Guidelines for the connection of small generators in parallel with the ActewAGL distribution network

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1 OBJECTIVE

The objective of this document is to outline to developers and other proponents of embedded synchronous generation facilities (the ***Proponent***); ActewAGL Distribution's (***ActewAGL***) requirements for the connection to, and parallel operation with, ActewAGL's distribution network.

2 SCOPE

This document outlines the requirements for embedded LV (<1000V) synchronous generators with a total nameplate rating up to but not exceeding 5MW at a single connection point; that are intended to be connected to and operate in parallel with, any part of ActewAGL's distribution network under normal operating conditions, including where the export of power is intended regardless of the network connection point being at the low voltage or high voltage of ActewAGL's distribution network.

This document does not apply to

- Small scale parallel customer generation via Inverters (refer to ActewAGL's *Guidelines for grid- connected photovoltaic installations via inverters*)
- Non-parallel back-up generation (break before make).

This document does not cover issues associated with the sale of electricity exported into the ActewAGL distribution network. This is a matter between the proponent and their selected electricity retailer.

3 BACKGROUND

The National Electricity Rules define an embedded generating unit as a generating unit connected within a distribution network and not having direct access to the transmission network.

The National Electricity Rules also identify the requirements for generating systems connected to transmission and/or distribution systems and, in part, requires that a person must not engage in the activity of owning, controlling or operating a generating system connected to the interconnected transmission or distribution system unless:

- the person is a ***Registered Participant***; or
- the person is exempt from the requirement to be a ***Registered Participant.***

AEMO has decided that small generating systems satisfying the following criteria cannot significantly affect market outcomes and/or impact on system security, and, therefore, the person owning, controlling or operating such generating systems is automatically exempt from the requirement to register as a generator/ registered participant.

- A generating system that has a total nameplate rating at a connection point of less than 5MW.
- A generating system that is not capable of exporting to a transmission or distribution system in excess of 5MW.

Notwithstanding the automatic exemption from becoming a ***Registered Participant*** under the National Electricity Rules, ActewAGL, as the Distribution Network Service Provider within the ACT, has an inherent obligation to ensure that such embedded generation facilities do not cause a material degradation in the quality of supply to other network users and do not adversely affect operation of the distribution network itself. This document outlines ActewAGL's minimum requirements to ensure these obligations are met.

4 APPROVALS

Developers and other embedded generation facility proponents must not connect embedded generators in parallel with any part of ActewAGL's distribution network until ActewAGL has provided written approval for the connection.

The proponent shall lodge a network connection enquiry. Upon receipt of the enquiry ActewAGL will prepare a response to the proponent. Details of the connection enquiry and ActewAGL's response are outlined in clause 6.

ActewAGL will not approve a prospective embedded generation facility until a complete and correct technical submission has been provided by the Proponent in accordance with Sections 5 and 6 below and a detailed analysis of the distribution network has been undertaken to establish the impact, if any, of the generator on the existing network. ActewAGL reserves the right to request the Proponent to modify the design specifications and intended operational practices for the purpose of limiting the adverse impacts of the embedded generation facility on the ActewAGL distribution network and other customers.

ActewAGL approval and acceptance of a proposed embedded generation facility shall only relate to the connection to, and parallel operation with, ActewAGL's distribution network. All other legislative and/or regulatory approvals required by ACTPLA, NCA, other ACT or Commonwealth Government agencies and/or other statutory bodies shall be the responsibility of the Proponent.

Where the proposed generation facility will require the installation of new distribution network infrastructure and/or augmentation of existing network infrastructure, ActewAGL will normally require that the need for, and scope of, such ActewAGL network infrastructure works be incorporated into the Proponent's planning and development approval application for the embedded generation facility. In this regard, the proponent should be aware that as the final ActewAGL electricity network infrastructure scope of work cannot typically be confirmed until the network analysis and detailed design have been finalised; submission of a revised planning/development approval application maybe necessary if ActewAGL requirements are not, or cannot be, established prior to the initial planning/development approval application.

Irrespective of ActewAGL's technical approval for the connection of a proposed embedded generation facility, the ActewAGL infrastructure works associated with that facility will not be able to commence until ACTPLA/NCA planning/development approval for the works, where applicable, has been confirmed in writing to ActewAGL.

5 TECHNICAL REQUIREMENTS

5.1 Permissible generator connection arrangements

Where a proponent intends to establish and operate an embedded generator in parallel with any part of ActewAGL's distribution network, an indirect Network Connection via the Customer's Installation is required irrespective of whether the export of power is intended. Connection of an embedded generator directly to ActewAGL's distribution network is not permitted because of the increased potential for harmonic and voltage regulation problems to adversely impact on other customers connected within the distribution network.

If the network connection point is at ActewAGL's LV network the generator connection shall occur indirectly at a main or other switchboard within the customer's LV installation and shall only be acceptable where the customer's LV installation is connected and supplied from a ***dedicated*** ActewAGL substation transformer. This will typically be appropriate where local customer load is to be supplied from the embedded generation facility under normal operating conditions. Typical applications may include:

- Cogeneration facilities
- Peak load lopping generators

- Loads requiring high reliability/no break power supply

However, to minimise the potential for adverse impact on the quality of electricity supply to other network customers, the following limitations shall apply for this connection arrangement:

- ActewAGL will not provide LV circuit ties between the dedicated transformer / LV circuit incorporating the embedded generator network connection point and adjacent transformers or substations.

- Only local load associated with the proponent's own installation shall be supplied from the section of the customer's installation that is supplied from the embedded generator. The connection of other customer loads to the dedicated substation or transformer as applicable shall not be permitted. Where this results in a requirement for additional network equipment or infrastructure, the total cost of such equipment/infrastructure shall be borne by the Proponent.

  If the embedded LV generation facility is proposed to connect to the ActewAGL distribution network at an existing transformer or substation, any existing non-local customer loads must be relocated to other network supply sources. The total cost of such works shall be borne by the proponent.

- The Proponent shall be required to, as part of the network connection agreement that must be established under section eight below, indemnify ActewAGL and accept liability for supply quality issues that occur when the generator is operating. ActewAGL shall provide supply to local customer loads on a no-risk basis. This requirement shall apply to all loads that are connected on the customer side of the network Boundary and which can be supplied from the generator.

Notwithstanding the above limitations, connection to, and parallel operation with, any part of ActewAGL's network shall be subject to achieving compliance with the requirements outlined in this document at each point capable of paralleling the generator with ActewAGL's LV distribution network.

Furthermore, in accordance with this document and ActewAGL's Electricity Network Service and Installation Rules, the proponent shall ensure that where an embedded LV generator connects within the customer's installation and supplies only part of the customer's installation:

- Adequate mechanisms are provided to ensure that paralleling of ActewAGL substation transformers from within the customer's installation cannot occur; and/or
- The generator cannot be connected to the ActewAGL LV distribution network without synchronisation and the associated protection systems.

5.2 Network connection point

The Proponent shall provide a means of isolation within the customer's electrical installation that is capable of disconnecting the whole of the embedded generation facility and associated customer installation from the ActewAGL distribution network.

This means of isolation must be lockable in the open position only by a separate padlock, such as an ActewAGL padlock, without reliance on other mechanisms.

5.3 Generator control

5.3.1 Synchronising

The generator shall incorporate automatic synchronising for the following.

- Connection of the generator in parallel with the ActewAGL distribution network.
- Connection and reconnection of an islanded customer installation to the ActewAGL distribution network.

The synchronising control settings shall be such as to maintain both steady state and transient voltages at the network connection point within the normal accepted operating limits.

The generator shall parallel with the ActewAGL distribution network without causing voltage fluctuation at the network connection point greater than +/- 4%.

Circuit breakers used for paralleling shall be rated for this duty.

5.3.2 Power system frequency variation

The generator shall operate with a nominal frequency of 50Hz and must be able to operate safely in the Normal Operating Frequency Excursion Band as specified in the Power System Security and Reliability Standard, which is produced by the AEMC reliability panel. Operating frequencies are also published by AEMO in System Operating Procedure SO_OP3151, *Control of power system frequency and time error*.

5.3.3 Voltage and reactive power control

Generators shall have adjustable kW, kVAr and voltage control. Automatic control of the generator shall ensure that voltage, kW and kVAr at the network connection point are maintained with the limits nominated by ActewAGL.

The required limits will be determined by ActewAGL at the detailed design stage after the detailed network studies have been undertaken.

Voltage variations can occur on a distribution network for a variety of reasons and are unavoidable. Variations can include the following.

- Voltage dips on one or more phases associated with network faults.
- Voltage rises on one or more phases associated with network faults.
- Voltage variations associated with tap-changer operations, variation in customer loads, sudden load changes resulting from switching operations, temporary HV or LV network reconfiguration.

The Proponent shall be responsible for ensuring that the embedded generator is able to operate safely without adversely affecting the ActewAGL distribution network under the conditions prevailing at the network connection point.

5.3.4 Frequency and load control

The generator control system shall incorporate appropriate controls to ensure that the generator can respond without overshoot to changes in system frequency and/or sudden changes in load. The generator active power output shall not respond to frequency variation.

The Proponent shall demonstrate by carrying out appropriate tests that the governors and automatic voltage regulator components of the generator control systems are adequate for maintaining steady state stability for the intended loading and excitation control to cater for load fluctuations and network switching operations in order to avoid disturbances to other customers connected to the network and maintain acceptable voltage control.

5.4 Quality of electricity generated

In general the Australian Standard on voltage disturbance limits (AS61000 series) shall apply to embedded generation facilities.

Accordingly, the generator shall not produce at any network connection point with the ActewAGL distribution network:

(a) Voltage fluctuations greater than the lesser of the acceptance levels determined in accordance with stage 1 or stage 2 procedures defined in AS/NZS 61000.3.7:2001.

(b) Harmonic voltage distortion greater than the lesser of the acceptance levels determined in accordance with stage 1 or stage 2 procedures defined in AS/NZS 61000.3.6:2001.

(c) Voltage unbalance greater than the levels defined in S5.1a.7 and table 5.1a.1 of the National Electricity Rules.

The generator shall also comply with AS 1359.101 and IEC 60034-1 for harmonic voltage distortion.

5.5 Protection systems

5.5.1 Protection system design philosophy

ActewAGL, similarly to other network service providers, utilises a main and backup protection system design philosophy to ensure that all credible faults are detected and cleared. The protection schemes shall be designed to include sufficient redundancy within both the primary and secondary system equipment to ensure that a faulted element within the protection zone is disconnected from the network, within the applicable fault clearance times, with any single protection system element out of service.

The proponent shall adopt the same main and backup protection system design philosophy to ensure that faulted elements are disconnected from the generator source.

The proponent shall utilise fail safe generator tripping design logic to cater for low DC or UPS battery voltage conditions.

5.5.2 Islanding

Network islanded mode

Embedded generators must not be able to operate in ***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 CB trips but the generator network connection CB 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 proponent 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:

- 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.

Appendix B contains typical schemes for anti-islanding protection.

Customer islanded mode

Operation of embedded generators in ***Customer 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.

5.5.3 Minimum protection system requirements

In addition to the protection systems installed specifically for protection of the generator itself, the Proponent shall install protection systems that:

- Prevent the generator connecting with 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 with 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) and/or SCADA communication links.
- 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.

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

Typical ActewAGL feeder automatic reclosing practices (where installed) are as follows although the Proponent 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 2.5 seconds and 10 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 1 and 3.

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

An embedded generator shall be prevented from attempting to automatically synchronise and reconnect to the ActewAGL distribution network for at least sixty (60) seconds after the network supply has been restored.

To achieve compliance with the above requirements the following protection schemes shall be installed and configured appropriately. The protection system requirements identified below are necessary to protect and limit interference to ActewAGL's distribution network and the other network customers supplied from that network. They are not intended to identify the requirements necessary for protection of the generator installation itself, which shall remain the responsibility of the Proponent.

Loss of mains protection

Where parallel operation of the generator is intended, Loss of Mains 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 will normally be the main protection scheme against network islanded operation of the embedded generator. Refer to Appendix B for backup protection requirements.

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; ie 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.

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.

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.

Negative sequence voltage & 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.

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 OCEF 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 Proponent can demonstrate that voltage depression at the generator during fault events will not adversely impact on protection scheme operation.

Neutral voltage displacement protection

Where the export of power is intended, 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 Proponent.

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 (Refer Section 5.10 below). The Proponent will be required to supply and install the NVD protection relay and associated equipment / wiring within the embedded generation facility.

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.

INTERTRIP

ActewAGL will advise the proponent if intertrip is required as a back up to loss of mains protection.

SCADA communications link integrity protection

To facilitate basic monitoring and control of the embedded generation facility by ActewAGL as outlined in Section 5.10 below, 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, 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.

Battery / battery charger and/or UPS integrity protection

To ensure all protection and control systems are capable of operation when the generator is operating in parallel with ActewAGL's distribution network, the generator must be automatically disconnected from the ActewAGL distribution network and any local customer loads and must not be reconnected to the network in the event of a supply failure to any of the generator and associated network connection point protection and control system equipment.

5.6 Primary and secondary protection system equipment

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

The network connection CB and any other CB intended to be a synchronising point must be certified by the manufacturer as being suitable for the generator duty/application.

5.7 Fault levels

The operation of an embedded generator in parallel with the ActewAGL distribution network can increase fault levels beyond the rating of existing installed equipment / infrastructure.

Accordingly, ActewAGL's detailed network analysis for a proposed embedded generation facility will include an assessment of the increased fault levels in relation to:

- ActewAGL existing or standard equipment / infrastructure;
- Adjacent customer installations;
- Protection system requirements / impacts.

The Proponent will be required to fund the total cost of all primary and/or secondary system equipment upgrades required to accommodate the increased fault levels that will result from the installation of the embedded generator.

In some circumstances it may be necessary for the Proponent to install fault current limiting equipment within their embedded generation facility.

5.8 Feeder ratings

The installation and operation of an embedded generator in parallel with the ActewAGL distribution network can increase the load flow within the distribution network above the capacity of the existing installed equipment / infrastructure.

Accordingly, ActewAGL's detailed network analysis for a proposed embedded generation facility will include an assessment of the increased load flow within the ActewAGL distribution network.

The Proponent will be required to fund the total cost of all network augmentation necessary to accommodate the increased load flows that will result from the connection of the generator. The Proponent may also be required to fund the total cost of additional power flow monitoring equipment at other locations in the HV distribution network if monitoring of network load flows becomes necessary due to the installation of the embedded generator.

In some circumstances, it may be more appropriate or practical to limit the export capability of the embedded generation facility to the capacity level of the existing infrastructure; and if this is the case, the Proponent will be required to install power export limiting protection systems.

5.9 Generator earthing

The embedded generation facility earthing shall comply with AS 3000, ACTPLA requirements and ActewAGL's Electricity Network Service & Installation Rules. The earthing system shall be designed to achieve safe step and touch potential arising from earth potential rises during fault conditions. External services shall be suitably electrically isolated to avoid hazardous transfer potentials.

Where it is proposed that the neutral of the generator will not be solidly earthed, the proponent shall be required to identify their proposed method of detecting phase to neutral faults and limiting neutral/earth voltage rise, especially where customer islanded operation is intended.

5.10 Monitoring & control (SCADA)

The Proponent shall provide the following remote monitoring and control functions, for each generator and/or network connection point, as applicable, to the ActewAGL Electricity Networks System Control Centre:

I/O Function (Refer Note 1)	**Power Export**	**No Power Export**
Network Connection 3 Phase Current (Amps)	M	NR
Network Connection 3 Phase Voltage (Volts)	M	NR
Network Connection Real Power Export (kW)	M	NR
Network Connection Reactive Power Export (kVAR)	M	NR
Network Connection Power Factor	M	NR
Generator Real Power Output (kW)	M	NR
Generator Reactive Power Output (kVAr)	M	NR
Generator Status (Running / Not Running)	M	M
Generator CB Status	M	M
Generator CB Protection Operated Alarm	D	D
Generator CB Fail Alarm	D	D
Network Connection CB Status	M	M
Network Connection CB Protection Operated Alarm	D	D
Network Connection CB Fail Alarm	D	D
Intermediate CB Status (Refer Note 2)	M	M
Intermediate CB Protection Operated Alarm (Refer Note 2)	D	D
Intermediate CB Fail Alarm (Refer Note 2)	D	D

Network Connection CB CLOSE Command by Generator (via Sync-Check Relay)	M	D
Battery &/or UPS Battery Low Volts / Fail Alarm (Refer Note 3)	D	D
Protection Intertrip Link Fail Alarm. (If intertrip installed)	M	M
Communications Link Fail Alarm.	M	M

Note 1: M – Mandatory / D – Desirable / NR – Not Required

Note 2: 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 3: This I/O point is required for batteries / UPS' providing generator & network connection protection/control and CB tripping supplies.

ActewAGL shall provide and the Proponent 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 as applicable.

I/O Function	**Power Export**	**No Power Export**
Network Connection CB Emergency Trip / OFF Command by ActewAGL. (Refer Note 2)	M	M
Network Connection CB Inhibit / Permit Close Command by ActewAGL. (Refer Note 2)	M	M
ActewAGL Feeder / Protection Intertrip Command (if intertrip installed)	M	M

Note 1: M – Mandatory / D – Desirable / NR – Not Required

Note 2: The Network connection CB Emergency Trip/Off and Inhibit / Permit Close must all be applied to the same CB.

The above three signals shall be electrically interlocked with the Generator controls to prevent the generator connecting to ActewAGL's network without ActewAGL authorisation.

The above I/O points are to be provided by the embedded generation facility proponent or ActewAGL, as applicable, in the following signal format to a Generator Interface Cubicle that will typically be located within the ActewAGL substation nearest to the network connection point.

- Analogue Values shall be provided as 0 – 5mA or 0 – 10mA signals.
- Digital Points shall be provided as voltage free contacts with the provision for a voltage signal of up to 240VAC/DC able to be applied.

ActewAGL shall supply and install the Generator Interface Cubicle and all associated terminals, fittings, signal isolation transducers and internal cubicle wiring. The Proponent shall be responsible for the supply and installation of all I/O cabling and wiring between the embedded generation facility and the Generator Interface Cubicle.

ActewAGL shall also supply and install all necessary ActewAGL remote monitoring and control (SCADA) equipment and associated equipment, fittings and wiring, as required, to interface with the ActewAGL Electricity Network System Control Centre.

ActewAGL shall terminate the Proponent supplied I/O cabling/wiring at the Generator Interface Cubicle. The terminals within the Generator Interface Cubicle shall be the monitoring and control system interface boundary between ActewAGL's network and the customer's embedded generation facility.

The Proponent will be required to fund the total cost of all ActewAGL remote monitoring and control works required to provide the above remote monitoring and control functions to ActewAGL Electricity Networks System Control Centre.

5.11 Metering

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

Proponent's expense. The metering point shall be within the customer's installation and be as close as practical to the network connection point.

Where the export of electricity is not intended, reverse power blocking shall be installed.

In accordance with the National Electricity Rules, metering (Class 0.5 accuracy) may also be installed to record the output of the embedded generator only.

Meter locations shall comply with the requirements of the ActewAGL Electricity Network Service and Installation Rules.

The Proponent of the embedded generation facility is responsible for engaging an accredited metering service provider and has the right to engage any appropriately accredited metering service provider where the total anticipated energy flow through the metering point (both export and import) exceeds 160MWh per annum.

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.

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.

Where the local customer load energy consumption and the embedded generation are connected to ActewAGL Distribution under one National Electricity Market Identifier (NMI), the generation energy and the local customer load energy can be offset against each other.

Where the export of electricity is intended and approved by ActewAGL the exported energy will be credited with the avoided Transmission Use of System (TUOS) component of the network charges.

Both the network connection point import/export meter and the generator output meter must be National Metrology Procedure and National Electricity Rules compliant interval type meters. This requires that the meters be interval type meters with 30 minute intervals. Energy flow (including both import and export where applicable) must be recorded for each 30 minute period.

5.12 Labelling

The customer's main switchboard and any other switchboard as applicable to the generator connection arrangement shall be provided with a notice in accordance with the requirements of Clause 5.5 of the ActewAGL Electricity Network Service and Installation Rules.

6 INFORMATION TO BE SUBMITTED WITH CONNECTION ENQUIRY AND GENERATOR CONNECTION APPLICATION

As indicated in Section 4 above, ActewAGL approval of a proposed embedded generation facility can not be provided until a network connection enquiry and complete and correct connection application has been provided by the Proponent; and a detailed analysis of the distribution network has been undertaken to establish the impact, if any, of the generator on the network.

The information to be provided with the network connection enquiry shall be as outlined in Schedule 5.4 of the National Electricity Rules. In addition to this the following is required:

- Is the export of power a possibility at any time
- Will generators run when the network is down to provide emergency supply
- A map indicating the exact location of each generator proposed.

On receipt of the connection enquiry ActewAGL will assess the suitability of the network to accept the proposed generator and prepare a response to the proponent. The response will include:

- Technical/performance requirements
- Technical data requirements
- Preliminary program
- Estimate of application fee (refer to Clause 9.1)
- Commercial requirements
- Access standards
- A listing of information that the proponent shall prepare to enable ActewAGL to fully assess the application to connect

This section outlines the minimum requirements for the technical submission component of the Connection Application including the generator attribute data that ActewAGL will require in order to undertake the detailed network analysis necessary to assess the impact of the generator on the existing distribution network.

The Proponent shall submit the following technical information as part of their Connection Application:

(a) Detailed description of the proposed embedded generation facility; including, but not limited to:
   - Number of generators
   - Proposed operating mode(s) - ie peak load lopping, continuous operation, seasonal operation etc.
   - Proposed interaction with ActewAGL's distribution network under both normal network conditions and abnormal network conditions.
   - Proposed local customer loads to be supplied from the embedded generation facility.
   - Requirement for ***Customer Islanded*** operation. Note ***Network Islanded*** operation is not permitted. Refer Section 5.5.2 above.
   - Power export intentions – refer also items (b) and (c) below.
   - Known future staging / development of the embedded generation facility and/or local customer loads.

(b) 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.

(c) 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.

(d) Site Plan showing the precise physical location of the embedded generator, the location of customer main switchboards and other relevant switchboards and the location of ActewAGL substations and associated infrastructure.

(e) 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.

(f) 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.

(g) 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.

(h) Generator data for each generator proposed to be installed as listed in Appendix A.

(i) Full details of the proposed metering equipment and associated current transformers.

(j) 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.

Sufficient detail must be provided to enable ActewAGL to assess compliance with the minimum requirements outlined in this document, and conduct protection and load flow studies to assess the impact on plant fault ratings, protection scheme requirements and power export limits of existing infrastructure; and assess generator power factor and voltage limit requirements.

7 OPERATIONS & MAINTENANCE

7.1 Initial testing & commissioning

All protection and control systems and equipment associated with the embedded generator and its connection in parallel with the ActewAGL distribution network shall be tested to demonstrate compliance of the installation to this document prior to connection with the network. All such testing and commissioning activities shall be undertaken by a suitably experienced party with the requisite skills and competencies.

ActewAGL reserves the right to attend and witness the final commissioning tests of the generator control, network connection and protection systems to verify compliance with the requirements outlined in this document. The Proponent shall provide at least seven days notice of such final commissioning tests to facilitate ActewAGL personnel attendance.

Following the successful commissioning of the embedded generation facility, the Proponent shall provide to ActewAGL a certified copy of the final commissioning test results verifying compliance with the requirements outlined in this document for ActewAGL's records.

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

7.2 Maintenance

All protection and control systems and equipment associated with the embedded generator and its connection / operation in parallel with the ActewAGL distribution network shall be tested to demonstrate correct operation at least once every three (3) years.

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

Failure to comply with the maintenance requirements may result in ActewAGL disconnecting the generator installation from the network.

7.3 Alteration to approved design

The owner of the embedded generation facility must not significantly or materially modify the approved design of the embedded generation facility without prior written authorisation from ActewAGL.

Settings of the protection relays and control systems/equipment and associated wiring must not be modified without prior written authorisation from ActewAGL.

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

8 NETWORK CONNECTION AGREEMENT

ActewAGL requires that, in addition to the approvals outlined in Section 4 above, the Proponent / Owner of the proposed embedded generation facility must enter into a Network Connection Agreement with ActewAGL Distribution in relation to the connection of the embedded generation facility to the ActewAGL distribution network.

Commissioning and connection of the embedded generator in parallel with the ActewAGL distribution network shall not be permitted until this Agreement is in place. It is desirable that this agreement be finalised and signed by the duly authorised representatives of both parties at least one month prior to the intended commissioning date.

ActewAGL will prepare and forward a draft Network Connection Agreement following the receipt of the Proponent's full and complete Connection Application.

9 FEES & CHARGES

9.1 Connection application fee

Submission of the Embedded Generation Connection Application must be accompanied by payment of the Connection Application Fee.

This fee covers the costs incurred by ActewAGL in undertaking the following:

- Receipt and processing of the Connection Application and liaison with the Proponent in regards to the completeness of the information provided;
- Detailed network analysis and assessment of the generator proposal as detailed in the Connection Application;
- Preliminary design and cost estimates for any new distribution network infrastructure or network augmentation necessary to accommodate the proposed generator;
- Preparation of a draft Network Connection Agreement; and

- Preparation of ActewAGL's Final Offer to Connect.

ActewAGL will confirm the Connection Application Fee amount in its response to the Proponent's Embedded Generation Preliminary Connection Enquiry.

9.2 Capital contributions

The Proponent is required to contribute the total cost of the infrastructure (both primary and secondary systems) necessary to accommodate the connection of the embedded generator to the ActewAGL distribution network.

Depending on the specific connection arrangements the Proponent will be required to contribute the following:

- The total cost of all ActewAGL substation primary equipment dedicated to the embedded generation facility's network connection point including but not limited to: HV switchgear, transformers, switchgear and all associated cabling and wiring.
- The total cost of all ActewAGL protection scheme (secondary systems) equipment at or adjacent the network connection point necessary to accommodate the generator's connection to ActewAGL's distribution network including but not limited to: protection relays, voltage transformers, current transformers and all associated auxiliary supplies, fixtures, fittings and cabling/wiring.
- The total cost of the ActewAGL SCADA monitoring and control facilities at or near the connection point including the Generator Interface Cubicle. Where ActewAGL would have normally established SCADA facilities at the network connection point irrespective of the proposed generator connection, the Proponent will only be required to contribute the total cost of the additional equipment, auxiliary supplies, fixtures, fittings and associated wiring / cabling that are necessary for the embedded generation facility. In this regard, Proponents of embedded generation facilities are advised that ActewAGL does not normally provide remote monitoring and control facilities at its distribution network substations; and, therefore, the Proponent can normally expect to bear the total cost of all SCADA facilities.
- The total cost of power flow monitoring within the adjacent HV distribution if it is considered necessary for effective infrastructure capacity management as a result of the embedded generation facility connection.
- The total cost of ActewAGL's SCADA system and associated equipment configuration as necessary to incorporate the Embedded Generation Facility into ActewAGL's Electricity Network System Control System.
- The total cost for ActewAGL to terminate the embedded generation facility's remote monitoring and control cabling and wiring at the ActewAGL Generator Interface Cubicle.
- The total cost of any upgrade or augmentation of existing primary network infrastructure required to accommodate the new generator connection.
- The total cost any additional or upgraded distribution network protection scheme (secondary system) equipment and associated cabling/wiring at ActewAGL's Zone Substation and/or other locations within the distribution network as necessary to accommodate the generator connection and operation in parallel with the ActewAGL distribution network.
- The total cost of a SCADA communications link between the network connection point and ActewAGL's System Control Centre as necessary to accommodate the remote monitoring and control of the embedded generation facility and its connection in parallel with the ActewAGL distribution network.
- The total cost of any intertrip communications link between the network connection point and the ActewAGL zone substation, if installed, to accommodate the generator connection and operation in parallel with the ActewAGL distribution network.

ActewAGL will provide a preliminary scope of work and "indicative budget only" cost if requested, in its response to an Embedded Generation Preliminary Connection Enquiry. It must be noted,

however, as the detailed network analysis will not have been undertaken at this preliminary stage any such preliminary scope of work and "indicative budget only" cost will include only the anticipated network connection point works; and not any network augmentation that may be identified as a result of the detailed network analysis.

ActewAGL will provide a firm offer (quotation) when the final scope of work has been confirmed at the completion of the detailed network analysis and any subsequent negotiations with the Proponent.

Payment of the quoted capital contribution will signify the Proponent's acceptance of ActewAGL's offer and will be required before any detailed design, equipment / material procurement action and/or works onsite will be initiated.

10 OTHER PARTY INVOLVEMENT

10.1 AEMO & transmission network service provider

In accordance with the National Electricity Rules, embedded generation facilities with a rating or export capability of 5MW or less *DO NOT* normally require the notification, involvement and/or approval of either AEMO or the Transmission Network Service Provider (nominally TransGrid) as part of ActewAGL's response to a request to connect an embedded generation facility in parallel with the ActewAGL distribution network.

10.2 Power purchase agreement

Where an embedded generation facility proponent intends to export electricity into the ActewAGL distribution network, the Proponent must, prior to commencing the export of electricity, enter into an ***Electricity Purchase Agreement*** with a registered Retailer in the ACT for the sale of the electricity exported into the distribution network. A listing of registered Electricity Retailers in ACT can be obtained from the ICRC website (www.icrc.act.gov.au).

The Proponent is advised, however, that should they establish an ***Electricity Purchase Agreement*** with a Retailer other than the host retailer for the ACT, they may need to confirm the requirements of the National Electricity Rules as it is ActewAGL's understanding at the time of preparing this document that registration with AEMO may be required under such circumstances.

The ***Electricity Purchase Agreement*** is separate to and independent of the network connection arrangement with ActewAGL Distribution as the "Networks" business. Ring fencing provisions apply to ActewAGL Distribution and its relationships with electricity retail businesses.

APPENDIX A – Generator 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	Rate 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 & Reactance)	PU
25	Zero Sequence Reactance	PU
26	Grounding Impedance (Resistance & 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.

Appendix B – Typical schemes for anti-islanding protection

	Generator Exporting	Generator Not Exporting
Main Scheme	Loss of Mains (eg frequency or voltage based)	Loss of Mains (eg frequency or voltage based)
Backup Scheme	Negative Sequence Voltage & Current plus Neutral Voltage Displacement plus Reverse Power set at export limit	Reverse Power set at nil export plus Negative Sequence Voltage and Current