Technical Standard - TS132

Low Voltage Embedded Generation Connection Technical Requirements – Capacity above 30kVA

Published: 12 May 2022

SA Power Networks

Empowering South Australia

Revision Notice:

Date	Details	Author	Authorised
6 May 2022	New document for LV EG above 30kVA. Supersedes TS130 & TS131	A. Lee	M. Napolitano

SA Power Networks:

SA Power Networks, ABN 13 332 330 749, a partnership of:

Spark Infrastructure SA (No.1) Pty Ltd, ABN 54 091 142 380
Spark Infrastructure SA (No.2) Pty Ltd, ABN 19 091 143 038
Spark Infrastructure SA (No.3) Pty Ltd, ABN 50 091 142 362
each incorporated in Australia
CKI Utilities Development Limited, ABN 65 090 718 880
PAI Utilities Development Limited, ABN 82 090 718 951
each incorporated in The Bahamas

1 Anzac Highway, Keswick, South Australia, 5035.

SA Power Networks' Disclaimer:

1. The use of the information contained in this document is at your sole risk.
2. The Information within this document is subject to change without notice.
3. SA Power Networks, its agents, instrumentalities, officers, and employees:
   3.1. Make no representations, express or implied, as to the accuracy of the information contained within this document;
   3.2. Accept no liability for any use of the said information or reliance placed on it; and
   3.3. Make no representations, either expressed or implied, as to the suitability of the said information for any particular purpose.
4. SA Power Networks and its agencies and instrumentalities do not endorse or in any respect warrant any third-party products or services by virtue of any information, material or content referred to or included on, or linked to this document.

SA Power Networks Copyright©2022:

Contents

Figures

Tables

1. Introduction

This technical standard provides designers, contractors, and consultants with an understanding of the technical requirements for low voltage (LV) embedded generation (EG) connections with a total nameplate capacity above 30kVA, which are to be connected to 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 a high voltage (HV) EG system connected to the network, refer to TS133.

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.

TS132 sets out the minimum technical requirements for LV 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.
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
Open Transition Transfer Switch	An electrical switch that provides a break-before-make transfer sequence.
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
HV	High Voltage
IEC	International Electrotechnical Commission
IES	Inverter Energy System
LEG	Large Embedded Generation
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
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 installer 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 2067	2016	Substations and high voltage installations exceeding 1 kV a.c.
AS 2467	2008	Maintenance of Electrical Switchgear
AS/NZS 1768	2007	Lightning protection
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 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 IEC 60947.1	2015	Low-voltage switchgear and control gear - Multiple Function equipment - Automatic switching equipment
AS/NZS 61439.1	2016	Low-voltage switchgear and control gear assemblies – General rules

AS 62040.1	2019	Uninterruptible power systems (UPS) Part 1: Safety requirements
AS/NZS IEC 62116	2020	Utility-interconnected Photovoltaic Inverters – Test Procedure of Islanding Prevention Measures
AS/NZS 61000.1.1	2000	Electromagnetic compatibility (EMC) - General - Application and interpretation of fundamental definitions and terms
AS/NZS 61000.4.30	2012	Electromagnetic compatibility (EMC) – Testing and Measurement Techniques – Power Quality Measurement Methods

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
IEC 60071-1	2019	Insulation co-ordination – Part1: Definitions, principles and rules

ENA:

ENA DOC-040	2019	Technical Guidelines for Low Voltage EG Connections

SA Power Networks Documents:

- Manual 18: SA Power Networks Connections and Ancillary Network Services
- Manual 32: Service and Installation Rules
- Technical Standards & NICC Brochures, in particular:
  - NICC 270: Connection of Medium and Large Embedded Generation Greater than 30kVA
  - TS129: Low Voltage EG Connections not exceeding 30kVA
  - TS132 F1: Medium Embedded Generation Commissioning Witnessing Plan Checklist
  - TS132 F2: Large Embedded Generation Commissioning Witnessing Plan Template and Checklist
  - TS133: High Voltage EG Connections Technical Requirements
  - TS134: 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 LV 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
- Electricity (General) Regulations 2012
- National Electricity Rules
- 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 LV EG systems, above 30kVA capacity, for both inverter energy systems (IES) and non-inverter energy systems.

All references to and requirements of IES within this document, assumes the requirements 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. Where there is no constraint identified by SA Power Networks, the maximum aggregate system for a standard LV embedded generation connection is as per Table 1.

Table 1: Maximum System Capacity

LV EG IES Connection	LV EG non-IES Connection
1,500 kVA	1,500 kVA

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 capacity of all aggregated generating units.

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

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 type.

All generating systems which require SCADA as per section 4.13 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 LV 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.

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 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 System

Inverter Energy Systems (IES) connected to SA Power Networks' LV network shall comprise of inverters that are:

- tested by an authorised testing laboratory and be certified as being compliant with AS/NZS 4777.2 with an accreditation number;
- registered with CEC as approved grid connect inverter;
- tested by an authorised testing laboratory and be certified as being compliant with AS/NZS IEC 62116 for active anti-islanding protection as per AS/NZS 4777.2;
- installed in compliance with AS/NZS 4777.1;
- compliant to any particular testing requirements that may be outlined on AEMO's website at the time of the application to SA Power Networks; and
- remote disconnection and reconnection capable.

4.4.1 Like for Like Warranty Replacements

Like-for-like warranty replacement of an inverter will not be required to be compliant with SA Power Network's current Technical Standards UNLESS the capability exists within the replacement inverter. In this case the settings must be updated to the current standard, in particular the power quality response mode settings. Like-for-like warranty replacement will be defined as equipment with the same manufacturer and model.

Replacement inverters must still comply with all necessary safety standards and requirements.

Any changes made to an installation must be advised to SA Power Networks via an EG application, including any inverter replacements under warranty or an increase in panel capacity.

4.5 Energy Storage System (ESS)

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

Inverter connected energy storage system which operates 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 permission signalling.

An ESS, such as a battery, which is not connected to the grid at low voltage via an AC input port but is connected behind an OTTS which is complaint to the Australian Standards is not considered grid connected.

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 require 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 to 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 detailed network investigations 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 LV EG earthing shall be in compliance with the SIR in addition to the requirements specified in AS/NZS 4777.1, AS/NZS 3000, AS/NZS 3010, and AS/NZS 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.

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 CT 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 failsafe 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 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.

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 2**, unless superseded by a site-specific setting specified in the Engineering Report.

Table 2: 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 higher voltages shall be set in accordance with Table 3, unless superseded by a site-specific setting specified in the Engineering Report.

Table 3: LV 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 and AS/NZS 4777.2 designed to mitigate impacts on grid during disturbances.

4.9.2 Central Protection

Table 4 below indicates the central protection requirements for LV EG IES units and for LV EG non-IES units.

Table 4: Central Protection Requirements

Protection Requirements	LV EG IES				LV EG Non-IES	
	≤200kVA		>200kVA			
	Exporting	Non-Exporting	Exporting	Non-Exporting	Exporting	Non-Exporting
Passive anti-islanding protection (27U/O, 59U/O, 81U/O, 81R)	✓	✓	✓	✓	✓	✓
Overcurrent facility fault, grid fault (50/51)	✓	✓	✓	✓	✓	✓
Directional power (32R)	-	-	-	✓	-	✓
Generator circuit Phase balance protection (46/47)	-	-	-	-	-	-
Inter-tripping	×	×	×	×	-	-

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.

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 permissive 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 protection capabilities, the inverter protection may 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 5 : LV EG IES Central Protection Voltage & Frequency Limit Values

Protection Function	SETTING (eg 230/400V)	DELAY (SEC)
Over Voltage (V >)	115% Nominal Voltage (265V)	2.0
Over Voltage (V > >)	120% Nominal Voltage (275V)	0.2
Under Voltage (V <)	78% Nominal Voltage (180V)	11.0
Under Voltage (V <<)	30% Nominal Voltage (70V)	2.0
Sustained over-voltage	112% Nominal Voltage (258V)	-
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. LV connected non-IES generating systems must disconnect from the network if the voltage (phase to earth) settings shown in Table 6 are exceeded.

Table 6: LV 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, Overcurrent Grid Fault and Earth Fault Protections

This protection must coordinate / discriminate with all relevant protection, including the distribution network protection and any other customers' protection, and must include high speed protection (ie no intentional delay).

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

Earth fault protection for LV connections is not required, however are strongly recommended.

The embedded generating system's protection system must be capable of discriminating between a fault that is internal or external to the generating system.

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 be required to 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 requirements of stage 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 otherwise advised in the Engineering Report the minimum import protection is to be implemented as follows:

1. Inverter System
   - 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% of 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, reverse power protection must be installed to detect and prevent islanding operation. The reverse 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 Phase Balance Protection

All LV EG connections may require to have phase balance protection in place where it's not inverter integrated.

All Non-IES shall require both current unbalance and voltage unbalance protection.

4.9.2.7 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 is 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.

4.9.2.8 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 generating system is connected to the network and be of failsafe design.

The generating 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.

4.9.2.9 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.

4.9.3 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.

4.9.4 Synchronisation

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.

4.9.5 Additional requirements for LV EG Non-IES

All EG systems comprising of rotating machine EG must be complaint with AS 60034.1 and AS 60034.22.

4.10 Operating Voltage and Frequency

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).

All LV connected inverter shall have a nominal voltage of 400V (230V).

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:

1. network voltage control;
2. voltage fluctuations;
3. harmonics; and
4. 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.

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 meet 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 7**.

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

Table 7: Generating System Voltage Unbalance Requirements

Voltage Unbalance Factor (%) for Three Phase Supplies	
Time Period	**Voltage Unbalance Factor (%)**
	LV Connection Point
30 minutes average	2.0
10 minutes average	2.5
1 minute average	3.0

4.12.2 LV EG IES Power Quality Response Modes

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 8 and Table 9 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 8: Mandatory: Volt-VAr Response 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 9: 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)

Table 10: Sustained Operation for Voltage Variations

Reference	Voltage
$V_{nom\text{-}max}$	258 Volts

The settings must be verifiable via visual inspection either on the inverter panel or software on device connected to the inverter.

Power quality response mode settings shall be the same for all the inverters at site.

Replacement inverters, including warranty replacements, shall be configured to operate with the required power quality response modes.

4.12.3 LV EG Non-IES Synchronous Power Quality

All synchronous LV EG Non-IES connections shall be designed and operated to adequately control active and reactive outpower through either of the following power quality response mode:

1. Voltage control mode, or
2. Fixed power factor mode that shall require achieving a power factor operating window at the connection point of typically 0.90 to 0.95 lagging and not leading unless otherwise agreed to or specified by SA Power Networks.

The power quality response mode and settings shall be determined depending on the outcomes of technical studies carried out by the customer to criteria specified by SA Power Networks and approved by SA Power Networks as part of the connection application process.

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 Dynamic Data and Information

Dynamic 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

The technical studies, as outlined in **Table 11**, are required to be conducted by the customer or at the customer's expense to enable connection to the distribution network. The technical studies will be verified by SA Power Networks to confirm settings and suitability for connection to the network within the parameters allowed with the Distribution Code.

Table 11: Technical Studies Required for LV EG Connections

Technical Studies	LV EG IES				LV EG Non-IES	
	≤200kVA		>200kVA			
	Exporting	Non-exporting	Exporting	Non-exporting	Exporting	Non-exporting
Voltage level (incl. power factor)	-	✗	✓	✗	✓	-
Power flow	-	✗	✓	✗	✓	✓
Fault level	-	✗	✓	✗	✓	✓
Protection grading	-	✗	✓	✗	✓	✓

Symbols are used to denote technical studies requirements, where:

- ✓ Represents that the technical studies shall be required
- \- Represents that the technical studies may be required
- ✗ Represents that the technical studies shall not be required

4.16.1 Modelling Data

SA Power Networks' minimum information requirements for LV embedded generating system 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.

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.

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 11kV 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 the Adelaide CBD where the:

1. Embedded generating 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 embedded generating unit and vice versa.; or
2. Embedded generating 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.

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.

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
2. Compliance testing - customer testing to demonstrate that the facility complies with SA Power Networks' technical requirements
3. Post connection or on-line commissioning - customer testing to demonstrate the generating system performs as agreed

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

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

SA Power Networks' typical site visit requirements are shown in **Table 12**.

Table 12: SA Power Networks Typical Site Visit Requirements for Inspection Testing and Witnessing

Testing and Witnessing Component
Connection compliance to SIR, testing and connection and SCADA installation and connection
Generation compliance witnessing (refer Note 1)
Post connection commissioning (refer Note 1)

Notes:

1. 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 must submit a commissioning plan to SA Power Networks a minimum of 20 business days prior to the commencement of commissioning.

Requirement 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.

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.

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 earthing systems (as applicable);

4. protection test results (either type test results and 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; and
6. serial numbers of all generating units, protection, and control devices.

6.4 Compliance Testing

Prior to connection of the generating system to the network, SA Power Networks is entitled to 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 tests must 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 may 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:

1. **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

2. **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 13 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 13** 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 13: Testing and Commissioning Requirements for LV EG Connections

Testing and commissioning requirements	LV EG IES				LV EG Non-IES	
	≤200kW		>200kW			
	Exporting	Non-Exporting	Exporting	Non-Exporting	Exporting	Non-Exporting
Protection settings and performance	✓	✓	✓	✓	✓	✓
Power quality settings and performance	✓	✓	✓	✓	✓	✓
Export limit settings and performance	-	✓	✓	✓	✓	✓
Communications settings and performance	-	-	✓	-	✓	✓
Shutdown procedures	×	×	-	-	✓	✓
Confirm system is as per specification	✓	✓	✓	✓	✓	✓
Confirm SLD is located on site	✓	✓	✓	✓	✓	✓

Symbols are used to denote technical studies requirements, where:

✓ Represents that the technical studies shall be required

\- Represents that the technical studies may be required

× Represents that the technical studies shall not be required

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 embedded generating system that is unsatisfactory for reliable connection to the distribution network. Any additional site visits by SA Power Networks 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.

The customer of the embedded generating 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 embedded generating system performs as expected and that operation is consistent with the assigned performance standards in the Connection Offer or engineering report.

Table 14 provides an indication of the post connection on-line tests that may be required for given generating system.

Please note that **Table 14** 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 embedded generating 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 14: Indicative Post Connection On-line Test Requirements

Post-Commissioning	AS/NZS 4777 IES	Any Other Generating System
Synchronisation	✗	✓
Ramp rate	✓	✓
Export limiting	✓	✓
SCADA readings (if applicable)	✓	✓
Set point controls	✓	✓
Generation dispatch limiter	✓	✓
Power factor controller	✓	✓
Reactive power capability	✓	✓
Quality of supply	✓	✓
Permissive Signalling (if applicable)	✓	✓

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

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.

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 embedded generating 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 for the individual harmonics and multiplied by 3 for each phase reading.

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

Table 15 details the specifications for the power quality measurement instruments and event recording.

Table 15: 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	AS/NZS 61000.4.7
Flicker (Pst and Plt)	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

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 non-IES (eg. rotating generators);
2. IES exporting greater than 200kW;
3. SCADA controlled generating systems (ie permission granted/denied); and
4. GDL/NEL and power factor set point controlled generating system.

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.

[1] Subject to equipment limitation, provision up to 15th harmonic may be permissible.

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; and
4. permission to connect / denied procedures.

The agreed 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 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. Maintenance and access arrangements; and
5. 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' distribution system. 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 actual frequency of testing should take into consideration all relevant factors including:

- the technology of the plant;
- experience with the particular generation technology;
- manufacturer's advice with respect to maintenance of the particular generating unit/ model; and
- 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:

- all protection systems (circuit breakers, relays, trip signals, generating system protection and DC supply);
- reactive power capability;

- active power control;
- voltage and reactive power control;
- quality of electricity generated;
- response to disturbances (frequency, voltage, contingency events); and
- power station auxiliary transformers/supplies; and Fault level/current mitigation devices.

The minimum frequency of testing is:

- Every 3 years;
- After any plant change; and / or
- After any disturbance event.

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

- Annually;
- After any equipment change; and / or
- After any disturbance event.

7.4 Notice of Alteration to Approved Installation

The IES generator/customer must not significantly alter, add or replace components of the approved design or protection settings of the IES 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 these inverters accumulates to more than three (3) units or
- the replacement of these inverters is equivalent to more than 10% of the IES or
- any Network Protection Unit (NPU) has been replaced.

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

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

Appendices

A. Deviations from the National DER Connection Guidelines

Section	Description of deviation	Type of deviation	Justification
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
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 LV Connection Arrangement

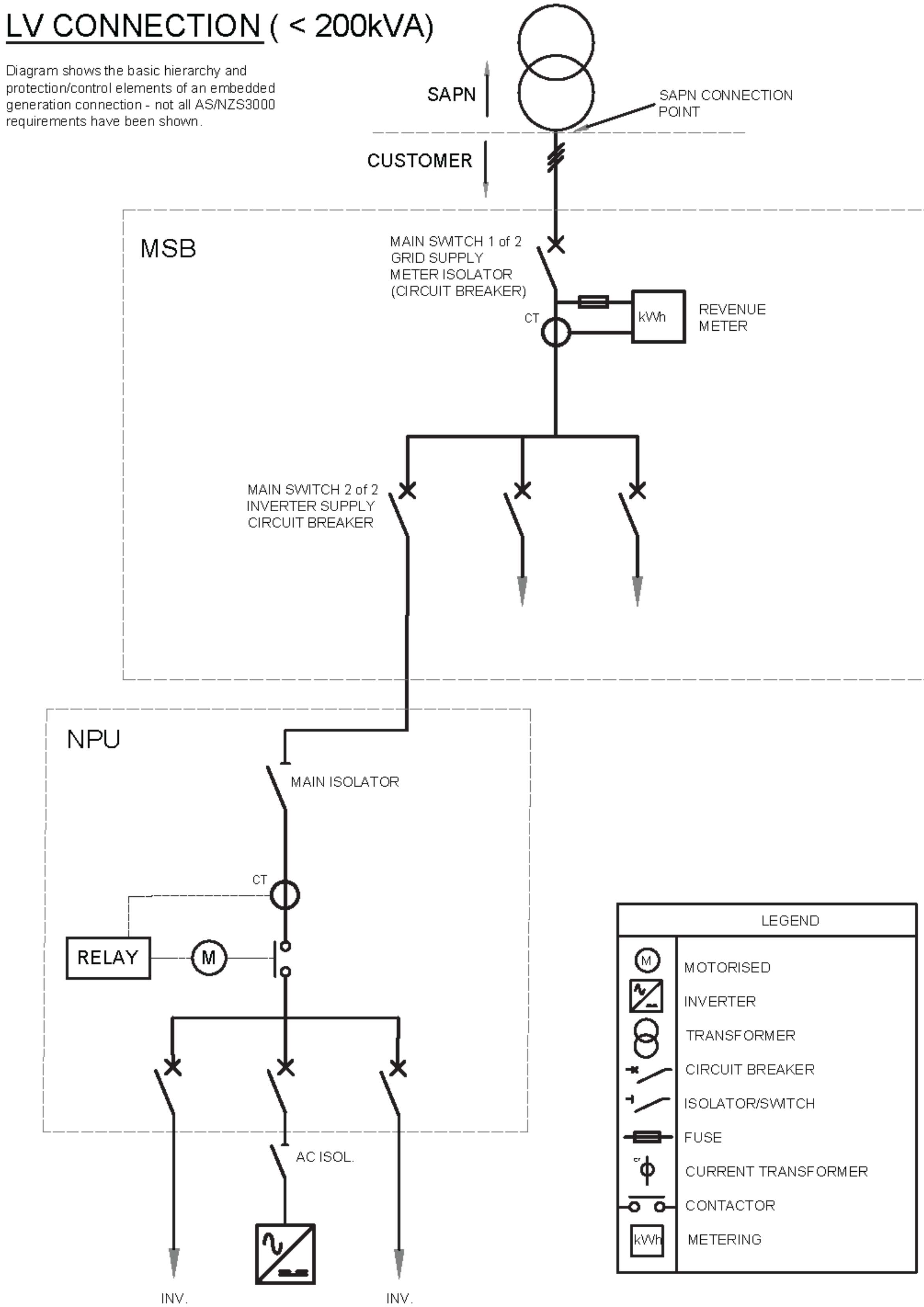

Figure 1 : SLD Typical LV Connection Less than and equal to 200kVA

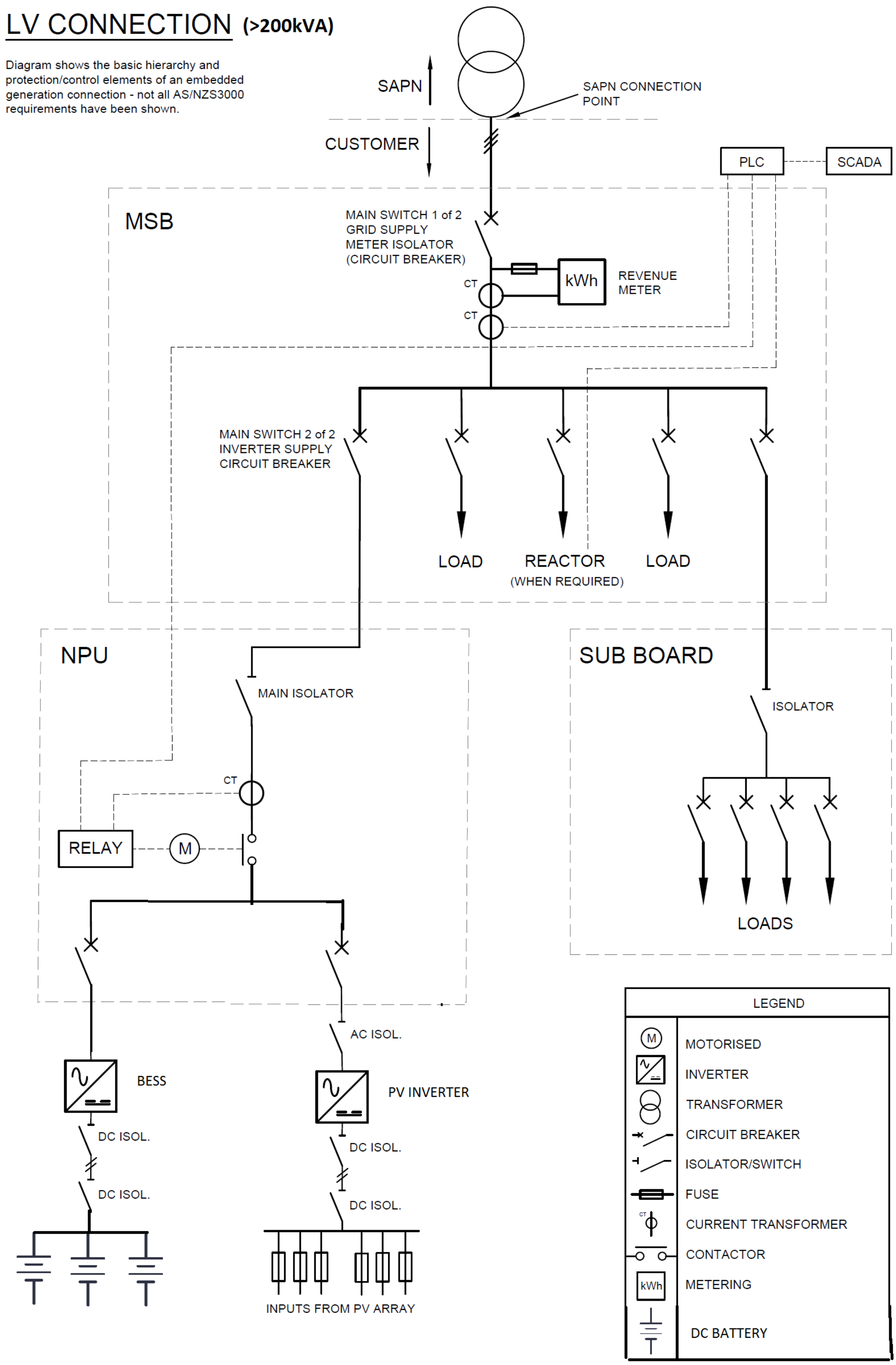

Figure 2: SLD Typical LV Connection Greater than 200kVA

C. Model Connection Agreement

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

D. Static Data and information

Static data 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 an 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; Number of phases with DER installed
   - (f) Central protection and control
   - (g) Islandable installation
   - (h) Protection and control modes
2. AC grid connection of a DER installation:
   - (a) Number of AC connections
   - (c) AC equipment type
   - (d) Inverter/small generating unit manufacturer
   - (e) Inverter series; 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); Under-frequency (Hz)
   - (m) Inverter – demand response enabled device interaction
   - (n) Inverter power quality response mode – volt-watt (where enabled)
   - (o) Inverter power quality response mode – volt-var (where enabled)
   - (p) Inverter power quality response mode – reactive power mode (where enabled)
   - (q) Inverter power quality response mode – fixed power factor mode (where enabled)
   - (r) Inverter power quality response mode – power factor curve/power response mode (where enabled)
   - (s) Inverter power quality response mode – power rate limit mode (where enabled)
   - (t) Non-inverter generator – voltage/reactive power regulation
   - (u) Non-inverter generator ramp rate (where enabled)
   - (v) Non-inverter generator frequency response mode (where enabled)
   - (w) 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)
   - (g) Nominal storage capacity (kVAh)