Connection Standard

Micro Embedded Generating Units (0 - ≤30 kVA)

These standards ensure that Ergon Energy's and Energex's requirements are met. If this standard is a printed version then the Ergon Energy or Energex internet site must be referenced to obtain the latest version to ensure compliance.

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Joint Standard Document between ENERGEX and Ergon Energy
ENERGEX Limited ABN 40 078 849 055 ■ Ergon Energy Corporation Limited ABN 50 087 646 062

Abstract: This standard has been prepared by Ergon Energy and Energex to provide owners and proponents of micro embedded generating (EG) unit installations (0 - ≤30kVA) information about their rights and obligations for the connection to and interfacing with the Ergon Energy or Energex Distribution Network. This standard is agnostic to the generation source (e.g. Solar, Wind etc), encapsulates energy storage (e.g. batteries), and includes energy from hybrid combinations (e.g. solar plus batteries) that connect to the electrical network via an inverter. In all instances, installations of a micro EG unit shall be compliant with the requirements of all parts of AS/NZS 4777.

Ergon Energy and Energex as the Queensland Distribution Network Service Providers have an inherent obligation to ensure that micro EG units do not cause a material degradation in the quality of supply to other network users and do not adversely affect operation of the distribution network.

Keywords: micro embedded generating unit, inverter, solar, photovoltaic, wind, energy storage system, export, low voltage

Standard for Micro Embedded Generating Units (0 - ≤30 kVA)

Contents

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Standard for Micro Embedded Generating Units (0 - ≤30 kVA)

1. Overview

1.1 Purpose

The object of this Standard is to provide Proponents of micro embedded generating (EG) units information about their obligations for connection to and interfacing with the Ergon Energy or Energex networks. This connection standard has been developed to ensure safe and stable parallel operation of micro EG units connected to Ergon Energy's or Energex's networks at the Proponents premise, in accordance with Section 225 of the Queensland Electrical Safety Regulation 2013. When connected to the Ergon Energy or Energex networks, a micro EG unit can impact the operating conditions, voltage profile and feeder load.

It is the Proponent and their electrical contractor's responsibility to ensure the proposed micro EG unit equipment and installation complies with the relevant national standards and regulations, in addition to this connection standard. The Proponent shall not add additional inverters, make modifications or install additional micro EG units, including energy storage systems (ESS), without prior written agreement from the DNSP.

1.2 Scope

This Standard outlines the requirements for micro EG units with a total nameplate rating up to but not exceeding 30 kVA at a single connection point; that are intended to be connected to and capable of operating in parallel with any part of Ergon Energy's or Energex's distribution networks. This standard is agnostic of the generation source and encapsulates ESS as well.

1.3 Application

This Standard applies to low voltage customers connecting a micro EG unit up to and including 30kVA total generation at a single connection point.

This Standard does not apply to:

- back-up generation that does not operate in parallel with the distribution network;
- synchronous embedded generators driven by hydro turbines, gas engines, gas turbines or diesel engines; or
- EGs of over 30 kVA. For such EGs, please refer to:
    - (30 kVA – 5000 kVA) RED 233 – Small to Medium Scale Embedded Generation Systems 30 to 5000 kVA (Energex) or STNW1165 – Standard for Connection of Embedded Generators in the Ergon Energy Distribution Network
    - (> 5000 kVA) STNW3365 – Standard for Embedded Generation (5 MW and above) (Ergon Energy).

2. References

2.1 Energex controlled documents

A copy of the latest version of this Energex Standard may be obtained by searching for **solar connection** from the following website:
https://www.energex.com.au/

2.2 Ergon Energy controlled documents

A copy of the latest version of this Ergon Energy Standard may be obtained by searching for **solar connection** from the following website:
https://www.ergon.com.au/

2.3 Other documents

Additional Australian Standards are listed in Ergon Energy and Energex's standard design documents.

AS 3100	Approval and test specification - General requirements for electrical equipment
AS/NZS 4777	Grid Connection of Energy Systems via Inverters, (all parts);
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008	Electrical installations – Selection of cables
AS 3011	Electrical installations – secondary batteries installed in buildings
AS 4509	Stand-alone power systems
AS/NZS 5033	Installation of Photovoltaic (PV) Arrays
AS 61400.2(Int)-2006	Wind turbines - Design requirements for small wind turbines
IEC 62109	Safety of power converters for use in photovoltaic power systems
BS EN61000-3-14	Electromagnetic compatibility (EMC) – Part 3-14 – Assessment of emission limits for connection of disturbing installations to LV Power Systems
NER	National Electricity Rules
QECMM	Queensland Electricity Connection and Metering Manual
Clean Energy Council	Grid-Connected Solar PV Systems – Design Guidelines for Accredited Installers
Clean Energy Council	Grid-Connected Energy Systems With Battery Storage
German Solar Industry Association	Safety Guidelines – Li-ion Home Storage Systems

3. Definitions, Acronyms, and Abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply.

3.1.1 **accredited person:** means a person accredited by the CEC who has demonstrated their competence to design and/or install renewable energy systems. This includes Accredited Installers, Designers and Supervisors operating within the classification of their accreditation. To be eligible for Renewable Energy Certificates a CEC accredited person must be engaged. In all instances though, a person authorised under the Queensland *Electrical Safety Act 2002* is required to certify the installation.

3.1.2 **Act:** means the Queensland Electricity Act 1994.

3.1.3 **Australian Energy Market Operator:** The Australian Energy Market Operator, responsible for the operation of the national electricity market under the NER.

3.1.4 **anti-islanding protection:** A protection system to detect islanded conditions and disconnect the inverter(s) from the network. This is a requirement as per AS/NZS 4777.

3.1.5 **Break before make switch -** A switch that is configured to break (open) the first set of contacts before engaging (closing) the new contacts. This prevents the momentary connection of the old and new signal paths.

3.1.6 **connection point:** The point at which the DNSP's assets end and the customer's assets start. The location of the connection point can range from the point of entry on a residence, to a low voltage fuse on a pole or pillar to the low voltage terminals of a distribution transformer.

3.1.7 **Distribution Network Service Provider:** As described in NER chapter 10, a person who engages in the activity of owning, controlling or operating a distribution system and who is registered by AEMO as a network service provider under Chapter 2. Energex is the owner, lessor and operator of the South East Queensland electricity distribution network. Ergon Energy is the owner, lessor and operator of the Queensland electricity distribution network excluding the South East corner operated by Energex. This term will be used to indicate Energex or Ergon Energy as relevant to the Proponent.

3.1.8 **energy storage systems:** means a system that has the ability to both collect and generate electrical energy as required, using a storage medium such as mechanical, electrochemical, chemical, or thermal. This includes, for instance, batteries – which consist of various chemistries. The complete system may include a management system for monitoring, controlling and protecting the system and its components.

3.1.9 **embedded generator:** a generator that is connected to a Proponent's electrical installation and capable of operating in parallel to the distribution network.

3.1.10 **export or exported energy:** the quantity of energy generated by the micro EG unit equipment and delivered to the distribution network.

3.1.11 **full-export:** a micro EG unit that is paralleled with the distribution network and which exports electricity to the distribution network up to the rated capacity of the inverter.

3.1.12 **generation source:** is the energy generation source supplying the micro EG unit. For instance this includes, but is not limited to solar PV, wind turbine, hydro turbine, fuel cells, combined heat and power plants, and energy storage.

3.1.13 **hybrid inverter:** is an inverter which can operate in both parallel and non-parallel operation modes.

3.1.14 **inverter:** Performs the conversion of the DC output of the generation source into a utility frequency AC power that can be fed into the Supply Network.

3.1.15 **isolated network:** refers to the small remote electricity networks operated by Ergon Energy that are not connected to the main electricity network, and supplied via dedicated power station.

3.1.16 **Low Voltage (LV):** Means a voltage of no more than 1,000 V.

3.1.17 **Maximum Power Point Tracking (MPPT):** A technique used by charge controllers to maximise the power output of micro EG units.

3.1.18 **Medium Voltage (MV) network or feeder:** Within the Energex supply network, MV is considered to be the 11kV network and feeders. Within the Ergon Energy supply network, depending on the geographical location the MV is considered to typically be the 11kV or 22kV network, however may be an alternative voltage level such as 6.6kV or 33kV network.

3.1.19 **micro embedded generating unit:** means a generating unit having a capability of less than 10 kVA for a single phase connection or 30 kVA for a three phase connection, or as contemplated by AS/NZS 4777.

3.1.20 **minimal-export:** a micro EG unit that is paralleled with the distribution network and which is designed and configured to only export electricity into the distribution network as follows:

(a) for more than 5% of the inverter capacity only when responding to fluctuations in on-site demand and only for a maximum period of 15 seconds; and

(b) for up to 5% of the inverter capacity for periods longer than 15 seconds as a result of minor fluctuations in on-site demand, delays in equipment response time and the accuracy of measuring devices.

3.1.21 **network coupling point:** The point at which connection assets join a distribution network, used to identify the distribution service price payable by a Connection Applicant.

3.1.22 **non-parallel operation:** A micro EG unit which can supply customer load in back-up, also known as “off-grid”, arrangement which is not connected in parallel and does not synchronise with the distribution network. Loads shall be isolated from the distribution network when being supplied from the non-parallel micro EG unit.

3.1.23 **parallel operation:** Also called “grid connected”, this is where the micro EG unit is configured such that the micro EG unit and the distribution network may operate in parallel from time to time (even if this is a very short period of time). This includes where energy storage systems can be tied directly or indirectly back to the distribution network through an AS/NZS 4777 grid connect inverter. It is irrelevant whether the micro EG unit (including any energy storage system) exports any electricity to the distribution network.

3.1.24 **partial-export:** a micro EG unit that is paralleled with the distribution network and which is designed and configured to only export electricity into the distribution network as follows:

(a) for more than *k*% of the inverter capacity only when responding to fluctuations in on-site demand and only for a maximum period of 15 seconds; and

(b) for up to *k*% of the inverter capacity for periods longer than 15 seconds as a result of minor fluctuations in on-site demand, delays in equipment response time and the accuracy of measuring devices.

Where *k* is equal to the approved partial-export power value as a percentage of the inverter capacity. For example where the approved partial-export value is 2.5kVA of a 5kVA inverter, *k* = 50%.

3.1.25 **power limiting operation:** The ability to reduce or stop power output from inverters when export power exceeds a defined value.

3.1.26 **Proponent:** Means the Generator, Customer or developer or their agent (e.g. Consulting Engineers).

3.1.27 **qualified person:** means a person authorised under the Queensland Electrical Safety Act 2002 to complete electrical work.

3.1.28 **reactive power:** The rate at which reactive energy is transferred, which is a necessary part of an alternating current system containing inductive and capacitive components, as it regulates the voltage within the system.

3.1.29 **Retailer:** Means the entity who is authorised to sell electricity to the customer at the premises.

3.1.30 **shall**: Indicates that a statement is mandatory.

3.1.31 **supply network:** As described in Part 4 section 8 of the Electricity Act - 1994, a system or part of a system, of electric lines, substations and associated equipment, other than a transmission grid, for distributing electricity to customers, whether or not generating plant is connected to it.

3.1.32 **three phase balanced inverters:** Means a three phase inverter configured for three phase connection to the LV network. The inverter output shall be balanced across all three phases at all times whilst connected to the Network and all three phases simultaneously disconnect from, or connect to the Network in response to protection or automatic controls (e.g. anti-islanding and subsequent reconnection).

3.2 Acronyms and Abbreviations

The following acronyms and abbreviations appear in this standard.

AEMO	Australian Energy Market Operator
BBM	Break-Before-Make
CEC	Clean Energy Council
DNSP	Distribution Network Service Provider
DRM	Demand Response Mode
EG	Embedded Generation
EMC	Electromagnetic Compatibility
ESS	Energy Storage System
LV	Low Voltage
MPPT	Maximum Power Point Tracking
MV	Medium Voltage
PLC	Programmable Logic Controller
POE	Probability of Exceedance
PV	Photovoltaic
RPC	Reactive Power Control
RPEQ	Registered Professional Engineer of Queensland
SWER	Singe Wire Earth Return

4. Connection Assessment Requirements

This section provides details of the specific technical considerations made by the DNSP for the connection of a micro EG unit, in relation to set AS/NZS 4777 inverter size thresholds. These thresholds are the sum of all new or existing (approved or unapproved) parallel operated inverters at the Proponent's premises. A summary of the requirements and thresholds are provided in Table 1 (Ergon Energy) and
Table 2 (Energex). It is important to note that any specified differences between requirements for connection to the Ergon Energy supply network compared to the Energex supply network are reflective of the differences in topology and design of the comparable networks.

Table 1 – Ergon Energy Micro EG units Connection Requirements (0 - ≤30 kVA)

Inverter Export Limit (kVA)	Main Grid		SWER Networks	Isolated Networks
	1 or 2 Phase	3 Phase		
0	No RPC	No RPC	No RPC	No RPC
2	RPC	RPC	No RPC	No RPC
3.5	RPC	RPC	No RPC	No RPC
5	RPC (2 phase)	RPC	No RPC	No RPC
10		RPC	No RPC	No RPC
30				

Automated Assessment Manual Assessment

Table 2 – Energex Micro EG units Connection Requirements (0 - ≤30 kVA)

Inverter Export Limit (kVA)	Export 1 or 2 Phase	Export 3 Phase
0	No RPC	No RPC
3	RPC	RPC
5	RPC (2 phase)	RPC
10		RPC
15		RPC
30		

Automated Assessment Manual Assessment

Notes for Tables 1 & 2:

1. For details on single-phase and multi-phase balancing requirements see Section 5.4.
2. For details on export limitation see Section 5.9.1.
3. RPC = Reactive Power Control. For details on power quality modes see Section 5.10.

5. Technical Requirements and Performance Standards

5.1 Scope

The following outlines the mandatory technical requirements that are applicable to the Proponents proposed micro EG unit and the premises where the micro EG unit connection point resides. In all instances, a micro EG unit shall meet the mandatory requirements of all parts of AS/NZS 4777.

The additional technical requirements in this standard have been developed for the safety of the DNSP's and the Proponent's people and assets under foreseeable operating conditions. These requirements enable operation of the micro EG unit in parallel with the Supply Network without interference to the continuity and quality of supply to the DNSP's other customers

5.2 Remote Network Supply Arrangements

5.2.1 Ergon Energy SWER Networks

SWER networks, located within the Ergon Energy supply network, typically consist of higher network impedances, longer LV and MV feeders, and lower capacity transformers, in comparison to the standard urban and rural networks. As such the capacity of micro EG units which these networks can safely accept is somewhat lower than normal LV networks.

5.2.2 Ergon Energy Isolated Networks

Isolated networks, not connected to the main grid and supplied by Ergon Energy with dedicated power stations, while having typically higher network impedances and lower capacity transformers, also have finite micro EG unit hosting capacities. These hosting capacities are based on several factors, largely underpinned by the technical limitations of the existing generating plant that is used to provide electricity to the networks. Hosting capacities are set to ensure reliable supply and relate to online generation reserve to make up for sudden loss of intermittent generation sources, and to prevent operation of the diesel plant at below their minimum loading requirements for extended periods of time. As such the collective capacity of micro EG units which these networks can safely accept is determined on a network-by-network basis, and in order to effectively manage this, a manual assessment is required for all micro EG units connecting to an isolated network.

5.3 Supply Network Environment

The Proponent shall ensure that the micro EG units and other systems and facilities at the premises operate satisfactorily:

- for the full range of variation of system parameters and characteristics; and
- within the distortions and disturbances specified in these technical requirements.

Ergon Energy and Energex do not guarantee the operation of any customer appliances, including micro EG unit and their associated components. The Proponent should take necessary steps to ensure their micro EG unit operates as anticipated, and shall adhere to their connection agreement.

5.4 Multi-Phase Inverters

Single phase inverters, whether full-, partial- or minimal-export, are acceptable up to and including 5kVA on a customer's installation. Proponents with a single phase service are limited to 5kVA, and will need to make application with their retailer to upgrade their service to two or three phases should they request net inverter rating in excess of 5kVA.

For premises with a multiphase connection to the network, the grid-connected inverter(s) shall be configured to ensure the difference in power generated into any two phases does not exceed 5kVA per phase in normal operation. As per Clause 4.1 of the QECMM, Proponents shall also ensure that the current in any phase does not exceed the current in any other phase by more than 20A or 20% whichever is the greater.

If multiple single phase inverters are used, they shall operate in an interlocked fashion so that they do not operate independently across phases. Should one or more inverters disconnect due to fault or grid-protection operation, then all inverters shall disconnect within 2.0 sec of the first inverter disconnecting.

5.4.1 SWER Networks

An exception is made for SWER as it is a single phase LV network connecting to a single phase MV network. For Proponents on SWER networks:

- Applications to connect ≤ 10kVA single phase inverter capacity with export limit ≤ 2kVA will not require technical assessments.
- Applications to connect ≤ 10kVA single phase inverter capacity with export limit > 2kVA are permitted but will require a technical assessment.
- For any single phase installations with total inverter capacity > 10kVA – whether minimal-, partial- or full-export – a technical assessment will be required.

5.5 Micro-inverters

Micro EG units using micro-inverters shall be treated in the same way and subject to the same rules as any inverter. The summated inverter ratings and export limits shall be used in Tables 1 and 2 to determine requirements. Internal voltage rise calculations shall use the closest AC isolator to the start of the inverter string as the generation start point.

Multi-phase micro EG units using micro-inverters shall ensure generation remains balanced on all phases in accordance with Clause 5.4.

Where 50% or more of the number of micro inverters on a single phase are tripped due to an anti-islanding protection operation, all micro-inverters in the system shall disconnect.

5.6 Changeover Switches

Any generation connected behind a break-before-make (BBM) switch – that is it isolates the changeover circuit when transferring between grid supply to generation supply - will be considered as off-grid. However, any generation connected behind a make-before-break switch – that is it results in a momentary connection between grid supply and generation supply circuits when performing a changeover - will be considered as grid connected and therefore will be required to comply with this Standard.

5.7 Energy Storage System (ESS)

An ESS (such as batteries) provides an independent source of power, and is defined as having the ability to operate in parallel with the grid via an inverter, regardless of whether charged directly from the grid or through energy produced from a generation source. Connection of an ESS is only allowed through a parallel operating AS/NZS 4777 compliant inverter, in line with other forms of micro EG units.

There are a number of guidelines referring to the safe installation of energy systems (including energy storage systems) in Section 2.

Switches to isolate the ESS from the main switchboard shall be clearly identified and accessible to the DNSP's Quality of Supply Officers in the event of an investigation.

ESS is also required to meet the following conditions:

(a) For both parallel and hybrid connected micro EG's, the system shall be certified for compliance by an Accredited Person accredited by the CEC PV grid connect systems, and either grid-connected or stand-alone battery storage systems.
(b) The total capacity of inverters cannot be increased under the terms of the agreement and any such increase would require reapplication to the DNSP.

Given the limitations of isolated networks to support intermittent generation sources, ESS are assessed on a case by case basis for connection on Ergon Energy's isolated networks.

5.8 Electric Vehicles

Electric Vehicles that are only capable of charging from the grid are not considered a micro EG unit but rather only a load, and are subject to the requirements outlined in section 4.2 of the QECMM.

An electric vehicle will however be considered a micro EG unit and therefore be subject to the requirements of this Standard, where it is:

- Capable of exporting energy into the Proponent's premises but not the Supply Network, resulting in a minimal-export configuration (also referred to as Vehicle-to-Building or V2B); OR
- Capable of exporting energy into the Supply Network, resulting in either a full- or partial-export configuration (also referred to as Vehicle-to-Grid or V2G).

5.9 Protection of the Distribution Network

Inverters connected to the supply network shall be compliant to AS/NZS 4777. The inverter settings shall be set to the values given in Table 3.

Table 3 – Prescribed Inverter Settings

Parameter	***Setting (See Notes 1, 2 & 3)***
Vnom-max	Energex - 257V Ergon Energy – 255V
Overvoltage 1 (V>)	260V
Overvoltage 2 (V>>)	265V
Undervoltage (V<)	180V
Overfrequency (F>)	52Hz
Underfrequency (F<)	47Hz
Disconnect time	As per AS4777.2
Reconnect time	60 – 90 seconds
Reactive Power Control	Fixed Power Factor of 0.9 lagging (inductive) OR Q(V) - As per Figure 1 V_1 = 207V; PF_1 = 0.95 leading V_2 = 220V; PF_2 = 1 V_3 = 248V; PF_3 = 1 V_4 = 253V; PF_4 = 0.9 lagging

Note:

1. These settings apply to inverters certified with AS/NZS 4777.2-2015.
2. Where inverters do not have the two stage Overvoltage setting as per Table 3 above, the Vmax setting for a 2 second trip shall be set at ***255V – Ergon Energy; or 257V – Energex.***
3. Reactive Power Control is not required by default for SWER or Isolated Networks however may be required as part of the connection agreement due to results of connection agreement.

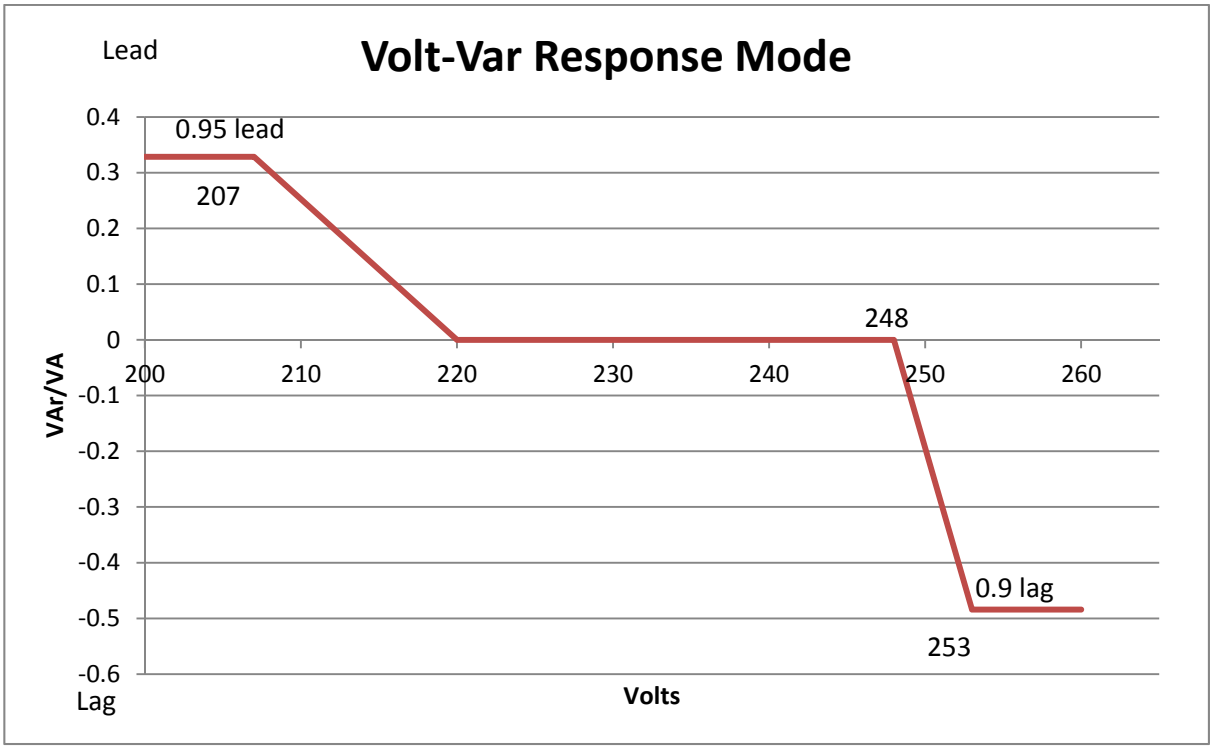

Figure 1 – Alternate Q-V Mode Settings

5.9.1 Power Limiting Operation

Where the connection of a micro EG installation to a distribution network has been approved on the basis that the export of energy to the distribution network is limited (that is, either a minimal-export or partial-export arrangement to a specified export limit), the Proponent shall ensure that the micro EG installation does not export energy to the distribution network over that export limit, including by complying with the following requirements:

- the export limit and over-voltage trip settings:
  - shall be set to DNSP's requirements;
  - shall be set and activated by a person qualified and authorised to carry out this work; and
  - shall not be changed by anyone other than a qualified and Accredited Person;
- the power limiting operation:
  - shall be achieved via either a separate protection relay, four quadrant power meter with programmable logic controller (PLC), or an inverter with the ability to adjust net power export to the approved export limit; and
  - shall not create flicker problems on the low voltage distribution network as a result of continuously switching inverters on and off. The maximum step size for switching must be limited to 15 kVA (3 phase), although lower step sizes are preferred;
- if current transformers or sensors are used, the terminals shall be sealed;
- the terminals of the power restricting relay/management system shall also be capable of being sealed to prevent tampering with connections – this could include a Perspex cover or lockable cabinet that the equipment is housed in (see Section 7 of the QECMM for options for metering locks); and
- the Proponent shall ensure that either:
  - a dedicated meter is installed to monitor the level of energy exported and feedback to the micro EG installation to remain under the export limit; or
  - if the revenue metering installation is used for this monitoring and feedback purpose:

- that the relevant *financially responsible Market Participant*, *Metering Provider*, and anyone else responsible for the provision and maintenance of that revenue metering installation commits to ensuring that the revenue metering installation continues to monitor the export of energy and feeds back to the micro EG installation to remain under the export limit; and
- satisfies the relevant Distribution Network Service Provider that this limit shall be maintained,

- where that meter operates in conjunction with the protection relay, four quadrant meter or adjustable inverter referred to above to facilitate compliance with the export limit; and
- the system shall be approved by an Accredited Person as meeting the above requirements;

Note that where the Distribution Network Service Provider is also the *Metering Provider*, the Distribution Network Service Provider may not guarantee appropriate monitoring interface with the revenue metering in all instances and appropriate options would need to be assessed on an individual case basis.

For configurations where an inverter provides the power limitation capability, the total cumulative export of all the inverters shall not exceed approved export limit. Should the inverter fail to receive a reading from an associated metering device, it must limit the total electricity output of the inverter to the programmed value for the maximum export to the distribution network. This feature shall not interfere with anti-islanding protection.

Settings for power limit function are provided in Table 4:

Table 4 – Power Limiting Settings

	Minimal Export	**Partial Export**
Export power limit	5% of inverter rating	*k*% of inverter rating
Definite time delay	15 sec	15 sec

Note:

1. Where k is equal to the approved partial-export power value as a percentage of the inverter capacity. For example where the approved partial-export value is 2.5kVA of a 5kVA inverter, k = 50%.

5.10 Power Quality Modes

As per Section 4 the DNSP may request the Proponent to implement a non-unity power factor setting on the inverter to reduce voltage rise at the network coupling point. In these cases inverters shall be used with the ability to vary power factor from unity down to 0.8 lagging, in accordance with Section 6.3 of AS/NZS 4777.2-2015. The default setting for export capable micro EG unit shall be fixed at 0.9 power factor lagging (inductive) unless otherwise negotiated with the DNSP.

Where required to implement a non-unity power factor configuration, the approved power quality response modes are:

- Fixed power factor mode (AS/NZS 4777.2 Section 6.3.3), or
- Volt-var response mode (AS/NZS 4777.2 Section 6.3.2.3)

Settings for the default mode are as defined in Section 5.9. If the DNSP provides an alternate lagging power factor for connection to reduce voltage rise at the network coupling point these settings shall be used in lieu of the default settings.

Power Quality Mode settings shall be the same for all of the inverters at site.

5.11 Demand Response Modes

Although not a mandatory requirement for general connections, where a Demand Response Mode capability is required as a result of the network connection agreement, the inverter shall be capable of the following modes as a minimum:

Table 5 – DRM Response Modes

Mode	*Description*
DRM 0	Operate the disconnection device
DRM 1	Do not consume power
DRM 4	Increase power consumption (subject to constraints from other active DRMs)
DRM 5	Do not generate power
DRM 8	Increase power generation (subject to constraints from other active DRMs)

Note DRM 1 and 4 are only relevant to micro EG units with energy storage system.

5.12 Steady State Voltage

The proposed installation shall be able to operate within the limits of supply voltage:

$$V_{phase\text{-}to\text{-}neutral} = 240V \pm 6\%$$

(Note – at the time of publishing Queensland are trialling a proposed move to 230V +10% / -6%. It is advisable that inverters are able to operate between both sets of limits.)

The proposed micro EG unit installation shall not cause more than 2% voltage rise at the network coupling point. Voltage rise shall be calculated in accordance with AS/NZ4777.1:2016. As a guide:

- Single inverter: voltage rise is calculated from the a.c. terminals of the inverter to the network coupling point.
- Multiple inverters with single a.c. isolation point (e.g. micro-inverters): voltage rise is calculated from where the interconnecting a.c. cable connects into the fixed installation wiring to the network coupling point.
- Multiple inverters with multiple a.c. isolation points: the voltage rise of all IES connected shall be considered together in calculation of the voltage rise for the micro EG unit installation.

5.13 Disturbance Issues

Disturbance to the LV network shall be assessed against BS EN61000-3-14 “Electromagnetic compatibility (EMC) – Part 3-14 – Assessment of emission limits for connection of disturbing installations to LV Power Systems.”

Measurement of voltage disturbances shall be as described in AS/NZS 61000.4.30:2012 using Class A or S instruments.

The DNSP may undertake, or may reasonably require, a program of tests performed at the Proponent’s cost, to ensure compliance with these disturbance limits under suspicion of breach. If such tests determine that the limits specified in this clause are exceeded and the non-compliance is due to the micro EG unit, then the Proponent shall take remedial action at its own expense to reduce any disturbance caused by the micro EG unit to less than the allowable levels. If the tests demonstrate compliance, or that the non-compliance is not caused by the operation of the micro EG unit, then the DNSP will reimburse the Proponent for the reasonable expenses incurred by the Proponent as a result of conducting the tests. If the tests demonstrate that the Proponent has

altered settings of the inverter or ancillary equipment from the originally approved settings, the DNSP shall disconnect the micro EG unit until the settings are changed and provisions have been taken to ensure indiscriminate changes are unable to be made in the future.

5.14 Metering

Metering requirements shall be in accordance with Section 10 of the Queensland Electricity Connection and Metering Manual (QECMM). Note that the micro EG unit may require an additional meter to be installed or, in the case of three phase customers, having a polyphase meter installed in lieu of three single phase meters.

5.15 Checklist and Accreditation of System

For all new and augmented connections, the Accredited Person shall ensure compliance of the system and complete the compliance checklist in Annex B, and a copy of this checklist shall be left on site for the DNSP's Connection Officers.

5.16 Commissioning

Commissioning tests for the inverter shall be in accordance with AS/NZS 4777, including:

- Operate the Main Switch (Inverter Supply) and verify the connection time is greater than 60 seconds.
- Isolate the Main Switch (Mains Supply) and verify the disconnect time is less than 2 seconds.
- Where power limiting operation is required, disconnect customer load and confirm export to the grid does not exceed approved limits.

Ensure that the micro EG unit is left with DC isolators on and AC isolators off until the necessary meter upgrade has been performed and the inverter maximum voltage settings have been verified as compliant with the connection and installation agreements.

Annex A - Compliance Checklist

The purpose of this compliance checklist is to aid the Proponent with the design and commissioning of the micro EG unit to ensure it meets the requirements, as per this standard.

Table 5 - General Inverter Settings

Parameter	***Setting***
Vnom-max	Energex - 257V Ergon Energy – 255V
Reactive Power Control	Fixed Power Factor of 0.9 lagging (inductive) OR Q(V) - As per Figure 1 V_1 = 207V; PF_1 = 0.95 leading V_2 = 220V; PF_2 = 1 V_3 = 248V; PF_3 = 1 V_4 = 253V; PF_4 = 0.9 lagging
Reconnect time	60 – 90 seconds

Table 6 - Disconnection Times

Parameter	***Setting***	***Trip Delay Time***	***Maximum Disconnection Time***
Overvoltage 1 (V>)	260V	1s	2s
Overvoltage 2 (V>>)	265V	-	0.2s
Undervoltage (V<)	180V	1s	2s
Overfrequency (F>)	52Hz	-	0.2s
Underfrequency (F<)	47Hz	1s	2s

Table 7- Power Limiting Settings

Parameter	***Setting***
Export Power Limit	As approved
Time delay	15s

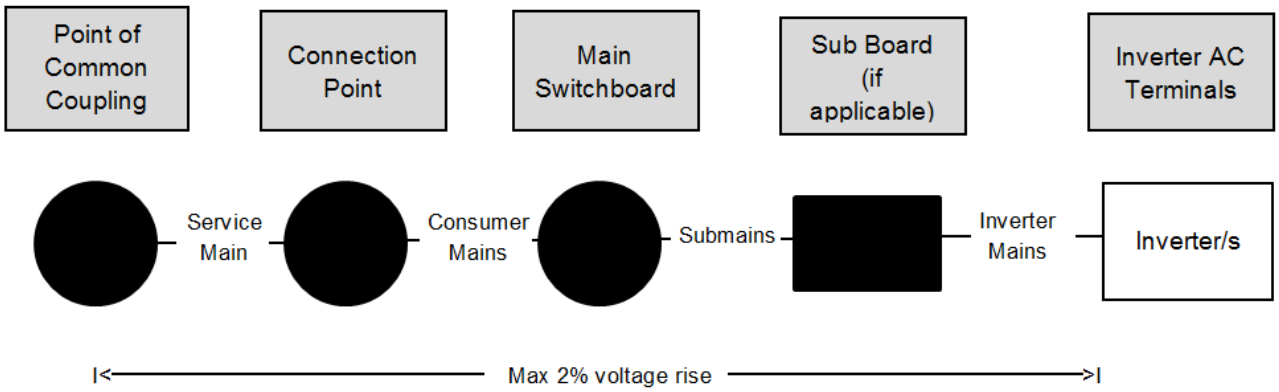

Figure 2 – Voltage Rise Calculation Diagram

Table 8 – Calculated Voltage Rise

Voltage Rise	***Service mains***	***Consumer mains***	***Submains***	***Inverter mains***	***Total Voltage Rise***
Calculated (V)					
Percentage (%)					

Annex B – Assessment Criteria for Applications

Annex B.1 Assessment Tests

Where a technical assessment is indicated as being required in Section 4 Table 1 or Table 2, the following tests may be performed by the DNSP. The Table 9 shows how Ergon Energy and Energex are applying these test criteria:

Table 9 - Application of Assessment Tests

	Energex	Ergon	Isolated Networks
Test 1	✓		
Test 2	✓		
Test 3	✓		
Test 4A/4B	✓	✓	✓
Test 5			✓

Test 1 – Transformer Penetration Test for LV Voltage Regulation

That the addition of the proposed micro EG's will not cause the total installed PV capacity off a **shared** transformer to exceed 25% of the transformer nameplate rating, reducing the probability of the transformer entering net export mode back onto the MV feeder.

Test 2 – Maximum Single Phase Inverter Test (Unbalance)

That the maximum single phase inverter size does not exceed 10% of the transformer nameplate rating for single phase transformers, or 8% of the nameplate rating for three phase transformers. There also shall not be an unbalance of any more than 5kVA between phases at any one connection, as per Clause 6.5. This test is not applicable to three phase balanced inverters.

Test 3– MV Feeder Voltage Fluctuation and Distortion Test

To minimise voltage disturbance to customers on the same MV network.

Ratio $\sum S_i / S_{schv} \leq 0.1\%$

Where:
S_i Three phase inverter rating (kVA)
S_{schv} Three phase fault level at network coupling point – MV (kVA)

Test 4– LV Feeder Voltage Regulation, Fluctuation and Distortion Test

To minimise voltage disturbance to customers on the same LV network.

Test 4A
Ratio $S_i / S_{sclv} \leq 1.0\%$

Where:
S_i Three phase inverter rating (kVA)
S_{sclv} Three phase fault level at point of common coupling – low voltage (kVA)

OR

Test 4B

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Conduct a voltage rise test based on **all** micro EG units connected to low voltage network. If the voltage rise does not exceed **1.0%** at the most distant micro EG units with the addition of the proposed micro EG units, then the system will pass Test 5.

Test 5 – Isolated Networks Only – Micro EG Unit Hosting Capacity Test

As the Ergon Energy's isolated networks' load is supplied via diesel generation, finite hosting capacity is available for connection of micro EG units. Hosting capacity is determined on a network-by-network basis, in order to ensure that the diesel generators:

- are able to respond to a sudden loss of generation from micro EG units, to maintain network stability; and
- do not operate below minimum loading for extended periods of time, to avoid irreversible damage to the diesel generators.

Annex B.2 Technical Considerations – Assessment and Mitigation Options

Where the proposed system fails to meet the five criteria outlined above, the Proponent may have the following options:

Fails Test 1 (Over supply of micro EG's on LV network)

- Reduce size of proposed micro EG's
- Install an approved power limiting device, as per Clause 5.9.1.
- Install a dedicated transformer.

Fails Test 2 (Over supply of micro EG's on single phase of LV transformer)

- Reduce size of proposed micro EG's
- Install a larger transformer
- Upgrade service connection to two phase or three phase

Fails Test 3 and 4 (Voltage rise on the MV or LV network)

- Reduce size of proposed system
- Install a three phase micro EG's in lieu of single phase
- Installing a dedicated low voltage circuit from the transformer (where Test 5 fails only)
- Installing a dedicated transformer (where Test 5 fails only)
- Install a four quadrant inverter with variable power factor setting and modify the power factor setting to reduce voltage rise to acceptable limits, as per Clause 5.12.
- Having additional reactive compensation to reduce voltage rise in combination with inverter shedding
- Augmentation of dedicated and shared assets to facilitate connection

Fails Test 5 (Isolated Networks – Micro EG Unit Hosting Capacity Test)

- Reduce the total inverter capacity of the micro EG unit (Note this option does not apply if the hosting capacity for the isolated network has been reached).
- Install an ESS for intermittent generation output ramp rate control. Note that this option is negotiated on a case-by-case basis and the ESS must meet additional requirements specific to operation on the isolated networks. Depending on the location of the proposed installation, this option may not be available due to technical limitations of the isolated networks.