



Part of the Energy Queensland Group

Standard for Connection of Embedded Generating Systems (>30 kW to 1,500 kW) to a Distributor's LV Network

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If this standard is a printed version, please download the latest version from Ergon Energy's and Energex's websites to ensure compliance.

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Abstract: This standard provides the requirements for connecting Embedded Generating (EG) systems 30 kW-1,500 kW in parallel with a Distributor's low voltage distribution network. Ergon Energy and Energex as the Queensland Distribution Network Service Providers have an inherent obligation to ensure that EG systems do not cause a material degradation in the quality of supply to other Distribution Network users and do not adversely affect operation of the Distribution Network.

Keywords: embedded, generating, low voltage, IES, solar, photovoltaic, wind, diesel, rotating, connection, synchronous, 1,500 kW, 1500 kW, 1.5 MW

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1 Overview

1.1 Purpose

The purpose of this Standard is to provide Proponents of embedded generating (EG) systems greater than 30 kW and no greater than 1,500 kW with information about their rights and obligations associated with connecting to a Distributor's Low Voltage Distribution System.

This Standard is also intended to assist the relevant Registered Professional Engineer of Queensland (RPEQ) in designing and commissioning EG systems for connection to a Distributor's Low Voltage Distribution System.

This Standard is intended to ensure safe and secure operation of a Distributor's Low Voltage Distribution System.

When reading this Standard, references to Distributors are to be read as references to either Energex or Ergon Energy, depending on which Distribution System the EG is being connected to.

1.2 Scope

This Standard applies to:

- all generating technology types including, but not limited to, Inverter Energy Systems (IESs) and rotating machines; and
- EG systems connected (directly or indirectly) to the Distributor's LV Distribution System; and
- where the aggregate installed nameplate capacity of all of the parallel connected EG systems at the Proponent's premises will exceed 30 kW but be no greater than 1,500 kW.

A Proponent will need to consult with the relevant Distributor to determine any additional requirements where the EG system is connected to the Distributor's Low Voltage Distribution System and shall:

- exceed 1,500 kW in capacity; or
- be connected to a Single Wire Earth Return (SWER) Distribution System; or
- be connected to an Isolated Distribution System.

For each of the generating technology types and operating regimes, this Standard gives consideration to the following:

- The safety and security of the Distribution System;
- Protection of the Interconnection between an EG system and the Distribution System;
- The management of thermal capacity limits of a Distribution System;
- Control of voltages and voltage fluctuation on the Distribution System;
- Contribution to fault levels by EG systems;
- Power factor and quality of supply of electricity generated;
- Stability of the Distribution System (voltage and transient); and
- Ongoing operating and maintenance procedures and communications.

Where possible the operating regime of the EG system has been considered, for example bumpless transfer, stand-by, export and non-export.

This Standard does not apply to:

- Off grid systems not connected in parallel with the Distribution System; and

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- Stand-by generating systems with a break-before-make changeover configured to ensure the generating system cannot be connected in parallel with the Distribution System.

1.3 Terminology

In this Standard, the word *shall* indicates a mandatory requirement, the word *should* indicates a recommendation and the word *may* indicates a requirement that may be mandatorily imposed on the Proponent, depending upon the outcome of detailed studies.

2 References

2.1 Energex controlled documents

A copy of the latest version of this Energex Standard may be obtained by searching for **embedded standard** from the following website:

<https://www.energex.com.au/>

Document number	Document name	Document type
Manual 01811	Queensland Electricity Connection Manual	Reference

2.2 Ergon Energy controlled documents

A copy of the latest version of this Ergon Energy Standard may be obtained by searching for **embedded standard** from the following website:

<https://www.ergon.com.au/>

Document number	Document name	Document type
NA000403R509	Queensland Electricity Connection Manual	Reference

2.3 Other documents

2.3.1 Australian and Australian/New Zealand Standards

Document #	Document name	Document type
AS/NZS 3000	Electrical installations (known as the Australian/ New Zealand Wiring Rules)	AU/NZ Joint Standard
AS/NZS 4777	Grid connection of energy systems via inverters (multiple parts)	AU/NZ Joint Standard
AS 60034.1	Rotating electrical machines, Part 1: Rating and performance	Australian Standard
AS 60034.22	Rotating electrical machines, Part 22: AC generators for reciprocating internal combustion (RIC) engine driven generating sets	Australian Standard
AS 60038	Standard Voltages	Australian Standard
AS 60044	Instrument transformers (multiple parts)	Australian Standard
AS/NZS IEC 60947.6-1	Low-voltage switchgear and controlgear - Multiple function equipment - Automatic transfer switching equipment	AU/NZ Joint Standard

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Document #	Document name	Document type
SA/SNZ TR IEC 61000.3.14	Electromagnetic compatibility (EMC), Part 3.14: Limits— Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems	AU/NZ Technical Report
SA/SNZ TR IEC 61000.3.15	Electromagnetic compatibility (EMC), Part 3.15: Limits— Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network	AU/NZ Technical Report
AS 61000.3.100	Electromagnetic compatibility (EMC)—Limits—Steady state voltage limits in public electricity systems	Australian Standard

2.3.2 International Standards

Document #	Document name	Document type
IEC 60255-1	Measuring relays and protection equipment – Part 1: Common requirements	International Standard
IEC 60255-132	Electrical relays - Part 132: Functional requirements for over/under power protection	International Standard
IEC 60255-26	Electrical relays - Part 26: Electromagnetic compatibility requirements	International Standard
IEC 60255-27	Electrical relays - Part 27: Product safety requirements	International Standard
IEC 60255-127	Measuring relays and protection equipment - Part 127: Functional requirements for over/under voltage protection	International Standard
IEC 62116	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures	International Standard
IEEE Std 1547-2018	IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces	IEEE Standard

3 Legislation, regulations, rules, and codes

This Standard refers to the following:

Legislation, regulations, rules, and codes
<i>Electricity Act 1994</i> (Qld) and <i>Electricity Regulation 2006</i> (Qld)
Frequency Operating Standards (Mainland) published by the AEMC's Reliability Panel
National Electricity Law and National Electricity Rules as they apply in the Queensland jurisdiction
<i>Professional Engineers Act 2002</i> (Qld)

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4 Definitions, acronyms, and abbreviations

4.1 Definitions

For the purposes of this Standard, the following definitions apply. Please note that certain abbreviations and acronyms are separately defined in the next section.

Term	Definition
Anti-islanding protection	A protection system to detect islanded conditions and disconnect the inverter(s) or rotating plant from the Distribution System.
Connection Agreement	Contract issued under connection application process used for an EG system connection as outlined in Chapter 5A of the NER (or if the Proponent elects to use it, Chapter 5 of the NER), also referred to as a consent agreement.
Connection Assets	Those components of a Distribution System which are used to provide connection services.
Connection Point	An agreed point of supply established between the Distributor and a Proponent.
Distribution Network	A network which is not a transmission network. This Standard refers to the Low Voltage portion of the Distribution Network.
Distributor	In this Standard, Distributor means either Energex (who owns and operates the Distribution System in South East Queensland) or Ergon Energy (who owns and operates the Distribution System in the remainder of Queensland).
Distribution System	A Distribution Network together with relevant Connection Assets.
EG system(s)	One or more electricity generating units and auxiliary equipment that are interconnected with a Distribution Network.
Energy Laws	Relevant laws relating to the subject matter of this Standard, including, without limitation and where applicable, the <i>Electricity Act 1994</i> (Qld), the <i>Electricity Regulation 2006</i> (Qld), the <i>Electrical Safety Act 2002</i> (Qld), the <i>Electrical Safety Regulation 2013</i> (Qld), the Electricity Distribution Network Code, the National Electricity (Queensland) Law, the National Electricity (Queensland) Rules, the National Energy Retail Law (Queensland) and the National Energy Retail Rules (Queensland).
Export	Net power that is fed into the Distribution System through the Connection Point.
High Voltage (HV)	A voltage exceeding 1,000 V.
Interconnection	Connection of an EG system capable of parallel operation with a Distribution System.
Inverter Energy System (IES)	A system comprising one or more inverters together with one or more energy sources (which may include batteries for energy storage), controls and one or more grid protection devices.
Isolated Distribution System	Refers to the small remote electricity Distribution Systems operated by Ergon Energy that are not connected to the main electricity Distribution System, and supplied via a dedicated power station.
Isolation Device	Device designed to safely prevent the flow of current such as circuit breaker or contactor.
Low Voltage (LV)	A voltage of no more than 1,000 V.
Multiple Earth Neutral (MEN)	A multiple earth neutral system of earthing is one in which the LV neutral conductor is permanently connected to earth.
NER	The National Electricity Rules under the National Electricity Law as in force in Queensland.

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Term	Definition
Network Coupling Point	The point at which Connection Assets join the shared Distribution Network.
Proponent	The relevant owner, operator or controller of the EG system (or their agent).
PSCAD™/EMTDC™	Refers to a software package developed by the Manitoba-HVDC Research Centre that comprises a power systems computer-aided design package which includes an electromagnetic transients (including DC) simulation engine, and which is used to carry out electromagnetic transient type studies.
Technical Assessments	A study to evaluate the effects that the proposed connection of the EG system will have on the Distribution System under different loading conditions or in the event of particular faults.

4.2 Acronyms and abbreviations

The following abbreviations and acronyms appear in this standard.

Abbreviation or acronym	Definition
AEMC	Australian Energy Market Commission
CBF	Circuit Breaker Fail
CP	Connection Point
DNISP	Distribution Network Service Provider
EG	Embedded Generating
GPR	Grid Protection Relay
HV	High Voltage
IES	Inverter Energy System
LV	Low Voltage
MEN	Multiple Earth Neutral
NER	National Electricity Rules
NVD	Neutral Voltage Displacement
ROCOF	Rate of Change of Frequency
RPEQ	Registered Professional Engineer of Queensland
SWER	Single Wire Earth Return

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5 Connection arrangements

5.1 General

Under the Energy Laws, Proponents of EG systems shall obtain consent from a Distributor before Interconnecting their EG system with the Distributor's Distribution System.

This Standard covers the installation of EG systems to premises having LV connections to the Distribution System. The EG systems may be connected to a dedicated or shared LV circuit or a dedicated transformer.

The negotiation of a Connection Agreement with the Distributor involves the Distributor assessing the EG system (as at the Connection Point) to determine what impact the EG system will have on the Distribution System so that it can provide technical connection requirements.

Where there are multiple EG systems at a premises connected to a single Connection Point, the Technical Assessment will consider the aggregate of the existing and proposed EG systems. Connection proposals for bulk metered sites (e.g. strata title) are also considered as the aggregate EG systems. Metering options for bulk metered connections are given in Section 9.1 of this Standard.

Annex A summarises the connection requirements for different types of EG systems.

5.2 Methods of operation and export capability

For the purpose of this Standard, Table 1 illustrates the operation types, nature of parallel operation and export capability for all EG systems that may connect to the Distribution System.

Table 1 Types of EG systems

Operation Type	Parallel Operation		Export Capability
	Duration	Frequency	
Bumpless transfer	up to 2 seconds	N/A	Non-export only
Stand-by (for testing only)	up to 6 hours	Every 3 months	Either export or non-export
Continuous parallel	Greater than 24 hours	In a year	Either export or non-export

5.2.1 Export EG systems

EG systems that export electricity into the Distribution System can be categorised as partial-export or full export.

Partial-export EG systems shall be designed and operated to limit the amount of export into the Distribution System to an agreed export threshold set out in the Connection Agreement.

Full export EG systems will not incorporate any such limitations and can export into the Distribution System to the full nameplate capacity (full AC rating) of that EG system.

5.2.2 Non-export EG systems

EG systems that are not approved to export electricity into the Distribution System shall be designed and operated to prevent this export of electricity.

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5.2.3 Bumpless transfer EG systems

Bumpless transfer EG systems shall incorporate a make-before-break automatic transfer switch compliant with AS/NZS IEC 60947.6-1. Parallel operation with the Distribution System shall comply with the duration limits shown in Table 1. Bumpless transfer EG systems do not require assessment for the effect of increased thermal or fault ratings on the Distribution System, and are exempt from certain specific protection requirements detailed in Section 7.4.11.

5.3 Specific nature of connection

EG systems can be connected to the Distribution System through a shared or dedicated transformer arrangement. Connection and parallel operation with any part of the Distribution System is dependent upon compliance with the requirements outlined in this Standard at each point where the EG system can parallel with the Distribution System.

EG systems that supply only part of the Proponent's installation shall have adequate mechanisms in place to prevent the following:

- Parallel connection of the Distributor's substation transformers; and/or
- Connection of the EG system to the Distribution System occurring without synchronisation and the operation of associated protection systems.

Unless otherwise agreed with the Distributor, an EG system shall only connect to the Distribution System via a single Connection Point. It is the Proponent's responsibility to provide an Isolation Device at the Connection Point, EG system transformer(s) (if required) and all associated protection controls and ancillary equipment.

5.4 Technical Assessments

Technical Assessments will be completed by the Distributor as part of the connection application process for EG systems. The connection application process usually used for these connections is outlined in Chapter 5A of the NER (or if the Proponent elects to use it, Chapter 5 of the NER) and can be found on both Distributor's websites:

- Energex: <https://www.energex.com.au/home/our-services/connections/major-business/large-generation-and-batteries>
- Ergon Energy: <https://www.ergon.com.au/network/connections/major-business-connections/major-connections>

To permit the connection of an EG system to the Distribution System, the Distributor shall require sufficient information to perform the Technical Assessment, and fees shall apply. More information on these fees can be found on each Distributor's website:

- Energex: <https://www.energex.com.au/home/our-services/pricing-And-tariffs>
- Ergon Energy: <https://www.ergon.com.au/network/network-management/network-pricing>

The required information to be provided during the connection application process will be indicated at the time of the connection application. On occasion, the Distributor may request additional information to assist in processing the connection application.

The Distributor shall conduct penetration or capacity checks on the existing Distribution System and depending on the constraints identified may conduct a number of further tests during the Technical Assessment, being:

- Power quality checks (fluctuation/distortion/voltage rise) on the Distribution System;
- System strength testing for systems located in weak grid configurations;
- Distribution System protection; and
- Fault current contribution for rotating machines.

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Where the EG system is greater than 200kW and is identified to be connecting to a Distribution System with constraints, the Distributor may request a manufacturer-developed EMT model of the EG unit(s) with relevant site-specific settings. The EMT model shall be developed using PSCAD™/EMTDC™.

6 EG system requirements

6.1 General

The designer of an EG system shall consider both the Distribution System performance requirements, as per this Standard, and the specific requirements for the generating equipment and the installation.

6.2 Distribution System equipment ratings

The ratings of equipment both within the Distribution System and the Proponent's side of the Connection Point shall not be exceeded when the EG system operates in parallel with the Distribution System.

6.3 Fault levels and protection impacts

In designing the EG system, protection systems shall be used to manage faults and abnormalities:

- Within the EG system generating unit(s);
- Within the Proponent's installation associated with the EG system;
- In the vicinity of the Connection Point; and
- In the wider Distribution System.

Fault levels shall not exceed the equipment rating of the EG system, associated switchgear and protection equipment. Where the EG system is able to contribute to fault levels, the Distributor will:

- Conduct fault studies inclusive of faults in the Proponent's installation and the Distribution System ; and
- Provide the Proponent with the existing fault levels and protection equipment ratings to assess whether the design of the EG system exceeds relevant equipment ratings.

Where it is determined the design of the EG system has the potential to raise the fault levels on the Distribution System beyond the capacity of the Distributor's protection device(s), the Proponent shall meet the cost to upgrade the protection device(s) and ensure that their switchboard and equipment can withstand the total prospective fault currents.

Fault level considerations shall be made for the following configurations of EG systems with rotating machine EG unit(s):

- Bumpless transfer EG systems shall have fault levels considered only at the LV Distribution System level;
- Stand-by EG systems shall have a pro-rated factor applied to the prospective fault levels, which shall be dependent on the number of EG systems connected to the relevant part of the Distribution System at the same time; and
- Continuous parallel EG systems shall have fault levels considered for both HV and LV Distribution Systems.

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6.4 Means of isolation

The Proponent shall provide a means of isolation that is capable of disconnecting the whole of the EG system from the Distribution System. Where the EG system is an aggregate of smaller distributed EG systems, multiple isolation points may exist. The means of isolation shall be able to be locked in the open position only.

6.5 Operating voltage and frequency

6.5.1 Standard power system voltage

The EG system shall be designed and operated to ensure that phase to neutral voltage at the Connection Point is 230 V +10%/-6% as per AS 60038 and AS 61000.3.100.

The EG system shall be designed and operated so that there is a maximum 2% voltage rise from the EG system to:

- (for a shared Distribution System connection) – the Network Coupling Point; and
- (for a dedicated Distribution System connection) – the transformer's LV terminals.

6.5.2 Standard power system frequency

The EG system shall be designed and operated to meet the power system power frequency requirements under the NER and the AEMC's Frequency Operating Standards.

6.6 Inverter Energy Systems

6.6.1 Standards compliance

All EG systems comprising an IES EG unit(s) shall:

- use inverters that have certified compliance with AS/NZS 4777.2 and IEC 62116 Edition 2; and
- where the EG system is ≤ 200 kVA, be compliant with AS/NZS 4777.1.

6.6.2 Voltage limits for sustained operation

All inverters in the EG system shall automatically disconnect within 3 seconds when the average voltage for a 10 minute period exceeds the V_{nom_max} with the setpoint as follows:

- Ergon Energy: $V_{nom_max} = 255$ V
- Energex: $V_{nom_max} = 257$ V

The sustained operation for voltage variations shall not interfere with the voltage protection requirements given in Section 7.3.2 of this Standard.

6.6.3 Power Quality Modes

EG systems that comprise an IES EG unit(s) shall have volt-var response modes enabled and configured as shown in Table 2 and Figure 1.

Proponents may request to enable volt-watt response mode. The use of volt-watt response mode is subject to agreement with the Distributor. Where volt-watt response mode is enabled it shall be configured as shown in Table 3 and Figure 2.

Note – The volt-var and volt-watt response mode settings required are not the default settings specified in AS/NZS 4777.2:2015.

The Distributor may require these settings to be further modified in some cases.

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Table 2 volt – var response mode settings

Reference	Voltage	var % rated VA	Power Factor
V ₁	207 V	31% leading	0.95 leading
V ₂	220 V	0%	1
V ₃	250 V	0%	1
V ₄	260 V	44% lagging	0.9 lagging

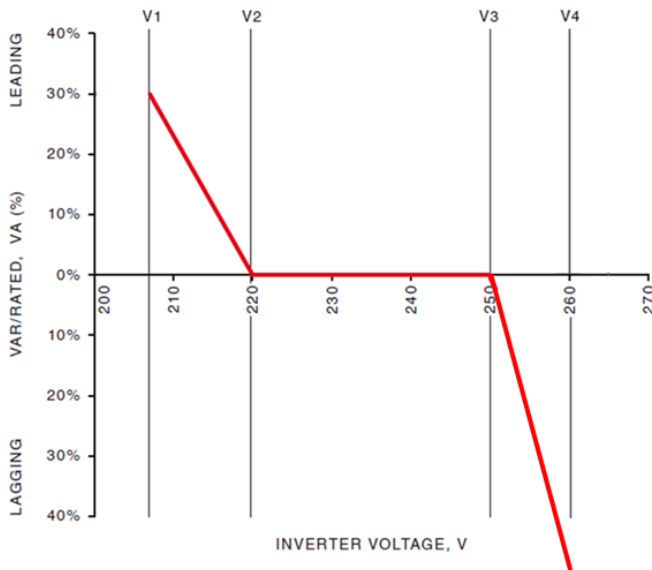


Figure 1: volt – var Control Mode

Table 3 volt - watt response mode settings

Reference	Voltage	Max value (P/P_{rated}^1), %
V ₁	207 V	100%
V ₂	220 V	100%
V ₃	250 V	100%
V ₄	260 V	20%

Note 1 - Where P is the output power of the inverter and P_{rated} is the rated output power of the inverter

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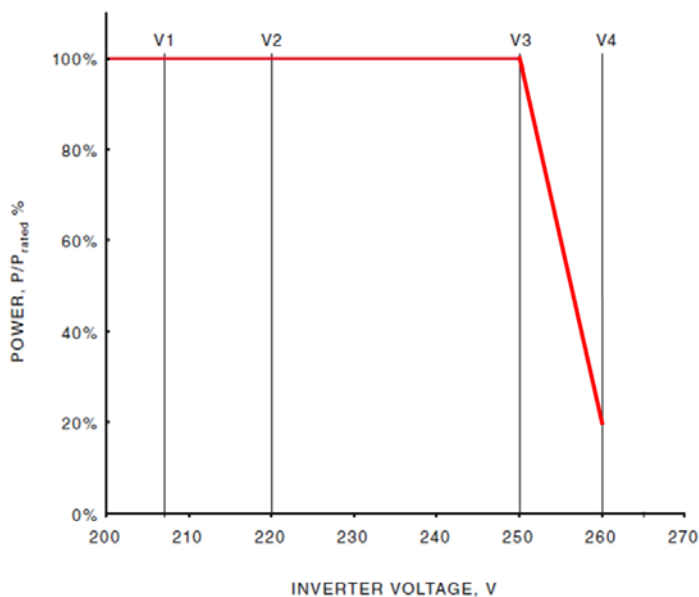


Figure 2: volt – watt Control Mode

6.6.4 Power Limiting

Export power limiting control shall be used for IESs where the EG system has been approved by the Distributor as a non-export or partial-export EG system. This export power limiting control shall limit export with reference to the Connection Point, comply with the export control requirements of Section 3.4.8 of AS/NZS 4777.1 using a soft limit, and achieve the requirements shown in Table 4.

Table 4 Power limiting settings for IESs

	Non-export	Partial-export
Export power limit	0 kW ¹	n kW ^{1,2}

Note 1 – A measurement tolerance of +5% of the rated size of the EG system for the set export power limit is allowable for compliance with this standard. For example, a 100 kW non-export EG system can have measured export of up to 5 kW at the Connection Point for durations longer than 15 seconds and any export above 5 kW shall occur for no longer than 15 seconds.

Note 2 – n is equal to the approved partial-export power limit for the EG system. For example, where the approved partial-export value is 50 kW of a 100 kW IES, $n = 50$ kW.

6.6.5 Multiple inverters

Where the EG system comprises multiple inverters:

- The EG system shall have a protection scheme for the Connection Point in addition to protection for each inverter;
- There shall be balanced output between phases at all times whilst connected to the Distribution System; and
- All inverters on all three phases of the EG System shall simultaneously disconnect from, or connect to, the Distribution System in response to the operation of protection or automatic controls.

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6.7 Rotating machines

6.7.1 Standards compliance

All EG systems comprising a rotating machine EG unit(s) that are installed under this Standard shall be compliant with:

- AS 60034.1 Rotating electrical machines, Part 1: Rating and performance; and
- AS 60034.22 Rotating electrical machines, Part 22: AC generators for reciprocating internal combustion (RIC) engine driven generating sets.

6.7.2 Re-energisation and Synchronising

The Distributors apply an automatic feeder re-closing scheme on the majority of their Distribution System. Automatic re-energisation of the feeder during this process opens the circuit breaker (with minimum delay) following a power system fault, and then attempts to automatically re-energise the feeder component after a predefined disconnected time (dead time). Automatic reclosing can happen multiple times depending on the Distribution Network location.

The EG system shall disconnect within this dead time upon a loss of mains power to ensure safe restoration. Failure of the EG system to so disconnect when there is a loss of supply from the Distribution System may result in damage to the EG system.

When the system voltage has been restored on the Distribution System side of the Connection Point, and the voltage and frequency have been maintained within protection limits for a period of greater than 60 seconds, the EG system may reconnect with the Distribution System.

The EG system shall incorporate either automatic or operator-controlled equipment that ensures the frequency, voltages, and phase sequence of the EG system is identical with (synchronised to) those in the Distribution System before it connects to the Distribution System. The EG system shall not reconnect until it is synchronised with the Distribution System.

6.7.3 Power control

EG systems shall be capable of injecting or absorbing reactive power. The Distributor will specify the acceptable operating power factor setting or mode as part of the Technical Assessment.

An EG system comprising a rotating machine EG unit(s) shall be designed and operated to adequately control real and reactive power output to achieve a power factor at the Connection Point of greater than 0.8 lagging and not leading unless agreed to by the Distributor.

7 Protection

7.1 General

The protection requirements outlined in this Standard are in relation to the protection of Distributor assets and staff, and are not intended to replace or override any of the protection specifically required for the Proponent's installation and EG system.

The protection schemes shall be designed with main and backup protection designed to detect all credible AC fault types. This protection shall include sufficient redundancy to ensure that a faulted element within the protection zone is disconnected from the Distribution System within the applicable fault clearance time with any single protection element (which may include communications upon which that protection system depends) out of service.

In the event of a loss of supply from the Distribution System, EG systems shall not be able to operate connected to the Distribution System, unless this has been explicitly approved by the Distributor. To prevent the EG system operating in islanded mode with respect to the Distribution System, a Distributor-approved protection scheme or schemes shall be installed.

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In addition to the protection installed for the EG systems, the Proponent shall install a protection system so that:

- If one or more phases of the Distribution System are lost, the EG system disconnects from the Distribution System; and
- The EG system shall automatically disconnect from the Distribution System in the event of failure of any auxiliary supplies to the protection equipment that would inhibit its correct operation.

When any of the above conditions are detected, the EG system shall be disconnected from the Distribution System through an EG system Isolation Device that ensures complete disconnection.

Testing and commissioning of the protection shall meet the requirements outlined in Section 11 of this Standard.

7.1.1 Device approval and compliance

Protection equipment shall operate the Isolation Device either directly or through interposing equipment. Such protection equipment and any interposing equipment shall have certified compliance with the following:

- IEC 60255-1 Common requirements;
- IEC 60255-26 EMC requirements;
- IEC 60255-27 Product safety requirements;
- IEC 60255-127 Functional requirements for over/under voltage protection; and

For EG systems requiring power limiting protection as per Section 7.4.7:

- IEC 60255-132 Functional requirements for over/under power protection.

Marshalling of protection trips through control equipment shall be compliant with IEC 60255.

The instrument transformers used to interface the protection equipment with the Proponent's installation shall have certified compliance with:

- AS 60044.1 Current transformers;
- AS 60044.2 Inductive voltage transformers; and
- AS 60044.3 Combined transformers.

7.1.2 Remote or Transfer Trip (Inter-tripping)

The Proponent's design shall not require an inter-trip from the Distributor.

7.1.3 Grid Protection Relay

The Grid Protection Relay (GPR) is a protection device that shall meet the following requirements:

- Be based on a measurement at the Connection Point;
- Provide under voltage, over voltage, under frequency, over frequency and ROCOF protection designed to meet the requirements of this Standard;
- Be integrated in such a way that it fails safe, and not allow generation whilst the protection is out of service; and
- Open the Isolation Device at either the Proponent's Connection Point or EG system.

The GPR shall be configured to meet the settings specified for inverter energy systems in Table 7 and for rotating machines in Table 8.

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7.2 General protection functions

7.2.1 Over current and earth fault protection

Overcurrent and earth fault protection shall also be provided at the EG system in accordance with AS/NZS 3000. This protection shall be set to detect faults within the Proponent's installation. This protection shall coordinate with the protection scheme of the Distribution System.

7.2.2 Isolation Device fail protection

Loss of mains and anti-islanding protection scheme design shall make allowance for the failed operation of an Isolation Device.

The protection scheme shall not operate the same Isolation Device for both primary and backup protection. There may be multiple Isolation Devices for either primary or backup protection.

The Proponent may elect to use another form of Isolation Device fail protection, such as a circuit breaker fail (CBF) scheme, subject to the Distributor's agreement.

7.3 Inverter Energy Systems

7.3.1 Loss of mains protection

Loss of mains protection for IES EG systems requires:

- Passive and active anti-islanding protection achieved through the installation of inverters with certified compliance to both AS/NZS 4777.2 and IEC 62116 Edition 2; and
- A GPR backup protection device.

7.3.2 Voltage protection

Under and over voltage protection shall be installed to monitor all three phases at the Connection Point. Passive anti-islanding set-point values from AS/NZS 4777.2 shall be applied to the inverter as per Table 5.

Table 5 IES voltage protection settings

Setting parameter	IES Settings		
	Pickup	Trip Time Delay	Maximum Disconnection Time
Overvoltage 1 (V>)	260 V_{I-n}	1.0 s	2.0 s
Overvoltage 2 (V>>)	265 V_{I-n}	0.0 s	0.2 s
Undervoltage (V<)	180 V_{I-n}	1.0 s	2.0 s

7.3.3 Frequency protection

Passive anti-islanding set-point values from Table 13 of AS/NZS 4777.2 shall be applied to the inverter. Any backup protection should grade over the inverter settings.

The default over and under frequency protection settings from AS/NZS 4777.2 for central protection are given in Table 6. If required by the Distributor following the Technical Assessment, site-specific settings will be provided to the Proponent.

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Table 6 Frequency protection settings.

Setting parameter	IES Settings		
	Pickup	Trip Time Delay	Maximum Disconnection Time
Over frequency (OF, f>)	52 Hz	0.0 s	0.2 s
Under frequency (UF, f<)	47 Hz	1.0 s	2.0 s

7.3.4 GPR settings

The GPR shall be configured to meet the requirements in Section 7.1.3 and the settings specified for IES in Table 7.

Table 7 IES Grid Protection Functions

Protection functional description	ANSI/IEEE C37.2 Code	IEC 60617 Code	Default Setting	Time Delay
Level 1 backup protection				
Under voltage (UV)	27P	U<	180 V _{L-n}	3.0 s
Over voltage (OV)	59P	U>	260 V _{L-n}	3.0 s
Under frequency (UF)	81U	f<	47 Hz	3.0 s
Over frequency (OF)	81O	f>	52 Hz	3.0 s
Rate of change of frequency (ROCOF)	81R	df/dt	3 Hz/s	0.0 s ¹

Note 1 – Sampling size to be between 4 -12 cycles

7.3.5 IES protection arrangements

A typical protection arrangement for an EG system comprising IES EG units is shown in Figure 3.

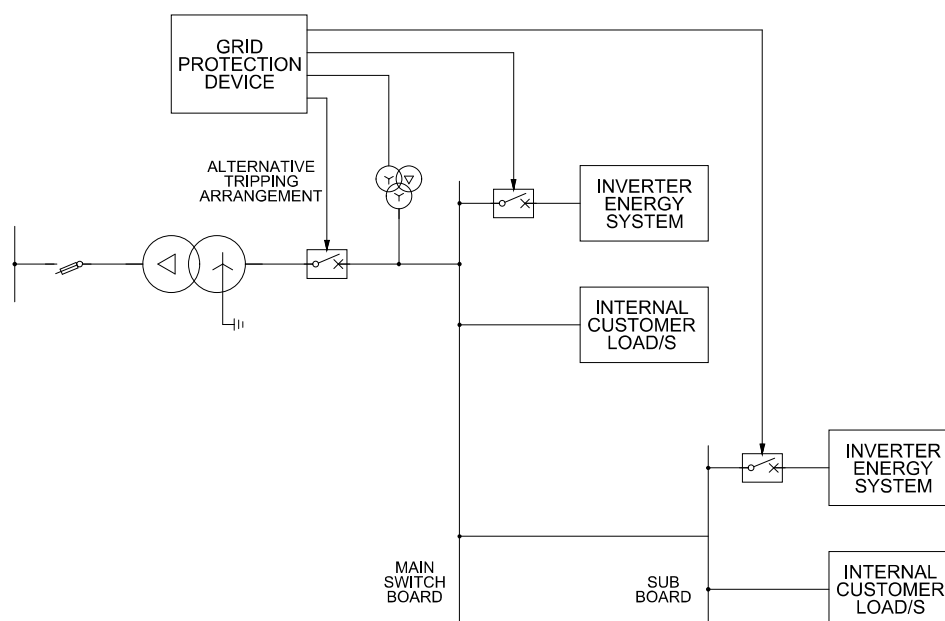


Figure 3 Protection arrangement for EG systems comprising IES EG unit(s)

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7.3.6 Wireless transfer

Where an EG system's GPR and export monitoring device is remote from the EG system's Isolation Device or inverters, a wireless communication system may be used. A GPR and export monitoring device utilising a wireless communication system shall meet the following requirements:

- Have a supervised wireless communications link; and
- Disconnect the EG system from the Distribution System for any loss of communications longer than 5 seconds.

7.4 Rotating machines

7.4.1 Loss of mains protection

The EG system shall be automatically disconnected from the Distribution System whenever the Distribution System is de-energised for either a fault or routine switching operation. Loss of mains protection for EG systems comprising a rotating machine EG unit(s) requires:

- ROCOF protection as per Section 7.4.5; and
- Neutral voltage displacement protection as per Section 7.4.8.

7.4.2 Voltage protection

Under and over voltage protection shall be installed to monitor all three phases at the Connection Point. This protection shall be set to detect if the phase to neutral voltage on any phase at this point exceeds predetermined limits, which shall be based on the proposed connection arrangement and operating requirements. The Distributor will provide voltage protection limits for EG systems comprising a rotating machine EG unit(s) as part of the Technical Assessment.

7.4.3 Unbalance protection

Negative sequence voltage and current protection may need to be installed and appropriate settings applied at the EG system to protect against voltage and current unbalance from the Distribution System and/or the Proponent's network.

7.4.4 Frequency protection

Under and over frequency protection shall be installed at either the Connection Point and/or the EG system. The frequency protection tripping shall be based on the proposed connection arrangement and operating requirements, as outlined in the Connection Agreement. The frequency protection settings shall be determined at the Proponent's design stage, and are subject to the results of the Technical Assessment.

7.4.5 ROCOF protection

EG systems shall have a ROCOF relay to monitor frequency excursions and control the disconnection of the EG system from the Distribution System.

The Proponent shall determine the ROCOF to prevent an island being formed when the Distribution System is de-energised. Where the calculated value is greater than 3 Hz/s, the Distributor shall be consulted.

7.4.6 GPR settings

The GPR shall be configured to meet the requirements in Section 7.1.3 and the settings specified for rotating machines in Table 8.

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Table 8 Rotating Machine Grid Protection Functions (Note 2)

Protection functional description	ANSI/IEEE C37.2 Code	IEC 60617 Code	Default Setting	Time Delay
Level 1 backup protection				
Under voltage (UV)	27P	U<	180 V _{I-n}	2.0 s
Over voltage (OV)	59P	U>	260 V _{I-n}	2.0 s
Under frequency (UF)	81U	f<	47 Hz	2.0 s
Over frequency (OF)	81O	f>	52 Hz	2.0 s
Rate of change of frequency (ROCOF)	81R	df/dt	See Note 1	0.0 s ¹
Level 2 backup protection				
Neutral voltage displacement (NVD)	59N	U0>	20%	3.0 s
Non-Export EG Systems				
Directional power	32	P→	From Technical Assessment	From Technical Assessment
Other methods to that may be required depending on the outcome of Distribution System studies				
Negative sequence voltage	47	U2>	From Technical Assessment	From Technical Assessment
Negative sequence current	46	I2>	From Technical Assessment	From Technical Assessment

Note 1 – ROCOF calculated by the Proponent to ensure an island is not sustained when the Distribution System is de-energised. Where the calculated value is greater than 2 Hz/s, the Distributor shall be consulted. Sampling size to be between 4 -12 cycles.

Note 2 – See Clause 7.4.11 for exemptions for self-exciting induction machines.

7.4.7 Reverse power or power limit protection

Where the EG system has been approved by the Distributor as either a non-export or partial-export system, reverse power or power limit protection (respectively) shall be installed at the Connection Point or upstream of all EG unit(s) within the Connection Point. Any power limiting protection settings will be determined by the Distributor as part of the Technical Assessment.

7.4.8 Neutral voltage displacement (NVD) protection

NVD protection shall be installed for EG systems comprising a rotating machine EG unit(s). NVD protection is required to ensure that an EG system disconnects if there is a high voltage network earth fault. NVD protection requires either phase-neutral or an open delta voltage measurement of the relevant part of the HV Distribution Network.

NVD protection requires equipment to be installed on the Distributor's assets.

7.4.9 Additional overcurrent and earth fault protection requirements

For EG systems comprising rotating machines the overcurrent and earth fault protection relays shall provide compensation for under voltage field weakening. Compensation for under voltage field weakening is not required where the Proponent can demonstrate that voltage depression at the EG system during fault events shall not adversely impact on the operation of the protection scheme.

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7.4.10 Backup anti-islanding protection

An additional anti-islanding protection relay shall be installed to operate the Isolation Device at the Connection Point. This relay shall provide backup protection functions in parallel with the GPR for loss of mains.

7.4.11 Exemptions

Due to the reduced risk associated with the specific EG system configurations, the following configurations are exempt from particular protection requirements of this Standard as detailed:

- Asynchronous (induction) EG systems with ratings not exceeding 200 kW do not specifically require NVD protection;
- EG systems with bumpless transfer operation do not specifically require NVD protection, loss of mains protection or backup anti-islanding protection; and
- EG systems with stand-by operation do not specifically require NVD protection.

8 Earthing

8.1 General

Depending on the location of the proposed connection, the Distribution System is operated as either a solidly- or impedance-earthed system. All metallic equipment housing and fixtures shall be connected to an earth point in accordance with AS/NZS 3000.

The Proponent shall provide satisfactory earthing for the EG system independent of the Distribution System in accordance with regulatory requirements. Any subsequent connection to the Distributor's earth grid shall be by mutual agreement in writing.

8.2 Multiple Earth Neutral

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

8.3 Neutral harmonics

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

9 Metering

9.1 Bulk metered connections

Where connections are bulk metered, like a strata titled development (such as townhouses or a retirement village), as illustrated in Annex B, there are three supply options available to the Proponent:

- Option 1 – Aggregated EG systems off a separate circuit from the main switchboard that are not separately metered by the Proponent;
- Option 2 – Separate reticulation circuit for EG systems and individual metering of each EG system by the Proponent; or
- Option 3 – Aggregated EG systems and premises load off mixed circuits.

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Option 1 requires additional anti-islanding protection in accordance with Section 7.1.3 of this Standard. Options 2 and 3 may have the requirement for additional anti-islanding protection waived if the total installed capacity is less than 30% of the nameplate rating of the transformer supplying the bulk metered connection.

10 Power quality

10.1 General

All power quality measurements and limits are at the Connection Point.

10.2 Connection Point power factor

Power factor shall be set as per the power control requirements in Section 6.6.3 of this Standard for IES or Section 6.7.3 of this Standard for rotating machines.

10.3 Voltage changes and flicker

The Proponent shall ensure that the EG system is designed and commissioned to:

- Achieve the acceptable level and frequency of step voltage changes advised by the Distributor following the Technical Assessment; and
- Achieve flicker levels compliant with SA/SNZ TR IEC 61000.3.14 Section 9.2.3. Also comply with the following:
 - For non-export EG systems, P_{st} and P_{lt} limits of 0.50 and 0.40 respectively; or
 - For export EG systems, P_{st} and P_{lt} limits of 0.30 and 0.25 respectively (based on SA/SNZ TR IEC 61000.3.14).

10.3.1 Short duration over voltages

The Proponent should comply with Section 7.6 of SA/SNZ TR IEC 61000.3.15 in order to minimise damage to its equipment from short duration over voltages.

The transient voltage limits for EG systems comprising an IES EG unit(s) specified in Section 5.8 of AS/NZS 4777.2 shall be met by Proponents.

10.4 Harmonic distortion

Recommended limits of harmonic voltages permitted to be injected into the Distribution System at the Network Coupling Point shall be as agreed with the Distributor, and specified in the Connection Agreement, prior to the connection.

Harmonic emission levels shall be assessed in accordance with Section 8 of SA/SNZ TS IEC 61000.3.14.

10.4.1 Inverter Energy System

The harmonics emission limits specified in AS/NZS 4777.2 shall apply for all inverters with certified compliance to AS/NZS 4777.2.

Where multiple inverters are installed on a shared low voltage network, the summated effect shall be calculated as per Section 7 of SA/SNZ TS IEC 61000.3.14.

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10.4.2 Rotating machines

The relevant harmonic emission limits for EG systems comprising a rotating machine EG unit(s) are given in Section 7.3 of IEEE Std 1547-2018.

The harmonic current distortion level of the EG system should be less than the emission limits specified by the Distributor when all of the EG units of the EG system are in service.

Table 9 Maximum odd current distortion limits for the Distribution System (IEEE Std 1547-2018)

Individual odd harmonic order h	h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h	TRD *
Percent (%) of rated Current	4.0	2.0	1.5	0.6	0.3	5.0

(* Total Demand Distortion)

Table 10 Maximum even current distortion limits for the Distribution System (IEEE Std 1547-2018)

Individual even harmonic order h	h = 2	h = 4	h = 6	8 ≤ h < 50
Percent (%) of rated Current	1.0	2.0	3.0	Associated range specified in Table 9

10.5 Voltage unbalance

The Proponent shall ensure that the current injected in each phase at each of its low voltage Connection Points is balanced so as to achieve average voltage unbalance less than or equal to the values set out in Table 10, where the average voltage unbalance is determined using the following formula:

$$\text{average voltage unbalance (\%)} = \text{average}_{\text{period}} \left(\frac{\text{negative sequence voltage}}{\text{positive sequence voltage}} \right) \times 100$$

Table 11 Unbalance levels

Condition	Averaging period	Voltage Unbalance
No contingency	30 minute	2.0%
Credible contingency event	30 minute	2.0%
General	10 minute	2.5%
Once per hour	1 minute	3.0%

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11 Operation

11.1 Commissioning and testing

Prior to the Interconnection of the EG system with the Distribution System, the Distributor is entitled to inspect the EG system and, where necessary, require the Proponent to arrange for testing of those parts of the EG system that have a direct effect on the Distribution System. This is to enable the Distributor to verify that the EG system is acceptable for Interconnection, and that it complies with this Standard and the Connection Agreement.

The Proponent shall arrange for a commissioning plan to test the EG system. The commissioning plan shall be followed to confirm that the EG system complies with the technical requirements specified in the relevant Connection Agreement.

In addition, commissioning shall verify that the EG system:

- Does not adversely affect the security of the Distribution System or the quality of supply of electricity through the Distribution System; and
- Minimises any possible threat of damage to the Distribution System, or any other plant, equipment or installations of any other person that is connected to the Distribution System.

The commissioning plan and a report shall be carried out under engineering supervision by an RPEQ. The Proponent shall keep a written record of all protection settings and of test results. A copy of this record shall be made available to the Distributor on request. Engineering supervision by an RPEQ need not be required for the commissioning of an EG system with bumpless transfer connection to the Distribution System.

11.2 Ongoing operation, monitoring and maintenance

The Proponent shall ensure that adequate operational, monitoring, maintenance procedures and programs are documented and undertaken to ensure compliance with the Connection Agreement.

The Proponent shall not change the installation or operation of the EG system in a manner that contravenes the Connection Agreement.

The Proponent shall notify the Distributor of any scheduled and unscheduled protection or communications outages or failures.

The Distributor may require access to the site of the EG system and isolation points for Distribution System maintenance and testing purposes.

Distribution System maintenance may cause interruptions to the operation of the EG system. Co-operative scheduling of these activities should be undertaken to reduce the outage period and minimise the associated impacts.

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Annex A Connection arrangement requirements (informative)

	> 30 kW ≤ 1,500 kW Inverter Energy System (3 Phase)				> 30 kW ≤ 1,500 kW Rotating Machine (3 Phase)			
	Shared Transformer		Dedicated Transformer		Shared or Dedicated Transformer			
					Limited Parallel Operation		Continuous Parallel Operation	
	Non-Export	Export	Non-Export	Export	Bumpless Transfer	Stand-by (6 h per 3 months)	Non-Export	Export
Level 1 Backup protection ¹	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Level 2 Backup protection ²	No	No	No	No	No	No	NVD (on case by case basis)	NVD
Reverse power flow protection	No	No	No	No	No	No	Yes	Yes
AS/NZS 4777.2 inverters required with active anti-islanding to IEC 62116 requirements	Yes	Yes	Yes	Yes	Not Applicable			
Distribution System capacity review required	No	Yes	No	Yes	No	No	No	Yes
Power quality to AS/NZS61000 series requirements	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Fault level contribution to the Distribution System included in the Distributor's Technical Assessment ³	No	No	No	No	No	Yes	Yes	Yes
RPEQ design & commissioning plan	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

1. Level 1 backup protection – Over and under voltage, over and under frequency and rate of change of frequency.
2. Level 2 backup protection – Neutral voltage detection/unbalance
3. Fault current contribution is dependent on size, number and hours of operation

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Annex B Strata title bulk metering arrangement (normative)

