AE-NR04-S

LSDG Connection Standard

Version 1.0

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I Document Control

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II Approval and Revision History

Version	Date	Revision Notes
1.0	01/04/2021	

For submitting feedback or a change request refer to the Aurora Energy Controlled Document System homepage.

III External References

Reference Code	Title
AS/NZS 3010	Electrical Installations – Generating sets
AS/NZS 61000	Electromagnetic compatibility (EMC)
AS/NZS 4777	Grid connection of energy systems via inverters
AS/NZS 3000	Electrical installations (Australian / New Zealand Wiring Rules)

1 Introduction

1.1 Purpose

This document covers Aurora Energy's requirements for the connection of Large Scale Distributed Generation (LSDG) with a maximum export capacity >10 kW, including inverters connected to energy sources or energy storage systems, that can connect to and operate in parallel with the Aurora Energy distribution network.

The document provides information to help the approval process for LSDG, it is intended as a comprehensive guide to enable acceptable connection applications. Each LSDG installation is unique with requirements changing depending on type, capacity and location; applications require assessment by the engineering team and conditions may be imposed on earthing, protection or power export.

1.2 Scope

This document covers generators that are designed to connect to and operate in parallel with the Aurora Energy network. It includes standby generators designed to synchronise with the Aurora Energy network, for a short time, to facilitate a no-break transfer of load on network supply restoration.

Generators at installations that are not designed to operate in parallel with the Aurora Energy network shall have changeover facilities that comply with the requirements of AS/NZS 3010 which will ensure such generators cannot be connected to the Aurora Energy network.

1.3 Definitions

Aspect	Definition
Distributed Generation	Electrical generation facility capable of operating in parallel with the Aurora Energy network
Safety Manual Electricity Industry	This document defines the requirements for safety in New Zealand Electricity Generation Transmission and Distribution Industry

1.4 Acronyms

Short Form	Long Form
LSDG	Large Scale Distributed Generation
HV	High Voltage
MV	Medium Voltage
LV	Low Voltage
DG	Distributed Generation
EGR	Electricity Governance Rules
NVD	Neutral Voltage Displacement
PCC	Point of Common Coupling
SM-EI	Safety Manual Electricity Industry
PV	Photo Voltaic

2 Connection methods

Only induction generators and inverter connected generation with a capacity up to 30kVA are permitted to connect directly to the Aurora Energy low voltage network. All other connections shall be to the MV or HV networks via a transformer.

All LSDG connections shall be three-phase.

Synchronous generators can connect to the HV network either directly or via a transformer. Direct HV connection is not recommended due to the possibility of excessive generator damage if the generator should develop an earth fault. All connections to the 33kV and 66kV networks must be via transformers.

All DG installations connected to the Aurora Energy network, where the primary purpose is to export energy into the Aurora Energy network, shall be connected via a circuit breaker on the Aurora Energy side of any generation transformers.

3 Network capability issues

3.1 Network Congestion

Aurora Energy will determine if the connection of the proposed DG will result in thermal ratings of Aurora Energy's equipment being exceeded under all expected operating conditions. If equipment ratings will be exceeded, then network upgrades will be required to accommodate the DG or alternatively it may be possible to avoid equipment overloads by imposing operating constraints on the DG e.g. restricting generator output during circuit outages or under certain loading conditions.

3.2 Power Factor

Distributed generation may reduce the load power factor at Transpower grid exit points. This can result in penalty charges from Transpower and non-compliance with the EGR. If the power factor is unacceptable then the cost of Transpower penalty charges or the cost of installing power factor correction will be allocated to the generators that are causing the problem.

3.3 Upstream Voltage Regulators

If the DG site has an HV neutral earth reference and is connected to a three-phase HV feeder supplied by voltage regulators, then the voltage regulator must consist of a three-phase regulator or three single-phase units controlled to have each unit on the same tap. This is necessary to avoid circulating zero sequence currents that can cause the mal-operation of earth fault protection

3.4 Ripple Signal Absorption

Aurora Energy operates ripple injection systems on its network. Generation can result in a reduction in the ripple signal level. If ripple signal reduction to an unacceptable level results from the connection of new generation then the owner of the generation will be required to fund mitigation measures.

4 General Requirements

4.1 Fault Levels

The connection of DG shall not result in the fault rating of any Aurora Energy equipment being exceeded. The normal design fault level on Aurora Energy's 6.6kV, 11kV, 33kV and 66kV networks is

25kA but in certain 11kV and 6.6kV areas there may be equipment with a lower rating (usually dropout fuses with a 13kA rating). The equipment within the DG installation must be capable of withstanding the fault current supplied by the DG and the Aurora Energy network.

4.2 Voltage Regulation

The DG shall not actively regulate the voltage at the PCC. The DG shall not cause the voltage at other installations on the Aurora Energy's network go outside the range specified in the Electricity Regulations.

4.3 Voltage Fluctuations

The DG shall not create objectionable flicker for other customers connected to the Aurora Energy network. Flicker is considered objectionable if the limits prescribed in AS/NZS 61000 are exceeded at the PCC.

4.4 DC Injection

The DG and its interconnection system shall not inject a dc current greater than 0.5% of the full rated output current of the generation at the point of DG connection.

4.5 Harmonics

The harmonics introduced into the Aurora Energy network by any generation installation shall not exceed the limits defined in NZECP36 "New Zealand Code of Practice for Harmonic Levels"; the total harmonic voltage distortion at any point of common coupling with a nominal system voltage of less than 66 kV shall not exceed 5 percent.

The harmonic current limits of inverter connected generation shall comply with the requirements of AS4777.2 (2005) Clause 4.5.

4.6 Means of Isolation

Every DG plant must have a means of isolation that is capable of disconnecting the generating plant in-feed from the Aurora Energy network. The isolation switch or circuit breaker must be suitably labelled and lockable, in the open position, with a standard Aurora Energy padlock. Access to the points of isolation must be kept clear and unobstructed. Aurora Energy's authorised contractors shall have access to the means of isolation without undue delay.

4.7 Synchronising

Automatic synchronising must be provided at the generator circuit breakers. Check synchronising or interlocks shall be fitted to any other breaker that could connect the DG to the Aurora Energy network.

4.8 SCADA Monitoring

When the primary purpose of the generation is to inject energy into the Aurora Energy network it shall be monitored by the Aurora Energy SCADA system. This will require the installation of an appropriate SCADA RTU and communication facilities. The minimum information to be telemetered via the RTU is:

- Status of circuit breakers
- Voltage at the PCC or other agreed location
- The kW and kVA output of the generation for each generation type (e.g. wind, hydro, PV)
- Status of protection relay outputs

5 Islanding

Normally Aurora Energy does not provide for intentional islanding and distributed generators are not required to design their systems to supply islanded sections of the Aurora Energy network.

Protection and switching operations can result in distributed generators attempting to supply an islanded section of the Aurora Energy network. This is an undesirable because:

- Voltage and frequency provided to consumers supplied from the islanded section of the network will be unpredictable creating the possibility of damage to consumer equipment,
- Islanding may cause a hazard to maintenance workers or the public by causing a circuit to remain energised when it has been assumed to be disconnected from all energy sources,
- The generators connected to the island could be damaged when the island is reconnected to the Aurora Energy network. An out-of-synchronism reconnection may also result in further outages on the Aurora Energy network,
- Islanding may interfere with the restoration of normal service to neighbouring Aurora Energy consumers.

Aurora Energy requires that DG must disconnect for faults on the Aurora Energy circuit that the generation is connected to within three seconds of the fault occurring. If the formation of an island is possible for faults upstream of the circuit the generation is connected to, then special operating procedures or protection inter-tripping may be required.

DG must not, under any circumstances, re-energise parts of the Aurora Energy network that have been disconnected from the rest of Aurora Energy's network.

6 Earthing

6.1 Direct Connected Generators

The earthing of generators directly connected to the Aurora Energy LV network shall be in accordance with the requirements of AS/NZS 3000:2007.

Generators connected directly to the Aurora Energy HV network shall have the generator neutral earthed via a suitable resistor or reactor.

6.2 Generators connected via a Transformer.

The earthing requirements for generators connected via a transformer are dependent on the generator category and are detailed below.

6.2.1 Category 1 - Export required

When the DG will export energy into the Aurora Energy network then the DG installation must provide a neutral earth reference or neutral voltage displacement (NVD) protection on the Aurora Energy side of the transformer used to connect the generator to the Aurora Energy network. The choice between neutral point earthing and NVD protection will depend on the network configuration and protection systems in the vicinity of the DG connection.

Neutral earth references on the 33kV and 66kV networks supplied from the Cromwell, Clyde or Frankton grid exit points shall include neutral earthing resistors to minimise the magnitude of earth fault currents.

6.2.2 Category 2 - No export and unable to sustain an island

When the distributed generation is connected to the LV side of a standard consumer distribution transformer and there is no requirement to export energy into the

Aurora Energy network and it is not likely the generator can supply a viable island, then an HV earth reference shall not to be provided. The formation of a viable island is considered unlikely if the generator maximum output is less than half the minimum load on the HV feeder supplying the DG installation.

6.2.3 Category 3 - No export but can sustain an island

When the distributed generation is connected to the LV side of a standard consumer distribution transformer and there is no requirement to export energy into the Aurora Energy network and it is possible for the generation to supply a viable island then an effective HV earth reference shall not be provided. However, if the generator is going to operate in parallel with the Aurora Energy network for more than 500 hours per year NVD protection shall be provided.

7 Protection

7.1 Protection Objectives

Aurora Energy requires protective equipment to be fitted to the DG to achieve the following objectives:

- Inhibit connection of the generator to the Aurora Energy network unless all phases of Aurora Energy supply are energised and within acceptable frequency and voltage limits.
- Disconnect the generator from the Aurora Energy network when a system abnormality results in an unacceptable deviation in voltage or frequency at the connection point.
- Disconnect the generator from the Aurora Energy network for faults on the Aurora Energy network.

7.2 Mandatory Protection Requirements

All DG installations shall have the following protection:

- External system over and under voltage
- External system over and under frequency
- External system phase unbalance
- Overcurrent

External system voltage and phase balance shall be monitored immediately adjacent to the circuit breaker making the parallel connection to ensure the supplies are healthy at that point.

The protection specified in this document is to ensure Aurora Energy's network is adequately protected. It is the responsibility of the DG owner to ensure DG assets are appropriately protected.

7.3 Direct Connected LV Generation

Installations with LV generation that is directly connected to the Aurora Energy LV network will be connected via LV HRC fuses rated to carry the capacity of the connection. Anti-islanding protection of inverter connected generators shall be in accordance with the requirements of AS4777.3

The specific requirements for the direct connection of an induction generator have yet to be established.

7.4 Generators Connected via Transformers

The protection required for generation connected via transformers depends on the generation category and is detailed below.

7.4.1 Category 1 - Export Required

When export of energy onto the Aurora Energy network is required the generation connection shall have either an effective earth reference or provide NVD protection as per the requirements of Section 9.2. When an effective earth reference is provided, residual current operated earth fault protection shall be fitted. Where no effective earth reference is provided then NVD protection shall be provided. NVD protection shall only be the backup method of clearing earth faults on the Aurora Energy circuit supplying the DG installation. The primary method of clearing earth faults shall be provided by other means such as inter-tripping. Additional protection may be required at the DG site or at other locations on the Aurora Energy network to maintain the pre-existing standard of network reliability and security.

7.4.2 Category 2 - No export and cannot sustain an island

In the situation where the DG is used to supply customer load, is never required to export and the minimum load the generator will attempt to pick-up if the DG becomes islanded is twice the rating of the generator then the following protection is required:

- Reverse Power
- Vector Shift with minimum import control (see Section 8.5) OR
- HV fuse switch inter-trip (see Section 8.6)

7.4.3 Category 3A - No export, can sustain an island and annual operating hrs <500

When the DG is used to supply customer load, is never required to export and the minimum load the generator will attempt to pick-up if it becomes islanded is less than twice the rating, and the generator will operate in parallel with the Aurora Energy network for less than 500 hrs per year then the protection required can be the protection specified for either a Category 2 or Category 3B situation.

7.4.4 Category 3B - No export, can sustain an island and annual operating hrs >500

When the DG is used to supply customer load, is never required to export and the minimum load the generator will attempt to pick-up if it becomes islanded is less than twice the rating, and the generator will operate in parallel with the Aurora Energy network for more than 500 hrs per year then the following protection is required:

- Reverse Power
- NVD Protection.

7.5 Vector Shift Protection

When utilising vector shift protection, the load change on the generator generally needs to be between 10% and 20% of the generator rating to ensure appropriate operation. To ensure this load shift will occur, it is normally necessary to operate the generator with a minimum import.

7.6 HV Fuse Switch Intertrip

In situations where DG is connected to the LV side of a distribution transformer protected by an HV fuse switch one method of ensuring the generation will be disconnected for faults between the fuse switch and the transformer or the transformer HV windings is to provide an intertrip signal from an auxiliary switch on the fuse switch to the consumers incoming LV circuit breaker.

7.7 Reclosing Coordination

Where the DG is connected via a circuit subject to auto reclosing it is important that the DG disconnect from the network before a reclose is attempted. An out-of-synchronism reclose can cause serious damage to rotating generators and motors. Most Aurora Energy reclosers have a dead time setting of three seconds but the exact setting for each location requires confirmation.

Modern field reclosers normally have a live line blocking facility which can be enabled if DG is supplied from the recloser. This facility shall only be considered as a backup to anti-islanding protection.

7.8 Short Term Paralleling

At sites where the purpose of the DG connection is to only allow infrequent transfer of load from a generator to the Aurora Energy network then reduced protection requirements can apply at the discretion of Aurora Energy but will not be less than the requirements specified in Section 8.2. The paralleling time shall be automatically controlled to a maximum of 5 minutes.

7.9 Protection Location and Indication

Protective equipment must be located in a suitable cabinet that affords immediate access by the DG operator but is secure from interference by unauthorised personnel.

Protection systems shall indicate the reason for all protection operations that result in a circuit breaker trip.

7.10 Protection Relay Standards

All protection relays associated with DG installations that have voltage and current inputs derived from a primary source rated greater than 415 volts shall be distribution quality relays compliant with IEC 60255. Protection devices monitoring 230/400 volt primary quantities can be industrial grade relays or the protection functions can be provided by a micro-processor generator controller.

7.11 Trip Circuit Supervision

Any HV circuit breakers required to disconnect DG from the Aurora Energy network shall be fitted with trip circuit supervision.

7.12 DC Trip Supply

All protection functions shall operate with a dc voltage down to 80% of the nominal dc voltage. If there is a failure of any supplies to protective equipment which will inhibit its correct operation the generation shall be automatically disconnected and shutdown or at sites where there is competent supervision, initiate an audible or visual alarm.

8 Inspection and testing

All testing and associated costs are the responsibility of the DG owner. Aurora Energy reserves the right to have a representative witness the testing. All commissioning tests shall be carried out in accordance with a written test plan and procedures that have been approved by Aurora Energy prior to commissioning. The commissioning tests shall include a full functional test of the auto synchronisation equipment prior to the first synchronisation. All protection functions shall be tested including all interlocks and the facilities to ensure the generator is disconnected from the Aurora Energy network in the event of an Aurora Energy supply failure.

The owner of the DG shall keep written records of test results and protection settings and a copy of these records shall be sent to Aurora Energy.

Periodic tests shall be carried out to verify the settings and serviceability of the protection. These tests shall be carried at out at intervals not exceeding three years. The results of these tests shall be available for inspection by Aurora Energy.

9 Metering

Metering of the DG injection must be certified and comply with the requirements of the EGR.

DG installations that export more than 500kW shall provide meter pulses to the Aurora Energy SCADA RTU at the site. The meter pulses will be used for load management purposes by Aurora Energy.

10 Operational requirements

10.1 Operating Personnel

The DG owner shall designate persons to operate their generation. These operators shall be competent and appropriately trained. They shall follow written operating instructions and the sections relating to interfacing with the Aurora Energy network shall be approved by Aurora Energy.

10.2 Communications

There shall be adequate, reliable and documented means of communication between Aurora Energy's System Controllers and the operators of DG.

10.3 Reconnection

After the DG has been disconnected from the Aurora Energy network due to a network disturbance, it shall not reconnect to the Aurora Energy network until the voltage and frequency at the PCC have been within acceptable limits for 5 minutes or when authorised by the Aurora Energy System Controller.

10.4 Isolation

When work is carried out on Aurora Energy's equipment in the vicinity of the DG plant, the generating plant shall be isolated from the Aurora Energy network in accordance with Aurora Energy's safety procedures.

All assurances on the state of the DG plant shall comply with the requirements of the SM-EI. The DG owner and Aurora Energy may have to agree on scheduling of real and reactive power output into the Aurora Energy network to ensure Aurora Energy's network is within its capacity and voltage limits.

10.5 Power factor

It is preferred that generators connected to the Aurora Energy network export reactive power kVAr when operating in parallel with the Aurora Energy network. When the generation is associated with consumer load, and there is no export of energy, the generation shall be operated to maintain the power factor at the consumers connection point greater than 0.95.

For generators not associated with consumer load the power factor at the generation PCC should be between 0.85 and 0.9 leading subject to network voltages remaining within acceptable limits.

11 Records and information

Aurora Energy is responsible for ensuring its plans and records of DG installations are maintained at its control rooms so contractors working on the Aurora Energy network can be advised appropriately.

11.1 GIS Information

The DG owner shall provide all necessary information required to facilitate the recording the location and attributes of all DG plant and associated, switchgear, lines and cables on the Aurora Energy geographic information system (GIS).

11.2 Schematic Diagrams

The DG owner shall have available at all times at the DG site an up to date single-line diagram and protection schematic of the DG plant. Aurora Energy shall be supplied with copies of these diagrams.

11.3 Manuals

The owner of the DG shall have manuals on the installation, operation and maintenance of the DG equipment.

11.4 Protection Settings

Records shall be kept on protection setting values with details of calculations and logic used to select the settings.

11.5 Test Results

The DG owner shall maintain test records as required by Section 10.

11.6 System Operator (Transpower) Notification

The EGRs require Aurora Energy to notify the System Operator of the existence of any generators connected to the Aurora Energy network with a maximum capacity greater than or equal to one MW. The DG owner is responsible for providing the System Operator with details of the generation that the System Operator requires.