

Low Voltage EG Connection Technical Requirements

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1.1	25/06/2019	Minor update to include Schedule 5 System Parameters
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Cover Note – Applicability and Requirements of the Pilbara Harmonised Technical Rules
<p>This document outlines the requirements for connecting Low Voltage Embedded Generation to Horizon Power’s systems. In accordance with the requirements of Section 3.5 of the Pilbara Harmonised Technical Rules, this document also forms the procedure setting out Horizon Power’s requirements for the connection of Low Voltage Embedded Generation to Horizon Power’s low voltage distribution system via inverters in the Pilbara Grid.</p>

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1. Introduction

The purpose of this document is to:

1. Provide Proponents of Low Voltage (LV) Embedded Generation (EG) connections, information about their obligations for connection to and interfacing with Horizon Power's low voltage (LV) distribution network (Electricity System);
2. Enable Horizon Power to meet its obligations to ensure the safe and reliable operation of the Horizon Power Electricity System for personnel, Consumers and the general public; and
3. Meet Horizon Power's obligations under Section 3.5 of the Pilbara Harmonised Technical Rules, in providing Horizon Power's requirements for the connection of Basic Embedded Generation to the Horizon Power's low voltage distribution system via inverters in the Pilbara Grid.

This document applies to all Consumer connected LV EG connections, regardless of whether such systems export electricity into the Electricity System or not.

The LV Connections Technical Requirements are prepared by Horizon Power under the Horizon Power Technical Rules Clause 3.5 and conform with the National Distributed Energy Resources Connection Guidelines for LV EG Connections as published by Energy Networks Australia (ENA) with the exception of the deviations set out in Appendix A.

For all enquiries, please contact Renewables@horizonpower.com.au.

1.1 Scope – Inclusions

Consistent with the Energy Networks Australia (ENA) Distributed Energy Resources Grid Connection Guidelines, Horizon Power has five types of EG connections, as shown in Table 1.

This document applies to new **Low Voltage EG** connections or modifications to existing LV EG connections, which can be comprised of an inverter energy system (IES) with or without an energy storage system (ESS) or non-inverter based technology.

Table 1: Connection Types

Connection Type	Connection Voltage	Technology Type	Capacity	Relevant Standard
Basic EG connection	Up to 1 kV	IES without ESS	≤30 kVA three-phase ≤10 kVA single-phase	Basic EG Connection Technical Requirements
		IES with DC Coupled ESS	≤30 kVA three-phase ≤10 kVA single-phase	
		IES with AC Coupled ESS	≤60 kVA three-phase (IES ≤30 kVA, ESS ≤30 kVA) ≤20 kVA single-phase (IES ≤10 kVA, ESS ≤10 kVA)	

Connection Type	Connection Voltage	Technology Type	Capacity	Relevant Standard
Low Voltage EG Connection	Up to 1 kV	IES without ESS (three-phase)	Determined at time of connection. Limited to 1000 kVA	Low Voltage EG Connection Technical Requirements <i>(This document)</i>
		IES with DC Coupled ESS (three-phase)		
		IES with AC Coupled ESS (three-phase)	Determined at time of connection. Limited to IES ≤ 1000 kVA, ESS ≤ 1000 kVA	
		Non-inverter based	>30 kVA and ≤1 MVA three-phase ≤10 kVA single-phase	
Medium Voltage Connection	1 kV to 35 kV	Any	Any size up to 10 MW	Horizon Power Technical Rules
High Voltage Connection	>35 kV	Any	Any size	Horizon Power Technical Rules

A Low Voltage (LV) EG connection is defined as:

A LV EG connection with a total system capacity of greater than 30 kVA and less than or equal to 1000 kVA for a three-phase IES (excluding ESS) network connection, that is:

1. intended to be connected to and capable of operating in parallel with any part of the LV distribution network (Electricity System); and
2. meeting all other technical requirements set out in this document.

OR

A LV EG connection with a total system capacity of greater than 0 kVA and less than or equal to 1000 kVA for a single-phase or three-phase non-IES (synchronous or asynchronous) network connection, that is:

1. intended to be connected to and capable of operating in parallel with any part of the LV distribution network (Electricity System); and
2. meeting all other technical requirements set out in this document.

Due to the rural nature of the Horizon Power network and its low load density connections, single phase inverter-based connections greater than 10 kVA are not permitted; the maximum single phase connection is 10 kVA capacity which is classified as a Basic EG connection.

1.2 Subcategories

The following subcategories for which different technical settings may apply for LV EG connections include:

1. **LV EG IES (excluding ESS) connection ≤ 200 kVA** – Any LV EG connection, that is not a Basic EG system, with a total system capacity less than or equal to 200 kVA for a three-phase IES (excluding ESS) network connection, meeting all relevant technical requirements for LV EG connections set out in this document.
2. **LV EG IES (excluding ESS) connection > 200 kVA** – Any LV EG connection, with a total system capacity greater than 200 kVA and less than or equal to 1000 kVA for a three-phase IES (excluding ESS) network connection, meeting all relevant Technical Requirements for LV EG connections set out in this Document.
3. **LV EG non-IES connection** – Any LV EG connection, that is synchronous or asynchronous, with a total system capacity greater than 0 kVA and less than or equal to 10 kVA for a single-phase network connection or less than or equal to 1000 kVA for a three-phase network connection, meeting all relevant technical requirements for LV EG connections set out in this document.
4. **Non-standard connections** – LV EG connections shall be initially classified as either (1), (2) or (3), plus additional requirements apply to any low voltage EG system connecting to a non-standard part of the network. Horizon Power currently identifies the NWIS as a standard network and all non-NWIS systems as non-standard networks in the application of this guideline. Refer to Horizon Power's service area map in Appendix G for more information.

In circumstances where a Premises includes LV EG connections from multiple subcategories the technical requirements relevant to each subcategory of LV EG connection apply.

For all enquiries, please contact Renewables@horizonpower.com.au.

1.3 Scope – Exclusions

This document does NOT apply to the following connection types:

1. EG units covered by Horizon Power's Basic EG Connection Technical Requirements.
2. EG units covered by the technical requirements for medium or high voltage (MV/HV) connected EG's.
3. Electric vehicles, unless the electric vehicle charger being installed has the capability to export electricity into either the Consumer's premises or the Electricity System (in which case the requirements shall apply).
4. Distributed Energy Resources (DER) systems that do not generate electricity, including demand response/demand management systems, unless they impact on the ability of the LV EG connection to meet the Technical Requirements.
5. Off-grid systems such as Standalone Power Systems (SPS), except as described in Section 4.5.2.3.

1.4 Proponent Obligations

The general obligations of Proponents include the obligation to:

1. Set LV EG connections that are IES, or ESS, to have settings applicable to region "Australia C" per AS/NZS 4777.2, with exception of the IES upper connection and reconnection frequency which are to be set at 50.5Hz.
2. Comply with Energy Management requirements (Refer to Section 4.3.4).
3. Comply with the requirements in this document as well as relevant national standards, industry codes, legislation and regulations, and any local planning and building requirements, except where otherwise stated in this document. Please refer to Section 3 for more information.

4. Ensure that the LV EG connection is compatible with the characteristics of Horizon Power's supply as defined in Section 2 of the Horizon Power Technical Rules.
5. Ensure that any IES ≤ 200 kVA shall be tested by an authorised testing laboratory and certified as being compliant with IEC 62116 for active anti-islanding protection as per AS/NZS 4777.2.
6. Not connect additional inverters, make modifications, upgrades or install additional LV EG units, including ESS, without submitting a new application to Horizon Power.
7. Notify Horizon Power in writing if an existing LV EG connection is permanently disconnected. Notification shall be provided within two months following the disconnection.
8. Comply with Horizon Power's Connection Agreement.
9. Design, procure equipment, install and operate the LV EG connection in compliance with the requirements in this document as well as all other applicable Australian Standards and Regulations and the Horizon Power Technical Rules.
10. Ensure all design and installation works for LV EG connections with renewable energy sources, including ESS, shall be undertaken by a Solar Accreditation Australia (SAA) accredited person, with valid certification appropriate to installation type at the time of the connection application.
11. Update any settings in relation to a LV EG connection upon request from Horizon Power.
12. Provide Horizon Power with full and unrestricted access to the LV EG connection, main switchboard, and any power supply, network connection, or secure gateway device (SGD) installed as part of the LV EG connection, to perform any up front and ongoing works, including but not limited to inspection, maintenance and replacement of the secure gateway device and audits for compliance purposes. Such access shall also extend to Horizon Power's authorised contractors to the extent that their authorisation permits.

1.5 Horizon Power and Proponents to Act Reasonably

1.5.1 Acting Reasonably

Horizon Power and Proponents shall act reasonably towards each other in regard to all matters under these LV EG Technical Requirements.

Whenever Horizon Power or a Proponent is required to make a determination, form an opinion, give approval, make any request, exercise a discretion or perform any act under these Rules, it must be formed, given, made, exercised or performed reasonably and on reasonable grounds, and not capriciously or arbitrarily refused, or unduly delayed.

1.5.2 Dispute Resolution

Resolution of all disputes concerning these LV EG Technical Requirements shall be on the basis of Chapter 10 of the Access Code.

1.6 Existing LV EG Connections

The Proponent's obligations in Section 1.4 apply where they relate to existing (and new) LV EG connections.

All existing LV EG connections shall comply with the relevant technical requirements that applied at the time the connection was approved to connect to the grid. Horizon Power may direct a Proponent to change the settings on an existing LV EG connection at any time, including to meet the current technical requirements, or for other reasons it determines necessary.

1.7 Modifications or Upgrades to Existing LV EG Connections

If a Proponent seeks to modify or upgrade an existing LV EG connection, a new application shall be submitted and the modified or upgraded LV EG connection shall comply with the requirements in this document.

If a Proponent seeks to install an additional LV EG connection to a Premises with an existing approved LV EG connection the following requirements shall apply:

1. The Proponent shall submit a new application.
2. The Proponent's obligations in Section 1.4 shall apply.
3. The existing LV EG connection shall be updated to comply with the most recent Energy Management Requirements in Section 4.3.4 and the Modbus maps in Appendix I of this document. For all other technical requirements, the existing LV EG connection may comply with the relevant technical requirements that applied at the time the connection was approved to connect to the grid.
4. The additional LV EG shall meet the requirements set out in this document.
5. The total system capacity (including the existing and the additional connections) shall not exceed the LV EG capacity limits shown in Table 1.

If a Proponent seeks to replace an inverter under warranty, which was connected in accordance with an earlier version of these technical requirements, that inverter can be replaced under warranty where:

1. The replacement inverter is the same make and model (like-for-like); and
2. The replacement is for warranty purposes; and
3. The replacement inverter shall be capable of Volt-Var power quality response mode, short duration undervoltage ride-through and be configured with settings applicable to region "Australia C" per AS/NZS 4777.2, with the exception of the IES upper connection and reconnection frequency which are to be set at 50.5Hz; and
4. The inverter is set up to comply with the existing connection agreement.

Where any of the above requirements in 1. to 4. cannot be met, compliance with the latest technical requirements will be required.

1.8 Modifications to Settings on Existing LV EG Connections

Following commissioning of a LV EG connection the system settings should generally not need to be changed. In cases where Horizon Power has approved a change in setting on an existing LV EG connection, the approved change in setting is deemed to comply with relevant Technical Requirements that applied at the time of that connection.

1.9 Renewable Energy Buyback

Renewable Energy Buyback may be offered on a 'net export' basis. Please refer to the Eligibility Calculator on Horizon Power's website and associated 'Terms and Conditions' for details (<https://www.horizonpower.com.au/solar/buyback/>).

2. Definitions and Abbreviations

2.1 Definitions

Table 2 provides a list of definitions relevant to this document and apply in addition to defined terms listed in the relevant Australian Standards (including AS/NZS 3000 and AS/NZS 4777), Western Australian Electrical Requirements (WAER) and Electricity (Licensing) Regulations.

Table 2 : Definitions

Term	Definition
Break before make switch	A switch that opens a connection prior to closing the new connection.
Bumpless transfer	The Consumer's load is transferred from the Distribution Network to the Embedded Generation or from the Embedded Generation to the Distribution Network, and there is no loss of Supply to the Consumer load.
Central protection	Central protection is the protection contemplated by AS/NZS 4777 (grid connection of energy systems via inverters) installed to perform the functions of: coordinating multiple inverter energy system installations at one site, providing protection for the entire inverter energy system installation and islanding protection to the connected grid as well as preserving safety of grid personnel and the general public.
Connection point	As defined in Western Australian Service and Installation Requirements (WASIR).
Consumer	The party to the connection agreement with Horizon Power for the provision of a retail supply or covered service at a connection point.
Contribution Agreement	An agreement between Horizon Power and a Consumer whereby that Consumer agrees to procure Solar Smoothing Services from Horizon Power.
Coordination	The use of technologies such as Embedded Generation local or remote control to adjust consumption by, or export from, Distributed Energy Resources for the benefit of the Electricity System.
Current Transformer (CT)	A current transformer is used for measurement of alternating electric currents.

Term	Definition
Distributed Energy Resources (DER)	<p>Power generation or storage units that are connected directly to the Electricity System.</p> <p>A general description for the range of distributed energy devices such as dispersed power generation (including solar PV), energy storage, demand management and smart inverters located at Consumer premises or connected directly to the Electricity System.</p> <p>Whilst DER is often used to refer to renewable generation sources, it also includes dispersed non-renewable generation sources.</p>
Distributed Energy Resources Management System (DERMS)	Horizon Power's control system for managing distributed energy resources.
Document	This document and any annexed schedules, together with any document referred to, or incorporated into, this document.
Electrical installation	As defined in AS/NZS 3000.
Electricity system	The electricity grid owned and operated by Horizon Power and connected to the Premises.
Embedded generating unit	A generating unit connected within an Electricity System and not having direct access to the transmission network.
Energy Management	A type of Generation Control, where the output from a EG can be remotely managed by Horizon Power, as required, to protect the safety of personnel or the public, manage threats to power system security, and or to prevent damage to electrical plant and equipment.
Energy Storage System (ESS)	A system comprising one or more energy storage devices that store electricity generated by distributed energy resources or directly from the grid, and that can discharge the electricity to loads.
ESS capacity	<p>The Energy Storage System capacity (kVA)</p> <p>Note ESS Capacity does not refer to the energy capacity (i.e. kWh) it refers to the IES capacity directly associated to the ESS (kVA).</p>
Final loads	All electrical loads on the Consumer's premises not part of the Renewable Energy Installation.
Generating unit	The plant used in the production of electricity and all related equipment essential to its functioning as a single entity.
Generation	The production of electrical power by converting another form of energy in a generating unit.
Generation control	The use of technologies such as EG local or remote control and DERMS to control the output of the EG.
Generation management	Refer to Generation Control

Term	Definition
Generator	A person who owns, operates or controls a generating unit.
Grid	The Electricity System.
Grid Connected	Where the LV EG Connection is capable of operation in parallel with the Electricity System.
Installer	The person who installs and commissions the LV EG connection on behalf of the proponent.
Inverter	The device forming part of an EG system which: <ul style="list-style-type: none"> a) limits the DER Electricity exported to the Electricity System; b) complies with the technical requirements in this document; c) may convert direct current generated electrical energy into alternating current electrical energy; and d) relates to the AS/NZS 4777 definition.
Inverter Energy System (IES)	A system comprising of one or more inverters that convert direct current to alternating current.
IES capacity	The inverter energy system nameplate rating (kVA).
Low Voltage (LV)	The mains voltages as most commonly used in any given network by domestic and light industrial and commercial consumers (typically 240 V, 415 V).
Make before break switch	A switch that results in a momentary, or longer, connection between grid supply and the downstream Generation supply circuits when performing a changeover.
Maximum system capacity	The maximum nameplate rating (kVA) of an individual LV EG connection at a premises.
Maximum aggregate system capacity	The maximum allowable aggregate nameplate rating across all LV EG connections at a premises. The maximum allowable total system capacity for LV EG connections on different strata titles, but at the same network connection point (e.g. retirement villages) is defined at the connection point.
Medium Voltage (MV) / High Voltage (HV)	Any voltage greater than 1 kV AC.
Metering equipment	As applicable, the import, export, bi-directional, parallel and revenue meters installed at the Premises to measure the import and export of electricity to the Consumer's Premises.
Multiple mode inverter	An inverter that operates in more than one mode; for example, having grid-interactive functionality when mains voltage is present, and stand-alone functionality when disconnected from mains supply. A stand-alone inverter that can inject energy into the grid would be considered a multiple-mode inverter.

Term	Definition
Notice of Completion	A notice of completion as required under Regulation 52 of the <i>Electricity (Licensing) Regulations 1991</i> (WA).
Off-grid system	A property which does not have Horizon Power's metering system on their Premises and / or is not connected to Horizon Power's Electricity System; this document is not applicable to an off-grid system except circumstances discussed in Section 4.5.2.3.
Power conversion equipment	An electrical device that converts one kind of electrical power from a voltage or current source into another kind of electrical power with respect to voltage, current and frequency. This category is for devices which are not IES, but are connected between a renewable energy generator and an application circuit. Examples include DC/DC converters and charge controllers. Shall have the same meaning as defined in AS/NZS 4777.
Preliminary notice	The preliminary notice for notifiable works shall be provided as per the <i>Electricity (Licensing) Regulations 1991</i> .
Premises	The premises nominated in the Application Documents, or existing Connection Agreement, owned or occupied by the Consumer, which must be the same Consumer supplied at that premises in accordance with an Electricity Supply Agreement.
Proponent	A person proposing to become a Generator (the relevant owner, operator or controller of the generating system (or their agent)).
Photovoltaic (PV)	A renewable energy generation device that creates electrical energy as a result of harnessing energy from the sun collected on photovoltaic cells.
Registered generator	For Horizon Power this means a generator greater than 10 MW.
Renewable Energy Smoothing	Participating Consumers with Renewable Energy Smoothing Devices that mitigate system instability risks. For example; energy storage, load control or any other method that meets the required ramp rates.
Renewable Energy System	A system used for the generation of electricity from a renewable energy source, that has a generating capacity exceeding 1.5 kW but not exceeding 1 MW unless otherwise agreed in writing by Horizon Power.
Renewable Source Electricity	Electricity generated by a Renewable System.
Secure gateway device (SGD)	This is the control interface between the Proponent's LV EG connection and Horizon Power's communications system. This device is for the purposes of Energy Management of the LV EG connection.

Term	Definition
Single Wire Earth Return (SWER)	Parts of the Electricity System that use a single live conductor to supply single-phase or split-phase electric power with higher network impedances, and with distribution supplying low voltages to premises.
Site generation limit	The generation threshold that the embedded generation system cannot exceed, measured downstream of the connection point.
Solar Smoothing Services	<p>The Solar Smoothing Services provided by Horizon Power which may include, but are not limited to:</p> <ul style="list-style-type: none"> a) provision of BESS or other primary infrastructure for the purposes of addressing credible contingencies and intermittency effects which may arise on the Electricity System as a result of the installation of an LV EG connection consistent with that installed or to be installed by the Proponent; b) electrical connection of that infrastructure to the Electricity System; c) provision of control systems including Energy Management to coordinate and manage the effects of an LV EG connection on the Electricity System; d) operation of the infrastructure and control systems in a suitable control mode (for example frequency control) to mitigate against credible contingencies and intermittency effects which may arise on the Electricity System as a result of the installation of a LV EG connection consistent with that installed or to be installed by the Proponent; and e) any required maintenance, repair and replacement of the infrastructure and control systems.
Stand-alone inverter	An inverter that is not designed to inject power into the grid, and is used for the supply of extra-low (ELV) and/or low voltage (LV) electric power to a single load, or an electrical installation via batteries or a renewable resource, PV, wind, hydro etc. The inverter may or may not contain a charging function.
System diagram	A conceptual diagram that illustrates the relationships between separate subsystems using lines.
System impact study	A system study to assess the impact of renewable energy connection on Horizon Power's generation and transmission & distribution network.
System instability	A disturbance to the Electricity System that affects the reliability and quality of power to Consumers.
Technical Requirements	The provisions set out in this Document, including any relevant requirements in the Horizon Power Technical Rules HPC-9DJ-01-0001-2012.

Term	Definition
Total system capacity	<p>The aggregate nameplate rating (kVA) of all individual EG systems at a premises.</p> <p>The total system capacity for LV EG connections on different strata titles, but at the same network connection point (e.g. retirement villages), is defined as the aggregate nameplate rating (kVA) of all individual EG systems at the connection point.</p>
Vehicle-to-Building (V2B)	An electric vehicle that storage system that is capable of exporting energy into the Consumer's premises but not the Electricity System, resulting in a minimal-export configuration (also referred to as Vehicle-to-Building or V2B).
Vehicle-to-Grid (V2G)	An electric vehicle that storage system that is capable of exporting energy into the Electricity System, resulting in either a full or partial export configuration (also referred to as Vehicle-to-Grid or V2G).
Wind	A renewable energy generation device that creates electrical energy as a result of harnessing moving air.

2.2 Acronyms

Table 3 provides a list of all acronyms used in this document.

Table 3: Acronyms

Abbreviation or Acronym	Definition
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AS/NZS	A jointly developed Australian and New Zealand Standard
CEC	Clean Energy Council
CT	Current Transformer
DER	Distributed Energy Resources
DERMS	Distributed Energy Resources Management System
DNSP	Distribution Network Service Provider
DRM	Demand Response Mode
EG	Embedded Generation
ENA	Energy Networks Australia
ESS	Energy Storage System
HV	High Voltage
IEC	International Electrotechnical Commission
IES	Inverter Energy System
LV	Low Voltage
MEN	Multiple Earthed Neutral
MV	Medium Voltage
NER	National Engineering Register
NIA	Network Impact Assessment
NMI	National Metering Identifier
NWIS	North West Interconnected System
PCE	Power Conversion Equipment
PLC	Programmable Logic Controller
PV	Photovoltaic

Abbreviation or Acronym	Definition
SAA	Solar Accreditation Australia
SCADA	Supervisory Control and Data Acquisition
SGD	Secure Gateway Device
SIS	System Impact Study
TCP/IP	Transmission Control Protocol/Internet Protocol
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
WAER	Western Australian Electrical Requirements
WASIR	Western Australian Service and Installation Requirements

2.3 Terminology

The following instructional terms are to be interpreted as follows:

1. The word 'shall' indicates a mandatory requirement
2. The word 'may' indicates a requirement that may be mandatorily imposed on the Proponent
3. The word 'should' indicates a recommendation that will not be mandatorily imposed on the Proponent.

3. Relevant Rules, Regulations, Standards and Codes

3.1 Relevant Rules, Regulations, Standards and Codes

Table 4¹ lists reference material containing requirements for the design, manufacture, installation, testing and commissioning, and operation and maintenance of all plant and equipment for LV EG connections to the Horizon Power Electricity System.

Unless otherwise stated within this document, the Proponent shall comply with the current versions of all relevant legislation, regulations, codes, technical requirements, Australian Standards, and applicable industry guidelines listed here, and any local planning and building requirements, as well as any other applicable requirements not explicitly stated.

Table 4: Reference Documentation

Horizon Power and Other Documents	
WA Service and Installation Requirements (WASIR)	
Pilbara Harmonised Technical Rules	
HPC-9DJ-01-0001-2012	Horizon Power Technical Rules
HPC-9FJ-13-0001-2018	Horizon Power Standard for Bumpless Transfer of Embedded Generators.
Legislation and Regulations	
WA Electricity Industry (Code of Conduct) Regulations 2005	
WA Electricity Licensing Regulation 1991	
WA Electricity Act 1945	
WA Electrical Requirements (WAER)	
Electricity Industry (Network Quality and Reliability of Supply) Code 2005	
Electricity Regulations, WA, 1947	
Codes	
WA Electricity Industry (Metering) Code 2012	
Australian and International Standards	
AS/NZS 3000	Electrical Installations (Wiring Rules)
AS/NZS 3011	Electrical Installations – Secondary batteries installed in buildings
AS/NZS 3017	Electrical installations — Verification guidelines

¹ The Relevant Standards, Codes, Legislation and Regulation have been provided in a single table for convenience, rather than in separate sections as suggested in the National Distributed Energy Resources Connection Guidelines for Low Voltage EG Connections.

AS/NZS 3100	Approval and Test Specification – General Requirements for Electrical Equipment
AS/NZS 4777.1 2024	Grid Connection of Energy Systems via Inverters
AS/NZS 4777.2	Grid Connection of Energy Systems via Inverters
AS/NZS 5033	Installation and Safety Requirements for Photovoltaic Arrays
AS/NZS 5139	Electrical Installations – Safety of Battery Systems for use with Power Conversion Equipment
AS 60947.6.1: 2015	Low-voltage switchgear and control gear Part 6.1: Multiple function equipment— Transfer switching equipment
AS IEC 62619:2017	Safety Requirements for lithium cells and batteries
IEC 62109 (all parts)	Safety of Power Converters for use in Photovoltaic Power Systems
IEC 62116	Utility-Interconnected Photovoltaic Inverters – Test Procedure of Islanding Prevention Measures
Guidelines	
Battery Energy Storage Systems: A guide for Electrical Contractor	
National Distributed Energy Resources Grid Connection Guidelines – Framework and Principles	
National Distributed Energy Resources Grid Connection Guidelines – Framework and Principles – Technical Guidelines for LV EG Connections	

3.2 Order of Precedence

In the event of any inconsistency arising in the requirements outlined in the reference documents listed in Table 4, the following order of precedence in Table 5 shall apply.

Table 5: Order of Precedence (Highest to Lowest)

Order	Reference Document
1	Legislation
2	Regulations
3	Technical Requirements
4	Australian Standards, Codes and Guidelines

The Proponent shall notify Horizon Power of any such conflict prior to undertaking work in relation to this document.

4. Technical Requirements

All LV EG connections that operate in parallel with Horizon Power Electricity System whether they are exporting, partial-exporting or non-export systems, shall comply with all relevant technical requirements in this document.

Table 6 summarises the key technical requirements and considerations for different subcategories of LV EG connections. Additional technical requirements also apply and are contained in relevant sections of this document. In circumstances where a Premises includes LV EG connections from multiple subcategories the technical requirements relevant to each subcategory of LV EG connection apply.

Notes in relation to Table 6:

- 1 Proponents shall ensure that all LV EG connections that are of type IES or ESS have settings applicable to region “Australia C” per AS/NZS 4777.2, with exception to the upper IES reconnect frequency which is to be set 50.5Hz.
- 2 Proponents shall comply with Energy Management requirements, and install equipment required to interface to Horizon Power’s Distributed Energy Resources Management System (DERMS). Refer to Section 4.3.4.
- 3 Renewable Energy Smoothing, or entry into and compliance with a Contribution Agreement for Solar Smoothing Services, is required for all low voltage EG connections in non- standard network areas.
- 4 Export limit represents a limit applied to the generation of active power (kW) from the LV EG connection expressed at the connection point.

4.1 Labelling and Signage

For LV EG connections labels and signs on the installation, including cables shall be as per AS/NZS 4777 (all parts), AS/NZS 3000, AS/NZS 5033 and AS/NZS 5139.

The LV EG connection must include a durable single sided schematic-wiring diagram of the installation showing all equipment and switches affixed on the site adjacent the inverter system.

Additional labelling requirements also apply for Energy Management (refer to Appendix H) and LV EG connections with bumpless transfer (refer to Section 4.5.2.2).

4.2 Maximum System Capacity

The maximum system capacity for each subcategory of LV EG connection is shown in Table 6.

4.2.1 Connections on different strata titles, but at the same connection point

The system capacity for LV EG connections on different strata titles, but at the same network connection point (e.g. retirement villages), are to be defined by the capacity at the connection point.

Table 6: Summary of Key Technical Requirements

Technical Requirements – LV EG connections						
LV EG Connection Subcategory	LV EG IES (excluding ESS) connection ≤ 200 kVA		LV EG IES (excluding ESS) connection > 200 kVA		LV EG non-IES connection	
Maximum Aggregate System Capacity	IES without ESS (three-phase)	200 kVA	IES without ESS (three-phase)	Determined at time of connection. Limited to 1000 kVA	Single-phase	≤ 10 kVA
	IES with DC Coupled ESS (three-phase)		IES with DC Coupled ESS (three-phase)			
	IES with AC Coupled ESS (three-phase)	IES ≤ 200 kVA, ESS ≤ 200 kVA	IES with AC Coupled ESS (three-phase)	Determined at time of connection. Limited to IES ≤ 1000 kVA, ESS ≤ 1000 kVA	Three-phase	> 30 kVA and ≤ 1 MVA three-phase Determined at time of connection.
Energy Management	Energy Management is a requirement for all LV EG connections (Refer to Section 4.3.4).					
ESS Required?	As required for Renewable Energy Smoothing					
Renewable Smoothing	In non-standard network areas only					
Maximum Aggregate Export Limit at the Connection Point	To be determined by Horizon Power at the time of application					
Additional Export Limit Control Requirements at the Connection Point	Under certain circumstances only, as determined by Horizon Power (Refer to Section 4.3.2)					

Technical Requirements – LV EG connections	
Phase Balancing Requirements	<p>Phase balancing control does not apply to single-phase LV EG connections on single-phase supplies.</p> <p>Where a multiple-phase IES is used and comprised of individual single-phase inverters, or single-phase-inverters in combination with three-phase inverters:</p> <ul style="list-style-type: none"> the difference in current injected into any two phases shall not exceed 20.8 amps (being 5 kVA at 240 V) for more than 15 seconds; and Where the nameplate rating of any two individual inverters differs by more than 5 kVA Central Protection shall be installed in accordance with Section 4.3.6 and Section 4.7.2.2.
Central Protection	Central Protection is required. Refer to Section 4.7.2
Network Impact Assessment	A Network Impact Assessment will be performed by Horizon Power
System Impact Study	A System Impact Study will be performed by Horizon Power.
System Diagram	Refer to Appendix B.

4.3 Generation Control

LV EG connections require Generation Control in accordance with the following requirements.

4.3.1 Export Limits at the Connection Point

Horizon Power will assess whether an LV EG connection requires an export limit at the connection point during the connection application process. The Proponent may choose to apply a specific export limit if required. In these circumstances the Proponent shall advise Horizon Power of the required export limit as part of the connection application.

Factors to be considered in determining the export limit include, but are not limited to:

- Existing asset ratings, including main switch rating (refer to Section 4.3.3 and 4.5.1).
- Existing power quality at the relevant network location.
- Existing and forecast DER penetration at the relevant network location.

In circumstances where Horizon Power requires an export limit at the connection point the export limit is the maximum aggregate export limit accounting for all individual LV EG connections that may be connected to the Premises.

The export limit control function shall be interpreted as a maximum “soft limit” causing the IES or non-IES LV EG connection to reduce its output so that the export limit is not exceeded for more than 15 seconds at the connection point.

Irrespective of the type of LV EG connection, where a fault or loss of operability is detected with the soft limit control function the output from the inverter or multiple inverter combination is reduced to zero within 15 seconds.

Export limit control functions may be integrated into the IES or ESS, where relevant, or managed using an external device. Export limit control functions shall not interfere with the anti-islanding protection. The settings for export limit controls must be password protected.

The ability of the Proponent’s LV EG connection to export at the export limit is not guaranteed, but rather, it will depend upon network characteristics which change over time. For example, power quality response modes may reduce export under high or low voltage conditions.

ESS that stores energy may be used to assist with managing the export limit requirements.

4.3.2 Additional Export Limit Requirements

In the event of network or contractual constraints, Horizon Power may require any subcategory of LV EG connection (including ESS) to permanently have a lower export limit than that defined in Section 4.3.1, including a zero-export limit. Where a lower export limit is required, it shall not be exceeded for more than 15 seconds at the connection point, consistent with the definition of “soft limit” per AS/NZS 4777.1 and AS/NZS 4777.2.

4.3.3 Main switch compatibility

Section 4.5.1 contains information on the installation main switch requirements. The export limit at the connection point shall not exceed the capability of the installation main switch at the Premises.

The Proponent may separately apply to Horizon Power for an increase in the allowable network service capacity so that the Proponent can upgrade the installation main switch and service protection device, where relevant, to increase the export limit. Where such an upgrade is not approved by Horizon Power the LV EG export limits at the connection point shall be limited to avoid exceeding the rating of the installation main switch.

4.3.4 Energy Management

Horizon Power requires control of the LV EG connection to protect the safety of personnel or the public, manage threats to power system security, and prevent damage to electrical plant and equipment.

The Proponent shall allow Horizon Power to connect to the LV EG connection via Horizon Power's Distributed Energy Resources Management System (DERMS), and via the Consumers Inverter Manufacturer portal, to monitor and control the LV EG connection and to remotely disconnect the LV EG connection from and reconnect it to the Electricity System.

Horizon Power will provision and supply a Secure Gateway Device (SGD) to allow Energy Management of the LV EG connection via Horizon Power's DERMS. Horizon Power will own and maintain the SGD.

All Proponents of LV EG connections shall provide the necessary facilities to interface to the SGD at the time of connection.

The Energy Management subsystem shall comply with functional requirements including but not limited to:

- Enable monitoring of the LV EG connection.
- Enable remote control of the LV EG circuit breaker.
- Enable remote control of the active power output of the LV EG connection.
- Enable remote control of the reactive power output of the LV EG connection.
- Enable remote updating of inverter settings via the inverter manufacturer portal.

Further detail on the Energy Management requirements are provided in this section and in Appendix H.

Further detail on the communications system requirements is provided in Section 4.11.

4.3.4.1 Energy Management – Proponent Obligations

The Proponent shall satisfy the following requirements for IES LV EG connections. The extent to which non-IES LV connections shall satisfy the requirements will be determined by Horizon Power on a case-by-case basis.

- Allow Horizon Power to remotely monitor and control the LV EG connection via Horizon Power's Distributed Energy Resources Management System (DERMS) and connect to the inverters comprising the LV EG connection via the Consumers Inverter Manufacturer portal, *including changing of inverter settings as required*.
- Provide active communication between the LV EG connection and Horizon Power via a secure gateway device (SGD – refer Appendix H) and Horizon Power's communication infrastructure.
- Provide a single control interface between the LV EG connection and the SGD (the LV EG connection control system). Configure the LV EG connection control system to provide suitable control and monitoring inputs to Horizon Power's SGD. Horizon Power requires that the LV EG connection control system has Modbus TCP protocol capabilities, and the LV EG connection control system must comply with the Modbus mapping table in Appendix I.
- Provide a single-phase 240 V AC general purpose outlet (GPO) with an external weatherproof switch in accordance with Appendix H. The GPO will supply power to the SGD.
- Provide a hard-wired ethernet internet connection to the supplied SGD. The ethernet internet connection will be connected to the Consumer's internet connection and shall be used to connect the supplied SGD to the internet via the Consumer's internet modem router and Horizon Power's DERMS.

- The Consumer's internet connection shall be active at all times and provide a Dynamic Host Configuration Protocol (DHCP) service. The LV EG connection may be disconnected during periods where an active internet connection is not available.
- Provide an enclosure which will house the GPO along with all terminations of the ethernet internet and LV EG connection control system communications, in accordance with Appendix H.
- Provide a suitably protected and IP rated Ethernet cable connection (minimum Cat 5e 300V RMS rated) from the LV EG control system communications port to the SGD enclosure.
- Provide a separate internet connection to each inverter making up the LV EG connection for the purposes of connecting each inverter to the inverter manufacturer's platform.
- Install and commission the GPO, hard-wired ethernet internet connection, SGD enclosure, SGD (provided by Horizon Power) and any associated wiring and accessories, in accordance with Appendix H.
- Connect the SGD to the internet via the hard-wired ethernet internet connection, LV EG connection control system via the Ethernet cable, and to the power supply.
- Install any replacement gateway devices which may be required from time to time.
- Complete Appendix J – LV EG Connection Control System Information Sheet and return to Horizon Power.

4.3.4.2 Energy Management – Horizon Power Obligations

Horizon Power shall undertake the following in relation to the Energy Management subsystem:

- Supply an approved and preconfigured gateway device which will be owned by Horizon Power.
- Confirm the commissioning of the LV EG communications subsystem is to the satisfaction of Horizon Power.
- Perform control and monitoring of the LV EG installation output.

4.3.4.3 Energy Management Functional Requirements

The Energy Management subsystem shall comply with the functional requirements outlined in Table 7.

Table 7: Communications Functional Requirements

Requirement	Description	Mandatory (Y/N)
Monitoring	Monitoring the output of supported inverters. Make the data listed in Appendix I available to Horizon Power.	Y
Monitoring for Batteries	Additional monitoring is required for installations with batteries, as detailed in Appendix I.	Y
Control – System Disconnection & Reconnection	Disconnect and reconnect the LV EG connection from the network.	Y
Control Gross Output	Receiving a signal from Horizon Power, controlling the active power gross output of the LV EG connection including both PV generation and batteries.	Y
Loss of Communications – Gross Setpoint	Default to safe level of active power gross output in the event of loss of communications with Horizon Power.	Y
Control Reactive Power Output	Receiving a signal from Horizon Power, controlling the reactive power output of the LV EG connection.	Y
Control of Inverter Settings	Allow remote updates to inverter settings via inverter manufacturer portal in accordance with Horizon Power's Technical Requirements for Distributed Energy Resources	Y
Control of Batteries	Ability to enable and disable energy storage charging from the grid, set maximum charge and discharge limits, and initiate charging and discharging of batteries.	Y
Loss of Communications – Reactive Power Setpoint	Default to safe level of reactive power output the event of loss of communications with Horizon Power.	Y

4.3.4.4 Monitoring of the LV EG Connection

Horizon Power requires the signals listed in Appendix I to be monitored and sent back via Horizon Power's SGD interface.

Monitoring must be made available at a summary level information for the Premises.

4.3.4.5 Controlling the LV EG Circuit Breaker

The LV EG circuit breaker must be able to be remotely controlled by Horizon Power. Appendix B outlines the connection arrangements and single line drawings applicable for LV EG connections, including location of circuit breakers. Appendix H provides additional information regarding the configuration of the Proponent's LV EG connection to communicate via the DERMS.

A pulse on digital command signal shall be sent via Horizon Power's DERMS to the Proponent's LV EG connection gateway device to open / trip the circuit breaker. A separate pulse on digital command shall be sent to close the circuit breaker. The LV EG connection circuit breaker open and close status signals are required to be readable by the LV EG connection either as hardwired digital inputs or communications digital inputs (via protection relay).

The digital Trip LV EG connection Isolation Point command is a pulse output signal issued by the DERMS to trip the LV EG connection isolation point. Note that the actual isolating function is performed by the local LV EG control system.

The digital Close LV EG connection Isolation Point command is a pulse output signal issued by the DERMS to close the LV EG connection isolation point. Note that the actual isolating function is performed by the local LV EG connection control system.

4.3.4.6 Controlling the Active Power Output

The following signals will be issued for control of LV EG connections via Horizon Power's DERMS:

- Setpoint – Maximum (%) gross output as measured at the terminals of the LV EG connection.
- Setpoint – Transition ramp rate (% gross output per second) from one output level to the next.

The LV EG connection shall ramp the power output of the inverter(s) to the power setpoint advised by Horizon Power at a ramp rate to be configured by Horizon Power. The transition ramp rate shall be sent as a parameter via Horizon Power's DERMS. The configurable ramp rate enables the target setpoint to be achieved without causing a sudden step change in the power station load.

When any new LV EG connection is commissioned, it must be initially configured with a transition ramp rate equal to the renewable smoothing ramp rate in Section 4.3.4.

4.3.4.7 Controlling the Reactive Power Output

The Proponent's LV EG connection monitoring and control system must respond to the following signals, issued via Horizon Power's DERMS:

- Setpoint – Reactive power output as measured at the terminals of the LV EG connection (kVAr)

The Proponent shall control system output as per the set-points provided.

4.3.5 Site Generation Limit Downstream of Connection Point

Site generation limits downstream of the connection point of the LV EG connection may be applicable and shall be determined by Horizon Power at the time of application.

Factors to be considered in determining the site generation limit include, but are not limited to:

- Retail and market operations.
- Existing asset ratings.
- Existing power quality at the relevant network location.
- Existing and forecast DER penetration at the relevant network location.

4.3.6 Phase Balancing Control

For LV EG connections, the Proponent shall ensure there is no more than 5 kVA unbalance between any phases as per AS/NZS 4777.1 at the connection point.

Phase balancing control does not apply to single-phase LV EG connections.

All LV EG connections comprised of a multi-phase inverter must satisfy the current balance requirements in Section 2.11 of AS/NZS 4777.2.

Where a multiple-phase IES is used and comprised of individual single-phase inverters, or single-phase-inverters in combination with three-phase inverters:

- the difference in current injected into any two phases shall not exceed 20.8 amps (being 5 kVA at 240 V) for more than 15 seconds; and
- Where the nameplate rating of any two individual inverters differs by more than 5 kVA Central Protection shall be installed in accordance with Section 4.7.2.2.

Irrespective of the method used to mitigate the current phase unbalance on a site, the requirements of AS/NZS 3000 clause 3.4.1 shall be met.

4.3.7 Charging of ESS from the Electricity System

Under normal operation, charging of ESS from the Electricity System is permitted in accordance with the technical requirements of this document.

For systems with Energy Storage installed for smoothing and Export Limit requirements, the grid connected Inverter shall not supply power to the local load until the Energy Storage Devices have sufficient energy stored to meet the ramp rate requirements described in Section 4.3.8.

Horizon Power may at any time direct the enabling or disabling of ESS charging, with settings as required by Horizon Power. If Horizon Power directs the disabling of ESS charging, ESS will still be permitted to charge in three circumstances:

1. to manage overfrequency disturbance events, in accordance with AS/NZS 4777.2 (Sections 3.4.3 and 4.5.3.1) for region "Australia C".
2. to maintain battery health. One cycle of the ESS per month (in aggregate) is permitted for this purpose.
3. for ramp rate testing purposes.

Any Proponent found to be charging ESS from the Grid not in accordance with these requirements, may have their LV EG connection disconnected from the Electricity System until the LV EG connection is shown to have been modified to meet these technical requirements.

4.3.8 Renewable Energy Smoothing Requirements

Renewable Energy Smoothing, or entry into and compliance with a Contribution Agreement for Solar Smoothing Services provided by Horizon Power², is required for LV EG connections in non-standard network areas (refer to Appendix G for more information on non-standard areas).

In circumstances where a Proponent enters into a Contribution Agreement for Horizon Power to provide Solar Smoothing Services the Proponent does not need to provide renewable energy smoothing locally at the Premises; the requirements in this Section 4.3.8 do not apply in this case.

If Renewable Energy Smoothing is required and a Solar Smoothing Service is not provided by Horizon Power, the Proponent shall meet the following requirements locally at the Premises.

Controlling the ramp rate of the Inverter output is a requirement of the Renewable Energy Smoothing type of Generation Control. Renewable Energy Smoothing requires the Proponent to install an Energy Smoothing Device (or alternative technology)³ that provides for a gradual ramp-up or ramp-down over a period of time if the Renewable Source Electricity output changes too suddenly (ramp down is shown in Figure 1). This allows enough time for Horizon Power and Independent Power Producers to ramp up their generation assets to cover for a loss in Consumer generation. The method for achieving the required ramp rate is at the discretion of the Proponent.

² Refer to the definition of Solar Smoothing Services for more information on what this service includes.

³ Load control or other technologies may be accepted if proven and signed off by an NER accredited engineer.

The Renewable Energy Smoothing Requirements applies at the terminals of the LV EG connection (being the combined response of the inverter and Proponents smoothing device), although Horizon Power may also accept control at the connection point under some circumstances.

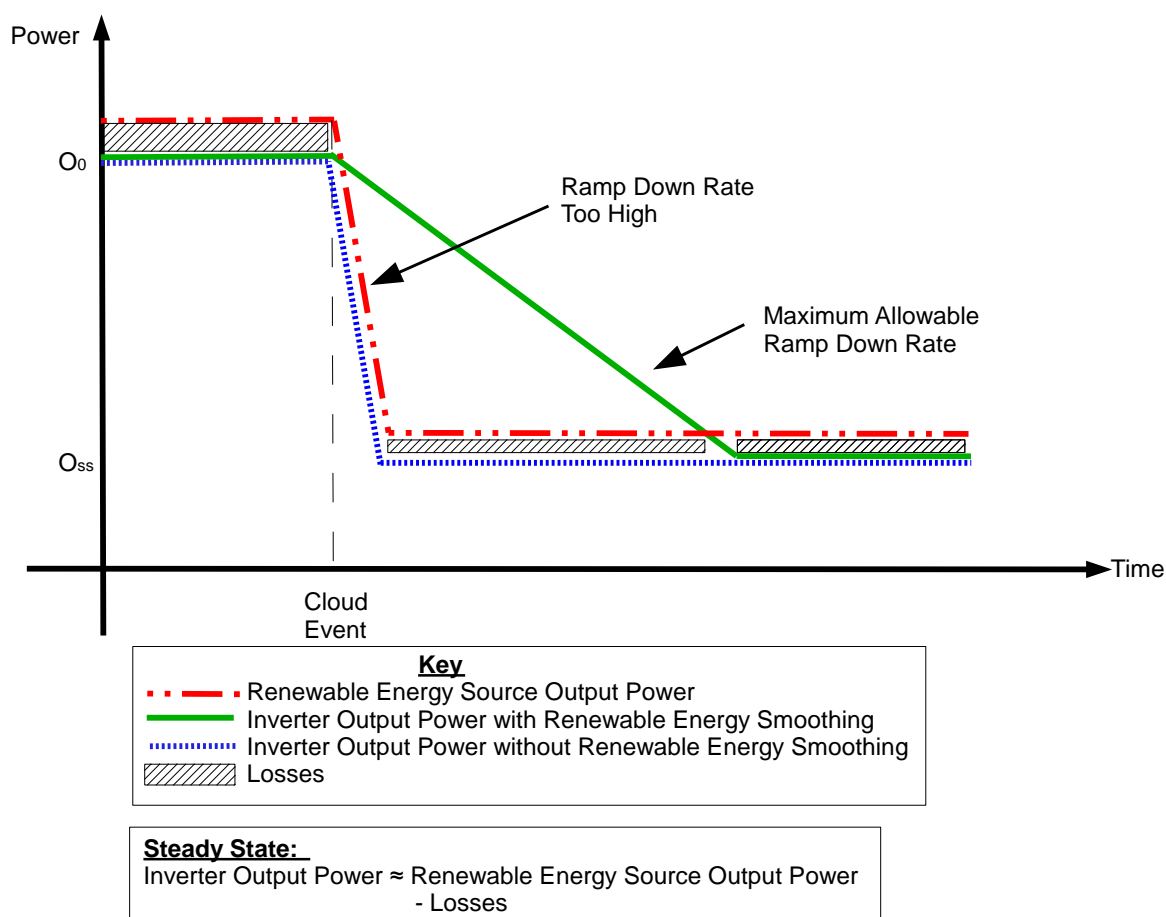


Figure 1: Ramp Down Rate with and without Renewable Energy Smoothing

Figure 2 shows the required ramp down characteristic for the output power of a grid connected inverter (including the smoothing device⁴). The characteristic curve is defined as the desired combined output behaviour of the grid connected inverter (including smoothing device) at the terminals⁵, initially operating at nominal rated output, in response to a step change in renewable energy source output at time $t = 0$ seconds to 0 kW.

The ramping response of the LV EG connection shall comply with nominal ramp down and ramp up times as follows. The ramp down and ramp up times are considered to be maximum ramping times in both directions:

1. The nominal ramp down time is defined as the time taken for the inverter (including smoothing device) to ramp down from nameplate rating (kVA) to 0 kW as reflected in the equation shown in Figure 2 ($R_n = -1000 * O_n / T_n$ [W/s]). All LV EG connections employing System Diagrams D⁶

⁴ The smoothing device may be an ESS connected to a hybrid inverter, or a separate ESS.

⁵ Horizon Power may also accept control at the connection point under some circumstances.

⁶ Refer to Schedule 2

shall have a nominal ramp down time T_n of 720 seconds. Control action is only required when the ramp down rate of the renewable energy source exceeds R_n in magnitude and shall be interpreted as a maximum “soft limit” so that the LV EG connection only exceeds the ramp requirement for no more than 15 seconds.

2. The nominal ramp up time R_p is defined as the time taken for the inverter to ramp up from 0 kW to nominal rated output, where $R_p = 1000 * O_n / T_p$ [W/s]. All LV EG connections employing System Diagrams D shall have a nominal ramp up time T_p of 360 seconds. Control action is required when the ramp up rate of the renewable energy source exceeds R_p in magnitude and shall be interpreted as a maximum “soft limit” so that the LV EG connection only exceeds the ramp requirement for no more than 15 seconds.

The LV EG connection shall not exceed the ramp down rate (R_n) and ramp up rate (R_p) by more than 10% for more than 15 seconds as defined by the Characteristic Curve depicted in Figure 2. Horizon Power may require smaller period than 15 seconds in some circumstances, subject to System Impact Studies.

The ramping system shall be within the required performance characteristic (shall not exceed the ramp down rate (R_n) and ramp up rate (R_p) by more than 10%) for 99% of the time across any period.

There are various methods and equipment that can be used to achieve the ramp rate requirements. The Proponent shall design, install and test a system to meet the ramp rate requirements ensuring the functionality does not compromise the ability of the LV EG connection to comply with other relevant requirements in this document.

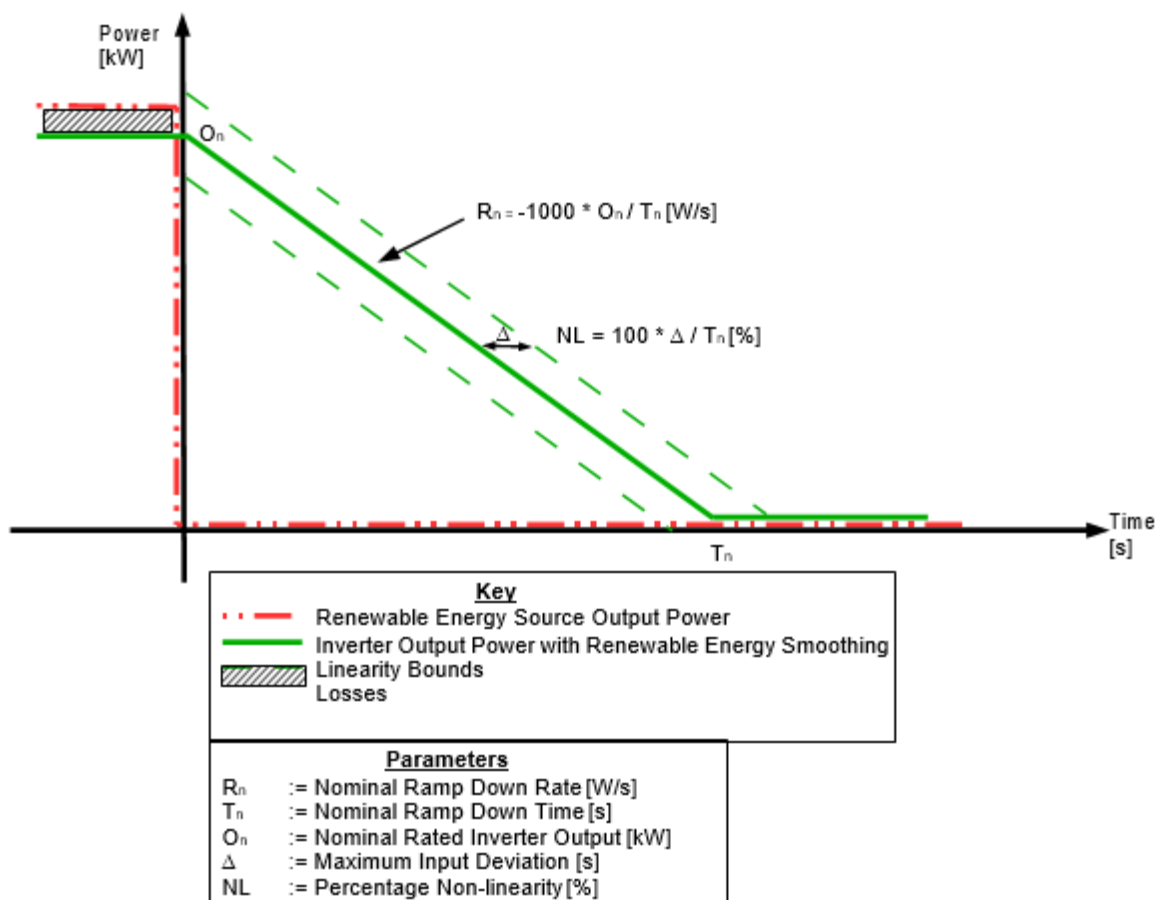


Figure 2: Ramp Down Characteristic Curve

4.4 Inverter Energy System (IES)

4.4.1 General

The following requirements apply to inverter energy systems:

1. IES shall be tested by an authorised testing laboratory and be certified as being compliant with the latest version of AS/NZS 4777 (all parts)⁷ with an accreditation number as well as AS/NZS 3100, IEC 62109 and any other relevant requirements listed in Section 3.
2. IES shall comprise of inverters that are registered with CEC as approved grid connect inverters. The CEC inverter listing shall not have expired at the time of connection application and IES installation.
3. IES shall comprise of inverters that are tested by an authorised testing laboratory and certified as being compliant with IEC 62116 for active anti-islanding protection as per AS/NZS4777.2
4. IES shall comprise of inverters installed in compliance with AS/NZS 4777.1.
5. IES shall comprise of inverters that are configured for region "Australia C", with exception to the upper IES reconnect frequency which is to be set 50.5Hz.
6. IES shall have Modbus protocol capabilities.

4.4.2 Energy Storage System (ESS)

ESS capable of supplying electricity to a Premises or the Electricity System is considered Grid Connected, unless the ESS is connected behind a break-before-make switch in compliance with AS/NZS IEC 60947.6.1.

Where an ESS is considered to be Grid Connected:

1. It shall comply with the technical requirements in this document including the requirements in Section 4.4.1 .
2. The installation of the ESS shall comply with AS/NZS 5139.
3. The maximum capacity of the ESS shall not exceed the requirements in Section 4.2.
4. The Export limit for the ESS will be considered as part of the aggregated Export limit at the Connection Point in accordance with Section 4.3.1.

The installation and commissioning of ESS shall be certified as compliant by an accredited person.

4.4.3 Electric Vehicles

An electric vehicle shall be considered a LV EG connection when the nameplate capacity of the inverter meets the capacity requirements for an LV EG connection in Table 1 and:

1. it is capable of exporting energy into the Consumer's Premises but not the Electricity System, resulting in a minimal-export configuration (also referred to as Vehicle-to-Building or V2B);
2. it is capable of exporting energy into the Electricity System, resulting in either a full or partial export configuration (also referred to as Vehicle-to-Grid or V2G); or

⁷ At the time of writing this included AS/NZS 4777.1 2016 and AS/NZS 4777.2.

3. the electric vehicle charger being installed has the capability to export electricity into either the Consumer's Premises or the Electricity System.

The inverters for electric vehicles considered to be an LV EG connection shall comply with these technical requirements in this document. Where an electric vehicle is an LV EG connection or part of an LV EG connection it shall comply with requirements of Section 4.3.7.

4.5 Network Connection and Isolation

Network connection and isolation requirements for IES shall be as per AS/NZS 4777.1 and AS/NZS 3000 for LV EG connections less than or equal to 200 kVA, LV EG IES connections greater than 200 kVA and LV EG non-IES connections.⁸

Network connection and isolation requirements for IES shall include but not be limited to the following:

1. As a minimum, mechanical isolation shall be as per AS/NZS 3000 in that the isolator must always be readily accessible.
2. Any means of isolation (where lockable) shall be able to be locked in the open position only.
3. For PV systems, isolation requirements shall be as per AS/NZS 5033.

Network connection and isolation requirements for Non-IES connections shall be determined by Horizon Power in the connection application stage.

4.5.1 Main switch

The Proponents electrical installation shall have an installation main switch or switches installed as prescribed by AS/NZS 3000, the WAER, WASIR and Horizon Power's Technical Rules. In accordance with WASIR requirements, the main switch(es) shall be a circuit breaker rated to the lesser value of:

- The network connection service capacity or the Consumer's requested and agreed calculated maximum demand; or
- where multiple main switches are installed, the sum of the current ratings of the individual protection devices shall not exceed the lesser value of network connection service capacity or service protection device (SPD) rating, where the network connection service capacity can be found in the WASIR, table 3.

Please also refer to Section 4.3.3 dealing with the main switch compatibility with export limits.

4.5.2 Changeover switches

Changeover switches shall comply with AS 60947.6.1.

4.5.2.1 Make before break

If the LV EG connection meets any of the following requirements it shall be considered as a Grid Connected LV EG connection. In these circumstances the Proponent shall submit a connection application to Horizon Power prior to any connection being made and the LV EG connection will be required to comply with the technical requirements in this document.

⁸ AS/NZS 4777.1 applies to IES systems less than or equal to 200 kVA although Horizon Power requires connection and isolation requirements in AS4777.1 to apply to all LV EG connections.

1. The LV EG connection is connected behind a make before break switch that results in a momentary (however brief), or longer, connection between grid supply and Generation supply circuits when performing a changeover;
2. The LV EG connection includes a multiple mode inverter with uninterruptible power supply (UPS) mode functionality that is Grid Connected but also supplies an Off-grid circuit.

Irrespective of whether the make before break switch is of automatic or manual type, the Proponent shall:

1. comply with Energy Management requirements to allow Horizon Power to manage the power system and cater for re-connection of step loads on the system (please refer to Section 4.3.4 for more information on Energy Management); and
2. ensure that immediately after connection to the Electricity System the change in demand drawn from the Electricity System is limited so that the maximum change in demand supplied to the Premises is achieved following a linear ramp rate in no less than 60 seconds.

4.5.2.2 Bumpless Transfer

Bumpless transfer requirements only apply to non-IES LV EG connections in accordance with Horizon Power's Standard for Bumpless Transfer of Embedded Generators (HPC-9FJ-13-0001-2018).

4.5.2.3 Break before make

Any LV EG connection behind a break-before-make switch that isolates the changeover circuit when transferring between grid supply to generation supply will be considered as an Off-grid system.

Horizon Power will not permit use of an automatic break before make switch for the purpose of connecting the Electricity System to a Premises with an Off-grid system. Any break before make changeover switch must be of manual type.

The Proponent shall submit a connection application to Horizon Power for approval prior to installation of a break before make switch. Information in the connection application informs Horizon Power about the Off-grid arrangement so that Horizon Power can manage the power system adequately during changeover events.

4.6 Earthing

The earthing requirements for all LV EG connections shall include:

1. For IES, earthing requirements shall conform with AS/NZS 4777.1 and AS/NZS 3000.
2. For Non-IES, earthing requirements shall conform with AS/NZS 3000 and AS/NZS 3010.
3. For ESS, earthing requirements shall conform with AS 3011.
4. For PV systems, earthing requirements shall conform with AS/NZS 5033.

4.6.1 Multiple Earth Neutral

LV EG connections that are connected to the Electricity System via a delta/star transformer (delta on the Distribution System side), may have the neutral directly connected to earth via a Multiple Earth Neutral (MEN) link, in accordance with AS/NZS 3000. 4.6.2.

4.6.2 Neutral harmonics

Effective isolation of the neutral may be required to inhibit the flow of harmonic currents through the neutral. The Proponent shall advise Horizon Power of their proposed method to limit harmonic currents through the neutral.

4.7 Protection

4.7.1 Inverter Integrated Protection

Inverter integrated protection requirements shall be as per AS/NZS 4777.1 and AS/NZS 4777.2 for all LV EG connections. A summary of the required settings associated with region “Australia C” are provided in Appendix E.

Passive anti-islanding requirements and settings shall be as per Table 4.1 and Table 4.2 in AS/NZS 4777.2 for region “Australia C”. Active anti-islanding protection requirements shall be as per AS/NZS 4777.2 and IEC 62116.

4.7.2 Central Protection

Central protection requirements shall be as per AS/NZS 4777.1 for all LV EG connections (AS/NZS 4777.1 currently only applies to IES systems less than or equal to 200 kVA although Horizon Power requires this standard to be met for all LV EG connection sizes).

Table 8 provides a summary of central protection requirements, with further details as per Sections 0 to 4.7.2.5 of this document. For installations with bumpless transfer Horizon Power’s Standard for Bumpless Transfer of Embedded Generators also applies (HPC-9FJ-13-0001-2018).

For LV EG connections, the central protection equipment shall be located as close as practical to the connection point.

Table 8: Central Protection Requirements

Protection Requirements	LV EG IES		LV EG Non-IES
	≤200 kVA	>200 kVA	
Grid reverse power (32R)	Not required		
Generator circuit Phase balance protection (46/47)	May be required		Shall be required
Overcurrent facility fault, grid fault and earth fault protection (50/51)	Shall be required		
Passive anti- islanding protection (27U/O, 59U/O, 81U/O, 81R)			
Inter-tripping	Not Required		

4.7.2.1 Grid Reverse Power Protection

Central protection for Grid Reverse Power is not required. Reverse Power protection may be required on non-IES LV connections as part of the generator protection. It may also be required in bumpless transfer arrangements with zero export limitations.

4.7.2.2 Phase Balance Protection

Phase balance protection shall be required for all LV EG non-IES connections and for LV EG IES connections where:

1. inverters are connected across more than one phase at a Connection Point; and
2. one or more inverters are single phase; and
3. one or more phases has greater than 5 kVA of aggregate inverter capacity.

Phase balance protection shall respond to current imbalance at the Connection Point by disconnecting all non-IES generating units, or in the case of LV EG IES connections, disconnecting all the inverters from the installation automatically where the unbalance exceeds the requirements continually for 30 seconds.

For IES LV connections disconnection for phase balance shall be by a method compliant with Clause 3.4.4.2 of AS/NZS 4777.1. For LV EG non-IES connections disconnection for phase balance shall result in a trip of the non-IES LV connection.

4.7.2.2.1 Current Unbalance Protection

For LV EG non-IES connections and, where required for LV EG IES connections, specific settings for current unbalance protection shall be determined by Horizon Power as part of the System Impact Study.

4.7.2.2.2 Voltage Unbalance Protection

Where voltage unbalance protection may also be required and shall be in accordance with the voltage unbalance provisions in the Horizon Power Technical Rules.

4.7.2.3 Overcurrent Facility Fault, Overcurrent Grid Fault and Earth Fault Protection

The requirements for overcurrent facility fault, overcurrent grid fault and earth fault protection shall be determined via Horizon Power as part of the System Impact Study at the time of the connection application.

4.7.2.4 Passive Anti-islanding Protection

Passive anti-islanding requirements and settings shall be as per Table 4.1 and Table 4.2 in AS/NZS 4777.2 for region "Australia C" for all LV EG IES connections as well as LV EG non-IES connections.

4.7.2.5 Inter-tripping

Inter-tripping is not normally required for LV EG connections. Horizon Power will determine if inter-tripping is required as part of System Impact Study at the time of the connection application.

4.7.3 Interlocking

Where multiple single-phase inverters are connected to more than one phase:

- Inverters shall operate to achieve the balancing requirements of Section 4.3.6; and
- phase balance protection is required in accordance with Section 4.7.2.2.

4.7.4 Power Factor Control

Power factor control is not required for LV EG connections.

4.7.5 Synchronisation

Automatic synchronising and synchronisation check requirements apply for non-IES LV EG connections as outlined in Horizon Power's standard for Bumpless Transfer of Embedded Generators (HPC-9FJ-13-0001-2018).

4.7.6 Additional Requirements for LV EG Non-IES

Additional protection functions apply for EG non-IES LV EG connections as outlined in Horizon Power's standard for Bumpless Transfer of Embedded Generators (HPC-9FJ-13-0001-2018).

4.8 Operating Voltage and Frequency

Horizon Power's supply characteristics are defined in Section 2 of the Horizon Power Technical Rules.

The automatic disconnection device shall disconnect the LV EG connection when the average voltage for a 10-minute period exceeds the setting per Table 4.3 in AS/NZS 4777.2 for region "Australia C".

The Proponent shall be responsible for ensuring that the maximum voltage rise within the Premises complies with AS/NZS 4777.1 and shall submit evidence for Horizon Power's record keeping in the form of Schedule 4.

4.9 Metering

This section refers to the Horizon Power's revenue metering at the Proponent's connection point to Horizon Power's network.

4.9.1 Approved Meters

Only Horizon Power approved metering equipment in accordance with Horizon Power Metering Standards and the WA Metering Code shall be used. If the Proponent has existing non-conforming metering equipment, then they shall be replaced as a part of the installation of the LV EG connection at the Proponent's cost.

4.9.2 Approved Installers

The meter shall be installed by Horizon Power or its approved contractor.

4.9.3 Upgrading of Enclosure

To meet the meter installation requirements of the WASIR, the Proponent may be required to upgrade the enclosure where the metering equipment is housed.

4.9.4 Measurement of Meters

Horizon Power shall perform measurements in accordance with the Metering Code and Horizon Power Metrology Procedures.

4.9.5 Cost of Metering Equipment

If meter replacement is required, the cost of materials and installation of meters shall be borne by the Proponent in accordance with the Consumer's Buyback Contract. This includes the cost of upgrading of enclosures and switchboard if required.

4.10 Power Quality

4.10.1 Quality of Supply

LV EG connections shall comply with the applicable power quality requirements of the AS/NZS 61000 series as well as relevant state-based regulations and license conditions, including but not limited to:

1. Network voltage control.
2. Voltage fluctuations.
3. Harmonics.
4. Voltage balance.

4.10.2 LV EG IES Power Quality Response Modes

4.10.2.1 *Security of operational settings*

The settings of the demand response or power quality response modes of the inverter shall be secured against inadvertent or unauthorised change. Changes to the settings shall require the use of a tool and special instructions not provided to unauthorised personnel.

4.10.2.2 *Volt-Watt Response Mode*

The Volt-Watt Response Mode shall be **enabled by default** and settings shall be as per Table 3.6 in AS/NZS 4777.2 for region "Australia C".

For multiple mode inverter operation with energy storage the Volt-Watt Response Mode shall be **enabled by default** when charging and settings shall be as per Table 3.8 in AS/NZS 4777.2 for region "Australia C".

Horizon Power may at any time direct the enabling or disabling of Volt-Watt Response Mode or a change to the region "Australia C" settings.

4.10.2.3 *Volt-Var Response Mode*

The Volt-Var Response Mode shall be **enabled by default** and settings shall be as per Table 3.7 in AS/NZS 4777.2 for region "Australia C".

Horizon Power may at any time direct the enabling or disabling of Volt-Var Response Mode or a change to the region "Australia C" settings.

4.10.2.4 *Voltage Balance Mode*

Where an IES has Voltage Balance Mode it shall be **disabled by default**.

Horizon Power may at any time direct the enabling or disabling of Voltage Balance Mode if the IES has this feature, or a change to the Voltage Balance Mode settings.

4.10.2.5 Fixed Power Factor Mode

Fixed Power Factor Mode shall be **disabled by default**.

Horizon Power may at any time direct the enabling or disabling of Fixed Power Factor Mode or a change to the Fixed Power Factor Mode settings.

4.10.2.6 Reactive Power Mode

Reactive Power Mode shall be **disabled by default**.

Horizon Power may at any time direct the enabling or disabling of Reactive Power Mode or a change to the Reactive Power Mode settings.

4.10.2.7 Power Rate Limit Mode

All inverters are required to have a Soft Ramp Up after Connect or Reconnect mode as per AS/NZS 4777.2 Section 3.3.4.3.2. Horizon Power only requires for soft ramp up to be applied to reconnection (i.e. ramp up / soft start).

The ramp up power rate limit shall be set to $W_{Gra+}=16.67\%$ of nameplate rating (per minute).

All ESS inverters shall also have a ramp down power rate limit when charging, which is set to $W_{Gra-}=8.33\%$ of nameplate rating (per minute).

4.10.2.8 Frequency Response Mode (Hz-Watt)

Frequency Response Mode (Hz-Watt) shall be **enabled by default** and settings shall be as per Table 4.5 to 4.7 in AS/NZS 4777.2 for region “Australia C”. Table 4.5 in AS/NZS 4777.2 also contains settings for multiple mode inverters.

4.10.3 ESS Power Quality Response Modes

A ESS inverter is a multiple mode inverter as per AS/NZS 4777.2. The required voltage response is dependent on the energy storage level and required mode (e.g. fully charged status battery can discharge and generate but won't be able to charge to act as a load).

For an ESS inverter the Volt-Watt mode shall be enabled for charging / energy absorption and discharging through the grid-interactive port of a multiple mode Inverter in conformance to AS/NZS 4777.2.

The requirements of Section 4.10.2.3 for Volt-Var Response Mode shall apply to the charging mode of ESS inverters.

4.10.4 LV EG Non-IES Synchronous Power Quality Response

4.10.4.1 Voltage Control

Synchronous LV EG non-IES connections shall be designed and operated to adequately control reactive power output through either of the following power quality response modes:

1. Voltage droop control mode; OR
2. Fixed power factor mode.

The required power quality response mode shall be determined by Horizon Power as part of the System Impact Study at the time of the connection application.

4.10.4.2 Frequency Control

Synchronous LV EG non-IES connections shall be designed and operated to adequately control frequency using frequency droop control.

The frequency droop control requirements shall be determined by Horizon Power as part of the System Impact Study at the time of the connection application.

4.11 Communications Systems

Communication systems are required for LV EG connections to provide Horizon Power direct control of the LV EG connection (including ESS if relevant) via its Distributed Energy Resources Management System (DERMS).

This section identifies the communications systems requirements for LV EG connections. Further information on the requirements to interface with DERMS are contained in Section 4.3.4 and Appendix H.

4.11.1 Data Sampling Frequency

The frequency for data sampling will be 1-minute intervals and all data shall be timestamped.

Information regarding latency requirements for provision of this data to the Horizon Power is outlined in Section 4.11.9 – Communications System Performance Requirements.

4.11.2 Response Time for Control Signals

The response time for control signals shall be determined from the time the signal is posted via Horizon's DERMS to the time confirmation is received via Horizon's DERMS.

4.11.3 Availability

Information regarding availability requirements for the communications system is outlined in Section 4.11.9 – Communications System Performance Requirements.

4.11.4 Control & Communication Interfaces

Horizon Power's DERMS is used for connection of LV EG installations to Horizon Power's Distributed Energy Resources Management System (DERMS). Further details of Horizon Power's DERMS may be found in Appendix H.

4.11.5 Loss of Communications to Horizon Power

For LV EG installations, Horizon Power will provide the LV EG connection with the following data:

- Heartbeat counter – an analogue signed integer produced by Horizon Power's DERMS that is incremented by one every second.
- Default (safe state) gross power setpoint (%).
- Default (safe state) reactive power setpoint (%).
- Setpoint – Loss of Communications Transition ramp rate (% gross output per second) from one output level to the next. Note this is separate to the transition ramp rate specified under Section 4.3.4.6.

The heartbeat counter and default setpoint are transmitted to local LV EG control system via the DERMS.

In the case of communication loss to Horizon Power, the heartbeat counter will stop incrementing.

If the heartbeat counter is unchanged for 60 seconds, the LV EG connection shall ramp the power output of the system to the default gross power and reactive setpoints advised by Horizon Power, at the

transition ramp rate as outlined in Section 4.11.6. The configurable ramp rate enables the target setpoints to be achieved without causing a sudden step change in the power station load.

If the communications to Horizon Power is re-established (heartbeat value updated), the LV EG connection shall restore the gross power and reactive power output of the system to the power setpoints in existence before the communications loss, at the transition ramp rate.

In some circumstances, these signals may be erroneously set to zero during certain loss of communication situations. The local LV EG control system is to hold the last good values and ignore zero values during the loss of communication.

When any new LV EG connection is commissioned, it must be initially configured with a transition ramp rate equal to the renewable smoothing ramp rate advised in Section 4.3.4.

4.11.6 Installations with Multiple Inverters

Where an installation consists of multiple inverters, that is combinations of PV inverters, or battery inverters, the Proponent shall aggregate the parameters of the multiple inverters. The Proponent shall provide these aggregated parameters as read, and where applicable write values that can be accessed/set by Horizon Power.

Where a control set-point is provided by Horizon Power, the Proponent shall coordinate the aggregated inverters to ensure that they respond correctly to the set-point provided by Horizon Power.

Horizon Power will only interface with one LV EG control system per site.

For LV EG connections comprising only one inverter, Horizon Power will allow direct connection of the SGD to that inverter in lieu of provision of a dedicated control system, in accordance with Appendix H.

4.11.7 Equipment

The communication subsystem shall comprise the following components:

- An approved gateway device with hardwired connection to the inverter system, including provision of dedicated single phase 240 V AC GPO for the SGD.
- One or more cabinets IP rated to suit local conditions to house the above components. Installation shall be away from direct sunlight.
- Installation shall be robust, as reasonably practicable, to discourage the people from tampering with the approved gateway device and its connection to the inverter.
- The Proponent shall declare to Horizon Power the name and model of CEC approved inverters that it proposes to monitor and control (Supported Inverters).
- All Low voltage EG systems (all inverters) shall have Modbus protocol capabilities. A summary of the required parameters for LV EG installations is provided in Appendix I. The Proponent must provide all Modbus register information for the proposed installation.

4.11.8 Gateways

The following requirements apply for gateways utilised as part of the communications system:

1. Only Horizon Power supplied gateway devices shall be used.
2. Horizon Power shall supply the approved gateway device at the Proponent's cost.
3. The gateway device shall be pre-programmed by Horizon Power.
4. The gateway device shall be installed by an accredited installer or Horizon Power authorized personnel.

4.11.9 Communications System Performance Requirements

The performance requirements in Table 9 shall be met for communication systems.

Table 9: Communications System Performance Requirements

Requirement	% Accuracy ⁹	Latency ¹⁰	Availability ¹¹
Monitoring	±10%	5 min	99.9%
Control Gross Output	±10%	1 min	99.9%
Control Net Export	±10%	1 min	99.9%
Loss of Communications setpoints	±10%	1 min	99.9%
Circuit Breaker Control	ON/OFF	15 sec	99.9%
Monitoring of Batteries	±10%	5 min	99.9%
Control of Batteries	±10%	1 min	99.9%

4.12 Data and Information

4.12.1 Static Data and Information

The Proponent is to provide the following information to Horizon Power as part of the connection application.

1. Completed Application Form.
2. **Compliance Checklist (Not Mandatory).** This is a checklist comprising the key elements that need to be satisfied to comply with this document (refer to Schedule 1 of this document).
3. **System Diagram.** A diagram that illustrates the functional relationships between key electrical and communication subsystems. An example is provided as Schedule 2.
4. **Circuit Diagrams.** One or more diagrams detailing the electrical connections from the connection point through to the LV EG connection energy source. Refer to Schedule 3 of this document for an example. The Proponent's Circuit Diagram shall be in accordance with the Standards in Section 3 and other relevant requirements of this Document. The Circuit Diagram shall include:
 - a. Electrical connections for all phases.
 - b. Neutral and earth connections (AC & DC).
 - c. Switchboard electrical connections (depiction of Proponent final loads not required).
 - d. Connections of all electrical elements of the LV EG including inverters, energy storage devices, chargers, renewable energy sources, DC and AC protection devices etc.

⁹ Accuracy requirements for Low voltage EG systems must be met for 99.97% of the time.

¹⁰ Latency describes the period of time from the time the signal is posted via Horizon Power's DERMS to the time confirmation is received via Horizon's DERMS.

¹¹ System availability including network availability.

5. **Cable Data.** Data associated with power cables connecting the Proponent's LV EG connection to Horizon Power's Electricity System. This includes the consumer mains cable. Refer to Schedule 4 of this document for an example. Cable data to be provided includes:
 - a. Location of cable in installation.
 - b. Number of cores.
 - c. Cross sectional area and insulation type.
 - d. Cable Length.
 - e. Method of installation (e.g. underground in conduit).
6. **System Parameters (Not Mandatory).** The Proponent is to document the parameters (including power quality response modes and protective functions) that will be applied to the LV EG connection. Any departures from the default region "Australia C" shall be clearly identified. Refer to Schedule 5 of this document for the system parameters list).
7. **NER Signoff** (refer Schedule 6). An NER accredited engineer shall validate that the design is in accordance with this document. An installer may reuse a NER declaration for multiple installations providing the installations do not differ with the NER validated reference design in the following elements:
 - a. Make and model of inverters
 - b. Installed EG and ESS (where required for Renewable Energy Smoothing) capacity
 - c. System Diagram
 - d. Circuit Diagram (changes to protection and cable sizes permitted)
 - e. Electrical arrangement of LV EG connection.
 - f. Changes to firmware that affect compliance with this Document.
 - g. Changes to equipment that affect compliance with this Document.
 - h. Changes to the type of technology or methodology used to achieve compliance with this Document.
 - i. If a NER declaration is reused, a cover letter shall be supplied stating:
 - j. The project and date of the reference design
 - k. That the new project does not differ from with the NER validated design in the elements described above.
 - l. Sample letters for NER declaration and declaration reuse are contained in Schedule 6.
8. **Static Data and Information** (refer Appendix C).

Upon receipt of the application and all required information, Horizon Power shall undertake a Network Impact Assessment (NIA) and a detailed System Impact Study (SIS). The SIS fees shall apply.

The Proponent shall supply a **PowerFactory model** of the proposed installation to enable Horizon Power to complete the SIS. The PowerFactory model shall comply with the modelling requirements defined in Horizon Power's "PowerFactory Modelling Guideline" available at:

<https://www.horizonpower.com.au/contractors-installers/manuals-standards/>.

4.12.2 Dynamic Data and Information

Dynamic data and information requirements that apply for LV EG connections are outlined in Section 4.3.4.4.

4.12.3 Information To Be Provided After Commissioning

Please refer to Section 6.6.

4.13 Cybersecurity

Horizon Power shall notify the Proponent of any cybersecurity requirements, which may include:

1. Monitoring and communications devices shall be in screw sealed or lockable enclosures
2. Protection and control from the network systems (firewalls)
3. Privilege settings and password protection
4. Limiting access to only that which is required to monitor the generating unit.
5. Communications shall be over secured channels or Modbus TCP
6. No unauthorised changes to the SGD

4.14 Technical Studies

Technical Studies are required to be completed as part of the connection application as per Table 10 and as per jurisdictional requirements.

Table 10: Technical Studies Required for LV EG Connections

Technical Studies	LV EG IES		LV EG Non-IES
	≤200 kVA	>200 kVA	
Voltage level (inc. power factor)	System Impact Study shall be required		
Power flow			
Fault level			
Protection grading	May be required	Shall be required	

Horizon Power undertakes system impact studies for Low Voltage EG installations to ensure the effect of those installations on the power system are appropriately managed. The criteria, relevant inputs, relevant outputs, and information requirements for system impact studies (including details of the required PowerFactory model of the proposed installation) are outlined Horizon Power's "PowerFactory Modelling Guideline" available at <https://www.horizonpower.com.au/contractors-installers/manuals-standards/>.

In some cases, the technical studies may identify additional technical requirements for the Proponent's Low Voltage EG connection (for example alternative export limits or specific energy management requirements), or the requirement for generation or network augmentation.

Any additional requirements for the Proponent's Low Voltage EG connection or generation or network augmentation identified in technical studies will be at the Consumer's cost.

5. Fees and Charges

5.1 System Impact Study

Horizon Power shall charge a fee for a System Impact Study.

Additional fees may also apply in the event the Network Impact Assessment or System Impact Study identifies the requirement for network augmentation.

5.2 Metering equipment

A meter re-configuration fee may apply once the LV EG connection is installed, depending on the metering arrangements at the time of the application.

5.3 Energy Management

All LV EG connections shall have Energy Management.

With regard to Energy Management:

- Horizon Power shall charge a fee for configuring LV EG connections for Energy Management.
- Horizon Power will provide and configure a Secure Gateway Device (SGD).
- The Proponent is responsible for all costs associated with installation and commissioning of the SGD and associated control functionality.
- The Proponent is responsible for all costs associated with providing power and an ongoing active internet connection to the SGD.
- Horizon Power is not responsible for installation, testing and commissioning costs associated with Energy Management.

Please refer to Section 4.3.4 and Section 4.11 for more information on Energy Management and Communications Systems, respectively.

5.4 Renewable Energy Smoothing

In circumstances where renewable energy smoothing is required, Horizon Power shall charge a fee to witness testing where required.

5.5 Contribution Agreement for Solar Smoothing Services

A contribution fee will apply if the Proponent chooses to enter into a Contribution Agreement for Solar Smoothing Services.

5.6 Further information

Please refer to Horizon Power's website for further information on fees and charges.

<https://www.horizonpower.com.au/utilities/pricing/>

6. Testing and Commissioning

All electrical installation, commissioning and maintenance work, wherever required, shall be carried out by an electrical contractor licensed under the Electricity (Licensing) Regulations, (1991).

6.1 Pre-commissioning requirements

This data shall be provided by the Proponent (for all Low voltage EG Systems) at least 4 weeks prior to commissioning date:

- Letter to Horizon Power stating all approval conditions are met;
- Proponent's inverter and mains protection settings;
- Inverter's fault ride through capabilities and settings;
- Commissioning Plan; and
- Operation & Maintenance Manual.

Testing and commissioning requirements for LV EG connections are listed in Table 11 including:

1. Testing and commissioning plans shall be produced by the Proponent and may be required to be signed off by Horizon Power prior to finalising the connection agreement.
2. Testing and commissioning acceptance:
 - a. shall be signed off either by a NER Engineer, or by a Horizon Power-approved suitably qualified person; and
 - b. may require Horizon Power to carry out witnessing.
3. For IES, testing and commissioning requirements shall be in accordance with AS/NZS 4777.1, AS/NZS 3000, AS/NZS 3017 and AS/NZS 5033 (where applicable), the equipment manufacturer's specifications and Horizon Power's technical requirements to demonstrate that the LV EG IES system meets the requirements of the connection agreement. Compliance to AS/NZS 3000 and AS/NZS 5033 (where applicable) may be tested by suitably qualified local electrical authorities.
4. For Non-IES, testing and commissioning requirements shall be in accordance with the equipment manufacturer's specifications and Horizon Power's technical requirements to demonstrate that the LV EG non-IES system meets the requirements of the connection agreement.
5. The Proponent shall retain a complete set of manuals, installation drawings; permits, inspection and verification test reports and make them available to Horizon Power if requested.

Table 11: Testing and Commissioning Requirements for LV EG Connection

Testing and commissioning requirements	LV EG IES		LV EG Non-IES
	≤200kVA	>200kVA	
Protection settings and performance	Shall be required		Shall be required
Power quality settings and performance			
Export limits settings and performance			
Communications settings and performance	May be required	Shall be required	
Shutdown Procedures	Shall not be required		
Confirm system is as per specifications	Shall be required		
Confirm SLD is located on site			
Renewable Energy Smoothing	May be required		

6.2 Type Testing of Renewable Energy Smoothing Systems

For installations where Renewable Energy Smoothing is required, Horizon Power needs to be able to verify whether a Proponent's LV EG connection complies with both the ramp down and ramp up requirements specified in Section 4.3.8 unless the Proponent enters into and complies with a Contribution Agreement for Solar Smoothing Services. This is achieved by the validation of an NER accredited engineer that the Renewable Energy Smoothing system is in accordance with the ramp testing requirements specified in Section 6.3. Horizon Power reserves the right to witness testing or request evidence of testing results.

6.3 Routine Testing of Renewable Energy Smoothing Systems

Annually from the date of commissioning it is a requirement that the results of one of the test methods outlined in Section 6.2.1 are provided to Horizon Power. The results may be provided manually or be automated from the inverter/battery controller. Validation is achieved by Horizon Power certifying that the ramp rate requirements are being met.

Results are to be sent to Renewables@horizonpower.com.au

6.3.1 Testing Method

The testing method shall be one of the following Test Methods shown in Table 12.

Table 12: Types of Test Methods

Test Method	Description
Pushbutton Self-Test. A pushbutton may be a multifunction, accessible by menus or dedicated button	A pushbutton is pressed which initiates a test sequence that results in a PASS or FAIL.
Battery Health Indicator	An indicator guaranteeing the health of the battery system and showing there is sufficient capacity in the battery system to perform the test sequence

6.3.2 Ramp Testing Procedure

Figure 3 illustrates the test requirements. In addition, an example of test measurements is contained in 0. Note that two consecutive ramp up and down tests are to be performed to check consistency and repeatability.

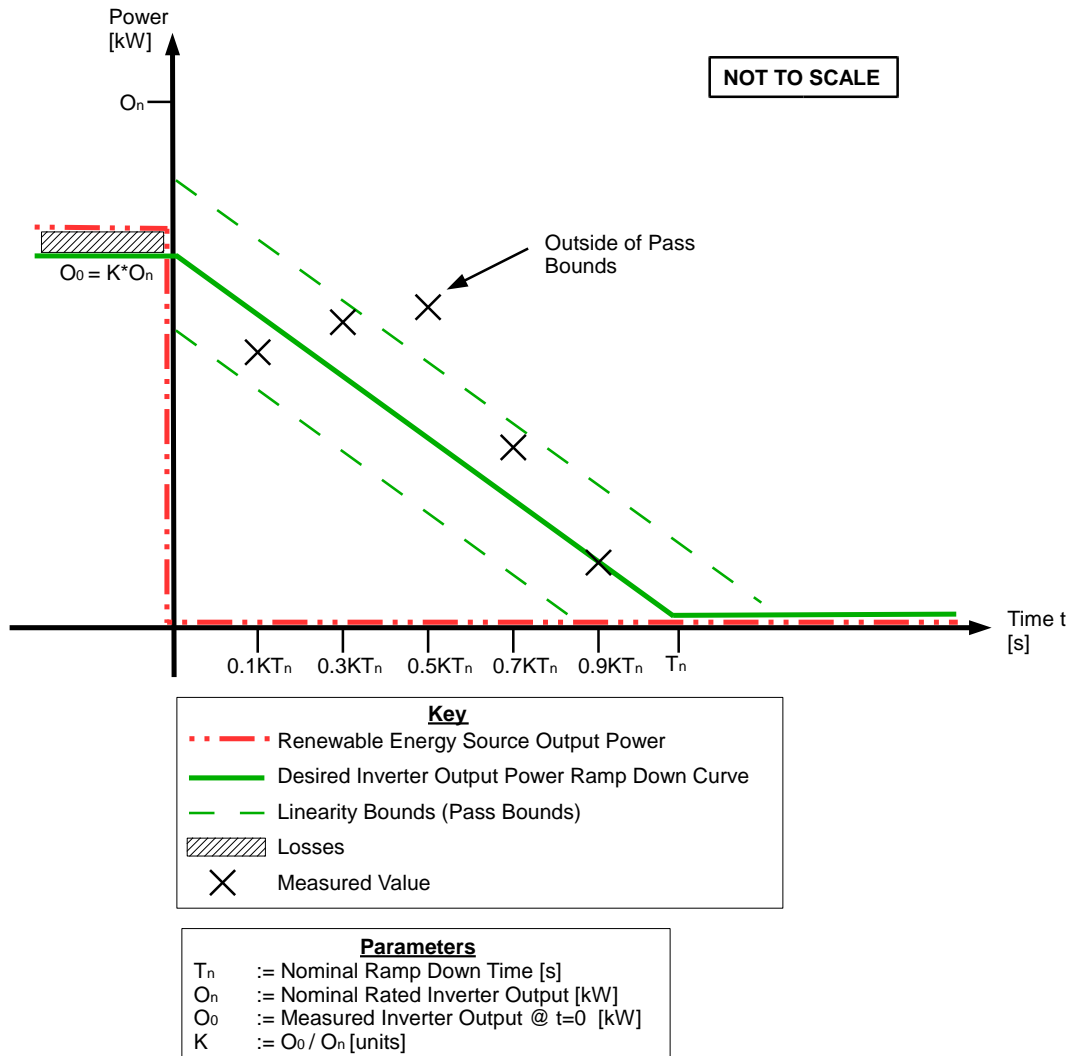


Figure 3: Example of Ramp Down Test Measurements Where Result is TEST FAIL

Procedure:

1. Measure inverter output power prior to commencement of test, O₀
 - a. Let O_n be the nameplate rating of the inverter
 - b. Let $K = O_0 / O_n$

2. If $K < 0.4$ abort test¹²
3. Identify at least five test points and the pass bounds for each power measurement. Note Horizon Power may require additional test points if the system total output is too low. The Pass Bounds must not be exceeded for more than 15 seconds in accordance with “soft limit” control. Table 13 shows an example of five test points and lower and upper pass bounds.

Table 13: Test Points

Measuring Time	Power Measurement Pass Bounds not to be exceeded for more than 15 seconds	
	Lower	Upper
0.1 KTn	0.8 KOn	KOn
0.3 KTn	0.6 KOn	0.8 KOn
0.5 KTn	0.4 KOn	0.6 KOn
0.7 KTn	0.2 KOn	0.4 KOn
0.9 KTn	0	0.2 KOn

4. Electrically isolate the renewable energy source from the rest of the Renewable Energy Installation.¹³
5. Start timer.
6. Record measured inverter output value $O_{measured}$ at each test point specified in step 2.
7. If all five measured output values $O_{measured}$ are not outside the pass bounds in step 3 for more than 15 seconds then TEST PASSED, else TEST FAILED
8. Indicate Status.
9. If TEST FAILED disconnect inverter from grid according to Section 6.3.5.
10. If TEST PASSED, allow permanent connection to the grid to Section 6.3.5.
11. Reconnect the renewable energy source to the rest of the Renewable Energy Installation.
12. Test Complete.

6.3.2.1 Alternative Ramp Testing Procedure

In certain circumstances, Horizon Power will require monitoring over a period of time to validate compliance with the ramp rate curves. This may be done as an alternative test for installations where

¹² The best time to perform the test is during peak output (typically. 12-2pm)

¹³ This could be done by sending an energising signal to a relay that actuates the DC breaker immediately upstream of the renewable energy source.

witness of smoothing tests is not practical (e.g. cloud prediction technologies). Horizon Power will require a data capture resolution rate of no less than 2 seconds for this procedure.

6.3.3 Measurement Accuracy

Each measured value shall be accurate to within 4% and with repeatability of 2%.

6.3.4 Recording of Data

Test data shall be stored in an electronic format that guards against tampering. Data associated with the previous 12 ramp down tests shall be able to be stored. Data shall include:

1. Date and time of test.
2. Test result: Pass or Fail.
3. Five test measurement values.
4. Values of K, Tn, O0, On at the time of the test.

6.3.5 Action on Test Completion

The Proponent may connect their LV EG connection to Horizon Power's Electricity System for the purposes of conducting the ramp down test, with permission from Horizon Power. This is a temporary connection only.

The table below describes the action required once a test result is obtained.

Table 14: Action Required Once Test Result Obtained

Method	Action on TEST FAIL	Action on TEST PASS
Pushbutton Self-Test	Automatic Disconnection of Inverter. Permanent Connection of LV EG connection to Horizon Power Grid not allowed and prevented by software interlock.	Permanent Connection of LV EG connection to HP Grid now allowed
Battery Health Indicator	Conduct a Pushbutton Self- Test	NA

6.4 Testing and Commissioning of Communications Systems

6.4.1 Test Objectives

The tests must ensure the communications system performs within the performance requirements of Table 9.

6.4.2 General Test Requirements

The following general requirements apply to any Proponent who conducts testing of a communications system:

1. The supply of test results shall include:
 - a. a brief log showing when tests were done (site, time, date, test alphanumeric identification);
 - b. plots of system measurements, appropriately annotated;

- c. relevant schematics of equipment and the local system configuration, including details of the system configuration at the start of, end of, and any other appropriate time during the test sequence; and
 - d. test data in Microsoft Excel spreadsheets, including lists of any data collected manually.
2. Provide information in advance of the tests including:
 - a. A detailed schedule of tests to be completed as agreed by Horizon Power. For more information on the required tests, refer to Appendix K. The schedule must list the tests, when each test is to occur and whose responsibility it will be to perform the test.
 - b. Schematics of the LV EG connection plus any descriptive material necessary to draw up/agree upon a schedule of tests.
 - c. Most up to date relevant technical data and parameter settings of equipment.
3. Provide a minimum of 15 business day prior notice of test commencement to Horizon Power for the purpose of arranging witnessing of tests.
4. Horizon Power's representative must be consulted about proposed test schedules, be kept informed about the current state of the testing program and give permission to proceed before each test is carried out.
5. Unless agreed otherwise, tests must be conducted consecutively.
6. Test result data must be presented to Horizon Power within 10 business days of completion of each test or test series.
7. Where test results show that the system performance does not comply with Section 4.11.9 it will be necessary to rectify problem(s) and repeat the tests.
8. All Factory Acceptance tests and reports shall be approved by an accredited engineer listed on the Australian National Engineering Register.

6.4.3 Commissioning and Site Acceptance Tests (SAT)

Site acceptance tests apply to all new LV EG connections (refer to Appendix K). Site acceptance tests shall be conducted during field commissioning of the LV EG connection.

The Proponent must provide evidence to demonstrate the tests meet the performance requirements of Table 9, including required ramp rates.

Horizon Power will witness all testing at its discretion to ensure the Proponent meets the requirements of this document.

The commissioning sheets for Low voltage EG communications systems shall be completed as follows:

- LV EG control system information sheet. This is to be completed by the Proponent and returned to Horizon Power. Refer to Appendix J.
- Communications system commissioning checklist. This will be completed by Horizon Power.

6.4.4 Ongoing Testing

6.4.4.1 Routine Testing

No Routine Testing of the Communications system is required by Horizon Power at this time.

6.4.4.2 Non-Routine Testing

Horizon Power may on an ad hoc basis inspect or require testing of LV EG monitoring and control systems to re-confirm its correct operation and continued compliance with this document.

6.5 LV EG connection Commissioning

Commissioning and verification shall be in accordance with section 8 of AS/NZS 3000, AS/NZS 5033 (if applicable), WASIR, WA Electrical Requirements and manufacturer specifications. In addition, if applicable, the Proponent shall perform a ramp down and/or ramp up test prior to the commencement of use (refer to Section 6.3.2).

Horizon Power reserves the right to witness commissioning or request evidence of commissioning results.

Commissioning may require the involvement of Horizon Power personnel as part of the commissioning process.

6.6 Information to be provided to Horizon Power after Commissioning

The Proponent shall ensure the following information is made available to Horizon Power within six weeks of completion the testing and commissioning requirements, and retain copies of the information provided including:

1. Final installation drawings.
2. Renewable Smoothing test results.
3. Harmonics and Flicker test results.
4. Energy Management System Commissioning test results.
5. Photographs as required in Section 6.7.
6. Information in relation to bumpless transfer and LV EG non-IES connections, if relevant (refer to Horizon Power's standard for Bumpless Transfer of Embedded Generators HPC-9FJ-13-0001-2018).

Information is to be sent to Renewables@horizonpower.com.au.

6.7 Photographs

The Proponent shall ensure the following photographs are made available to Horizon Power on completion of the testing and commissioning requirements (including verification tests) and retain copies:

1. photographs of the installation clearly showing evidence that installation of the LV EG connection has been performed in accordance with:
 - a. all relevant requirements documented in Table 4;
 - b. the requirements in this document including:
 - i. labelling and signage;
 - ii. communications systems including DER-Management;
 - iii. main switch compatibility; and

- iv. changeover switch requirements (evidence that an appropriate changeover switch is installed).
- 2. photographs or other such evidence that the IES (and ESS if relevant) has been configured with regional "Australia C" settings.

Refer to Section 6 for more information on testing and commissioning requirements.

Photographs shall be emailed to Horizon Power at Renewables@horizonpower.com.au on along with other information required to be sent to Horizon Power on completion of commissioning.

7. Operations and Maintenance

LV EG connections shall be operated and maintained to ensure compliance with the Connection Agreement, including compliance with all relevant legislation, codes, and/or other regulatory instruments, including Horizon Power's Technical Rules, always.

The Proponent shall continue to meet the Proponent Obligations in Section 1.4.

Horizon Power may inspect the Proponent's low voltage EG system at any time. This inspection will be at Horizon Power's cost.

Operations and maintenance requirements for LV EG connections shall include, but not be limited to:

1. An operation and maintenance plan shall be produced, and Horizon Power may require for it to be signed off prior to forming a Connection Agreement
2. Maintaining the electrical installation at the Premises in a safe condition.
3. The LV EG connection shall be operated and maintained to ensure compliance with the Connection Agreement and all legislation, codes, and/or other regulatory instruments at all times.
4. Periodic maintenance and testing of protection systems to ensure sustained safe and acceptable operation of the system.
5. All electrical installation, commissioning and maintenance work, wherever required, must be carried out by an electrical contractor licensed under the Electricity (Licensing) Regulations, (1991). The persons performing the electrical installation, commissioning and maintenance work shall hold a valid Certificate of Compliance issued in respect of any of the changes.
6. Operation and maintenance reports may be required by Horizon Power at a specified interval no more frequently than annually.
7. Ensuring that settings of the demand response, power quality response modes and protection functions of the inverter are secured against inadvertent or unauthorised change. Changes to the settings shall require the use of a tool and special instructions not provided to unauthorised personnel.

7.1 Periodic reviews

The Proponent shall provide and periodically review operating procedures, testing and maintenance protocols and contact information and provide updates to Horizon Power.

7.2 Inspection

Horizon Power may inspect the Proponent's LV EG connection at any time. This inspection will be at Horizon Power's cost.

Should Horizon Power wish to inspect a Proponent's LV EG connection:

1. Horizon Power will make arrangements with the Proponent for the inspection;
2. The Proponent must have the appropriate tools and passwords necessary for Horizon Power to confirm all settings have been applied correctly; and
3. If requested by Horizon Power, the Proponent shall arrange for historical data to be exported from the LV EG connection records and provided to Horizon Power, if the functionality is available.

7.3 Compliance Audits (Health Checks)

Horizon Power may undertake audits of the LV EG connection for compliance with the requirements in this document.

Note that compliance audits of existing LV EG connection connected prior to this version of the technical requirements may also be undertaken; these systems shall be assessed against the version of the technical requirements at the time the system was approved to connect to the grid, accounting for any changes in settings Horizon Power may have directed since that time.

Horizon Power may perform desktop audits on a LV EG connection using:

- Information provided with the connection application and post commissioning including photographs;
- Querying information accessible via DERMS;
- Inverter manufacturer portals and settings databases; and
- Advanced Meter Data.

In some cases, Horizon Power may determine a site audit is necessary. Where this is required, Horizon Power will contact the Proponent to arrange for an audit of the LV EG connection at the Premises. The Proponent shall provide full unrestricted access to the LV EG connection to the Horizon Power personnel or authorised Horizon Power contractor undertaking the audit. Please also refer to inspection requirements in Section 7.1.

The results of the audit will be recorded on Horizon Power's system for future reference.

7.4 Non-Compliance Process

Should a non-compliance of any kind be identified, the Proponent shall be given a period of 21 business days to rectify the non-compliance.

In cases where a non-compliance remains unresolved, or a non-compliance is identified which poses a safety or system reliability risk, a Fault Note will be placed on the installation and the LV EG connection will be disconnected from Horizon Power's Electricity System. The LV EG connection will not be reconnected to Horizon Power's Electricity System until Horizon Power is satisfied that the non-compliance has been resolved.

Rectification of non-compliance issues shall be at the Proponent's cost.

Horizon Power will generally audit a Premises no more than once annually, but more frequent audits may be carried out if a LV EG connection has previously been non-compliant or Horizon Power has reason to believe a LV EG connection is non-compliant.

APPENDIX A. DER CONNECTION GUIDELINES DEVIATIONS

The National Distributed Energy Resources Grid Connection Guidelines - Technical Guidelines for Low Voltage EG Connections (ENA DOC 040-2019) require Horizon Power to document each deviation from these guidelines and the reasoning. Table 15 provides a list of the deviations and refers to these guidelines as “Guidelines”. Proponents should contact Horizon Power at Renewables@horizonpower.com.au should they require further information on any of these deviations.

Table 15: Table of Deviations from National DER Connection Guidelines

Section of ENA Technical Guideline	Description of Deviation	Type of Deviation	Justification
1 Introduction	Scope changes	Consistency with Australian Standard practice.	Changed comply to conform as no ENA guideline is a legal requirement. This usage aligns with Australian Standards practice.
1 Introduction	No LV EG single phase connection	Jurisdictional.	Due to the rural nature of the Horizon Power network and its low load density connections of this type are not permitted; the maximum single phase connection is 10 kVA capacity which is covered by the Basic EG Technical Requirements.
2.3.1 Subcategories	Removed exporting and non-exporting subcategories	Jurisdictional.	Considered superfluous in the context of how other technical requirements are specified in this document.
4.2 Maximum System Capacity	Separate capacity requirements for AC and DC coupled ESS systems	Equity among technology types.	To provide equity between these different system types AC coupled ESS systems require generation limiting to the same capacity as DC coupled systems.
4.3.1 Export Limits at Connection Point	Export limits at the connection point expressed in kW rather than kVA and balancing requirements separated to site generation limits coupled with Central Protection.	Jurisdictional.	To provide more flexibility for volt-var control functions to control voltage when active power limits are binding. AS/NZS 4777.2 requires three-phase inverters shall inject three-phase balanced currents (Section 2.11) and as a result such installations have limited capacity to control unbalance at the connection point.

Section of ENA Technical Guideline	Description of Deviation	Type of Deviation	Justification
4.3.2 Site Generation Limit Downstream of Connection Point	Slight reordering of clauses to incorporate additional export limits and Energy Management requirements. Now 4.3.5.	Jurisdictional	Required to introduce additional requirements at appropriate places in the document.
4.7.1 Inverter Integrated Protection	Table of setpoint values provided in an Appendix (Appendix E) rather than in the body of the document.		The settings are grouped in the appendix with other settings providing a consolidated set.
4.7.2 Central Protection	Where required, phase balance protection is set to greater than 12.06 amps (5 kVA at 240 V) between phases instead of 21.7 amps (5 kVA at 230 V) as specified in AS/NZS 4777.1	Jurisdictional	N/A
4.11 Communications Systems	Horizon Power mandates all LV EG connection have communications capabilities and integrated with its Distributed Energy Resource Management System (DERMS).	Promote improved benefit to Australia's electricity system.	Requirement to manage power system security and reliability.
Multiple	Inclusion of BESS requirements throughout multiple sections		Horizon Power considers ESS systems as a type or part of a LV EG connection

In addition to the deviations in Table 15 Horizon Power also requires Proponents to install Renewable Energy Smoothing in non-standard network areas to cater for power station constraints in Horizon Power's systems (ref section 4.3.8).

APPENDIX B. CONNECTION ARRANGEMENT REQUIREMENTS

Table 6 identifies the System Diagram that is applicable to the Proponent's LV EG connection.

A system diagram illustrates the functional relationships between key subsystems using solid lines. The lines do not represent wiring, rather energy flows between subsystems. Details such as intermediary protection devices, chargers, internal device connections, switches and links are not displayed on the provided system diagrams.

The Proponent's Electrical Installation shall be in accordance with one of the following system diagrams:

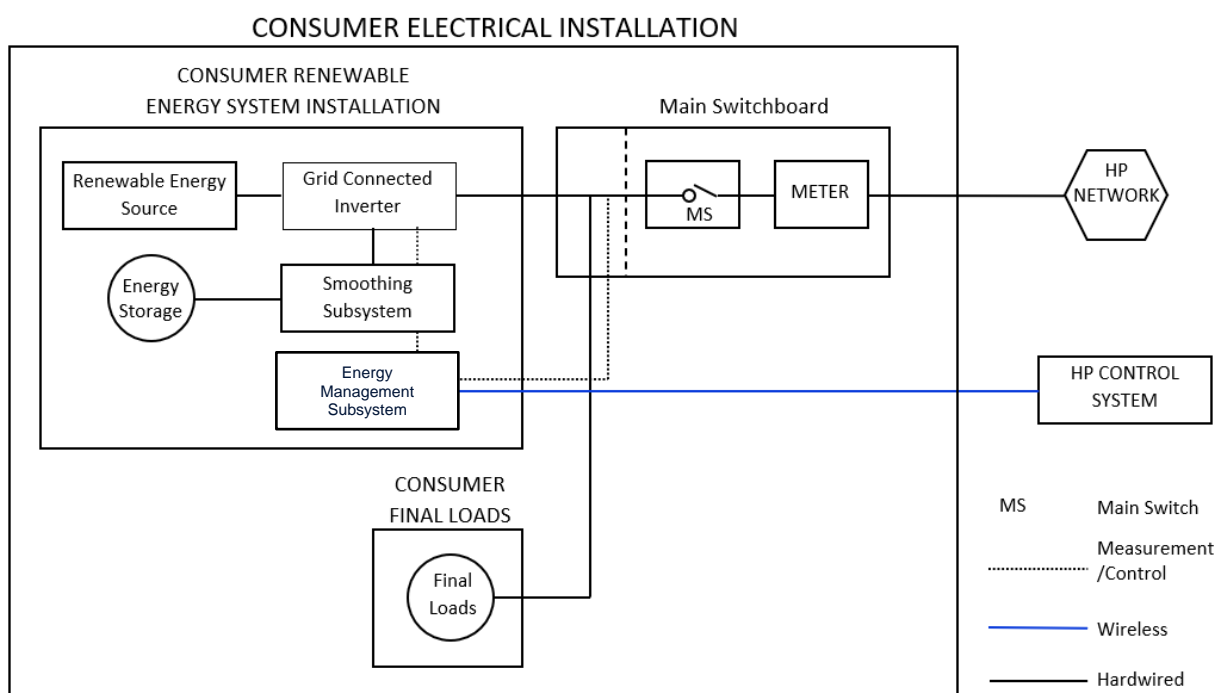
- System Diagram D (LV EG connection with **communications and smoothing**).
- System Diagram E (LV EG connection with **communications**).

Common elements to both system diagrams include, but are not limited to:

- A single point of connection between the Proponent's Electrical Installation and Horizon Power's Low Voltage Grid.
- Splitting of the Proponent's Electrical Installation into the following elements:
 - DER
 - Proponent Final Loads
 - One or more switchboards
 - Tariff Meter and sub meters
- The DER may include, but is not limited to the following devices:
 - Renewable Energy Sources (e.g. photovoltaic cells, wind turbine)
 - Grid Connected Inverter
 - Other Inverters (if required)
 - Chargers
 - Grid Protection Devices
 - Energy Storage Devices (e.g. battery bank)
 - Energy Management Devices
 - Associated control, monitoring, protection and auxiliary equipment (e.g. gateway devices)
- Final Proponent Loads
 - Final Proponent Loads requiring energy
 - Associated control, monitoring, protection and auxiliary equipment

System Diagram D: LV EG connection with Communications and Smoothing

System Diagram D is represented in Figure 4 below.



NOTE: Indicative layout only. To be read in conjunction with AS/NZS 3000, AS/NZS 4777.1 and WASIR

Figure 4: System Diagram D - Generation Managed with Communications and Smoothing

Key elements of System Diagram D are:

- Use of communications and smoothing devices (see Sections 4.11 and 4.3.4).
- Requirement for Energy Storage devices to be installed either on the DC or AC side of the grid connected inverter or other intermediary devices.
- Direct communication required between the Proponent's Electrical Installation and Horizon Power's Control System.
- No direct connection is permitted between the Proponent's LV EG connection and Proponent Final Loads. The connection must be made via the switchboard.

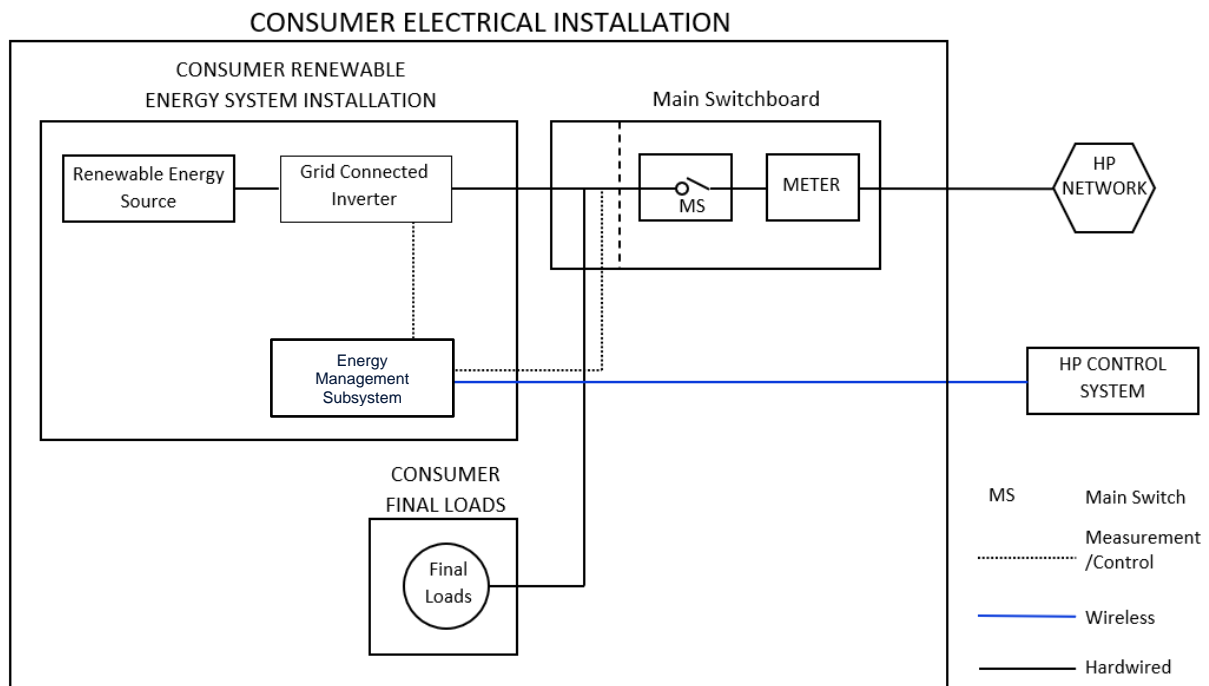
Note: The Energy Management and/or smoothing subsystems may be integral or separate with the grid-connected inverter.

Where an installation requires Energy Management, the gateway device shall communicate with only one interfacing device to provide the Energy Management signal to the Proponent's LV EG connection

Where an installation consists of multiple inverters, the communications with the gateway device (refer to Section 4.11.15) shall be through a PLC or suitable equivalent device that aggregates the parameters from multiple inverters. The design and installation of the aggregation system is the Proponent's responsibility.

System Diagram E: LV EG connection with Communications

System Diagram E is represented in Figure 5 below.



NOTE: Indicative layout only. To be read in conjunction with AS/NZS 3000, AS/NZS 4777.1 and WASIR

Figure 5: System Diagram E – LV EG connection with Communications

Key elements of System Diagram E are:

- Use of Communications (see Section 4.11).
- The energy storage device or Renewable Energy Smoothing is not a mandatory requirement. It may be added by the Proponent as long as the export limit requirements in Section 4.3.1 are addressed.
- No direct connection is permitted between the Proponent's LV EG connection and Proponent Final Loads. Connection must be made via the switchboard.

Note: The Energy Management subsystem may be integral or separate with the grid connected inverter.

APPENDIX C. STATIC DATA AND INFORMATION

This appendix includes the static data and information that is required to be provided by the Proponent to Horizon Power, including as a minimum:

1. LV EG connection or Off Grid application
2. NMI meter numbers (10 digit)
3. DER Devices
 - a. Fuel source – primary {renewable/biomass/waste; fossil; hydro; geothermal; solar; wave; wind; tidal; storage}
 - b. Fuel source – descriptor
 - c. Make, model and manufacturer
 - d. Maximum capacity (kW or MW)
 - e. Storage capacity (kWh/MWh of available storage)
 - f. Installer
 - g. Whether the device is remotely controllable (Y/N)
 - h. Compliance with Australian Standards
4. Inverter
 - a. Make, model and manufacture
 - b. Confirmation that the region “Australia C” setting has been applied.
 - c. Confirmation that the settings detailed in 0 have been applied. Any departures shall be advised including details of any changes
 - d. Nameplate rating (kVA) and maximum active power capability (kW)
 - e. Date of installation
 - f. Confirmation of Compliance with Australian Standards
5. Main switch rating
6. Trip settings
 - a. Frequency trip settings {over-frequency, under frequency}
 - b. Voltage trip settings {over-voltage, under-voltage}
 - c. Other protection functions and settings
7. Central Protection – Confirmation of Compliance with Central Protection requirements.
8. Photographs of the final installation showing the LV EG connection meets the requirements of this document, including any communications facilities.

Horizon Power will retain this information along with post commissioning and testing information provided to it in accordance with Section 6.6.

APPENDIX D. LIST OF AMENDMENTS TO PREVIOUS VERSION

Table 16 documents amendments made to this document since the previous version. The table is provided as an overview only and is not an exhaustive list of all changes made to this document.

Table 16: Table of Amendments since the previous version

Section	Amendment(s)
1.7 Modifications or Upgrades to Existing LV EG Connections	Updated requirements for existing LV EG connections to comply with Energy Management requirements and latest Modbus maps when an additional LV EG connection is being added.
2.1 Definitions	The new term “Coordination” has been defined.
4.3.7 Charging of ESS from the Electricity System	Significant changes made to simplify this section and update requirements for charging of ESS from the Electricity System.
Appendix I. Required Modbus Parameters	Added a notification that Modbus control signals and monitoring data (as tabled) are currently under review for LV EG connections with ESS. These changes are pending and will be advised as they become available.

APPENDIX E. SUMMARY OF INVERTER SETTINGS

Table 17 summarises the settings required for IES connected to Horizon Power's Electricity System. The settings are in accordance with AS/NZS 4777.2.

When configuring the IES the Proponent shall set the region to "Australia C", with exception to the upper IES reconnect frequency which is to be set 50.5Hz.

Table 17: Summary of Required Inverter Settings

AS/NZS 4777.2 Clause	Description	AS/NZS 4777.2 Default setting	Horizon Power required settings
Various	Region	NA	Region "Australia C" shall be selected.
3.2	Inverter demand response modes	DRM 0 Disconnect - required. DRM 1 to DRM 8 - optional.	DRM 0 shall be enabled . DRM 1 to DRM 8 shall be disabled .
3.3.2.2	Volt-watt response mode	Default - enabled	Volt-watt response shall be enabled and Australia C settings apply in accordance with Table 3.8 of AS/NZS 4777.2.
3.3.2.3	Volt-var response mode	Default - enabled	Volt-var response shall be enabled and Australia C settings apply in accordance with Table 3.7 of AS/NZS 4777.2.
3.3.2.4	Voltage balance mode	Default - disabled	Voltage balance mode shall be disabled
3.3.3	Fixed power factor mode and reactive power mode	Default - disabled	Voltage balance mode shall be disabled
3.3.4.2 3.3.4.3.1	Gradient of power rate limit (Ramp Rate) Modes: (a) Soft Ramp Up after connect or reconnect Note: This will be applied to reconnection (i.e. ramp /soft start)	Required.	Required , with ramp limit: WGr⁺ = 16.67% of rated power per minute (6 min ramp up rate) For multiple mode inverters with energy storage when charging WGr⁻ = 8.33% of rated power per minute (12 min ramp down rate)
4.3	Active anti-islanding protection	Required.	Test method to IEC 62116 is required

4.4	Voltage and frequency limits (passive anti-islanding protection)	Required – Australia C	Required – Australia C settings apply in accordance with Table 4.2 of AS/NZS 4777.2.
4.5.2	Sustained operation for voltage variations	Required.	Required – Australia C settings apply.
4.5.3.1	Sustained operation for frequency variations – Response to frequency variations and hysteresis	Required.	Required – Australia C settings apply in accordance with Table 4.5 and 4.7 of AS/NZS 4777.2.
4.6	Disconnection by external signal.	Required.	Required – Implemented as directed by Horizon Power for individual connections.
4.7	Connection and reconnection procedure	Required.	Required. The upper connect and reconnect frequency for Horizon Power shall be set to 50.5Hz.

APPENDIX F. EXAMPLE OF RAMP TESTS

EXAMPLE RAMP DOWN TEST

Table 18: Example Ramp Down Test Parameters

Description	Parameter	Value
Nominal Rated Inverter Output	On	5 kW
Nominal Ramp Down Time	T _n	720 s ¹⁴
Initial Inverter Output	O ₀	4.57 kW
Calculated Scaling Constant	K	0.914
Measurement Error	ε	4%

Table 19: Example Ramp Down Test Data

Test Point	Measuring	Power Measurement Pass Bounds		P _{measured} (kW)	O _{measured} (%)	Result
	Time (s)	Lower (%)	Upper (%)		[error range]	
t1	63	80	100	4.57	91	PASS
					[87.36-94.64]	
t2	189	60	80	3.43	69	PASS
					[66.24-71.76]	
t3	315	40	60	1.90	38	FAIL
					[36.48-39.52]	
t4	441	20	40	1.75	35	PASS
					[33.6-36.4]	
t5	567	0	20	1.05	21	PASS
					[20.16-21.84]	

¹⁴ Note that AS/NZS 4777.2 specifies a different default nominal ramp down time

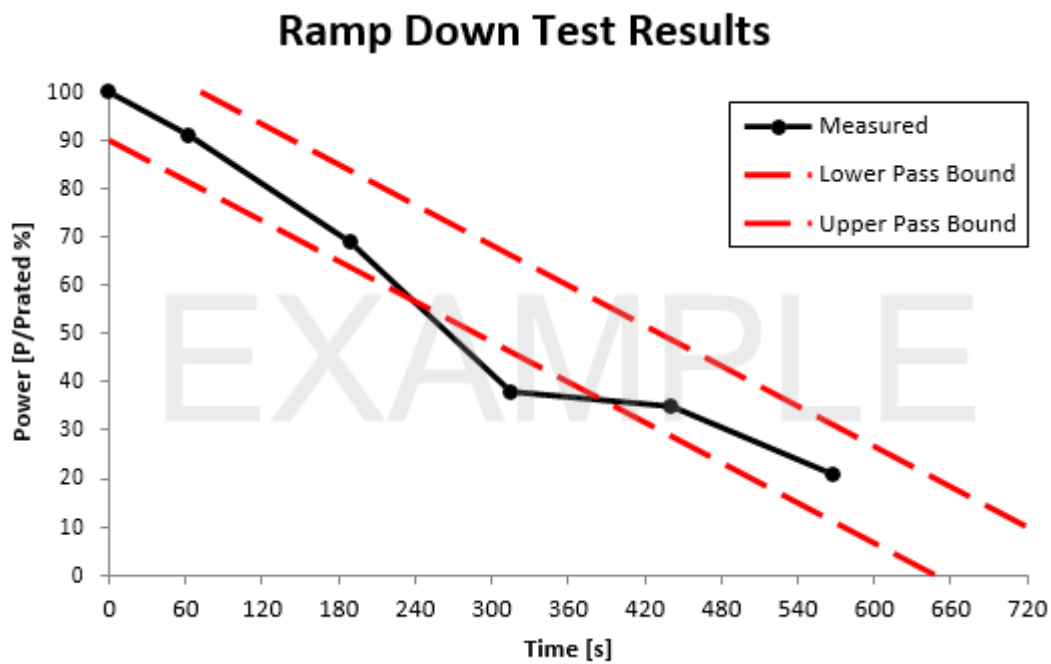


Figure 6: Example Ramp Down Test Results

EXAMPLE RAMP UP TEST

Table 20: Example Ramp UpTest Parameters

Description	Parameter	Value
Nominal Rated Inverter Output	On	100 kW
Nominal Ramp Up Time	Tn	360 s ¹⁵
Initial Inverter Output	O0	0.0 kW
Measurement Error	ε	4%

¹⁵ Note that this ramp up time is the same as set by default in AS/NZS 4777.2

Table 21: Example Ramp Up Test Data

Test Point	Measuring	Power Measurement Bounds		P _{measured} (kW)	O _{measured} (%)	Result
	Time (s)	Lower (%)	Upper (%)		[error range]	
t1	27	0	0	0	91 [7.68-8.32]	PASS
t2	88	14.4	34.4	26.0	69 [24.96-27.04]	
t3	142	29.4	49.4	43.0	38 [41.28-44.72]	PASS
t4	208	47.8	67.8	74.0	35 [71.04-76.96]	
t5	293	71.4	91.4	88.0	21 [84.48-91.52]	PASS

Ramp Up Test Results

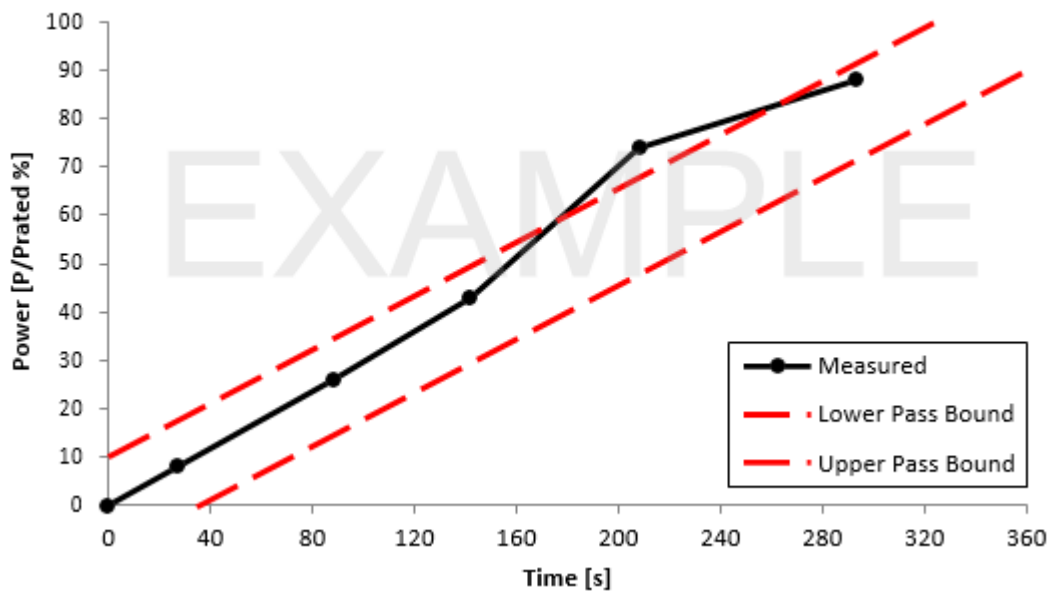


Figure 7: Example Ramp Up Test Results

APPENDIX G. HORIZON POWER SERVICE AREA

Horizon Power's service area is shown in the figure below. The NWIS covers the area between Karratha and Port Hedland and surrounding suburbs.

Service area

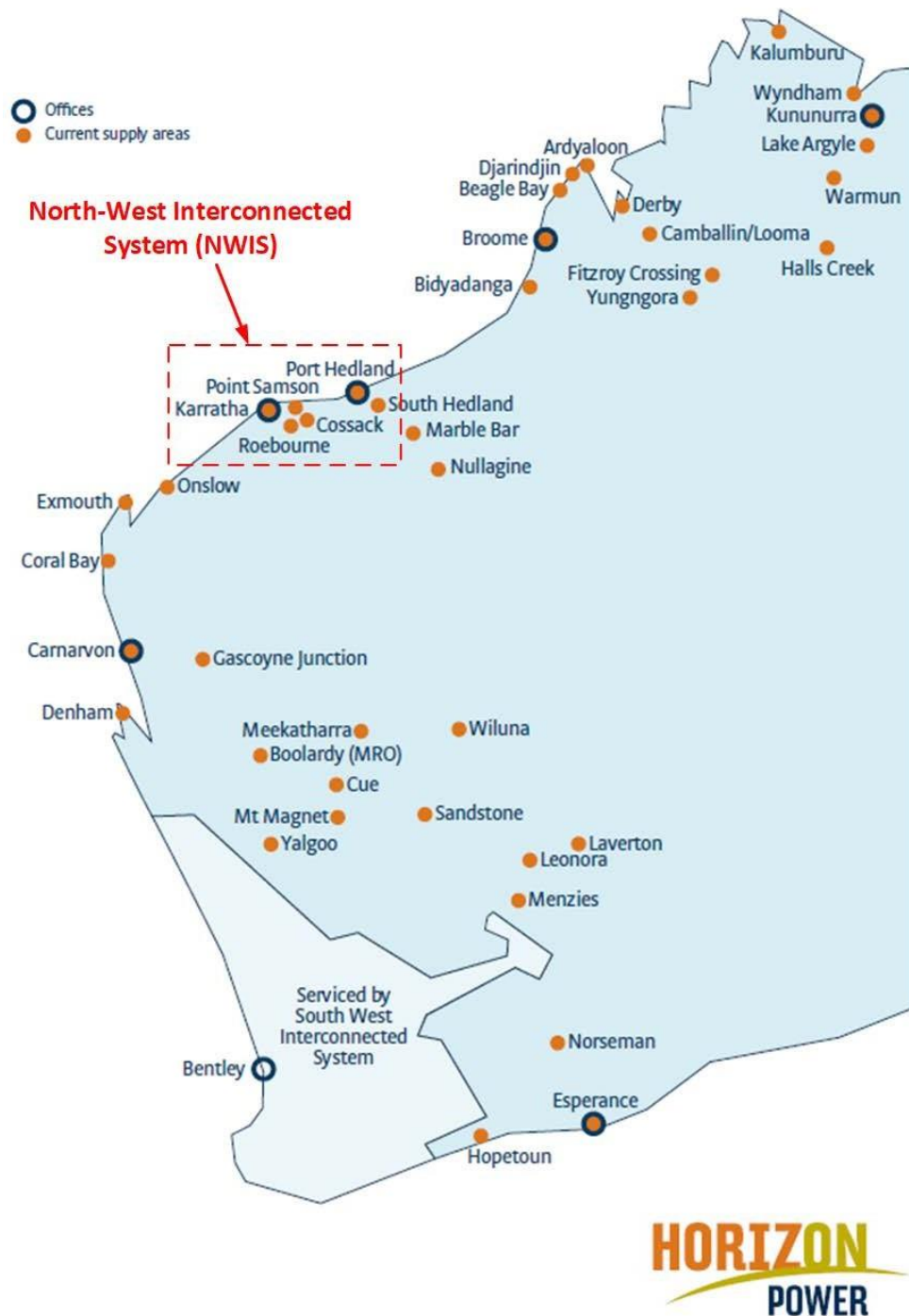


Figure 8: Horizon Power Service Area map showing NWIS

APPENDIX H. ENERGY MANAGEMENT

All LV EG connections require Energy Management. This requires the Proponent to provide an enclosure which houses a 240 V AC general purpose outlet and sufficient additional room for all DERMS related communication facilities, including a Secure Gateway Device (SGD).

More detail on the SGD, enclosure, GPO requirements and connection of the SGD are provided below.

The Proponent shall allow Horizon Power to remotely monitor and control the LV EG connection in accordance with the requirements outlined in this document.

What is SGD?

SGD stands for 'Secure Gateway Device'. It is a requirement to install a SGD for all LV EG connections. The SGD acts as a gateway device between Horizon Power's DERMS and the LV EG connection. The SGD polls the DERMS for operational limits to ensure the Electricity System remains balanced and secure. Where operational limits are necessary the SGD issues commands to the LV EG connection accordingly.

The SGD is provisioned and supplied by Horizon Power. The SGD (and any associated SIM card if applicable) will remain Horizon Power's property over the lifetime of the asset.

The SGD provides a single point interface for the LV EG control system to Horizon Power's DERMS.

The Proponent shall install the SGD and cooperate with Horizon Power to test and commission the SGD and associated control functionality.

The Proponent shall also provide Horizon Power with remote access permission to connect to the inverter via internet.

The SGD is a device dedicated to communications between Horizon Power and the LV EG connection. It shall not be used for any other purpose.

Horizon Power's chosen SGD is supplied by SwitchDIn. Key technical specifications of the SGD are available at www.horizonpower.com.au/contractors-installers/connect-solar-battery-ev/.

Figure 9 and Figure 10 shows the Horizon Power SGD and overview of ports.



Figure 9: Horizon Power's SGD hardware and port overview 1



Figure 10: Horizon Power's SGD hardware and port overview 2

System Overview & Connection Diagram

The following figure shows the high-level system diagram of a Low voltage EG System connected to Horizon Power's DERMS via the SGD.¹⁶

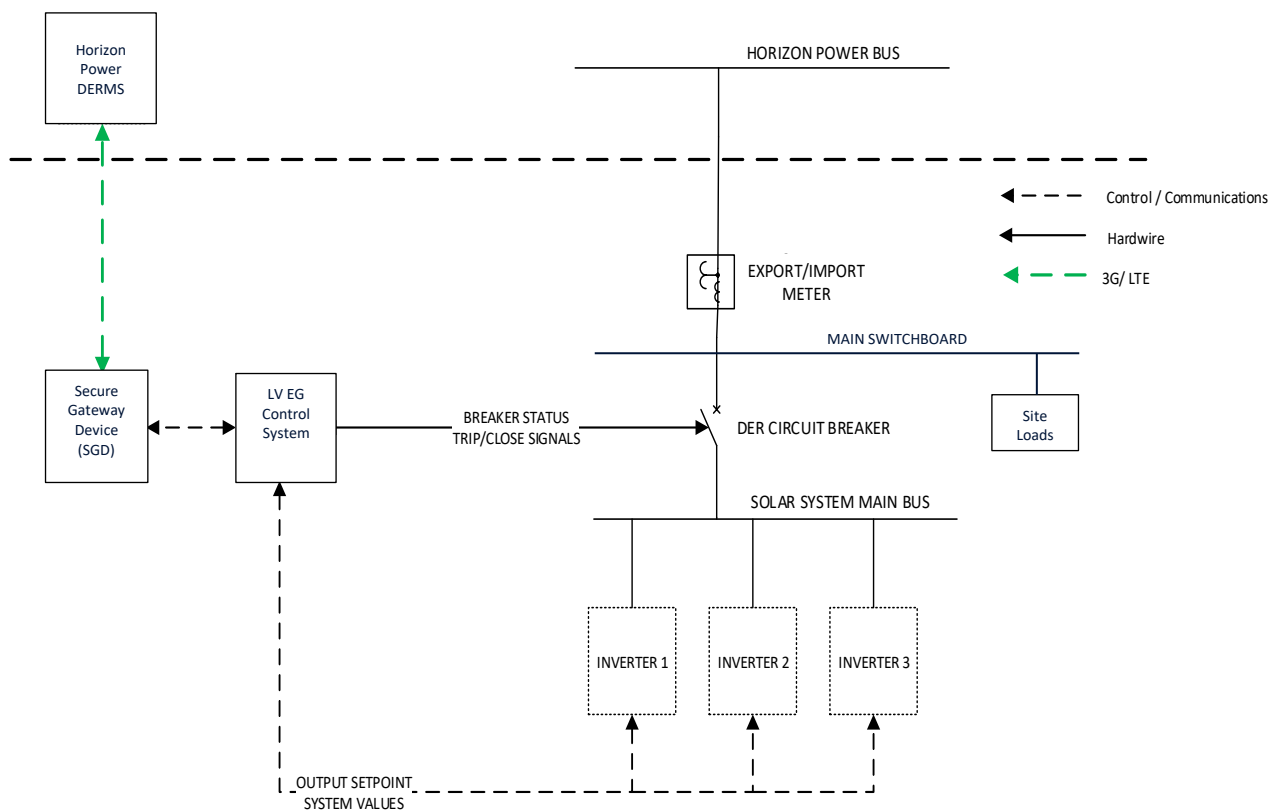


Figure 11: System Overview and Connection Diagram

The system contains the following key elements:

¹⁶ The figure above is an indicative layout only. It should be read in conjunction with AS/NZS 3000, AS/NZS 4777.1 and WASIR.

1. Secure gateway device issued by Horizon Power, which provides the **LV EG connection** a single point of interface to the Horizon Power DERMS.
2. The Proponent's LV EG connection control system device that interfaces with the LV EG connection equipment, and communicates with Horizon Power via the Horizon Power SGD.
3. An export/import meter that provides the LV EG control system with the export/import data¹⁷.
4. A main isolation point / circuit breaker.
5. Inverter(s) or array(s) of inverters that can receive and ramp to achieve the power output setpoint issued by the LV EG control System directly or indirectly via any sub-control system devices. The inverters used in the LV EG connection shall comply with the requirements of this Document.
6. Where an installation consists of multiple inverters, the communications with the gateway device shall be through a single PLC or suitable equivalent device that aggregates the parameters from multiple inverters (the LV EG Control System). The design and installation of the aggregation system is the Proponent's responsibility.

SGD Enclosure

The Proponent shall install a communications enclosure to house the GPO and Secure Gateway Device (SGD) to facilitate communications between Horizon Power and the LV EG connection.

The enclosure shall comply with the following requirements:

- approximate minimum dimensions of (W) 300 mm x (H) 200 mm x (D) 150 mm, sufficient to house the SGD, GPO and powerpack supply to the SGD. There shall be at least 30 mm spacing on all sides (and front) of the equipment installed within the enclosure.
- shall allow for the use of one or more DIN rails for connection of the SGD and the GPO;
- IP rated to suit local conditions to adequately protect against weather and dust particles;
- suitably UV rated and non-transparent;
- mounting shall be:
 - within 1000 mm of the inverter;
 - a minimum height of 1500 mm from the finished ground or floor level and maximum height of 2100 mm from the finished ground or floor level;
 - be easily accessible, with a 750 mm x 750 mm ground level clearance around the SGD enclosure (a 750 mm x 750 mm cleared area at ground level below the SGD enclosure);
 - out of direct sunlight; and
 - not mounted above the inverter.
- The enclosure shall be screw sealed or hinged lockable;
- The enclosure shall be labelled 'Inverter Communications'.

¹⁷ The export/import meter must be provided by the Consumer. The Horizon Power utility meter may not be used for this purpose.

- The enclosure shall permit cable entry from the bottom of the enclosure; and
- The enclosure provided shall be in accordance with AS/NZS 3000 and must be able to be accessible to non-electrical workers for the purposes of installation and ongoing maintenance.

In rare circumstances, Horizon Power may require provision for an external antenna to be installed with the SGD enclosure. In these circumstances Horizon Power will notify proponents before the approval of the LV EG connection.

General Purpose Outlet (GPO) with External Weatherproof Switch

The Proponent shall install a 240V general purpose outlet (GPO) and an external weatherproof isolator switch to supply power to the SGD via the supplied SGD power supply. The GPO and external weatherproof isolator switch shall comply with the following requirements:

- The GPO shall be installed inside the SGD enclosure (refer to section on SGD Enclosure above) which is adjacent to the Basic EG connection and switched from outside the SGD enclosure via a weatherproof isolation switch.
- The GPO shall be rated at 10A (minimum) and supplied from a shared or dedicated circuit from the Consumer's distribution board.
- The GPO shall be surface mounted inside the enclosure.
- The external weatherproof isolator switch shall be:
 - Wired in series with the GPO and meeting relevant wiring standards;
 - Mounted external to the SGD enclosure and within 500mm of the SGD enclosure;
 - A 240V, 2-pole switch rated at 10A (minimum);
 - Weatherproof with IP66 rating; and
 - Labelled 'SGD Power'.

Figure 12 provides an indicative diagram for the SGD enclosure with Figure 13 and Figure 14 providing an approved example installation

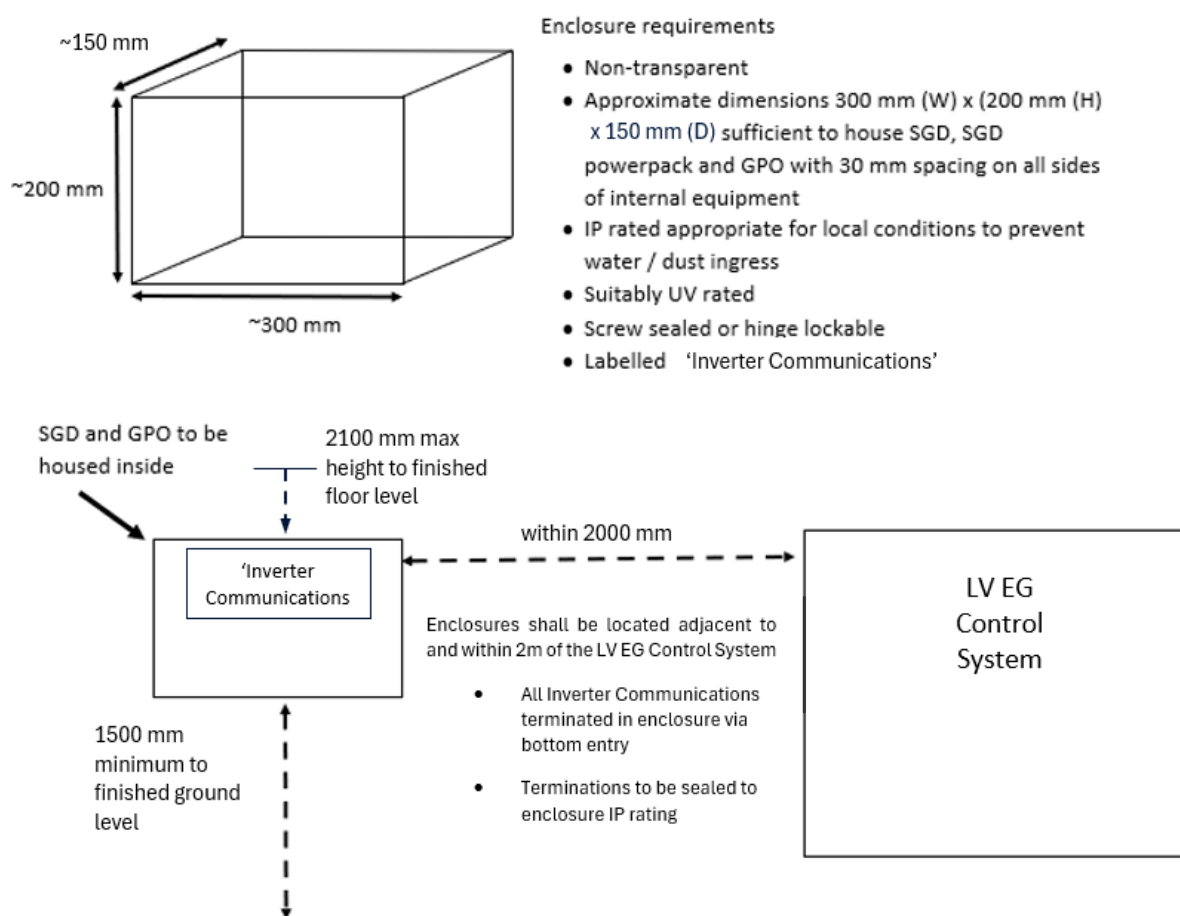


Figure 12: SGD Enclosure Installation Diagram (Indicative)



Figure 13: Example SGD enclosure



Figure 14: Example SGD enclosure open

Figure 15 provides an overview of the SGD power and network connections:

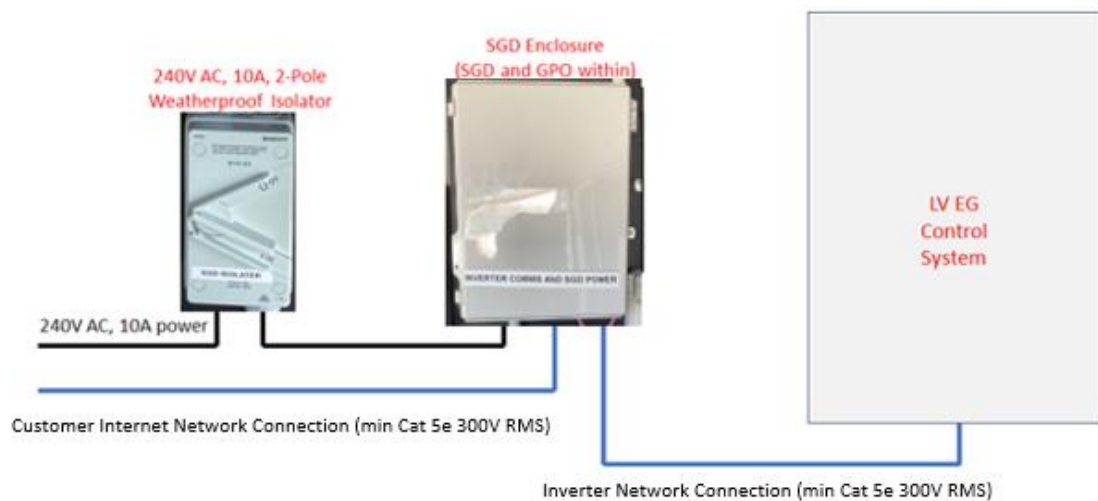


Figure 15: SGD Power and Network Connections (Indicative)

LV EG Connection Control System Requirements and Communication Parameters

The Proponent's LV EG Control System can be any type of smart control system device but preferably a Programmable Logic Controller (PLC) that is able to:

1. Communicate MODBUS TCP/IP protocol as a Server (Slave) device to Horizon Power DERMS via the secure gateway device (SGD).
2. Communicate with the Export/Import Meter to collect metering data.
3. Communicate with the LV EG connection circuit breaker or main protection relay unit to read breaker status (open/close) and send remote operation commands (trip/close).
4. Send active power setpoint to the inverter(s) or array(s) of inverters, directly or indirectly via any sub-control systems.
5. Perform all logical calculations required to meet the functional requirements of the system.

The Proponent's LV EG Control System is required to communicate MODBUS TCP/IP protocol with Horizon Power as a server (slave) device. Further details regarding the required MODBUS parameters for Low voltage EG installations is provided in Appendix I.

Internet Connection

All LV EG connections shall have a hard-wired active internet connection to the SGD at all times. The SGD shall also be connected via a hard-wired ethernet connection to the inverter.

Horizon Power will accept alternative approaches to achieving the hard-wired internet connection (e.g. LAN connection direct to home router, power line carrier devices, WI-FI range extenders) but the final connection to the SGD must be a hard-wired minimum Cat 5e cable with internet available. The ethernet cable is to have an insulation rating that meets a minimum of 300V RMS and is marked as such from the manufacturer.

In addition to providing a connection to Horizon Power's DER Management System, the Proponent shall also connect each inverter comprising the LV EG connection to the internet for the purposes of remote management of the inverter via the inverter manufacturers portal.

The Proponent shall provide Horizon Power with remote access permission to connect to the inverter via internet.

Compatible Inverters

Horizon Power requires the LV EG connection to connect to Horizon Power's DERMS via a single SGD. A LV EG control system is required to interface with the SGD for LV EG connections. Any inverter type accredited with the Clean Energy Council may be used provided the LV EG Control system manages the mapping through to the Horizon Power SGD in accordance with the Modbus map in Appendix I.

SGD installation and commissioning process

The following outlines the steps of the installation and commissioning process:

Step 1 - Horizon Power to issue SGD

Horizon Power will provision and supply the SGD.

Step 2 - Schedule SGD commissioning with Horizon Power

The Proponent shall schedule a test session with Horizon Power to coordinate the install, test and commissioning activities associated with the SGD and DERMS. Contact Horizon Power DER Technologies Support Hotline – 08 6310 1124 or renewables@horizonpower.com.

Step 3 - SGD Installation

The Installer shall complete the SwitchDin SGD training course and be accredited with SwitchDin for installation of the SGD.

The SGD shall be installed in the enclosure provided by the Proponent and powered by the GPO inside the enclosure.

The Installer shall install, connect and power the provided SGD. Install the SGD onto a DIN rail using the provided DIN rail clips. The SGD power source must be fed by a stable power source backed by UPS or battery. It is a requirement that the SGD power source remains permanently energised.

Connect the SGD to the LV EG Control System device or a network switch that has connectivity to the LV EG Control System device, using a 300V RMS or greater insulated Cat 5e RJ45 Ethernet cable or higher. The Cat 5e Ethernet cable is to be supplied by the Proponent.

Complete the LV EG Control System Information sheet (refer to Appendix J) and return the result to Horizon Power.

Refer to the SGD Quick Start Guide that comes with the SGD for more information.

All cable entries into the enclosure shall be from the bottom of the enclosure only. The cable entry points shall be sealed with appropriate glands. The use of an adhesive to seal the cable entry points is prohibited.

All communications from the inverter(s) shall be terminated inside the enclosure.

Step 5 - SGD test and commissioning

The Installer shall cooperate with Horizon Power to test and commission the SGD and associated control functionality.

The Installer shall contact Horizon Power to arrange registration of the LV EG connection in DERMS. Whilst registration is underway, the Proponent shall configure the SGD and DER via SwitchDin's support application.

Detailed instructions for the commissioning and registration of the SGD are available at www.horizonpower.com.au/contractors-installers/connect-solar-battery-ev/ or www.switchdin.com.

The Horizon Power test engineer will confirm successful DER registration and guide the Installer through the testing process until the system is commissioned and operational.

Indicative duration for registration and SGD commissioning for LV EG connections is:

- SGD configuration and installation: ~ 90 mins
- DER Registration in DERMS: ~15 mins
- Test & Commissioning SGD to DERMS with the Proponent on-site: ~90 mins

Operations and Maintenance Requirements

The following operational and maintenance requirements shall apply to the SGD:

- SGD shall remain installed at the premises as part of the LV EG connection.
- The Proponent shall not tamper with the SGD including disconnection or de-powering the device.
- The Proponent shall allow Horizon Power to access the premises, with reasonable notice, to inspect, maintain, troubleshoot, or replace the SGD.

APPENDIX I. REQUIRED MODBUS PARAMETERS

Overview

For Low Voltage EG connections, the Horizon Power DERMS communicates with the remote SGD using IEEE 2030.5. The SGD then communicates with the LV EG control system using Modbus TCP/IP.

In this architecture, with reference to the IEEE2030.5 communications:

- Horizon Power DERMS is the IEEE2030.5 Server
- The SGD is the corresponding IEEE2030.5 Client

With reference to the Modbus TCP/IP communications:

- The SGD is the Modbus Master
- The LV EG connection is the Modbus Slave

The LV EG connection is required to receive control setpoints from the Horizon Power DERMS (via the SGD) and is required to make system monitoring data available for polling by the SGD. The LV EG connection is required to receive controls and provide monitoring data in the same format as detailed in the following tables, unless otherwise specified.

Control Signals (Commands and Setpoints)

Table 22 and Table 23 present the Modbus control signals that are required, as a minimum, for LV EG connections.

The control signals in Table 22 are currently under review for LV EG connections with ESS. These changes are pending and will be advised as they become available.

Modbus register allocations are as follows:

- 41230 to 41231 – Digital control signals
- 41232 to 41239 – Analogue control setpoints

The LV EG connection is responsible for converting the provided scaled analogue values into the specific formats required by the LV EG equipment (inverters).

For example, DERMS will issue the energy management power setpoint as an integer scaled up by a factor of 100. Therefore, if a setpoint of 60.21 % is required, this will be issued by DERMS as integer value of 6021.

Table 22: Low voltage EG System Control Signals Table

<i>Read/Write</i>	<i>Function Code</i>	<i>Holding Register</i>	<i>Register Length</i>	<i>Data Type</i>	<i>Endianness</i>	<i>Byte Order</i>	<i>Significant Bit</i>	<i>Word Order</i>	<i>Scale Factor</i>	<i>Eng. Units</i>	<i>Signal Description</i>	<i>Comment</i>
Read/Write	03,06,16	41230	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	LV EG Connection Circuit Breaker Control	1 = Open, 2 = Closed (alternatively, see Bit Enumeration Table 24)
Read/Write	03,06,16	41231	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	Reserved / Spare	
Read/Write	03,06,16	41232	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	Heartbeat Counter	Incremented by SGD as a heartbeat (controls timeout after 60 sec)
Read/Write	03,06,16	41233	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Gross Active Power Limit (% of 41227)	
Read/Write	03,06,16	41234	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Default Gross Active Power Limit Setpoint (% of 41227)	Power limit value on loss of comms
Read/Write	03,06,16	41235	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%/s	Gross Active Power Limit Ramp Rate (%/s of 41227)	Power limit ramp rate value on loss of comms
Read/Write	03,06,16	41236	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Reactive Power Setpoint (% of 41225/41226)	Sign convention (Export is positive)
Read/Write	03,06,16	41237	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Default Reactive Power Limit Setpoint	Power limit value on loss of comms (Export is positive)
Read/Write	03,06,16	41238	1	NA	NA	NA	NA	NA	NA	NA	Spare	
Read/Write	03,06,16	41239	1	NA	NA	NA	NA	NA	NA	NA	Spare	

Table 23: Low voltage EG System Control Signals – Bit Enumeration (41230 and 41231)

<i>Read/Write</i>	<i>Holding Register</i>	<i>Bit(s)</i>	<i>Data Type</i>	<i>Signal Description</i>
Read/Write	41230	0	BOOL	LV EG Connection Circuit Breaker Open Command
Read/Write	41230	1	BOOL	LV EG Connection Circuit Breaker Close Command
Read/Write	41230	2 - 15	BOOL	Reserved / Spare
Read/Write	41231	0 - 15	BOOL	Reserved / Spare

System Monitoring Data (Statuses and Analogue Measurements)

Table 25 and Table 26 present the Modbus System Monitoring Data that is required, as a minimum, from LV EG connections.

The monitoring data in Table 25Table 22 are currently under review for LV EG connections with ESS. These changes are pending and will be advised as they become available.

Modbus register allocations are as follows:

- 40000 to 40055 – LV EG connection overhead information
- 40100 – Applied scaling factor for Active and Reactive Power Ratings (enumerated value)
- 41200 to 41201 – Digital status signals
- 41202 to 41229 – Analogue values

Overhead Information

Note that the overhead information (Manufacturer, Model Name, Model Version, and Serial Number) uses ASCII base 128 (7-bit character code). The string is transmitted verbatim (i.e. a string of “ABCDEF” is transmitted “ABCDEF” (low word first)).

Analogue Values

It is important that the analogue values are configured in accordance with the parameters in the tables – including the scale and engineering units.

For example, if the LV EG connection is reading an actual Total AC Current of 1.25 A, this must be scaled up by a factor of 100 before being presented on the Modbus Slave interface. The value would then become an integer value of 125.

Aggregated Inverter Status (41224)

Given that an LV EG System will likely have multiple inverters, the Inverter Status (Register 41224) is to be an aggregate status (determined/calculated by the LV EG System Controller) based on the following priorities:

- If any inverter is reporting a value other than 5 (THROTTLED) then report the value in the following priority:
 - Fault = 7

- OFF = 1
- Shutting Down = 6
- Sleeping = 2
- Starting = 3
- Standby = 8
- MPPT = 4
- Throttled = 5

Dynamic Nameplate Ratings (41225, 41226, 41227)

Given that an LV EG System will likely have multiple inverters, the Active and Reactive Power Ratings are to be dynamically updated by the LV EG System Controller based on inverter availability. The remaining dispatchable capacity of the LV EG System is to be updated in these registers.

That is, if an inverter is in a state rendering it not available for dispatch, then the Active and Reactive Power Ratings shall be reduced accordingly.

Applied Scaling Factor (40100)

Note that the applied scaling factor (register 40100) relates to the Active and Reactive Power Ratings (registers 41225, 41226, 41227) and accepts enumerated values of 0, 1 and 2, which are defined as follows:

- **0** = scaling factor of **100** (default)
- **1** = scaling factor of **10**
- **2** = scaling factor of **1**

Implement the applied scaling factor enumerated values (register 40100) based on the LV EG system size as outlined in the table below:

Table 24: Applied scaling factor enumerated values as applicable to LV EG system sizes

<i>System Size</i>	<i>Applied Scaling Factor (Enumerated Value) in Register 40100</i>	<i>Actual Scaling Applied to Registers 41225, 41226, 41227</i>
<320 kW	0	100
>=320 kW AND <3200 kW	1	10
>=3200 kW	2	1

Example of implementing the applied scaling factor (register 40100) and the LV EG system size values (registers 41225, 41226, 41227) based on different sized LV EG systems:

- For an LV EG system with nameplate of 150 kW:
 - *Applied scale factor (Reg 40100): 0* (this corresponds to a scale factor of 100)
 - *Active Power Rating (Reg 41227): 15000*

- For an LV EG system with nameplate of 750 kW:
 - *Applied scale factor (Reg 40100):* **1** *(this corresponds to a scale factor of 10)*
 - *Active Power Rating (Reg 41227):* **7500**

- For an LV EG system with nameplate of 3500 kW:
 - *Applied scale factor (Reg 40100):* **2** *(this corresponds to a scale factor of 1)*
 - *Active Power Rating (Reg 41227):* **3500**

The same concept applies to the Reactive Power Ratings, as for the Active Power Rating in the examples above.

Table 25: Low Voltage EG System Monitoring Data Table

<i>Read/Write</i>	<i>Function Code</i>	<i>Holding Register</i>	<i>Register Length</i>	<i>Data Type</i>	<i>Endianness</i>	<i>Byte Order</i>	<i>Significant Bit</i>	<i>Word Order</i>	<i>Scale Factor</i>	<i>Eng. Units</i>	<i>Signal Description</i>	<i>Comment</i>
Read	03	40000	16	String	Big Endian	ABCD-	Bit 15 = MSB	Low Word First	-	-	Manufacturer	Using ASCII (base 128) (7-bit character code)
Read	03	40016	16	String	Big Endian	ABCD	Bit 15 = MSB	Low Word First	-	-	Model Name	Using ASCII (base 128) (7-bit character code)
Read	03	40032	8	String	Big Endian	ABCD	Bit 15 = MSB	Low Word First	-	-	Model Version	Using ASCII (base 128) (7-bit character code)
Read	03	40040	16	String	Big Endian	ABCD	Bit 15 = MSB	Low Word First	-	-	Serial Number	Using ASCII (base 128) (7-bit character code)
Read	03	40100	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	Scale Factor for Nameplate Ratings (as enumeration)	Applied scaling factor for registers 41225, 41226 and 41227. Accepted values are 0, 1 and 2. Values are an enum defined as: 0 = 100 scaling factor (default) 1 = 10 scaling factor 2 = 1 scaling factor
Read	03	41200	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	LV EG Connection Circuit Breaker Status	1 = Open, 2 = Closed (alternatively, see Bit Enumeration Table 26)
Read	03	41201	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	Reserved / Spare	
Read	03	41202	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	Heartbeat Counter Status	Readback of (41232)
Read	03	41203	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Received Gross Active Power Limit Setpoint (% of 41227)	Readback of Output Limit Setpoint (41233)
Read	03	41204	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	A	Total AC Current	Sum of all Phases RMS Current

<i>Read/Write</i>	<i>Function Code</i>	<i>Holding Register</i>	<i>Register Length</i>	<i>Data Type</i>	<i>Endianness</i>	<i>Byte Order</i>	<i>Significant Bit</i>	<i>Word Order</i>	<i>Scale Factor</i>	<i>Eng. Units</i>	<i>Signal Description</i>	<i>Comment</i>
Read	03	41205	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	V	Phase A Voltage	Line to Neutral RMS voltage
Read	03	41206	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	V	Phase B Voltage	Line to Neutral RMS voltage
Read	03	41207	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	V	Phase C Voltage	Line to Neutral RMS voltage
Read	03	41208	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	-	Power Factor	
Read	03	41209	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	Hz	Frequency	
Read	03	41210	2	INT32	Big Endian	CDAB	Bit 15 = MSB	Low Word First	100	kW	Active Power	(Export is positive)
Read	03	41212	2	INT32	Big Endian	CDAB	Bit 15 = MSB	Low Word First	100	kVAr	Reactive Power	<i>Sign convention matches Fronius</i> (Export is positive)
Read	03	41214	2	INT32	Big Endian	CDAB	Bit 15 = MSB	Low Word First	100	kVA	Apparent Power	<i>Sign convention matches Fronius</i>
Read	03	41216	2	UINT32	Big Endian	CDAB	Bit 15 = MSB	Low Word First	1	kWh	Export Energy	(No longer used)
Read	03	41218	2	UINT32	Big Endian	CDAB	Bit 15 = MSB	Low Word First	1	kWh	Import Energy	(No longer used)
Read	03	41220	2	INT32	Big Endian	CDAB	Bit 15 = MSB	Low Word First	100	kW	Nett Site Export Active Power	Grid power meter (includes loads etc.) (Export is positive)
Read	03	41222	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Default Active Power Limit Readback (% of 41227)	
Read	03	41223	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	%	Active Power Limit Readback (% of 41227)	
Read	03	41224	1	UINT16	Big Endian	AB	Bit 15 = MSB	-	1	-	Inverter Status	As per IEEE203.5 (refer to Inverter Status Enumeration Table 27) Inverter Status reported shall be prioritised as follows: 7 (Fault), 1 (Off), 6 (Shutting Down), 2 (Sleeping), 3 (Starting), 8 (Standby), 4 (MPPT), 5 (Throttled/External Control)

<i>Read/Write</i>	<i>Function Code</i>	<i>Holding Register</i>	<i>Register Length</i>	<i>Data Type</i>	<i>Endianness</i>	<i>Byte Order</i>	<i>Significant Bit</i>	<i>Word Order</i>	<i>Scale Factor</i>	<i>Eng. Units</i>	<i>Signal Description</i>	<i>Comment</i>
Read	03	41225	1	INT16	Big Endian	AB	Bit 15 = MSB	-	<i>see Reg. 40100</i>	kVAr	Delivered Reactive Power Rating	This value must be updated dynamically based on the number of healthy, available (dispatchable) inverters.
Read	03	41226	1	INT16	Big Endian	AB	Bit 15 = MSB	-	<i>see Reg. 40100</i>	kVAr	Received Reactive Power Rating	This value must be updated dynamically based on the number of healthy, available (dispatchable) inverters. Negative value
Read	03	41227	1	INT16	Big Endian	AB	Bit 15 = MSB	-	<i>see Reg. 40100</i>	kW	Active Power Rating	This value must be updated dynamically based on the number of healthy, available (dispatchable) inverters.
Read	03	41228	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	-	Delivered Power Factor Rating	
Read	03	41229	1	INT16	Big Endian	AB	Bit 15 = MSB	-	100	-	Received Power Factor Rating	Negative value

Table 26: Low Voltage EG System Monitoring Data – Bit Enumeration (41200 and 41201)

<i>Read/ Write</i>	<i>Holding Register</i>	<i>Bit(s)</i>	<i>Data Type</i>	<i>Signal Description</i>
Read	41200	0	BOOL	LV EG Connection Circuit Breaker Open Status
Read	41200	1	BOOL	LV EG Connection Circuit Breaker Closed Status
Read	41200	2 - 15	BOOL	Reserved /Spare
Read	41201	0 - 15	BOOL	Reserved / Spare

Table 27: Low Voltage EG System Monitoring Data – Inverter Status Enumeration (41224)

<i>Enumeration</i>	<i>Inverter Status (IEEE2030.5)</i>
0	NA
1	OFF
2	SLEEPING – Device is in auto-shutdown or DER is at low output power
3	STARTING – Starting Up or ON but not producing power
4	MPPT – Maximum Power Point Tracking
5	THROTTLED – Forced power reduction/derating
6	SHUTTING DOWN
7	FAULT – One (or more) faults exist
8	STANDBY – Standby (service on unit) or DER at high output voltage/power
9	[As defined in Manufacturer status]
10	[Reserved]

APPENDIX J. LV EG CONTROL SYSTEM INFORMATION SHEET

The purpose of this information sheet is to record all the required information regarding the LV EG Control System. The information will be used to by Horizon Power to configure the SGD and DERMS.

Site Name: _____

Address: _____

Assessed By: _____

Contact Number: _____

Date: _____

Ongoing Site Contact Details

These are the details of the Consumer's nominated site representative after the LV EG connection has been approved to connect to Horizon Power's grid.

Horizon Power may contact the site representative if any issues are observed with the LV EG connection, or if the LV EG connection is required to be isolated for any reason.

Name: _____

Contact Number: _____

Email Address: _____

Item No	Item	Value
DER Central Control System Hardware		
1	Make / Manufacture	
2	Model	
DER Central Control System Communications		
3	IP Address of the Modbus Module / Port	
4	Modbus Device ID (Typically 1)	
5	Modbus Port Number (Typically 502)	
6	Starting Modbus Holding Register for HP FIM Communication (in the 400000 range). Refer to 0	
7	Ending Modbus Holding Register for HP FIM Communication (in the 400000 range). Refer to 0	
8	IP Address to be allocated to Horizon Power Router. This needs to be in the same network with the DER Central Control System	

APPENDIX K. COMMUNICATIONS SYSTEMS – SCHEDULE OF TESTS

Test No	General Description	Changes Applied	Test Conditions	Mandatory Tests (Y/N)
				Site Acceptance Tests
M1	Monitor gross output	-	Normal operation ¹⁸ 5 min	Y
M2	Monitor net export	-	Normal operation 5 min with load in service	Y
M3	Monitor connection status	LV EG connection On/Off	Normal operation	Y
M4	Monitor other mandatory parameters as detailed in 0 and Section 4.3.4.4	-	Normal operation 5 min	Y
M5	Monitor battery parameters as detailed in 0 and Section 4.3.4.4	(a) normal operation 5 min (b) charging 5 min (c) discharging 5 min	Battery initial SOC 60% to 85%	Y
C1	Control of LV EG circuit breaker	LV EG connection On / Off	Ramp the LV EG connection to minimum load or 0 kW.	Y
C2	Control of gross output	LV EG connection or VPP gross output set to: (a) 0% rated kW (b) 25% rated kW (c) 50% rated kW (d) 75% rated kW (e) 100% rated kW	LV EG connection initial output 75% to 100%	Y
C3	Communications fail – inverter defaults to gross output setpoint	Upon comms loss, LV EG connection or VPP gross output set to: (a) 0% rated kW (b) 25% rated kW (c) 50% rated kW (d) 75% rated kW (e) 100% rated kW	LV EG connection initial output 75% to 100%	Y

¹⁸ Normal operation is where all elements of the LV EG connection are in service, the LV EG connection is producing normal output of between 75%-100% of rated kW, and no active curtailments are in place.

C4	Control of net export	LV EG connection or VPP net export set to: (a) 0% rated kW (b) 25% rated kW (c) 50% rated kW (d) 75% rated kW (e) 100% rated kW	LV EG connection initial output 75% to 100%	N
C5	Communications fail – inverter defaults to net export setpoint	Upon comms loss, LV EG connection or VPP nett export set to: (a) 0% rated kW (b) 25% rated kW (c) 50% rated kW (d) 75% rated kW (e) 100% rated kW	LV EG connection initial output 75% to 100%	N
C6	Control of reactive power	LV EG connection or VPP reactive power set to: (a) +30% rated kVAr (b) -30% rated kVAr (c) +60% rated kVAr (d) -60% rated kVAr (e) +100% rated kVAr (f) -100% rated kVAr	LV EG connection power output 75% to 100% of rated kW throughout test LV EG connection initial reactive power output 0%	N
C7	Communications fail – inverter defaults to reactive power setpoint	Upon comms loss, LV EG connection or VPP reactive power set to: (a) +30% rated kVAr (b) -30% rated kVAr (c) +60% rated kVAr (d) -60% rated kVAr (e) +100% rated kVAr (f) -100% rated kVAr	LV EG connection power output 75% to 100% of rated kW throughout test LV EG connection initial reactive power output 0%	N
C8	Control of batteries - initiate charging and discharging of batteries, and disable energy storage charging from the grid.	(a) charging 5min (b) discharging 5min (c) repeat (a) and (b) and demonstrate disabled charging from the grid	Battery initial SOC 60% to 85%	N

APPENDIX L. SCHEDULES

The following Schedules shall be submitted to Horizon Power by the Proponent as part of their application:

- Schedule 1 Proponent Compliance Checklist
- Schedule 2 System Diagram (example included below)
- Schedule 3 Circuit Diagram (example included below)
- Schedule 4 Cable Data (example included below)
- Schedule 5 System Parameters
- Schedule 6 NER Sign off (example included below)

SCHEDULE 1. PROPONENT COMPLIANCE CHECKLIST (NOT MANDATORY¹⁹)

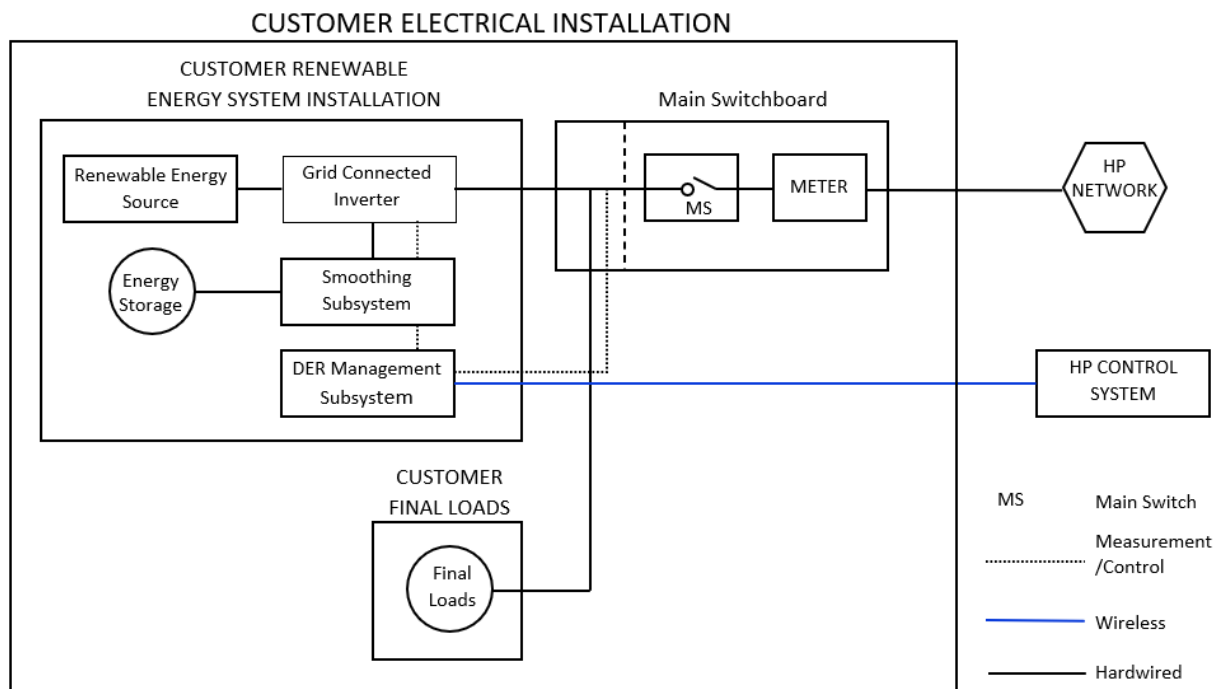
Relevant System Diagram (D or E?):			Comments
Description	Clause	Complies (Yes / No)	
Proponent Obligations	1.4		
Labelling and Signage	4.1		
Maximum System Capacity	Table 6		
Export Limit	4.3.1		
Main Switch Compatibility	4.3.3 and 4.5.1		
Balanced Generation	4.3.3		
Renewable Energy Smoothing	4.3.4		
Energy Management	4.3.6		
Region "Australia C" configuration	Multiple		
Inverter Energy System	4.4		
Network Connection and Isolation	4.5		
Changeover switches	4.5.2		
Bumpless Transfer Requirements	4.5.2.2		
Earthing	4.6		
Protection Requirement	4.7		
Horizon Power Meter at Property	4.9		
Communications Systems	4.11		

¹⁹ Schedule 1 – Proponent Compliance checklist is no longer a mandatory schedule to be submitted.

Data and Information	4.12		
Cybersecurity	4.13		
Testing and commissioning	0		
Information to be provided to Horizon Power	6.6		
Operations and Maintenance	7		
Schedule 1			
Schedule 2			
Schedule 3			
Schedule 4			
Schedule 5			
Schedule 6			

SCHEDULE 2. SYSTEM DIAGRAM

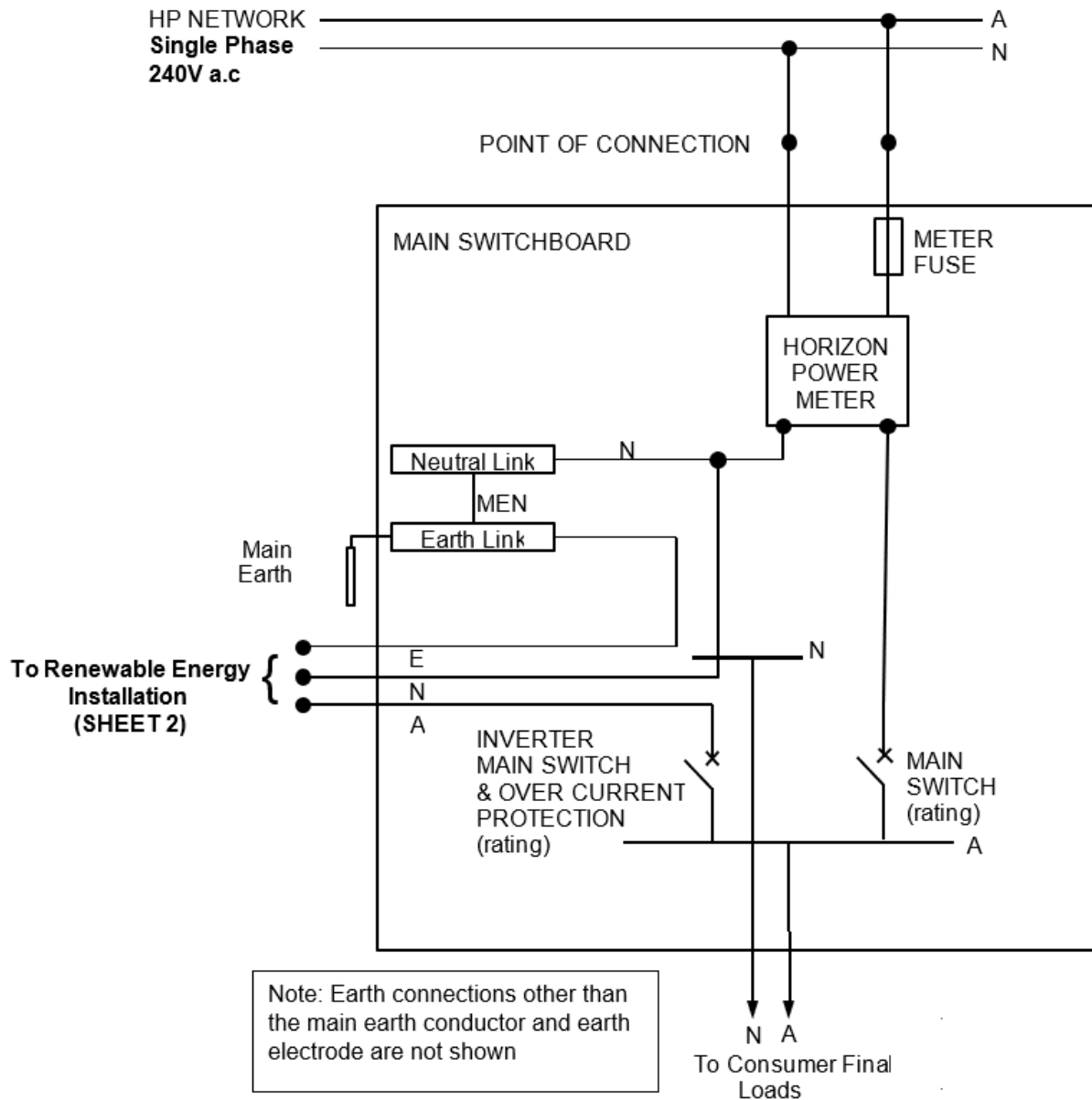
*****SAMPLE ONLY*****



NOTE: Indicative layout only. To be read in conjunction with AS/NZS 3000, AS/NZS 4777.1 and WADCM

SCHEDULE 3. CIRCUIT DIAGRAM

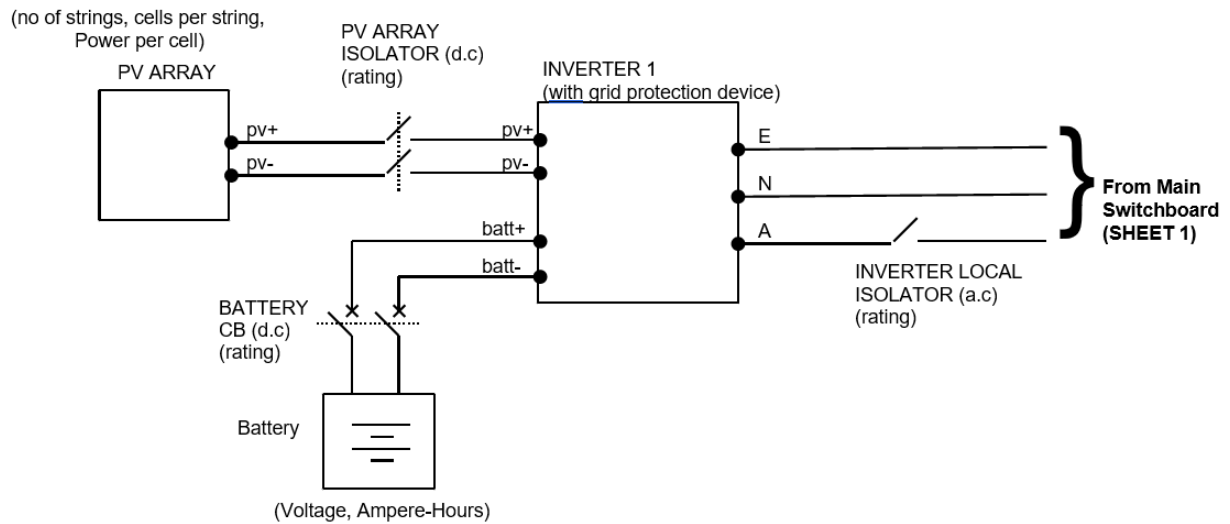
*****SAMPLE ONLY*****



Note: For indicative purposes only - the Proponent shall rely on the other requirements of this Document together with AS/NZS 4777.1, AS/NZS 3000, AS/NZS 5033 (PV only) and other applicable documents to connect the internal components of Renewable Energy Installation correctly

(Schedule 3 continued)

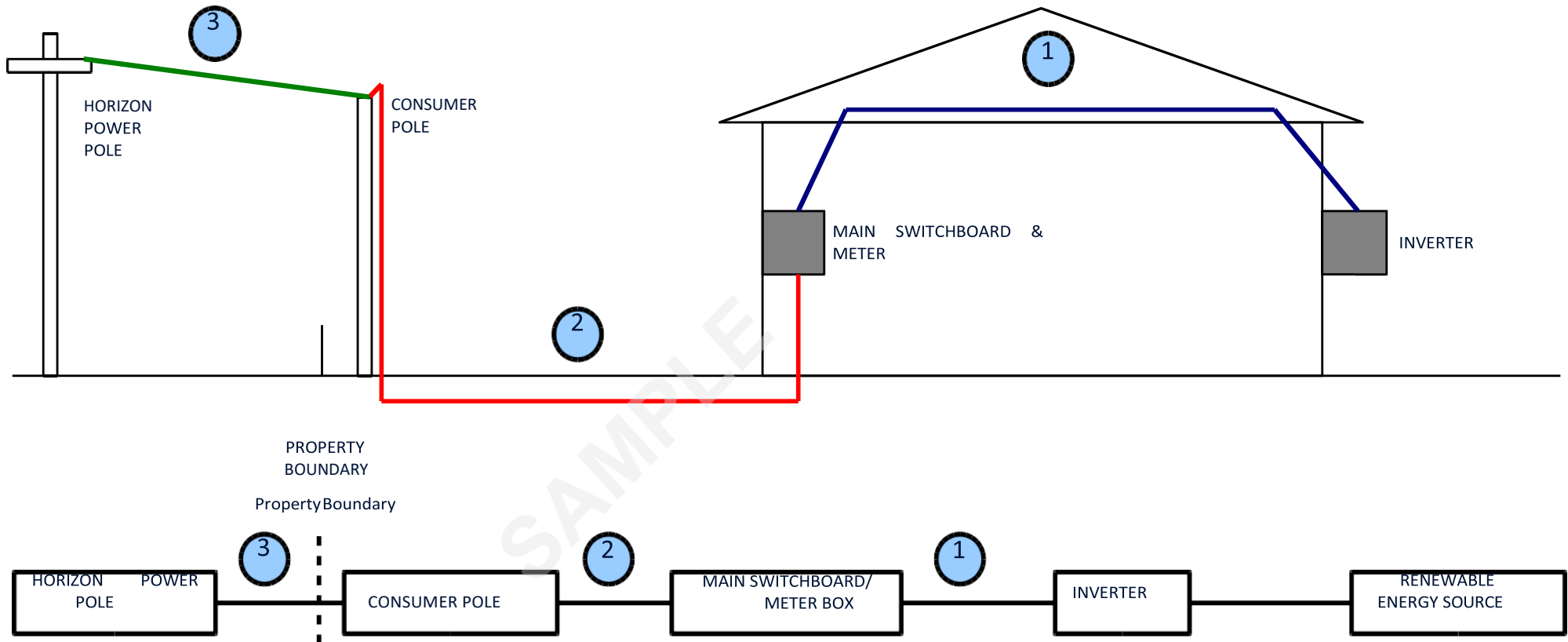
*****SAMPLE ONLY*****



SCHEDULE 4. CABLE DATA

*****SAMPLE ONLY*****

Concept Drawings (Sample):



(Schedule 4 continued)

*****NOTE: Include cable information for all power cables between Inverter and Point of Supply*****

Concept Drawing Item	Cable Length	Cable Type	Installation type
1	10m	6mm ² , 2 Core + Earth, PVC/PVC, Copper	In Roof Space
2	20m	6mm ² , 2 Core, PVC/PVC, Copper	Underground
3	30m	6mm ² , 2 Core, Bare, Copper	Overhead

SCHEDULE 5. SYSTEM PARAMETERS (NOT MANDATORY²⁰)

Site Export Limit			
Total site export limit to Horizon Power Grid			kW
Region "Australian C" configuration			Yes or N/A ?
Document departures from Region "Australia C" settings where relevant (refer to Appendix E)			
Ramp rate			
Ramp up rates		W/sec	Refer to LV EG connection Technical Requirements - Section 6.3
Ramp down rates		W/sec	
Non linearity		%	Refer to LV EG connection Technical Requirements - Section 4.3.8
Testing measurement accuracy			
Measurement error		%	Refer to LV EG connection Technical Requirements – Section 6.3.3
Notes			

²⁰ Schedule 5 – System Parameters is no longer a mandatory schedule to be submitted.

SCHEDULE 6. NER SIGNOFF

*******SAMPLE ONLY: NEW REFERENCE DESIGN*******

Horizon Power

18 Brodie Hall Drive Technology Park Bentley, WA, 6102

Your Ref: **XXXXXX**

Our Ref: **YYYYYY (if applicable)**

DD/MM/YY

Dear Sir/Madam

Subject: Renewable Energy Connection - Project Name, Project Location

Please find attached our submission for the abovementioned project.

This letter is to certify that as a Chartered Professional Engineer and by virtue of my training and experience, the submission documentations issued together with this letter complies with the requirements of the following:

- HPC-9DJ-13-0002-2019 Low Voltage EG Connection Technical Requirements (*State latest revision*)
- Electricity (Licensing) Regulations 1991
- AS/NZS 3000 (State latest revision)
- Western Australian Electrical Requirements (*State latest revision*)
- Western Australian Distribution Connections Manual (*State latest revision*)
- AS/NZS 3100 (State latest revision)
- AS/NZS 4777 (State latest revision)
- AS/NZS 5033 (State latest revision)

In addition, the following schedules have been submitted as part of the application:

- Schedule 1: Compliance Checklist
- Schedule 2: System Diagram
- Schedule 3: Circuit Diagrams
- Schedule 4: Cable Data
- Schedule 5: System Parameters

Should you have any queries, please contact the undersigned.

Yours Sincerely,

Chartered Professional Engineer's Name and NER Number Professional Title

Company Name Company Address Contact Detail

*******SAMPLE ONLY: COVER LETTER FOR REUSED REFERENCE DESIGN*******

Horizon Power
18 Brodie Hall Drive Technology Park Bentley, WA, 6102

Your Ref: **XXXXXX**
Our Ref: **YYYYYY (if applicable)**

DD/MM/YY

Dear Sir/Madam

Subject: Renewable Energy Connection - Project Name, Project Location

Please find attached our submission for the abovementioned project. This letter is to declare that the abovementioned project makes use of the reference design for Project (State Project) dated (State Date). An NER accredited chartered professional engineer has checked the reference design and it has been attached to our submission for your consideration.

The abovementioned project does not differ with the NER validated reference design in the key elements described in Section 4.12 of the Technical Requirements.

In addition, the following schedules have been submitted as part of the application:

- Schedule 1: Compliance Checklist
- Schedule 2: System Diagram
- Schedule 3: Circuit Diagrams
- Schedule 4: Cable Data
- Schedule 5: System Parameters

Should you have any queries, please contact the undersigned.

Yours Sincerely,

Name Professional Title Company Name Company Address Contact Detail.