Guidelines for embedded generator connection to ActewAGL's low voltage (LV) network

Release date: March 2013

Contents

1 INTRODUCTION

Under National Electricity Rules (NER Rule 5.3) ActewAGL has an obligation to review and process applications to connect or modify a connection which are submitted to it and must enter into a connection agreement with the applicant. This requirement applies to both customer load and embedded generation plant.

Embedded generation systems when connected to the ActewAGL network can impact the operating conditions, voltage profile and loading on the feeder. ActewAGL has in place minimum technical requirements that must be met in the design and installation of embedded generation facilities to ensure that these impacts can be controlled to maintain safe and reliable operation of the network for operating personnel, customers and the general public.

These guidelines outline the technical requirements for the installation of embedded generation systems connecting to and operating in parallel with ActewAGL's distribution network. This document does not relate to eligibility for any feed-in-tariff or any other tariff.

There may be additional requirements over that specified in this document for installations in unique situations. These requirements will be identified by ActewAGL at the enquiry processing stage.

These guidelines only consider technical requirements from the distribution network point of view. They do not specify requirements for the customer side of the embedded generation system itself or any plant associated with its installation and operation.

2 SCOPE

This document applies to the following embedded generation systems connecting to and operating in parallel with ActewAGL's low voltage (LV) network.

- **Single phase LV installations up to 10kW.**
- **Three phase LV installations up to and including 1500kW.**
- **Short term paralleling (greater than 400ms).**

This document applies to installations connected via inverters, such as photovoltaic (PV) installations and non-inverter connections such as alternating current (AC) rotating machines, for example, synchronous generators. The requirements for the two types of connections are generally the same in principle but where the requirements differ they are noted accordingly throughout the document.

This guideline does not apply to connections to the high voltage (HV) network and break before make (backup) generators. For connection of systems larger than 1500kW and/or connection to the HV network, ActewAGL will consider the inquiry on a case by case basis and provide the customer with the appropriate requirements.

It must be noted that approval for connection for embedded generation systems greater than 30kW will be based on the results of the network technical studies as outlined in this document.

3 OBJECTIVE

ActewAGL is committed to connecting renewable generation to its network while ensuring at all times that power supply to its customers is delivered in accordance to ActewAGL and industry safety and reliability standards. ActewAGL's prime directives are:

a) the safety of personnel who work on the electricity network and to the general public; and
b) to minimise asset loss-of-life, reduced performance and to prevent damage to electricity network assets;
c) to minimise disruption to all customers (quality of supply) inclusive of the customer's own site; and
d) to not intentionally cause harm to the environment and to encourage development that supports the environment's ability to satisfy the needs of future generations.

The objective of this document is to outline to customers of embedded generation systems ActewAGL's requirements for the connection to, and parallel operation with, ActewAGL's distribution network.

This guideline should be read in conjunction with AS4777 parts 1 to 3 and *ActewAGL's service and installation rules.*

ActewAGL's service and installation rules can be accessed on the ActewAGL website at the following link:

http://www.actewagl.com.au/About-us/The-ActewAGL-network/Electricity-network/~/media/ActewAGL/ActewAGL-Files/Products-and-services/Building-and-renovation/For-professionals/Service-installation-rules-for-connection-to-electricity-network.ashx

Alternatively you can contact ActewAGL Southern Services Centre on 02 6293 5749 for a copy of the rules.

4 DEFINITIONS AND REFERENCES

4.1 Definition of terms in this document

ActewAGL

For the purpose of these guidelines “ActewAGL” refers to ActewAGL Distribution. Any reference to ActewAGL Retail will be stated as ‘ActewAGL Retail’.

It is important to note the difference between ActewAGL Distribution and ActewAGL Retail. ActewAGL Distribution is the ACT’s principal Distribution Network Service Provider (DNSP) and is responsible for the distribution of electricity to all distribution grid-connected customers within the ACT under a regulatory framework. ActewAGL Distribution designs, installs, up-grades, repairs and maintains the poles, substations and wires which make up the distribution network carrying electrical energy to ACT homes and businesses.

ActewAGL Retail is one of the ACT’s local electricity retailers and has a license to buy and sell electricity. An agreement made with ActewAGL Distribution does not constitute an agreement with ActewAGL Retail. Nor does an agreement made with another electricity retailer constitute an agreement with ActewAGL Retail.

Anti-islanding (loss of mains) Protection

A protection system to detect islanded conditions and disconnect the embedded generation system from the network.

Bi-Directional Metering

A meter capable of registering energy supplied to the premises (E) and energy exported from the premises (B) as separate data streams. Such a meter is capable of ‘Period of Billing’ Net metering.

Class 1, 2, 3, 4 or 5 Embedded Generator

For the purposes of these guidelines embedded generation installations have been classified according to their nameplate rating as shown in the table below.

Class	Nameplate Rating
1	Up to 10kW single phase or 30kW three phase
2	Above 30kW up to 60kW three phase
3	Above 60kW up to 120kW three phase
4	Above 120kW up to 200 kW three phase
5	Above 200kW up to 1500kW three phase

To remove any ambiguity, a generator with a nameplate rating which lies on the threshold falls into the larger class, for example, a generator of exactly 120kW is considered Class 4.

Customer

Customer has the definition given to it by the regulatory documents outlined in Section 5. For the purposes of this document the word customer also includes proponents of embedded generators planned to be connected to the ActewAGL network, their agents and representatives where appropriate.

Embedded generating unit

A generating unit that is connected directly to and operating in parallel with the distribution network without direct access to the transmission network. The generating unit may include photovoltaic (PV) system via inverters, rotating machines, solar thermal and other renewable generation, such as wind power generation or fuel cells.

Environment and Sustainable Development Directorate (ESDD)

ESDD is the inspecting authority in the ACT and is responsible for inspecting and approving customer's electrical installation (previously known as ACTPLA). Contact number is 02 6207 7775.

External protection

For the purposes of these guidelines external protection means a protection device that is not part of the plant's internal protection.

Generator Connector Cubicle (GCC)

A standardised enclosure designed to provide backup protection, supervisory control and data acquisition (SCADA) and communication for the embedded generation system. Refer to *Appendix A4* for a description of the GCC.

Gross metering

For the purpose of these guidelines gross metering means a metering arrangement in which both the total amount of energy created and the total amount of energy consumed by a customer are recorded separately. This is achieved either by a separate meter or by a second 'element' within the meter.

Installer

For inverter systems: A person who possess a Clean Energy Council (CEC) accreditation and holds an ACT A grade electrician licence.

For non-inverter systems: an engineering consultant body or an electrical contractor with relevant knowledge, expertise and experience.

Internal protection

For the purpose of these guidelines internal protection means a protection device that is part of the generator equipment.

Inverter

An inverter performs the conversion of the variable DC output from PV modules or other DC sources into a utility frequency AC current that can be fed into the electricity network.

Islanding

Occurs when supply from the network is isolated and one or more embedded generators remain connected to the isolated network and continue to supply load in this part of the network.

Micro-embedded generator

Shall have the meaning defined in the National Electricity Rules (NER) Chapter 5A.

'Must' and 'Shall'

For the purposes of these guidelines the words 'must' and 'shall' indicate a mandatory requirement.

Maximum power point tracker (MPPT)

A device, typically located within an inverter, which regulates incoming DC power to the inverter and optimises solar panel performance.

Net metering

For the purpose of these guidelines 'net metering' occurs when a generator is connected on the customer (load) side of the ActewAGL meter. This can be used and billed as *Period of Billing Net metering* or *Instantaneous Net metering*

Period of Billing Net Metering shall mean a metering arrangement in which the difference is calculated between the total amount of energy fed into the grid from the customer and the total amount of energy supplied by the grid to the customer, for that billing period (typically 1 month for commercial customers). Energy generated by the customer and directly consumed on site at that instant is not recorded by the ActewAGL meter.

Under an *Instantaneous Net metering* arrangement, energy fed into the grid from the customer when the customer is an exporter of electricity (ie customer demand is low and generation is high) is *not* subtracted from usage from times when the customer was an importer of electricity.

Network Connection Breaker (NCB)

A customer owned circuit breaker which defines the demarcation between ActewAGL network and the customer installation. The NCB provides the disconnection point of the embedded generator. ActewAGL requires control over the NCB as described in this document.

National Electricity Rules (NER)

The Rules made under the National Electricity Law to control the operation of the National Electricity Market.

National Energy Customer Framework (NECF)

The National Energy Customer Framework (NECF) was introduced in the ACT on 1 July 2012. The NECF introduces a new set of national laws, rules and regulations governing the retail sale and distribution of energy to customers and provides protection for energy users.

Network Charges

For the purpose of these guidelines 'network charges' shall refer to the costs invoked by ActewAGL for the use or augmentation of ActewAGL's network. See *Appendix A3* for details.

Network technical study

The connection of an embedded generator installation to a distribution network will inevitably result in some local changes to the characteristics of the network. To evaluate the possible consequences of these changes ActewAGL will carry out a network study with the installation included in the network model. This involves the use of detailed databases describing the electrical characteristics of the network and can be used to analyse how the network will behave under different loading conditions or in the event of particular faults. Refer to *Section 7.3* and *Appendix A5* for details.

Point of Common Coupling (PCC)

The closest electrical point to the generator which also serves to supply customer loads. See Figure 1 and Figure 2 on page 27.

SCADA (Supervisory Control and Data Acquisition):

A computer system that remotely monitors and is capable of switching the embedded generation connected to the electricity network.

4.2 List of references

1. *AS3000: Electrical Installations (known as the Australia/New Zealand Wiring Rules)*
2. *AS4777.1: Grid Connection of Energy Systems via Inverters Part 1 – Installation Requirements*
3. *AS4777.2: Grid Connection of Energy Systems via Inverters Part 2 – Inverter Requirements*
4. *AS4777.3: Grid Connection of Energy Systems via Inverters Part 3 – Grid Protection Requirements*
5. *AS5033: Installation of Photovoltaic Arrays*
6. *AS/NZS6100.3.2: Electromagnetic Compatibility – Limits for Harmonic Current Emissions*
7. *AS/NZS61000.3.6, AS1359.101 and IEC60034-1 for harmonic voltage distortion*
8. *National Electricity Rules – Chapter 5, 5A and Schedule 5*
9. *ActewAGL's Service and Installation Rules*

5 GENERAL REQUIREMENTS

5.1 Regulatory

The embedded generation installation and its connection process shall implement the regulatory requirements and recommendations of:

- The National Electricity Rules (NER)
- All other relevant laws, rules and regulations.

5.2 Embedded generator connection contract

Customers proposing an embedded generator connection are required to enter into a connection contract with ActewAGL as the electricity distributor.

In accordance with the applicable regulations listed in *Section 5.1*, the customer proposing a *micro-embedded generator* is offered ActewAGL's *model standing offer* to provide *basic connection services* to *retail customers* who are *micro embedded generators*. The *model standing offer* sets out the terms of connection of the embedded generator to ActewAGL's electricity network. A micro-embedded generator may request ActewAGL Distribution's *terms and conditions for non-standard connections.*

Customers of other embedded generators will be provided with ActewAGLs *terms and conditions for non-standard connections.*

The *terms and conditions for non-standard connections* are subject to commercial negotiations between the parties and will encompass both the technical and commercial aspects of the connection, address the access standards and specify the terms and conditions, including the connection charge. The process regarding the formation of connection contracts contained in Chapter 5A of the NER will apply for non-standard connections.

The *terms and conditions for non-standard connections* also require the customer to indemnify ActewAGL against any liability resulting from the customer's use of the distribution network in a manner prejudicial to the safety and efficiency of the network.

It is desirable that the *terms and conditions for non-standard connections* (if required) be finalised and signed by the duly authorised representatives of both parties at least one month prior to the intended commissioning date.

Where required, ActewAGL will prepare and forward ActewAGL Distribution's *terms and conditions for non-standard connections* following the receipt of the Customer's full and complete C*onnection application*. Commissioning and connection of the embedded generation installation will not be permitted until this contract is in place.

Customers seeking to be a registered participant should contact ActewAGL as different terms, conditions and processes may apply

Any contractual questions surrounding any incentive schemes for generation, including feed-in tariffs, should be directed towards the customer's energy retailer.

5.3 Compliance with the National Electricity Rules (NER)

The National Electricity Rules (NER) regulate the access of the distribution network to generators subject to the generating unit's capacity and the amount of energy generated.

Chapter 5A of the NER provides the framework for this access and aims to:

- establish the process to be followed;
- detail the guidelines and principles governing the connection application and access to a network;
- address the Customer's reasonable expectations of the level and standard of power transfer capability; and
- establish the process to ensure ongoing future compliance with the technical requirements of the connection with the network.

6 INSTALLATION AND TECHNICAL REQUIREMENTS

6.1 General requirements

Unless otherwise specified the inverter shall comply with the requirements of AS4777. As noted in AS4777 although this Standard does not apply to inverters larger than 30kW 3-phase units, similar principles may be used for the installation of such systems.

Only inverters that are either included in the list of approved inverters published by the Clean Energy Council or have been tested by an authorised testing laboratory and certified as being in compliance with AS 4777 will be accepted for connection to the ActewAGL network.

Where systems employ inverters greater than 30kW approval to connect these inverters will be determined on a case by case basis and may require the customer to have the inverter evaluated by an engineering consultant body with relevant knowledge, expertise and experience. Please see *Appendix A1.2* for the requirements regarding approval of non CEC listed inverters

For rotating machines ActewAGL require the machine to be a synchronous generator. However consideration for other types such as induction generators may be given on a case by case basis.

Appendix A6.1 shows a typical connection arrangement for PV system between 30 and 200kW (gross metered), *A6.2* shows a typical non-inverter connection arrangement and *A6.3* shows a typical SCADA and communication arrangement.

6.2 Wiring of the embedded generation installation

The embedded generation installation shall meet the wiring requirements of AS/NZS3000 (also known as the Australian/New Zealand Wiring Rules). It shall also meet the requirements of *ActewAGL's Service and Installation Rules*, with specific attention to Sections 1.9 and 1.10 of the main document.

However, it should be noted that ActewAGL is not an inspecting authority and cannot connect a new installation to the electricity network until that work has been inspected and approved

for connection by the Environment and Sustainable Development Directorate (ESDD) or other relevant inspecting authorities.

6.3 Labelling of the embedded generation installation

The embedded generation installation shall meet the labelling requirements outlined in section 5.5 of AS4777.1. It shall also meet the requirements of *ActewAGL's Service and Installation Rules*, with specific attention to clauses 5.1.5 and 5.5 of the rules.

6.4 Safety

The embedded generation installation shall not impose a safety hazard to personnel working on the network, ActewAGL customers and members of the public.

6.5 Connection arrangement

The maximum value for the rating of a generator allowed for single phase installations is 10 kW. Single phase generators in three-phase configuration will be allowed. Embedded generation installations with capacities greater than 10kW must be three-phase systems with generation balanced equally (maximum 10 percent variation between any two phases) amongst the three phases. The capacity is based on the nameplate kW rating of the generator(s) on each phase.

6.6 Permitted embedded generation installation capacity

ActewAGL has limits on the maximum generation capacity that can be connected to a local LV network. This is largely driven by the thermal capacity of the feeder, impedance of the feeder (causing voltage rise), distribution transformer rating and the combined effect of the connected generation plant on ActewAGL network performance, operation and safety. For generators of Class 2 and above, the network study will determine the maximum embedded generation installation capacity that may be connected. There may also be cases where the proposed installation may be required to connect at a reduced capacity or where no connection is allowed.

In some instances, depending on the location of the proposed installation, network augmentation and or additional protection and control functions (for either or both ActewAGL network and the embedded generation installation) may be required to ensure network safety and performance standards are not compromised. ActewAGL will identify these as part of the network study and advise the applicant if additional work is required. The cost for some or all of this work will be attributed to the customer.

Applications will be processed strictly in the order in which they are received.

For the purposes of these guidelines ActewAGL has classified embedded generation installations by the nameplate rating of the generator. Please refer to Clause 4 '*Definitions and References'* for details.

6.7 Power supply reliability

Connection of the embedded generation system shall not create a situation where the reliability of the supply network is degraded.

6.8 Power supply quality

Operation of the embedded generation system shall not cause undue interference with the supply to other customers. In particular the installation shall comply with the requirements of

- *AS4777.2 Section 4.4 for power factor (for inverter connections)*
- *AS4777.2 Section 4.5 for harmonic currents injected into the network (for inverter connections)*
- *AS4777.2 Section 4.6 for voltage fluctuations and flicker (for inverter connections)*
- *AS4777.2 Section 4.8 for transient voltage limits (for inverter connections)*
- *AS4777.2 Section 4.9 for direct current injection. (for inverter connections)*
- *AS/NZS 61000.3.6:2001, AS 1359.101 and IEC 60034-1 for harmonic voltage distortion*
- *NER Schedule S5.2.5*

The output voltage of the embedded generation system shall be within the range specified in *ActewAGL's Service and Installation Rules*, which is the average voltage over any given 10 minute period at the connection point shall be within the range of 225.6V to 254.4V. Voltages outside this range may damage or reduce the lifetime expectancy of electrical appliances.

6.9 Protection

Protection and SCADA requirements for embedded generation systems operating in parallel with the ActewAGL network

<table>
<tr><th>Protection</th><th colspan="2">Less than 30kW
(up to 10kW/phase)</th><th colspan="2">30kW to 200kW</th><th colspan="2">200kW to 1500kW</th></tr>
<tr><th>Generator type</th><th>Inverter</th><th>Non-inverter</th><th>Inverter</th><th>Non-inverter</th><th>Inverter</th><th>Non-inverter</th></tr>
<tr><td>Phase and neutral lockable isolation switch at customer connection point</td><td colspan="6">Required.</td></tr>
<tr><td>Main protection</td><td colspan="6"></td></tr>
<tr><td>Anti- islanding protection</td><td colspan="6">Required.</td></tr>
<tr><td>Synchronisation</td><td rowspan="3">Provided for in AS4777 compliant inverters.</td><td rowspan="3">Required.</td><td rowspan="3">Provided for in AS4777 compliant inverters. inverters >30kW will need to demonstrate compliance as per Appendix A1.2</td><td rowspan="3">Required.</td><td colspan="2" rowspan="7">Required.</td></tr>
<tr><td>Loss of mains</td></tr>
<tr><td>Under/over voltage (27, 59)</td></tr>
<tr><td>Under/over frequency
(81U, 81O)</td></tr>
<tr><td>Overcurrent and earth fault</td><td colspan="2">Not Required.</td><td colspan="2">Required.</td></tr>
<tr><td>Negative sequence voltage & current</td><td colspan="2" rowspan="4">Not required.</td><td>Required for 60kW (class 3) and over – part of GCC.</td><td>Required.</td></tr>
<tr><td>Reverse VAr (1 and 3 phase) (55R)</td><td colspan="2">Required for 60kW (class 3) and over – part of GCC.</td></tr>
<tr><td>Over VAr (1 and 3 phase) (55O)</td></tr>
<tr><td>Neutral voltage displacement</td><td>Not required.</td><td>Not required.</td><td colspan="2">Required if exporting.</td></tr>
</table>

Protection	**Less than 30kW (up to 10kW/phase)**		**30kW to 200kW**		**200kW to 1500kW**	
Generator type	**Inverter**	**Non-inverter**	**Inverter**	**Non-inverter**	**Inverter**	**Non-inverter**
Reverse power	Required if not exporting.					
Intertrip	Not required, customer will be advised following network technical study for specific cases where this is required.					
Loss of SCADA/Communication	Not required.		Required for 120kW (Class 4) and over - part of GCC.		Required.	Required.
Loss of battery/charger					Required.	Required.
SCADA			SCADA requirements “A” for > 120kW.		SCADA requirements “B” for > 200kW.	
Disconnection and reconnection	<2 second trip, >60 second reconnect.				2 second trip, >60 second reconnect, Any additional requirements will be advised after network technical study	
Additional and backup protection						
GCC	Not Required.		Required for 60kW (class 3) and over – part of GCC.		Required.	
Backup loss of mains						
ROCOF						
Backup under/over voltage (27, 59)						
Backup under/over frequency (81U, 81O)						
Backup overcurrent and earth fault						

6.9.1 Anti-islanding Protection

Anti-islanding protection is an important requirement of embedded generation protection systems. Islanding creates serious safety issues for personnel working on the distribution network or on an embedded generation system during an outage. It also interferes with the quality of supply to other customers and can damage equipment. All protection equipment associated with a grid-connected embedded generation system must be designed, installed and tested to ensure islanding does not occur.

ActewAGL requires technical studies be carried out to assess islanded operation risk levels for all new installations and specify control measures to manage identified risks if deemed necessary. The installation may be required to connect with a reduced capacity or not at all.

Embedded generators must not be able to operate in ***Network Islanded Mode***.

6.9.1.1 Network islanded mode

Network Islanded Mode occurs when the embedded generator is the only source of supply into a section of ActewAGL's distribution network. This situation could arise when a distribution network fault occurs and the ActewAGL source circuit breaker (CB) trips but the generator Network Connection Breaker (NCB) does not trip. Similarly, this situation could also occur when the section of the ActewAGL network containing the network connection point is de-energised for planned works but the generator network connection CB does not trip.

Operation of an embedded generator in ***Network Islanded Mode*** creates significant risks for both the customer and ActewAGL. Therefore the generator must be automatically disconnected from ActewAGL's distribution network if ActewAGL's network at the network connection point is de-energised for any reason. The major risks associated with an embedded generator operating in ***Network Islanded Mode*** are as follows.

- The significant safety risk to ActewAGL electricity network personnel and members of the general public, and
- The significant risk that when the network supply is restored, through either auto-reclosure or manual control, the generator will not be synchronised with the network supply at the network connection point resulting in damage to the generator, and/or distribution network equipment.

6.9.1.2 Customer islanded mode

Operation of embedded generators in c***ustomer islanded mode*** is permitted provided that the generator is first disconnected, either manually or as the result of a loss of supply, from the ActewAGL distribution network, AND reconnection of the customer island to ActewAGL's distribution network does not occur until the network supply has previously been fully restored and is stable so that synchronisation from within the customer's installation can occur.

Customer islanded mode occurs when the embedded generator is only supplying into the customer's installation or a section of the customer's installation and the section being supplied has been electrically disconnected from the ActewAGL distribution network.

Approval will need to be sought from ActewAGL for customer islanded mode of operation.

6.9.1.3 Anti-islanding protection systems to be installed by the customer

Embedded generation installations must automatically disconnect from ActewAGL's distribution network and must not connect to the network in the event that one or more phases of the distribution network are not energised. The protection system must ensure the installation is disconnected from the network within two seconds and must not reconnect for at least 60 seconds after the network supply has been restored.

The protection system installed by the customer shall do the following.

- Prevent the generator connecting to the ActewAGL distribution network unless all phases of the network are energised, there is correct phase rotation and no unbalance at the network connection point.
- Prevent the generator connecting to ActewAGL's distribution network unless the generator supply is synchronised with the ActewAGL distribution network.
- Disconnect the generator from the ActewAGL distribution network in the event that one or more phases of the distribution network at the network connection point is lost.
- Disconnect the generator from the ActewAGL distribution network in the event that a network abnormality causes unacceptable voltage and/or frequency deviations at the network connection point.
- Disconnect the generator from the ActewAGL distribution network in the event that the generator output becomes unstable causing unacceptable voltage and/or frequency deviations at the network connection point.
- Prevent the generator connecting with, or disconnect the generator from, the ActewAGL distribution network in the event of failure of the electrical supplies to protection and/or control system equipment.
- Prevent the generator connecting with, or disconnect the generator from, the ActewAGL distribution network in the event of failure of intertrip (if installed), SCADA communication links or loss of DC supply.
- Prevent the export of power unless this has been approved by ActewAGL; or limit the export of power where ActewAGL has established a power export limit due to constraints associated with the existing network infrastructure.

For inverter systems, inverters which have been tested and approved against AS4777 are known to incorporate the above protection and are approved to export power into the ActewAGL network.

	Generator exporting	Generator not exporting
Inverter based generation		
Main scheme	Loss of mains, usually frequency and voltage based.	
Backup scheme	Active anti-islanding through frequency shift, frequency instability, impedance change detection (current injection), power variation.	
Non- inverter generation		
Main scheme	Loss of mains (for example frequency or voltage based)	
Backup scheme	Negative sequence voltage and current plus neutral voltage displacement plus reverse power set at export limit	Reverse Power set at nil export plus negative sequence voltage and current

Table 1: Typical Anti-Islanding Protection Methodologies

6.9.2 Loss of mains protection

Where parallel operation of the generator is intended, loss of mains (anti-islanding) protection shall be installed at the network connection point to disconnect the whole of the embedded generation facility from the ActewAGL distribution network on loss or partial loss of network supply at the network connection point.

Loss of mains (anti-islanding) will normally be the main protection scheme against network islanded operation of the embedded generator.

6.9.3 Synchronisation

Automatic synchronising and synchronisation check closing protection shall be installed at all locations where it is intended that parallel operation of a generator will occur, to prevent non-synchronised connection to ActewAGL's distribution network.

Connection of the generator in parallel with ActewAGL's distribution network shall be prevented unless all phases of the distribution network at the network connection point are energised; that is the network connection CB shall not be able to close onto a de-energised distribution network.

ActewAGL circuit breakers are not fitted with synchronising facilities and therefore all synchronising facilities must be provided within the customer's installation.

6.9.4 Under/Over voltage protection

Under and over voltage protection shall be installed at the network connection point and the generator.

This protection will be set to operate if the phase to neutral voltage on any phase at the network connection point varies outside predetermined values, which will be based on the generator's proposed network connection arrangement and operating requirements.

The required under/over voltage protection settings will be determined by ActewAGL at the detailed design stage after the detailed network studies have been undertaken.

6.9.5 Under/Over frequency protection

Under and over frequency protection shall be installed at the network connection point and the generator.

The frequency protection set points will be based on the generator's proposed network connection arrangement and operating requirements.

The required under/over frequency protection settings will be determined by ActewAGL at the detailed design stage after the detailed network studies have been undertaken.

6.9.6 Negative sequence voltage and current protection

Negative sequence voltage and current protection shall be installed at the generator to protect against voltage and current imbalance from the generator source, which together with neutral voltage displacement (NVD) protection also provides back-up protection to the loss of mains protection.

6.9.7 Overcurrent and earth fault protection

Bi-directional overcurrent and earth fault protection to detect faults on the ActewAGL distribution network and within the customer's installation shall be provided at the network connection CB. This protection shall be set to grade with ActewAGL's network protection schemes.

Overcurrent and earth fault protection shall also be provided at the generator and this shall provide back-up to the protection installed at the network connection point. This protection shall be set to detect faults within the customer's installation and ActewAGL's distribution network (back-up to the network connection CB overcurrent and earth fault protection). This protection must grade with ActewAGL's network protection scheme.

Generator overcurrent and earth fault protection relays should have compensation for under voltage field weakening unless the customer can demonstrate that voltage depression at the generator during fault events will not adversely impact on protection scheme operation.

6.9.8 Reverse-VAr and Over-VAr protection

The operating strategy for the embedded generator needs to ensure the power factor falls within the range specified by the service and installations rules. Pf 0.9 lagging to unity.

Inverter systems are to operate by default at pf = 1 however some situations for inverters in installations of Class 2 and above may warrant different settings which will be advised to customers after the Network technical study.

Rotating machines, as a default, should be set to maintain the power factor at the point of connection, within the limits specified by the service and installation rules.

The GCC reverse VAr and over VAr protection is to be set slightly beyond the operating strategy limits.

- Reverse VAr to be set at 0.95 lead
- Over VAr to be set at 0.8 lagging

6.9.9 Neutral voltage displacement

Where the export of power is intended and the installation is larger than 200kW, neutral voltage displacement (NVD) protection shall be installed.

As this protection scheme will require the installation of voltage transformer(s) on the ActewAGL HV distribution network near the network connection point; the voltage transformer(s) will be supplied and installed by ActewAGL. The total cost of this VT and associated equipment will be borne by the customer.

The voltage transformer(s) required for this protection scheme may be either 3 x single phase voltage transformers or a single three phase 5 limb voltage transformer, with the primary winding star point connected to earth and the secondary winding connected in broken delta supplying a NVD protection relay.

ActewAGL will provide the VT secondary wiring to the generator interface cubicle. The customer will be required to supply and install the NVD protection relay and associated equipment/wiring within the embedded generation facility.

6.9.10 Reverse power/power limit protection

Reverse power or power limit protection shall be installed at the network connection point, where the export of power HAS NOT been approved by ActewAGL.

Similarly, where ActewAGL has nominated a limit on the amount of power that can be exported to the distribution network as a result of network infrastructure or performance constraints power limit protection shall be installed at the network connection point.

Any power limit protection settings will be determined by ActewAGL at the detailed design stage after the detailed network studies have been undertaken.

Where the detailed network analysis establishes that the existing network infrastructure capacity exceeds the worst case export capability of the generator, power limit protection need not be installed.

6.9.11 Intertrip

ActewAGL will advise the customer if intertrip is required as a back up to loss of mains protection. However, intertrip will generally not be required for LV connection.

6.9.12 SCADA communications link integrity protection

To facilitate basic monitoring and control of the embedded generation facility by ActewAGL as outlined in Section 6.10, a communications link will be required between the embedded generation facility and the ActewAGL distribution substation nearest to the network connection point (or other point nominated by ActewAGL).

This link shall be continuously monitored for integrity and in the event that the link fails that is the failure is more than ten seconds, the generator shall automatically disconnect from ActewAGL's distribution network. A pre-existing failed communications link shall also prevent the generator connecting to the ActewAGL distribution network.

6.9.13 Battery/battery charger and/or UPS integrity protection

To ensure all protection and control systems are capable of operation, the generator must be automatically disconnected from the ActewAGL distribution network in the event of a failure of the direct current (DC) supply to the protection and control systems.

All primary and secondary protection system equipment installed by the customer in order to comply with the requirements outlined in this document must comply with the relevant Australian Standards and/or IEC Standards.

6.9.14 Control and Monitoring (SCADA)

Section 6.10 outlines the SCADA requirements for the various types and sizes of the embedded generation systems.

6.9.15 Disconnection and Reconnection

Many of ActewAGL's distribution feeders incorporate automatic reclosing. The customer shall ensure that the design of protection and control systems adequately accommodate this functionality.

An embedded generator shall have primary protection set to trip at two seconds and shall be prevented from attempting to automatically synchronise and reconnect to the ActewAGL distribution network for at least 60 seconds after the network supply has been restored.

Typical ActewAGL feeder automatic reclosing practices (where installed) are as follows although for Class 5 and above systems the customer will need to confirm the specific settings with ActewAGL on a case by case basis.

- The typical de-energised time period before automatic reclosure (reclose time) varies between two and a half seconds and ten seconds.
- The typical time before resetting on restoration of supply (reclaim time) is 15 seconds.
- The number of automatic "reclose" attempts to restore supply before lock-out occurs varies between one and three.

The customer shall ensure that the protection systems to prevent network islanding operate before automatic reclosure can occur.

6.9.16 GCC additional and backup protection

A grid connection cubicle is required for Installations Class 3 and above. This provides basic backup protection for loss of mains, and under/over frequency and voltage.

The GCC also provides some additional primary protection features. These include rate of change of frequency (ROCOF), loss of SCADA, Loss of UPS, NVD (where required), Over/reverse VAr and negative sequence voltage.

<table>
<tr><th>Size
Requirement</th><th>Class 1
0
to 30kW</th><th>Class 2
30kW
to
60kW</th><th>Class 3
60kW
to
120kW</th><th>Class 4
120kW
to
200kW</th><th>Class 5
200kW to
1500kW</th></tr>
<tr><td>GCC with circuit breaker and provision for future protection relay and Remote Control and Monitoring</td><td>Not Required.</td><td>Required (if future expansion is planned >60kW).</td><td colspan="3" rowspan="2">Required.</td></tr>
<tr><td>External Protection: Micom P142 relay + circuit breaker at customer connection point incorporates:
• LOM
• Under and over f
• Under and over V
• ROCOF
• Negative sequence V and I</td><td colspan="2">Not required.</td></tr>
<tr><td>Neutral voltage displacement (NVD)</td><td colspan="4">Not required.</td><td>Required if exporting.</td></tr>
<tr><td>Remote control and monitoring (SCADA)</td><td colspan="3">Not required.</td><td>SCADA requirements “A”.</td><td>SCADA requirements “B”.</td></tr>
</table>

Table 2: GCC functions for embedded generation systems

Note: These are minimum requirements. In unique situations additional protection and or control/monitoring may be required for any class of installation to manage performance or safety issues determined by network studies and system checks.

To remove any ambiguity, a generator with a nameplate rating which lies on the threshold falls into the larger class, for example, a generator of exactly 120kW is considered Class 4.

6.10 SCADA

SCADA requirements for Inverter and non-inverter (rotating machine) embedded generators are as follows.

	Less than 30kW (up-to 10kW/phase)	30kW to 200kW	200kW to 1500kW
SCADA	Not required	SCADA requirements "A" for > 120kW	SCADA requirements "A" and "B"

ActewAGL will provide, install and maintain the antenae, radio modem and remote terminal unit (RTU) at customer's cost for sites requiring SCADA.

It must be noted that ActewAGL will not be monitoring the alarms or the status of the generator but will record them for network performance analysis and historical reasons. ActewAGL will have control of the generator to trip it under emergency conditions such as in cases where our prime directives are compromised. The customer has the following options.

- Monitor the alarms and take appropriate actions using their local system such as BMS; or
- Formulate a service agreement with ActewAGL to monitor the generator alarms and status.

The input/ouput (I/O) points are to be provided by the embedded generation facility customer according to Table 3 (page 21) and
Table 4 (page 23) as applicable. The I/O points are to be sent to the ActewAGL RTU which may be part of the GCC or a separate interface cubicle (typically located in the substation).

In the instance where the RTU is located within the GCC, the GCC manufacturer is to install and terminate all wiring (including IO wiring) within the cubicle.

Where the RTU is located separately to the GCC, ActewAGL shall terminate the customer supplied I/O cabling/wiring at the SCADA Interface Cubicle. The terminals within the SCADA Interface Cubicle shall be the monitoring and control system interface boundary between ActewAGL's network and the customer's embedded generation facility.

The customer will be required to fund the total cost of all ActewAGL remote monitoring and control works.

Drawings of typical SCADA arrangements can be found in *Appendix A6.3.*

6.10.1 SCADA Requirements A: for embedded generation systems greater than 120kW

ActewAGL shall provide and the customer must accept and integrate into the generator monitoring, control and protection systems, the following ActewAGL initiated remote monitoring and control functions for each generator and/or network connection point.

	I/O Function	Signal Type Digital/ Analogue Input/ Output[2]	Digital Signal States
A1.	Network Connection CB Emergency Trip / OFF Command by ActewAGL.[5]	DI	Generator operation as normal: 1 Trip: 0
A2.	Network Connection CB enable/disable Close Command by ActewAGL.[3, 5]	DI	Enable: 1 Disable: 0
A3.	RTU Fail Alarm	DI	Link ok: 1 Link fail: 0
A4.	RTU Maintenance Switch	DI	Maintenance mode on: 1 Generator operation as normal: 0
A5.	Trip Command Acknowledgement	DO / Comms	5 seconds pulse to Hi (1)
A6.	Enable/Disable Close Command Acknowledgement	DO / Comms	5 seconds pulse to Hi (1)
A7.	Network Connection CB CLOSE Command by Generator (via Sync-Check Relay for rotating machines)	DO / Comms	5 seconds pulse to Hi (1)
A8.	Battery &/or UPS Battery Low Volts/Fail Alarm[4]	DO / Comms	Battery/UPS ok: 1 Battery/UPS fail: 0
A9.	Network Connection CB Status	DO / Comms	CB Closed: 1 CB Open: 0
A10.	Network Connection CB Protection Operated Alarm[6]	DO / Comms	Protection operated: 1 Generator operation as normal: 0
A11.	Network Connection CB Fail Alarm	DO / Comms	CB ok: 1 CB fail: 0

Table 3: SCADA requirements A

Note 1: Y = Yes, N = No

Note 2: The Input/output designation is from the point of view of the Generator. This may be the Micom P142 or P143 in the case of a GCC or alternatively the Generator's own PLC control unit.

Note 3: The Network connection CB Emergency Trip/Off and Enable/Disable Close must all be applied to the same CB.

Note 4: This I/O point is required for batteries/UPSs providing generator and network connection protection/control and CB tripping supplies.

Note 5: These signals shall be electrically interlocked with the Generator controls to prevent the generator connecting to ActewAGL's network without ActewAGL authorisation. The GCC has compatibility with providing and receiving these signals.

Note 6: This signal should latch and not reset until the generator is reconnected or until the generator receives a rising edge of the enable/disable command (Signal A2).

6.10.2 SCADA Requirements B: for embedded generation systems greater than 200kW

In addition to SCADA Requirements A, larger generators require the following points

	I/O Function (Refer to Note 1)	**Unit**	**Input/ Output**	**Instance where required**		**Digital Signal States**
				Power export	**No power export**	
B1.	Network connection 3 phase Current	Amps	Comms	Y	N	
B2.	Network connection 3 phase Voltage	Volts	Comms	Y	N	
B3.	Network connection real power export	kW	Comms	Y	N	
B4.	Network connection reactive power export	kVAr	Comms	Y	N	
B5.	Network connection power factor		Comms	Y	N	
B6.	Generator real power output	kW	Comms	Y	N	
B7.	Generator reactive power output	kVAr	Comms	Y	N	
B8.	Generator status (running/not running)[2]		DO/Comms	Y	Y	Running;1 Not running: 0
B9.	Generator CB status[2]		DO/Comms	Y	Y	CB Closed: 1 CB Open: 0
B10.	Generator CB protection operated alarm[3,4]		DO/Comms	Y	Y	Protection operated: 1 Generator operation as normal: 0
B11.	Generator CB fail alarm[2]		DO/Comms	Y	Y	CB ok: 1 CB fail: 0
B12.	Intermediate CB status[3]		DO/Comms	Y	Y	CB Closed: 1 CB Open: 0
B13.	Intermediate CB protection operated alarm[3,4]		DO/Comms	Y	Y	Protection operated: 1 Generator operation as normal: 0
B14.	Intermediate CB fail alarm[3]		DO/Comms	Y	Y	CB ok: 1 CB fail: 0

Table 4: SCADA requirements B

Note 1: Y = Yes, N = No

Note 2: Applicable for net connected generators, where the NCB is separate from the GCB.

Note 3: This I/O point is required where additional CBs exist between the Generator CB and the Network connection CB. A “group” I/O point covering all such intermediate CBs is acceptable where there is more than 1 intermediate CB.

Note 4: This signal should latch and not reset until he generator is reconnected or until the generator receives a rising edge of the enable/disable command (Signal A2).

6.10.3 Signal Types and Formats

The customer shall use an application layer of modbus (standard for PLCs) or DNP3 (standard for relays) where comms signals are used. Internet/Ethernet (TCP/IP) protocol over a fibre-optic physical layer is preferred for all communication signals.

Digital inputs and outputs may be accepted/provided by hard wired voltage free contacts or by the above protocols.

Upon application the customer must provide an index of points and other details regarding their SCADA.

For interfaces between equipment, which ActewAGL has not interfaced before, the customer will be required to submit their PLC or relay to ActewAGL for a bench test to ensure SCADA functionality before installation on site.

6.11 Metering

The below table provide information on the metering options available for embedded generation.

	Gross metering	**Period of billing net metering**	**Instantaneous net metering**
Customers eligible	All LV customers.	Must have meter capable of E and B datastreams and on interval tariff. E datastream measures energy transferred from the grid to the site. B datastream measures energy transferred from the site to the grid.	All sites except some HV customers.
Customers not eligible	Customers on HV tariff (unless the customer provides appropriate dedicated step-up transformers and HV metering panel for embedded generator).	Sites without appropriate metering.	Some customers on HV tariff: HV metered sites may have multiple metering points allowing energy to flow through the site and out to other customers. Any generation is automatically included in the E-B subtraction and therefore it is not possible to record net generation separately.
Metering type	MP1, MP2, MP3, MP4.	Site requires E-B metering. This is typically available on sites which have: Interval metering, MP4, CT metering or bi-directional tariff metering.	Any.
CT metering	Required for generators greater than 60kW that is 20kW per phase.	Required for generators greater than 60kW. Usually already present for sites which have Bi-direction, MP4 or interval metering.	Required for generators greater than 60kW.
Meter upgrades required	Gross meter or dual element meter to be installed.	Where export of electricity is intended, bi-directional tariff metering (Class 0.5 accuracy) shall be installed and maintained by an authorised and accredited metering. service provider at the customer's expense.	

Metering provided by	Where the total anticipated energy flow through the metering point (both export and import) is less than 160MWh per annum, ActewAGL, as the default network service provider, must provide the metering services. ActewAGL is an accredited metering service provider and can provide this service, on a fee for service basis, in conjunction with the overall network infrastructure works required for the connection of the embedded generation facility to the ActewAGL distribution network. Refer to the *Electricity network* *schedule of charges* for ActewAGL's charges to provide this service. Where the total anticipated energy flow through the metering point (both export and import) exceeds 160MWh per annum, the Proponent of the embedded generation facility (or their representative, for example, retailer) is responsible for engaging an accredited metering service provider. If the site of the existing installation for a proposed embedded generator is not an ActewAGL metered site the customer should contact their electricity retailer to arrange appropriate metering.		
Metering location	Meter locations must comply with the requirements of the *ActewAGL Electricity Service and Installation Rules*. The metering point shall be within the customer's installation and be as close as practical to the network connection point.		
Generator Point of Common Coupling (PCC)	At main switchboard Upstream of customer's usage meter. See Figure 1 (page 27)	At main switchboard (MSB) Downstream of customer's usage meter. See Figure 2 (page 27) Connection may also be permitted at a switchboard further downstream of the MSB with special approval.	
Further information	Appendix A2 gives possible meter configurations for customers with embedded generation installations with less than 10kW capacity.	Where the export of electricity is not intended, reverse power blocking shall be installed. This arrangement are sometimes referred to as 'hiding behind the meter'. In accordance with the National Electricity Rules, ActewAGL reserves the right to install metering with Class 0.5 accuracy to record the output of the embedded generator separately.	
Typical applications	Standard connection type for Solar PV installations.	Peaking-lopping generators, Solar PV and Co-gen wishing to reduce site demand.	Peaking-lopping generators. Generators used solely for backup purposes.
Notes	Required for the ACT Government's feed-In-tariff as well as the ActewAGL Retail 'Solar buyback scheme'.		*While this option is available to all sites in ActewAGLs network, generation can only offset energy used on site at that instant. Energy exported will*

			receive no compensation. ActewAGL is not able to record instantaneous export unless bi-directional metering is included and programmed.

6.11.1 Metering Diagrams

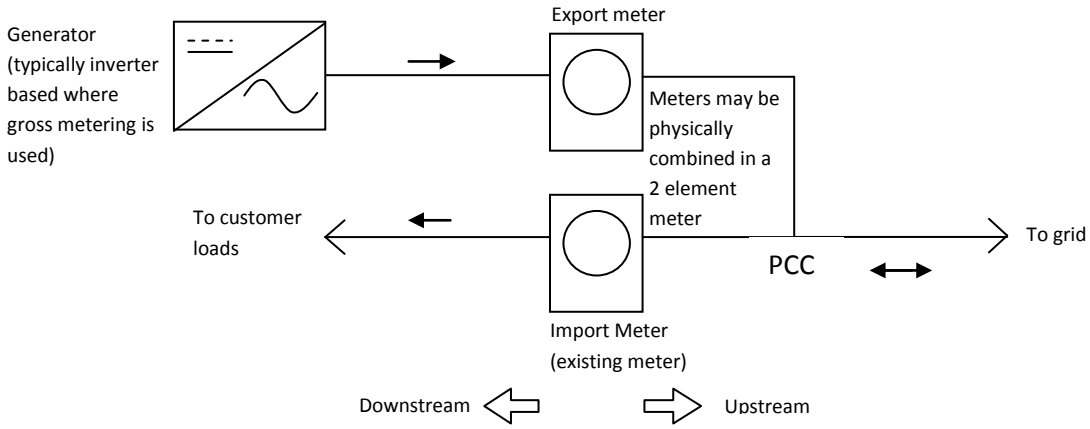


Figure 1: Gross Metering Arrangement

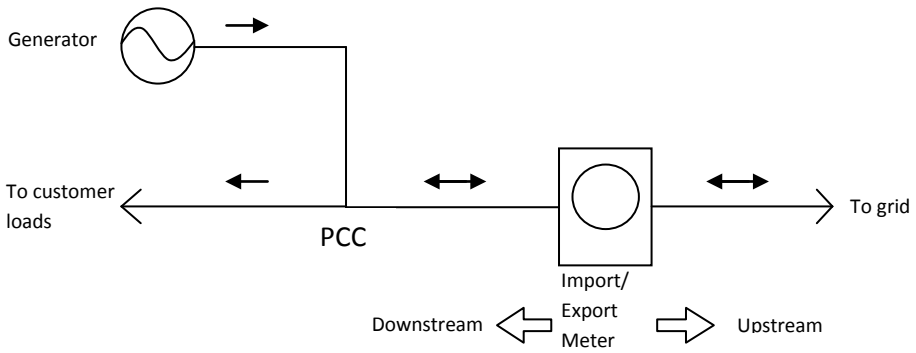


Figure 2: Net Metering Arrangement

6.11.2 Examples of Net and Gross metering

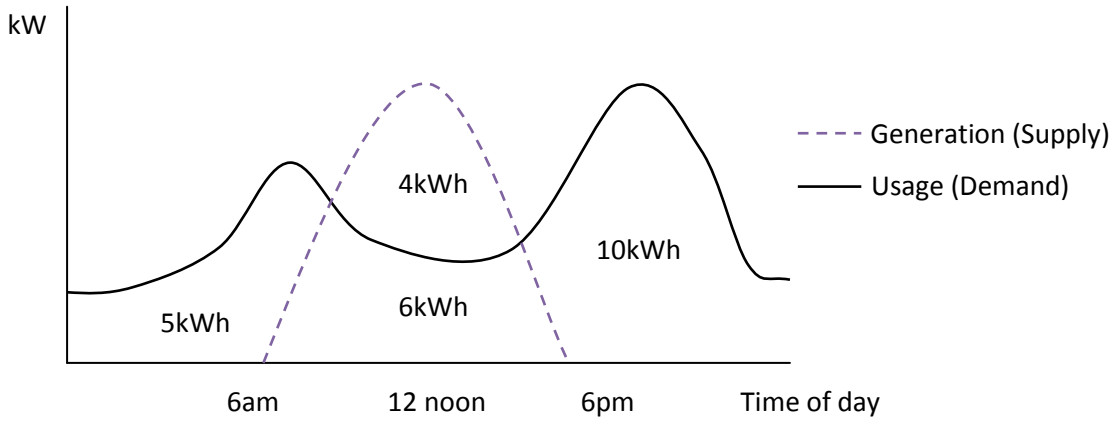


Figure 3: Net and Gross metering example

The below example calculations refer to Figure 3: Net and Gross metering example

An example period of 1 day has been used. Domestic customers have a standard monthly billing period of 3 months, while commercial billing periods may have a standard monthly billing period.

6.11.2.1 Gross metering

At the end of this period a gross meter would show:

- Generation recorded: 10kWh (area under the blue curve: 4kWh + 6kWh)
- Usage recorded: 21kWh (area under the black curve: 5kWh + 6kWh + 10kWh)

Different rates (charges for usage or reimbursements for generation) may apply. The customer should contact their electricity retailer for a schedule of these rates.

6.11.2.2 Period of billing net metering

For a Period of billing net meter, the meter would show:

- total amount of energy fed into the grid from the customer: 4kWh (area under the blue curve in excess of the black curve)
- total amount of energy supplied by the grid to the customer: 15kWh (area under the black curve in excess of the blue curve: 10kWh + 5kWh)
- energy generated by the customer and directly consumed on site at that instant: 6kWh (area covered by both the blue and black curves).

The difference is calculated between the total amount of energy fed into the grid from the customer and the total amount of energy supplied by the grid to the customer for that billing period. An example billing period of 1 day has been used. Typical billing period is 1 month for period of billing net metering customers.

In this example the customer will be charged for 15kWh – 4kWh = 11kWh.

If energy fed into the grid was greater than the 15kWh supplied by the grid, then the customer would be a net exporter for that billing period. The customer would be required to negotiate a rate with the retailer for this exported energy.

6.11.2.3 Instantaneous net metering

- Total amount of energy fed into the grid from the customer: 4kWh (area under the blue curve in excess of the black curve)
- Total amount of energy supplied by the grid to the customer: 15kWh (area under the black curve in excess of the blue curve: 10kWh + 5kWh)
- Energy generated by the customer and directly consumed on site at that instant: 6kWh (area covered by both the blue and black curves).

Different rates (charges for usage or reimbursements for generation) may apply. The customer should contact their electricity retailer for a schedule of these rates.

Note that if this metering scheme is desired then ActewAGL cannot record the energy fed into the grid by the customer unless bi-directional metering is included on the site and appropriately programmed. In the absence of this, all that would be shown by the meter in this circumstance is the 15kWh supplied by the grid to the customer. This metering strategy is usually only appropriate if the customer anticipates sufficient load to absorb the energy generation as it is produced.

7 CONNECTION PROCESS

Customers will be required to enter into contracts or agreements as described in *Clause 5.2*. The processes for enquiring and applying to ActewAGL for connection of an embedded generator are subject to the regulatory requirements detailed in NER Chapter 5A. See Clause 5.3 for more information.

The business processes for both the inverter and non-inverter installations are outlined below.

7.1 Technical information to be provided by the customer

The Proponent shall ensure the design and construction of the installation shall only be carried out by an engineering consultant body or an electrical contractor with relevant knowledge, expertise and experience. In the case of inverter based installations CEC accreditation is also required.

The Proponent shall submit the following technical information as applicable as part of their connection enquiry.

<table>
<tr><th></th><th colspan="5">Applicable installations</th></tr>
<tr><th></th><th>Class 1
0
to 30kW</th><th>Class 2
30kW
to
60kW</th><th>Class 3
60kW
to 120kW</th><th>Class 4
120kW
to 200kW</th><th>Class 5
200kW to
1500kW</th></tr>
<tr><td>Special connection request</td><td colspan="5">Required.</td></tr>
<tr><td>Generator description</td><td colspan="5">Details in Section 7.1.2 as applicable.</td></tr>
<tr><td>Generator data</td><td colspan="5">Rotating machines: required

Inverters: Not required for 4777 compliant inverters.</td></tr>
<tr><td>Load profiles</td><td colspan="4">Not required.</td><td>Required.</td></tr>
<tr><td>Single line diagram</td><td colspan="5">Required.</td></tr>
<tr><td>Protection information</td><td colspan="2">Inverters: not required providing AS4777 compliant.

Rotating machines: required.</td><td colspan="3">Required.</td></tr>
<tr><td>Site plan</td><td colspan="2">Not Required.</td><td colspan="3">Required.</td></tr>
<tr><td>SCADA information</td><td colspan="3">Not applicable.</td><td colspan="2">Required.</td></tr>
<tr><td>Earthing schematic</td><td colspan="5">Required for rotating machine generators
Inverters: not required providing AS4777 compliant</td></tr>
<tr><td>Power factor correction details</td><td colspan="5">Required where power factor correction equipment is proposed.</td></tr>
</table>

Sufficient detail must be provided to enable ActewAGL to:

- assess compliance with the minimum requirements outlined in this document
- conduct Network technical study to assess the impact on plant fault ratings, protection scheme requirements and power export limits of existing infrastructure
- assess generator power factor and voltage limit requirements.

7.1.1 Special connection request form

A special connection request form is required for all generator proposals and can be accessed via the following link.

http://www.actewagl.com.au/~/media/ActewAGL/ActewAGL-Files/About-us/Publications/Special-electricity-connection-request.ashx

7.1.2 Generator description

A description of the proposed embedded generation facility using the list below where applicable shall be provided.

- Proposed operating mode(s) for systems for example peak lopping control regime, demand response regime, any storage strategies.
- Proposed interaction with ActewAGL's distribution network under abnormal network conditions for example, network support operation and or customer islanded mode operation.
- Details of any voltage control or power factor control strategies proposed
- Proposed local customer loads to be supplied from the embedded generation facility where applicable.
- Known future staging/development of the embedded generation facility and/or local customer loads.

7.1.3 Generator Data for rotating machine installations

Generator data required for each generator proposed to be installed as listed in *Appendix* A1*A1.1.*

7.1.4 Generator Data for Inverter based installations

Please see *Appendix A1.2* for inverter data required for inverters outside the scope of AS4777.

7.1.5 Single line diagram

Detailed electrical single line diagram(s) showing the configuration of all embedded generation facility/customer equipment and circuits between the embedded generator(s) and the network connection point; including as a minimum:

- all primary circuit equipment such as main switchboards, other switchboards, circuit breakers and isolators/load break switches. In particular, all points where the customer embedded generation facility and the ActewAGL distribution network can be connected / disconnected must be clearly identified

- all secondary protection and control equipment associated with the generator's connection and parallel operation with the ActewAGL distribution network including, current transformers, voltage transformers, protection and control elements and sensing points
- local customer load connections including any interconnections with other parts of the customer's installation. In particular, where interconnection with other parts of the customer's installation are proposed the means to prevent paralleling of ActewAGL substations / transformers and/or unsynchronised connection to the ActewAGL distribution network shall be clearly identified
- all metering equipment associated with the generator and the import and export of power from/to the ActewAGL distribution network
- all proposed power factor correction equipment that will be installed within the part of the customer's installation that is supplied directly from the embedded generator.

7.1.6 Protection Information

Detailed functional block/schematic diagram of the protection and control systems relevant to the generators connection to the ActewAGL distribution network showing the philosophy of the protection and control systems including all relevant relay current circuits, relay potential circuits, alarm and monitoring circuits, back-up systems, auxiliary power supply systems and proposed parameters/settings of all protection and control system elements.

7.1.7 SCADA Information

Where SCADA is required, the following information is needed.

- A drawing indicating all SCADA connections. Example concept drawings can be provided by ActewAGL upon request.
- Contact information for customer's SCADA programmer (email and phone).
- Contact person for site access (email and phone).
- Anticipated commissioning date.
- An Index/ schedule of points, required inputs/outputs are listed in the embedded generation guidelines at Section 6.10

Data required for modbus

- Modbus address or index number
- Slave number
- IP address

Data required for DNP3

- Slave profile of relay
- Device profile

7.1.8 Load Profiles

- Anticipated 24 hour local customer load profiles (both summer and winter) for the local customer loads that are to be normally supplied from the embedded generation facility. The profiles shall include apparent power (S), active power (P) and reactive power (Q) for both lightly loaded and maximum demand scenarios.

- Anticipated 24 hour power import/export profiles (both summer and winter) at the network connection point. The profiles shall include apparent power (S), active power (P) and reactive power (Q) for both lightly loaded and maximum demand scenarios.

7.1.9 Site plan

Site plan showing the physical location of the

- embedded generator
- customer main switchboards
- Grid connection cubicle (GCC), where present
- possible antennae locations for SCADA, where SCADA is required
- other relevant switchboards and the location of ActewAGL substations and associated infrastructure.

7.1.10 Earthing schematic

Detailed schematic diagram of the proposed earthing system arrangements for the embedded generation facility and associated customer electrical installation including, all proposed earth connections, MEN connections and relevant switchboard earthing arrangements.

7.1.11 Power factor correction equipment details

Full details of any proposed power factor correction equipment including:

- rating of capacitors – individual stages and total installation (kVAr)
- rating of switching reactors (kVAr)
- capacitor Bank capacitance (microfarads)
- inductance of switching reactor (millihenries)
- resistance of the capacitors and the reactors (Ohms)
- method of switching including capacitor bank stage sizes
- description of the automatic control of the power factor correction unit such that its operating characteristics can be determined.

7.2 Connection process for Class 1 installations

A flowchart of this process is given in *Figure 4* (page 36).

Step 1: Customer finds an installer
The customer must first choose an accredited installer. Customers who are proposing an inverter based system may refer to the current list of accredited installers available at the Clean Energy Council website.

Step 2: Installer selects/designs a generator system
The chosen installer will select or design a system to meet the customer's requirements.

Step 3: Customer and installer complete ActewAGL's special connection request form

The customer in conjunction with the installer must fill out and return to ActewAGL a Special Connection Request form. This form contains key information about the installation. and can be obtained from the above link or by contacting the ActewAGL Southern Services Centre on 02 6293 5749.

Step 4: Gain approval from ActewAGL

ActewAGL will provide an initial response to the enquiry within ten (10) business days of receiving the connection enquiry to advise on the process and the applicable charges.

If the information provided on the special connection request is incomplete, ActewAGL will request any additional information within ten (10) business days of receipt of the special connection request.

ActewAGL will ensure that the proposed connection complies with all relevant Australian Standards and has current test certificates. If the system is compatible with the network and suitable for connection, approval will be given.

If approval is denied the non-compliant component of the system will need to be replaced or redesigned and the process recommences at Step 2.

Step 5: Customer enters into a contact with ActewAGL

Customers will be advised if their proposal is not a *basic customer connection* with *micro-embedded generation*.

For connections that do not fall within the definition of a basic connection, the customer is required to decide to proceed with the connection and they will be required to enter into a connection contract as described in *Section 5.2*.

If the connection is a *basic customer connection*, the contract and basic customer connection process is commenced at step 8. The basic connection process is described at:

http://www.actewagl.com.au/~/media/ActewAGL/ActewAGL-Files/About-us/Publications/NECF/basic-connections-elec-factsheet.ashx

Step 6: Customer contacts the Environment and Sustainable Development Directorate (ESDD)

The installer working on the system must advise ESDD of the electrical work taking place. At this stage the installer may commence on the installation of the system. However the work is not complete until ESDD has inspected and approved the installation and ActewAGL has set-up the required metering arrangement by either installing a second meter or replacing the existing meter.

Step 7: Installer completes installation

The installer and electrician will complete the installation to a point where it is ready for the new solar meter to be fitted.

Step 8: Customer requests for an appointment

The customer's installer must submit a Request for Service (RFS) form to ActewAGL for an appointment to install metering. This form can be accessed from the above link.

The electrician can submit this form at any time after Step 4. It is at this point ActewAGL becomes aware that the installation is proceeding and that the customer will require a new meter or meter replacement soon. ActewAGL will arrange a suitable appointment date with the installer to carry out this work. For *basic customer connections* it is the RFS which initiates the connection contract process.

Step 9: Installation of new metering arrangement by ActewAGL
ActewAGL will meet the customer's installer on-site to install a second electricity meter, or replace the existing meter. ActewAGL will only install the meter and connect the system to the network if and only if Steps 1 to 8 are completed.

Step 10: ESDD notification*
The installer/electrician notifies that the installation is complete and is ready for inspection through filing the 'Certificate of Electrical Safety' to ESDD.

Step 11: ESDD inspection
ESDD will carry out an inspection of the wiring and other electrical work. If the installation passes the inspection ESDD will place an approval sticker adjacent to the existing metering installation or in the meter box.

Step 12: Installer commissions installation
The installer will then commission the installation and it may be connected to the electricity grid and is permitted to generate electricity.

Step 13: ActewAGL notifies Retailer of successful installation
ActewAGL will notify the customer's electricity retailer of the completion of all electrical work. This is done via a national business to business process where an electronic notification is sent to the retailer informing them of the new meter, date installed and the revised default tariffs.

Step 14: Customer applies for Solar Generation Tariff (if applicable)
The customer applies to the retailer for the solar generation tariff. A higher than default tariff may be available through Government legislation or through a program of the Retailer.

Step 15: Customer switched to the Solar Generation Tariff (if applicable)
The customer's retailer will make the necessary changes to their account.

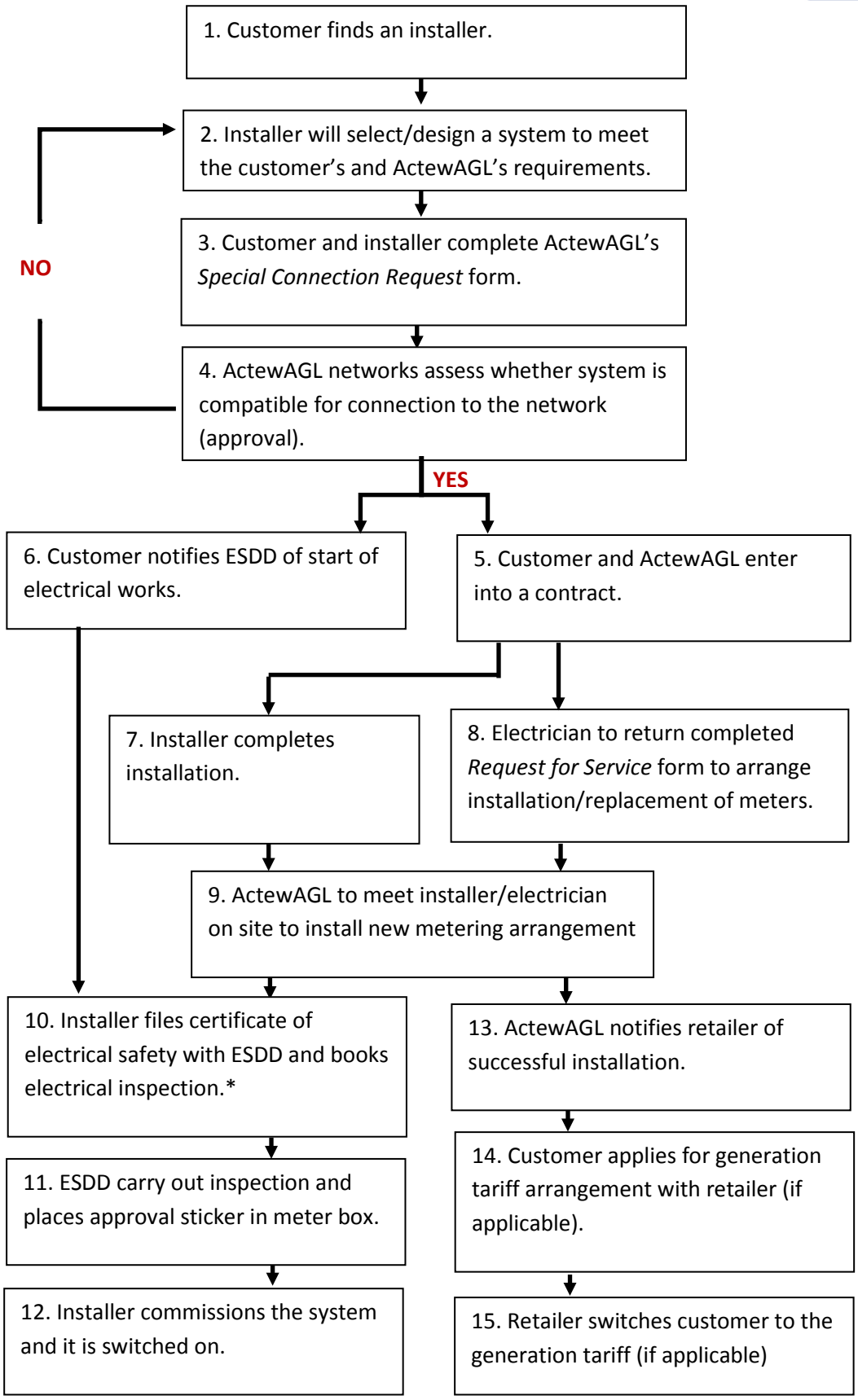


Figure 4: Flow chart for approval of Class 1 installations

*ESDD may require additional approval processes, such as BA or DA before approving the installation

7.3 Connection process for Class 2 to 5 installations

A flowchart of this process is given in Figure 5 (page 41).

Step 1: Customer advises ActewAGL of intent to connect (connection enquiry)
The customer must advise ActewAGL of the proposed connection by submitting a completed Special Connection Request form or a written connection enquiry. This shall be done prior to undertaking any detailed design or committing to expenditure or material and resources. ActewAGL will meet any reasonable request for information on its network that would enable the customer to prepare a connection application that best meets the customer's technical and commercial considerations. Requests for information on network layout and ratings for a specific section of the network are considered reasonable by ActewAGL.

ActewAGL will provide an initial response to the enquiry within five business days of receiving the connection enquiry and also advise of the applicable charges.

Appendix A3 shows the charge for processing this connection enquiry. If the customer wishes to go ahead with the enquiry and pay the charges ActewAGL will issue a quote/invoice and submit to the customer within ten days.

The customer should also notify ESDD of the intention to connect.

Step 2: Response from ActewAGL
ActewAGL will process the connection enquiry and respond to the connection enquiry within 20 days of payment. This will include advice to the customer on:

- technical feasibility of the proposed connection based on the preliminary information provided
- network studies required to determine the impact of the installation on the distribution network
- additional information required from the customer for ActewAGL to carry out the above studies
- preliminary program of works to make the connection; provided that the customer has informed ActewAGL of their schedule to connect
- network technical study charge payable by the customer. This will cover costs for ActewAGL to carry out network technical studies and to investigate and recommend appropriate measures to address any issues identified. *Appendix A3* shows the charges for Network technical study for various classes.

Step 3: Customer requests ActewAGL to conduct Network technical study
The customer must confirm intent to take the connection enquiry to the next stage by submitting to ActewAGL a written confirmation to proceed with the Network technical study and provide the following information.

- confirmed location (suburb, block and section or address) of the proposed installation
- details of embedded generator – Refer to *Appendix A1* for both rotating machine and inverter data requirements

- typical generation/load profile over a 24 hour period at point of connection
- any specific requirements for supply service levels and connection arrangement
- additional information specific to the proposed installation as requested by ActewAGL in order for it to complete the assessment.
- required timing for connection.
- single line diagram showing proposed connection arrangement.

Upon receipt of the written confirmation ActewAGL will raise a quote/invoice and submit to the customer. Once payment is received ActewAGL will commence the study.

Step 4: Network technical study (NTS) and proposal to connect by ActewAGL
ActewAGL will conduct a detailed assessment of the connection enquiry to determine its impact on the safety and operation of the network. Network technical studies and connected plant reviews are part of this assessment and include the following.

- Load flow studies to check effect on voltage profiles and thermal loading on feeders and transformers.
- Fault level study to confirm equipment fault ratings are not exceeded.
- Protection co-ordination study, if required, to check effect of generation on operation of ActewAGL protection system.
- Review of connected generation type and capacity, load type and capacity and inverter specification to evaluate risk of islanded operation.

The outcome of the above studies and reviews will provide the basis for ActewAGL's preparation of a *Proposal to connect* for submission to the customer. The *Preliminary offer to connect* will include the following:

- Advice that the proposed location can accept the power generation planned, or, if the initial proposal cannot be accommodated then ActewAGL will advise on the maximum generation capacity and details of connection arrangement that can be accepted at the proposed location without incurring augmentation or modification costs.
- Details of network augmentation or modification, if required, to enable the proposed connection.
- Budgetary estimate of the costs to be funded by the customer including network augmentation or modification costs if required.
- Non-refundable design charge.
- Preliminary timeframes to complete the connection including, if required, augmentation or modification work.
- Applicable service standards.

Appendix A5 contains the scope of the study.

ActewAGL will provide the customer with the preliminary offer within 20 days of receiving the payment for the NTS, providing all necessary information has been provided.

Step 5: Customer to notify ActewAGL if connection conditions are acceptable

On receiving the *Proposal to connect* the customer must decide if the connection conditions are acceptable and if so the customer must advise ActewAGL in writing of the acceptance. ActewAGL will require a non-refundable design charge with the application which will be offset against the cost should the customer choose to accept the offer to proceed with the construction.

On receipt of the written acceptance ActewAGL will raise and submit a quote/invoice for the design charge to the customer.

The customer shall make the payment and then lodge a formal application to connect to the network in accordance with the Electricity network capital contribution code, which can be found at the link below.

http://www.icrc.act.gov.au/__data/assets/pdf_file/0005/150179/Electricity_Network_Capital_Contributions_Code_August_2007.pdf

On receipt of the payment and application ActewAGL will prepare the connection plans which include the cost to augment the electricity network to enable a connection to occur.

Step 6: Connection offer

ActewAGL will then issue a connection offer within 65 days of receiving the payment and application. The connection offer will contain the amount the customer needs to contribute and a works program, and the terms and conditions of the connection contract, as described in *Section 5.2*. Customers of embedded generators class 2 through 5 will be provided with ActewAGLs *terms and conditions for non-standard connections*.

Upon acceptance by the customer of the connection offer to connect, ActewAGL will then raise and issue to the customer a quote/invoice for the customer contribution. Once payment is made for the customer contribution ActewAGL will proceed with the construction as per the works program.

Step 7: Customer contacts the Environment and Sustainable Development Directorate (ESDD)

The installer working on the embedded generation system must advise ESDD of the electrical work taking place. At this stage the installer may commence on the installation of the system. However the work is not complete until ESDD has inspected and approved the installation and ActewAGL has set-up the required metering arrangement by either installing a second meter or replacing the existing meter if required.

Step 8: Installer completes installation

The installer and Electrician will complete the installation to a point where it is ready for the new meter to be fitted or existing meter replaced (if required).

Step 9: *Customer requests for an appointment*
The customer's installer must submit a Request for Service form to ActewAGL for an appointment to install metering. This form can be accessed from the above link.

The electrician can submit this form at any time after Step 6. It is at this point ActewAGL becomes aware that the installation is proceeding and that the customer will require a new meter or meter replacement soon. ActewAGL will arrange a suitable appointment date with the installer to carry out this work.

***Step 10:* Installation of new metering arrangement by ActewAGL**
ActewAGL will meet the customer's installer on-site to install a second electricity meter, or replace the existing meter (if required). ActewAGL will only install the meter and connect the installation to the network if and only if Steps 1 to 9 are completed.

Step 11: ESDD notification*
The installer/electrician notifies that the installation is complete and is ready for inspection through filing the *Certificate of electrical safety* to ESDD.

Step 12: ESDD inspection
ESDD will carry out an inspection of the wiring and other electrical work. If the installation passes the inspection ESDD will place an approval sticker adjacent to the existing metering installation or in the meter box.

Step 13: Installer commissions embedded generation installation
The installer will then commission the installation as per Clause 8.1 and it may be connected to the electricity grid to generate electricity.

Step 14: ActewAGL notifies Retailer of successful installation
ActewAGL will notify the customer's electricity retailer of the completion of all electrical work. This is done via a national business to business process where an electronic notification is sent to the retailer informing them of the new meter, date installed and the revised default tariffs.

Step 15: Customer applies for Solar Generation Tariff if applicable
The customer applies to the retailer for the Solar Generation Tariff for PV installations. A higher than default tariff may be available through Government legislation or through a program of the retailer.

Step 16: Customer switched to the Solar Generation Tariff if applicable
The customer's retailer will make the necessary changes to their account.

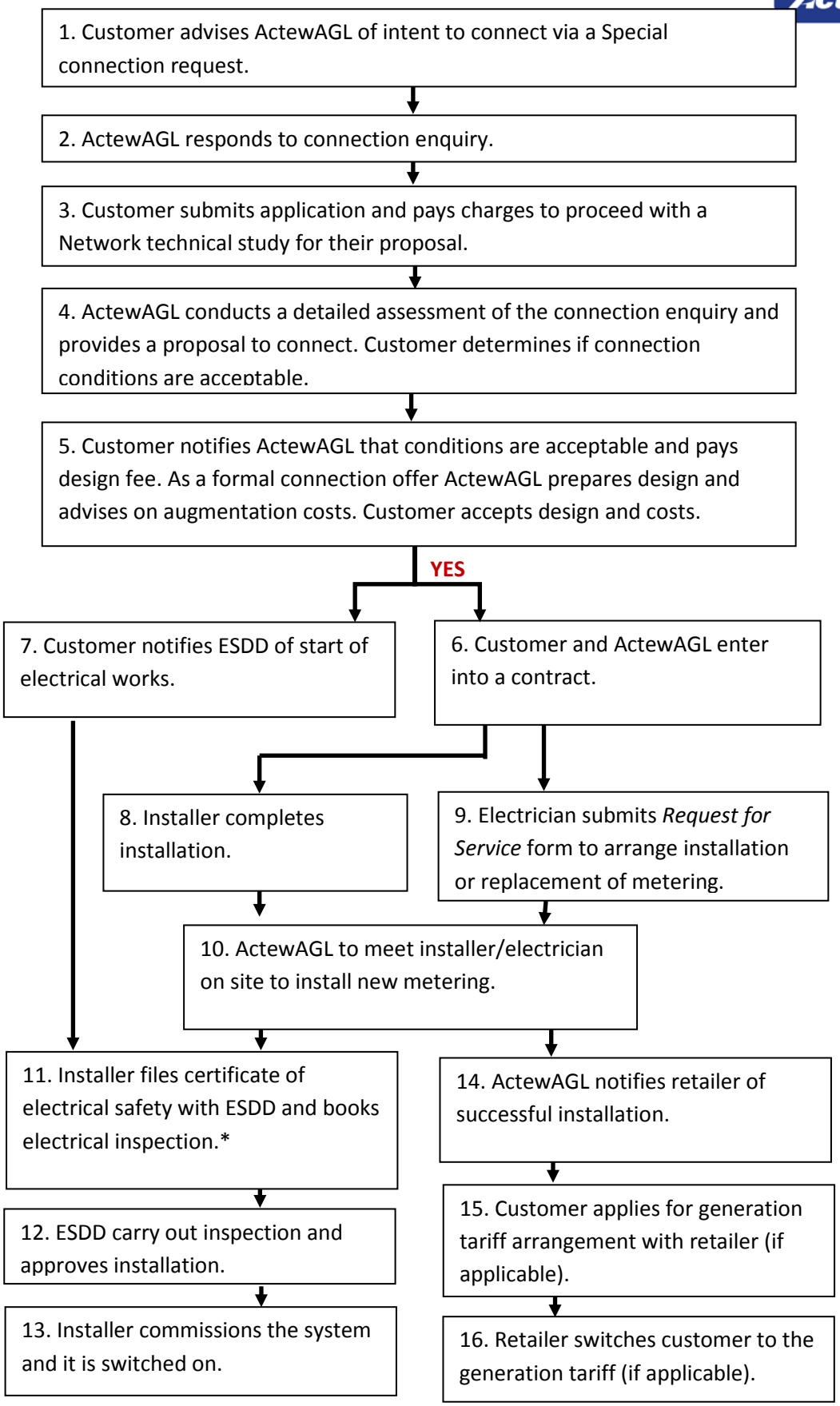


Figure 5: Flowchart of business process for class 2 to 5 grid-connected installations

*ESDD may require additional approval processes, such as BA or DA before approving the installation.

7.4 SCADA process

When the customer is required to have SCADA for the embedded generator then some of the above steps will require additional actions as outlined below.

Step 4

The customer is required to provide the SCADA information as detailed in Section 7.1.7

The customer shall submit the cubicle layout, IO points list, wiring schematic and contact details for their SCADA technician and site access. ActewAGL will conduct a radio survey of the site. ActewAGL will advise on SCADA costs (including commissioning) in the results of the Network technical study.

Step 8

Proponents proposing a programmable logic controller (PLC) or relay which has not been interfaced before will be required to provide their equipment to ActewAGL for a bench test to ensure the correct functioning of the interface between the customers equipment and the ActewAGL RTU.

Step 13

ActewAGL SCADA technicians will attend the site to field test the equipment during the commissioning of the system. The commissioning steps are part of the site acceptance test and can be made available to customers upon request.

7.5 Alterations to proposals

You must apply to us with a new *Special connection request* to:

- relocate a generator proposal
- alter the installation contractor
- alter the generator equipment proposed.

Relocations or proposals for equipment materially different from the original proposal may require ActewAGL to return to an earlier step in the connection process. For example to re-assess the Network technical study.

A *Special connection request* which is an alteration to an existing proposal should clearly state this on the comments section on the form.

The customer or business name should remain unchanged on the new *Special connection request.*

An altered proposal's eligibility for an incentive scheme should be directed to the body which administers the scheme. ActewAGL will determine the eligibility for the feed-in-tariff.

7.6 Another party acting as an agent

From time to time a customer may wish to authorise another party to deal with ActewAGL on their behalf. This may be a consultant, contractor, partner or some other party.

ActewAGL will require a written indication from the original customer authorising the agent to deal with ActewAGL in relation to that proposal.

8 OPERATION AND MAINTENANCE

8.1 Testing

All protection, control systems and equipment associated with the embedded generation system and its connection to the ActewAGL distribution network shall be tested by the installer completing the electrical work to demonstrate full and correct functionality and compliance to these guidelines prior to connection to the network. The tests shall include factory and site acceptance tests.

A test procedure for the period testing of small inverters can be found at

http://www.actewagl.com.au/about-us/~/media/ActewAGL/ActewAGL-Files/About-us/Publications/Electricity%20network%20PDFs/Periodic-PV-Inverter-Test-Procedure.ashx

Before carrying out commissioning the customer shall provide the test procedure to ActewAGL.

A test procedure for a commissioning the grid connection cubicle can be obtained from ActewAGL upon request.

Commissioning will be carried out by both the customer and ActewAGL and the commissioning date(s) will need to be agreed on at least three weeks prior to the commissioning taking place.

For the customer component of the commissioning ActewAGL may wish to attend and witness the commissioning tests of the embedded generation system's control, network connection and protection systems to verify compliance with the requirements outlined in this document. The customer shall provide at least three weeks notice of such final commissioning tests to facilitate ActewAGL personnel attendance.

Following the successful commissioning of the embedded generation installation, the customer must keep records of the final commissioning test results verifying compliance with the requirements outlined in this document and must provide ActewAGL with a certified copy of the final commissioning test results if requested by ActewAGL. However for Class 2 to 5 embedded generation installations the test results must be provided to ActewAGL.

ActewAGL component of the commissioning will include but not limited to synchronising, loss of mains (anti-islanding), loss of SCADA, loss of DC supply, reverse power (where installed) and neutral voltage displacement (where installed).

Failure to comply with the testing requirements may result in ActewAGL disconnecting the embedded generation installation from the network.

8.2 Periodic maintenance

All protection, control systems and equipment associated with the embedded generation system and its connection to the ActewAGL distribution network shall be periodically tested to demonstrate operation. For Class 1 systems, the period is at least once every 5 years.

The periodic PV inverter test procedure can be accessed via the following link.

http://www.actewagl.com.au/About-us/~/media/ActewAGL/ActewAGL-Files/About-us/Publications/Electricity%20network%20PDFs/Periodic-PV-Inverter-Test-Procedure.ashx

The inverter test declaration form and test records form can be accessed via the following link.

http://www.actewagl.com.au/About-us/~/media/ActewAGL/ActewAGL-Files/About-us/Publications/Electricity%20network%20PDFs/Periodic-PV-Anti-Islanding-Inverter-Testing%20Forms.ashx

The customer shall submit periodic test results to ActewAGL.

The owner of the embedded generation system must keep records of all such tests and provide ActewAGL with a certified copy of the test results.

If the generator disconnects due to a fault on the generator installation or alarms are activated or fails to automatically disconnect when required, the customer shall investigate the cause of the fault and rectify the problem. The customer then shall provide a full report done by a suitably qualified and experienced person to ActewAGL outlining the details of the investigation, cause of the fault, details of the rectification, changes undertaken to prevent re-occurrence and re-tests carried out. The generator will only be allowed to be re-connected once ActewAGL is satisfied the report complies with its requirements.

Where the generator fails to disconnect automatically when required or where nuisance or unexpected operations of the generator occur ActewAGL will disconnect the generator and will only allow reconnection once a satisfactory report as outlined above is submitted to ActewAGL.

Failure to comply with the testing requirements as stipulated above may result in ActewAGL disconnecting the embedded generation installation from the network.

8.3 Alteration to approved design

The owner of the embedded generation facility must not modify the approved design of the embedded generation system without informing ESDD and receiving prior written authorisation from ActewAGL.

Settings of the protection relays and control equipment must not be modified without informing ESDD and receiving prior written authorisation from ActewAGL.

Upon receipt of a written request to modify the approved design and/or settings, ActewAGL will advise the customer if it is considered necessary to undertake a new assessment on the impact on ActewAGL's network, the associated costs involved and the timeframe expected to complete the study and associated report.

Appendix A1 Generator data

A1.1 Rotating machine data

The following information shall be provided for each generator proposed to be installed:

Item	Data Description	Units
1	Type of generator	Text
2	Connection arrangement (Delta or Star/Wye)	Text
3	Rotor type (round rotor or salient pole)	Text
4	Nominal rated output	kVA, kW & kVAr
5	Nominal terminal voltage (line to neutral)	V or kV
6	Highest voltage (line to neutral)	V or kV
7	Rated lightning impulse withstand voltage	kVp
8	Rated short duration power frequency withstand voltage	kV
9	Maximum current	kA
10	Rated short time withstand current	kA for seconds
11	Ambient conditions under which Item 9 & 10 currents apply	Text
12	Synchronous reactance – D Axis (X_d)	PU
13	Synchronous reactance – Q Axis (X_q)	PU
14	Transient reactance – D Axis (X'_d)	PU
15	Transient reactance – Q Axis (X'_q)	PU
16	Subtransient reactance – D Axis (X''_d)	PU
17	Subtransient reactance – Q Axis (X''_q)	PU
18	Open circuit transient time constant – D Axis	Seconds
19	Open circuit transient time constant – Q Axis	Seconds
20	Open circuit subtransient time constant – D Axis	Seconds

21	Open circuit subtransient time constant – Q Axis	Seconds
22	Armature resistance	PU
23	Negative sequence resistance	PU
24	Locked rotor impedance (resistance and reactance)	PU
25	Zero sequence reactance	PU
26	Grounding impedance (resistance and reactance)	Ohms
27	Saturation co-efficient at 1.0PU and 1.2PU	-
28	Mechanical inertia constant	Seconds
29	Fault contribution from the generator(s) at the network boundary	kA
30	Description of the proposed voltage, active power (P) and reactive power (Q) control system including details of the operation and performance of the system under normal conditions, fault conditions, and network disturbance conditions.	Text

Where the data item unit is identified as PU it shall be the PU value calculated on a base of the generator nominal terminal voltage and nominal generator kVA rating.

A1.2 Inverter data

If inverter does not have Clean Energy Council (CEC) approval ActewAGL will require additional information such as, but not limited to compliance standards and manufacture's certification stating inverter has been tested and passed requirements of AS4777.2 and 3.

Evaluation of inverters > 30kW must include, but not be limited to the following.

- Testing standards which include the method of testing and expected results, such as:
    - inverter – type tests and routine tests
    - protection tests
    - performance tests
    - periodic tests
    - power factor tests
    - harmonic current limit tests
    - transient voltage limit tests
    - quality of supply tests.
- An evaluation of the required level of safety and performance of the inverter including, control of real and reactive power and the circuitry used, the power factor, performance degradation over time and lifetime expectancy.

- Inverter data, such as impedances, fault levels and ratings required for network technical studies.
- A risk assessment, including type and failure modes, the probability of failure, impact on personnel and public safety, network assets and quality of supply.
- Information on Australian and overseas experience (safety and operational) with a particular inverter, including details of where it was installed and operational.

Appendix A2 Meter configuration for Gross Metering < 10kW

Note: SPRINT 200 use Internal Clock to Control Load Contactor

Combinations of Meters for a 600mm x 600mm Meter Board		Meter 1	Meter 2	Meter 3
1	Single phase energy plus embedded generation	2 element SECURE	N/A	N/A
2	Single phase energy with off-peak hot water plus embedded generation	1 element SECURE	2 element SECURE	N/A
3	Single phase energy with single phase off-peak slab heating plus embedded generation	1 element SECURE	2 element SECURE	N/A
4	Single phase energy with off-peak hot water and single phase off-peak slab heating plus embedded generation	1 element SECURE	2 element SECURE	N/A
5	Single phase energy with three phase off-peak hot water plus embedded generation	2 element SECURE	SPRINT 200	N/A
6	Single phase energy with three phase off-peak slab heating and single phase off-peak hot water plus embedded generation	2 element SECURE	SPRINT 200	N/A
7	Three phase energy plus embedded generation	SPRINT 200	1 element SECURE	N/A
8	Three phase energy with single phase off-peak hot water plus embedded generation	SPRINT 200	2 element SECURE	N/A
9	Three phase energy with three phase off-peak slab heating plus embedded generation	SPRINT 200	SPRINT 200	1 element SECURE
10	Three phase energy with three phase off-peak slab heating and single phase off-peak hot water plus embedded generation	SPRINT 200	SPRINT 200	1 element SECURE

Table 5: Possible Meter Configuration for customers with micro embedded generation installations

Appendix A3 Schedule of charges

A3.1 Connection enquiry processing charges

- Class 1: Nil
- Class 2 to 5: $550 (incl GST) per installation.

A3.2 New meter installation

Refer to the *ActewAGL Electricity network schedule of charges*

http://www.actewagl.com.au/About-us/The-ActewAGL-network/Electricity-network/~/media/ActewAGL/ActewAGL-Files/About-us/Electricity-network/Electricity-network-prices/Electricity-network-prices-2012-13.ashx

A3.3 Network technical study charges by generator class

Embedded Generation Class	Network technical study charge (inc GST)
1	Nil
2	$3,960
3	$5,170
4	$8,470
5	LV Connection: ActewAGL will conduct study: $11,470 HV Connection: $13,870 (data provision only) – customer to conduct study

Table 6: Network technical study charges

A3.4 Augmentation charges

These charges will be advised by ActewAGL after receipt of the application to connect.

A3.5 SCADA commissioning

An indicative figure for these works is $5,500 (Inc GST). Site specific charges will be advised by ActewAGL after the Network technical study has been conducted.

Appendix A4 Generator connection cubicle

The connection of all new embedded generation systems greater than 60kW to the low voltage electricity network will require the applicant to install a generator connection cubicle (GCC). Embedded generators less than 60kW intending later expansion above this threshold also require a GCC. The primary purpose of this GCC is to assure ActewAGL that embedded generation installations that are connected to the low voltage electricity network do not operate as islanded generators and to provide SCADA facility to embedded generation units generally greater than 120kW. That is, the GCC is a backup protective device to the embedded generator's existing active anti-islanding circuitry. This backup arrangement will provide ActewAGL with assurance that reasonable steps have been taken to provide for the following ActewAGL prime directives.

a) The safety of personnel who work on the electricity network and to the general public;
b) To minimise asset loss-of-life, reduced performance and to prevent damage to electricity network assets;
c) Minimise disruption to all customers (quality of supply) inclusive of the applicants site; and
d) To not intentionally cause harm to the environment and to encourage development that supports the environment's ability to satisfy the needs of future generations.

The applicant has the choice of either forwarding a design proposal to ActewAGL for a GCC that offers anti-islanding backup protection and SCADA facility or to install a GCC that has been approved by ActewAGL. If the applicant wishes to design their own GCC then the design needs to comply with the performance specification as outlined below. It must be noted that the GCC belongs to and is the responsibility of the owner and not ActewAGL.

A4.1 Concept Drawings

ActewAGL can provide concept drawings for the GCC on request. These drawing will be provided on the condition that it will only assist the applicant to design their own GCC and must not be used as construction drawings.

A4.2 GCC Tests

The factory and site acceptance tests on the GCC shall be carried out by the customer. Test procedures can be obtained from ActewAGL upon request.

A4.3 Performance specification: generator connection cubicle (GCC)

A4.3.1 Introduction

The increased penetration of embedded generation in ActewAGL's LV network has created the need now for added scrutiny of every new connection to assess its impact on network operation and safety.

ActewAGL requires a GCC to be installed by the applicant. The performance specification of the GCC is as follows.

A4.3.2 Methodolgy

The installation shall be located in a prominent position near the MSB and be shall be clearly labelled and accessible 24/7 to ActewAGL and Emergency Service personnel.

The GCC applies to the following installations.

- Class 2: typically 30kW to 60kW – required where future expansion is intended (Cubicle and Circuit Breaker only)
- Class 3: typically 60kW to 120kW (Class 2 + Protection Relay + UPS)
- Class 4: typically 120W to 200kW (Class 3 + SCADA + Communication)
- Class 5: typically 200 to 1500kW (Class 4 + NVD)

To remove any ambiguity, a generator with a nameplate rating which lies on the threshold falls into the larger class. For example, a generator of exactly 120kW is considered Class 4.

These classes serve only as a guide. ActewAGL will determine the appropriate installation interface for each Special Connection Request application. However, it is important that provision be made to install all options in an installation so as to accommodate for future generation augmentation.

The installations comprise six main components as follows:

A4.3.3 Components

A4.3.3.1 The cubicle - required

The cubicle shall be designed to include the following.

- Constructed of steel and have a lockable hinged door. Locking shall be accessible by ActewAGL staff and property facility manager.
- Wall mounted (preferred) or free standing.
- Overall internal and external dimensions to be fit for purpose.
- Vermin proof, weather proof and secure to IP66. A lower IP rating may be approved for GCCs located indoors.
- Contents must not exceed their normal operating temperature range. It requires anti-condensation heater and cooling fans. If the GCC receives greater than 30 minutes of full sunlight per day during summer it will require double skinned walls.
- Opening the door will automatically activate a light that will enable the internal components and schematic diagram to be viewed clearly.
- An internally mounted GPO.
- Labeled externally to identify the purpose of the installation and show a unique location number to be provided by ActewAGL (the authorization number). Label shall be visible in low light conditions.

- Labelled internally to identify the purpose of all internal components, number secondary wiring and include a generator shutdown procedure. A schematic diagram will be shown on the inside of the hinged door.
- All secondary components including wiring shall be dead front that is, no exposed live metal.
- An externally mounted light to indicate the generator is energised.
- An externally mounted emergency manual trip button (lockable) to be located at the fire control panel, Main switchboard (MSB) and generator control panel. If the MSB is adjacent to the GCC then the trip button is only required on the GCC.
- Provision for the attachment and safe housing of ActewAGL load survey equipment. This includes having sufficient spread on entry and exit cables to allow for easy and safe attachment of split core current transformer (CT) logging equipment

A4.3.3.2 Circuit breaker (CBG) - required

The circuit breaker CBG shall be designed to include the following.

- Rated to disconnect a three phase continuous load of up to 200kW.
- Ganged four pole operation (load break fault make, neutral to be switched)
- Manually tripped.
- Manually closed (only by an authorised person, label required).
- Optional electrically tripped (by the protection relay under local fault detection conditions or remotely by SCADA when fitted).
- Optional electrically closed (by the protection relay under local fault-free conditions or remotely by SCADA subject to local fault-free conditions when fitted).
- Optional electrical interlocking (to prevent closing until protection relay status is in-service when fitted).

A4.3.3.3 Protection relay - optional

The protection relay shall be designed to include the following.

- Provision shall be made to include a protection relay that is optional.
- Make and model shall be approved by ActewAGL (presently MiComm P142).
- The protection relay will have settings approved by ActewAGL.
- The primary purpose of the protection relay is to monitor for a generator fault event and when “true” to isolate the generator by electrically tripping the generator circuit breaker (GCB).
- The protection relay shall have a self test capability (in-service or failed). A relay failure shall also trip CBG.
- The status of the protection relay shall also be made available to the building BMS system.
- Easily installed and removed (that is, easily replaced).

- Located in a prominent position such that the display is readable by a person of normal height (range 1.5m to 2m).
- Typical settings required for the P142 relay are:

  f< 49.8Hz f> 50.2Hz

  ∆f 0.2Hz in 10mins

  U< U>. 240volts volts ± 6% outside range for more than 10 mins

  ∆ U outside range above for more than 10 mins

  Rapid < U

  Cos Θ (Lagging) Range: 0.9 – Unity.

  Odd Harmonics 3rd and 9th

  UPS stability – self test failure, Battery impedance out of range – alarm only

  C/B operation

A4.3.3.4 Power supply - optional

The power supply (UPS) shall be designed to include the following.

- Provision shall be made to include a UPS that is optional. The UPS shall be installed if a protection relay is installed.
- Rated to provide an uninterruptable supply of energy to the protection relay, SCADA and communication equipment. There shall be sufficient battery capacity for a minimum of two hours without supply from the distribution electricity network.
- Easily installed and removed that is, easily replaced.
- Self test functionality and status reporting.

A4.3.3.5 SCADA (optional)

The SCADA system shall be designed to include the following.

- Provision shall be made to include SCADA equipment that is optional. The RTU will be provided, installed and maintained by ActewAGL.
- The primary purpose of the SCADA system is remote tripping of the circuit breaker CBG via the protection relay. The trip command will be initiated by ActewAGL.
- The secondary purpose of the SCADA system is to monitor the status of the circuit breaker CBG (open or close), protection relay (in-service or failed) and UPS (in-service or fail). This information shall also be made available to the building management system (BMS) system.
- The other purpose of the SCADA system is to report the status of selected protection relay fault registers.
- Easily installed and removed that is, easily replaced.

A4.3.3.6 Communications (optional)

The communications system shall be designed to include the following.

- The communications equipment shall be installed when a SCADA system is installed.
- The radio modem and the antenna will be provided, installed and maintained by ActewAGL at the customer's expense.

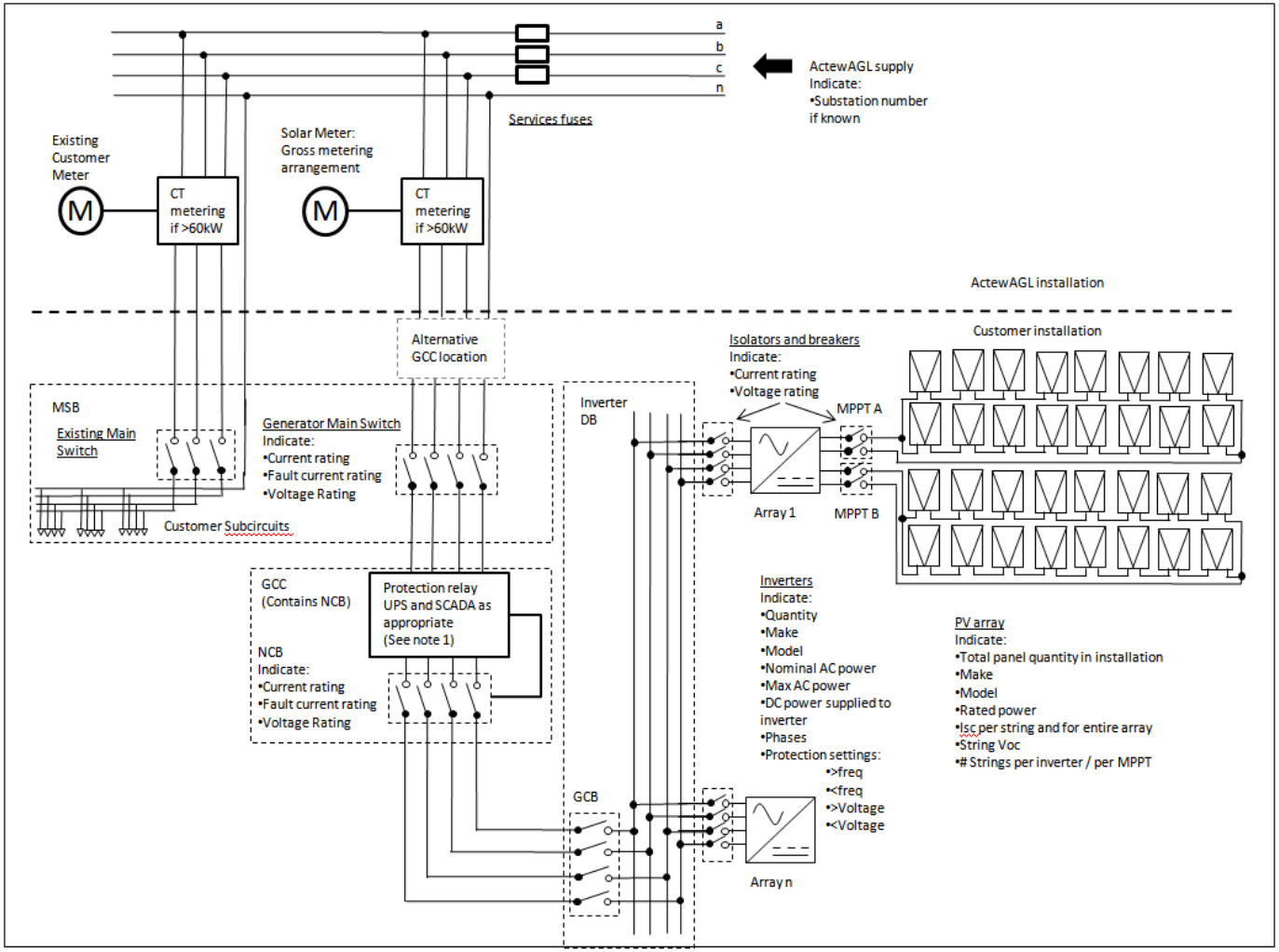
Appendix A5 Network technical study scope

The scope of the Network technical study is as follows.

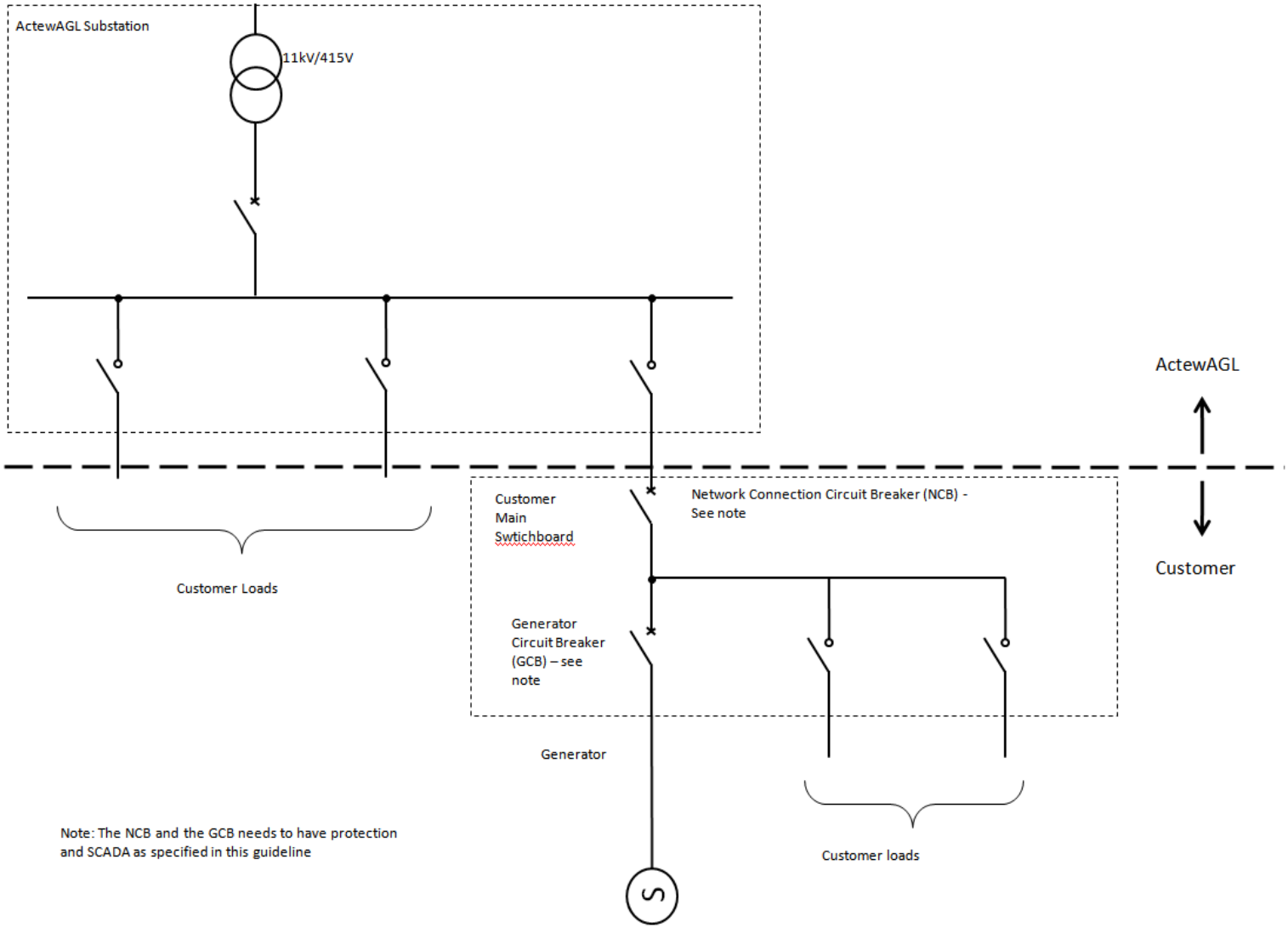
Task	Description	Procedure	Activity
1	Review enquiry Form	1	Location, capacity, voltage, connection and timing details provided?
2	Check inverter compliance to AS4777	1	CEC compliance
		2	Manufacturer's certificate available
		3	AS4777.2 & 3 compliance
		4	Witness Testing if required
3	Model LV network	1	Obtain data on connected load - minimum, maximum estimates **OR**
		2	Confirm network data - feeder and service type, length, substation details
		3	Model LV network including new connection downstream of distribution transformer
4	Network studies	1	Check 11kV feeder loading level (% thermal rating) under minimum local load demand conditions
		2	Check LV feeder loading level (% thermal rating) under minimum local load demand conditions
		3	Check distribution transformer loading level (% thermal rating) under maximum and minimum local load demand conditions
		4	Check voltage (% Vn) under minimum load at PCC
		5	Check voltage (%Vn) under maximum load at PCC
		6	Check Fault Level, kA
5	Assess risk level of islanded operation. Increased risk if at least one of checks 1 to 4 are not met	1	Check load generation match (Sinv: Sload <0.7)
		2	Check [Pinv]:[Pload] <0.8 or >1.2
		3	Check [Qinv]:[Qload] <0.8 or >1.2
		4	Number of 3-ph Inverters on LV feeder

Appendix A6 Drawings

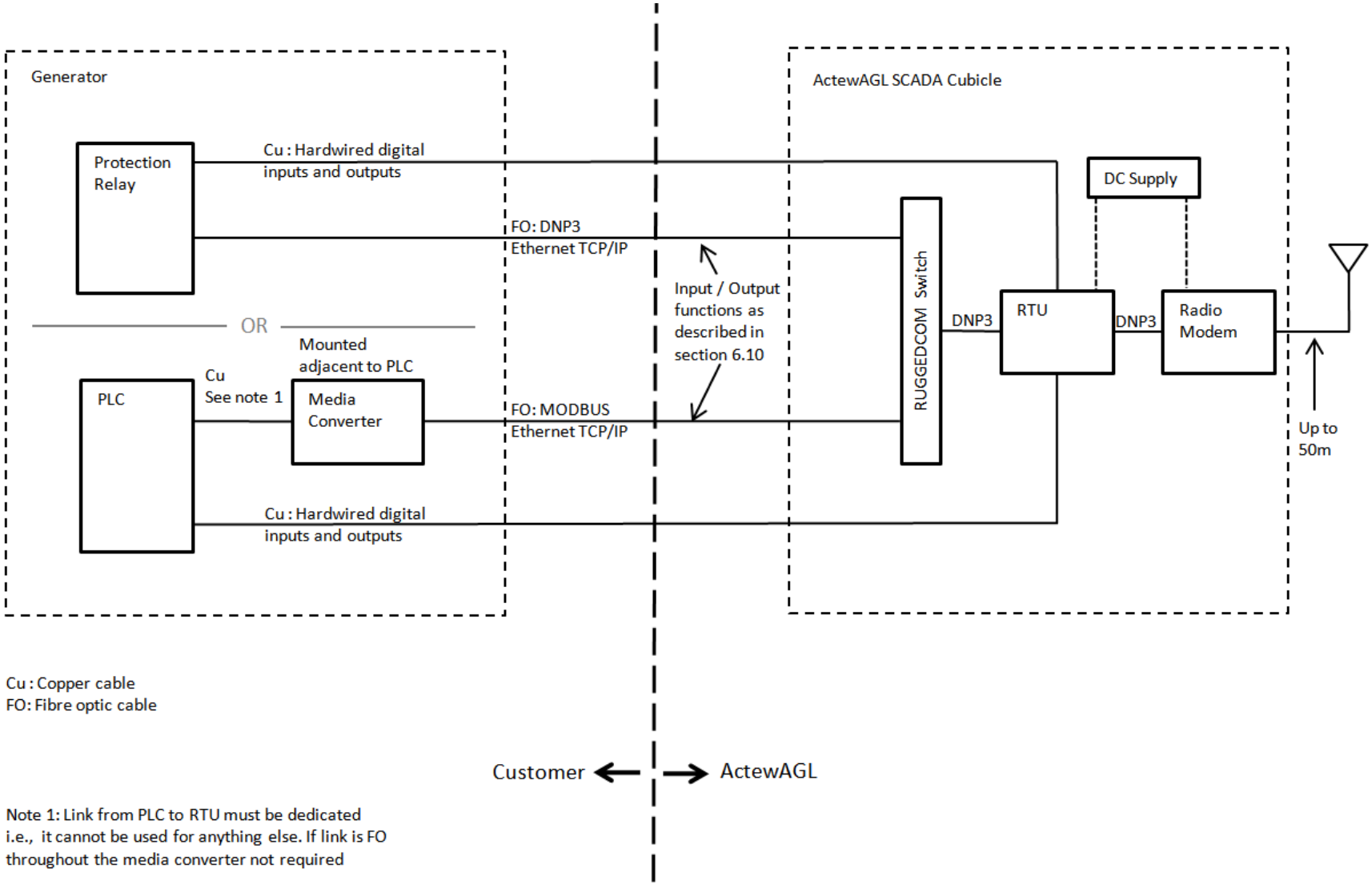
A6.1 Typical inverter based connection 30kW to 200kW (Gross metered)



A6.2 Typical Non-inverter Connection



A6.3 Typical SCADA arrangement



Cu : Copper cable
FO: Fibre optic cable

Note 1: Link from PLC to RTU must be dedicated i.e., it cannot be used for anything else. If link is FO throughout the media converter not required