the dynamic loads of transporting the entire weight of the ESS Package installed to site.
- 9) All ESS enclosures shall have engineered lifting points rated for the forces likely to be experienced while lifting and shall be certified by a structural engineer.
- 10) All ESS enclosures shall have an engineered support structure designed to raise the structure above the finished ground level. The support structure shall be designed so that the lowest point of the ESS enclosure shall be at least 0.5 m above the site 100 year flood level.
- 11) All Landings and stairs shall be designed and built to comply with AS 1657 and BCA requirements.

9.3 Battery Module Racking (where applicable)

This section is only applicable to Battery Energy Storage Systems.

Battery cells and modules for the BESS shall be installed on stands with a minimum elevation of 100 mm off the floor of the enclosure. Integrated racking systems that do not meet this requirement shall demonstrate how maintenance procedures and battery modules are not adversely affected by this.

The Battery Racks shall be appropriately designed for the support of Static and dynamic loads for the full weight of the number and type specified batteries.

9.4 Material Selection

All materials used for the ESS Package shall be proven and sufficient for the Site Conditions over the associated equipment Design Life including resistance to corrosion factors.

Products containing the following materials are not permitted to be used:

- 1) Asbestos.
- 2) Polychlorinated biphenyl.
- 3) Hexavalent Chromium.
- 4) Mercury.
- 5) Non-metallic materials shall be resistant to UV exposure and high temperatures.

9.5 Paint and Corrosion Protection

All structures and fixings shall be appropriately finished and protected for corrosion resistance, and appropriate to the Site Conditions to last for the specified Design Life without any maintenance.

All ESS enclosures and the LV Connection Board shall be compliant with the Horizon Power Standard for Coating and Colour Coding: HPC-9AJ-01-0001-2014. The external appearance of the ESS may be as supplied by the OEM.

No structural metalwork shall be embedded into the soil unless it is protected from corrosion by utilising concrete that encapsulates the metalwork, e.g. if a portion of a steel post is to be below ground level, the portion below ground level shall be embedded within a concrete pile.

9.6 Doors

All enclosures shall have sufficient external doors so that all internal equipment can be removed without having to make any modifications to the equipment enclosures, and that no personnel are required to enter any enclosures.

All exit doors to ESS building to have a minimum of two exit doors with panic bars and ensure no obstruction when exiting the building.

9.7 Locks

All enclosures and switchboards shall be lockable with the keys to be common to the site locking facilities and Horizon Power requirements.

All enclosures and switchboards contained within the ESS Package shall be lockable.

Horizon Power will supply all required padlocks and keys at the time of Operational Handover.

9.8 Signage and Labelling

All signage and labelling shall be of the type, colour, and in the locations required by the relevant Australian Standards, Building Codes, Regulations, and Horizon Power requirements.

External labels and signage shall be made of durable (able to withstand UV radiation, extreme weather), non-corrosive material such as aluminium, and printed with indelible characters. All external labels shall be fixed by suitable weatherproof adhesive. Fixing of external labels by penetrative means such as rivets or screws is not permitted where this may compromise the IP rating of the equipment.

Labels internal to enclosures may be fixed by penetrative means where this does not compromise the IP rating of the equipment. All equipment labelling shall be permanent in nature and shall be clearly identified with black on white labels engraved in no less than 6 mm letters on traffolyte or equivalent.

At a minimum, the following signs shall be displayed at appropriate points on the ESS Package equipment:

- 1) Restricted access to authorised personnel only.
- 2) PPE requirements and PPE to be worn.
- 3) Warning signs outlining:
 - That the device is automatically controlled, may start at any time; and
 - Any integrated tripping associated with opening specific doors.
- 4) Equipment maximum voltage and short circuit current.
- 5) Shutdown and isolation procedure.
- 6) LV Connection Board arc flash and current rating.
- 7) Information for emergency services.
- 8) Battery chemistry type.

Horizon Power will supply an equipment register detailing the equipment name and asset number for all required labels that shall be created and fixed prior to commissioning. The minimum equipment to be labelled is:

- 1) Each enclosure.
- 2) Each compartment within each enclosure.

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- 3) Each Battery Rack (when relevant).
- 4) Each switchboard panel.
- 5) PCE compartment(s).
- 6) Individual PCE's.
- 7) Comms and control cubicles and equipment.
- 8) Devices/ Component (relays, PLCs, media converter, network switches); and
- 9) The LV Connection Board.

9.9 Branding

The ESS shall be dressed out in Horizon Power branding prior to deployment to site. The Vendor shall supply finalised drawings of the ESS kiosk to Horizon Power's Customer & Community Team for review. The Scope of Works shall have further details on branding requirements.

9.10 Ingress Protection

All enclosures shall have an IP protection class in accordance with AS 60529 standards and to meet the requirements of the equipment being contained for the Site Conditions.

All ESS enclosures shall have a rating of no less than IP65 for outdoor enclosures, and IP54 for all other enclosures, unless otherwise approved. All enclosures shall be vermin proof.

All terminals etc. that are exposed as part of routine operation and maintenance of the switchgear, and which are energised at 50 V or above shall be shrouded to IP2X, in accordance with AS 60529.

9.11 Wind Loading Design

The ESS Package shall be suitably designed, constructed and certified to meet wind loading requirements for the Site Conditions as defined by AS/NZS 1170.2. The Wind Loading design criteria are defined in Appendix A1. Wind loading calculations verifying the ESS Package's structural suitability shall be supplied to Horizon Power.

9.12 Seismic Design

The ESS Package shall be designed for earthquakes or similar seismic events as per the requirements of AS/NZS 1170.4 using the criteria outlined in Appendix A1.

10 CIVIL REQUIREMENTS

All civil works shall be compliant with the relevant Australian standards, the Scope of Works and ESS Package OEM requirements.

10.1 Site Preparation

All site preparation shall be undertaken prior to installation of the ESS Package. This includes:

- 1) Any required clearing and grubbing of trees or roots in compliance with permit conditions.
- 2) Removal of topsoil, or any other soil, that contains significant quantities of organic material (e.g. plant roots).
- 3) Excavation and removal of any refuse, unsuitable material and/or localised softened zones identified by visual examination of the ground surface.

10.2 Bulk Earthworks & Trenching

Any required earthworks shall be carried out in accordance with the WA Code of Practice – Excavation and AS 3798.

Any required topsoil stripping shall be carried out carefully and the excavated topsoil shall be stockpiled in approved stockpile areas for re-use.

10.3 Backfill for Buried Cables and Conduit

The following requirements apply for all buried conduits and cables:

- 1) All initial backfill material over bedded cables and joints shall be clean sand, free from stone, wood, shell or any chemically active materials.
- 2) Prior to the commencement of excavation backfilling, all spaces around cable and conduits are filled and packed with clean backfilling sand.
- 3) Conduits and penetrations shall be suitably grouted where the cable exits to prevent the ingress of foreign bodies and maintain fire rating of the equipment; and
- 4) The levels and surface condition of all backfilled trenches are to be as near to the original condition as practical.

10.4 Fill Materials

Material used for fill shall require the approval of Horizon Power.

Fill material shall be:

- 1) Clean, free from all organic material, and free from damaging rocks; and
- 2) Where applicable, be well graded and suitable for compaction.

All fill materials shall be placed and compacted in successive horizontal layers of loose material, not less than 150 mm in depth and not more than 300 mm in depth.

10.5 **Compaction**

All fill material shall be compacted to the satisfaction of Horizon Power, and in accordance with good industry practice.

10.6 **Finished Surfaces**

The finished surface shall complement the ongoing operations and maintenance of the ESS Package.

The finished surface levels of all earthworks and ground surrounding the ESS Package shall be designed such that the ESS Package is capable of withstanding a 1 in 100 year's rainfall event.

The finished surface of any pad mounting structure shall comply with the requirements of the ESS OEM.

The finished site shall have an adequately graded finish such that ponding will not occur.

10.7 **Equipment Footings and Foundations**

The ESS Package shall contain all required foundations, footings, and concrete pads in accordance with the requirements of the ESS OEM. The foundations shall allow for any required operation and maintenance procedures to be carried out in accordance with the ESS OEM recommendations.

Where concrete footing foundation structures are installed, anchoring shall be supplied where required to satisfy the relevant wind loads for the Site Conditions.

10.8 **Concrete**

All concrete works shall be designed and constructed in accordance with AS 3600. Concrete work shall be supplied, formed, placed and cured to AS 3600 and other relevant standards.

Concrete shall be a durable and workable mix manufactured in accordance with Australian Standards using GP cement. The Concrete characteristic strength (f'_c) shall be at a minimum:

- 1) S32 MPa.
- 2) N15 MPa for blinding (when required).
- 3) Concrete aggregate: max 20 mm; and
- 4) Concrete slump: delivered concrete slump shall be 80 +/-20 mm.

Reinforcing steel: The following grades of steel in Table 13 shall be used for concrete reinforcement. The use of galvanised or stainless reinforcing steel shall be considered for aggressive environments.

Table 13: Corrosion Resistant Reinforcing Steel

Type	Designation Grade	Yield Strength	Standard
Plain bars	250R	fy =250 MPa	AS 1302
Deformed bars	D500N	fy =500 MPa	AS/NZS 4671
Welded Mesh	500F	fy =500 MPa	AS 1304

10.9 Anchor Bolts

Anchor bolts shall be galvanised and grade 4.6 unless otherwise specified.

10.10 Grout

All base plates shall have a minimum thickness of 30 mm of grout between base plate and concrete pedestal. No gaps shall be present in any grouting that may enable water to penetrate beneath any equipment baseplates or similar.

Grout shall not extend to vertical surfaces of the structural base plate. Grout shall be trimmed back to the lower edge of the base plate and tapered to a 45° angle once the grout has reached an initial set.

11 COMMUNICATIONS, SCADA, AND INSTRUMENTATION

11.1 ESS Controller

The ESS Controller shall be the single interface point for the ESS with the MGC and/or Horizon Power SCADA and shall have a proven interface with the Energy Storage Medium.

The use of DNP3 over TCP/IP is the preferred protocol for this interface.

If the ESS Controller is provided by a third party (i.e. is not an intrinsic part of a ESS vendor package), the ESS Controller shall be from the latest approved version of the *HPC-9NC-21-005-2020 OT Standard Equipment List*.

If the ESS Package contains an MGC, the ESS Controller shall interface with the MGC via a DNP3 over TCP/IP connection from the Horizon Power supplied network switch.

The ESS Controller shall be capable of meeting all compatibility requirements for integration into the Horizon Power SCADA system and any other local network and be compatible with all Horizon Power network firewalls.

11.2 Supported Protocol Connections

The ESS Controller or any associated or integrated RTU shall have a minimum number of protocol connections, and be capable of communicating to the MGC and Horizon Power SCADA as per the supported protocol connections requirements defined in Appendix A1.

11.3 Energy Storage Management System

The ESS ESMS/BMS shall have a proven SOC algorithm which is calibrated based on kWh throughput, cell voltage and self-consumption.

The ESMS/BMS shall monitor and make available to the ESS Controller at a minimum:

- 1) SOC (in accordance with the medium).
- 2) SOH (in accordance with the medium).
- 3) Individual battery module voltage and current.
- 4) Battery Rack voltage and current.
- 5) Battery System voltage and current.
- 6) Temperature and alarms for each battery string and battery module.

All required BMS variables, faults, and alarms shall be communicated to the MGC and Horizon Power SCADA via the ESS Controller, and shall not require the MGC or Horizon Power SCADA to interface directly with the BMS.

11.4 SCADA/Control Enclosure

All communication, SCADA, instrumentation and control equipment not contained within the ESS shall be located in the separated control and communications section of the LV Connection Board (Section 6.5). This shall include any Free Issued Materials (Section 1.3) provided by Horizon Power such as the MGC and network switch.

All communication, SCADA, instrumentation and control equipment shall be backed up by an Uninterruptable Power Supply (Section 6.13), and shall be accessible without having personnel exposed to voltages above 50 V.

11.5 Time Synchronisation

All equipment shall be time synchronised using Network Time Protocol (NTP).

11.6 Communication Protocols

The ESS Controller shall be capable of communicating (control and monitoring inputs) to the MGC and/ Horizon Power SCADA system using DNP3 TCP/IP protocol. The BMS and PCE shall also be able to communicate using Modbus TCP/IP protocol.

The ESS Controller shall be able to act as a DNP3 client and server device and connect to a single DNP3 master (MGC or Horizon Power SCADA) for monitoring and control.

The ESS Controller shall be patched into the free issued Horizon Power network switch.

Any device installed capable of communication using an industry standard protocol such as DNP3 TCP, Modbus TCP, Ethernet IP, shall be connected to the local area network with a unique IP address, so that Horizon Power can remotely access the equipment firmware interface.

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The use of serial-based communications (e.g. RS-232, RS-485) should be avoided.

During commissioning and operational trial, the ESS Controller shall be able to be accessed via the Horizon Power SCADA network for remote monitoring, maintenance and troubleshooting by the ESS OEM and Horizon Power.

In the event of abnormal system behaviour, the ESS Controller shall be capable of storing event data (alarms, digital IO state changes and analogue trends) in a data historian for a minimum of eight (8) hours, even in the case of full system shutdown. The data historian shall be accessible to Horizon Power to provide buffered data to the Horizon Power master historian once communications are re-established.

11.7 Monitoring and Alarming

The ESS shall have a monitoring and alarm system that shall:

- 1) Be equipped to log data with on-board non-volatile memory.
- 2) Contain a troubleshooting interface.
- 3) Provide data in an online format which is accessible remotely.
- 4) Provide for full remote reset functionality of the ESS.

The following data and alarms shall be available to the MGC and Horizon Power SCADA via the ESS Controller:

- 1) Energy Storage Medium System voltages (individual battery modules and battery strings).
- 2) Battery State of Charge (SOC) %; the SOC shall constantly re-calibrate against cell voltage and kWh throughput and shall update for self-consumption.
- 3) Energy Storage Medium Temperature.
- 4) PCE and BMS/ESMS fault statuses and codes.
- 5) Operating mode.
- 6) Enabled/disabled droop responses.
- 7) ESS system status (e.g. Idle, Charging, Discharging, Faulted).
- 8) ESS Controller hardware fault.
- 9) Every inter-trip.
- 10) Individual PCE phase voltage and currents.
- 11) PCE temperatures.
- 12) CB, switch and contactor statuses (AC and DC).
- 13) Active Power.
- 14) Reactive Power.
- 15) Apparent Power.

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- 16) Available Discharge Power (total system discharge KW capacity based on SOC, PCE and BMS health).
- 17) Available Charge Power (updated on availability/health of PCE and battery modules and SOC).
- 18) Parasitic Power (i.e. auxiliary power consumption).
- 19) Power Factor.
- 20) kWh exported.
- 21) kWh imported.
- 22) Auxiliary kWh consumed.
- 23) Energy Storage Medium room temperature.
- 24) Fire system status.
- 25) Auxiliary supply status; and
- 26) Thermal management system status.

Loss of communications between the ESS Controller and the MGC or Horizon Power SCADA shall generate a comms alarm. The coms alarm shall have a programmable delay for both alarming and control response.

All alarms shall be time stamped to a common time source provided by Horizon Power SCADA, and the ESS Controller shall also generate a time stamped 24-hour log file with all parameters and active control alarms recorded.

11.8 Internet Browser Interface

The ESS shall be able to be monitored and controlled by an internet browser-based interface which provides password-controlled access for a minimum of five parties.

The browser interface shall be capable of supporting different levels of access, such as operator, supervisor, engineer, system manager, etc. Access control shall be provided which requires logging of any access and function performed.

Access shall be arranged to restrict functional access to predefined users. Access privileges shall be freely definable and shall determine access to areas such as:

- 1) Functions (controls, displays, etc.).
- 2) Displays.
- 3) Controls.
- 4) Editing or creating data files; and
- 5) Database and graphic display amendment.

11.9 Displays and Trending

The ESS shall provide a display that allows users to view operational measurements, modify set points, operational parameters (e.g. ramp rates, limits etc.), change control modes and manage alarms.

This display shall be provided over the Internet Browser Interface.

11.10 Cybersecurity

Horizon Power shall configure the Horizon Power supplied network switch, and all associated cybersecurity/firewalls. All equipment shall be capable of communicating effectively with all firewalls in place.

At Operational Handover, any separate network connection to the ESS in addition to the Horizon Power corporate network connection (such as a separate 4G connection used to commission the system) shall be deactivated, so that the only way to access the ESS control system remotely is via the Horizon Power OT network.

12 TESTING AND COMMISSIONING

The ESS Package shall be commissioned and tested in accordance with:

- 1) AS/NZS 3000, AS/NZS 3017, AS/NZS 4777.1 and AS/NZS 5139.
- 2) The OEM requirements.
- 3) Horizon Power's requirements, which include:
 - As required by the Horizon Power Technical Rules (HPC-9DJ-01-0001-2012).
 - As outlined in the Scope of Works.
 - Factory Acceptance Testing (FAT) (Section 12.1)
 - Stage 1 Testing and Pre-Commissioning (Section 12.3)
 - Stage 2 Commissioning (Section 12.4).
 - Reliability Testing (Section 12.6)

Testing and commissioning records shall be maintained and provided to Horizon Power when requested and prior to Operational Handover.

12.1 Factory Acceptance Test

An integrated FAT which tests the entire ESS Package equipment and system integration shall be carried out prior to installation on site. The FAT shall be carried out with the full-sized ESS (entire Energy Storage Medium capacity and PCE installed), the fully fitted out LV Connection Board, an adequately sized load bank, and a diesel generator (or grid supply subject to sizing).

All plans and tests related to FAT including equipment required shall be submitted to Horizon Power for review and approval.

Factory Acceptance Testing includes as a minimum:

- 1) Testing that the ESS Package meets all requirements defined in this specification, excluding tests that can only be performed when the ESS Package is installed onsite; and
- 2) Benchtop testing with the MGC and Horizon Power SCADA system to verify all control and Horizon Power SCADA interfaces.
- 3) The tests required by AS/NZS 3000 Physical inspections, torque tests, Point to point, polarity and phase rotation tests.

Note: Thermal derating shall be applied to test results to represent Site Conditions.

12.2 Practical Completion

Practical completion is granted on HPs review and approval of the documentation required for the Factory Acceptance Test (Section 12.1).

12.3 Stage 1 Testing and Pre-Commissioning

Once the ESS Package has been constructed on site, pre-commissioning tests and Stage 1 commissioning tests shall be carried out.

All plans and tests related to Stage 1 Testing and Pre-Commissioning shall be submitted to Horizon Power for review and approval.

Stage 1 Testing and Pre-Commissioning includes as a minimum:

- 1) Ensuring all systems have arrived on site in place without damage and are in an acceptable condition.
- 2) Testing that the ESS Package meets all requirements defined in this specification, except for tests that can only be carried out after Operational Handover; and
- 3) Ensuring that the ESS Package can be safely connected to the power system and is ready for operation.

12.4 Stage 2 Commissioning

Stage 2 commissioning shall occur post successful Stage 1 Testing & Pre-Commissioning.

All plans and tests related to Stage 2 Commissioning shall be submitted to Horizon Power for review and approval. A functional test plan workshop is required to ensure all parties are in agreement on the testing methodology prior to the Stage 2 Commissioning.

Stage 2 Commissioning shall include as a minimum:

- 1) Testing that the ESS Package meets all remaining requirements not tested during Stage 1 commissioning as defined in this specification.
- 2) Carrying out all applicable Technical Rules compliance tests as defined in the Horizon Power Technical Rules (HPC-9DJ-01-0001-2012), refer to Appendix 4.

Note: Some Technical Rules tests may not be applicable for the Intended Use Case and/or Project specific requirements. Any omissions or changes to Technical Rules compliance tests including pass criteria shall form part of the project specific scope. All Technical Rules compliance plans and tests are to be submitted for review and approval by HP prior to the commencement of the Stage 2 Commissioning. An Operational risk assessment shall be completed for each test and be submitted for review and approval by HP.

12.5 Training

Training shall be provided to Horizon Power operational staff onsite at the completion of Stage 2 commissioning. Training shall include:

- 1) Provision of all written training materials to Horizon Power.
- 2) Detailed functional description of the individual system components and their function Description of Mechanical and Electrical Equipment.
- 3) System interfaces and communication.
- 4) Operation and control of the system.
- 5) Basic fault finding and alarm recognition.
- 6) Monitoring and maintenance of all components including battery module replacement.

12.6 Reliability Period

The ESS Package shall demonstrate continuous reliable operation free from defective performance in accordance with this specification during the Reliability Period.

The Reliability Period will not be less than 60 days.

13 DRAWINGS AND DOCUMENTATION

A Manufacturer's Data Report (MDR) shall be supplied to Horizon Power prior to Operational Handover. This shall be supplied in both electronic and hard copy form and include all drawings and documentation for the ESS Package.

Note: A durable single sided schematic-wiring diagram of the installation showing all equipment and switches shall be affixed on the site adjacent the ESS Package.

13.1 Management Process

The Vendor shall develop and manage an overall Supplier Document & Drawings List (SDDL) that details all documentation and drawings required for the Works. The SDDL is a live document, owned by the Vendor and will be issued on an agreed periodic basis to Horizon Power for review and comment; irrespective of change.

Horizon Power shall supply all drawing and document numbers on request. All requests for numbers shall be sent to Horizon Power Drawing Management Group (hpdc@horizonpower.com.au) and Horizon Power's Representative.

The Vendor shall ensure all drawings and documentation submitted to Horizon Power are uniquely numbered and revision controlled. Specific document control specifications include:

- 1) Engineering Drawings, General Requirements, Practices and Preparation of Drawings / CAD Specification, HPC-9CA-01-0001-2012.
- 2) Numbering & Titling Specification, HPC-9CA-01-0002-2012.

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All Issued for Construction (IFC) drawings and subsequent revisions, shall be submitted to Horizon Power Drawing Management Group and Horizon Power's Representative, in both .pdf and .dgn (Bentley Microstation) file formats as soon as practicable.

Prior to Operational Handover the Vendor shall ensure the following items are completed and issued to Horizon Power Drawing Management Group and Horizon Power's Representative:

- 1) All Issued For Use (IFU) documents critical to operation of the equipment.
- 2) All Red Line Mark-ups (RLM) drawings.

Prior to Completion the Vendor shall ensure the following items are completed and issued to Horizon Power Drawing Management Group and Horizon Power's Representative:

- 1) All drawings back drafted as, As-Built (AB) including RLM drawings and any non-RLM IFC drawings. Note: AB drawings must be issued in both .pdf – wet signed by draftsman and designer, pdf clean and .dgn file format.
- 2) All IFC documents contained on the SDDL that have been updated since Operational Handover or which were not issued prior to Operational Handover.

All deliverables shall be transmitted to Horizon Power Drawing Management Group at hpdg@horizonpower.com.au, and access to all drawings shall be through the same contact email.

Horizon Power reserve the right to reject drawings and/or documents which are not submitted in accordance with the Specifications (including the specifications outlined above) and the Vendor shall correct the issue and resubmit the drawing and/or document.

13.2 Drawing Requirements

The minimum required documents and drawings for the ESS Package are:

- 1) Drawing Schedule/Register in the form of SDDL.
- 2) Site layout, showing the ESS, LV Connection Board, any equipment footings, cable routes, and civil/structural works.
- 3) ESS General Arrangement.
- 4) LV Connection Board General Arrangement.
- 5) Electrical Single Line Diagram(s), showing protection and metering CT's and equipment, individual elements of Energy Storage Medium, and system DC disconnection devices.
- 6) Control and communications drawings, showing metering, protection, MGC, ESS Controller, network switch, UPS, fire detection, and communications protocol.
- 7) Primary, secondary and instrumentation wiring schematics.

13.3 Documentation

All documentation for the ESS Package shall be supplied in the MDR and include as a minimum:

- 1) All commissioning and testing documentation including Inspection and Test Records (ITR's).
- 2) Structural certification, demonstrating compliance with AS 1170.2 for the appropriate wind speed region and terrain category.
- 3) OEM test documentation, including any ESS or battery module OEM testing results.
- 4) Data sheets for all equipment, which shall include enough information on battery module and Battery Rack protection and safety devices to determine maximum arc flash potential.
- 5) A fire protection report or vendor documentation demonstrating compliance with Section 7.2.
- 6) AS 4777.2 certification, demonstrating compliance of the PCE with AS 4777.2 by an accredited testing laboratory, with an accreditation number.
- 7) Lifting instructions for all large equipment.
- 8) Equipment lists for all equipment installed, including labelling and part numbers.
- 9) Engineering calculations, including cable, circuit breaker sizing, earthing and lightning calculations and assessment.
- 10) Thermal management system calculations or vendor documentation that provides evidence of the ESS thermal management system's capability to maintain equipment temperatures within allowable operating envelopes during worst-case conditions at the site, as per Section 8.1.
- 11) A DigSilent PowerFactory Model of the ESS; that complies with the requirements defined in the Appendix I of the Horizon Power standard HPC-9DJ-13-0002-2019: Low Voltage EG Connection Technical Requirements.
- 12) Battery / Energy Storage Medium module product warranty.
- 13) Battery / Energy Storage Medium module energy capacity warranty.
- 14) PCE warranty.
- 15) MSDS's.
- 16) Operations and Maintenance Manual.
- 17) Material and electrical type test certificates.
- 18) A label and signage schedule.
- 19) Equipment performance data.
- 20) Equipment manufacturers operating and maintenance brochures.
- 21) All test certificates.
- 22) Maintenance schedules.
- 23) Troubleshooting details.

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- 24) An electronic copy of all programmable device configuration files (e.g. PLCs, RTUs, MGCs, HMIs).
- 25) Parts and spare parts information, including procurement details; and
- 26) Site maintenance records/logbooks.

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A1 ESS REQUIREMENTS

Parameter	Applicable Clause	Value
Performance Requirements		
Intended use case(s)	4.1	Refer to Scope of Works for selection
Peak Shifting	4.1.1	Option 1) or 2) see Scope of Works
Renewable Energy Smoothing	4.1.2	Option 1) or 2) see Scope of Works
Spinning Reserve	4.1.3	Option 1) or 2) see Scope of Works
Renewable Curtailment Reduction	4.1.4	Option 1) or 2) see Scope of Works
Voltage Support	4.1.5	Option 1) or 2) see Scope of Works
Frequency Support	4.1.6	Option 1) or 2) see Scope of Works
Power Quality Response	4.1.7	See Scope of Works
Reactive Power Compensation	4.1.8	See Scope of Works
Dispatch Optimisation	4.1.9	See Scope of Works
Hydrocarbons Off	4.1.10	See Scope of Works
Design Life	4.2	Refer to Scope of Works for values greater than minimum set
Battery System/Energy Storage Medium	Table 7	Min. 10 years
PCE	Table 7	Min. 10 years
ESS Enclosure	Table 7	Min. 20 years
LV Connection Board	Table 7	Min. 20 years
Controls, software and instruments	Table 7	Min. 15 years
Other electrical systems	Table 7	Min. 15 years
Cables and wirin <h>h</h>	Table 7	Min. 25 years
Civil works	Table 7	Min. 40 years
Power Capacity	4.3	Refer to Scope of Works
Minimum Power Capacity (kVA)		Specified in Scope of Works
Charge Power (kW)		Specified in Scope of Works
Discharge Power (kW)		Specified in Scope of Works
Minimum Useable Energy Capacity (kWh)	4.4	Refer to Scope of Works

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Parameter	Applicable Clause	Value
Annual Energy Throughput (kWh/year)	4.5	Refer to Scope of Works
Minimum Reactive Power Capacity (kVAr)	4.6	Refer to Scope of Works and Technical Rules Section 3.3.3.1
Minimum Fault Current Contribution (A) for Fault Duration (sec)	4.7	Refer to Scope of Works
Overload Capability (of minimum Power Capacity of ESS Package)	4.8	120% for 10 minutes, 130% for 10 seconds, unless otherwise specified in Scope of Works
Minimum Availability	4.9	95%
Power Swing Capability	4.10	100%
PQ Set-point Accuracy Tolerance	4.11	± 1.0 %
Grid Forming Droop Mode Set-point Tolerance	4.12	Refer to Scope of Works
Response Times	4.13	
Primary Control Response Time		<100 ms
Secondary Control Response Time		<750 ms
High/Low Voltage Ride Through Capability	4.14	Table 10 & Table 11
Continuous operation		90-110% of V_{nom}
A period of 10 seconds		75 – 110 % of V_{nom}
Fault Duration time plus 30 ms Safety margin		0% of V_{nom}
Frequency Ride Through Capability	4.15	Table 10 & Table 11
Minimum Over Frequency		55 Hz continuous
Minimum Under Frequency		45 Hz continuous
Minimum Round Trip Efficiency	4.16	85%
Noise Limits	4.17	< 85 dBA inside any enclosure, < 65 dBA outdoors
Quality of Supply	4.18	3ph, 415 V_{L-L} (+/- 6% settable), 50 Hz

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Parameter	Applicable Clause	Value
Voltage Flicker	4.18.1	Section 3.2.1(b) of Technical Rules
Harmonics	4.18.2	Section 3.2.1(c) and Table 2.5 of Technical Rules
Unbalance	4.18.3	Section 3.2.1(d) of Technical Rules
Equipment Warranties (Minimum)	4.19	Refer to Scope of Works for values greater than minimum
Battery System Product		10 Years
Useable Energy Capacity Product		10 Years
PCE Product		10 Years
OT/SCADA Equipment*		10 Years
Control Requirements		
Standard Operating Modes	5.2	Required
Grid Forming Droop Mode	5.2.1	Required, default operating mode of the ESS Frequency-Watt Droop Curve Slope of 4%, and Volt-Var Droop Curve Slope of 17% unless otherwise specified in Scope of Works Response "Option 1) or 2)" to be determined in Scope of Works
Grid Following Mode	5.2.2	Required, response "5.2.2.1, or 5.2.2.2, or 5.2.2.3" to be determined in Scope of Works
PQ Response	5.2.2.1	Positive and Negative power limits and ramp rate limits to be determined in Scope of Work
Frequency-Watt Droop Response	5.2.2.2	Droop of 4%, Deadband of ± 0.6 Hz, unless otherwise specified in Scope of Works
Volt-Var Droop Response	5.2.2.3	Droop of 17%, Deadband of ± 5 V, unless otherwise specified in Scope of Works
Failsafe Mode	5.3	Required
Manual Mode	5.4	Required
State of Charge Limitations	5.5	Required, configurable minimum and maximum SOC setpoints to be determined in Scope of Work

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Parameter	Applicable Clause	Value
Controllable Set Points and States	5.6	Required
Unplanned Islanding	5.7	Required, unless specified otherwise in Scope of Works
Active Anti-islanding	5.8	Required, default operating mode of the ESS
Electrical Requirements		
General	6.1	Required
Energy Storage Medium	6.2	Required, refer to Scope of Work
Power Conversion Equipment	6.3	Required, refer to Scope of Work
Switchgear	6.4	Required, refer to Scope of Work
LV Connection Board	6.5	Required
Emergency Stop	6.6	Required
Fault Current Rating	6.7	One transformer - 31.5 kA / 1 sec. Two transformers - 63 kA / 1 sec.
Electrical Cables and Wiring	6.8	Required
Earthing	6.9	Required
Lightning and Surge Protection	6.10	Required
Lighting System	6.11	Required
Auxiliary AC Supply	6.12	Required
Uninterruptable Power Supply	6.13	Required
Metering	6.14	Required, Note: HP free-issue meter
Protection Requirements		
Central Protection	7.1	Required, including Table 10
PCE Passive Anti-islanding	7.2	Required as per Table 11
PCE Active Anti-islanding	7.3	Required, deactivated by default
PCE DC Disconnection and Protection Device	7.4	Required
Battery System DC Protection	7.5	Refer to Scope of Works

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Parameter	Applicable Clause	Value
Battery Module DC Protection	7.6	Refer to Scope of Works
Synchronisation	7.7	Required
ESS Enclosure Doors	7.8	Required
Arc-flash Mitigation	7.9	Required
Mechanical Requirements		
Thermal Management System	8.1	Required
Fire Detection and Protection	8.2	Refer to Scope of Works
Fire Suppression	8.3	Refer to Scope of Works
Structural Requirements		
Allowable layout types	9.1	Refer to Scope of Works for Type 1, 2, 3 or 4
ESS Enclosure	9.2	Required, refer Scope of Work
Battery Module Racking	9.3	Refer Scope of Work
Material Selection	9.4	Required
Paint and Corrosion Protection	9.5	Required
Doors	9.6	Required
Locks	9.7	Required
Signage and Labelling	9.8	Required
Branding	9.9	Required, refer Scope of Work
Ingress Protection	9.10	Outdoor enclosures: IP65 Indoor enclosures: IP54 Exposed terminals >50 V: IP2X shrouded
Wind Loading Design	9.11	Refer Scope of Work, Terrain Category-2, 1/500 return period, unless otherwise specified in Scope of Works
Seismic Design	9.12	In accordance with Table 3.2, Figure 3.2(c) and 3.2 (d) of AS 1170.4 Earthquake Design Category: II

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Parameter	Applicable Clause	Value
Civil Requirements		
Site Preparation	10.1	Required, unless otherwise specified in Scope of Works
Bulk Earthworks & Trenching	10.2	Required
Backfill for Buried Cables	10.3	Required
Fill Materials	10.4	Required
Compaction	10.5	Required
Finished Surfaces	10.6	Required
Equipment Footings and Foundations	10.7	Required
Concrete	10.8	Required, refer to Table 13
Anchor Bolts	10.9	Required
Grout	10.10	Required
Communications, SCADA and Instrumentation Requirements		
ESS Controller	11.1	Required, unless otherwise specified in Scope of Works
Supported protocol connections for ESS Controller	11.2	Minimum of 10 x DNP3 TCP/IP, 2 x DNP3, unless otherwise specified in Scope of Works
Energy Storage Management System	11.3	Required
SCADA/Control Enclosure	11.4	Required
Time Synchronisation	11.5	Required
Communication Protocols	11.6	Required
Monitoring and Alarming	11.7	Required
Internet Browser Interface	11.8	Required
Displays and Trending	11.9	Required
Cybersecurity	11.10	Required, further requirements may be specified in Scope of Work

A2 MINIMUM INTENDED USE CASES

The ESS Package Use Cases outlined below are typical applications for ESS performance and functionality. The applications required for each project shall be specified in the Scope of Works. An example of the typical cycle scenarios which is specified in the Scope of Works is shown in Table 14.

Table 14: Typical Intended Use Case Scenario details specified in Scope of Works

Use case	Scenario	Charge C-rate	Discharge C-rate	Days per year	DOD (%)	SOC (%) Range	Cycle(s) per day
...
...
...
...
...

A3 ESS PACKAGE CONCEPT DRAWINGS

Allowable ESS Package layout drawing Types are provided in Table 15.

Table 15: ESS Package layout drawings

Layout Type	Drawing Number
Type 1	HPA-HG-EL-SLD-0001-01
Type 2	HPA-HG-EL-SLD-0001-02
Type 3	HPA-HG-EL-SLD-0001-03
Type 4	HPA-HG-EL-SLD-0001-04

A4 TECHNICAL RULES REQUIREMENTS

- (1) The Equipment shall comply with all relevant requirements of the Horizon Power Technical Rules (HPC-9DJ-01-0001-2012).
- (2) The Vendor shall produce a Technical Rules Compliance Report.
- (3) Specific references with high relevance to this Specification include but are not limited to:

Table 16: Technical Rules Clauses for ESS

Specific References	Section or Clause
Commissioning of User's Equipment	Section 4.2
Critical Fault Clearance Times	Clause 2.5.5
Design Requirements (Including Earthing requirements)	Clause 3.6.8
Duplication of Protection	Clause 2.5.2
Failure of Generator's Protection Equipment	Clause 3.4.12
Fault rating limits	Clause 2.4.4 & Clause 2.5.6
Generating Unit response to disturbance in the power system	Clause 3.3.3.3
Inspection and Testing	Section 4.1
Maximum fault currents	Clause 2.4.5
Power System Performance Standards	Section 2.2
Protection	Section 2.5
Protection (General requirements)	Clause 2.5.1
Protection (Small Generating Units)	Clause 3.4.10
Protection of Generating Units from Power system Disturbances	Clause 3.3.3.8
Protection Sensitivity	Clause 2.5.6
Quality of Supply	Clause 3.2.1 & Table 2.5
Reactive Power Capability	Clause 3.3.3.1

Specific References	Section or Clause
Requirements for Energy Storage Facilities	Section 3 – Table 3.1 outlines the relevant sections to be complied with for Battery Energy Storage Systems.
Monitoring and control requirements	Section 3.3.4
Requirements for Connection of Energy Storage Facilities	Section 3.7
Requirements for Connection of Loads (Applicable to ESS when charging)	Section 3.6
Requirement for Connection of Small Generators (≤ 10 MW)	Section 3.4
Synchronising	Clause 3.4.7.3
Tests to Demonstrate Compliance with Connection Requirements for Generators	Clause 4.1.3, HPTR Attachment 11 and refer to HPC-8DJ-12-0003-2019 Appendix A5 for minimum required tests

A5 MINIMUM HP TECHNICAL RULES COMPLIANCE TESTS FOR ESS

The minimum HP Technical Rules Compliance Tests for ESS shall be carried out in accordance with the below table and the requirements of HP Technical Rules HPC-9DJ-01-0001-2012. As Commissioned settings to be exported and provided to HP as part of final submissions, each test shall have an Operational Impact risk assessment.

Table 17: Technical Rules Testing Requirements for ESS

Testing Requirements (ESS)	Technical Rules Schedule of Tests Reference
Compulsory System Tests	C1-C14 (as applicable to Energy Storage Systems)
Special System Tests	S2, S7, S8, S11, S12, S15, S19, S20*

***Note:** The required special tests listed in the above table are the minimum tests required. Additional special tests may be required in some cases and will be specified as part of the technical project scope requirements.