Technical Standard - TS133

High Voltage Embedded Generation Connection Technical Requirements

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SA Power Networks

Empowering South Australia

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1. Introduction

This technical standard specifies to designers, contractors, and consultants the technical requirements for embedded generation (EG) systems where the network connection is at high voltage (HV) on SA Power Networks' distribution network.

This document shall be read in conjunction with NICC270: Connection of Medium and Large Embedded Generation Greater than 30kVA and SA Power Networks' Service and Installation Rules (SIR), which are available at (www.sapowernetworks.com.au), and the installation shall be in accordance with the relevant AS/NZS standards (refer section 3).

For small EG system capacity not exceeding 30kVA, refer to TS129 and for EG systems above 30kVA connected to SA Power Networks' low voltage (LV) network, refer to TS132.

This standard does not detail SA Power Networks' or the generator's obligatory requirements to comply with Essential Services Commission of SA (ESCOSA) - Electricity Distribution Code (EDC), Electricity Metering Code (EMTC), licensing, Australian Energy Market Operator (AEMO) and National Electricity Rules (NER). It is the responsibility of the customer, to ensure that their installation is compliant with these requirements, and to ensure all required third party approvals and/or licenses are obtained.

The technical requirements outlined in this technical standard do not apply to systems that are connected via a compliant Open Transition Transfer Switch (OTTS) and do not operate in parallel with the network (eg. back-up generator).

The customer is advised **not** to procure or commit to procure any land or equipment associated with their proposed generating system until receipt of an engineering report from SA Power Networks.

TS133 sets out the minimum technical requirements for HV connected EG. Any additional site-specific requirements will supersede these minimum requirements and will be specified in the Engineering Report.

2. Definitions and Abbreviations

2.1 Definitions

Central Protection	The protection installed to perform the functions of coordinating multiple EG unit installations at one site, providing protection for the entire EG system installation and islanding protection to the connected grid as well as preserving safety of grid personnel and the general public.
Closed Transition Transfer Switch	An electrical switch that provides a make-before-break transfer sequence.
Cluster	The aggregation of generating units on the same title or adjacent titles of land when they are owned or operated by customers that share an interest in the other generator(s), and/or the land, regardless of the number of NMIs or connection points.
Connection Point	As per Electricity (General) Regulations 2012: A connection point to a transmission or distribution network. For this document, connection point also has the same meaning as point of supply as defined in AS/NZS 3000. The point of supply established between SA Power Networks and the customer.
Customer	A person who engages in the activity of purchasing electricity supplied through the distribution network to a connection point and is registered by AEMO as a customer under chapter 2 of the NER.
Distributed Energy Resources	Power generation or energy storage units that are connected directly to the distribution network.
Distribution Network	References to distribution network means the network poles, wires, underground cables, transformers, substations, etc, operated by SA Power Networks, which transports electricity to and from a customer's connection point.
Earth Potential Rise	Earth potential rise (EPR) occurs when large current flows to earth through an earth grid impedance. The potential relative to a distant point on the earth is highest at the point where current enters the ground and decreases with distance from the source.
Electricity Distribution Code	The Electricity Distribution Code made by ESCOSA pursuant to Section 28 of the Essential Services Commission Act 2002.
Embedded Generating Unit	A generating unit connected within a distribution network and not having direct access to a transmission network.
Embedded Generator	A customer who owns, operates, or controls an embedded generating unit.
Energy Storage Unit	Plant that is able to both, store electricity from, and discharge electricity to, units within the same generating system and/or distribution network (ie act as both a load and a generating unit)
Energy Storage System	A system comprising one or more energy storage units
Generation Despatch Limit	A real power output limit value sent via a SCADA signal by the DNSP to be applied at the individual generating unit terminals.

Generating System	All embedded generating units and the associated control and protection equipment that is located on the customer's side of 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.
Generator	A person/entity who engages in the activity of owning, controlling, or operating a generating system that supplies electricity to, or who otherwise supplies electricity to, a transmission or distribution network.
Grid	Portion of the electrical distribution system that is operated by an electrical distributor. Note: An alternative term for grid is electricity distribution network.
Grid Isolation Device	A device designed to safely break voltage and current such as a circuit breaker or contactor on the customer side of the connection point.
High Voltage	Voltage exceeding low voltage
Inter-trip	An anti-islanding protection scheme that is operated by the distribution network service provider to disconnect the embedded generating system when a network fault occurs.
Inverter	The device that may form part of the generating system which uses semiconductor / power electronics devices to convert direct current to alternating current.
Inverter Energy System	A system consisting of one or more inverters that operate by converting direct current to alternating current. In the context of system capacity, this definition includes the capacity of ac coupled energy storage systems.
Large Embedded Generation	IES EG installations with a combined nameplate rating greater than 500 kVA
Low Voltage	Voltage exceeding 50V ac or 120V ripple free dc and not exceeding 1,000V ac or 1,500V dc
Medium Embedded Generation	IES EG installations with a combined nameplate rating greater than 30kVA and no more than 500kVA
Model Connection Agreement	A document that is a model standing offer, or an equivalent document that may or may not be approved by the Australian Energy Regulator, and that is used to provide a basis for low voltage or high voltage embedded generation connection services. The document contains (amongst other things) details of the standard safety and technical requirements to be complied with by the customer.

Multiple Mode Inverter	Inverter that operates in more than one mode, for example having grid-interactive functionality when grid voltage is present and in stand-alone mode when the grid is de-energised or disconnected
Nameplate Rating	The maximum continuous output or consumption in MW of an item of equipment as specified by the manufacturer, or as subsequently modified. Where the rating of an item of plant is specified by the manufacturer in MVA and not MW, the nameplate rating is determined by converting the manufacturer's rating in MVA to the rating in MW by applying a conversion factor of 1.
National Electricity Rules	The rules as defined in the National Electricity Law as set out in the Schedule to the National Electricity Act 1996 (SA).
Net Export Limit	A real power export limit value sent via a SCADA signal by the DNSP to be applied at the proposed generating system's connection point.
Non-inverter Energy System	System that does not include an inverter ie rotating generators
Point of Common Coupling	The location at which the impact of the generating system on the network will be assessed.
Photovoltaic	The generation of electrical power by converting solar radiation into direct current electricity.
Rate of Change of Frequency	An islanding detection method for decentralised generation units
Small Embedded Generation	A single phase or three phase inverter connected embedded generation system up to 30kVA.
System Capacity	Nameplate ratings of the inverter energy system or non-inverter energy systems, measured in VA
Supply	The delivery of electricity.
Total System Capacity	Sum of the nameplate ratings of the inverter energy systems or non-inverter energy systems comprising the embedded generation connection, measured in VA
Transmission Network	Network operated by ElectraNet.
Uninterruptible Power Supply	A device that provides battery backup when the electrical power fails or drops to an unacceptable voltage level.
Voltage Unbalance	In a three-phase system, voltage unbalance takes place when the magnitudes of phase or line voltages are different and the phase angles differ from the balanced conditions, or both.

2.2 Abbreviations

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator Limited (ACN 072 010 327)
AER	Australian Energy Regulator
AS/NZS	A jointly developed Australian and New Zealand Standard
AS	Australian Standard
BESS	Battery Energy Storage System
CB	Circuit Breaker
CBD	Central Business District
CT	Current Transformer
CTTS	Closed Transition Transfer Switch
CEC	Clean Energy Council
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
EDC	Electricity Distribution Code
EG	Embedded Generation or Embedded Generating
EMTC	Electricity Metering Code (ESCOSA)
ENA	Energy Networks Australia
ESCOSA	Essential Services Commission of South Australia
ESS	Energy Storage System
GDL	Generation Dispatch Limit
GPS	Generator Performance Standard
HV	High Voltage
IEC	International Electrotechnical Commission
IES	Inverter Energy System
LV	Low Voltage
MMI	Multiple Mode Inverter
MSB	Main Switchboard
NEL	Net Export Limit
NER	National Electricity Rules
NEM	National Electricity Market
NMI	National Meter Identifier
NOC	SA Power Networks' Network Operations Centre

NPU	Network Protection Unit
OLTC	On-load Tap Changer
OTTS	Open Transition Transfer Switch
PCC	Point of Common Coupling
PLC	Programmable Logic Controller
PSS	Power System Stabiliser
PV	Photovoltaic
ROCOF	Rate of change of frequency
RTU	Remote Telemetry Unit (Also known as 'Remote Terminal Unit' or 'Remote Telecontrol Unit')
SCADA	Supervisory Control and Data Acquisition
SEG	Small Embedded Generation
SIR	Service & Installation Rules
SLD	Single Line Diagram
SVG	Static VAr Generator
SWER	Single Wire Earth Return
TNSP	Transmission Network Service Provider
UPS	Uninterruptible Power Supply
VDRT	Voltage Disturbance Ride Through
VT	Voltage Transformer

2.3 Terminology

may	Indicates a requirement that is not mandatory but can be imposed on the customer as deemed appropriate by SA Power Networks.
must	Indicates a mandatory requirement.
shall	Indicates a mandatory requirement.
should	Indicates a recommendation that will not be mandatory but can be imposed on the customer as deemed appropriate by SA Power Networks.
Suitable (or Suitably):	To the satisfaction of the relevant SA Power Networks Manager.

3. Relevant Rules, Regulations, Standards and Codes

3.1 Standards and Codes

The following listed documents are for additional information and other documentation may be required on a project specific basis. Please note: It is the responsibility of the customer to ensure you have complied with all applicable, SA Legislative Regulations (under Acts), ESCOSA/ENA/AEMC/IEC documentations, relevant AS/NZS standards, the SA Power Networks publications, and you have ensured their current publications, before implementing them.

Standards Australia Publications:

AS 1319	1994	Safety Signs for the Occupational Environment
AS 1359.0	1998	Rotating Electrical Machines - General Requirements Part 0: Introduction and list of parts
AS/NZS 1768	2007	Lightning protection
AS 1824.1	1995	Insulation co-ordination - Definitions, principles, and rules
AS 1931.1	1996	High voltage - Test techniques - General definition and test requirements
AS 2067	2016	Substations and high voltage installations exceeding 1 kV ac
AS 2467	2008	Maintenance of Electrical Switchgear
AS/NZS 3000	2018	Electrical Installations (known as the wiring rules)
AS/NZS 3010	2017	Electrical Installations - Generating sets
AS 3011.1	2019	Electrical Installations – Secondary batteries installed in buildings Vented cells
AS 3011.2	2019	Electrical Installations – Secondary batteries installed in buildings Sealed cells
AS/NZS 3017	2007	Electrical installations - Testing User Guides
AS/NZS 3100	2017	Approval and test specification - General requirements for electrical equipment
AS/NZS 3835.1	2006	Earth Potential Rise - Protection of Telecommunications Network Users, Personnel and Plant - Code of practice
AS/NZS 3835.2	2006	Earth Potential Rise - Protection of Telecommunications Network Users, Personnel and Plant - Application guide
AS/NZS 3947.6.1	2001	Low-voltage switchgear and control gear - Multiple Function equipment - Automatic transfer switching equipment
AS/NZS 4777.1	2016	Grid connection of energy systems via inverters - Installation requirements
AS/NZS 4777.2	2020	Grid connection of energy systems via inverters - Inverter requirements
AS/NZS 5033	2014	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 5139	2019	Electrical Installations - Safety of Battery Systems for Use with Power Conversion Equipment
AS 60034.1	2009	Rotating Electrical Machines – Rating and Performance
AS 60038	2012	Standard voltages
AS 60068.1	2003	Environmental testing - General and Guidance
AS 60434.22	2010	Rotating Electrical Machines – AC Generators for Reciprocating Internal Combustion (RIC) Engine Driven Generating Sets
AS 60529	2004	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS 61000.1.1	2016	Electromagnetic compatibility (EMC) - General - Application and interpretation of fundamental definitions and terms
AS/NZS IEC 62116	2020	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures

IEC

IEC 60255-12	1980	Electrical Relays – Directional relays and power relays with two input energizing quantities
IEC 60255-26	2013	Electrical relays – Part 26: Electromagnetic compatibility requirements
IEC 60255-27	2013	Measuring relays and protection equipment – Part 27: Product safety requirements
IEC 60255-127	2010	Measuring relays and protection equipment – Part 127: Functional requirements for over/under voltage protection
IEC 61727	2004	Photovoltaic (PV) systems – Characteristics of the utility interface
IEC 62109-1	2010	Safety of power converters for use in photovoltaic power systems Part 1: General requirements
IEC 62109-2	2011	Safety of power converters for use in photovoltaic power systems Part 2: Particular requirements for inverters
IEC 62109-3	2020	Safety of power converters for use in photovoltaic power systems Part 3: Particular requirements for electronic devices in combination with photovoltaic elements

ENA:

ENA DOC-041	2019	Technical Guidelines for Medium Voltage and High Voltage EG Connections

SA Power Networks Documents:

- Manual 18: SA Power Networks Connections and Ancillary Network Services
- Manual 32: Service & Installation Rules

- Technical Standards & NICC Brochures, in particular:
  - NICC 270: Connection Requirements of Large Embedded Generation
  - TS 129: Low Voltage EG Connection not exceeding 30kVA
  - TS 132: Low Voltage EG Connection Technical requirements – Capacity above 30kVA
  - TS132 F1: Medium Embedded Generation Commissioning Witnessing Plan Checklist
  - TS132 F2: Large Embedded Generation Commissioning Witnessing Plan Template and Checklist
  - TS 134: Communication Systems (inc. SCADA) for Embedded Generation

3.2 Legislation and Regulations

This section provides a list of the relevant legislation and regulations which shall apply to the design, manufacture, installation, testing and commissioning, and operations and maintenance of all plant and equipment for HV EG connections to the distribution network.

In an event where there is any inconsistency between legislation and regulations and these technical requirements, the legislation and regulations shall prevail.

- Electricity Act 1996 (SA)
- Electricity (General) Regulations 2012
- National Electricity Rules (NER)
- Electricity Distribution Code (ESCOSA)
- Work Health and Safety Act 2012
- Work Health and Safety Regulations 2012

4. Technical Requirements

This section specifies the technical requirements for HV EG systems for both inverter energy systems (IES) and non-inverter energy systems.

All references to, and requirements of, IES within this document, assumes the principles outlined within AS/NZS 4777 will be met. Any inverter not compliant with AS/NZS 4777 and AS/NZS IEC 62116 will be required to demonstrate compliance with these principles as part of their commissioning and witnessing tests as well as providing certification or documentation from the manufacturer as evidence at the request and satisfaction of SA Power Networks.

4.1 Labelling and Signage

The installer of the EG system shall supply and install appropriate signage in accordance with the requirements outlined in SA Power Networks' Service & installation Rules (SIR).

Protection systems shall be clearly labelled as stated in the SIR.

4.2 Maximum System Capacity

The maximum generating system capacity shall be verified by SA Power Networks at the time of assessment.

The standard HV connections are to SA Power Networks' 11, 33 and 66 KV distribution networks. Dedicated feeders may be required depending on the proposed capacity being installed and on any network constraints. SA Power Networks aggregates clusters of generating units on the same title or adjacent titles of land when they are owned or operated by customers that share an interest in the other generator, and / or the land, regardless of the number of NMIs or connection points. The technical requirements within this document apply to the total generating system's combined nameplate rating of all aggregated generating units.

It should be acknowledged that there can be significant variation in network characteristics, plant thermal ratings, customer loads depending on location and connection at different voltage levels, and as such an accurate assignment of transfer capacity cannot be made without undertaking the appropriate network studies or calculations.

SA Power Networks does not permit connection of single-phase EG systems to the HV distribution network above the thresholds specified in TS129.

4.3 Generation Control

4.3.1 Export Limits at Connection Point

The EG system's transfer capacity to the distribution network will depend on many factors including:

- the network connection voltage;
- thermal and fault rating of network plant and equipment;
- characteristics of the network plant and equipment;
- proximity and capacity of adjoining loads and generating systems;
- the configuration and status of upstream distribution network assets; and
- generation capacity and characteristics.

The customer must provide a control system with appropriate metering at the connection point to ensure the export limit for the site is not breached.

The connection point's dynamic net export limit is to be interpreted as a 'soft' limit that will cause the IES or non-IES to reduce its output, preventing ongoing export greater than the limit to suit the network conditions.

The export limit is to be interpreted by the customer as a maximum. The ability of the customer's EG system to export at the export limit is not guaranteed.

Depending on the capacity of the EG system, dynamic stability studies may be required to assess grid stability issues and identify the maximum generation capacity that can be dispatched under normal and contingency operating conditions.

Additional control systems may be required to support the management of EG system dispatch under contingency operating conditions.

The sudden disconnection of EG system capacity should not produce network voltage changes that adversely impact on other network users and must be below levels specified under the NER or by SA Power Networks.

4.3.2 Site Generation Limit Downstream of Connection Point

The site generation limit is considered to be the sum of the nameplate rating of all generators on site. This limit will be assessed by SA Power Networks at the time of the application and stipulated in the Engineering Report. Factors that are considered include:

- Market operations
- Existing asset ratings
- Existing power quality at the relevant network location
- Existing demand at peak generation
- Existing and forecast DER penetration at the relevant network location.

4.4 Inverter Energy Systems

1. IES EG units connected at SA Power Networks' HV network should comprise of inverters that are:
   (a) If used in solar PV systems: type tested and certified as being complaint with an accreditation number of suitability as evidence of compliance to IEC 62116 for anti-islanding protection
2. IES EG units shall comprise of inverters that have the following inverter power quality response modes available:
   (a) Reactive power control mode
   (b) Central control mode
   (c) Volt response modes (ie volt-var and volt-watt)
   (d) Fixed power factor or reactive power mode
   (e) Power rate limit (ie ramp rate control)
3. IES EG units generating at LV should comprise of inverters that are:
   (a) If used in solar PV systems: type tested and certified as being complaint with an accreditation number of suitability as evidence of compliance to AS/NZS IEC 62116 for anti-islanding protection
   (b) Tested by an authorised testing laboratory and certified as being complaint, with an accreditation number of suitability as evidence of compliance to AS/NZS 4777.2
   (c) Registered with CEC as approved grid connect inverters
   (d) Installed in compliance to AS/NZS 4777.1

4.5 Energy Storage System

Energy storage systems shall comply with the requirements specified within SA Power Networks' technical standards and Service and Installation Rules.

Inverter connected energy storage systems which operate in parallel with the network shall use 'Multiple Mode Inverters' (MMI) that satisfy the requirements as prescribed in AS/NZS 4777.2. Inverters with battery storage ports are considered as MMI.

When an energy storage system has the ability to charge from the network, the proposed system may be subject to limits on the time and/or rate at which it may charge, and a constraint may also be applied on the amount and/or rate of energy discharged back into the network.

SA Power Networks will indicate those times when an energy storage system may or may not connect to and operate in parallel with the network through demand availability signalling. The demand availability signalling scheme is in addition to permissive signalling.

4.6 Reactive and Active Power Control

4.6.1 Reactive Power Control

Without suitable controls, the connection of EG systems to the distribution network may adversely impact SA Power Networks' ability to satisfactorily regulate network voltages. For this reason, SA Power Networks requires EG systems to control reactive power output, within their capability, to maintain the connection point voltage to an agreed target or operate at an agreed power factor at the connection point such that voltage variations are maintained within prescribed limits.

All generating systems which require SCADA as per Section 4.13 shall be fitted with power factor controls to automatically control reactive power absorption or output to assigned levels. SA Power Networks will have the ability to issue a power factor setpoint signal to the EG systems via a SCADA control interface and the sent-out generation reactive capacity must not deviate from this setpoint value.

The EG system may require additional sources of reactive power (eg STATCOMs, SVGs, reactors) or network augmentations to regulate network voltages within acceptable limits.

The final operating reactive power requirements for the EG system will be identified by the site-specific network studies and included within the engineering report.

4.6.1.1 Reactive Power where Generators are also Customers

Where a proposed generating system is connected to a connection point that also supplies electrical load, the reactive power requirements at the connection point will be a combination of the supply and generation requirements.

4.6.2 Active Power Control

To ensure control over the active power "in feed" to the distribution network, adequate control must be provided over the governor or primary energy source.

All generating systems which requires SCADA as per Section 4.13 will be fitted with 'Generation Dispatch Limit' (GDL) and if applicable 'Net Export Limit' (NEL) controls to automatically control active power output to the network as seen at the generating unit terminals and connection point respectively to assigned levels and maintain security and reliability of other customers' supply. SA Power Networks will issue a maximum GDL / NEL signal to the EG system via a SCADA control interface and the output of the generating system must be managed by the customer's system such that the active power exported to the network does not exceed this limit.

Notwithstanding the requirements to install an operational GDL/NEL control scheme, any generating system connected to SA Power Networks' network shall have the capability of ramping active power output at an agreed rate in response to an external signal.

Depending on the network connection location, SA Power Networks may also place restrictions on the ramping of active power production to support the management of network voltages and detailed studies may be required assess the impact of dispatch with existing generation capacity.

4.7 Network Connection and Isolation

A network isolation device shall be installed in accordance with the requirement prescribed in SA Power Networks' SIR.

4.7.1 Back-up Supply Including Generators

Behind the meter IES or non-IES that are arranged to provide back-up supply only in the event of a loss of supply from the network may use a closed transition transfer switch (CTTS) to transfer supply from the network connection to these back-up generators and vice-versa upon restoration of grid supply. The CTTS installation shall be in accordance with the requirements stated in the SIR.

An EG system that is connected via a compliant CTTS may be installed without the need for SA Power Networks to undertake a detailed network investigation or enter into a connection agreement for that generating system, however, they will be subject to inspection by SA Power Networks to ensure compliance with these requirements.

4.8 Earthing

The HV EG earthing shall be in compliance with the SIR in addition to the requirements specified in AS 2067, AS/NZS 3010, AS 3011 and AS 5139.

4.9 Protection

The protection scheme shall be designed in accordance with the applicable regulations and this standard which require a protection system that detects all credible fault types.

All protection equipment must comply with IEC60255.

For all appropriate protection settings, the customer shall ensure that, the provisions of NER clause S5.2.2 – Application of Settings and the ESCOSA license requirements are complied with as appropriate, including seeking approval from SA Power Networks (and if required AEMO) of any settings applied or proposed to be altered.

Protection design at the connection point shall be capable of achieving reliable discrimination of faults within the generating system installation and those on the network.

If required, the customer must provide adequate protection CTs cores for protection systems and VT reference signals as required and specified by SA Power Networks. These must not be installed in sealed CT chambers.

All generating system protection systems shall be of fail-safe design such that affected generating units, or the entire generating system is disconnected from the network automatically should a protection element (and its backup system where applicable) fail.

Most of SA Power Networks' distribution lines and feeders are programmed for automatic re-closing within 1 to 5s after successful clearance of a line or feeder fault. Therefore, failure of the customer's equipment to rapidly disconnect during a SA Power Networks' loss of supply event may result in damage to the generating system's equipment or pose a health and safety risk to the public and SA Power Networks' personnel.

4.9.1 Inverter Integrated Protection

Inverter integrated protection shall comply with AS/NZS 4777.2 for all inverter generating at LV. Inverters connected at HV shall be compliant with the principles of AS/NZS 4777, unless agreed otherwise with SA Power Networks.

4.9.1.1 Passive Anti-islanding Voltage and Frequency Limits

Passive anti- islanding settings for inverters connected at LV shall be set in accordance with **Table 1**, unless superseded by a site-specific setting specified in the Engineering Report.

Table 1: LV Inverter Passive Anti-islanding Voltage & Frequency Limit Values

Protective Function	Protective Function limit	Trip Delay Time	Maximum Disconnection Time
Under voltage 2 (V < <)	70 V	1 s	2 s
Under voltage 1 (V <)	180 V	10 s	11 s
Over voltage 1 (V >)	265 V	1 s	2 s
Over voltage 2 (V > >)	275 V	-	0.2 s
Under frequency 1 (f<)	47 Hz	1 s	2 s
Over frequency 1 (f>)	52 Hz	-	0.2 s

Passive anti- islanding settings for inverters connected at HV shall be set in accordance with **Table 2**, unless superseded by a site-specific setting specified in the Engineering Report.

Table 2: Inverter Passive Anti-islanding Voltage as % & Frequency Limit Values

Protection Function	Protection Function limit	Trip Delay Time	Maximum Disconnection Time
Under Voltage 2 (V < <)	30% Nominal Voltage	1 s	2 s
Under Voltage 1 (V <)	78% Nominal Voltage	10 s	11 s
Over Voltage 1 (V >)	115% Nominal Voltage	1 s	2 s
Over Voltage 2 (V > >)	120% Nominal Voltage	-	0.2 s
Under frequency 1 (f <)	47Hz	1 s	2 s
Over frequency 1 (f >)	52Hz	-	0.2 s

Inverters must not connect or reconnect to the network unless the voltage and frequency of the network has been maintained for at least 60 seconds.

4.9.1.2 Active Anti-Islanding Protection

The inverter must include at least one method of active anti islanding protection, which will operate the disconnection device within two seconds.

4.9.1.3 Voltage Ride Through

All inverters must comply with under voltage ride-through requirements stated in the Electricity (General) Regulations 2012 designed to mitigate impacts on grid during disturbances.

4.9.2 Central Protection

Table 3 below indicates the central (back-up) protection requirements. The central protection for IES EG units is in addition to the inverter integrated protection.

Table 3: Generating System Protection Requirements

Protection Requirements	HV EG IES	HV EG non-IES
Passive anti-islanding: Under-voltage (27) and over-voltage (59) Under-frequency (81U) and over-frequency (81O) ROCOF (81R)	 ✓ ✓ ✓	 ✓ ✓ ✓
Overcurrent facility fault, grid fault and earth fault (50/51)	✓	✓
Directional power (32R) (32F)	-	-
Synchronisation facilities (25)	-	✓
Generator phase balance protection (47)	-	-
Generator pole slip	×	✓
Inter-trip	-	✓[1]
DC system or UPS integration protection	✓	✓
Fail-safe tripping	✓	✓
Interlocking	-	-
Grid Isolation device	✓	✓

Symbols are used to denote protection requirements, where:

✓ Represents that the protection shall be required.

- Represents that the protection may be required.

× Represents that the protection shall not be required.

Note 1: Inter-trip is not required for non-exporting HV EG non-IES

Anti-islanding protection schemes are required to operate within the reclose time of the applicable SA Power Networks' protection device to protect the generating system from damage. The anti-islanding protection settings must be designed to ensure generator fault ride through capability for remote network faults and reliable operation for islanding events. Anti-islanding protection must not trip for fault ride through events unless agreed otherwise with SA Power Networks.

Non-IES shall not be reconnected to the network after the restoration of the grid supply without verification that normal conditions have been restored and a permission signal is received from SA Power Network.

For IES, reconnection shall be in accordance with AS/NZS 4777.

4.9.2.1 Passive Anti-Islanding Protection

4.9.2.1.1 Voltage and frequency Limits – EG IES

Where the generating system uses inverters that have internal under/over voltage protection and under/over frequency, the inverter protection can be used as the main protection with a single back-up protection scheme.

Under/over frequency protection must be installed to ensure the generating system is disconnected from the network when the system frequency varies outside the nominated range. The frequency protection settings must be based on the customer's proposed distribution network connection arrangement and operating requirements.

Table 4 : EG IES Central Protection Voltage & Frequency Limit Values

Protection Function	SETTING	DELAY (SEC)
Over Voltage (V >)	115% Nominal Voltage	2.0
Over Voltage (V > >)	120% Nominal Voltage	0.2
Under Voltage (V <)	78% Nominal Voltage	11.0
Under Voltage (V <<)	30% Nominal Voltage	2.0
Sustained over-voltage	112% Nominal Voltage	-
Under Frequency (f <)	47 Hz	2.0
Over Frequency (f <)	52 Hz	2.0

4.9.2.1.2 Rate of change of frequency limits – EG IES

The inverter shall maintain continuous operation for frequency excursions with a rate of change of frequency (ROCOF) that do not exceed ± 4Hz/s for a duration of 250ms.

4.9.2.1.3 Voltage and frequency Limits – EG Non-IES

Under/Over voltage protection must be installed to monitor all three phases at the connection point. HV connected non -IES generating systems must disconnect from the network if the voltage (phase to earth) settings shown in **Table 5** are exceeded.

Table 5: EG Non-IES Central Protection Voltage & Frequency Limit Values

Protection Function	SETTING	DELAY (SEC)
Over Voltage (V >)	120% Nominal Voltage	2.0
Over Voltage (V > >)	125% Nominal Voltage	0.2
Under Voltage (V <)	80% Nominal Voltage	2.0
Under Voltage (V <<)	70% Nominal Voltage	0.4
Under Frequency (f <)	47 Hz	0.4
Over Frequency (f <)	52 Hz	0.4

4.9.2.1.4 Rate of change of frequency limits – EG Non-IES

The generating system shall maintain continuous operation for frequency excursions with a rate of change of frequency (ROCOF) that do not exceed ± 4Hz/s for a duration of 250ms.

4.9.2.2 Overcurrent Facility Fault, Overcurrent Grid Fault and Fault Protection

Over-current and earth fault protection must be installed at the connection point of the HV supplied site. This protection is used to detect faults within the customer's installation. Earth fault protection for LV connections is not required, however are strongly recommended.

The overcurrent and fault protection shall be in accordance with the requirements stipulate in the SIR.

Export generating systems requiring connection via a dedicated feeder or distribution line shall be fitted with protection systems provided by SA Power Networks. The customer shall make available space within their control room for the installation of SA Power Networks' relays and associated infrastructure.

4.9.2.3 Directional Power Protection

Directional power protection is required when the export of the generating system is to be limited to a certain value (including a minimum import) to ensure that the imported/exported power does not breach the agreed limit.

The directional protection scheme is in addition to other SA Power Networks' generating system network protection requirements. This directional power protection serves as a back-up in addition to control systems designed by the customer to limit export, eg PV cluster controllers. Export limiting is required where stipulated in the SA Power Networks' engineering report.

All generating systems with a maximum export limit may include directional power protection to detect and prevent the inadvertent exceeding of the agreed export limit to the network. Minimum import protection is also acceptable for inverter generating systems at sites with net zero export to the network.

Unless otherwise advised in the Engineering Report, two-stage directional power protection is to be implemented as per the following:

1. Inverter Generating Systems
    - Stage 1 = 100% agreed export limit with 120s delay; and
    - Stage 2 = the lower of the 120% agreed export limit or the nameplate rating of the generating system with 0.4s delay
2. Rotating Generating Systems
    - Stage 1 = 100% agreed export limit with 2s delay; and
    - Stage 2 = 150% agreed export limit with 0.4s delay
3. Hybrid Generating Systems
    - SA Power Networks will advise the required settings within the Engineering Report

If the customer's installation is unable to perform two stage directional power protection, the more sensitive requirement stages of 1 & 2 are to be implemented (ie. 100% with 0.4s delay).

The directional power protection must include three-phase power monitoring relays installed at the connection point, or other agreed location, and electrically disconnect the generating system upon operation. Whenever the power export threshold is breached within the time delay specified above, the generating system must be automatically disconnected from the network using a current-breaking device. The directional power protection circuit must be of fail-safe design.

When the generating system is transferring back to supply from the network following a blackout, the directional power protection must be enabled in less than 1.5 seconds after closing the main CB.

4.9.2.4 *Minimum Import Protection*

Unless an inter-trip protection scheme is installed, all zero-export rotating generating systems must include minimum import protection to detect an islanding event and to prevent the inadvertent export of electricity into the distribution network. Unless stipulated in the Engineering Report, the minimum import protection is to be implemented as follows:

1. Inverter Systems
   - Stage 1 = 10% of Agreed Maximum Demand with 120s delay; and
   - Stage 2 = 5% of Agreed Maximum Demand with 2s delay.
2. Rotating Systems
   - Stage 1 only = 10% Agreed Maximum Demand with 0.4s delay

4.9.2.5 *Seamless Transfer*

Where a customer proposes to utilise minimum import protection and plans to return to SA Power Networks' supply with a seamless or 'bumpless' transfer, special consideration must be given to the minimum import protection arrangement. The generating systems shall not be reconnected to the network after the restoration of the grid supply without verification that normal conditions have been restored and a permission signal is received from SA Power Network.

Under this scenario, and if determined feasible by SA Power Networks, the minimum import protection may be temporarily inhibited for a short duration to allow the seamless transfer of the customer's facility to SA Power Networks' supply.

This temporary inhibit will ensure the generating system is able to be unloaded to a level that ensures correct operation of the uninhibited minimum import protection scheme.

Where SA Power Networks has agreed to allow a temporary inhibit of the minimum import protection, directional power protection must be installed to detect and prevent islanding operation. The directional power protection must be set as low as practical, considering the protection relay, CT accuracy and generating system synchronisation characteristics. In this instance, such protection will be set at 5% of the agreed connection point capacity with a 1s delay. The design of control systems will need to minimise reverse power flow immediately following synchronisation.

4.9.2.6 *Synchronisation facilities*

The generating system must ensure it is synchronised with the network before connection to the network. If one or more phases of the network are lost, then the generating system must disconnect from the network. To prevent non-synchronised connections, auto-synchronising and synchronisation check closing protection shall be installed across all CB's that could be closed out of synchronisation.

4.9.2.7 *Generator pole slip*

All non-IES generating units must include pole slip protection that disconnects the generating unit.

4.9.2.8 *Inter-trip*

Inter-trip protection is required for non-IES EG systems that are exporting. It may also be required where the combined generation capacity represents a significant portion of the total area load, the implementation of a minimum import protection scheme is not feasible or where it's deemed necessary by SA Power Networks. The inter-trip scheme is in addition to other EG system protection requirements.

Where an inter-trip protection scheme has been deemed necessary, a communication link between the EG system and the relevant SA Power Networks' substation shall be provided at the customer's expense. Depending on the location and connection voltage, SA Power Networks may require diversity or duplication of these communications links.

The inter-trip protection scheme shall be installed so that the EG system is disconnected from the network when the distribution network is de-energised.

The inter-trip communication links must be continuously monitored for integrity. In the event of a loss of the inter-trip communications to SA Power Networks for more than 30 seconds or failure of the inter-trip protection, a 'permission denied' is to be carried out by the customer and a disconnection of the generating system from the Network is to be initiated by the Customer's PLC. SA Power Networks will not be responsible for any losses (direct or indirect) incurred by the customer.

It is the responsibility of the customer to trip the agreed circuit breaker/s within 0.4s of the inter-trip signal being sent.

The inter-trip signal from the interface panel to the agreed circuit breaker/s, including the communications link, must be of fail-safe design. Communications for protection signalling will be via a single set of either optic fibre or radio. The use of mobile phone networks for protection signalling communications will not be accepted.

The customer must also include tripping of the generating system if DC supply to the protection scheme is lost.

4.9.2.9 DC System or UPS Integration Protection

All protection systems installed as part of the EG system shall remain operational following a loss of mains supply from the network (eg have DC supplies (110 / 24V dc) of suitable capacity and survival time (24-hours)) whilst the EG system is connected to the network and be of fail-safe design.

The EG system must be automatically disconnected from the network in the event of a failure of the DC supply or 'Uninterrupted Power Supply' (UPS) to the protection and control systems. In the event that there is a loss of DC supply to the protection and control system the generating system shall not be reconnected to the network until all relevant protection and control systems are suitably powered and ready for operation.

Where the protection scheme for a EG system involves an inter-trip and line differential scheme signal from SA Power Networks, duplicate (ie Set 1 and Set 2) DC supplies must be provided irrespective of whether multiple communication links exist or not.

4.9.2.10 Fail-safe Tripping

The generating system is to automatically disconnect from the network in the event of the failure of any supplies or loss of communications to the protection equipment that would inhibit the correct operation of the protection equipment.

The customer must ensure that all the protection relays and control circuits remain operational in the event of circuit breaker failure or a of loss of supply from the network. The protection and control circuits must be a fail-safe design to ensure that the EG system is completely isolated upon loss of supply from the network and prior to depletion of any back-up systems (eg DC or UPS supply). Islanded system operation is not considered suitable in the event of a down-stream circuit breaker fail event.

The SCADA signal from the interface panel to the generating unit's circuit breakers, including the communications link, must be of fail-safe design.

4.9.2.11 Interlocking

Where customers are provided with alternative supplies from different sources within the network, these supplies shall be connected in such a way that they cannot be connected in parallel to ensure isolation between the relevant sources within the network. Refer to SA Power Networks' SIR for interlocking requirements.

4.9.2.12 Grid Isolation Device

Refer to SA Power Networks' SIR for grid isolation device (incoming circuit breaker) requirements.

4.9.3 Protection Relay

The protection relay(s) must be in compliance with IEC60255 and SA Power Networks' SIR. The protection relay(s) must operate a contact or circuit breaker independent of the generating system's in-built protection functions (eg inverter's automatic disconnection device) to disconnect (electrically isolate) the generating system from the network.

4.9.4 Runback Scheme

A runback scheme may be required on specific connections in certain location on the network.

EG system connections emanating from substations, transmission or sub-transmission connection points, substations which are experiencing a firm delivery reverse N-1 overload constraint will be subject to export limits by SA Power Networks to mitigate all overloads and impacts to the network. Where a credible network constraint has been identified, SA Power Networks will design the runback scheme based on network conditions and the customer will receive a signal to either ramp or disconnect, within an acceptable response time, until the network constraint has been lifted.

The cost of the required runback scheme and/or network augmentation shall be borne by the customer.

For more information on SA Power Networks substations and its constraints, please refer to the latest published SA Power Networks' Distribution Annual Planning Report.

4.9.5 Feeder/Line Protection

Where a generating system is required to be connected to the network via either a dedicated feeder (ie 11kV) or sub-transmission line (ie 33kV or 66kV), SA Power Networks will require this dedicated asset to be protected by SA Power Networks' protection systems which will be provided by SA Power Networks at the customer's expense. Refer to SA Power Networks SIR HV section for further details.

4.9.6 Protection Labelling and Security

Protection systems should be clearly labelled and must be tamperproof to prevent unscheduled or inadvertent changes of setting. The protection labelling and security shall be as described in the SIR.

4.10 Operating Voltage and Frequency

The HV EG system shall be designed and installed to maintain compliance with the following:

1. AS/NZS 4777.2 for IES EG units (where applicable)
2. AS/NZS 61000.3.7 and AS/NZS 61000.3.100 for non-IES EG

Under and over voltage limits, and under and over frequency limits are as per Section 1.1.1.

For LV IES where the inverter has a maximum voltage limit for sustained operations (based on averaged measurements over periods 10 minutes or less), this parameter must be set to 258V (phase to neutral).

The customer must ensure that at all times during the operation of the proposed generating unit(s), the voltage levels within the installation are compatible with the installed electrical equipment.

4.11 Revenue Metering

Revenue metering is subject to Chapter 7 'Metering' of the NER and SA Power Networks' Service and Installation Rules and is in addition to the SCADA and remote monitoring requirements outlined in this technical standard.

4.12 Power Quality

4.12.1 Quality of Supply

The generating system must not impact on the quality of supply to SA Power Networks' distribution networks and their network users/customers. The generating system must comply with all applicable requirements of the NER, ESCOSA's license conditions, AS/NZS 61000 series and SA Power Networks' SIR, including but not limited to:

- network voltage control;
- voltage fluctuations;
- Ramp rate
- harmonics; and
- voltage balance.

As part of any application to connect, SA Power Networks will undertake the required network studies to determine compliance or otherwise based on assigned power quality of supply limits. The results of the studies, and any associated operational constraints will be advised within the engineering report.

SA Power Networks' assessment and allocation of power quality limits for generating systems will be in accordance with the AS/NZS 61000 series. Subject to existing power quality limitations at the proposed network connection point, SA Power Networks will consider establishing negotiated access standards in accordance with NER.

It is the responsibility of the owner of the EG system to ensure ongoing compliance with their assigned power quality obligations and undertake appropriate tests as required.

Unscheduled or scheduled disconnection of EG system must not result in changes to customer supply voltages (at the end of feeders) in excess of those defined in the NER and EDC technical requirements. Detailed studies may be required to identify the extent of customer voltage variations following tripping of an EG system.

The operation of an EG system must not cause any cycling of network protection or control systems. This dispatch of EG system capacity must not result in a material increase in the number of transformers tap changer operations in the adjoining network.

4.12.1.1 Voltage Fluctuation and Flicker

The customer must ensure that voltage disturbances caused by the generating system, the overall electrical installation or by any appliances, do not result in voltage disturbances to other network users, greater than the limits prescribed in AS/NZS 61000, at the connection point.

4.12.1.2 Ramp Rate

The voltage changes from various loading / unloading rates and its resulting impact on the network voltage control systems form part of SA Power Networks' feasibility assessment. To ensure that there is no adverse impact on the network voltage control systems, the maximum allowable rate at which the generating units can be loaded and unloaded shall not exceed the following limits:

- Any inverter generating unit – 16.67% of rated power per minute, as per AS/NZS 4777.2 unless advised otherwise in engineering report
- Any rotating generating unit – typically maximum of 1,000kW per minute unless advised otherwise in engineering report

In addition, when carrying a controlled shut down of any generating system, the load on the generating system should be reduced to a minimum before opening any of the generating unit's circuit breakers.

All inverters shall have 'Soft Ramp Up after Connect or Reconnect Mode' as specified in AS/NZS 4777.2.

Compliance with these requirements must be able to be demonstrated and confirmed by commissioning tests.

4.12.1.3 Harmonics

The customer must ensure that the permissible harmonic limits associated with the electrical installation meets the requirements stated the S&IR.

4.12.1.4 Voltage Unbalance

The voltage unbalance at the point of common coupling caused by the customer's electrical installation shall operate within the limits prescribed in **Table 6**.

If voltage unbalance protection is required (i.e. non-IES systems), the protection settings shall be coordinated with and trip the generating units for voltage unbalance conditions greater than or equal to the values show.

Table 6: Generating System Voltage Unbalance Requirements

VOLTAGE UNBALANCE FACTOR (%) FOR THREE PHASE SUPPLIES	
Time Period	**Voltage Unbalance Factor (%)**
	HV Connection Point
30 minutes average	1.3
10 minutes average	2.0
1 minute average	2.5

4.12.2 Power Quality Response

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

a) Activating in-built power quality responses where the capabilities exist, or;
b) A central control mode via a master/slave system.

For LV EG IES, unless the generating system is required to operate in fixed power factor control at the connection point, the customer must ensure the South Australian power quality response modes have been set in the inverters as per Table 7 and Table 8 below and must not be changed without written approval from SA Power Networks.

Generating systems required to operate in fixed power factor control at the connection point are only required to enable Volt-Watt response mode.

Table 7 : Mandatory Volt-VAr Repose Mode for AS/NZS 4777 Compliant Inverters

Reference	Voltage (eg 230/400V)	VAr % Rated VA
V_1	90% Nominal Voltage (207V)	44% leading (sourcing Vars, 3.4%/V)
V_2	96% Nominal Voltage (220V)	0
V_3	104% Nominal Voltage (240V)	0
V_4	112% Nominal Voltage (258V)	60% lagging (sinking Vars, 3.3%/V)

Table 8 : Mandatory Volt-Watt Response Mode for AS/NZS 4777 Compliant Inverters

Reference	Voltage (eg 230/400V)	W % Rated VA
V_1	110% Nominal Voltage (253V)	100%
V_2	113% Nominal Voltage (260V)	20% (11.4%/V)

All HV EG systems shall have power quality response modes enabled. The specific power quality response mode will be determined based on the outcome of the technical study, and will be either:

a) Voltage control mode; or
b) Fixed power factor mode.

Whilst generating electricity and connected to the network, the customer must maintain at the connection point a power factor as specified in the Engineering Report which may be varied from time to time by SA Power Networks to suit ongoing network requirements, taking into consideration the technical and reasonable limitations of the generating system.

A satisfactory voltage profile must be maintained whilst the generating system is operated and connected to the network, with no delay between generation kW change and inverter VAr change to maintain power factor. The customer must be able to demonstrate that the proposed generating system can and will comply with this requirement and the results must be confirmed by commissioning tests and long-term monitoring.

4.12.2.1 Additional Reactive Plant

Appropriately sized reactive plant, such as reactor banks or SVG, that may be required to mitigate any unacceptable voltage issues along the feeder arising from the generating system is considered to form part of the generating system.

The reactive plant must be set and operate to constant power factor control mode to maintain the specified power factor set point at the connection point.

Any capacitive power factor correction units are to be isolated when the generating system is net exporting unless specifically advised by the customer to be utilised as reactive power support and deemed suitable for application by SA Power Networks.

The customer's control system must be capable of disconnecting reactive plant following a loss of mains supply from SA Power Networks. Failure to isolate reactive plant could result in voltages which prevent the generating system from reconnecting upon restoration of supply from SA Power Networks.

For any protection trips or control commands that either isolate or limit generation output, the reactive plant must respond instantaneously, either by switching off or adjusting reactive load to maintain the specified power factor. This includes instantaneously responding to any constant or passing cloud cover that impacts on PV output.

For any planned or unplanned outages of the reactive plant, the generating system must not operate until the reactive plant is back in service, unless explicitly detailed in the Engineering Report. This failsafe is to be demonstrated during system commissioning.

The customer is to appropriately develop dead bands or hysteresis for the reactive plant operating thresholds to prevent frequent voltage changes due to the combination of generation intermittency.

4.13 Communication Systems

Remote monitoring and control will be required in cases where the combined generation capacity represents a significant portion of the total area load (typically export of 200kW or more), or a credible network constraint has been identified or where deemed necessary by SA Power Networks.

The communication system, including SCADA, shall be in compliance with *TS134 – Communication Systems (inc SCADA) for Embedded Generation.*

4.14 Data and information

4.14.1 Static Data and Information

Static data requirements are outlined in Appendix D .

4.14.2 Real Time Data and Information

Real time data shall be sent to SA Power Networks as outlined in Section 4.13 Communication Systems.

4.15 Cybersecurity

Cybersecurity requirements are outlined in SA Power Networks' document TS207 - Operational Technology Cybersecurity Standard which can be supplied on request.

4.16 Technical Studies

4.16.1 Modelling Data

4.16.1.1 Generating Systems 5MW and Above

Generating systems with a nameplate rating of 5MW and above will be required to provide SA Power Networks with modelling data in accordance with the NER to support system studies and the assessment of power quality and security of supply.

For generating systems with a nameplate rating of ≥ 5MW, SA Power Networks will perform a preliminary system strength impact assessment in accordance with Clause 5.3.4B of the NER to determine whether a full impact assessment needs to be conducted.

Where this preliminary assessment determines that a full impact assessment is required, the customer will be required to provide SA Power Networks with an Electro-Magnetic Transient (EMT) model (ie PSCAD model) of their proposed generating system in accordance with AEMO’s Power System Model Guidelines.

For asynchronous generating systems with a nameplate rating ≥ 5MW, both steady state and dynamic root mean square (RMS) models (ie PSS/E) in accordance with AEMO’s model guidelines will be required.

For generating systems containing purely synchronous generating units with a combined nameplate rating of ≥ 5MW, the customer is to provide to SA Power Networks, RMS steady state and dynamic model representations of the generating system (ie PSS/E models) for feasibility assessment.

For hybrid generating systems containing both asynchronous and synchronous generating units, the customer is to provide to SA Power Networks, RMS steady state and dynamic model representations of the generating system (ie PSS/E models) for feasibility assessment.

For BESS systems with a nameplate rating of ≥ 5MW, both EMT and RMS steady state and dynamic models of the generating system will be required, and the customer will be required to register as both a market scheduled generator and a market customer as per AEMO’s Generator Exemption and Classifications Guide.

The principles above will apply in most cases; however, SA Power Networks reserves the right to request dynamic RMS and / or EMT models of the generating system where deemed necessary (eg if connecting to a meshed 66kV network) to ensure system security and generator performance.

Generating systems connecting under Chapter 5 of the NER are required to lodge an application to connect as per the requirements in AEMO's Generator Connection Application Checklist, together with the necessary models and simulations. The customer's proposed Generator Performance Standards (GPS) will be assessed in accordance with Clause 5.3.4A of the NER and formally agreed with both SA Power Networks and AEMO prior to proceeding to pre-connection (R1) stage. The R1 model package must be submitted to SA Power Networks and AEMO at least 3 months prior to the commencement of any commissioning.

The customer may also be required to complete post commissioning tests to validate their pre-connection (R1) generator models in accordance with the AEMO’s Power System Model Guidelines. Any subsequent model representations post commissioning are referred to as R2 models. R2 models must be submitted to AEMO within 3 months of completion of any commissioning tests.

Where a variance in performance between the R1 and R2 models is deemed by SA Power Networks and / or AEMO to be significant, the previously completed network studies may need to be re-performed and the GPS renegotiated prior to granting final connection approval. Any costs associated with the re-performance of studies, GPS renegotiation etc. will be borne by the customer.

Table 9: Typical Modelling Requirements

Requirement	Generating System Size (Nameplate) (MW/MVA)[1,4]		
	<1MVA	≥1MVA & 5MVA	≥5MVA
AEMO Power System Design and Setting Data Sheets	Not Required	Not Required[3]	S, D, R1 & R2[2]
EMT Model (tuned & site-specific)	Not Required	Not Required[3]	Required
Steady State RMS Model	Not Required	Required	Required
Dynamic RMS Model	Not Required	Not Required[3]	Required[4]
Releasable User Guide	Not Required	Not Required[3]	Required[4]
Model Source Code	Not Required	Not Required[3]	Required[4]
R2 Testing & Models	Not Required	Not Required[3]	Required[4]

Notes:

1. For IES, MW ratings shall be taken at unity power factor (ie MW = MVA nameplate rating)
2. Letters specified refer to data categories within AEMO's Power System Design & Settings Data Sheets. S = Standard Planning Data, D = Detailed Planning Data, R1 = Pre-connection Registered Data, R2 = Post-connection Registered Data.
3. Modelling requirements may differ depending on the customer's intended registration category and their intention to participate in ancillary services market such as system restart and frequency control.
4. Modelling requirement may differ depending on the proposed export limit, as well as customer's site locality (such as system strength, fault levels, % penetration)

The data/models provided to SA Power Networks must be compliant with the software versions specified by SA Power Networks and/or AEMO.

Copies of AEMO's generating system modelling guidelines, data sheets, templates etc are available from AEMO website (www.aemo.com.au) and refer to AEMO publication titled "Data and Model Requirements for generating systems of less than 30 MW", Table 2.

4.16.1.2 Generating Systems Less than 5MW

SA Power Networks' minimum information requirements for customers proposing to connect generating systems with installed nameplate rating under 5MW are listed in our application to connect forms, available from our website. SA Power Networks reserves the right however, to request any additional information deemed reasonably necessary to perform the required network assessment (eg simplified and protection single line diagrams).

Depending on the proposed installed capacity, proximity to other generating systems and network connection location, generating systems with a nameplate rating less than 5MW may require additional generating modelling data. In these circumstances, the model and data requirements will be as per AEMO requirements as summarised in **Table 9**.

Customers intending to participate in any form of ancillary service markets should seek firm advice from AEMO with respect to their intended market arrangement and registration categories which will determine the scope of the technical assessment and the connection process applicable for the proposal. Based on the intended registration category, the customer may be assessed under technical requirements of Schedule 5.2 of the NER and follow the Chapter 5 connection process where GPS studies must be conducted to satisfy technical requirements of SA Power Networks and AEMO.

Customers with generating systems less than 5MW may also be required by SA Power Networks to complete post commissioning tests (ie R2 tests) to confirm or calibrate their generator models and establish compliance with any agreed generator performance standards (GPS).

4.16.2 Fault Levels

4.16.2.1 Generating System Fault Level Contributions

EG systems may contribute to the fault levels of the distribution network beyond the safe operating level of SA Power Networks' and existing network users' equipment.

Fault level contributions from any proposed generator installation must be determined at the design stage and SA Power Networks can provide source impedance data to assist customers if required.

Depending on the network connection location and voltage, the EG system may need to select appropriate generator, step-up transformer, and grounding options to mitigate potential fault level issues. Alternatively, fault mitigation equipment approved by SA Power Networks may be utilised by the customer to reduce fault level contributions.

Any additional short circuit fault current sources are to be accurately defined and carefully managed. The customer will bear any costs that SA Power Networks may incur in respect of applying or reviewing or approving any fault level control mitigation measures.

4.16.2.2 Specific Requirements for Areas of Constraint

The distribution network has areas that are approaching the maximum safe fault level of both the customers' and SA Power Networks' existing HV equipment. Unless very significant modifications are made to these areas, no additional short circuit fault sources can be connected to these parts of the network, this includes any rotating EG unit.

However, with appropriate protection and control equipment, SA Power Networks may permit the installation of such generating units within this area where the:

1. EG units operate electrically islanded from the distribution network (and therefore do not contribute to the distribution network's short circuit fault current level). This includes generating units designed for island operation with momentary closed transition of the load between the distribution network and the EG unit and vice versa, in compliance with Section 4.7.1; or
2. EG systems designed to limit the fault contribution to the network to their full load current or near zero value. This may be achieved through the incorporation of:
   - (a) fault current limiting devices; or
   - (b) generating units connected via grid connected inverters, which limit the fault current contribution to their full load current or a near zero value.

It is important to note that these restrictions only apply to connections which impact the constrained areas of the 11kV distribution network.

4.16.2.3 SA Power Networks' Ultimate Network Fault Levels

Where the connection of any proposed generating system will cause the fault rating of any existing equipment to exceed the values stated in the SIR, augmentation may be required to raise the fault rating of SA Power Networks' equipment. Alternatively, the customer may elect to install fault current limiting equipment to enable connection of the proposed generating system to the network. The cost of either option will be borne by the customer.

4.16.3 Distribution Loss Factor (DLF)

Distribution Loss Factors (DLF) are used to describe the average energy losses for electricity transferred across different levels of a distribution network, between a distribution system connected generator and a transmission connection point for a given financial year. In effect, DLFs are a proxy for distribution energy losses at different levels of the network and their values are recalculated each year to reflect changes in:

1. customer load;
2. connected generation capacity;
3. generation dispatch patterns; and
4. network configuration.

DLFs are used in the settlement process for customer and will impact on the revenue received from generation dispatch. It is important that customer consider the economic impact of DLF assignment and potential for their value to change (either due to themselves or others) on their project economics.

For EG systems with a nameplate rating greater than 10MW, SA Power Networks are required to calculate the applicable site specific DLF as part of the application to connect. For all other generating systems, SA Power Networks will, on request from the customer and at the customer's expense, calculate the applicable site specific DLF in line with Clause 3.6.3 of the NER.

Where a customer requests the calculation of a site specific DLF under Clause 3.6.3 of the NER, SA Power Networks is obliged to apply this DLF irrespective of whether the value calculated is to the benefit or detriment of the customer.

Each year, SA Power Networks reviews and where necessary re-calculates its DLFs for applicable EG systems in line with clause 3.6.3 of the NER and provides this to AEMO for publication on the AEMO website (www.aemo.com.au).

4.16.4 Fault Ride Through Capability

The ability of an EG system to ride through selected network faults will be a requirement for network connection depending on the location and capacity of the EG system.

While it is possible that tripping of a single generating unit due to a system fault may not cause material impact on local customer supply, SA Power Networks may need to consider the potential for "cascade" or "co-incident" tripping of multiple EG units following a network fault and evaluate their combined impact on system security and reliability of supply to customers.

The above concerns are captured under NER clause S5.2.5.5 - Generating system response to disturbances following contingency events.

SA Power Networks may need to evaluate the impact of both transmission and distribution faults on generating system performance. Depending on the outcome of these studies, EG systems may be required to ensure fault ride through capability in accordance with the NER and ESCOSA's license conditions.

4.16.5 Insulation Co-ordination

The customer must ensure that the insulation co-ordination requirements stipulated in SA Power Networks' SIR are met.

5. Fees and Charges

Fees and associated charges applicable to customers are documented in SA Power Networks' NICC270 and Connections & Ancillary Network Services (Manual No. 18).

6. Testing and Commissioning

The customer connecting to SA Power Networks' network has an obligation to permit and participate in the inspection, testing and commissioning of the generating system. These requirements are outlined under NER Chapter 5 Part C Clause 5.7 - Inspection and testing and Clause 5.8 - Commissioning and the customer should make themselves familiar with these requirements.

The SA Power Networks project completion stage is comprised of three distinct parts:

1. Pre-connection off-line testing - customer testing to ensure the generating system is ready for connection to the network - (Refer Section 6.3)
2. Compliance testing - customer testing to demonstrate that the facility complies with SA Power Networks' technical requirements - (Refer Section 6.4)
3. Post connection or on-line commissioning - customer testing to demonstrate the generating system performs as agreed - (Refer Section 6.5)

It should be noted that for those EG systems requiring AEMO registration, on-line testing will only be permitted following successful registration (based on R1 data and analysis) submission of a dispatch bid and the issuing of a dispatch approval instruction from AEMO. Generating Systems connecting under Chapter 5 of the NER will be required to perform additional R2 post-commissioning activities to prove compliance with the agreed GPS.

Customers required to be registered as market, scheduled generators should discuss registration requirements with AEMO directly and ensure market bidding arrangements are in place prior to the commencement of on-line testing.

6.1 SA Power Networks Site Visit Requirements

As part of the project's connection, SA Power Networks will attend site to witness the commissioning and compliance testing.

A HV connection compliance officer will attend the customer's site to verify the compliance to the Service & Installation Rules. During this visit, SA Power Networks' SCADA devices will be installed and connected to the installation.

Following verification to the SIR, SA Power Networks' representatives will attend the site to witness the commissioning of the generating system to verify operation and compliance of the protection and control schemes to the requirements of this standard and the Engineering Report.

SA Power Networks' typical site visit requirements are shown in **Table 10**.

Table 10: SA Power Networks Typical Site Visit Requirements for Inspection Testing and Witnessing

Testing and Witnessing Component
Site visit during generator's pre-connection testing (refer Note 1), if advised as required.
HV connection compliance to SIR, testing and connection and SCADA installation and connection
Generation compliance witnessing (refer Note 2)
Post connection commissioning (refer Note 2)
Where dynamic studies are involved, site visit will be required to confirm any R2 or model confirmation testing being undertaken (refer Note 1)

Notes:

1. Where dynamic studies are involved, the pre-connection testing may require SA Power Networks to engage a consultant to verify any off-line step response tests that are required.
2. For all large generating systems, the compliance testing and post connection commissioning may be done on the same day. For this to happen, the following must occur:
   (a) this must have been nominated in the commissioning plan submitted; and
   (b) the commissioning officer must be satisfied that the pre-connection testing was passed successfully.

SA Power Networks' attendance at site or any subsequent visits will be at the customer's cost.

For generating systems requiring AEMO registration, AEMO are also entitled to witness the performance of any testing and will require typically a minimum of one-month advance notice to attend site. Any costs associated with AEMO attending site will be borne by the customer.

6.2 Commissioning Plan Requirements

For generation systems with installed capacity above 500kVA, customers may need to submit a commissioning plan to SA Power Networks a minimum of 20 business days prior to the commencement of commissioning.

Requirements for the submission of a commissioning plan for generating systems below 500kVA may be required subject to SA Power Network's discretion.

SA Power Networks will review the nature and relative timing of EG system commissioning tests with respect to the impact on other customers, coordination with other network outages and advise accordingly.

The commissioning plan is to be divided into three (3) parts:

1. Part A: Pre-connection off-line testing
2. Part B: Compliance testing; and
3. Part C: On-line commissioning.

The customer's commissioning plan is to be of sufficient detail to allow SA Power Networks to understand the following:

1. what elements of the generating system are proposed to be tested
2. for each element that is being tested, the specific steps that the customer proposes to undertake/require testing this element
3. pass/ fail criteria for each test, including any settings/values that are to be verified; and
4. the proposed timeframe for testing and commissioning.

If the customer is required to complete post commissioning tests (R2) in accordance with the AEMO generating system Model Guidelines, a copy of the (R2) test plan should be included with the commissioning plan submitted to SA Power Networks one month prior to commencement of commissioning.

Where such testing is required, AEMO may also nominate to be present during the performance of such tests. Any costs incurred by SA Power Networks or AEMO in witnessing these tests will be at the customer's expense. Further information relating to AEMO's commissioning requirements can be found on their website.

6.3 Pre-Connection Offline Testing and Commissioning

Pre-connection off-line testing and commissioning is required to prove that the equipment that has been installed is operating correctly under test conditions. It also confirms the required functionality of each individual component prior to network connection and on-line testing and operation.

SA Power Networks is entitled to witness customer testing and commissioning of those parts of the generating system that may have direct impact on the network. This could include injection testing for incoming circuit breakers, earth grid testing or other generator control system testing.

Where dynamic studies are required, the pre-connection testing may require SA Power Networks to engage a consultant to verify any offline step response tests that are required, the cost of which will be borne by the customer.

6.3.1 Pre-Connection Commissioning Documentation

Pre-connection commissioning records for all tests undertaken must be kept by the customer.

SA Power Networks requires some of these commissioning records be submitted for review and acceptance. SA Power Networks will not attend site to complete the next phase of commissioning until the required documentation has been submitted.

The following commissioning documents must be submitted to SA Power Networks five clear business days prior to the date arranged with SA Power Networks to attend site. Documents showing compliance with all relevant Standards, including:

1. a copy of the Electrical Certificate of Compliance
2. for IES, a copy of the commissioning records in line with AS/NZS 5033
3. any other applicable off-line testing records, including HV and earthing systems as applicable)
4. protection test results (either type test results or injection test results as required)
5. written statement from a competent protection technician certifying that the system is installed as per engineering report and or connection offer and protection settings applied are as agreed by SA Power Networks
6. serial numbers of all generating units, protection, and control devices
7. for generating systems greater than 5MW, evidence of, or exemption from, registration with AEMO is required; and
8. for HV connected installations, confirmation from SA Power Networks' connection compliance officers that the installation has complied with the requirements of the Service & Installation Rules.

6.4 Compliance Testing

Prior to connection of the generating system to the network, SA Power Networks may inspect and where necessary, require the customer to test those parts of the generating system that may have a direct adverse effect on the distribution network should they fail to operate as intended.

Compliance testing shall be undertaken by suitably accredited parties having appropriate skills and competencies. All 'Injection Testing' should be performed by a competent protection technician. SA Power Networks' representatives witness the compliance tests undertaken by the customer or their representative in accordance with their approved commissioning plan. SA Power Networks is not responsible for directing, leading, or performing any of the required tests.

The extent of compliance testing will vary depending on the generation capacity and connection configuration, and will include a combination of:

a) Injection Testing:

Simulation of system events by applying test signals to protection and control systems and confirming the correct response of the generator unit control system; and

b) Controlled Testing:

Controlled testing of the protection and control systems by manipulating relevant settings and confirming the correct response of the generating system circuit breakers or isolation facilities.

Table 11 provides an indication of the compliance tests that may be required for given protection and control elements. Where tests are nominated as required by both injection testing and controlled testing, compliance can be undertaken based on either test method or a combination of both. Injection testing are only applicable to installations above 200kVA and/or if controlled testing could not be performed.

Please note that **Table 11** is intended as a guide only. The actual extent of pre-commissioning testing and commissioning will vary depending on the type, size and connection location of the EG system and will be advised in the engineering report or in response to the submitted commissioning plan for your project.

Table 11: Protection and Control Compliance Test Requirements

Compliance Requirement	EG IES		EG Non -IES	
	Injection Test	Controlled Test	Injection Test	Controlled Test
Inhibits / Interlocks	✗	✓	✗	✓
Under/ Over frequency	✓	✓	✓	✓
Under/ Over voltage	✓	✓	✓	✓
ROCOF/ Delta V	✓	✗	✓	✗
Voltage unbalance	✓	✓	✓	✓
Synchronisation	✗	✗	✗	✓
Pole slip	✗	✗	✓	✗
Inter-tripping	✗	✓ (See Note 2)	✗	✓
Circuit breaker fail	✓	✗	✗	✓
Minimum import (See Note 1)	✓	✓	✓	✓
Fault level interlocks	✗	✗	✓	✗

Symbols are used to denote testing and commissioning requirements, where:

✓ Represents that the testing and commissioning shall be required

✗ Represents that the testing and commissioning shall not be required

Notes:

1. Where minimum import testing is proposed through controlled testing this must occur when the site load is at or near the agreed maximum demand. Only applicable to non-export systems.
2. Inter-tripping will be required for exporting IES generating systems above 5MW and will involve a 'Controlled Testing'.

Any deficiencies detected during the compliance tests must be resolved before making the final network connection and a revised commissioning plan must be submitted. SA Power Networks will not connect an EG system that is unsatisfactory for reliable connection to the distribution network. Any additional site visits by SA Power Networks (and AEMO) to witness commissioning tests shall be at the expense of the customer.

6.5 Post Connection or On-line Commissioning

Post connection or on-line commissioning is required to confirm that the generating system performs as expected and that operation is consistent with the performance standards included in the connection offer or engineering report. The extent of post connection commissioning testing will vary depending on the type, size, and connection location of the proposed generating system.

Commissioning of the generating system whilst connected to the network must not commence until the protection scheme has been fully tested by a competent protection technician.

The customer of the EG system must keep a written record of all SA Power Networks' approved protection settings and test results. A copy of this record should be available at the connection point or as required by SA Power Networks and should not be altered without the prior written approval of SA Power Networks.

Post-commissioning tests are also required to confirm that the EG system performs as expected and that operation is consistent with the assigned performance standards in the connection offer or engineering report.

Table 12 provides an indication of the post connection on-line tests that may be required for given generating system.

Please note that **Table 12** is intended as a guide only. The actual extent of post connection on-line commissioning will vary depending on the type, size and connection location of the EG system and will be advised in the engineering report for your project. For generating systems to be registered with AEMO, reference should be made to AEMO's commissioning requirements.

Table 12: Indicative Post Connection On-line Test Requirements

Post-Commissioning	AS/NZS 4777 IES	Any Other Generating System
Synchronisation	×	✓
Ramp rate	✓	✓
Export limiting	✓	✓
SCADA analogues and readings (if applicable)	✓	✓
Set point controls	✓	✓
Generation dispatch limit	✓	✓
Power factor controller	✓	✓
Reactive power capability	✓	✓
Quality of supply	✓	✓
Permissive Signalling (if applicable)	✓	✓
Performance standards tests (See Note 1)	✓	✓
R2 or Model confirmation tests (See Note 1)	✓	✓

Symbols are used to denote testing and commissioning requirements, where:

✓ Represents that the testing and commissioning shall be required

× Represents that the testing and commissioning shall not be required

Notes:

1. R2 or model confirmation tests to be undertaken if requested by AEMO or SA Power Networks. This will require extensive testing to demonstrate the dynamic response of the generating system. Further information regarding this is available within AEMO's commissioning requirements and R2 Testing Guideline.

The customer must compile the commissioning test results in a commissioning report and submit this report to SA Power Networks for review within 20 business days of undertaking the tests. The commissioning report must confirm that all protection and control systems are functional, and their settings are consistent with information provided to and approved by SA Power Networks. If required, a report confirming compliance with the assigned Generator Performance Standards and R2 model report must also be provided. Any R2 model report should be submitted to AEMO within 3 months of commissioning of the generating system.

Any deficiencies detected during the post connection tests must be resolved in a timeframe to be agreed between the customer and SA Power Networks. SA Power Networks will not allow the ongoing connection of EG system that has demonstrated unsatisfactory performance testing in order to maintain the integrity of the distribution network. Such disconnection may be made by SA Power Networks via permissive signalling where available.

For sites registered with AEMO, any non-compliances must be reported to AEMO via SA Power Networks together with a rectification plan as soon as possible, using the non-conformance template available from the AEMO website. The NER requires that any such non-conformances are rectified with 6 months.

6.6 Post Connection Power Quality Monitoring

Post connection logging of the quality of electricity generated is required to be undertaken by the customer, using measurement instruments meeting the specifications listed below.

The minimum period that the logging equipment must be installed is seven days, and this should include a period of at least two days where the generating system is not operating. In cases where potential for power quality issues have been identified as part of the network studies, the logging period required may be greater than one week, and the time periods will be advised as part of the engineering report.

10-minute aggregated readings are required, and the complete power quality logging data is to be provided to SA Power Networks in Microsoft Excel (or .csv) format, as an accompaniment to the commissioning report. Please provide in the format below with an additional 50 columns per phase for the individual harmonics.

Timestamp	Voltage	Current	kW	kVAr	kVA	PF	Frequency	THDV%	Harmonic V% 1-50	Flicker Pst	Flicker Plt

Table 13 details the specifications for the power quality measurement instruments and event recording.

Table 13: Power Quality Measurement Requirements

Attribute	Relevant Standard or Specification
Methods for measurement and interpretation of results	AS/NZS 61000.4.30
Class of measurement	Class S
Voltage, Amps, Freq, Power Factor, kV, kVA, kVAR	AS/NZS 61000.4.30
Sample rate	AS/NZS 61000.4.7
Total harmonic distortion & harmonics[1]	AS/NZS 61000.4.7
Flicker (Pst and Plt)[2]	AS/NZS 61000.4.15 (10min Pst & 2hr Plt)
Voltage and current unbalance	AS/NZS 61000.4.30
High speed event recording	Voltage, current and transient trigger enabled
RMS and waveform snapshots	Enabled

Notes:

1 The customer contribution to the network must not exceed values as per standard and engineering report

2 Short term flicker value shall not exceed 1.0 and long-term flicker value shall not exceed 0.65 as per AS/NZS 61000

7. Operations and Maintenance

7.1 Joint Operating Protocols

Joint operating protocols are required for systems with SCADA to ensure coordinated management of the operation and dispatch of generation capacity. The joint operating protocols will be developed in conjunction with the customer.

The requirement for a joint operating protocol will be determined post acceptance of the connection offer for your project, however, in general the following types of generating system will require the development of a joint operating protocol:

1. export generating systems, excluding large IES generating system exporting 200kW or less;
2. SCADA controlled generating systems (ie permission granted/denied);
3. GDL/NEL and power factor set point controlled generating system; and
4. HV connected generating systems.

The principles within the joint operating protocol will include, but not be limited to:

1. the customer should inform SA Power Networks' NOC prior to the connection and disconnection of any generator to the network;
2. an authorised representative of the EG system must be available always when the generating plant is operating to receive communications and directions from the SA Power Networks' NOC so that emergencies can be addressed, and dispatch limits applied if required; and
3. the customer will ensure that appropriately trained operators are available as required, consistent with the operating protocol.

These protocols will be revised at regular intervals or as required considering any changes in system operating conditions, generation dispatch arrangements or contact detail changes. It is the responsibility of the customer to advise SA Power Networks should any contact details change and ensure the joint operation protocol is permanently up to date/valid.

7.2 Operating Procedures

The customer must develop its internal operating procedures to cover the initial connection to the network, pre-commissioning, and commissioning of the generating system as well as its ongoing operation and maintenance activities associated with the connection.

Prior to completion of the project, operational procedures must have been developed and adopted for the day-to-day operation of the installation. These procedures must complement the joint operating protocols to be developed. Similarly, visibility of the generating system must be available to SA Power Networks' NOC via SCADA.

The protocols and procedures shall set out the operating interfaces between SA Power Networks' NOC and the customer, having regard to the safe and efficient operation of the network in compliance with the NER and ESCOSA's Electricity Distribution Code.

The operating procedures will be designed to protect the network and to maximise the customer's access to and use of the network within the agreed limits. The operating procedures will need to include, amongst other things:

1. details of the operating procedures and nomenclature standards to be adopted in relation to the interface between SA Power Networks' NOC and the customer's generating system;
2. details of the procedures to be adopted by both parties in relation to the NOC oversight, monitoring, control, and operation of the network and generating system access;
3. contact details for both parties' authorised persons available on 24 hours, seven days a week basis;
4. permission to connect / denied procedures; and
5. HV and isolation switching procedures.

The operating procedures once developed, will need to consider the existing operating procedures used by SA Power Networks' NOC for the operation of the entire network.

The operating procedures must be considered as an active document in so far as the procedures may need to be reviewed and revised from time to time as both technology and circumstances require.

The onus of ensuring the operating conditions are up to date rests with the customer. If SA Power Networks attempts to contact the nominated contacts contained within the job and it is unable to do so, SA Power Networks reserves the right to issue a 'permission denied' signal or disconnect the generating system from the network without notice, to manage the network at any time.

7.2.1 Additional Operating Protocol Requirements for Inter-trip Interface Signals

When inter-trip interface signals are a requirement, SA Power Networks in consultation with the customer will develop and agree on the proposed operating protocols prior to commissioning of the generating system.

The operating protocols will generally address the following:

1. SA Power Networks / customer's asset interface definition;
2. SA Power Networks / customer's liaison responsibility and communication;
3. Both parties' obligations & operations under emergency and fault conditions;
4. HV switching procedures;
5. Maintenance and access arrangements; and
6. Plant capability and limitations.

SA Power Networks will provide to the customer its model operating protocols document for export generating systems for modification and submission by the customer.

7.3 Compliance Monitoring and Maintenance

The obligation of ensuring compliance with any generator performance standards resides with the customer and will require ongoing demonstration of compliance with SA Power Networks' requirements and appropriate standards and regulations under the National Electricity Rules.

The customer must adequately maintain the protection and control systems of the generating system and any other service provided by the customer in relation to the generating systems that impacts on the individual generating unit, its safety or operation, or the safety or operation of the distribution network.

The customer will ensure that the overall electrical installation and generating system is maintained in accordance with good electricity industry practice and will not create a hazard or cause interference with the SA Power Networks' network. The customer must arrange for periodic testing of the protection system to ensure it continues to function as designed and commissioned.

The customer must develop and submit to SA Power Networks a compliance monitoring program for review at least 5 business days prior to the date of commissioning and connection of the generating system to the network.

The compliance monitoring program shall include:

- Proposed methods and test procedures by which the Customer can demonstrate ongoing compliance of the Generating System with this Engineering Report; and
- Proposed periodic testing times to confirm ongoing compliance with each applicable requirement in the Engineering Report. The frequency of testing shall be once every three years, or after any internal disturbance event and any plant change at the Customer's site. This is subject to change upon review by SA Power Networks.

The customer will make available a copy of the agreed compliance monitoring program to SA Power Networks within three months of initial connection to the network and any resultant test results as and when required by the agreed compliance monitoring program. The cost of such compliance testing and maintenance shall be borne by the customer.

Failure to provide a compliance monitoring program, or adhere to its requirements, SA Power Networks reserves the right to issue a 'permission denied' signal preventing operation of the generating system until an appropriate program is in place. SA Power Networks will not be liable for any losses (direct or indirect) incurred by the customer in issuing any such permissive signalling.

7.3.1 Frequency of Testing

The compliance program must include the frequency and the testing methods at which the tests will be undertaken to prove ongoing compliance with the applicable performance standards or requirements in the engineering report. The customer will make available a copy of the agreed compliance monitoring program to SA Power Networks and resultant test results as and when required.

The actual frequency of testing should take into consideration all relevant factors including:

1. the technology of the plant;
2. experience with the particular generation technology;
3. manufacturer's advice with respect to maintenance of the particular generating unit/ model; and
4. the level of maintenance required to provide reasonable assurance of compliance.

For most performance standards or requirement in the engineering report, the tests undertaken shall include, but not limited to:

1. all protection systems (circuit breakers, relays, trip signals, generating system protection and DC supply);
2. reactive power capability;
3. active power control;
4. voltage and reactive power control;
5. quality of electricity generated;
6. response to disturbances (frequency, voltage, contingency events); and
7. power station auxiliary transformers/supplies; and fault level/current mitigation devices.

The minimum frequency of testing is:

1. Every 3 years;
2. After any plant change; and / or
3. After any disturbance (eg voltage or frequency) causing plant trip.

For communications equipment (comms links including backup), remote monitoring capability (SCADA) and UPS systems, the frequency of testing is:

1. Annually;
2. After any equipment change; and / or
3. After any disturbance event.

7.4 Notice of Alteration to Approved Installation

The generator/customer must not significantly alter, add, or replace components of the approved design or protection settings of the generation installation without the prior written consent of SA Power Networks. The approved design is to be the design of the plant as covered by the network studies and/or included within the connection contract. Where failure of an item of plant occurs, this may be replaced with a direct equivalent subject to approval from SA Power Networks.

SA Power Networks may reattend site to witness commissioning and compliance testing if

- the replacement of inverters accumulates to more than three (3) units;
- the replacement of inverters is equivalent to more than 10% of the IES; or
- any Network Protection Unit (NPU) has been replaced.

If at any time the generator wishes to propose an increase in the agreed nameplate rating of the generation installation, the generator must request the increase in writing to SA Power Networks.

Upon receipt of the written request, SA Power Networks will advise the generator if it is necessary for SA Power Networks to undertake a new network analysis (at the generator's cost) to ascertain the operational constraints of the generation installation with the proposed changes to the installation and/or protection settings.

Appendices

A. Deviations from the ENA's National DER Connection Guidelines

Table 14: Table of Deviations from National DER Connection Guidelines

Section	Description of deviation	Type of deviation	Justification
1	Term Medium voltage not used in document	Administrative	Term medium voltage not used in SAPN
1	Definition of MV/HV EG connection simplified	Administrative	To improve readability
2.3	Subcategories section not included.	Administrative	To improve readability
3	SAPN documents included	Administrative	Identification of documents applicable to SAPN
4.2	Addition of cluster requirements	Improvement	Network stability
4.3.2	Site generation limit defined	Administrative	Improve understanding
4.5	Addition of section 'Energy Storage Systems'	Improvement	SAPN requirement
4.6	Reactive and Active Power Control section added	Network Stability	SAPN requirement
4.7	Title changed from 'Network Isolation' to 'Network Connection and Isolation'	Administrative	Clearer title on section information
4.7.1	CTTS section added	Improvement	SAPN requirement
4.9.1	Inverter settings included	Improvement	To improve readability
4.9.1	Voltage Ride through added	Jurisdictional	Electricity (General) Regulations 2012
4.9.2	Title changed from 'Grid Reverse Power Protection or Grid Low Forward Power Protection' to 'Directional Power Protection'	Administrative	Clearer Title

Section	Description of deviation	Type of deviation	Justification
4.9.2	Minimum Import Protection section added	Administrative	To improve readability
4.9.2	Seamless Transfer section added	Administrative	To improve readability
4.9.6	Feeder/Line Protection section added	Improvement	SAPN requirement
4.9.7	Protection Labelling section added	Improvement	SAPN requirement
4.11	Title changed from 'Metering' to 'Revenue Metering'	Improvement	Clearer Title
4.13	Communication details included in separate document	Administrative	To improve readability

B. Typical HV Connection Arrangement

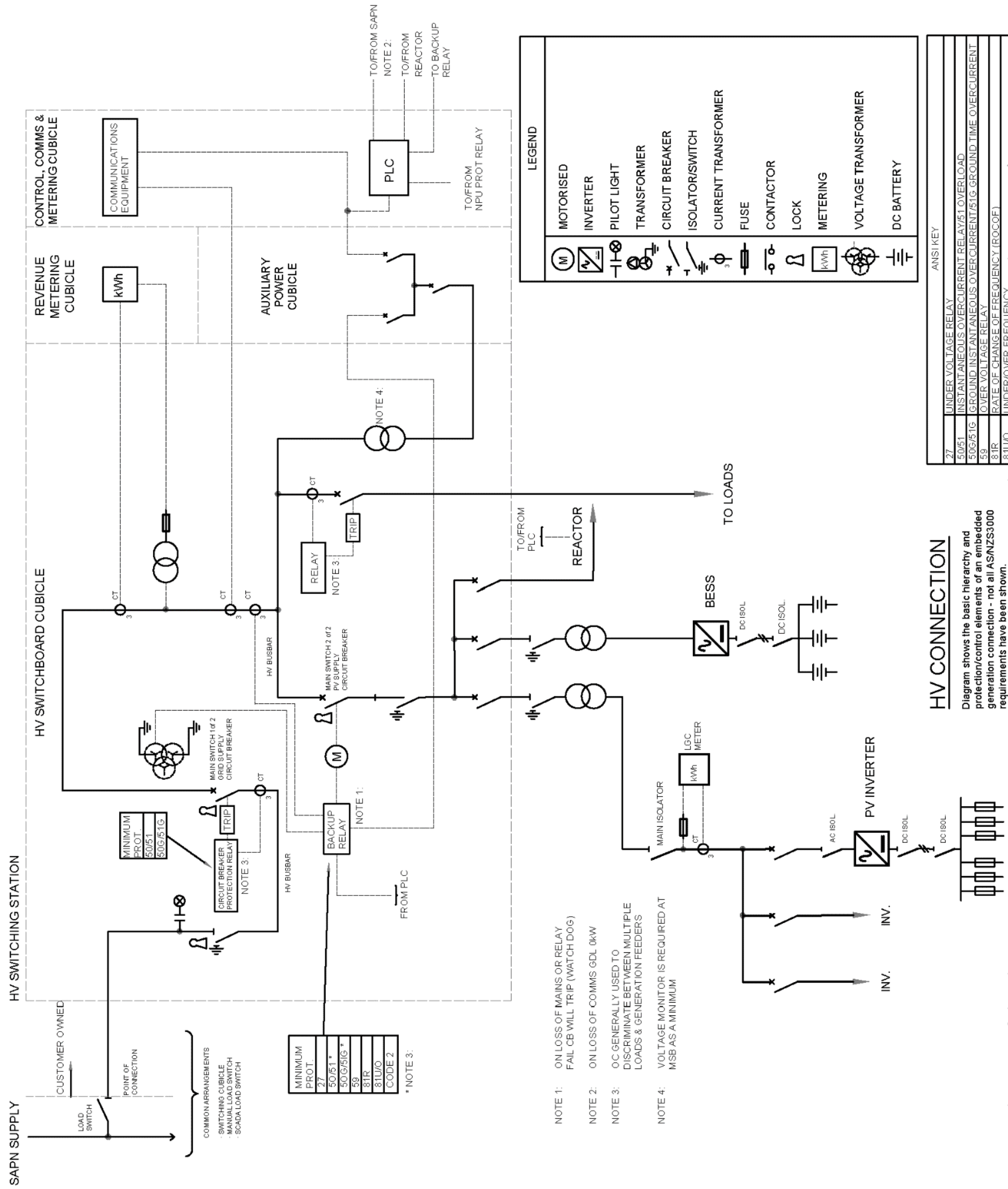

Figure 1: SLD Typical HV Connection

C. Model Connection Agreement

Details on the process of obtaining a model connection agreement is outlined in SA Power Networks' NICC270 - Connection of Large Embedded Generation.

D. Static Data and Information

Static data and information that is required to be provided by the customer to the DNSP as per the AEMO DER Register Information Guidelines, and as a minimum this includes the following categories of data:

1. DER Installation at a NMI in aggregate:
   - (a) NMI
   - (b) Approved capacity
   - (c) Installer identification
   - (d) Connection agreement 'Job number' (provided by SA Power Networks)
   - (e) Number of phases available
   - (f) Number of phases with DER installed
   - (g) Central protection and control
   - (h) Islandable installation
   - (i) Protection and control modes
2. AC grid connection of a DER installation:
   - (a) Number of AC connections
   - (b) AC equipment type
   - (c) Inverter/small generating unit manufacturer
   - (d) Inverter series
   - (e) Inverter model number
   - (f) Inverter serial number
   - (g) Commissioning date
   - (h) Status of inverter (active, inactive, or decommissioned)
   - (i) Inverter device capacity (kVA)
   - (j) What standards apply to the inverter
   - (k) Sustained overvoltage (V)
   - (l) Over-frequency (Hz)
   - (m) Under-frequency (Hz)
   - (n) Inverter – demand response enabled device interaction
   - (o) Inverter power quality response mode – Volt-Watt (where enabled)
   - (p) Inverter power quality response mode – Volt-VAr (where enabled)
   - (q) Inverter power quality response mode – reactive power mode (where enabled)
   - (r) Inverter power quality response mode – fixed power factor mode (where enabled)
   - (s) Inverter power quality response mode – power factor curve/power response mode (where enabled)
   - (t) Inverter power quality response mode – power rate limit mode (where enabled)
   - (u) Non-inverter generator – voltage/reactive power regulation
   - (v) Non-inverter generator ramp rate (where enabled)
   - (w) Non-inverter generator frequency response mode (where enabled)
   - (x) Protection and control modes (ie ROCOF, vector shift, inter-trip, neutral voltage displacement)
3. DER energy sources:
   - (a) Number of devices
   - (b) Manufacturer
   - (c) Model number
   - (d) Status
   - (e) Device type
   - (f) Nominal rated capacity (kVA)