NE-STD-0001 – Distributed Generation Standard

New Energy – Distributed Energy Resources

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Version Change Table

VERSION	PAGE	PARAGRAPH	DESCRIPTION OF CHANGE

Contents

Appendices

1. Scope

This document prescribes PowerNet requirements for connecting distributed generation (DG) to the PowerNet managed networks.

PowerNet's vision is 'Energy Partner of Choice' and its purpose is 'Safe, Efficient, Reliable, Power to Communities'. DG, especially if oversized for the local network, poses the risk of not delivering on this vision and purpose – causing power quality issues, impacting other customers, and making the network less safe for those working on it and for our customers.

The document outlines the PowerNet application process and the technical requirements for connecting DG to the PowerNet managed networks.

1.1. Intended Audience

The information required in applying to connect DG to PowerNet's managed networks is technical in nature so this standard has been written aimed at installers. PowerNet recommends that the applicant reads and understands this standard so they can make informed decisions when purchasing DG, especially as the EIPC does not apply to contractors or agents acting for the generator – a participant cannot contract out of its obligations.

1.2. Referenced Documents

Parties using this document shall apply the most recent edition of the following Statutory Acts, Regulations, PowerNet Standards and Industry Codes of Standards.

1.2.1. Legislation

- Electricity Act 1992
- Electricity Industry Act 2010
- Electricity Industry Participation Code 2010
- Electricity (Safety) Regulations 2010
- Health and Safety at Work Act 2015

1.2.2. PowerNet Documents

- NE-POL-0001 – Congestion Management Policy
- AM-STD-0002 – Installation Connection Standard

1.2.3. International Standards

- AS 3011.1:2019, Electrical installations - Secondary batteries installed in buildings - Vented cells
- AS 3011.2:2019, Electrical installations - Secondary batteries installed in buildings- Sealed cells

- AS/NZS 5139:2019, Electrical installations - Safety of battery systems for use with power conversion equipment
- AS 4777.1:2016, Grid connection of energy systems via inverters – Installation requirements
- AS 4777.2:2020, Grid connection of energy systems via inverters – Inverter requirements
- AS 62040.1:2019, Uninterruptible power systems (UPS) – Safety requirements
- AS/NZS 1768:2021, Lightning protection
- AS/NZS 3000:2018, Electrical installations (Wiring Rules)
- AS/NZS 5033:2021, Installation and safety requirements for photovoltaic (PV) arrays
- AS/NZS 61000.3.6:2012, Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
- AS 62052.11:2018, Electricity metering equipment (ac) – General requirements, tests and test conditions
- IEC 62109.1:2010, Safety of power converters for use in photovoltaic power systems. Part 1: General requirements
- IEC 62109.2:2011, Safety of power converters for use in photovoltaic power systems. Part 2: Particular requirements for inverters

1.2.4. Guidelines

- EEA Power Quality (PQ) Guidelines
- Electric Vehicle Charging Safety Guidelines, Part 1: Safety fundamentals, WorkSafe NZ, 2019
- Electric Vehicle Charging Safety Guidelines, Part 2: Selection and installation, WorkSafe NZ, 2019
- Electric Vehicle Charging Safety Guidelines, Part 3: Electric vehicle supply equipment – New Zealand specific requirements, WorkSafe NZ, 2019
- Safety Guidelines – Li-ion Home Storage Systems, German Solar Industry Association
- The Australian Battery Guide – Energy Storage Council, May 2016
- Best Practice Guide for Battery Storage Equipment – Electrical Safety Requirements

1.3. Definitions

All definitions applicable to this document. Definitions to confirm the meaning of industry terms used. Definitions sorted alphabetically.

Distributed Generation (DG)	equipment used, or proposed to be used, for generating electricity that is: a) Connected, or proposed to be connected, to PowerNet managed networks that is directly or indirectly connected to the grid, or to an installation that is connected to distribution networks that PowerNet manages. b) Capable of injecting electricity into distribution networks that PowerNet manages.
DG applicant	The person or party applying to PowerNet, intending to connect distributed generation to a network managed by PowerNet. This is typically the owner, not the installer.
DG hosting capacity	The maximum export power, per ICP with DG installed, on a network which can be tolerated without causing voltage or current limits to be exceeded, for a given DG penetration level.
DG penetration level	The proportion of ICPs in a given network that have export-capable DG installed.
Electrical energy storage system	A system in which energy may be stored in electrochemical, mechanical, thermal, kinetic, potential or other form and in which the stored energy can be converted to electricity on demand.
Export power threshold	A threshold of DG hosting capacity, which can be either a lower export power threshold, H_1, or a higher export power threshold, H_2. The higher export power threshold is used to determine if a proposed DG connection requires manual assessment.
H_1	The lower export power threshold, which is the DG connection's DG hosting capacity above which mitigation measures are necessary, specified in Watts.
H_2	The upper export power threshold, which is the DG connection's DG hosting capacity above which mitigation via inverter Volt-Var response alone is insufficient, specified in Watts.
Incremental Costs	Reasonable costs that an efficient distributor would incur in providing electricity distribution services with connection services to DG, less the costs that the efficient distributor would incur if it did not provide those connection services.
Inverter energy system (IES)	A system comprising of inverter(s), energy source(s) which may include electrical energy storage, wiring, control, monitoring and protection devices connected at a single point in an electrical installation. Multiple IES installations can exist within a single electrical installation.

Inverter operational modes	Modes of operation of an inverter which will contribute to export congestion management or to maintaining the power quality, in the vicinity of the distributed generation's ICP. These various operating modes, if available, may be enabled or disabled in an inverter and may include, but not be limited to, the following as described by AS/NZS 4777.2: a) Power quality response modes including volt-var and volt-watt, fixed power factor or reactive power mode, power response mode, and power rate limit, b) Demand response modes, and c) Multiple mode inverter operation.
LV network	A distribution transformer and all electrical circuits associated with the LV side of the transformer.
Multiple mode inverter	An inverter that operates in more than one mode, for example having a grid-interactive functionality when grid voltage is present and strong-alone functionality when the grid is de-energized or disconnected, as defined by AS/NZS 4777.2. Inverters with battery storage ports are also considered multiple mode inverters.
Maximum export power	The maximum active power exported into the PowerNet's network at the distributed generation's ICP, being equal to the nameplate capacity minus the minimum load at the point of connection, or to the power export limit imposed by an active export control device, specified in Watts.
Nameplate capacity	The maximum gross power generator of the DG system, being the lesser of the continuous inverter apparent power rating and the maximum continuous active power output of the energy source, specified in Watts.
PowerNet managed networks	PowerNet manages the electricity network assets and operations for four network owners listed below: • The Power Company Limited – covers rural Southland/West Otago and the outskirts of Invercargill City • Electricity Invercargill Limited – covers most of Invercargill City and the Bluff township • OtagoNet – covers South, East and North Otago • Lakeland Network – covers Frankton and two embedded networks in Central Otago
Power quality response modes	Modes of operation of an inverter which will contribute to export congestion management or to maintaining the power quality, in the vicinity of the distributed generation's ICP. These various operating modes, if available, may be enabled or disabled in an inverter and specifically include, but are not be limited to, the following as described by AS/NZS 4777.2: volt-var and volt-watt, fixed power factor or reactive power mode, power response mode, and power rate limit.

1.4. Acronyms

AC	Alternating Current
EES	Electrical Energy Storage system
CoC	Certificate of Compliance
DG	Distributed Generation
EA	Electricity Authority
EDB	Electricity Distribution Business
EIPC	Electricity Industry Participation Code 2010
EV	Electric Vehicle
ICP	Installation Control Point
IES	Inverter Energy System
LV	Low Voltage (nominal voltage levels at 230V or 400V)
LPS	Lightning Protection System
PV	Photo-voltaic
SPD	Surge Protection Device
UPS	Uninterruptible Power Supply

2. Connection Application

DG connection applications shall follow the application assessment requirements detailed in the EIPC 2010, Schedule 6.1. Parts 1 and 1A detail general information that has been included in the PowerNet DG application form for generating capability of 10kW or less. Part 1 is the default application path, or alternatively an Inverter Energy System (IES) connection application may be made under Part 1A. Part 2 is for generating capability of greater than 10kW.

Part 1A allows for a simplified application process, and can be followed if the DG:

(a) Is designed and installed in accordance with AS 4777.1; and

(b) Incorporates an inverter that

a. Has been tested and issued a Declaration of Conformity with AS/NZS 4777.2 2020 by a laboratory with accreditation issued or recognised by International Accreditation New Zealand; and

b. Can perform the inverter operational modes outlined in Section 3.7.

(c) Has protection settings that meet PowerNet's connection and operation standards (including this standard); and

(d) Has a maximum export power that is less than any export power threshold specified by PowerNet, at the DG location, available on the PowerNet website.

Schedule 6 Clause 6.3 of the EIPC states the distributors make application forms publicly available. Applications to PowerNet shall be done using the PowerNet DG Connection Application form. A DG owner must make an application to PowerNet when intending to directly or indirectly connect new DG, when changing an existing DG installation, or replacing an inverter. The DG owner may use an agent (such as the installer) to provide an application to PowerNet, but the owner remains responsible. Schedule 6.1 Clauses 9B(1) and (2) of the EIPC lists information that the DG applicant must submit to PowerNet for a Part1A application. Clause 2(3) lists information that PowerNet may require for Part 1 application. The PowerNet DG Connectional Application form includes these requirements.

The flowchart for DG applicants for determining which Part of Schedule 6.1 to apply under is included below in Figure 1, and summarised below in Table 1.

The flowchart for application process for Part 1A, Part 1, and Part 2 applications are included in Appendix A, Appendix B, and Appendix C respectively.

DG export power thresholds H_1 and H_2 are hosting capacities specific to an LV network and are dependent on the DG penetration level. H_1 defines the threshold above which mitigation is required, and above H_2 a manual assessment is required. These export power thresholds are included on the PowerNet congestion maps available on our website. If no export power thresholds are given the applicant can assume that the IES maximum export power is less than these thresholds. More information on export power thresholds and congestion is included in NE-POL-0001 – Congestion Management Policy.

The amount of information required will depend on the size and type of generation, and shall remain confidential between the parties unless agreed otherwise. PowerNet reserves the right to release sufficient information relating to Distributed Generators for the purpose of meeting its obligations to

Transpower, if Transpower requires such information under the Common Quality Requirements. For Part 2 applications, additional information will need to be provided alongside the application.

Table 1 Inverter and Assessment requirements for DG connection applications

IES Maximum Export Power	AS/NZS 4777.2 2020 Compliance	Requirements for connection
P > 10kVA	-	• Part 2 Application
P ≤ H_1	Yes	• Part 1A Application • Volt-Watt and Volt-Var response modes enabled
	No	• Part 1 Application • Must be at least AS 4777.2 2015 compliant • Volt-Watt and Volt-Var response modes enabled if available
H_1 < P ≤ H_2	Yes	• Part 1A Application • Volt-Watt and Volt-Var response modes must be enabled
	No	• Part 1 Application • Must be at least AS 4777.2 2015 compliant • Volt-Watt and Volt-Var response modes required and must be enabled
P > H_2	-	• Part 1 Application • Connection is by negotiation on a case-by-case basis • Manual assessment required • Network mitigation measures may be necessary to realise full DG export potential during periods of low load and peak generation

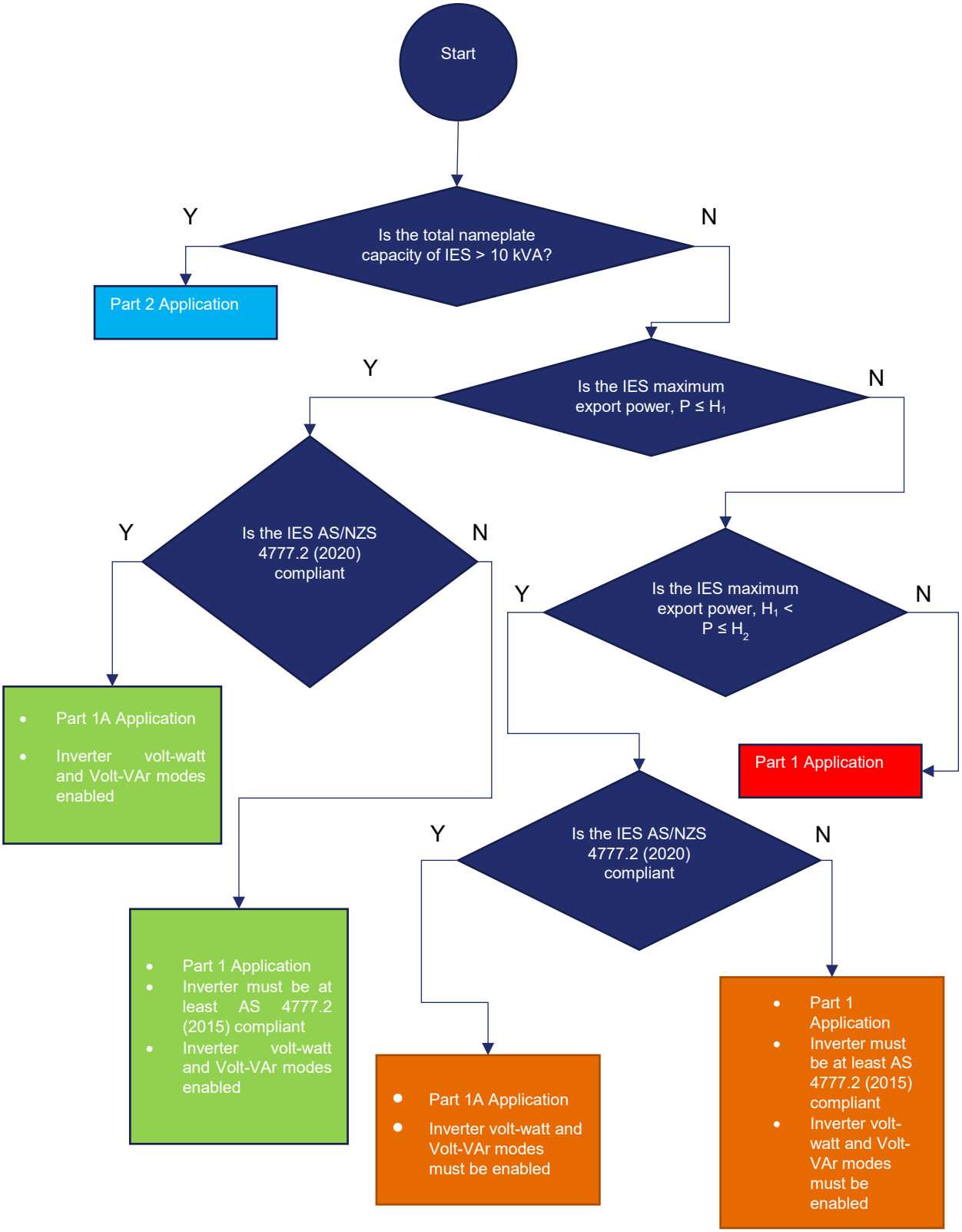


Figure 1 Process flow for assessing connection application for inverter-based DG

PowerNet will act impartially when processing application, including processing in order received and following the process set out in Part 6 Clause 6.11 of EIPC.

2.1. Certificate of Compliance

The DG owner must provide PowerNet a copy of the Certificate of Compliance (CoC) issued under the Electricity (Safety) Regulations 2010 as soon as its available, but no later than 10 business days after the approval of the application as per EIPC. This is typically provided by the installer. Failure to do so could be considered a breach of the EIPC and can result in a fine of up to $10,000.

2.2. Unauthorised connection of DG

If the DG can inject electricity into PowerNet's network, the DG owner is a participant of the EIPC and must comply with it. The DG is in breach of the code if it:

- Connects without final approval to connect from PowerNet
- Does not comply with PowerNet's connection and operations standards, including this document.

If PowerNet considers that a DG may:

- Adversely affect the service provided to other distribution network customers; or
- Cause damage to the distribution network or other facilities; or
- Present a hazard to a person; then

PowerNet will advise the DG owner as soon as reasonably practicable. If, after receiving that advice, the DG owner fails to remedy the adverse operating effect within a reasonable time, PowerNet may electrically disconnect the DG by giving reasonable notice (or without notice when reasonably necessary in the event of an emergency or hazardous situation) as per the regulated terms in Schedule 6.2 of Part 6 of the EIPC.

2.3. Connection Contract Types

For Part 1A applications the regulated terms under Schedule 6.2 of Part 6 of the EIPC shall apply.

For Part 1 applications:

- If the final application is approved by PowerNet, the DG owner must give written notice to PowerNet that it wishes to negotiate a connection contract within 10 business days. If the DG owner fails to give notice, PowerNet has no obligation to progress the DG owner's final application (but can agree to extend this).
- If the parties (PowerNet and DG owner) do not enter into a negotiated contract before 30 business days have expired, then the regulated terms under Schedule 6.2 of Part 6 of the EIPC apply.

For Part 2 applications:

- If the final application is approved by PowerNet, the DG owner must give written notice to PowerNet that it wishes to negotiate a connection contract within 30 business days. If the DG owner fails to give notice, PowerNet has no obligation to progress the DG owner's final application (but can agreed to extend this).
- Either:
    - A connection contract is negotiated and PowerNet will allow the DG to connect in accordance with the contract as soon as practicable; or
    - A connection contract is not negotiated within 30 business days, the regulated terms apply, and PowerNet will allow the DG to connect as soon as practicable.

These requirements are included in the process flowcharts for Part 1A, Part 1, and Part 2 application in Appendix A, Appendix B, and Appendix C respectively.

2.4. Priority of final applications for Part 2 Applications

Capacity will not be reserved for DG that has not provided a final application as final approval must be decided on capacity available at the time.

If PowerNet receives a final application (the first application) and receives another final application, within 20 business days after receiving the first application, relating to a particular part of the distribution network that PowerNet considers would be affected by the approval of the first application:

- PowerNet may consider the final applications together as if they were competitive bids to use the same part of the distribution network; and
- PowerNet will consider the final applications in light of the purpose of Part 6 of EIPC (i.e. to enable DG to be connected to PowerNet network)

In any other case (i.e. outside of 20 business days) in which PowerNet receives more than 1 final application relating to a similar part of the distribution network, PowerNet will consider the earlier final application in priority to other final application. This priority of final applications is included in Schedule 6.1 of Part 6 of the EIPC.

These requirements are included in the process flowchart for a Part 2 application in Appendix C.

2.5. Disputes process

All parties must give written notice to the other party of the dispute. The parties must attempt to resolve the dispute with each other in good faith. If the parties are unable to resolve the dispute, either part may complain in writing to the EA. The complete default dispute resolution process is included in Schedule 6.3 of Part 6 of the EIPC. Schedule 6.3 provides the regulatory framework under which disputes may be considered, and includes connecting pricing disputes.

3. Technical Requirements

3.1. General Requirements

The maximum rating for a single-phase IES (Inverter Energy System) in an individual installation is limited to 5 kVA, and a multi-phase IES shall have a balanced output with respect to its rating with a tolerance of no greater than 5 kVA unbalance between any phases, as per AS/NZS 4777.1:2016

3.2. Reactive power capability

Minimum reactive power capability requirement is outlined below in Figure 2 and Table 2

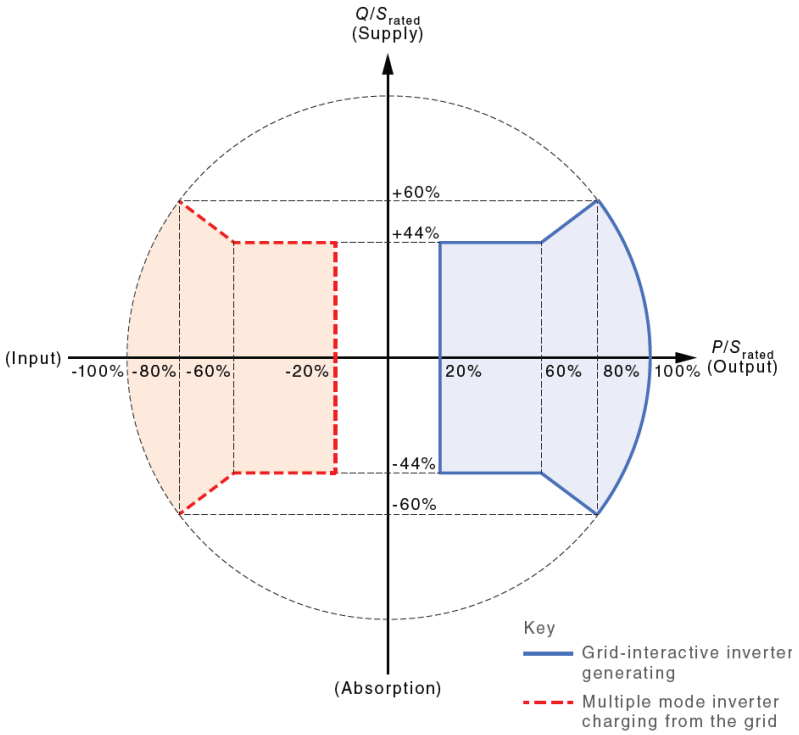


Figure 2 Minimum reactive power capability

Table 2 Minimum reactive power capability

Active Power Output or Input	Reactive power being absorbed or suppled
< 20% rated apparent power	May be reduced due to limitation of inverter power factor
Between 20% and 60% rated apparent power	At least 44%
> 60% rated apparent power	At least 60% (Power factor of 0.8)

This figure is based on AS/NZS 4777.2:2020, Clause 2.6.

3.3. Power Quality

The inverter shall operate the automatic disconnection device within 3 seconds of the average voltage exceeding $V_{nom-max}$, where $V_{nom-max}$ is 249 V, for a 10 minute period, in accordance with AS/NZS 4777.2:2020, Clause 4.5.2. Additional voltage limits and anti-islanding requirements are included below in Section 3.4.

The inverter shall be capable of supplying rated power for frequencies between 45 Hz and 52Hz. If the system frequency rises above 50.2 Hz, due to a disturbance on the grid, the inverter shall curtail power in compliance with AS/NZS 4777.2:2020, Clause 4.5.3.1.

The IES shall comply with the relevant clauses in AS/NZS 4777.2:2020 with respect to voltage fluctuation and flicker, transient voltage limits, and DC current injection (AS/NZS-4777.2:2020 Clause 2.8, Clause 2.8, 2.9, and 2.10 respectively)

3.3.1. Harmonics

Harmonic Currents

Harmonic currents produced by inverters shall not exceed values outlined below in Table 3 and Table 4. The total harmonic current distortion (I_{THD}) to the 50th harmonic shall be less than 5%.

The inverter should not significantly radiate or sink frequencies of 217,317, and 492Hz used for ripple control by PowerNet. Fitting of additional filtering components may be required in some areas.

Table 3 Odd harmonic current limits

Odd harmonic order number (h)	Limit for each individual odd harmonic based on percentage of fundamental (%)
3, 5, and 7[1]	4
9, 11 and 13	2
15, 17 and 19	1.0
21, 23, 25, 27, 29, 31 and 33	0.6

Table 4 Even harmonic current limits

Even harmonic order number (h)	Limit for each individual even harmonic based on percentage of fundamental (%)
2,4, 6 and 8	1
10, 12, 14,16, 18, 20, 22, 24, 26, 28, 30 and 32	0.5

[1] The GREEN Grid NAG recommends a stricter 7th harmonic current limit of 2% of fundamental (rather than 4%) be enforced to align with the EEA Power Quality Guidelines. Whilst PowerNet would prefer this 2% limit, it accepts the 4% limit for the 7th harmonic included in Table 3 and AS/NZS 4777.2:2020, Clause 2.7.

These harmonic limits are set in AS/NZS 4777.2:2020, Clause 2.7.

Harmonic Voltages

Harmonic voltages produced by inverters shall not exceed values outlined below in Table 5, Table 6 and Table 7. The total harmonic voltage distortion (V_{THD}) shall be less than 7.2%.

Table 5 Odd non-multiple of 3 harmonic voltage limits

Odd harmonic non-multiple of 3 order number (h)	Limit for each individual odd harmonic based on percentage of fundamental (%)
5	5.4
7	4.5
11	3.15
13	2.7
17 ≤ h ≤ 49	$2.043 \times \left(\frac{17}{h}\right) - 0.27$

Table 6 Odd multiple of 3 harmonic voltage limits

Odd harmonic multiple of 3 order number (h)	Limit for each individual odd harmonic based on percentage of fundamental (%)
3	4.5
9	1.35
15	0.36
21	0.27
21 < h ≤ 45	0.18

Table 7 Even harmonic voltage limits

Even harmonic order number (h)	Limit for each individual odd harmonic based on percentage of fundamental (%)
2	1.8
4	0.9
6 and 8	0.45
10 ≤ h ≤ 50	$0.225 \times \left(\frac{10}{h}\right) + 0.25$

These voltage harmonic limits are set to 90% of the compatibility level outlined in AS/NZS 61000-3-6, to give a 10% margin, as recommended by the EEA Power Quality Guidelines.

3.3.2. Power Quality Response Modes

PowerNet has the authority to specify, as an additional requirement, the activation of power quality response modes, as per AS/NZS 4777.1, Clause 3.4.7. For connection approval, PowerNet may require the activation of the volt response or fixed power factor modes.

Volt Response Modes

The volt response modes respond to changes in voltage at the inverter terminals. The intent of applying these modes is to allow IES to be connected to the grid while avoiding any adverse effect on the voltage at the point of supply.

PowerNet has adopted the GREEN Grid NAG recommended values for Volt-VAr and Volt-Watt Response which fall within compliance with AS/NZS 4777.2 2020.

Table 8 Volt-VAr Voltage Response Modes

Refence	Response Values (V)	VAR/Rated VA (%)
V_1	207	60 leading (0.8 PF)
V_2	220	0%
V_3	235	0%
V_4	244	60 lagging (0.8 PF)

Table 9 Volt-Watt Voltage Response Modes

Refence	Response Values (V)	Power P/P_{rated} (%)
V_1	207	100
V_2	220	100
V_3	244	100
V_4	246	20

The Volt-Watt response mode varies the active power output of the inverter, and the Volt-VAr response mode varies the reactive power output.

If possible, both the Volt-Watt and Volt-VAr response modes should be enabled by default with reference voltages set to Table 8 and Table 9.

If the inverter does not have provision for separate voltage response reference values for Volt-Watt and Volt-VAr modes, or if both modes cannot be enabled simultaneously, the Volt-Watt response

mode shall be disabled by default, and the Volt-VAr response mode shall be enabled by default with reference voltages set to Table 8.

If the inverter does not have provision for Volt-Var response mode, the Volt-Watt response mode shall be enabled by default with reference voltages set to Table 9.

PowerNet's voltage response requirements are summarised below in Table 10:

Table 10 Voltage Response Requirements summary table

Available	Enable
Both Volt-VAr and Volt-Watt	Both Volt-VAr and Volt-Watt
Either Volt-VAr or Volt-Watt	Volt-VAr
Only Volt-Watt	Volt-Watt

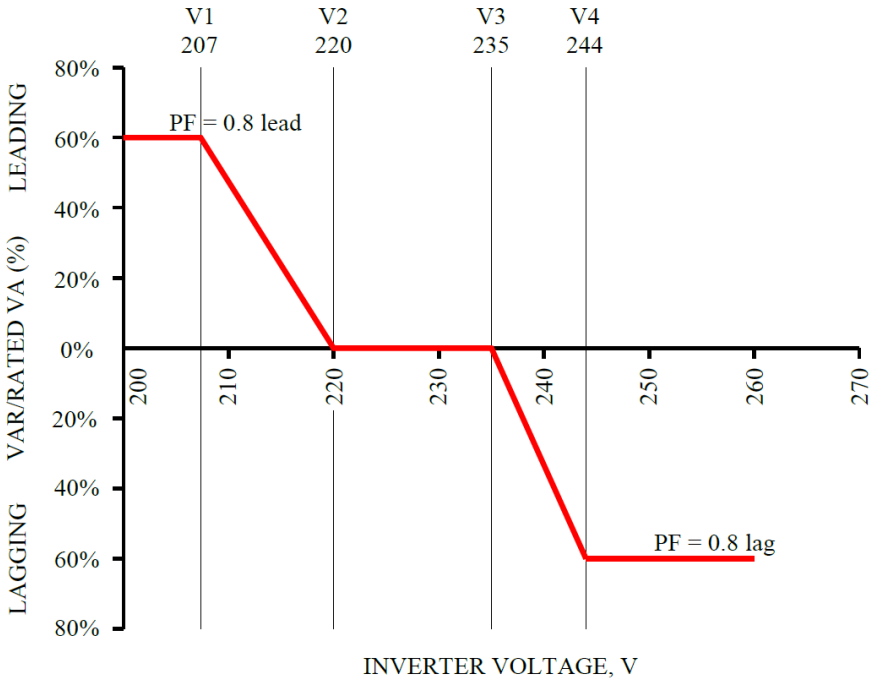


Figure 3 Required Volt-VAr response mode

The Volt-VAr response mode is displayed in Figure 3. This is constructed using the Volt-VAr reference values specified in Table 8 and the corresponding 60% VAr/rated VA set-points levels given by Table 3.7 in AS/NZS 4777.2:2020. The inverter lagging reactive power activates at the reference voltage V_3 of 235V and increases linearly to reach maximum lagging reactive power activation at the reference voltage V_4 of 244V

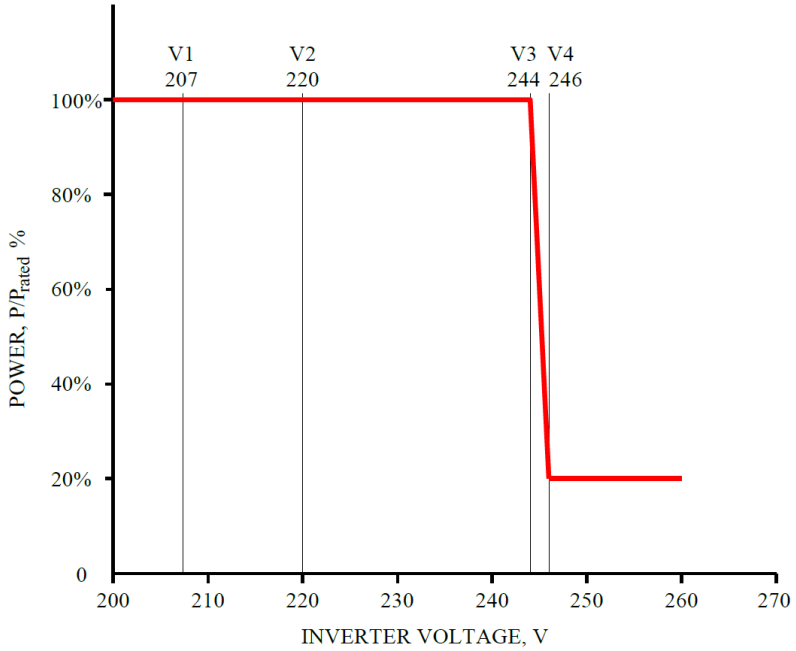


Figure 4 Required Volt-Watt response mode

In comparison, the Volt-Watt response of Figure 4 does not begin to curtail inverter active export power until the refence voltage V_3 of 244V is reached. Where both voltage modes are enabled this results in the Volt-VAr response mode becoming fully activated before the Volt-Watt response mode begins curtailing active power export.

PowerNet prefers prior Volt-VAr activations as:

- Power export curtailment caused by the Volt-Watt response mode is avoided or deferred by prior Volt-VAr response mode activation. This is a better outcome for the DG owners who will maximize their power export revenue within the capability of the network. Actual use of Volt-Watt response is only intended as a back-up response to safeguard regulatory compliance.
- Volt-VAr response tends to minimise instances where DG owners located near the end of LV feeders, who are likely to encounter the highest voltages, are unfairly required to reduce active export power.
- PowerNet networks tend to have lower resistance to reactance (R/X) ratios making Volt-VAr response effective.

AS/NZS 4777.2:2020 compliant inverters are expected to be configured to the settings in Table 8 by the installing electrician.

Fixed power factor and reactive power mode

The fixed power factor mode or the reactive power mode may be enabled in some situations by PowerNet to meet local network requirements, one of these modes shall be enabled if the volt-var mode is disabled. These modes shall be disabled by default.

For the fixed power factor mode, the minimum range of settings shall be 0.8 to 1.0 supplying reactive power, and 1.0 to 0.8 absorbing reactive power, the default power factor setting shall be 1.0. The

fixed power factor mode is for control of the displacement power factor over the range of inverter power output.

The volt-watt mode and fixed power factor mode shall be able to operate concurrently.

For the reactive power mode, the minimum setting range for ratio of reactive power (vars) to rated apparent power shall be at least 60% absorbing to 60% supplying, the default reactive power setting shall be 0%.

The volt-watt mode and reactive power mode shall be able to operate concurrently.

3.4. Safety and Protection

Certain IES installations and inverter must comply with the safety and protection requirements detailed in AS/NZS 4777.1 and AS/NZS 4777.2:2020. Additionally, all wiring and grounding must comply with AS/NZS 3000 and the Electricity (Safety) Regulations 2010.

Where a photo-voltaic (PV) array is used as an energy source, the installation of the array shall comply with AS/NZS 5033 and the PV array earth fault/earth leakage detection shall be compliant to AS/NZS 4777.2:2020, Clause 2.4.

Inverters for use in IES with PV arrays or other energy sources shall comply with the appropriate electrical safety requirements of IEC 62109.1 and IEC 62109.2, and of AS/NZS 4777.2. Inverters for use in IES that have energy storage (batteries) as the only possible energy source shall comply with the electrical safety requirements of AS 62040.1.1, and of AS/NZS 4777.2. These IES requirements are specified in AS/NZS 4777.2:2020, Clause 2.2.

To meet lightning safety requirements, particularly for roof-top PV systems, AS/NZS 1768 should be complied with. The requirement for a Lightning Protection System (LPS) and a Surge Protective Device (SPD) depends on the installation's building environment. An assessment for the type of building environment needs to be undertaken according to AS/NZS 1768, Clause 2.

Based on this assessment, if necessary, an LPS with an SPD is required as recommended in Clauses 4, 5, and 6 of AS/NZS 1768. The earthing and lightning protection requirements for the IES are provided in AS/NZS 5033, Clause 3.

All electrical work shall be undertaken by appropriately licensed persons.

3.4.1. Voltage limits and anti-islanding

Inverters shall have the settings as per Table 11. The table includes sustained voltage limit $V_{nom\text{-}max}$ and passive anti-islanding set-points specified for New Zealand according to AS/NZS 4777.2. The inverter must include an automatic disconnection device that incorporates at least one method of active anti-islanding protection, as per AS/NZS 4777.2:2020, Clause 4.3.

Table 11 Settings for Inverter Voltage and Frequency Limits (Passive Anti-Islanding Set-Point Values)

Parameter	Limit	Time (s)	
		Minimum Trip Delay	Maximum Disconnection (Trip)
$V_{nom-max}$ (10-minute average)	249V		3
Overvoltage 1	265V	1	2
Overvoltage 2	275V	-	0.2
Undervoltage 1	180V	10	11
Undervoltage 2	70V	1	2
Under-frequency	45Hz	1	2
Over-frequency	55Hz	-	0.2
Minimum reconnection time	60s		

3.4.2. Export control and settings

PowerNet reserves the right to approve an installation subject to zero net export to the grid, or to limit net export to the grid. In this instance export control is required. The export control function may be integrated into the inverter or be an external device. The export control function for an IES may operate with the following export limits:

- Hard limit – a limit that will require the IES to disconnect; and
- Soft limit – a limit that will cause the IES to reduce its output, preventing ongoing export greater than the limit.

The export limit may be set to allow export to the grid or to provide a minimum import load from the grid. These allowances for export control device are described by AS/NZS 4777.1, Clause 3.4.8.

PowerNet's export control requirements are:

- The export control function should include one of the following:
  - A separate protection relay (may omit for limited export).
  - A four quadrant (non-revenue) power meter with programmable logic controller (PLC).
  - Be a part of an inverter with the ability to adjust maximum export power to the grid to a specified limit, or to zero.
- The export control shall not create flicker problems on the low voltage network by continuously switching inverters on and off.

- The export-limit settings are set to PowerNet's requirements. Export limit will vary with the area hosting capacity.
- If current transformers or sensors are used, they shall have their terminals sealed by the installer.
- The export control device settings shall be secured against inadvertent or unauthorized tampering, as described by AS/NZS 4777.1, Clause 3.4.8.
- The export control device must not interfere with the inverter's passive or active anti-islanding performance.

Measurement of power shall be in accordance with AS 62052.11 or equivalent. Specific hard limit and soft limit requirements are described in AS/NZS 4777.1, Clause 3.4.8. Soft limit settings are included below in Table 12.

Table 12 Soft limit settings

	Zero Export	Limited Export
Export power limit	Up to 5% of inverter rating	As per connection agreement
Maximum trip delay	15s	15s

3.4.3. Impact on protection

Connection of IES on PowerNet's managed networks shall not contribute significantly to increasing the existing network fault levels based on engineering analysis.

3.5. Voltage rise

The overall voltage rise from the point of supply to the inverter AC terminals shall not exceed 2% of the nominal voltage at the point of supply, according to AS/NZS 4777.1, Clause 3.3.3.

3.6. Signage

Signage and levelling requirements for an IES installation are included in AS/NZS 4777.1, Section 6. Marking requirements for inverters are detailed in AS/NZS 4777.2:2020, Section 7.

3.7. Operational Modes

PowerNet reserves the discretion to select any of the operational modes outlined below in Table 13 in order to approve a DG connection. The inverter shall detect and initiate a response to all supported demand response commands within 2 seconds. The inverter shall continue to respond while the mode remains asserted.

Table 13 Optional demand response modes (DRMS)

Response Mode	Requirement
DRM 0	Operate the disconnection device
DRM 1	Do not consume power
DRM 2	Do not consume at more than 50% of rated power
DRM 3	Do not consume at more than 75% of rated power AND supply reactive power if capable
DRM 4	Increase power consumption (subject to constraints from other active DRMs)
DRM 5	Do not generate power
DRM 6	Do not generate at more than 50% of rated power
DRM 7	Do not generate at more than 75% of rated power AND absorb reactive power if capable
DRM 8	Increase power generation (subject to constraints from other active DRMs)

For Part 1A applications PowerNet does not currently require any of the above operational modes to be enabled.

3.8. Electrical energy storage (EES) systems

An EES system is a system in which energy may be stored and be converted to electricity on demand. Connection of an EES system is only allowed through a parallel operating, AS/NZS 4777.2:2020 compliant inverter. Multiple mode inverters shall be arranged to comply with the installation methods of AS/NZS 3000 and AS/NZS 4777.1. When the multiple mode inverter is disconnected from the grid any stand-alone port shall ensure that all active conductors are also isolated from the grid-interactive port, as per AS/NZS 4777.2:2020, Clause 3.4.

A labelled isolation device must be installed between any energy source and the inverter as required by AS/NZS 4777.1, Clause 4.5. Where the EES system incorporates a battery storage system, the battery isolator switch should be located adjacent to the battery storage system and must ensure all inputs and outputs to the battery storage system are able to be externally isolated.

Where lead-acid and nickel cadmium batteries are used, the system shall also comply with the requirements of AS 3011, and AS/NZS 5139, as indicated by AS/NZS 4777.1, Clause 4.5. All other battery types should be installed according to manufacturer's instructions. For lithium ion batteries, the following guidelines may be of use:

- Safety Guidelines – Li-ion Home Storage Systems, German Solar Industry Association
- The Australian Battery Guide – Energy Storage Council, May 2016
- Best Practice Guide for Battery Storage Equipment – Electrical Safety Requirements

3.9. Electric Vehicles

Electric vehicles (EVs) that are only capable of charging are considered to be only loads, and not connected DG. However, an EV will be considered to be connected DG, and therefore be subject to this standard and both parts of AS/NZS 4777, if it is capable of:

- Exporting power into the DG applicant's premises (also referred to as Vehicle-to-Building, V2B, or Vehicle to Home, V2H); or
- Exporting power into the network (also referred to as Vehicle-to-Grid or V2G).

WorkSafe New Zealand has published Electric Vehicle Charging Safety Guidelines. AS/NZS 3000 provides guidance for circuits intended for V2G export.

3.10. Installation documentation and commissioning

AS/NZS 4777.1, Section 7 describes specific documentation, inspection, and commissioning requirements including commissioning tests for the inverter and have been adapted by PowerNet. Commissioning includes anti-islanding testing, programming and recording of all protection settings, checking IES shut-down, and testing any export limit if specified by PowerNet.

3.11. Additional requirements

Any distributed generation that exceeds 1MW will need to meet Transpower requirements (including notification)[2].

The Electricity Act 1992 also includes obligations on generation that is equal to, or greater than, 10MW. Additionally, generators above 10MW may be subject to system operator dispatch and will be subject to dispatch if above 30MW as per Part 13 of Electricity Industry Participation Code 2010.

4. Network Congestion

Network Congestion is covered in NE-POL-0001 – Congestion Management Policy.

5. Metering

Metering is the responsibility of the generator owner (if an Electricity Market Participant) or the Electricity Market Participant that purchases any exported electricity (typically an electricity retailer). However, provided the metering is installed to the requirements of the Electricity Governance Rules, the metering can be arranged and owned by any party.

The DG owner can elect to gift surplus electricity to the electricity market (as per Clause 15.13 of Part 15 of the EIPC) but PowerNet still require metering data to be provided.

PowerNet requires metering that will measure both import and export volumes per trading period (30 minutes) that can be remotely interrogated. Metering should meet the requirements included in Section 13 of the Installation Connection Standard. and Part 10 of the Electricity Industry Participation Code 2010.

[2] https://www.transpower.co.nz/our-work/getting-you-connected/system-operator-engagement

6. Pricing

The DG owner is responsible for negotiating a contract for electricity that is sold to an electricity retailer, or to another party via an electricity retailer. All power exported must be sold to a retailer (i.e. cannot be 'lost' in the network).

Allocation of costs for connection of DG is in accordance with pricing principles stated in the EIPC 2010, Schedule 6.4 and included below in Table 14.

Table 14 Pricing Schedule

Generation Capacity	Application Type	Fees (NZD incl. GST)	
		Application	Witness and Commissioning Test
≤ 10kW	Default (Part 1)	230	69
	Fast Track (Part 1A)	115	69
> 10kW and ≤ 100kW	Part 2	575	138
> 100kW and ≤ 1000kW	Part 2	1150	1380
> 1000kW	Part 2	5750	1380

PowerNet may desire to observe the commissioning tests to ensure safe and reliable operation of the Distribution Network, to this ends at least five working days' notice of the commissioning testing shall be given.

PowerNet may need to perform further detailed investigative studies to identify any potential adverse effects the generation may have on the system. A fee may be chargeable for this and PowerNet will advise the DG installer before PowerNet approves the connection if this is required. Early discussions with PowerNet are essential.

PowerNet will not charge more than the incremental costs of providing connection services, net of transmission and distribution costs, that an efficient distributor would be able to avoid. Costs that cannot be calculated (e.g. avoidable costs) will be estimated with reference to reasonable estimates of how PowerNet's capital investment decisions and operating costs would differ, in the future, with and without the DG, and may be adjusted ex post.

If distinct capital expenditure for asset replacement or upgrade is required the cost may be payable by the DG owner before connection. Ongoing or periodic operating expenses, such as costs for routine maintenance may take the form of a periodic charge from PowerNet.

PowerNet may review the connection charges payable by the DG owner not more than once in any 12-month period. PowerNet will advise the DG owner in writing of any chance in the connection charges payable, and the reasons for any chance, not less than 3 months before the date the change is to take effect.

If multiple DG owners share an investment, the portion of costs payable by any one DG owner will be calculated considering:

- the expected peak of each DG injection

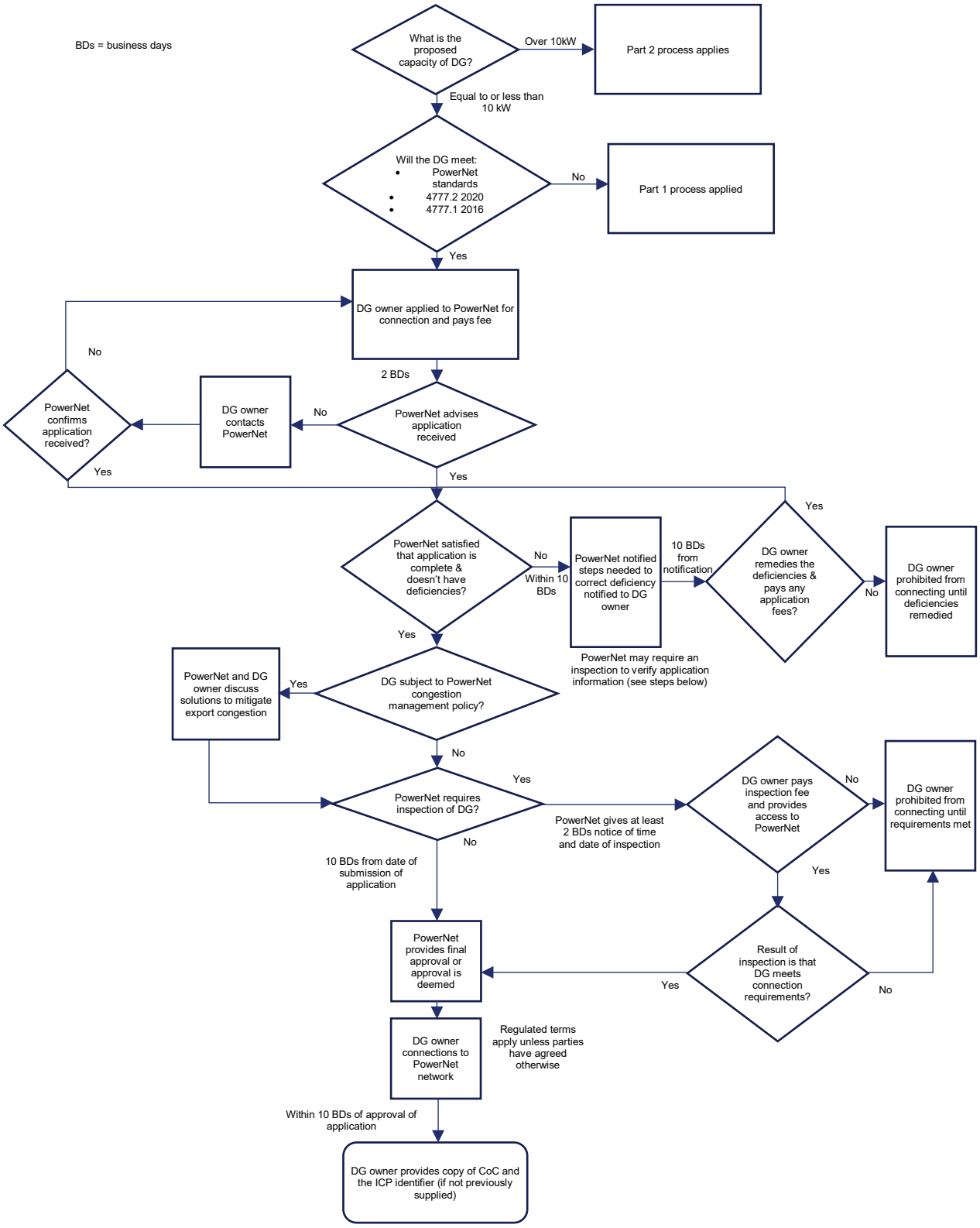
and may also have regard to:

- the percentage of assets that will be used by each DG,
- the percentage of distribution network capacity used by each DG
- the relative share of expected maximum combined peak, and
- whether the combined peak generation is coincident with the peak load on the distribution network.

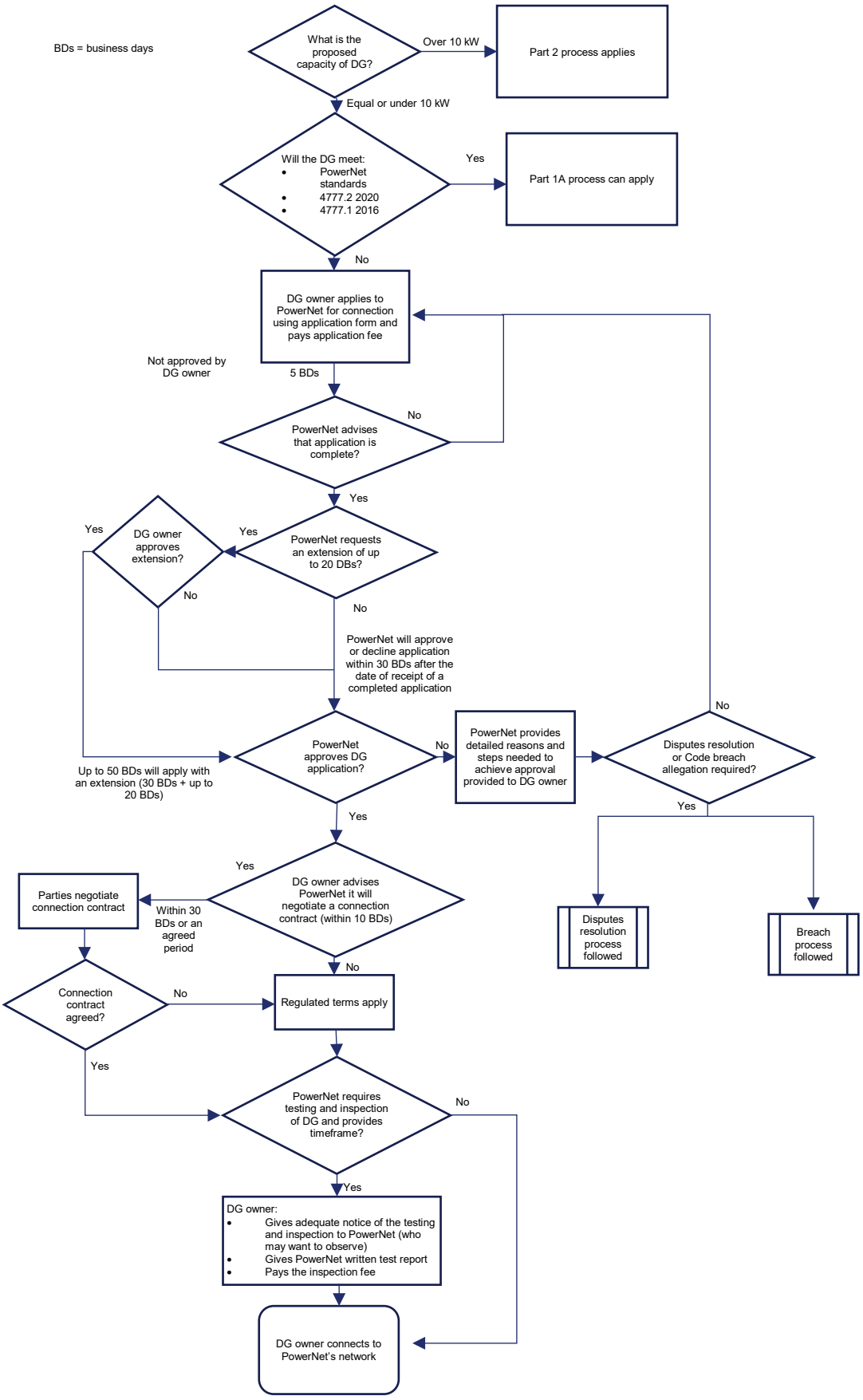
If a DG owner has paid connection charges that include (in part or whole) the cost of an investment that is subsequently shared by other DG owners within 36 months of connection, PowerNet will refund to the DG owner all connection charges paid to PowerNet in respect of that investment in accordance with the expected peak of that DG's injected generation over a period of time agreed between the DG owner and PowerNet.

Appendices

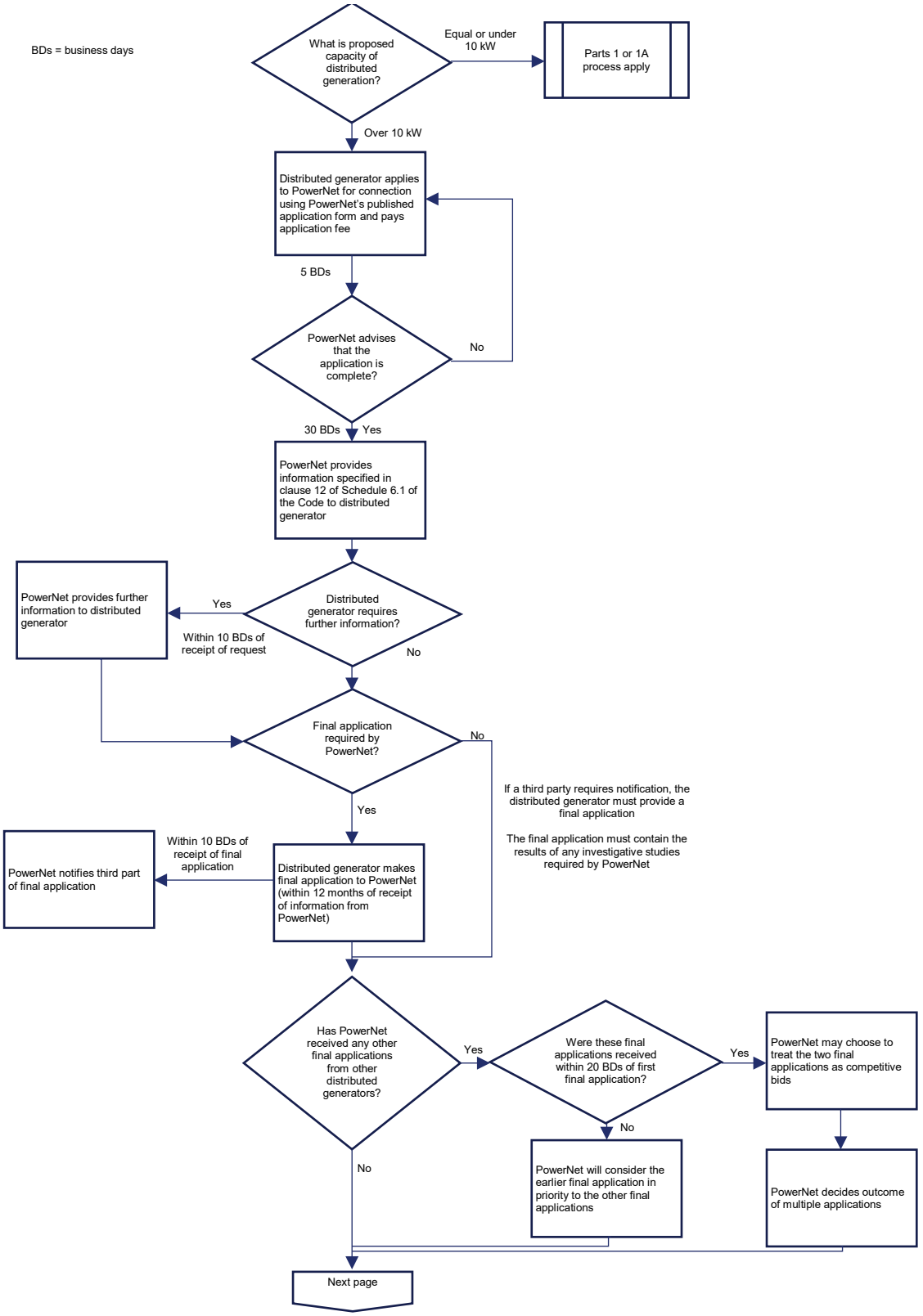
Appendix A. Part 1A Application Process

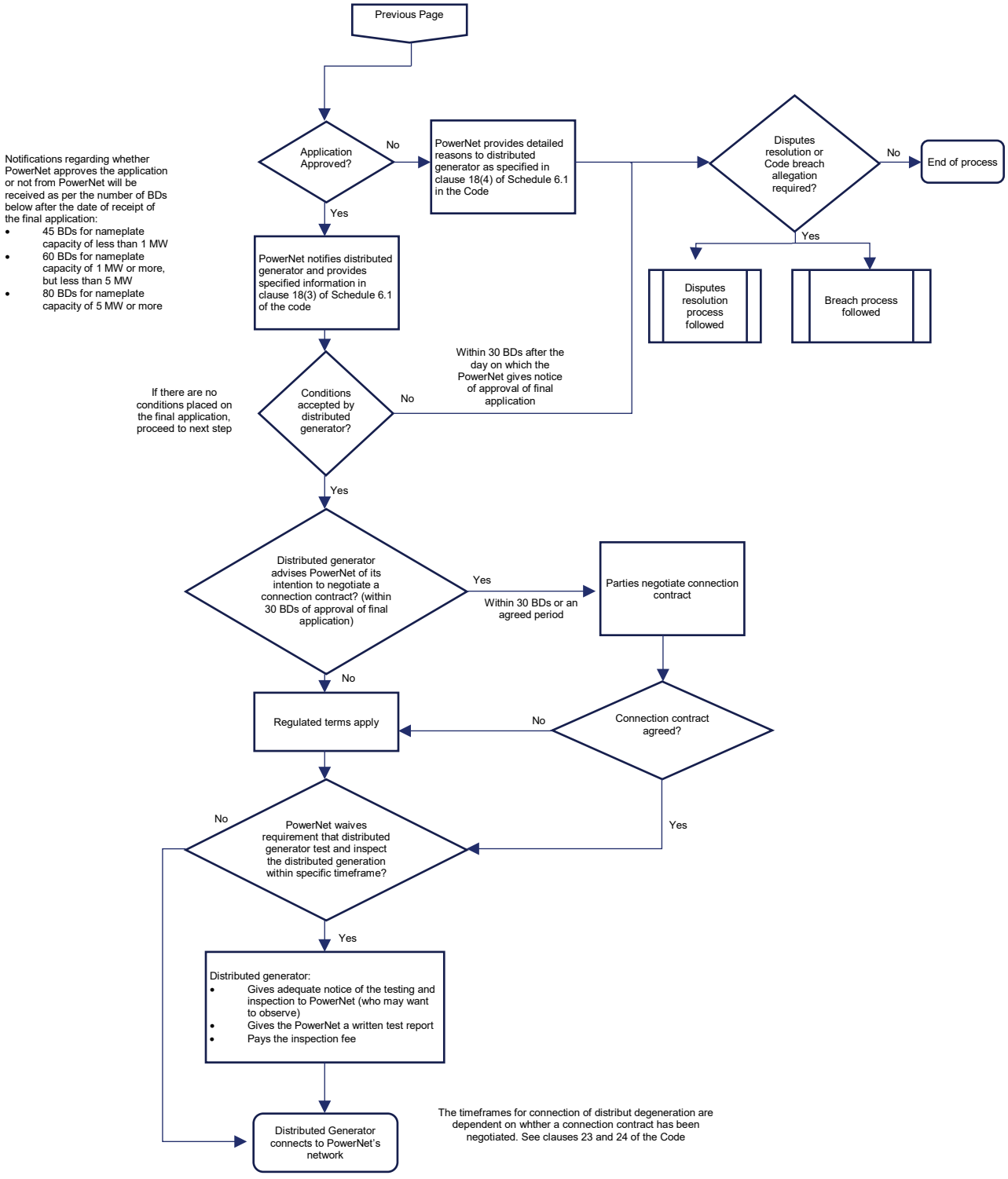


Appendix B. Part 1 Application Process



Appendix C. Part 2 Application Process




Previous Page
Application Approved?
No
Yes
PowerNet provides detailed reasons to distributed generator as specified in clause 18(4) of Schedule 6.1 in the Code
Disputes resolution or Code breach allegation required?
No
End of process
Yes
Disputes resolution process followed
Breach process followed
Notifications regarding whether PowerNet approves the application or not from PowerNet will be received as per the number of BDs below after the date of receipt of the final application:
45 BDs for nameplate capacity of less than 1 MW
60 BDs for nameplate capacity of 1 MW or more, but less than 5 MW
80 BDs for nameplate capacity of 5 MW or more
PowerNet notifies distributed generator and provides specified information in clause 18(3) of Schedule 6.1 of the code
Within 30 BDs after the day on which the PowerNet gives notice of approval of final application
If there are no conditions placed on the final application, proceed to next step
Conditions accepted by distributed generator?
No
Yes
Distributed generator advises PowerNet of its intention to negotiate a connection contract? (within 30 BDs of approval of final application)
Yes
Within 30 BDs or an agreed period
Parties negotiate connection contract
No
Regulated terms apply
No
Connection contract agreed?
Yes
No
PowerNet waives requirement that distributed generator test and inspect the distributed generation within specific timeframe?
Yes
Distributed generator:
Gives adequate notice of the testing and inspection to PowerNet (who may want to observe)
Gives the PowerNet a written test report
Pays the inspection fee
Distributed Generator connects to PowerNet's network
The timeframes for connection of distribut degeneration are dependent on whther a connection contract has been negotiated. See clauses 23 and 24 of the Code