



Part of Energy Queensland



STNW1175

# **Standard for High Voltage Embedded Generation Connections**

Effective from 08 November 2022

# Standard for High Voltage EG Connections

If this standard is a printed version, then the Ergon Energy Network or Energex internet site must be referenced to obtain the latest version to ensure compliance.

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**Abstract:** This standard provides the requirements for connecting Embedded Generating (EG) Systems in Parallel with a Distribution Network Service Providers' High Voltage Distribution Network. This standard covers all generating types.

**Keywords:** embedded, generating, high voltage, IES, solar, photovoltaic, wind, diesel, rotating, connection, rotating machine, 1,500 kVA, 1500 kVA, 5 MVA, 5 MW

## Table of Contents

1	Introduction.....	1
1.1	Purpose .....	1
1.2	Scope .....	1
1.3	Obligation of Proponents.....	3
2	Definitions and abbreviations.....	3
2.1	Definitions .....	3
2.2	Abbreviations .....	5
2.3	Terminology .....	6
3	Relevant rules, regulations, standards and codes.....	6
3.1	Standards and codes .....	6
3.1.1	Energex controlled documents .....	6
3.1.2	Ergon Energy Network controlled documents.....	7
3.1.3	Australian and New Zealand Standards .....	7
3.1.4	International Standards .....	8
3.1.5	Relevant technical documents.....	8
3.2	Legislation and regulation .....	8
4	General EG System requirements .....	10
4.1	Connection categories .....	10
4.2	Maximum EG System capacity .....	10
4.3	Generation control .....	11
4.4	Export limits at Connection Point.....	11
4.4.1	Export limit study.....	11
4.4.2	Export limit types.....	12
4.4.3	Export limit settings .....	12
4.4.4	Bumpless transfer EG Systems.....	12
4.5	Network connection and isolation.....	13
4.5.1	Coordination of EG Systems with Distribution System operation.....	13
4.5.2	Grid Isolation Device (GID).....	14
4.6	Earthing .....	15
4.6.1	Neutral isolation.....	15
4.7	Device approval and compliance .....	15
4.7.1	Protection equipment.....	15
4.7.2	Rotating EG Systems compliance .....	16
4.8	Operating voltage and frequency .....	16
4.8.1	Standard power system voltages.....	16

# Standard for High Voltage EG Connections

4.8.2	Lightning insulation levels for surge arrestors .....	16
4.8.3	Standard power system frequency .....	16
4.9	Fault levels and protection impacts .....	17
4.9.1	Fault withstand requirements.....	18
4.10	Power quality .....	18
4.10.1	General .....	18
4.10.2	Voltage changes and flicker.....	18
4.10.3	Short duration over voltages.....	18
4.10.4	Harmonic distortion .....	19
4.10.5	Voltage unbalance.....	19
4.10.6	Power quality meter.....	19
4.11	Communication and SCADA requirements .....	20
4.11.1	Communication systems .....	20
4.11.2	SCADA requirements .....	20
4.12	Data and information.....	20
4.12.1	Static data and information .....	20
4.12.2	Dynamic data and information .....	20
4.13	Cybersecurity and telecommunications .....	20
4.13.1	Communications link .....	20
4.13.2	Traffic inspection and notifications.....	21
4.13.3	Traffic flows .....	21
4.14	Power system modelling requirements.....	22
4.14.1	General .....	22
4.14.2	EMT modelling requirements.....	22
4.15	Interlocking .....	23
4.16	Curtailment schemes .....	23
4.17	Technical Studies.....	23
5	Class A1 and Class A2 EG System requirements.....	24
5.1	Inverter Energy Systems.....	24
5.1.1	Energy Storage System (ESS) .....	24
5.2	Class A1 and Class A2 protection requirements .....	25
5.2.1	Inverter integrated protection.....	25
5.2.2	Central Protection.....	26
5.2.3	Passive Anti-islanding protection.....	27
5.2.4	Overcurrent and earth fault protection .....	28
5.2.5	Grid reverse power or Power Limit protection .....	28
5.2.6	Synchronisation facilities .....	28
5.2.7	Neutral Voltage Displacement (NVD) protection .....	28

# Standard for High Voltage EG Connections

5.2.8	Inter-trip.....	29
5.2.9	DC systems or UPS integration protection.....	29
5.2.10	Fail-safe tripping.....	29
5.2.11	Grid Isolation Device .....	29
5.2.12	Grid Protection Relay .....	30
5.2.13	Wireless transfer .....	30
5.3	Power quality response.....	31
5.3.1	IES power quality response modes .....	31
5.3.2	Rotating Machines power quality response .....	31
5.4	Metering.....	31
5.5	Technical Studies – Class A1 and Class A2.....	32
6	Technical requirements for Class B EG Systems.....	32
6.1	General.....	32
6.2	Technical requirements overview.....	33
6.3	Reasonable approaches for voltage and reactive power control .....	33
6.3.1	Voltage control strategy.....	33
6.3.2	Control system .....	34
6.3.3	Control system damping.....	34
6.3.4	Control system testing.....	34
6.3.5	Power system stabiliser.....	34
6.4	Protection requirements for Class B.....	34
6.4.1	General protection requirements .....	34
6.5	DNBP Technical Study – Class B.....	36
6.5.1	Plant energisation.....	37
6.6	EMT modelling requirements – Class B .....	37
6.7	Communication requirements – Class B .....	38
6.8	SCADA requirements – Class B.....	38
6.8.1	General requirements.....	38
6.8.2	Plant status .....	39
6.8.3	Voltage control .....	40
6.8.4	Distribution System support mode.....	40
6.8.5	Curtailement.....	40
6.8.6	Remote start.....	40
6.9	Meteorological data.....	40
6.10	Inter-trip .....	40
7	Testing and commissioning .....	41
8	Operations and maintenance.....	43
	Appendix A: Deviations from the National DER Connection Guidelines (informative).....	45

# Standard for High Voltage EG Connections

Appendix B: Connection arrangement requirements (normative) .....	47
Appendix C: Model Standing Offer (informative) .....	49
Appendix D: Static data and information (informative).....	49
Appendix E: Short Circuit Ratio calculation methods (normative).....	50
Appendix F: Technical requirements summary– Class A1 and Class A2 (informative).....	51

## 1 Introduction

### 1.1 Purpose

This standard outlines a number of technical requirements that shall be met in order for a Proponent to connect an Embedded Generating System (EG System) to a High Voltage Distribution System owned and operated by either Energex or Ergon Energy Network (each a DNSP or together the DNSPs), where that EG System is intended to operate in Parallel with the Distribution System. This Standard has been developed to ensure safe and stable Parallel operation of HV EG Systems connected to a DNSP's Distribution Network without causing a material degradation in the quality of supply to Distribution Network users.

### 1.2 Scope

This standard applies to a new connection or alteration of a HV EG connection using generating technology types including, but not limited to, Inverter Energy Systems (IES) and Rotating Machines and where:

- a. the EG Units are intended to be connected to, and capable of operating in Parallel with the HV Distribution Network; and
- b. meeting all other technical requirements set out in this document.

This Standard does not apply to:

- i. electric vehicles, unless the Electric Vehicle Supply Equipment (EVSE) is capable of generating electricity to the HV Distribution Network or electrical installation (in which case the requirements shall apply).
- ii. electrical equipment that does not generate electricity, including demand response/demand management systems, unless they impact on the ability of the HV EG System to meet the technical requirements of this standard.
- iii. off grid systems not connected in parallel with the Distribution System.
- iv. 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.
- v. EG Systems covered by the following Energex and Ergon Energy Network connection standards:

Standard Number	Title
STNW1170	Standard for Small IES Connections
STNW1174	Standard for LV EG Connections
STNW3510	Dynamic Standard for Small IES Connections
STNW3511	Dynamic Standard for LV EG Connections
STNW3512	Standard for LV EG Connections to Isolated Networks

The technical requirements in this Standard comply with the National DER Connection Guidelines for MV/HV EG Connections as published by the Energy Network Australia (ENA), with the exception of the deviations set out in Appendix A: Deviations from the National DER Connection Guidelines.

# Standard for High Voltage EG Connections

Details of the connection process for EG Systems within the scope of this Standard can be found as follows:

Ergon Energy Network - <https://www.ergon.com.au/network/connections/major-business-connections/major-connections>.

Energex - <https://www.energex.com.au/home/our-services/connections/major-business>.



# Standard for High Voltage EG Connections

## 1.3 Obligation of Proponents

Proponents shall:

- a. obtain consent from the DNSP before interconnecting their HV EG System with the DNSP's Distribution System.
- b. ensure that the design certified by a Registered Professional Engineer of Queensland (RPEQ), as well as the construction, operation and maintenance of the proposed HV EG System, complies with the relevant Energy Laws, including any applicable regulations, standards, guidelines and codes of practice as they apply in Queensland.
- c. comply with this Standard and the terms and conditions of the applicable Connection Contract.
- d. not connect additional inverters, make modifications or install additional HV EG Units, including Energy Storage Systems (ESS), without the prior written agreement of the DNSP (and where applicable, follow any relevant process set out in the Energy Laws).
- e. meet the commissioning requirements applicable for connections to the HV Distribution System and complete commissioning under a commissioning plan certified by an RPEQ.

## 2 Definitions and abbreviations

### 2.1 Definitions<sup>1</sup>

Term	Definition
Anti-islanding Protection	A protection system to detect islanded conditions and disconnect the inverter(s) or rotating plant from the Distribution System.
Break-before-make	Break-before-make operation is used in a switch that is configured to break (open) the first set of contacts before engaging (closing) the new contacts.
Central Protection	Central Protection is the protection system installed to perform the functions of coordinating multiple EG Unit installations at one site, providing protection for the entire EG Energy System installation and islanding protection to the connected grid as well as preserving safety of grid personnel and the general public.
Connection Contract	A contract formed by the making and acceptance of a <i>connection offer</i> under Chapter 5A of the NER or an offer to <i>connect</i> under Chapter 5, where applicable or where the Proponent has made an election under rule 5A.A.2 of the NER.
Connection Assets	Those components of a Distribution System which are used to provide <i>connection services</i> .
Connection Point	The physical point or link where the DNSPs assets meet the Proponent's assets so as to permit the flow of electricity between the assets, being the agreed point of supply.
Distribution Network	A <i>network</i> which is not a <i>transmission network</i> . This Standard refers to the High Voltage portion of the Distribution Network.
Distribution System	A <i>distribution network</i> , together with the <i>connection assets</i> associated with the <i>distribution network</i> , which is connected to another <i>transmission system</i> or <i>distribution system</i> . The relevant <i>distribution system</i> owned and operated by the DNSP to which the HV EG Unit(s) is, or will be, <i>connected</i> .

<sup>1</sup> Terms in italics and not otherwise defined in this document, have the meaning given to that term in the NER or National Energy Retail Law.

# Standard for High Voltage EG Connections



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Term	Definition
Distribution Network Service Provider (or DNSP)	A person who engages in the activity of owning, controlling, or operating a <i>distribution system</i> . Depending on the context means either Energex (who owns and operates the Distribution System in South East Queensland) or Ergon Energy Network (who owns and operates the Distribution System in the remainder of Queensland).
Embedded Generating System(s) (or EG System(s))	One or more Embedded Generating Units and auxiliary equipment that are interconnected with a Distribution Network.
Embedded Generating Unit (or EG Units(s))	A Generating Unit connected within a Distribution Network and not having direct access to the transmission network.
Energy Laws	Relevant laws relating to the subject matter of this Standard as further detailed in Section 3.2 of this Standard.
Energy Storage System (or ESS)	A system comprising one or more components (e.g. batteries) that store electricity generated by Distributed Energy Resources or directly from the grid, and that can discharge the electricity to loads.
Export	Net electricity that is fed into the Distribution System through the Connection Point.
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.
High Voltage (or HV)	Any voltage greater than 1 kV a.c.
Inverter Energy System (or IES)	A system comprising one or more inverters together with one or more energy sources (which may include batteries for energy storage) and controls.
Isolation Device	Device designed to safely prevent the flow of current such as circuit breaker or contactor.
Low Voltage (or LV)	A voltage of no more than 1,000 V a.c. or 1,500 V d.c.
Metering Provider / Metering Coordinator	Is a function as defined in the NER.
Network Coupling Point	The point at which Connection Assets join the shared Distribution Network, used to identify the distribution service price payable by the Proponent.
Non-export	A HV EG System that is capable of operating in Parallel with the Distribution System and which is designed and configured to limit any Export of electricity to the Distribution System in reference to the Connection Point.
Parallel (or Grid Connected)	This is where the HV EG Unit is configured such that the HV 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 circumstances where energy storage systems can be tied directly or indirectly back to the Distribution Network through an AS/NZS 4777.2 grid connect inverter. It is irrelevant whether the EG Unit (including any energy storage system) Exports.
Partial-export	A HV EG System that is capable of operating in Parallel with the Distribution Network and which is designed and configured to only Export as prescribed to operate in Section 4.4.2 of this Standard.

# Standard for High Voltage EG Connections



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Term	Definition
Performance Standards	For a <i>Registered Participant</i> this means the term “ <i>performance standard</i> ” as defined in the NER. For non- <i>Registered Participants</i> , this means the technical performance standard agreed with the DNSP prior to Connection Offer and documented in the Connection Contract.
Power Limiting	The ability to reduce or stop power output from EG System when Export exceeds a defined value.
Premises	Means any land (whether a single block or multiple contiguous blocks), building(s) (whether whole or part), and structure(s) (or adjuncts thereto) that are owned, occupied or controlled by the Proponent in the vicinity of the proposed connection and which can reasonably be considered to be part of a single overarching operation.
Proponent	The relevant owner, operator or controller of the HV 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.
Single Wire Earth Return (or SWER)	Parts of the electrical Distribution Network 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.
Standard	This document that is entitled “Standard for HV EG Connections”.
Technical Study	A study to evaluate the effects that the proposed connection of the EG System will have on the Distribution Network under different loading conditions or in the event of particular faults. A document will be produced for the Proponent that will be incorporated into the Connection Contract.

## 2.2 Abbreviations

Term, abbreviation or acronym	Definition
a.c.	Alternating current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AS/NZS	A jointly developed Australian and New Zealand Standard
AS	Australian Standard
ANSI	American National Standards Institute
ACR	Automatic Circuit Recloser
CBD	Central Business District
CEC	Clean Energy Council
DER	Distributed Energy Resources
d.c.	Direct current
DRUPS	Diesel Rotating Uninterruptible Power Supply
EBGP	External Border Gateway Protocol
ED	Edge Defence
EG	Embedded Generating
EMC	Electromagnetic Compatibility

# Standard for High Voltage EG Connections

Term, abbreviation or acronym	Definition
ENA	Energy Network Australia
EVSE	Electric Vehicle Supply Equipment
GID	Grid Isolation Device
GPR	Grid Protection Relay
HV	High Voltage
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol v4
NER	National Electricity Rules
NVD	Neutral Voltage Displacement
PV	Photovoltaic
RPEQ	Registered Professional Engineer of Queensland
SCR	Short Circuit Ratio
TNSP	Transmission Network Service Provider

## 2.3 Terminology

In this Standard:

- the word “shall” indicates a mandatory requirement that the Proponent must comply with;
- the word “should” indicates a recommended requirement that will not be mandatorily imposed on the Proponent; and
- the word “may” indicates a requirement that the DNSP may determine the Proponent must comply with.

## 3 Relevant rules, regulations, standards and codes

### 3.1 Standards and codes

There are a range of applicable standards and industry codes which define connection types and applicable requirements, and network standards as set out below.

In the event of any inconsistency between:

- Australian and international standards and industry codes (except for legislated industry codes); and
- this Standard,

this Standard will prevail.

#### 3.1.1 Energex controlled documents

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

# Standard for High Voltage EG Connections

Other controlled documents include:

Document number	Document name	Document type
<a href="#">Manual 01811</a>	Queensland Electricity Connection Manual	Reference
STNW1174	Standard for Low Voltage EG Connections	Customer Standard
STNW1179	Standard for Plant Energisation	DNSP Standard

## 3.1.2 Ergon Energy Network controlled documents

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

Other controlled documents include:

Document number	Document name	Document type
<a href="#">NA000403R509</a>	Queensland Electricity Connection Manual	Reference
STNW1174	Standard for Low Voltage EG Connections	Customer Standard
STNW1179	Standard for Plant Energisation	DNSP Standard

## 3.1.3 Australian and New Zealand Standards

Document number	Document name	Document type
AS 2067	Substations and high voltage installations exceeding 1kV A.C.	Australian Standard
AS/NZS 3000	Electrical Installations – Wiring Rules	AU/NZ Joint Standard
AS/NZS 4777.1	Grid connection of energy systems via inverters Part 1: Installation requirements	AU/NZ Joint Standard
AS/NZS 4777.2	Grid connection of energy systems via inverters Part 2: Inverter requirements	AU/NZ Joint Standard
AS/NZS 5033	Installation and Safety Requirements for Photovoltaic (PV) Arrays	AU/NZ Joint Standard
AS/NZS 5139	Electrical Installations – Safety of battery systems for use with power conversion equipment	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 61000.3.100	Electromagnetic Compatibility (EMC) - Limits - Steady State Voltage Limits In Public Electricity Systems	Australian Standard
AS/NZS IEC 60947.6.1	Low-voltage switchgear and controlgear	AU/NZ Joint Standard
AS/NZS 61000 series	Electromagnetic compatibility (EMC)	AU/NZ Joint Standard
AS 61869	Instrument transformers (multiple parts)	Australian Standard
AS/NZS IEC 62116	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures	AU/NZ Joint Standard

# Standard for High Voltage EG Connections

## 3.1.4 International Standards

Document number	Document name	Document type
IEC 60255-1	Measuring relays and protection equipment – Part 1: Common requirements	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 60255-181	Measuring relays and protection equipment – Part 181: Functional requirements for frequency protection	International Standard
IEC 60617	Graphical symbols for diagrams	International Standard
IEEE Std 519	IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems	IEEE Standard
IEEE Std C37.2	IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations	IEEE Standard

## 3.1.5 Relevant technical documents

Document number	Document name	Document type
n/a	System Strength Impact Assessment Guidelines	AEMO guideline
n/a	Power System Model Guidelines	AEMO guideline
ENA DOC 025	EG-0 Power System Earthing Guide Part 1: Management Principles	ENA guideline
ENA EG1	Substation Earthing Guide	ENA guideline

## 3.2 Legislation and regulation

Set out below is a list of the related legislation and regulations (which may be amended, replaced, repealed, or have further instruments enacted from time to time).

In the event of any inconsistency between:

- legislation and regulation; and
- this Standard,

the legislation and regulations will prevail.

# Standard for High Voltage EG Connections

Document name	Document type
Construction and operation of solar farms – Code of Practice 2019	Code of Practice
<i>Electricity Act 1994</i> (Qld)	Legislation
<i>Electricity Regulation 2006</i> (Qld)	Regulation
<i>Electrical Safety Act 2002</i> (Qld)	Legislation
<i>Electrical Safety Regulation 2013</i> (Qld)	Regulation
<i>Electricity – National Scheme (Queensland) Act 1997</i> (Qld)	Legislation
National Electricity (Queensland) Law, as defined in the <i>Electricity – National Scheme (Queensland) Act 1997</i> (Qld)	Regulation
<i>National Energy Retail Law (Queensland) Act 2014</i> (Qld)	Legislation
National Energy Retail Law (Queensland), as defined in the <i>National Energy Retail Law (Queensland) Act 2014</i> (Qld)	Regulation
National Electricity Rules	Regulation
<i>Professional Engineers Act 2002</i> (Qld)	Legislation



# Standard for High Voltage EG Connections

## 4 General EG System requirements

### 4.1 Connection categories

The main categories of IES and Rotating Machine EG Systems are mentioned through the Standard for the differences in requirements. The technical requirements set out in this Standard shall apply to the following categories of HV EG Systems described in Table 1.

**Table 1 Categories**

Generation Capacity <sup>1</sup>	Short Circuit Ratio	Connection Category	Default NER Process
≤ 1.5 MVA	All SCR	Class A1	Chapter 5A of the NER <sup>2</sup>
> 1.5 MVA but < 5 MVA	SCR > 5	Class A2 <sup>3</sup>	Chapter 5A of the NER <sup>2</sup>
> 1.5 MVA but < 5 MVA	SCR ≤ 5	Class B <sup>4</sup>	Chapter 5A of the NER <sup>2</sup>
≥ 5 MVA	All SCR	Class B	Chapter 5 of the NER

Note 1: Generation capacity is the combined nameplate rating of the EG Unit(s) irrespective of any Export control limitation. Nameplate rating for any EG Unit shall be based on the maximum continuous AC rating of the EG Unit throughout this Standard. For stand-by Rotating Machines, a manufacturer specified AC stand-by rating shall be used for assessment. Note 2: A Proponent can elect to use the Chapter 5 NER process in certain circumstances. All EG Systems under Chapter 5 of NER shall be classified as Class B.

Note 3: Rotating machine EG Systems over 1.5 MVA and under 5 MVA shall be categorised as Class A2 regardless of the SCR.

Note 4: Class B connections connecting under Chapter 5A of NER shall comply with the applicable Performance Standards (for reference, it is expected that the Performance Standard will align with the requirements described in the Schedules to Chapter 5 of the NER, notwithstanding that the HV EG System may be exempt from registration).

EG Systems comprising of LV Inverters not complying to AS/NZS 4777.2 shall be assessed as Class B EG Systems.

The following networks are considered to be non-standard in the DNSP's network for HV EG connections and shall be assessed for technical limitations identified on a case-by-case basis:

- Brisbane CBD networks have fault rating limitations on network infrastructure. Therefore, connection of EG Systems in the Brisbane CBD will be constrained to systems which do not effectively contribute to a rise in fault level at the Connection Point.

To clarify which subcategory applies to a Proponent, contact [majorcustomers@energyq.com.au](mailto:majorcustomers@energyq.com.au).

Section 4 of this Standard has general requirements for all Classes of EG Systems.

Section 5 of this Standard has additional details that cover Class A1 and Class A2 requirements.

Additional requirements for Class B EG Systems are covered in Section 6.

Section 7 and 8 also applies for all Classes of EG Systems.

### 4.2 Maximum EG System capacity

Where no constraint is identified by the DNSP through the Technical Study, the maximum aggregate system capacity for standard HV EG Connections for each subcategory covered under this Standard is as per Table 2.



# Standard for High Voltage EG Connections

**Table 2 Maximum system capacity by subcategory**

Class A1 <sup>1</sup>	Class A2
1500 kVA	< 5000 kVA <sup>2</sup>

Note 1: See sections 5.2.2 and 5.5 of this Standard for variations on requirements for IES with aggregate nameplate capacities  $\leq 30$  kVA.

Note 2: EG Systems capacity between 1.5 MVA and 5 MVA maybe classified as Class B depending on the SCR

Where there are multiple EG Systems at a Premises connected to a single Connection Point, the Technical Study will consider the aggregate of the existing and proposed EG Systems.

For Premises with multiple HV Connection Points, Premises with network(s) connected to multiple Connection Points, or Fixed EG system(s) within a Premises being connected to multiple Connection Points:

- a. The maximum capacity for a Connection Point in respect of a Premises is based on the aggregate of all EG Units connected or proposed to be connected within the Premises.

The requirements set out in this Standard and the Technical Study will be applied and determined based on the aggregate maximum capacity of all the EG Units connected, or proposed to be connected, within the Premises. There is no limit for DC-coupled DER capacity. The limits for Technical Study will be based on the Aggregate AC capacity of the Generating Units.

## 4.3 Generation control

For all HV EG Systems that may connect to the Distribution System, Table 3 defines the operation types, nature of Parallel operation and Export capability.

**Table 3 Types of EG Systems**

Operation Type <sup>1</sup>	Parallel Operation		Export Capability
	Duration	Frequency	
Bumpless transfer	up to 2 seconds	N/A	Non-export only
Stand-by <sup>2</sup> (for testing only)	up to 6 hours	Every 3 months	Non-export
Continuous Parallel	Greater than 24 hours	In a year	Either Export or Non-export

Note 1: The DNSP shall determine the appropriate operation type to apply for generation technologies as part of the Technical Study. For example, IES and Diesel Rotary Uninterruptable Power Supply (DRUPS) are typically classified as Continuous Parallel.

Note 2: Stand-by operation is for operating EG System for maintenance purposes. If the Proponent of the EG System has an agreement with a *Small Generation Aggregator*, then it is automatically classified as Continuous Parallel regardless of planned duration or frequency.

## 4.4 Export limits at Connection Point

### 4.4.1 Export limit study

The Export limit shall be assessed and determined by the DNSP with reference to:

- b. existing and forecast of EG Systems on the Distribution System;
- c. asset capacity limits on the Distribution System;
- d. power quality checks on the Distribution System;
- e. existing demand at peak generation;

- f. voltage regulation impacts on the Distribution System; and
- g. Distribution System protection impacts.

Additional constraints may apply to non-standard connection arrangements or technologies used in HV EG connections. An indicative Export limit may be provided by the DNSP at the enquiry stage of the applicable connection process.

## 4.4.2 Export limit types

A Proponent can elect to have Partial- or Non-export EG System.

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 Contract.

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, noting dispatch constraints that may apply for Registered systems as well as curtailment schemes applicable for any EG Systems through the Connection Contract.

Export limits are to be interpreted as “soft” controls, where a limit that causes the IES or Rotating Machines to reduce its output and prevent ongoing Export greater than the limit. “Hard” controls, a limit that will cause disconnection from the network may be used if “soft” controls cannot be achieved practically.

## 4.4.3 Export limit settings

Where the EG System is approved by the DNSP as a Non-export or Partial-export system, it shall be fitted with Export power limiting control that limits the level of electricity exported at the Connection Point to the amount set out in the Connection Contract. Export limits are provided in Table 4 below.

**Table 4 Export limit settings**

	Non-export	Partial-export
Export limit setting (kW or MW)	0	$k$ of total EG System rating
Measured Export limit (kW or MW)	0.05 of total EG System rating	$k$ of total EG System rating

Note: Where  $k$  is equal to the approved Partial-export power value as a per unit value of the inverter capacity.

The Export limit of the Proponent’s HV EG System is the maximum allowable Export limit. The Export ability of the Proponent’s HV EG System to Export at the limits described above are not guaranteed and will depend on the characteristics of the Distribution Network, which may change over time. Circumstances which may cause the Export to be constrained include but are not limited to when power quality response modes or curtailment schemes are in operation.

## 4.4.4 Bumpless transfer EG Systems

Bumpless transfer for EG Systems shall incorporate a make-before-break automatic transfer switch. If incorporating an LV bumpless transfer system, the make-before break switch shall be compliant with AS/NZS IEC 60947.6.1. Parallel operation with the Distribution System shall comply with the duration limits shown in Table 3.

The following Table 5 prescribes the requirements for fault level studies for bumpless transfer EG Systems, including the scope for conducting studies for the fault level contribution of the EG System.

# Standard for High Voltage EG Connections

**Table 5 Bumpless transfer fault level study requirements**

	Proponent	DNSP
Class A1 / Class A2	All EG Systems for the contribution within the Proponent's installation beyond the Connection Point	May conduct for the contribution to Distribution System
Class B		Shall conduct for the contribution to Distribution System

The design and the commissioning shall be done under the supervision of an RPEQ for all bumpless transfer EG systems, except for Class A1 systems where no electronic interlocking is implemented and a compliant transfer switch is used.

## 4.5 Network connection and isolation

Unless otherwise agreed with the DNSP, an EG System shall only connect to the Distribution System via a single Connection Point. Connection to, and Parallel operation with any part of the Distribution System is dependent upon compliance with the requirements outlined in this Standard and the Connection Contract at each point where the EG System can Parallel with the Distribution System.

The EG System shall be designed so that it does not exceed the ratings of equipment both within the Distribution System and the Proponent's side of the Connection Point when the EG System operates in Parallel.

EG Systems that supply only part of the Proponent's installation shall have adequate mechanisms in place to prevent connection of the EG System to the Distribution System occurring without synchronisation and the operation of associated protection systems.

The Proponent shall provide a means of isolation that is capable of disconnecting the entire 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 (where lockable) shall be able to be locked in the open position only.

The Proponent shall be responsible for the energisation of its transformer(s) and associated equipment, as well as ensuring that the operation is within the obligations of the Connection Contract and any operating protocol agreed with the DNSP.

Where the auxiliary supply to the EG is from a separate Distribution System connection rather than the main EG System Connection Point, this shall be clearly identified in the approved drawings as well as in the SCADA system. The separate connection for auxiliaries shall only be through a dedicated distribution substation LV connection and shall be implemented and charged as per standard LV connection practices.

### 4.5.1 Coordination of EG Systems with Distribution System operation

The DNSPs apply an automatic feeder re-closing scheme on the majority of their Distribution System. During this process, the circuit breaker opens (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.

# Standard for High Voltage EG Connections

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 comply with this disconnection requirement 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 that 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.

## 4.5.2 Grid Isolation Device (GID)

The GID requirement is specified in Table 6 below.

**Table 6 GID requirements per connection category**

Connection Class	GID Requirement
Class A1	May be required through DNSP Technical Study
Class A2 / Class B	Shall be required

A GID shall consist of a HV Automatic Circuit Recloser (ACR) or a HV circuit breaker within a switchboard and its associated protection, control and remote communications equipment. The GID should be installed as close as possible at the boundary between the DNSP's assets and the Proponent's assets, such that a single point of isolation between these two entities can be achieved when required by the DNSP. The GID ACR shall be owned by the DNSP.

For existing HV installations connected to the Distribution Network, the use of an existing circuit breaker to form a GID may be acceptable if it is primarily an underground HV supply from the Connection Point to the HV switchboard and an isolation point exists on the Distribution Network side additionally (e.g. RMU isolation point). This circuit breaker shall be owned and operated as specified in Table 7.

**Table 7 Non-ACR GID ownership options**

Equipment / Function	Ownership
HV circuit breaker <sup>1</sup>	Proponent
HV isolation point	DNSP
Voltage transformer for NVD <sup>2</sup>	Proponent or DNSP

Note 1: The circuit breaker shall have DNSP owned protection, control and remote communications. Proponent to have its own separate protection and control of the circuit breaker.

Note 2: Where required for NVD and where separate voltage transformer (VT) is allocated. Where using a VT for NVD that is also providing metering functions, the NVD protection circuit shall be separately fused and complying with Section 5.4. Maintenance of the VT is the Proponent's responsibility.

# Standard for High Voltage EG Connections

The DNSP's owned and operated GID protection equipment settings shall provide a protection system that is considered as the primary protection for the Distribution System and is not considered a backup protection device for the EG System. The GID shall have protection and synchronising facilities that grade with the DNSP's equipment in the upstream HV Network.

## 4.6 Earthing

Depending on the location of the proposed connection, the Distribution System is operated as either a solidly- or impedance-earthed system. The Proponent shall provide satisfactory earthing for the EG System independent of the Distribution System in accordance with regulatory requirements and ENA earthing guidelines. This is required to prevent earth fault current flowing between the Distribution System and the EG System that can affect earth fault protection on the Distribution System. Any subsequent connection to the DNSP's earth grid shall be by mutual agreement in writing.

EG System and transformer earthing shall be reviewed and designed on a case by case basis by the DNSP and the Proponent.

The earthing requirements shall comply with relevant jurisdictional requirements and include:

- a. for all IES EG Systems, earthing requirements shall be as per AS 2067 and AS/NZS 3000.
- b. All EG Systems including Rotating Machines shall have earthing requirements shall be as per AS 2067 and AS/NZS 3010.
- c. any ESS shall have earthing requirements shall be as AS 2067 and AS/NZS 5139.

### 4.6.1 Neutral isolation

HV Generating Units directly connected to the Distribution System shall have their neutral effectively isolated from earth (i.e. isolated or earthed via high impedance). This is to limit any contribution to a Distribution System earth fault, and to inhibit the flow of harmonic currents through the neutral.

## 4.7 Device approval and compliance

This section sets out device approval and compliance requirements for all Classes of EG systems.

### 4.7.1 Protection equipment

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
- IEC 60255-181 Functional requirements for frequency protection.

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

# Standard for High Voltage EG Connections

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

- AS 61869.1 General requirements
- AS 61869.2 Additional requirements for current transformers;
- AS 61869.3 Additional requirements for inductive voltage transformers; and
- AS 61869.4 Additional requirements for combined transformers.

## 4.7.2 Rotating EG Systems compliance

All EG Systems comprising a Rotating Machine EG Unit(s) that are installed under this Standard shall be compliant with:

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

## 4.8 Operating voltage and frequency

### 4.8.1 Standard power system voltages

Available voltage for connection is dependent on the location and EG System capacity. DNSP HV Distribution Systems normally include systems operating at 132 kV, 110 kV, 66 kV, 33 kV, 22 kV and 11 kV.

EG Systems shall comply with the voltage control requirements in AS 60038 and AS 61000.3.100.

### 4.8.2 Lightning insulation levels for surge arresters

The Proponent shall (at a minimum) install surge arresters at the Connection Point. The minimum insulation levels and voltage ratings for the surge arresters are given in Table 8.

**Table 8 Lightning impulse withstand voltages for surge arresters**

Distribution System voltage (kV)	Network equipment lightning impulse withstand voltage (kVp)	Surge arrester rated voltage $U_r$ – non effectively earthed (kV)	Surge arrester rated voltage $U_r$ – effectively earthed (kV)
11	95	12	10.5
22	150	22	18
33	200	36	30
66	325		60
110	550		96
132	650		120

### 4.8.3 Standard power system frequency

The performance requirements for power frequency variations are governed by the NER and the Frequency Operating Standards published by the AEMC<sup>2</sup>, as given in Table 9.

<sup>2</sup> AS/NZS 61000.2.2 details that the frequency range is typically plus or minus 1 Hz, but it is usually much less where synchronous interconnection is used on a continental scale. This requirement is overridden by the National Electricity Rules.



# Standard for High Voltage EG Connections

**Table 9 Frequency Standard (except islands)**

Condition	Containment	Stabilisation	Recovery
Accumulated time error	15 seconds		
No contingency event or load event	49.75 to 50.25 Hz*, 49.85 to 50.15 Hz 99% of the time <sup>^</sup>	49.85 to 50.15 Hz within 5 minutes	
Generation event or load event	49.5 to 50.5 Hz	49.85 to 50.15 Hz within 5 minutes	
Distribution Network event	49 to 51 Hz	49.5 to 50.5 Hz within 1 minute	49.85 to 50.15 Hz within 5 minutes
Separation event	49 to 51 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes
Protected event / Multiple contingency event	47 to 52 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes
<sup>^</sup> - This is known as the normal operating frequency band. <sup>*</sup> - This is known as the normal operating frequency excursion band.			

The frequency standards in Table 10 apply where a part of the national grid becomes islanded. This table does not strictly apply to isolated Distribution Systems.

**Table 10 Frequency Standard for national grid - island conditions**

Condition	Containment	Stabilisation	Recovery
No contingency event or load event	49.5 to 50.5 Hz		
Generation event, load event or Distribution Network event	49 to 51 Hz	49.5 to 50.5 Hz within 5 minutes	
The separation event that formed the island	49 to 51 Hz or a wider band notified to AEMO by a relevant Jurisdictional Coordinator	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes
Protected event	47 to 52 Hz	49.0 to 51.0 Hz within 2 minutes	49.5 to 50.5 Hz within 10 minutes
Multiple contingency event including a further separation event	47 to 52 Hz (reasonable endeavours)	49.0 to 51.0 Hz within 2 minutes (reasonable endeavours)	49.5 to 50.5 Hz within 10 minutes (reasonable endeavours)

## 4.9 Fault levels and protection impacts

Fault levels shall not exceed the equipment rating of the EG System, Distribution Network equipment, associated switchgear and protection equipment. Where the EG System is able to contribute to fault levels, the DNSP shall:

# Standard for High Voltage EG Connections

- a. Conduct fault studies which includes the fault contribution from the Proponent's EG System; and
- b. 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 Network beyond the capacity of the DNSP'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):

- i. 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 System connected to the relevant part of the Distribution System at the same time; and
- ii. Continuous Parallel EG Systems shall have fault levels considered for both HV and LV Distribution Systems.

## 4.9.1 Fault withstand requirements

It is suggested that plant within the generating facility is specified with the following fault withstand requirements in Table 11.

**Table 11 Fault withstand requirements**

Distribution system voltage (kV)	Single phase fault level withstand	Three phase fault level withstand
11	25 kA/3 s	25 kA/3 s
22	25 kA/3 s	25 kA/3 s
33 – Ergon Energy Network	25 kA/3 s	25 kA/3 s
33 – Energex	31.5 kA/3 s	31.5 kA/3 s
66	25 kA/3 s	25 kA/3 s
132/110	40 kA/1 s	40 kA/1 s

## 4.10 Power quality

### 4.10.1 General

All power quality measurements and limits are with reference to the Connection Point. All measurements and limits shall also incorporate existing loads and devices that can have a material impact at the Connection Point.

### 4.10.2 Voltage changes and flicker

Voltage fluctuation (flicker, rapid voltage change) shall be through the compliance of S5.1a.5 of the NER and assessment methodology in AS/NZS 61000.3.7:2001. Additional details on the compliance levels shall be given by the DNSP through the Technical Study and Connection Contract. The limits are considered as the direct contribution of the EG System (i.e. the difference in flicker values between when the EG is operational and not operational).

### 4.10.3 Short duration over voltages

The Proponent shall comply with S5.1a.4 of the NER for over voltages.



# Standard for High Voltage EG Connections

## 4.10.4 Harmonic distortion

Harmonic voltage limits permitted to be injected into the Distribution System at the Connection Point shall be as agreed with the DNSP and specified in the Connection Contract.

Harmonic emission limits shall be allocated in accordance with AS/NZS 61000.3.6:2001. The harmonic distortion level of the EG System should be less than the emission limits specified by the DNSP regardless of the number of EG Units in service.

## 4.10.5 Voltage unbalance

The Proponent shall ensure that the HV Connection Point is balanced so as to achieve average voltage unbalance less than or equal to the values set in the Table 12.

**Table 12 Voltage unbalance limits**

Nominal supply voltage (kV)	Maximum negative sequence voltage (% of nominal voltage)			
	No contingency event	Credible contingency event or protected event	General	Once per hour
	30 minute average	30 minute average	10 minute average	1 minute average
More than 100	0.5	0.7	1.0	2.0
More than 10 but not more than 100	1.3	1.3	2.0	2.5
10 or less	2.0	2.0	2.5	3.0

## 4.10.6 Power quality meter

The requirement for a dedicated power quality meter is given as per Table 13. Stand-by and bumpless transfer EG systems are not required to have a power quality meter. A power quality meter shall meet the following requirements:

- Measurement to be based as close as practical to the Connection Point; and
- Installed, owned and managed by the Distributor; and
- The Proponent to bear the cost to establish the power quality meter;
- Be available to report and verify the power quality compliance at the Connection Point at any time.

**Table 13 Power quality meter requirements per connection category**

Connection Class	Power quality meter requirement
Class A1	Not required
Class A2 – IES	Shall be required
Class A2 – Rotating Machines	Shall be required for Export enabled EG Systems. Non-export EG Systems are exempt.
Class B	Shall be required

# Standard for High Voltage EG Connections

## 4.11 Communication and SCADA requirements

All communication and SCADA where established shall consider cybersecurity requirements in Section 4.13.

### 4.11.1 Communication systems

Communications interface requirements are outlined in Table 14.

**Table 14 Communications requirements per connection category**

Connection Class	Communications requirement
Class A1	No communications interface required
Class A2	Communications interface for SCADA indication and control. Inter-tripping if required will also utilise the communication interface.
Class B	Refer to Section 6.7

### 4.11.2 SCADA requirements

The requirements of this Section shall apply as per Table 15.

**Table 15 SCADA requirements per connection category**

Connection Class	SCADA Requirement
Class A1	No SCADA interface required
Class A2	SCADA interface required
Class B	Refer to Section 6.8

## 4.12 Data and information

### 4.12.1 Static data and information

Static data and information shall be provided by the Proponent to the DNSP in accordance with Appendix D: Static Data and Information.

### 4.12.2 Dynamic data and information

Refer to Sections 6.8.2 and 6.8.3 for data and information to be provided when communications is required as per Technical Study.

## 4.13 Cybersecurity and telecommunications

### 4.13.1 Communications link

The communications link is established to provide a method of transmitting the SCADA traffic via an IP medium.

The DNSP shall deploy an Edge Defence (ED) device that shall be physically installed within the communications room located within the DNSP zone substation, whilst the EG System shall deploy an Edge Defence (ED) Device that interfaces the DNSP telecommunications network.

The telecommunications link shall establish via IPv4 Layer 3 routable session (eBGP preferred) and shall transit both ED devices, between the DNSP and Proponent.

# Standard for High Voltage EG Connections

The DNSP and Proponent shall inform each party of any planned works and incidents on the telecommunications and ED equipment that may impact the communications link.

## 4.13.2 Traffic inspection and notifications

All IP traffic received from the EG shall undergo continuous deep packet inspection, intrusion detection and protection activities, before the packet is forwarded to the final destination.

The DNSP may disconnect all IP traffic flows upon suspicion of malicious activities or security breaches.

The Proponent shall inform the DNSP of any cyber security breaches that may impact the operational electrical environment.

The Proponent shall inform the DNSP of the vulnerability and risk management strategy upon knowledge of a vulnerability advisory affecting the operational electrical environment.

## 4.13.3 Traffic flows

The DNSP and Proponent shall allow SCADA communications between the DNSP SCADA interface point and the EG SCADA interface point to facilitate the control signalling capabilities.

The Proponent shall only be able to send SCADA communications to the single DNSP SCADA interface point within the zone substation.

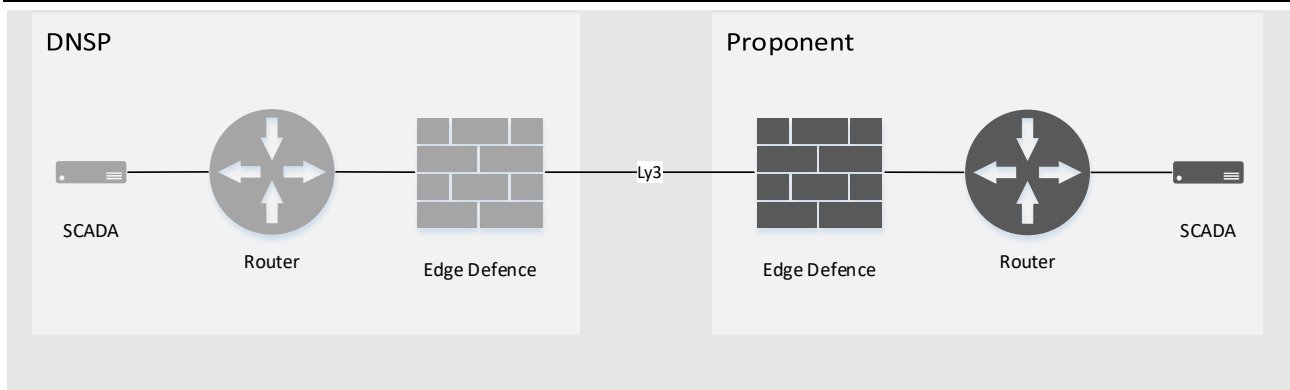
Internet Control Message Protocol (ICMP) traffic should be allowed between Edge Defence (ED) Devices to enable troubleshooting capabilities.

The DNSP shall deny all other traffic flows and shall be considered as suspicious activity.

Table 16 shows detailed information of security over information traffic flows.

**Table 16 Information traffic flow details**

Flow ID	Description	Source	Destination	Protocol	Security Controls
1	SCADA traffic	EG System SCADA	DNSP SCADA	DNP3	Deep packet inspection Next-generation firewall
2	SCADA traffic	DNSP SCADA	EG SCADA	DNP3	Deep packet inspection Next-generation firewall
3	Routing	DNSP ED device	EG ED device	eBGP or Open Shortest Path First (OSPF) or Enhanced Interior Gateway Routing Protocol (EIGRP) or static	Deep packet inspection Next-generation firewall
4	Troubleshooting	ED device	ED device	ICMP	Deep packet inspection Next-generation firewall
5	Implicit deny all	Any	Any	Any	Non approved flows alerted as possible suspicious activities



**Figure 1 Information traffic flow architecture representation**

## 4.14 Power system modelling requirements

### 4.14.1 General

The Proponent shall:

- a. undertake steady-state, root mean square (RMS) modelling as required to confirm compliance to this Standard's requirements; and
- b. develop and supply an EMT model to the DNSP as required in Section 4.14.2.

### 4.14.2 EMT modelling requirements

EMT modelling shall comply with the requirements in Table 17. The EMT modelling and analysis shall be through PSCAD™/EMTDC™ simulation.

All models and analysis shall be certified by an RPEQ who has competence in the relevant area of practice. The Proponent shall comply with the Power System Model Guidelines published by AEMO under S5.5.7(a)(3) of the NER and any other modelling requirements advised by the DNSP. Detailed requirements on EMT studies is found in Section 6.6.

**Table 17 Modelling requirements<sup>1</sup>**

Generation Capacity	Connection Type	Additional Modelling Requirement
Class A1, <= 1.5 MVA	Chapter 5A of the NER	EMT model generally not required <sup>2</sup>
Class A2, > 1.5 MVA < 5 MVA	Chapter 5A of the NER	Site-specific EMT model <sup>3,4</sup>
Class B, > 1.5 MVA < 5 MVA	Chapter 5A of the NER	Site-specific tuned EMT model by the Proponent
Class B, >= 5 MVA	Chapter 5 of the NER	Site-specific tuned EMT model by the Proponent

Note 1: Class A1 and Class A2 EG Systems are exempt from EMT modelling for bumpless transfer and stand-by operation.

Note 2: The DNSP may request an EMT model from Class A1 systems where system strength is very low (typically for an SCR less than 3). The reasons could be existing network devices or other Class A2/Class B EG Systems in the vicinity that has the potential to interact with the proposed EG System.

Note 3: Synchronous Rotating Machines are exempt from this requirement, and instead shall supply model block diagrams of the control system with all settings.

Note 4: The EMT Model shall be supplied with supporting documentation including site-specific settings.

## 4.15 Interlocking

Fail-safe interlocking mechanisms shall be required as specified in Table 18 for installations with multiple transformers or multiple Connection Points, bumpless transfer and off grid connections.

**Table 18 Interlocking requirements**

Connection arrangement	Fail-safe interlocking <sup>1</sup> requirements
Multiple transformers or multiple Connection Points	No customer transformers are connected in Parallel.
Bumpless transfer	During the transfer from one source to another, the interlock operation cannot enable the EG Unit and the Distribution System to both supply the load at the same time longer than the maximum allowable duration for bumpless transfer in Table 3 of Section 4.3 of this Standard. No distribution transformers will be connected in Parallel any point during the bumpless transfer.
Off grid	During the transfer from one source to another the interlock operation cannot allow the Generating Unit and the Distribution System to both supply the load at the same time.

Note 1: The interlocking mechanism should be a mechanical fail-safe system. Electronically controlled interlocking systems may be allowed upon approval of a functional design and operational specification certified by an RPEQ in the application stage.

## 4.16 Curtailment schemes

Where required for thermal protection or stability, a curtailment scheme may be required. This will be identified as part of the connection process. The DNSP shall provide a standard data exchange document outlining preferred hardware and configuration during the Technical Study.

Depending on the Connection Point to HV network (Sub-transmission or Distribution) there may be a need for generation reduction or curtailment signals between AEMO, TNSP, DNSP and EG control systems. If the Proponent operates outside the transmitted constraints, then the DNSP may disconnect the EG System from the Distribution System. Constraints include but are not limited to feeder and transformer thermal capacity, fault contribution, credible contingency events and network stability.

## 4.17 Technical Studies

As part of this process, the DNSP shall carry out certain Technical Studies to determine what impact the connection of the EG System shall have on the Distribution System. The specific detail of these Technical Studies depends upon the category that the particular EG System falls within.

In order to carry out these Technical Studies, the DNSP requires certain information from the Proponent. Details of the information requirements are provided to the Proponent during the connection process (this includes new connections and connection alterations), and the Proponent shall provide this information in order to progress through the connection process. In some circumstances the Proponent shall be requested to provide additional information to facilitate the Technical Studies.

## 5 Class A1 and Class A2 EG System requirements

### 5.1 Inverter Energy Systems

The following requirements apply to IES:

- a. The inverters should be registered with Clean Energy Council (CEC) as approved grid connect inverters. Where inverters are not registered with the CEC, certified compliance of the inverter shall be submitted for approval to the DNSP with the connection application.
- b. The inverters shall be tested and certified by an authorised testing laboratory as being compliant with AS/NZS IEC 62116 for active Anti-islanding Protection.
- c. IES EG Units shall comprise of inverters that have the following inverter power quality response modes:
  - Reactive power control mode;
  - Central control mode via a master/slave system;
  - Voltage control modes;
  - Fixed power factor mode;
  - Power rate limit (i.e. ramp rate control).

The following requirements apply to IES inverters:

- i. Inverters shall be tested and certified by an authorised testing laboratory as being compliant with AS/NZS 4777.2 (with an accreditation number issued).
- ii. The inverters shall be installed in compliance with AS/NZS 4777.1 for IES capacity less than or equal to 200 kVA for each IES within an installation.
- iii. The inverters shall have both volt-var and volt-watt response modes available and be capable of operating the modes concurrently, as per Section 5.3.1 of this Standard.
- iv. The inverters shall have regional settings as per Table 19:

**Table 19. Regional setting for Class A1 and Class A2 inverters.**

Connection Class	Regional setting
Class A1	Australia A <sup>1</sup>
Class A2	As per Technical Study

Note 1: See Technical Study for any variation to Australia A settings for Class A1 connection to a HV Distribution Network.

#### 5.1.1 Energy Storage System (ESS)

The connection of an ESS (such as batteries) capable of supplying electricity to an electrical installation such as a Premises or the Distribution System is considered Grid Connected, unless the inverter is connected behind a break-before-make switch in compliance with AS/NZS IEC 60947.6.1 or IEEE C37.20.2.

Where the ESS is considered to be Grid Connected:

- a. the ESS shall be subject to the requirements of this Standard.
- b. the inverters for the ESS shall be installed in accordance with Section 5.1 of this Standard.

- c. the installation of the ESS shall comply with AS/NZS 5139.
- d. ESS are either externally DC coupled to an AC inverter or packaged as a product into an integrated system with an AC inverter. The following requirements shall apply to ESS inverters:
  - i. the AC inverter capacity for the ESS will be included in the aggregated nameplate rating of inverters within the Premises behind the Connection Point (forming part of the Proponent's installation).
  - ii. the Export limit for the ESS inverter will be considered as part of the aggregated Export limit at the Connection Point.

## 5.2 Class A1 and Class A2 protection requirements

The protection requirements outlined in this Section 5.2 are in relation to the protection of DNSP assets and personnel, and are not intended to replace or override any of the protection specifically required for the Proponent's installation and EG System. Testing and commissioning of the protection shall meet the requirements outlined in Section 7 of this Standard.

The protection schemes for Class A1 & A2 EG Systems shall be designed with main and backup protection designed to detect all credible AC fault types. Section 6.4 has additional protection requirements for Class B EG Systems

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 DNSP. To prevent the EG System operating connected to the Distribution System, a DNSP-approved protection scheme or schemes shall be installed.

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

- a. The EG System cannot connect to the Distribution System unless all phases of the Distribution System are energised at the Connection Point. The connection shall ensure synchronisation before closure. If one or more phases of the Distribution System are lost, then the EG System shall disconnect from the Distribution System;
- b. It operates within the protection settings agreed with the DNSP;
- c. If a system abnormality occurs that results in an unacceptable deviation of voltage or frequency at the Connection Point, the EG system shall be disconnected from the Distribution System; and
- d. The EG System is to 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 these conditions are detected, the EG System shall be disconnected from the Distribution System at an agreed Isolation Device within the Proponent's facility that ensures complete disconnection.

### 5.2.1 Inverter integrated protection

Inverter integrated protection requirements shall comply with AS/NZS 4777.2 for all inverters generating at standard LV range (230 V). Protection settings including passive anti-islanding settings shall be set to the values given in Table 20 that is consistent with Table 13 from AS/NZS 4777.2.



# Standard for High Voltage EG Connections

**Table 20 Prescribed Inverter Settings**

Parameter	Settings	Trip delay time	Maximum disconnection time
Undervoltage 2(V<<)	70 V	1 s	2 s
Undervoltage 1(V<)	180 V	10 s	11 s
Overvoltage 1 (V>)	265 V	1 s	2 s
Overvoltage 2 (V>>)	275 V	—	0.2 s
Underfrequency (F<)	47 Hz	1 s	2 s
Overfrequency (F>)	52 Hz	—	0.2 s
Reconnect time	60 seconds	N/A	N/A

Class A2 EG Systems may be required to incorporate disturbance ride-through capability within the inverters units as per Technical Study.

## 5.2.2 Central Protection

The functional requirements for Central Protection are outlined in Table 21 and Table 22.

**Table 21 Central Protection requirements – Class A1**

Protection Requirements	IES <sup>1</sup>		Rotating Machines	
	Export	Non-export	Export	Non-export
Passive Anti-islanding Protection (27, 59, 81U/O, 81R)	Yes	Yes	Yes	Yes
Grid overcurrent fault and earth fault protection (50/51)	No	No	Yes	Yes
Grid reverse power (32R)	No	No	Yes <sup>3</sup>	Yes <sup>3</sup>
Power Limit protection (32)	No <sup>2</sup>	No <sup>2</sup>	No <sup>2</sup>	Yes
Synchronisation facilities (25)	No	No	Yes	Yes
Generator phase balance protection (46/47)	No	No	Yes <sup>3</sup>	Yes <sup>3</sup>
Neutral voltage displacement (59N)	No	No	Yes	Yes
Inter-trip	No	No	No	No
DC system or UPS integration protection	Yes	Yes	Yes	Yes
Failsafe tripping	Yes	Yes	Yes	Yes
Interlocking	No <sup>4</sup>	No <sup>4</sup>	No <sup>4</sup>	No <sup>4</sup>
Grid Isolation Device	No	No	No	No

Note 1: Central Protection requirements do not apply to IES EG Systems with an aggregate nameplate capacity of  $\leq 30$  kVA.

Note 2: Non-export or Partial-export systems shall meet the requirements of Section 5.2.5 Power Limiting



# Standard for High Voltage EG Connections

Protection.

Note 3: Required in Central Protection if not employed in Rotating Machine EG Unit protection.

Note 4: Refer to interlocking requirements of Section 4.15 for EG Systems on installations with multiple transformers or multiple Connection Points, or for bumpless transfer and off grid connections.

**Table 22 Central Protection requirements – Class A2**

Protection Requirements	IES		Rotating Machines	
	Export	Non-export	Export	Non-export
Passive Anti-islanding Protection (27, 59,81U/O, 81R)	Yes	Yes	Yes	Yes
Grid overcurrent fault and earth fault protection (50/51)	Yes	Yes	Yes	Yes
Grid reverse power (32R)	No	No	Yes <sup>2</sup>	Yes <sup>2</sup>
Power Limit protection (32)	No <sup>1</sup>	No <sup>1</sup>	No <sup>1</sup>	Yes
Synchronisation facilities (25)	No	No	Yes	Yes
Generator phase balance protection (46/47)	No	No	Yes <sup>2</sup>	Yes <sup>2</sup>
Neutral voltage displacement (59N)	Yes	Yes	Yes	Yes
Inter-trip	No	No	No	No
DC system or UPS integration protection	Yes	Yes	Yes	Yes
Failsafe tripping	Yes	Yes	Yes	Yes
Interlocking	No <sup>3</sup>	No <sup>3</sup>	No <sup>3</sup>	No <sup>3</sup>
Grid Isolation Device	Yes	Yes	Yes	Yes

Note 1: Non-export or Partial-export systems shall meet the requirements of Section 5.2.5 Power Limiting Protection.

Note 2: Required in Central Protection if not employed in Rotating Machine EG Unit protection.

Note 3: Refer to interlocking requirements of Section 4.15 for EG Systems on installations with multiple transformers or multiple Connection Points, or for bumpless transfer and off grid connections.

## 5.2.3 Passive Anti-islanding protection

Passive anti-islanding settings shall be determined through the connection-specific Technical Study. Disturbance ride-through may be required for Class A2 installations as specified in the Technical Study.

Passive Anti-islanding protection is not required for Bumpless transfer Rotating Machine Unit(s) as per Table 24.

# Standard for High Voltage EG Connections

## 5.2.4 Overcurrent and earth fault protection

Overcurrent and earth fault protection shall be provided for Rotating Machines and Class A2 IES systems isolating switch in accordance with the equipment rating. The overcurrent and earth fault protection relays for Rotating Machines 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. Unless this can be demonstrated, Voltage Controlled Overcurrent (VCO) functionality shall be incorporated to the Central Protection for Rotating Machine systems

Overcurrent and earth fault protection for the facility shall also be provided at the EG System in accordance with AS/NZS 3000 for the LV components. This protection shall be set to detect faults within the Proponent's installation.

## 5.2.5 Grid reverse power or Power Limit protection

Grid reverse power shall be installed for Rotating Machine EG Systems to be installed as EG Unit protection or as incorporated into Central Protection. Design of controls systems should minimise reverse power flow immediately following synchronisation. The Proponent shall identify the reverse power requirements and settings to protect its Rotating Machine EG Units and shall submit the settings as part of the compliance report (required under the Connection Contract).

Where the EG System has been approved by the DNSP as either a Non-export or Partial-export system and does not employ a "soft" controls as described in Section 4.4.2, Power Limit protection shall be installed at the Connection Point or upstream of all EG Unit(s) within the Connection Point. Any Power Limiting protection settings shall meet the requirements of Table 4. Further details on the settings, including disconnection time and trip delay time, shall be supplied through the connection-specific Technical Study.

## 5.2.6 Synchronisation facilities

IES EG Systems shall comprise of inverters with internal synchronisation facilities.

Rotating Machine EG Systems shall have synchronisation facilities for each of the EG Unit(s).

Class A2 and Class B EG connections shall have synchronisation facility on the GID.

## 5.2.7 Neutral Voltage Displacement (NVD) protection

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 a broken delta voltage measurement of the relevant part of the Proponent's HV assets. NVD protection can be integrated into the GID or the Grid Protection Relay (GPR) if there is no GID.

EG Systems comprising IES Unit(s) installed under this Standard, shall meet NVD requirements based on the connection class as shown in Table 23.

**Table 23. NVD Requirements for IES EG Systems**

Connection Class	NVD Requirement
Class A1	No NVD required
Class A2	HV NVD required
Class B	HV NVD required

# Standard for High Voltage EG Connections

EG Systems comprising Rotating Machine EG Unit(s) installed under this Standard, shall meet the protection requirements in Table 24 for NVD, loss of mains and Anti-islanding Protection based on operation type.

**Table 24 NVD, loss of mains protection and Anti-Islanding Protection requirements for Rotating Machine EG Systems**

	Bumpless transfer	Stand-by	Continuous Parallel
HV NVD	No	No	Yes
Loss of mains protection	No	Yes	Yes
Anti-islanding Protection	No	Yes	Yes

## 5.2.8 Inter-trip

The Proponent's design shall not require an inter-trip from the DNSP. The DNSP may send a backup control signal to the Proponent's control system for it to take immediate action through the SCADA system.

Where an inter-trip is in the design it shall be in accordance with Section 4.12 and 4.13.

## 5.2.9 DC systems or UPS integration protection

The EG System shall be automatically disconnected where a failure in the DC system supply or UPS supply to the central protection and control systems is detected. Where there is a failure in the DC system supply or UPS supply to the HV incomer relay protection, an alarm shall automatically be issued and the EG System should not be disconnected.

Duplicate DC supplies are required for the protection schemes when inter-tripping functionality is required to be implemented.

## 5.2.10 Fail-safe tripping

Loss of mains and Anti-islanding protection scheme design shall make allowance for the failed operation of the Proponent's Isolation Device. The Proponent need not provide a backup Isolation Device for the GID.

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 seek to use another form of Isolation Device fail protection, such as a circuit breaker fail (CBF) scheme, subject to obtaining the DNSP's prior agreement.

## 5.2.11 Grid Isolation Device

The GID shall be configured to meet the requirements of Section 4.5.1 and 4.5.2 and have the following functions as set out in Table 25.

# Standard for High Voltage EG Connections

**Table 25 DNSP Grid Isolation Device protection functions**

Protection functional description	ANSI/IEEE C37.2 Code	IEC 60617 Code
Overcurrent (OC)	51	I>
Earth Fault (EF)	51G	I0>
Under voltage (UV)	27P	U<
Over voltage (OV)	59P	U>
Neutral voltage displacement (NVD)	59N	U0>
Negative sequence current	46	I2>

## 5.2.12 Grid Protection Relay

The Grid Protection Relay (GPR) shall be installed to provide back-up protection functions to ensure the Distribution Network (at the Connection Point) and the installation is not exposed to a hazardous condition from the EG System.

The GPR shall meet the following requirements:

- a. coordinate multiple IES installations for one Connection Point<sup>1</sup>;
- b. provide protection functionality using one relay for all IES installations for the one Connection Point<sup>1</sup>;
- c. provide protection functions as prescribed in Table 20 for Class A1 and Table 21 for Class A2 to meet the requirements of this Standard<sup>2</sup>;
- d. be integrated in such a way that it fails safe, and EG System(s) do not generate whilst the GPR is out of service;
- e. open the Isolation Device at either the Proponent's Connection Point or the EG system(s); and
- f. preserve safety of grid personnel and the general public.

The GPR shall be connected as close to the Connection Point as practicable, referencing a single point beyond the Connection Point within the customer's installation.

The GPR reference point shall be connected at a location that has a lower impedance to the Connection Point than any EG Unit connected within the customer's installation.

Note 1: Where there are both IES and Rotating Machine EG Systems connected at a single Connection Point, two GPRs are allowed to be installed where one GPR shall coordinate all IES and one GPR shall coordinate all Rotating Machines.

Note 2: One GPR may be used for the entire installation, to coordinate IES and Rotating Machine EG Systems connected at a single Connection Point, where voltage and frequency setpoints align to suite with IES EG Unit protection. NVD and Power Limit requirements shall continue to apply as per Rotating Machine requirements.

Further information on GPR arrangements can be found in Appendix B: Connection arrangement requirements.

## 5.2.13 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 for Class A1 IES EG Systems. An Export monitoring device and/or GPR utilising a wireless communication system shall:

- a. Have a supervised wireless communications link;
- b. Consider in terms of reliability, availability and redundancy;
- c. Have a communication delay that does not exceed 0.5 seconds; and
- d. Disconnect the EG Unit(s) from the Distribution System for any loss of communications longer than 5 seconds.

## 5.3 Power quality response

A power quality response mode shall be enabled for all EG Systems through either:

- a. Enabling in-built power quality response where the capability exists within the EG Unit(s); or
- b. A central control mode via a master/slave system, with requirements as per Section 6.3.1 and 6.3.2.

### 5.3.1 IES power quality response modes

Default settings for Class A1 IES systems incorporating LV inverters will be as per STNW1174 (Table 12 and Table 13).

Site specific Technical Studies may override Class A1 requirements for voltage control.

Class A2 IES shall enable a control mode determined through the Technical Study.

Class A2 IES shall provide signals to indicate the power quality response mode the EG System is operating in. These modes shall be utilised by the DNSP Control System to determine whether the EG System may be tripped under contingency conditions.

If the EG System is operating in a mode that differs to what was agreed upon, DNSP control system may send a signal to disconnect the EG System.

For IES, one or more of the following modes shall apply, as determined through the Technical Study:

- a. Voltage control mode
- b. Voltage-var control mode
- c. Voltage-Watt support Mode
- d. Fixed power factor mode

### 5.3.2 Rotating Machines power quality response

All Rotating Machine EG Systems shall enable a connection-specific power quality response mode with either:

- a. voltage control mode;
- b. volt-var control mode; or
- c. fixed power factor mode,

to be determined by the Technical Study.

## 5.4 Metering

A DNSP review is required to access metering assets for non-revenue secondary functions like protection and communications. If DNSP determines that the use of these metering assets is technically suitable, A Metering Provider/ Metering Coordinator is required to review and approve the arrangement. Voltage transformers used for non-revenue functions require separately fused circuits.

# Standard for High Voltage EG Connections

## 5.5 Technical Studies – Class A1 and Class A2

The DNSP shall conduct a Technical Study for all Class A1 and Class A2 EG Systems. The Technical Study shall confirm the classification (i.e. Class designation) through a system strength assessment as described in Appendix E, and will also include:

- a. Distribution system capacity assessment;
- b. Identification of other generating systems which may impact the connection;
- c. Power quality allocation for fluctuation and distortion;
- d. Power quality assessment of voltage rise, informing the required control mode;
- e. Fault current contribution, if applicable;
- f. Protection requirements;
- g. Details of Performance Standards;
- h. Generation and/or load rejection studies;
- i. Plant energisation studies;
- j. Requirements for curtailment; and
- k. Identification of required power quality monitoring and SCADA connection.

For Non-export systems, the Technical Study shall verify the system classification and may also include:

- i. Fault current contribution, if applicable;
- ii. Identification of required voltage performance and control mode at the point of connection;
- iii. Protection requirements;
- iv. Details of Performance Standards;
- v. Generation and/or load rejection studies;
- vi. Power quality allocation for fluctuation and distortion; and
- vii. Identification or required power quality monitoring and SCADA connection.

There are reduced Technical Study requirements for IES EG Systems with an aggregate nameplate capacity of  $\leq 30$  kVA. Appendix F provides a summary of Technical Study requirements.

## 6 Technical requirements for Class B EG Systems

### 6.1 General

EG Systems having an aggregate nameplate rating of over 5 MVA shall comply with the *automatic access standard*. EG Systems over 5 MVA may be exempted from some requirements relating to Class B, if the EG System obtains an exemption from AEMO from the requirement to register as a *Generator*. Class B systems under 5 MVA shall meet the requirements in the Performance Standards which typically are set as close to the *automatic access standard* as practicable.

The Proponent shall meet additional requirements to this Standard as required by the NER where:

- a. Registration is required as a *Generator* for the EG System (refer to the applicable guidelines published by AEMO in respect of registration as a *Generator*); or
- b. For systems over 30 MW or as deemed relevant from applicable NER rules at the time of connection.

## 6.2 Technical requirements overview

The following Table 26 highlights the NER references and the associated performance requirements.

**Table 26 Technical requirements overview**

Technical Requirement	NER reference
Reactive power capability	S5.2.5.1
Quality of supply	S5.2.5.2
Response to frequency disturbance	S5.2.5.3
Response to voltage disturbance	S5.2.5.4
Response to disturbances following contingency events	S5.2.5.5
Quality of electricity and continuous uninterrupted operation	S5.2.5.6
Partial load rejection	S5.2.5.7
Protection of generating systems from power system disturbances	S5.2.5.8
Protection systems that impact on power system security	S5.2.5.9
Protection to trip plant for unstable operation	S5.2.5.10
Frequency control	S5.2.5.11
Impact on Network capability	S5.2.5.12
Voltage control	S5.2.5.13
Active power control	S5.2.5.14

## 6.3 Reasonable approaches for voltage and reactive power control

It is expected that a Class B EG System should be capable of achieving the *automatic access standard* set out in S5.2.5.13 of the NER. If a *negotiated access standard* is proposed by an Applicant under clause 5.3A.9(f) or 5.3.9 of the NER, this will be assessed by the DNSP and AEMO (in respect of the AEMO advisory matters) under the framework contemplated by clause 5.3.4A of the NER.

EG Systems under 5 MVA may be exempted from the requirement to operate in multiple modes.

### 6.3.1 Voltage control strategy

The DNSP may require that the design and operation of the control systems of an EG Unit or EG System be coordinated with the existing voltage control systems of the DNSP and of other Distribution System users, in order to avoid or manage interactions that would adversely impact on the DNSP and other Distribution System users.

There will be cases where the DNSP will require the EG System to operate in voltage control mode, constant power factor mode, or reactive power control mode as specified in the Technical Study and Performance Standard or a combination of all three as required by the *automatic access standard*.



The Technical Study shall show that the voltage control strategy from the Proponent does not hinder the DNSP from achieving the system standards in Schedule 5.1a of the NER.

Proponents should seek a control strategy with a dynamic response in accordance with the *automatic access standard* in the NER.

## 6.3.2 Control system

S5.2.5.13(b)(2)(i) and (ii) of the NER requires facilities for both monitoring of key variables and for testing its operational characteristics. Where appropriate, the main control system shall have duplicate power source (DC) similar to outlined in the protection requirements.

A fault recorder which logs events such as voltage disturbances, changes in set point, etc. to log and report on the control system's dynamic response to operational events is considered mandatory. The DNSP requires Proponents to provide details of how their testing and monitoring facilities shall prove its dynamic operating characteristics.

Where the control system utilises an internal communication system, such as from the power quality monitoring device to a central controller, an internal communications failure scheme shall be put in place.

## 6.3.3 Control system damping

The EG System shall have a voltage control system that ensures any oscillations are adequately damped with no degradation of critical oscillatory modes and with no instabilities such as hunting.

## 6.3.4 Control system testing

The control system shall include a way, means or method to test its performance during commissioning. Facilities for testing and their needs are to be agreed with the DNSP on the specified limits and requirements. One or more of the following methods may form the basis of a reasonable approach to control system testing:

- a. Simulating inputs with software;
- b. Test links; and
- c. Primary injection points.

The above list is not intended to be exhaustive; other methods may be proposed by the Proponent for consideration by the DNSP.

## 6.3.5 Power system stabiliser

The control system shall not detract from the performance of any power system stabiliser and shall be coordinated and as agreed by the DNSP.

## 6.4 Protection requirements for Class B

### 6.4.1 General protection requirements

Protection of the EG System and the Distribution System shall be in accordance with the NER and other relevant Energy Laws and standards and coordinated with the DNSP. Sufficient redundancy needs to exist in the protection system so that the protection scheme is able to operate with any single component out of service. This also applies to the DC systems, including batteries, chargers, and distribution boards that power the scheme. This requirement applies to the EG System as well as the other Distribution System connected equipment such as a utility substation (unless the DNSP specifically determines that this is unnecessary). The Proponent shall bear the cost to establish the protection system to the requirements set out in this Standard.



# Standard for High Voltage EG Connections

EG Systems with disturbance ride through mode may need to simulate and demonstrate performance compliance with the anti-islanding mode on or off. The DNSP may prescribe islanding protection requirements at the detailed design stage. The following is a minimum requirement for protection design which does not take into account site-specific constraints.

Where the connection between the EG System and the DNSP is a dedicated line terminating at the DNSP's zone substation busbar and the line is:

- a. Owned by the DNSP:
  - i. Full duplicate and diverse protection devices and related communications equipment owned and operated by the DNSP;
  - ii. Duplicate DC supply to the protection relays and communications equipment; and
  - iii. Dedicated CT winding and dedicated VT secondary winding; or
- b. Owned and operated by the Proponent:
  - i. Duplicate protection schemes that are compatible with the protection schemes employed by the DNSP at the supplying HV substation. The Proponent's protection scheme shall be coordinated with that of the DNSP.

Where the line between the EG System and the DNSP is not dedicated to connecting the EG System, the DNSP shall have a switching station with:

- One or more circuit breakers depending on the configuration and operational requirements of the DNSP;
- Full duplicate and diverse protection devices and related communications equipment;
- Duplicate DC supply to the protection relays, communications equipment and circuit breaker; and
- CTs and VTs with secondary winding available for protection and metering purposes.

Anti-islanding protection may also be specified as an additional requirement by the DNSP. Conditions of trip and other performance conditions shall be specified in the Connection Contract. The DNSP is not liable for loss or damage incurred by the EG System as a result of the fault on either the power system or the EG System's facility.

Applicable protection requirements are also outlined in:

- Class A1/A2 systems in this Standard; and
- If additional protection and SCADA schemes are required, the DNSP shall notify the Proponent after conducting the review of the Technical Study.

The Proponent shall provide the following:

- Protection single line diagram showing all the protection schemes including AC and DC circuits and circuit breaker tripping logic; and
- A report showing proper interface and coordination between the EG System and the Distribution System and confirmation that fault clearance times are as specified in Table S5.1a.2 of the NER.

Under the NER, the EG System shall provide primary, backup and breaker fail protection in accordance with the *automatic access standard* at the Connection Point. This is to ensure that the protection system is robust and reliable with as little impact on the rest of the power system as possible.

# Standard for High Voltage EG Connections

For EG Systems with inverters, the sustained fault current contribution shall not exceed the rated current of the inverter(s). If this occurs, then the use of short circuit current limiters shall be used in agreement with the DNSP.

## 6.5 DNSP Technical Study – Class B

Class B Technical Studies are carried out for those EG Systems identified as Class B in Table 1. For systems connecting under Chapter 5 of the NER, this will occur during the Detailed Enquiry phase, and shall cover the requirements under S5.4B of the NER.

The following items shall be addressed for all EG Systems connecting within the Distribution System:

- a. Distribution system capacity assessment and identification of power transfer capability;
- b. Identification of other generating systems which may impact the connection;
- c. Power quality allocation for fluctuation and distortion;
- d. Power quality assessment of voltage rise, informing the required control mode and proposal of acceptable setpoints and droop settings;
- e. Fault current contribution, if applicable;
- f. Protection requirements;
- g. Details of Performance Standards;
- h. Generation and/or load rejection studies;
- i. Plant energisation studies;
- j. Requirements for curtailment;
- k. Identification of operational considerations;
- l. Identification of required power quality monitoring and SCADA connection; and
- m. Preliminary assessment of system strength impact, calculating the Minimum Short Circuit Ratio (MSCR) as defined by the AEMO System Strength Assessment Guideline.

The Performance Standards identified define the access standards applicable to the connection. Access standards are divided into “automatic access standards” (the default position), “negotiated access standards” (a negotiated position) and “minimum access standards” (the minimum requirement for a *negotiated access standard*). Further information on this is set out in Table 27.

**Table 27 Access Standards Explanation**

Access Standard	Explanation
Automatic	EG Systems that meet the <i>automatic access standard</i> for a technical parameter shall not be denied access to the Distribution System based on that technical parameter. This is the default requirement for all EG Systems.
Minimum	This access standard is the minimum technical level of performance that the DNSP shall consider for connection to the Distribution System. EG Systems that do not meet the minimum access standard shall be denied access to the Distribution System.
Negotiated	Where an EG System is incapable of meeting the <i>automatic access standard</i> , the Proponent and the DNSP may agree on a lower access standard. This <i>negotiated access standard</i> shall be as close as possible to the <i>automatic access standard</i> and cannot be any lower than the relevant minimum access standard. Note that some <i>negotiated access standards</i> shall be reviewed not only by the DNSP but also by AEMO and the transmission network service provider, Powerlink Queensland.

## 6.5.1 Plant energisation

Energisation of reactive plant, extensive cabling systems, and power transformers shall comply with STNW1179 Standard for Plant Energisation.

Energisation of power transformers with remanent flux on weak networks may cause voltage excursions outside allowable limits. This should be identified early in the planning so appropriate single pole circuit breakers and point on wave controllers can be designed as part of the Connection Assets. Ownership of these assets to be agreed between the Proponent and DNSP and documented in the Connection Contract.

## 6.6 EMT modelling requirements – Class B

It is a requirement that all Class B systems provide a PSCAD™/EMTDC™ model with site-specific configuration and settings, tuned to the required network conditions and level of performance. Class B market participant EG systems shall have the PSCAD™/EMTDC™ model benchmarked against the PSS@E model. The PSS@E model shall be fine-tuned based on the benchmarking. Where the requirement is identified through a *preliminary assessment*, a *full assessment* shall be completed by the DNSP as contemplated by 4.6.6(b) of the NER.

The Proponent shall:

- a. Supply the model to the DNSP and AEMO (where the EG system is or intends to be registered with AEMO as a *Generator*), within agreed timeframes, compatible with the modelling package PSCAD™/EMTDC™ (version 4.6.3 or later), and Visual Studio 2015+, and which has been compiled using an Intel® Fortran Compiler (version 15 or later). The Proponent may elect to provide a black box encrypted model;
- b. Ensure that any model provided has been properly tested, certified and verified with the applicable OEM (with a copy of such provided to the DNSP) as representing the fully detailed inner control loops, phase locked loops, fault ride-through controllers, internal and external voltage controllers, system level controllers and all protection systems of the EG System, where possible embedding the actual hardware code;
- c. Provide modelling information to the DNSP and AEMO (for registered *Generators*), within agreed timeframes, which shall include an R1 data level accuracy pre-validated and current black box encrypted electromagnetic transient-type simulation model which includes all settings and the inverter and EG System control systems complete with the controller block diagrams (so as to explain the operation of the model without compromising the model veracity);
- d. Where R2 testing and model validation is required, update the model information to include the commissioned settings and provide evidence the model is as per actual performance. The model simulated performance shall be overlaid with actual performance, and shown to be within tolerable error bands of  $\pm 10\%$  of simulated value; and
- e. Not undertake any on-site tuning of any EG System parameters that impact dynamic EG Unit performance, or remotely adjust any EG System parameters, without prior written approval from the DNSP and AEMO (if applicable).

# Standard for High Voltage EG Connections

## 6.7 Communication requirements – Class B

S5.2.6.2 of the NER details the basic communications required between AEMO and the Proponent and the electrical supply requirements for the remote monitoring and control equipment. Table 28 provides the communication equipment guidelines the DNSP shall use to determine the level of access standard for the EG System.

**Table 28 Communications equipment access standards**

Access Standard	Requirements
Automatic	Two separate telephone facilities to be provided. Back-up power supply for remote communication and control facilities for three hours following on from a loss of supply.
Minimum	Provision of a telephone facility and one hour back up supply.
Negotiated	Agreed communication facilities between AEMO, the DNSP and the Proponent subject to the specified limits

Subject to availability, the use of fibre optic telecommunications cables between the EG System and the nominated SCADA interface point (typically the zone substation the EG System is connected to) and the nominated protection inter-tripping point is preferred. Where fibre optic telecommunication cables are not readily available the DNSP shall investigate the suitability of alternative radio options. The Proponent shall provide and install telephone line isolation equipment to comply with ACMA, the NER and telecommunications company requirement.

In the event of communications failure for the protection inter-tripping circuit, the Proponent shall be responsible for tripping the EG System protection equipment to disconnect the source of generation. The EG System protection equipment shall remain tripped until the protection inter-tripping communications circuit is operating.

Selected components of the DNSP's protection, SCADA, and communications systems shall be installed at the Proponent's facility to facilitate inter-tripping, SCADA and communications interface requirements. The DNSP shall provide the equipment in a panel. The Proponent shall provide space to house the DNSP's equipment.

## 6.8 SCADA requirements – Class B

### 6.8.1 General requirements

S5.2.6.1 of the NER deals with remote monitoring of EG Systems by AEMO and the DNSP's control centres to monitor the performance of the EG System. Table 29 provides remote monitoring guidelines which the DNSP shall use to determine the level of access standard for the EG System.

# Standard for High Voltage EG Connections

**Table 29 Remote monitoring and control access standards**

Access Standard	Requirements
Automatic	Subject to scheduling and size, the EG System shall have remote monitoring equipment to transmit to AEMO the specified quantities required for AEMO to discharge its duties. Details of the specified quantities are provided in Appendix D.
Minimum	Subject to scheduling and size, the EG System shall have remote monitoring equipment to provide AEMO with the information detailed in Section 6.7. IES EG Systems shall also comply with Section 6.8.
Negotiated	As agreed with AEMO and documented in the agreed Performance Standard. The Proponent shall provide SCADA indication as agreed through the Connection specific Technical Study.

The supported SCADA communications protocols shall communicate in order of preference of:

- a. DNP3 Level 1; Sequence of Events (SOE) timestamping required.
- b. Modbus (currently not available for EG System connections with the DNSP).

Note: Any Distribution System event such as switching or protection operation shall be time stamped at the source, and the time-stamped event sent to the DNSP.

For time-stamped data, the DNSP can provide the time source over DNP3 or the Proponent can synchronise via their GPS clock.

The DNSP has established an ethernet inter-connection capability method which can be considered for use by Proponents upon application. All telecommunications between the EG System and the DNSP Operational Technology Environment (OTE) will be conducted at layer 3 (IP) level which is controlled through an edge defence (ED) device (refer to Section 4.13 of this Standard).

## 6.8.2 Plant status

The Proponent shall transmit all necessary EG System and EG Unit status information required by the DNSP and third parties as required to operate the Distribution System. As a minimum, status information may include:

- a. Power production: MW, Mvar, current, voltage, power factor. Information shall indicate direction of power flow;
- b. Proponent's Connection Point circuit breaker status: Open /Closed /Tripped /Racked in or out;
- c. Auto/Manual start availability;
- d. IED status for critical components;
- e. EG System status (heartbeat);
- f. EG System specific information relevant to the EG Units such as number of wind turbines operating and available, battery state of charge; and
- g. For Proponents that can island their HV Network from the Distribution System, the Proponent shall provide information on the status of the Proponent's connection to the Distribution System.

## 6.8.3 Voltage control

Proponents controlling the HV bus voltage shall transmit the voltage control mode, control set point to the utility and the status of the voltage control; for example: constant power factor mode, volt/var mode. Unless otherwise agreed through the Technical Study, the control set point is determined by the DNSP. If Distribution System information is required for the operation of a voltage control mode it may be provided on negotiation.

## 6.8.4 Distribution System support mode

Proponents that provide Distribution System support shall transmit the necessary information to the DNSP, including whether the Proponent is in frequency creation or frequency reflection mode. If Distribution System information is required for the operation of a Distribution System support mode it may be provided on negotiation.

## 6.8.5 Curtailment

The DNSP shall send condition-based curtailment signals based on active power control requirements as per the requirements in NER.

The generic curtailment functionality shall provide the DNSP with a mechanism to curtail Export of an EG System in response to set requirements. These conditions may be caused by triggers such as network or primary plant constraints, signals from third party providers, or demand response. The application shall have a master control switch operable from the DNSP to enable/ disable the scheme. The application monitors conditions via an input signal, which shall be provided in the form of a digital signal, analogue signal input or logic conditions.

The input signal may be compared to a threshold or conditional value to determine ON/OFF states. Threshold values must be made available for remote modification from DNSP interface. Each input signal must have an associated threshold value.

The Scheme may need to send automated signals to the EG System as well as receive confirmation back for successful transmission.

## 6.8.6 Remote start

EG Systems capable of a remote start may enable this through the DNSP system. The DNSP may allow third party control for example an aggregator to start a peaking EG System for peak response market event.

## 6.9 Meteorological data

Where required, the Proponent shall transmit meteorological data, including wind speed and irradiance.

## 6.10 Inter-trip

The DNSP may require a backup Anti-islanding Protection scheme via the SCADA system if determined as required through the Technical Study.



# Standard for High Voltage EG Connections

## 7 Testing and commissioning

Generating system 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;
- Complies with the agreed access standards for registered EG Systems; and
- Minimises any possible threat of damage to the Distribution System, or any other equipment or installations of any other person that is connected to the Distribution System.

Testing and commissioning requirements for HV EG System connections under Chapter 5A of the NER include:

- a. testing and commissioning plans shall be prepared by the Proponent and may be required to be approved by the DNSP under the Connection Contract.
- b. the commissioning plan and acceptance shall be carried out by an RPEQ.
- c. testing and commissioning acceptance may require the DNSP to carry out witnessing at the Proponent's expense. For Class B systems, timing must be agreed.
- d. testing shall involve installation test, not type tests.
- e. for LV connected 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 the DNSP technical requirements to demonstrate that the HV EG IES system complies with the requirements set out in the Connection Contract.
- f. for Rotating Machines, testing and commissioning requirements shall be in accordance with the equipment manufacturer's specifications and the DNSP's technical requirements and shall demonstrate that the HV EG Rotating Machines system meets the requirements of the Connection Contract.
- g. the Proponent shall submit a compliance report as outlined in the Connection Contract that comprises (but is not limited to) the final approved drawings, installed settings, test results and specifications. The compliance report has checks to confirm compliance to this Standard and connection-specific Technical Study.
- h. connection shall only be approved (and permitted) after the DNSP has reviewed and accepted the compliance report.

The application of testing and commissioning requirements shall be applied to specific subcategories as shown in Table 30.



# Standard for High Voltage EG Connections

**Table 30 Testing and commissioning requirements**

Testing and commissioning requirements	IES				Rotating Machines Class A1,A2	
	Class A1		Class A2		Export	Non-export
	Export	Non-export	Export	Non-export		
Protection settings and performance	Yes	Yes	Yes	Yes	Yes	Yes
Power quality settings and performance	Yes	Yes	Yes	Yes	Yes	Yes
Power quality compliance testing	Yes <sup>1</sup>	Yes <sup>1</sup>	Yes	Yes	Yes	Yes <sup>1</sup>
Export limits settings and performance	Yes	Yes	Yes	Yes	Yes	Yes
Compliance with Performance Standards	Yes	Yes	Yes	Yes	Yes	Yes
Communications settings and performance	No	No	No	No	No	No
Shutdown Procedures	No	No	No	No	Yes	Yes
Confirm system is as per specifications	Yes	Yes	Yes	Yes	Yes	Yes
Confirm SLD is located on site	Yes	Yes	Yes	Yes	Yes	Yes

Note 1: Power quality meter not required as per Section 4.10.6. Power quality compliance testing requirement to be determined within the Technical Study.

Testing and commissioning requirements for HV EG System connections under Chapter 5 of the NER include:

- i. Test and commissioning plan as agreed with the DNSP and AEMO and described in clause 5.8 and 5.7.3 of the NER.
- ii. Registration with AEMO and acceptance of all applicable R1 data.
- iii. All pre-requisites, including SCADA connection, background recordings, curtailment scheme completion, and pre-commissioning activities have been completed as relevant for the particular site.
- iv. Agreed operating protocol.
- v. All required information, including applicable settings implemented in controllers and inverters and calibration certificates supplied to the DNSP and AEMO.
- vi. Required pre-test simulations have been provided to AEMO and DNSP.

- vii. Notice shall be given not less than three (3) months prior to commencement of commissioning.

## 8 Operations and maintenance

Operations and maintenance requirements for the connection of HV EG Systems shall include, but are not limited to:

- a. operations and maintenance plans are required to include:
  - i. a maintenance schedule for relevant equipment
  - ii. frequency of checks and type of checks
  - iii. maintenance of relevant equipment
  - iv. how evidence of operations and maintenance is to be recorded and stored
  - v. a template of the operations and maintenance report
  - vi. documented operating procedures including requirements for preserving the integrity of protection settings and interlocks and procedures for subsequent changes to settings
  - vii. signs/labels/safety warnings
- b. an operation and maintenance plan shall be produced by the Proponent and a copy to remain on site. This plan shall be made available to the DNSP on request.
- c. operations and maintenance reports are required to include:
  - i. maintenance items as per a maintenance schedule including dates of checks, details of conformances/non-conformances and rectification works;
  - ii. other operations and maintenance works relating to the equipment (e.g. warranty replacements or changes to the system) including dates and details of any works;
  - iii. other operations and maintenance works relating to the installation (e.g. signs/labels/safety warnings) including dates and details of any works.
- d. operations and maintenance reports are required to be produced and shall be made available to the DNSP on request.
- e. the EG System shall be operated and maintained to ensure compliance at all times with the Connection Contract and all applicable legislation (including Energy Laws), codes, and/or other regulatory instruments including AS 2067.
- f. the DNSP may at its own cost inspect the Proponent's HV EG System at any time with a minimum notice period provided to the Proponent. The DNSP may require access to the site of the EG System and isolation points for Distribution System maintenance and testing purposes.
- g. the Proponent shall seek DNSP approval prior to altering the connection in terms of an addition, upgrade, extension, expansion, augmentation or any other kind of alteration, including operational or protection settings of the EG System.

# Standard for High Voltage EG Connections

- h. subject to item g above, the Proponent shall ensure that any changes to the electrical installation at the supply address are performed by an appropriately qualified electrician permitted to do the work and that the Proponent holds a Certificate of Compliance issued in respect of any of the changes.
- i. the Proponent shall not make changes to firmware or control systems of the generating system without undertaking the appropriate S5.2.2 or 5.3.9 process as applicable for Registered Systems, or without giving written notice to the DNSP five business days prior to implementation for non-Registered Systems.
- j. the Proponent shall notify the DNSP of any scheduled and unscheduled protection or communications outages or failures.
- k. if the DNSP through an audit or an investigation determines that the EG System is non-compliant with the Connection Contract, the Proponent shall be advised of this in writing. Non-complying EG Systems are not permitted to reconnect until the Proponent prepares a rectification a plan and demonstrates compliance. This written advice of compliance may involve independent HV Auditor and/or RPEQ as required depending on the circumstances.
- l. costs associated with the operations and maintenance of the EG System are the responsibility of Proponent.

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.

# Standard for High Voltage EG Connections

## Appendix A: Deviations from the National DER Connection Guidelines (informative)

**Table 31 Table of deviations from National DER Connection Guidelines**

Section	Description of deviations	Type of deviation	Justification
1.2	IES systems under 30kVA excluded	n/a	These systems are covered under STNW1170 Standard for Micro EG Connections
1.2 and various other instances	“Rotating Machines” used instead “Non-IES”	Promote improved benefit to Australia’s electricity system	Rotating Machines or rotating electrical machines is an established term used in Industry and IEC standards.
1.2 and 5	EG Systems registered under Chapter 5 is included in scope	Promote improved benefit to Australia’s electricity system	The DNSPs had one standard for all HV EG Systems and this practice is carried forward with clear separation of requirements for different categories.
1.2, 4.1, 4.2, 4.4	Removed exclusion for ESS in both total system capacity and Export limits for IES.	Promote improved benefit to Australia’s electricity system	ESS can have an integrated inverter and be AC or be DC. An ESS with integrated inverter would not be excluded from either total system capacity or Export limit for IES due to impact on the Distribution System.
2.1	Different definitions for defined terms where appropriate. Italics is used to highlight specific terms in NER/National Energy Retail Law not defined in this Standard.	Promote improved benefit to Australia’s electricity system	For better clarity and alignment with other related documents.
2.2	Abbreviations replaced with new additions. Some acronyms also moved to the definitions section.	n/a	Documentation policy to not include abbreviations not required within the Standard.
2.3.1 onwards	Numbering structure changed	Promote improved benefit to Australia’s electricity system	To fit >5 MVA connections to form one Standard for HV EG Connections and improve readability for the end user.
4.8	Nominated maximum voltage set point is omitted.	n/a	Voltage control is covered under S 4.10.
4.11	Communications requirements excluded for Class A1 EG systems. Large Non-export EG Systems are required (Class A2 and above)	Promote improved benefit to Australia’s electricity system	Large Non-export EG Systems can still impact the network significantly. An example is importing a large amount of power in the event of a generating failure.

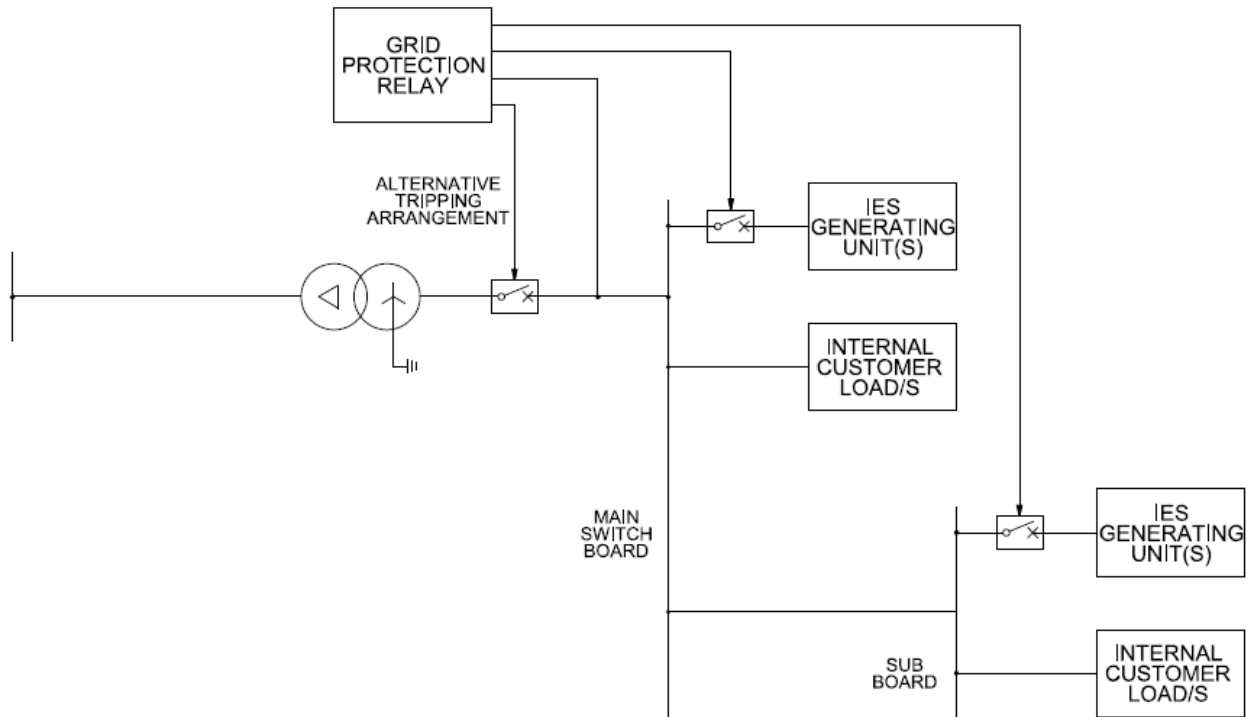
# Standard for High Voltage EG Connections

Section	Description of deviations	Type of deviation	Justification
5.2.2	Facility fault protection, Generator phase balance removed from Central Protection.	Promote improved benefit to Australia's electricity system	Compliance to best practice standards improves safety and performance.
5.2.2 and 5.2.4	Overcurrent and earth fault for Class A1 IES systems not required.	Promote improved benefit to Australia's electricity system	Acknowledging the low fault current rating of IES systems and aligning with the LV EG connection standard requirements for similar EG capacities.
5.2.4	Title shortened to "Overcurrent and earth fault protection"	n/a	Shortened to improve readability and formatting.
5.2.5	Grid Low Forward Power terminology replaced by Power Limit	n/a	Existing terminology used in Queensland EG Standards
5.2.11	GID requirement for Class A1 EG Systems exempted	Promote improved benefit to Australia's electricity system	
5.2.11	GID ownership changed to DNSP except in circumstances stated in section 4.5.2	n/a	
5.5	No information or link provided for time and costs to complete the Technical study	n/a	
6	Extra requirements for EG Systems connecting under Chapter 5 of NER	Promote improved benefit to Australia's electricity system	The DNSPs had one standard for all HV EG Systems and this practice is carried out with clear separation of requirements for different categories
7	Removed the requirement for DNSP to require an operation and maintenance plan for sign-off before energisation. Operational and maintenance report are only required to be produced on request to the DNSP.	Promote improved benefit to Australia's electricity system	This is not currently a requirement.

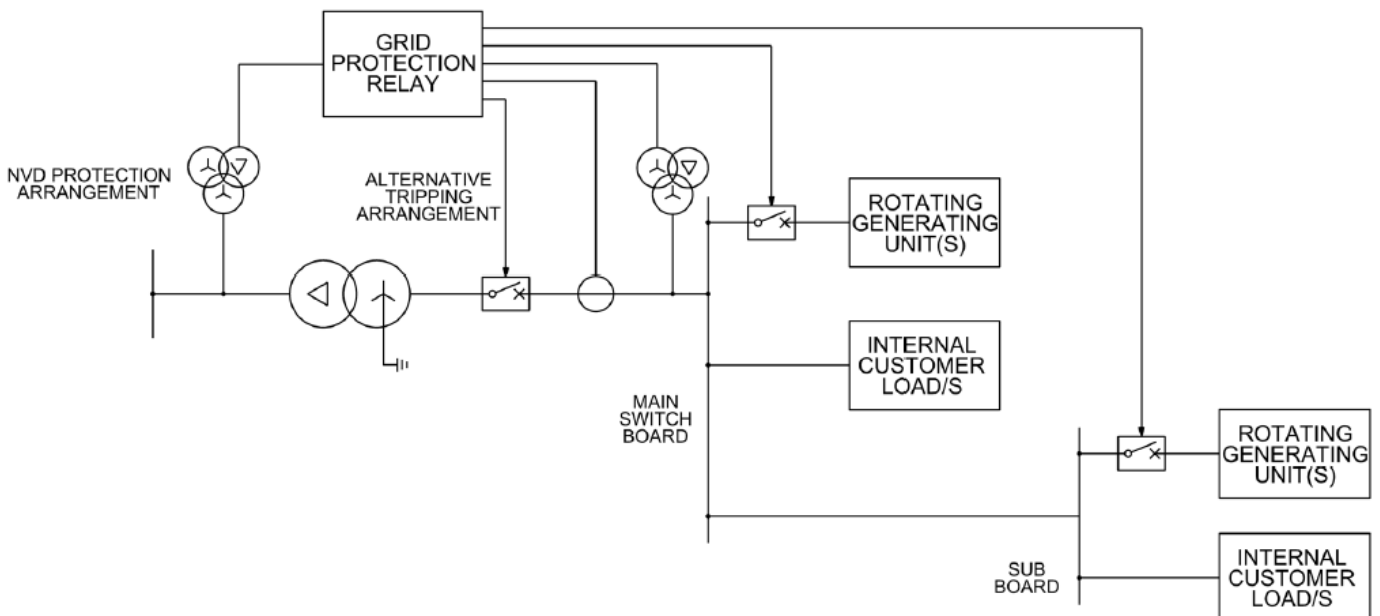
# Standard for High Voltage EG Connections

## Appendix B: Connection arrangement requirements (normative)

Following are representations for typical connection arrangements as considered in this Standard.



**Figure 2 Protection arrangement for EG Systems comprising Class A1 IES EG Unit(s)**



**Figure 3 Protection arrangement option for a Class A1 EG Systems comprising rotating EG Unit(s)**

# Standard for High Voltage EG Connections

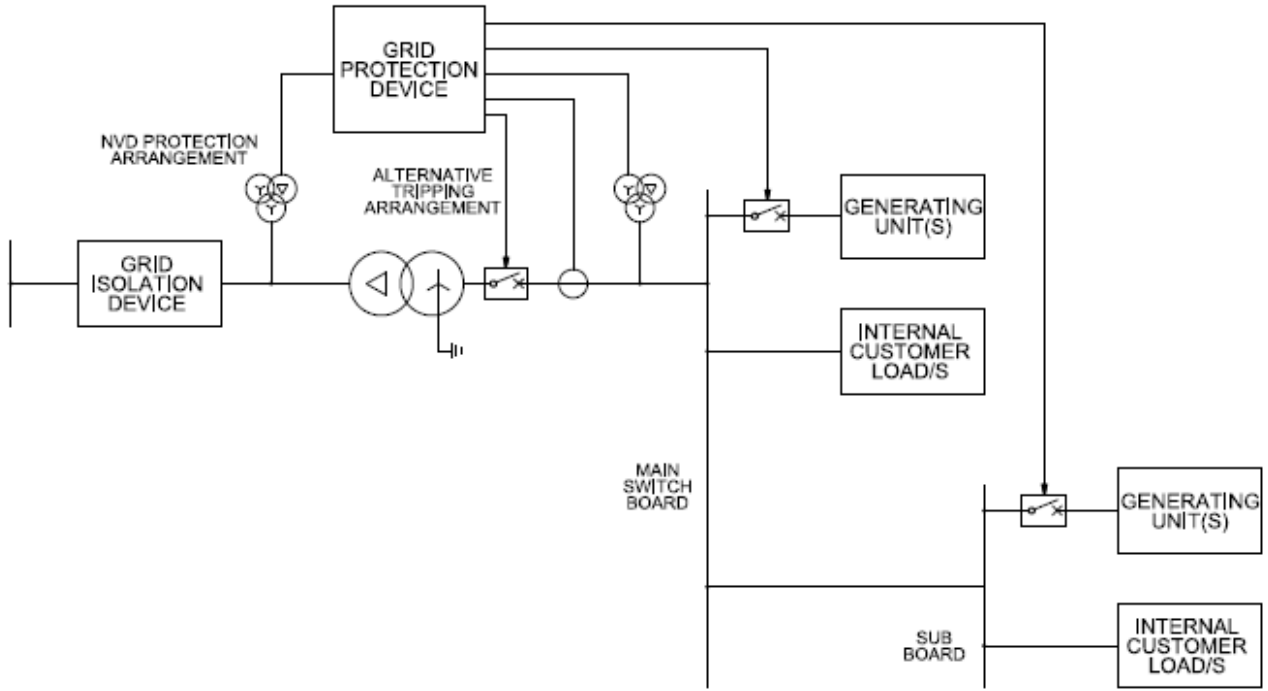


Figure 4 Protection arrangement option for Class A2 EG System with LV Generating Unit(s)

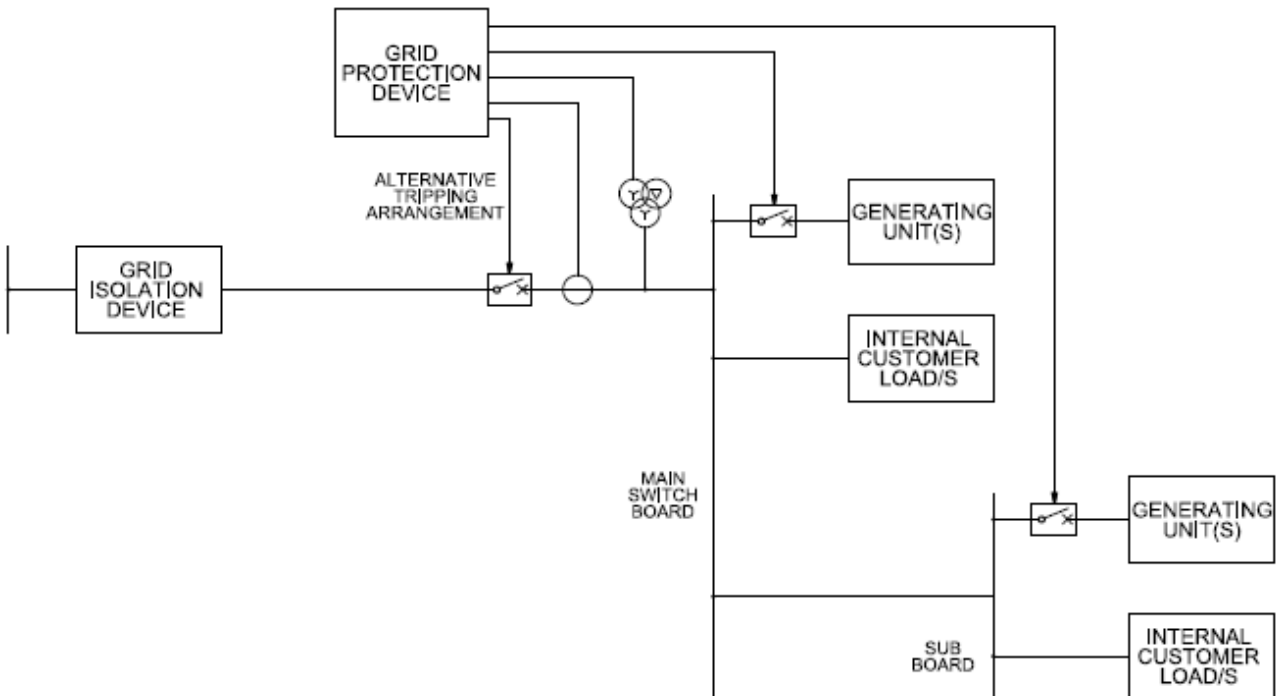


Figure 5 Protection arrangement option for a Class A2 EG Systems comprising of HV Generating Unit(s)



# Standard for High Voltage EG Connections

## Appendix C: Model Standing Offer (informative)

This Section is left intentionally blank.

## Appendix D: Static data and information (informative)

Static data and information shall be provided by the Proponent to the DNSP based on your application type and may include some of the following below (but not limited to):

1. NMI meter numbers
2. System information
  - a. Detailed single line diagram demonstrating Fixed EG Units connected, and proposed for connection, at the Premise (including detail of any interlocking).
  - b. Number of phases available and number of phases DER installed
  - c. Energy source
  - d. Maximum output rating
  - e. Any proposed Export limit (full / partial / minimal) and method of Export control
  - f. Metering scheme information (gross or net)
3. EG Unit Data
  - a. Make, model and manufacturer
  - b. Number installed
  - c. Power quality modes
4. Device information
  - a. Type (e.g. panel, battery)
  - b. Make, model and manufacturer
  - c. Number installed
5. Applicant and Customer information
  - a. Type
  - b. Business and / or Personal Names
  - c. Address and contact information
6. Installer information

# Standard for High Voltage EG Connections

## Appendix E: Short Circuit Ratio calculation methods (normative)

### Short Circuit Ratio (SCR)

Short Circuit Ratio is calculated with the following formula:

$$SCR = \frac{S_{CMVA}}{P_{max}}$$

Where

$S_{CMVA}$  is the minimum sub-transient fault contribution in MVA of the studied bus prior to the proposed connecting asynchronous (power electronic based) EG System

Or

$S_{CMVA}$  is the minimum sub-transient fault contribution in MVA of the studied bus with the proposed connecting Rotating Machine EG System; and

$P_{max}$  is the maximum EG capacity of the proposed EG System.

### Aggregated Short Circuit Ratio (WSCR)

Aggregated Short Circuit Ratio means consideration for combined generation in a shared Distribution Network which could be based on Weighted Short Circuit Ratio (WSCR), or other methods.

In this Standard, the Short Circuit Ratio also means the aggregated Short Circuit Ratio depending on the presence of nearby existing or committed EG Systems. WSCR is used in this Standard for assessment when nearby asynchronous EG Systems are present.

A WSCR calculation should be performed as per the following formula:

$$WSCR = \frac{\sum_i^N S_{SCMVAi} * P_{RMWi}}{(\sum_i^N P_{RMWi})^2}$$

Where

$S_{SCMVAi}$  is the minimum fault contribution in MVA at the connection point with only synchronous EG Systems connected;

$P_{RMWi}$  is the MW rating of the EG System to be connected;

N is the number of nearby asynchronous EG Systems; and

The EG System index is given by i.

### Minimum Short Circuit Ratio (MSCR)

The MSCR method as detailed in AEMO's System Strength Impact Assessment Guidelines is based on the following Premises:

- (a) The Available Fault Level after connection of the proposed EG System is compared against the minimum SCR/fault level for which it is capable of stable operation.
- (b) The headroom (or margin) between the two values (Distribution System Strength versus the EG System's requirements) provides an initial indication of the connection point capability to host the EG System and, therefore, the likelihood of an *adverse system strength impact* as defined in System Strength Impact Assessment Guidelines.

# Standard for High Voltage EG Connections

## Appendix F: Technical requirements summary– Class A1 and Class A2 (informative)

### Inverter Energy Systems

	Class A1 IES systems		Class A2 IES systems	
	Non-export	Export	Non-export	Export
Level 1 Backup protection <sup>1, 2</sup>	Yes	Yes	Yes	Yes
HV NVD protection	No	No	Yes	Yes
Grid Isolation Device Required	No	No	Yes	Yes
Distribution System Technical Study required	Yes	Yes	Yes	Yes
Power quality to AS/NZS 61000 series requirements	Yes	Yes	Yes	Yes
Communications / SCADA interface	No	No	Yes	Yes
Fault level contribution to the Distribution System included in the Technical Study	No	No	No	No
RPEQ for both design & commissioning <sup>2</sup>	Yes	Yes	Yes	Yes

1. Level 1 backup protection – Over and under voltage, over and under frequency and rate of change of frequency.
2. Not required for IES EG Systems with an aggregate nameplate capacity of ≤ 30 kVA.

# Standard for High Voltage EG Connections

## Rotating Machine systems

	Class A1 Rotating Machine systems				Class A2 Rotating Machine systems			
	Limited parallel Operation		Continuous parallel Operation		Limited parallel Operation		Continuous parallel Operation	
	Bumpless transfer	Stand-by	Non-export	Export	Bumpless transfer	Stand-by	Non-export	Export
Level 1 Backup protection <sup>1</sup>	No	Yes	Yes	Yes	No	Yes	Yes	Yes
HV NVD protection	No	No	Yes	Yes	No	No	Yes	Yes
Power Limit controls <sup>2</sup>	No	No	Yes <sup>2</sup>	No	No	No	Yes <sup>2</sup>	No
Voltage Controlled Overcurrent	No	No	No	Yes	No	No	No	Yes
Grid Isolation Device Required	No	No	No	No	No	Yes	Yes	Yes
Distribution System Technical Study required	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Power quality to AS/NZS 61000 series requirements	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Communications / SCADA interface	No	No	No	No	No	No	Yes	Yes
Fault level contribution to the Distribution System included in the Technical Study	Yes <sup>3</sup>	Yes <sup>4</sup>	Yes	Yes	Yes <sup>3</sup>	Yes <sup>4</sup>	Yes	Yes
RPEQ for both design & commissioning	Yes <sup>5</sup>	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1. Level 1 backup protection – Over and under voltage, over and under frequency and rate of change of frequency.
2. Zero power limit for Non-export systems, power limiting controls for partial-export systems.
3. Fault level contribution may be considered for bumpless transfer EG Systems depending on the connecting Distribution System.
4. Fault current contribution is dependent on size, number and hours of operation.
5. RPEQ commissioning is not required when electronically controlled interlocking is not implemented and the transfer switch is compliant as per S 4.4.4.

# Standard for High Voltage EG Connections

## DNSP Technical Study requirements summary for Class A1 and Class A2 EG Systems

Technical study	IES				Rotating Machines	
	A1 IES		A2 IES		Export	Non-export
	Export	Non-export	Export	Non-export		
Distribution system capacity assessment	Yes <sup>1</sup>	No	Yes	No	Yes	No
Impact on other EG Systems	Yes <sup>1</sup>	No	Yes	Yes <sup>2</sup>	Yes	No
Voltage fluctuation and distortion	Yes	Yes	Yes	Yes	Yes	Yes
Voltage rise	Yes	No	Yes	No	Yes	No
Generation and/or load rejection	Yes <sup>1</sup>	Yes	Yes	Yes	Yes	Yes
Power flow	Yes	No	Yes	No	Yes	No
Fault contribution	No	No	No	No	Yes	Yes
Protection	Yes	No	Yes	No	Yes	Yes
Plant energisation	Yes <sup>1</sup>	No	Yes	No	Yes	No
Requirement for curtailment	Yes <sup>1</sup>	No	Yes	No	Yes	No
Performance Standards	No	No	Yes	Yes	Yes	Yes

1. Not required for IES EG Systems with an aggregate nameplate capacity of  $\leq 30$  kVA.
2. Only required based on low SCR levels.



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