DISTRIBUTED GENERATION UP TO 10KW CONNECTION STANDARD GENERATE - AEN

1 GENERAL

1.1 Scope

This standard covers the implementation of micro embedded generation under either Part 1 or Part 1A of Schedule 6.1 of the Electricity Industry Participation Code.

Micro embedded generation is defined by Powerco as being embedded generation up to 10kW in in total.

This standard does not cover standby generators isolated from the network nor any other isolated generation.

Connection requirements for generators with capacity over 10kW are defined in Powerco's 393S012 *Distributed Generation Over 10kW Connection Standard*.

1.2 Application

This standard applies to all operators of embedded generation within the above-mentioned scope which is or is about to be connected to Powerco's electricity network. It should be applied in conjunction with the methodologies outlined in Powerco's *173S003 Distributed Generation Policy.*

This standard is intended primarily for Consumers wishing to connect alternative energy generation systems such as solar panels, wind or micro hydro turbines to the Powerco network.

Since micro generation is usually derived from an intermittent source (e.g., solar, wind or hydro), the energy is rectified to DC. The DC bus then feeds into a grid-tied inverter which commutates the energy into AC and synchronises it to the utility line frequency.

Most micro embedded generation systems use little or no DC storage (e.g., batteries) as energy is imported or exported as required or available.

1.3 Objective of This Standard

The main objective of this standard is to provide a clear perspective of Powerco's protocol for the enquiry, approval, installation and connection of micro embedded generation.

This standard may also serve as an informative document for Consumers wishing to connect micro embedded generation to the network.

1.4 Referenced Documents

AS/NZS 4777.1:2016 Grid Connection of Energy Systems via Inverters Part 1: Installation requirements

AS/NZS 4777.2:2020 Grid Connection of Energy Systems via Inverters Part 2: Inverter requirements

AS/NZS 3000:2018 – Electrical Installations (AS/NZ Wiring Rules)

Safety Manual – Electricity Industry (SM-EI) Parts 1, 2 and 3, latest version

Electricity Industry Participation Code 2010

Electricity Act

Electricity (Safety) Regulations and pursuant Codes of Practice

100R001 Risk Management Framework

170S001 Powerco Permanent Disconnections – Electricity Network

173S003 Powerco Distributed Generation (DG) Policy (Refer Powerco website)

393S007 Powerco Electricity Network Connection Standard

1.5 Definitions

Certificate of Compliance (Electrical)	A form that provides a statement of compliance with Regulation 39 of the Electricity (Safety) Regulations 2010.
Consumer / Customer	This term has the same definition and meaning as defined in the Electricity Act 1992, namely "…*any person who is supplied, or who applies to be supplied, with electricity*."
DG	Distributed Generation. A synonym for Embedded Generation.
Energy Retailer (of Electricity)	A person who supplies electricity to another person or persons for any purpose other than for resupply by the other person or persons; and "electricity retailing" has a corresponding meaning.
Embedded Generation	Generation connected to a (Powerco) distribution network intended to supply within the local network. The term differentiates from generation which is directly connected to a transmission network intended to supply at a regional or national level.
Grid	For the purposes of this document, Powerco's network.
Grid-Tied	Grid-Tied – An embedded generator electrically connected to, and operating in parallel with the network.
ICP	A point of connection on a local network or an embedded network which the distributor nominates as the point at which a retailer will be deemed to supply electricity to a consumer.
Inverter	An electronic device intended to convert DC into AC.
Micro Embedded Generation	A generator system connected to Powerco's network not exceeding 10kW, either single phase, two phase or three phase.
Modified Sine-Wave	A lower cost and usually more efficient type of inverter that outputs a trapezoid shape waveform rather than sine wave. This type of inverter causes high harmonic distortion making it unsuitable for connection in parallel with the network.
Net Metering	A system used in some countries where no alterations are made to the Consumer's wiring. The kWh meter is simply run in reverse when generation exceeds the load to offset the Consumer's energy usage. **This practice is illegal in New Zealand**.
Network (The)	A collective term commonly used as an abbreviation to mean the whole of the electricity distribution system – i.e., high voltage or low voltage delivery systems. In this document, The Network is taken to mean Powerco's network (or Powerco's works as defined in the Electricity Act 1992).
RCD	Residual Current Device. A type of circuit breaker that is triggered by 30mA of current flowing back through earth.
Service Main	For the purposes of this standard a Service Main has the meaning as defined in the (now revoked) Electrical Supply Regulations 1984, namely; "…*that portion of an electric line between the distribution line (i.e., the Distributor's supply system) or distribution main as the case may be, and the Consumer's main switchboard and which is used exclusively to supply electricity".*

1.6 Risk Identification and Management

A systematic method of identifying all risks shall be applied to all design, construction, maintenance and operation activities undertaken on Powerco's networks, generally as required by Powerco's *100R001 Risk Management Charter*. Appropriate risk elimination, mitigation or reduction methods shall be implemented before work commences on any network asset.

1.7 Copyright

1.8 Document Owner

Contact Person: Chief Engineer

2 SYSTEM REQUIREMENTS

2.1 Inverters and Installation Requirements

Inverters used for micro embedded generation differ from those usually available for consumer electronics.

Although low cost inverters intended for use in caravans, motor homes or boats are readily available, they are not suitable for grid-tied generation applications.

Inverters labelled as “grid-tied” and conforming to AS/NZS 4777 shall be used in order for the generation system to meet the performance and protection requirements deemed as necessary to connect to the Powerco network.

Installation requirements shall comply with AS/NZS 4777.1:2016, and that inverters shall comply with AS/NZS 4777.2:2020.

While this document describes the process for installations up to 10kW nameplate rating, note that Clause 2.3 of AS/NZS 4777.1:2016 includes the paragraph:

> “*Unless specifically stated by the distributor, the rating limit for a single-phase IES (Inverter Energy System) in an individual installation shall be equal 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*.”

In other words, the maximum single-phase connection is 5kVA, and above this a two-phase or three-phase connection is required, noting the 5kVA unbalance limit between phases.

It is strongly recommended that installers estimate the export capability at the customers installation to transport generated energy to the distribution network within acceptable voltage constraints. Higher levels of network voltage and impedance can result in export constraints. These conditions could lead to the inverter tripping on high voltage. Appendix E describes a method, including voltage and impedance checks, to determine installation export capability.

2.2 Operational Modes and Grid Protection Devices

It is recommended that the inverter have operational modes for both Volt-Watt and Volt-Var responses enabled. These response modes shall be the New Zealand based settings as per Clause 3.3.2 of AS/NZS 4777.2:2020.

Grid Protection Devices shall be installed to ensure that the inverter is isolated from the network in the event of an outage.

This is an important safety feature preventing the local LV network from being livened after it has been isolated further upstream which poses a risk to personnel. Grid protection devices are usually incorporated into the inverter and must meet AS/NZS 4777.2 specifications for anti-islanding and reconnection.

Powerco’s Minimum requirements are:

- Operate and auto-isolate on under voltage and over voltage limits for the delay and trip times described in Table 4.1 of AS/NZS 4777.2:2020;
- Operate and auto isolate on under frequency and over frequency limits for the delay and trip times described in Table 4.2 of AS/NZS 4777.2:2020;
- At least 1 method of active anti-islanding protection;

- Reconnection delay of at least 1 minute after normal grid supply is established, refer to Clause 4.7 of AS/NZS 4777.2:2020;
- Settings must be password or lock protected;
- Total Harmonic Current Distortion less than 5%; and
- Inverter power factor must be consistent with the Volt-Var mode of operation, refer to Clause 3.3.2.3 of AS/NZS 4777.2:2020.

2.3 Overvoltage Protection

In addition to the Operational Modes and anti-islanding protection specified in section *2.2 Grid Protection Devices*, Powerco requires protection against the generation causing excessive voltage at the network point of connection. New Zealand legislation states the allowable voltage range at LV customer's points of supply (POS) is 230 volts +/- 6%, or 216.2 to 243.8 volts. However, inverters can only measure the voltage at their terminals, and the voltage there is different from the POS voltage due to voltage drops / rises across the impedance between POS and the inverter terminals.

In order to safe guard against potential damage to consumer appliances the following is required:

- Inverter over voltage trip levels ~~=~~ $V_{nom\text{-}max}$, refer Clause 4.5.2 of AS/NZS 4777.2:2020, shall be set to 249 volts.
- When the average voltage at the inverter terminals exceeds $V_{nom\text{-}max}$ for a 10 minute period disconnection shall occur within 3 seconds of this limit being exceeded.
- Reconnection shall not occur until the conditions listed in Clause 4.7 of AS/NZS 4777.2:2020 have been met for at least 60 seconds.

2.4 Metering

The Energy Retailer may require a new kWh meter to be installed in an existing installation – usually replacing the current import meter.

The meter will measure energy imported and exported to and from the premises separately and must meet Electricity Industry Participation Code, Part 10, requirements for metering. Further information about metering should be obtained from the energy retailer.

The Consumer shall provide Powerco (at Powerco's request) interval data and cumulative data recorded by those meters.

2.5 Access

The Consumer shall provide Powerco, or a Powerco authorised service provider safe and unobstructed access to the generation site and all upstream equipment at all reasonable times, providing:

- Access is required for matters concerning the generation circuit and its connection to the Powerco network;
- Powerco shall make a written request to the Consumer to access the site for scheduled works;

- Powerco, or a Powerco authorised service provider may not interfere with the Consumer's equipment without their express permission. This does not include methods of isolation or the confirmation of inverter settings;
- Powerco may require immediate access to the Consumer's equipment in the event of an emergency (i.e., to prevent a breach of safety or damage to property). Powerco shall inform the Consumer of the circumstances and events as soon as practicable.

2.6 Interruptions / Temporary Disconnection from the Network

Powerco may, from time to time, isolate any embedded generation in order to perform certain maintenance tasks or manage the network capacity in accordance with the requirements of Powerco's 173S003 *Distributed Generation (DG) Policy*.

2.7 Permanent Disconnection

Permanent disconnection of the ICP should comply with the requirements of Powerco's *170S001 Permanent Disconnections - Electricity Network - Policy.*

Permanent disconnection of the embedded generator circuit only shall include:

- The Consumer informing their Energy Retailer of the disconnection;
- At least one device (circuit breaker, etc) must be removed from the embedded generator circuit to give physical disconnection;
- The remaining circuit, if any, must be "made safe" as per the provisions of *AS/NZS 3000: Wiring Rules*;
- All signs and labels shall be removed from the Consumer's service fuse (at point of network connection) by Powerco or an authorised Powerco service provider.

2.8 Signs or Labelling

It is the Consumer's responsibility to ensure that the generating circuit is clearly labelled on the main switchboard and any sub-main switchboards it passes through.

A label shall be placed on the Consumer's service fuse as a reminder to test and prove that the circuit is de-energised before carrying out any work on the Consumer's service main.

Refer to *4.2 Appendix B: Warning Tags for DG Circuits* for examples of signs and labels.

2.9 UPS Installations

Generation may be used in conjunction with batteries to provide an uninterruptible power supply (UPS) for certain circuits within the premises.

In this instance, no protection device shall interrupt the neutral or earth conductors between the network and the inverter.

This prevents the use of residual current devices (RCD's) between the inverter and the network.

3 THE CONNECTION PROCESS

3.1 Consumer Application for Connection

The Consumer must make an application in writing to Powerco about the connection of embedded generation in accordance with the requirements of Powerco's *173S003 Distributed Generation (DG) Policy.*

The application must include the following information:

- Location – i.e., the physical address of where the generation is to be installed and ICP number;
- Contact details of both the owner and installer of the equipment;
- The invoicing address for the application fee;
- Whether the DG installation is new or an increase to existing capacity;
- The part of the EIPC that the application is made under;
- The Energy Retailer at the DG site;
- Power – the maximum AC generation (number of phases and amps per phase) that will be injected;
- Type – the type of AC commutation device e.g., electronic inverter, AC induction, synchronous, etc;
- Technical Details – including, inverter make and model, compliance with AS/NZS 4777.2:2020, if Volt/ VAR and Volt/Watt response modes are enabled, compliance with Clause 2.2 and 2.3 of this standard, typical load at connection point, measured voltage at the switchboard, if the installation has battery storage and loop impedance;
- Schematic diagram distinctly showing the relevant existing circuits and the intended generation; and
- The intended time frame for connection.

3.2 Approval Process

The approval process shall begin once the Consumer has supplied satisfactory information about the intended connection to Powerco as detailed in Section 3.1 above.

3.3 Retailer Contractual Agreement

The Consumer shall achieve an agreement with their Energy Retailer for the export of energy.

3.4 Connection

The Consumer must provide a Certificate of Compliance and a completed commissioning test statement to Powerco, signed by the registered electrician installing the embedded generation or a licensed inspector verifying that the installation complies with the requirements of Powerco's *Electricity Network Connection Standard (393S007)* plus all other network requirements and is electrically safe (i.e. the installation fully complies with the requirements of AS/NZS 3000 – Wiring Rules). The commissioned equipment and settings shall not deviate from the approved application form. Powerco may then approve the plant for connection to The Network.

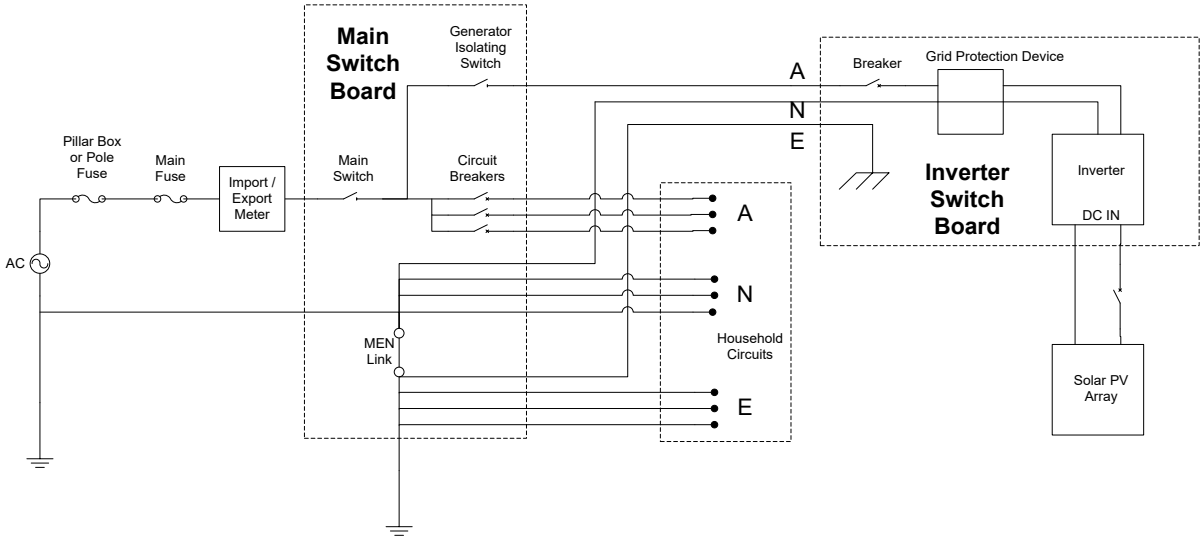
3.5 After Connection

The Consumer shall provide as-built information including drawings and schematics to Powerco following connection of the embedded generation to the network.

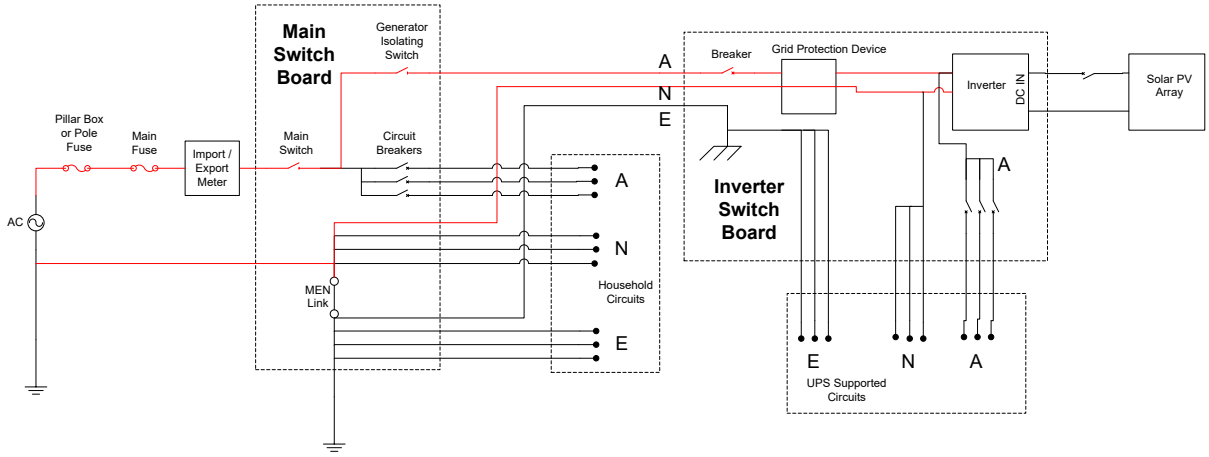
4 APPENDICES

4.1 Appendix A: Wiring Guidelines

The following diagram shows a typical grid tied solar PV array connected through a domestic site. Wiring topologies may vary considerably. Refer to AS/NZS 4777 for more detailed guidelines.



A UPS type system with appliances connected between the inverter and the grid protection device. Note the red lines showing the inverter circuit. In a UPS circuit, no residual current devices shall be placed between the point of supply and the inverter. The same is true for any protection device that breaks the neutral conductor.



4.2 Appendix B: Warning Tags for DG Circuits

4.2.1 Switchboard Warning Signs

An example sign on the switchboard to which the generator is directly connected:

WARNING
DUAL SUPPLY
ISOLATE BOTH NORMAL AND GENERATOR SUPPLIES BEFORE WORKING ON THIS SWITCHBOARD

An example sign on all other switchboards within the installation:

WARNING
DUAL SUPPLY
ISOLATE GENERATOR SUPPLY AT DISTRIBUTION BOARD DB01

Example stickers to be placed over the generator isolating switch:

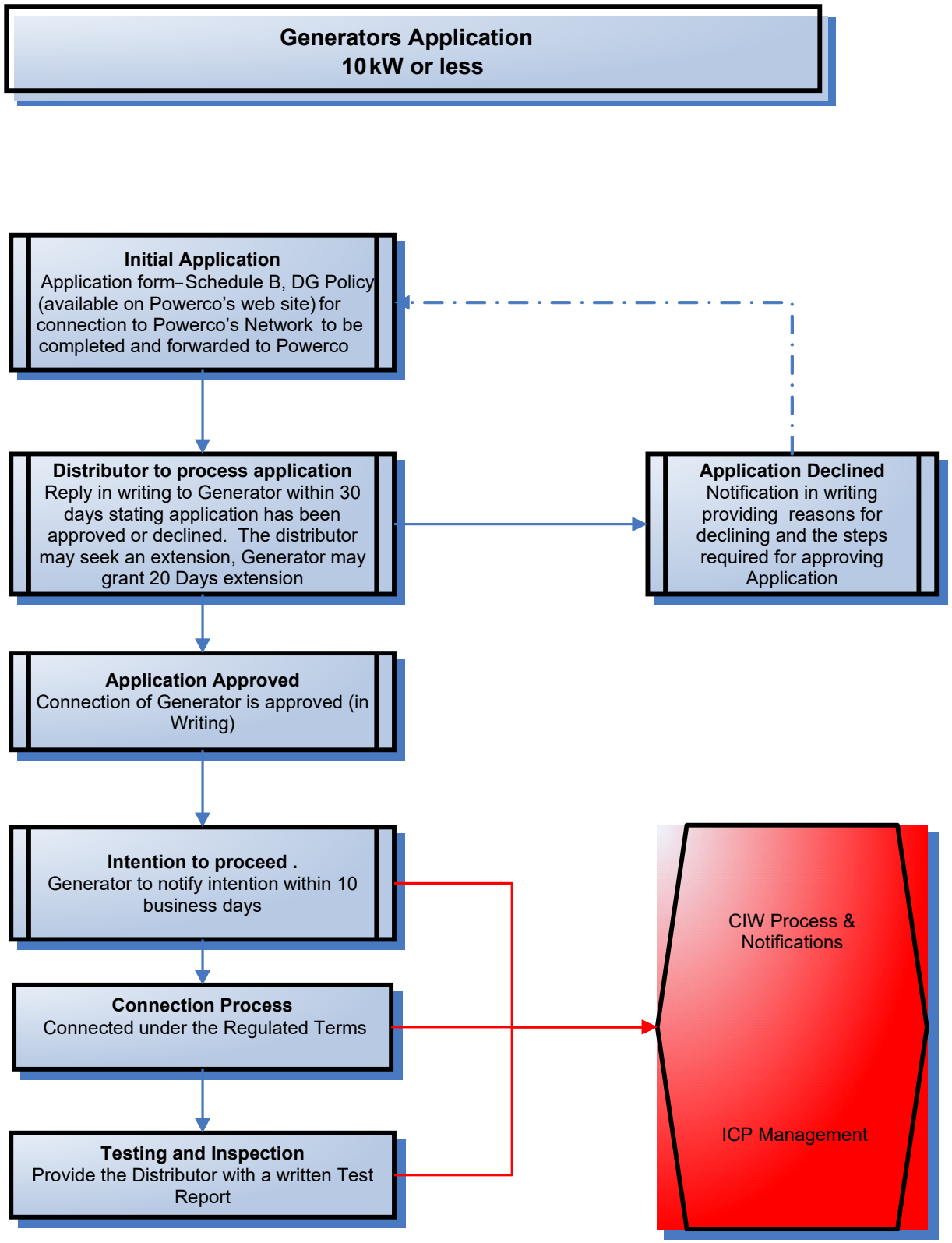
SOLAR
SUPPLY

4.2.2 Powerco Network Warning Signs

Example tag to be tied to the fuse holder of an underground pillar box or overhead service main connection point.

WARNING
THIS ICP CONTAINS EMBEDDED GENERATION. TEST AND PROVE DE-ENERGISED AFTER ISOLATING.

4.3 Appendix C: Application and Connection Process



4.4 Appendix D: Connection of Distributed Generation of 10kW or less in total

APPLICATION FORM FOR DISTRIBUTED GENERATION UNDER 10KW

Customer's contact details (Owner and operator of the DG)	Name					
	Address					
	Tel No.					
Installer's contact details	Name					
	Address					
	Tel No.		Email			
Application fee invoice address:						
Is this a new installation or capacity increase to existing?				new / capacity increase*		
This application is under Part 1 or Part 1A* (circle one) of Schedule 6.1 of the EIPC (refer to clause 1.1)						
Energy Retailer at DG site						
Proposed connection date:	DD / MM / 20YY					
Type of DG (photovoltaic, wind etc.)						
Maximum AC generation		Number of phases		Amps per phase		A
Inverter make and model						
Inverter complies with AS/NZS 4777.1&2?		Yes / No*		Any battery storage?		Yes / No*
DG connection point	ICP number					
	Street address					
Typical load at the proposed point of connection:						
Will Volt / Watt response mode be enabled? (this is recommended)						
Will Volt / VAR response mode be enabled? (this is recommended)						
Does the installation comply with Powerco's minimum requirements detailed in 393S089 Clause 2.2?						
Does the installation comply with Powerco's overvoltage protection requirements detailed in 393S089 Clause 2.3?						
Phase to neutral and phase to phase loop Impedance (including inverter wiring – refer to Appendix E)		R-N	Ω	R-W	Ω	
		W-N	Ω	R-B	Ω	
		B-N	Ω	W-B	Ω	
Voltage at switchboard					V	

*(circle the one that applies)

Declaration

[ ], being the applicant for the connection of the Distributed Generation (DG) referred to in this Application to Powerco's Distribution Network, certify that the above information is true and correct.

Signed for/by the applicant:

_____

_____
[insert name and position]

_____
[insert date]

For Powerco Use: Network Approval Confirmation		
Application requirements complete: Yes/No		
Application approved to progress to installation and testing: Yes/No		
Signed: Date:		
Network Connection Details		
Zone Substation	**Feeder**	**Distribution Transformer**

4.5 Embedded Generation Plant & Commissioning Report

EMBEDDED GENERATION - COMMISSIONING REPORT

Installation tested by:		
Date test completed:		
Loss of network supply auto-isolation test proven		Yes / No*
Auto-isolation disconnection speed:		seconds
Auto-restoration if existing after specified delay proven		Yes / No*
MEN Earth test results in Ohms:		Ω
Site Voltage and time taken	Specify with or without load and with or without generation	V at HH h mm (time) Load: Yes / No* Generation: Yes / No*
Volt/VARS enabled? (This is recommended)		Yes / No
Volt / Watts enabled? (This is recommended)		Yes / No
Loop Impedance Test results		Ω
Maximum export apparent power (kVA) on each phase		
Protection setting details. Attach additional details where necessary:		
Electrical inspection to AS/NZS3000:2007 and Electricity (Safety) Regulations 2010 completed		Yes / No
Name of Electrical Inspector:		

*(circle the one that applies)

Other tests requested by Powerco to be specified:

A Certificate of Compliance (COC) from a registered electrician/licensed electrical inspector that the DG complies with the Electricity (Safety) Regulations 2010 should accompany this report.

The completed report including a COC shall be forwarded to Distributed Generation, Powerco Ltd, Private Bag 2061, New Plymouth, 4340 or emailed to distributedgeneration@powerco.co.nz

Report completed by	Name	
	Address	
	Tel No.	

4.6 Appendix E: Determining an installation's export capability / limitations

In order to meet the dual objectives of fair access to the network, and to optimise inverter export capability, Volt-Var and Volt-Watt modes should be enabled and set consistently across all inverters on the LV network.

Check voltage

Measure the phase to neutral voltages at the installation's main switchboard, while the switchboard is unloaded, and at a time when the feeder load is expected to be low.

Record the voltages, the date, and the time.

Advise Powerco the measured voltage at the main switchboard

If any of the voltage readings are 244 volts or above, advise Powerco.

Powerco should investigate the reasons behind the high voltage, e.g.: distribution transformer tap setting, other distributed generation, HV network regulation etc, and remediate.

Determine the supply loop impedance

Measure (or calculate) the phase-neutral and phase-phase supply loop impedances at the installation's main switchboard, while the switchboard is unloaded.

Calculate the expected phase-neutral or phase-phase impedance/s of the cable from the main switchboard to the inverter and add it to the switchboard measured result above.

Record the total loop impedance/s, Loop Z.

Calculate the network impact product (NIP) for the installation

NIP = inverter kVA * Loop Z where:

Inverter kVA is the nominal per phase rating of the inverter

Loop Z is the phase–neutral loop impedance seen by the inverter

Eg: Calculate the Network Impact Product for a two-phase inverter system, rated 4 kVA per phase, connected to a supply which has a 0.5 Ω phase-neutral loop impedance.

NIP = 4 x 0.5 = 2

Check the calculated network impact product against the recommended limit

Inverter configuration	NIP limit (per phase)
Single-phase	2.4
Two-phase unbalanced	
Three-phase unbalanced	
Two-phase balanced	3.2
Three-phase balanced	4.8

Where the calculated NIP is less than the limit, the inverter voltage control modes should work as expected.

Where the calculated NIP is above the limit, voltage instability may occur at times. Options to improve/remediate this include upgrading the supply (lowering Loop Z), spreading export across more phases (lowering kVA/phase), phase balancing (reduces volt drop effect of neutral conductor).

4.7 DOCUMENT REVIEW HISTORY:

Version Number	Reviewed By.	Review Date	Reason
1	S. Hadley-Jones	24/09/07	First issue of document into BMS
2	M. Smith	14/10/08	Inclusion of references to international standards UL1741 and IEC61727 for inverters to enable approval of all compliant equipment. This does not reduce the requirements of this standard. H&S clause replaced. New Environmental and Hazard ID clauses added. Connection to Powerco network to comply with Powerco standard 393S007 requirements. Definitions of (The) Network and ICP redefined. Minimum requirements for grid tied generation connections defined (clause 3.2).
3	M. Smith	17/6/10	Included process diagram for application and connection. Included Plant and Commissioning Report template. Aligned terminology with 393S012 Small Embedded Generation Standard wherever applicable. Deleted H&S clauses (this standard is about setting technical parameters, not work practices outside Powerco network which are covered by other documents).
4	M. Smith	19/04/11	Updated to reflect legislative changes (Electricity Industry Participation Code 2010 and Electricity (Safety) Regulations 2010)
5	M. Smith	11/05/12	Title renamed (previously called “Micro Embedded Generation Standard”). Updated to align with updated DG Policy.
6	G. Vaughan M. Smith	14/ 3/14	Title changed by deleting “Embedded” and adding “Distributed”. *New* added clause 2.3 Overvoltage Protection to prescribe a maximum voltage for back feeding. s4.4 streamlined Application Form. Included reference to application fee mechanism. Added Powerco Network Approval sign off field.
7	M. Smith	09/04/15	Updated application form to meet EIPC Part 6 requirements.

8	T. Naidoo R. Pittwood	29/07/20	Updated references to Standards to reflect the latest names throughout the document Amended scope as follows: Included “under either Part 1 or Part 1A of Schedule 6.1 of the Electricity Industry Participation Code.” Changed generation up 10kW from “in both single and three phases” to “in total” Added “Connection requirements for generators with capacity over 10kW are defined in Powerco’s 393S012 *Distributed Generation Over 10kW Connection Standard*.’ to scope Removed references to the withdrawn standard AS/ZNS 4777.3 Changed document owner to Chief Engineer Changed 2.1 to Inverters and Installation Requirements In section 2.1 clarified the generation limits for single phase systems and multi-phase systems 4.5 Included Site Voltage, Volt/VARS enabled, Earth Loop Impedance and Maximum Export Power to commissioning report Amended postal address for commissioning report and added email address
9	T. Naidoo R. Pittwood	23/12/20	Update due to AS/NZS 4777.2:2020 being published Changed references to AS/NZS 4777.2: from 2015 to 2020 2.1 Added recommendation that installers investigate the export capability / limitations of customer service networks 2.2 Added recommendation that both Volt-Watt and Volt-Var response settings are enabled. Modified Powerco’s minimum requirements in line with AS/ANZ 4777.2:2020 recommendations 2.3 Modified Voltage and tripping time requirements 3.1 modified information to be included with the application form 3.4 Included “The commissioned equipment and settings shall not deviate from the approved application form” Application form and commissioning report modified Added Appendix E: Determining an installation’s export capability / limitations

5 POWERCO STANDARD - DOCUMENT CHANGE REQUEST

Memo To: **Chief Engineer**,
Junction Street,
New Plymouth.

Change Details: (Attach separate sheets as necessary).	
Paragraphs Affected:	
Priority:	**Urgent** ☐ (Within 1 week) **Routine** ☐ (Within 12 months) **Low** ☐ (Next Review)
	Submitted By (Print Name) / **Date**

Document Change Request - Acknowledgement

Dear ……

Thank you for your suggestion regarding changes to the above mentioned document.

Your request has been noted and added to our works program. Should we require any additional information regarding your notification then we will be in contact with you.

Thank you for your contribution to improving the quality of Powerco's documentation.

Regards,

…… ……..
Chief Engineer Date

393S089 Ends