NI 0538

Large Scale Generation Connection Standard

Version 4.0

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Version 2	Minor updates to Clause 1.3.2	May 2019
Version 3	Major rewrite and coordination with industry experiences	October 2024
Version 4	Changed to remove 1 MW and replace with over 10 kW as per EIPC, Changed TP to just system operator.	August 2025

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1 GENERAL

1.1 Scope

The purpose of this document is to establish the technical requirements for connecting and operating utility- scale power generation to Network Waitaki's network and to specify the minimum requirements for parallel connections of a generation facility with Network Waitaki's distribution or sub-transmission network. The generating unit must adhere to the standards outlined in this document.

This standard has been developed with the primary purpose of ensuring the secure and compliant connection of power generation systems to Network Waitaki's network.

The owner of the generator asset is responsible for ensuring that their generation plant complies with all mandatory safety obligations mandated by relevant New Zealand Acts, New Zealand Regulations, AS/NZS Standards, and all applicable Network Waitaki Standards. The requirements detailed in this document do not exempt the generator asset owner from any statutory responsibilities.

1.2 Application

This document applies to all new connection and modifications to existing connections for generation plants where the aggregate total of the plant’s nameplate capacity meets or exceeds 15 kW including synchronous, asynchronous and inverter-based generation that is connecting onto the Network Waitaki distribution (11 kV) and sub-transmission (33 kV, 66 kV and 110kV) networks.

1.3 Intended Audience

The intended audience for this standard is aimed at Network Waitaki employees, Customers, Developers and Consultants involved with proposing and evaluating utility-scale distributed generation intending to connect to Network Waitaki’s electrical distribution networks.

1.4 Reference Documents

1.4.1 Legislation

- Electricity Act 1992
- Electricity Industry Participation Code 2010 (Code)
- Electricity (Safety) Regulations 2010
- Electricity Act
- Electricity (Safety) Regulations

1.4.2 Guidelines, Industry Rules and Standards

- AS/NZS 5033:2021 - Installation and safety requirements for photovoltaic (PV) arrays
- AS/NZS 61000 3.6:2012 - Electromagnetic Compatibility (EMC) – Part 3.6: Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
- AS/NZS 61000 3.7:2012 - Electromagnetic Compatibility (EMC) – Part 3.7: Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems

- AS/NZS 62116.2:2020 - Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
- EEA (NZ) Connection of Generation Plant - Electricity Engineers' Association Guide for the Connection of Generation Plant
- EEA (NZ) Power Quality Guidelines - Electricity Engineers' Association Power Quality Guidelines
- IEC 60255 suite of standards - Measuring relays and protection equipment.
- NZECP36:1993 - New Zealand Electrical Code of Practice for Harmonic Levels
- GL-EA953 – Transpower Connection Study Requirements for Connecting a New Generating Station
- GL-EA404 – Transpower Generation Commissioning and Decommissioning Requirements
- TP Grid Impact - Transpower Grid Exit Point Impact Studies for Distributed Energy Resource Development

1.4.3 Network Waitaki Documents

- 173P001 - Network Waitaki Distributed Generation Policy [to develop]
- 393S012 - Distributed Generation Over 10 kW Connection Standard [large scale DG standard]

1.5 Definitions

Unless stated otherwise, all words and phrases used in this document shall have the following meanings:

Term	Definition
Anti-islanding protection	Anti-islanding protection detects the absence of a connected Network Waitaki network.
CPCB	Connection Point Circuit Breaker – A Network Waitaki owned circuit breaker located on the Network Waitaki side of the Demarcation point.
CPPR	Connection Point Protection Relay detects abnormalities such as overcurrent, overvoltage, underfrequency, or short circuits, and then isolate the affected section of the network to prevent further damage by opening the Connection Point Circuit Breaker.
Differential Protection	Differential protection is a unit-type protection connected across a specified zone or asset. It provides protective function by monitoring and responding to the difference between input and output currents.
Edge Device	Network Waitaki owned IT equipment used to collect operational information from the Generation Asset Owner's GPCB (and potentially other digital equipment operated by the Generation Asset Owner) for visibility within Network Waitaki's SCADA system.
The Code	New Zealand Electricity Industry Participation Code 2010.

Term	Definition
Energy Storage	A system comprising of energy storing components (i.e., batteries) where energy generated, or energy received via the Network Waitaki Network is stored and then latter discharged to supply the load or (and) the Network Waitaki Network.
Fault Ride Through (FRT)	The capability for a generation plant to be able to safely stay connected through a short period of network disturbance of voltage and/or frequency.
Generation Asset Owner	Refers to the owner of Generation Plant, in the context of this document. It also includes the Generation Plant Owner elected proponent (consultant).
Generation Plant	A generation plant contains all the generating units and aggregated generated power exported via a connection on the Network Waitaki network. Also referred to as Distributed Generation (DG).
Generation Unit	The combination of energy generating equipment that converts a source energy into AC or DC electrical power. All the equipment functions a single entity.
GPCB	Generation Plant Circuit Breaker – This is the first circuit breaker beyond Network Waitaki's network, that exported power must first flow through before entering Network Waitaki's electricity distribution network.
Grid (The)	The system of transmission lines, substations and other works, including the HVDC link used to connect grid injection points and grid exit points to convey electricity throughout the North Island and the South Island of New Zealand.
GXP	Grid Exit Point.
Inter-trip (Inter-tripping)	Inter-tripping is a protection method in which operation of a protection equipment at one end of a circuit causes a signal to be transmitted to trip a protection equipment at the remote end of the (or another) circuit.
IBR	Inverter-Based Generation is generation connected to the network using power electronics technology and requires adequate system strength for the inverters to work predictably and reliably.
Islanding	A livened portion of the Network Waitaki network (supplied by a generation plant), that is electrically isolated from upstream Network Waitaki network.
Network (The)	As defined in the Electricity Act, The Network means a collective term commonly used as an abbreviation to mean the whole of the electricity distribution system - i.e., High Voltage (HV) or Low Voltage (LV) delivery systems. The Network is taken to mean Network Waitaki's network in the Electricity Act.
Network Waitaki	Network Waitaki Ltd.
NOC	Network Waitaki Network Operation Centre.

Term	Definition
P2 Relay	An additional relay added, the relays operate in parallel with the primary (P1) relay and acts as an independent back-up to the P1 relay providing main protection should the primary relay fail.
Point of Common Coupling (PCC)	Point on a public supply system (in terms of use) which is electrically closest to the installation concerned, at which other installations are, or could be interconnected. The PCC is a point located upstream of, or at, the installation (POC).
Point of Connection (POC)	Point on a public supply system (in terms of use) where it is electrically closest to the installation concerned or can be connected.
PQM	Power Quality Meter (ASNZS 61000-4-30 Class A) instrument use to monitor power quality aspects. In this Standard PQM shall be owned by Network Waitaki.
Rate of Change of Frequency (ROCOF)	ROCOF is a measure of how quickly the frequency of the power system is changing over time expressed in Hertz per second (Hz/s) and used in protective relays and control systems to detect and respond to abnormal conditions.
Run-back	A runback or curtailment scheme is a special protection scheme which reduces the flow of electricity in a network element in a controlled way, in response to a specific event.
Synchronised/ Synchronising	Synchronised is when two network points have the same voltage magnitude and frequency and zero phase difference. Synchronising is the act of bringing two separated points of the network into synchronism.
SCADA	Supervisory Control and Data Acquisition system that provides real-time monitoring, control, and management capabilities.
System Operator	Transpower New Zealand Limited in its capacity of the System Operator is responsible for managing the real-time power system and operating the wholesale electricity market.
Transpower	Transpower New Zealand Limited in its capacity of Grid Owner owns and operates the National Grid.
Vector Shift	Vector shift refers to a condition where the angular displacement between voltage and current phasors deviates from the expected value due to system faults or abnormalities. Vector shift protection typically involves monitoring the phase angle relationship between voltage and current at specific points in the power system.

1.6 Copyright

1.7 Acknowledgement

This standard is based on Powerco's Utility Scale Generation Standard to provide a more consistent customer experience across distribution companies. We wish to acknowledge Powerco's generosity in sharing this standard with us.

1.8 Health, Safety and Environment

Written approval must be obtained before any generation can be connected to Network Waitaki's network, whether permanent, temporary, or upgrading existing generation capacity (including Distributed Energy Resources and energy storage).

Generation connected to Network Waitaki's network (either directly or via an inverter) poses a potential public safety risk and presents additional risk of damaging another customer or network equipment.

2 TECHNICAL REQUIREMENTS

This section outlines the technical requirements for connection and operation of utility scale distributed generation connected to the Network Waitaki network.

2.1 Voltage and Frequency

2.1.1 Standard Network Voltage

Distributed generators must ensure that their plant is capable of being operated, and does operate, in a stable and safe manner whenever the network is operated within the range of voltages set out in Table 1.

Table 1: Steady State Voltage Range

Nominal Voltage (kV)		Phase to phase Voltage ; 10-minute RMS		
	Minimum voltage (kV)	% of nominal	Maximum voltage (kV)	% of nominal
11	10.34	-6%	11.66	+6%
33	31.02	-6%	34.98	+6%
66	62.70	-5%	69.30	+5%
110	99.00	-10%	121.00	+10%

Generating plants must stay connected within the steady state voltage limits specified in the EEA (NZ) Power Quality Guidelines and Clause 8.22 of Part 8 of the Code. Generation Plant Owners must ensure that their generation plant is capable of being operated, and does operate, in a stable and safe manner whenever the network is operated within the range of voltages set out in Table 1.

2.1.2 Operating Voltage Limits

While the plant is required to remain stable and connected over the voltage ranges expressed in the previous section (Standard Network Voltage), the plant's operation must not cause the operating voltage limits shown in Table 2 to be exceeded.

Table 2: Operating Voltage Range

Nominal Voltage (kV)	Phase to phase Voltage ; 10-minute RMS			
	Minimum voltage (kV)	% of nominal	Maximum voltage (kV)	% of nominal
11	10.45	-5%	11.22	+2%
33	31.02	-6%	34.32	+2%
66	62.04	-6%	68.64	+4%
110	101.2	-8%	114.4	+4%

The upper limits (or maximums) expressed in Table 2 are likely to be the main concern for generation export, and these limits will be key parameters in determining the design and ultimately the generation export limits.

2.1.3 Frequency Support Obligation

All generation plant must contribute to the support of system frequency by continuing to operate in a stable manner during a grid frequency disturbance, particularly when frequency is falling. Generation plant must remain synchronised and sustain pre-event output for the durations as specified whenever frequency is in the ranges as set out in clause 8.19 of the Code.

Generators above 1 MW must comply with any System Operator requirements in this regard or as specified in Part 8 of the Code. The Generator Asset Owner is responsible for engaging with the System Operator to ensure that the generation plant fulfils any frequency support obligations.

2.2 Reactive Power Capability

The Generation Asset Owner must furnish the aggregated generation plant's reactive capability curve at the point of connection. The minimum requirement is for the generation plant to be able to maintain a power factor within the range of 0.95 leading and 0.95 lagging, as depicted in Figure 1. Generation plants equipped with broader reactive capability should be able to operate within the envelope defined by the product of the generating plant's rated active power and a ±0.33 pu range for reactive power, as illustrated in Figure 2.

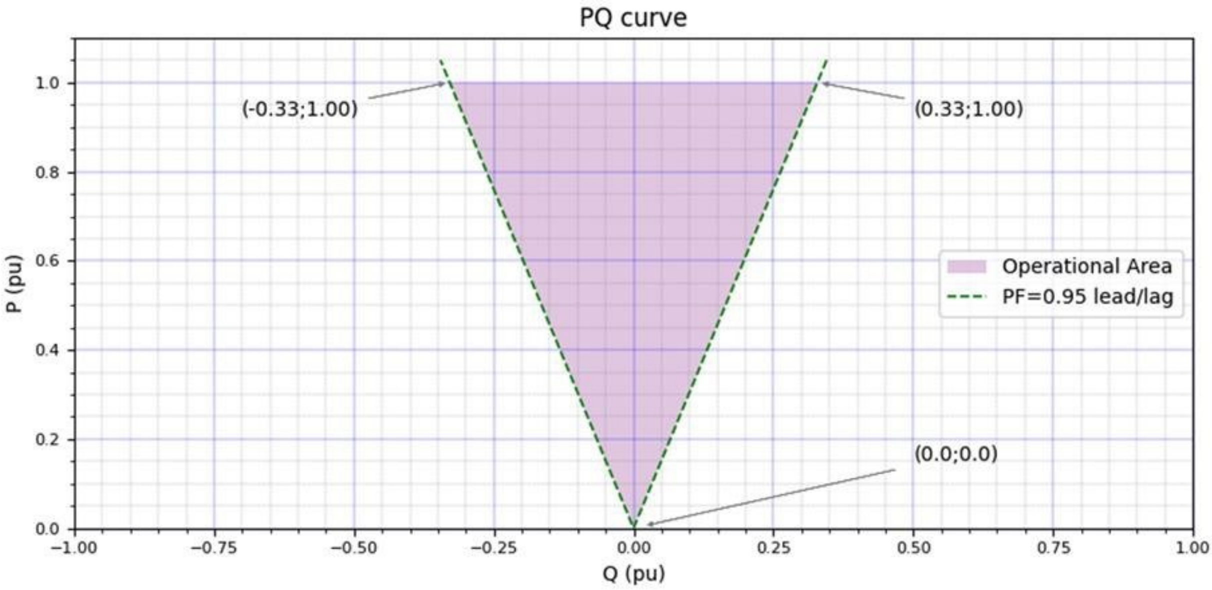

Figure 1: PQ operating region for 0.95 injection and absorption power factor

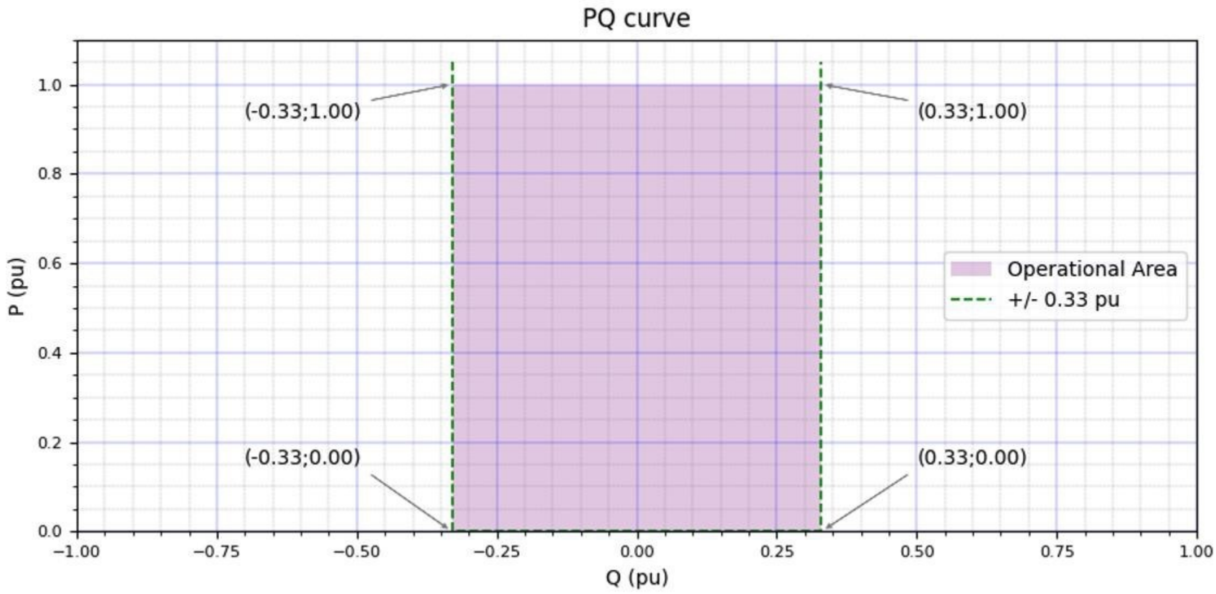

Figure 2: PQ operating region for ±0.33pu leading and lagging reactive power

Note, that this is the continuous reactive power capability that may be used to contribute to steady-state voltage management. Generators should also have a higher transient injection capability (being a mix of reactive power and real power), in order to contribute to the sustaining of network voltages during faults and to generate fault current contributions.

2.3 Reactive Power Control Modes

The generation plant must be designed with the capability to operate in voltage (V), power factor (pf), or reactive power (Q) modes. The actual control mode and operating point will be advised as operational parameters and may need to be altered at times to accommodate changing network conditions. Deviating from the specified operational mode could result in Network Waitaki needing to disconnect the generation plant if the reliability or operation of the network were to be compromised. Technical studies during the detailed design should inform the appropriate initial operating mode and set points.

The operating modes the generation control must be capable of implementing are listed in Table 2.

Table 3: Power Quality Control Response Modes

	Type of Generation	
	Inverter Based Generation	Rotating Generation
Typical Control Modes	Voltage-Var Voltage-Watt Power factor Reactive power	Voltage Power factor Reactive power

In cases where the point of connection is further away from a regulated bus, the generation plant may be required to inject or absorb reactive power in order to prevent the voltage exceeding network limits or to reduce dynamic voltage variations due to intermittent generation output. This behaviour must however be coordinated with other network voltage management devices.

2.3.1 Voltage Control Mode

Volt-VAR (voltage control mode) requires the generation plant controller to adjust reactive power absorption (and occasionally injection) to limit voltage variation caused by generation export. Reactive power is defined as a function of voltage using a droop curve.

Volt-Watt extends local voltage control mode, activated after all reactive power limits are reached, to reduce generator real power output and limit further voltage rise. Inverter-based generation must facilitate both Volt- Watt and Volt-VAR response modes concurrently when activated.

Volt-VAR and Volt-Watt are forms of congestion management, addressing only local voltage congestion. Generation can also cause voltage and thermal constraints elsewhere in the network or grid. Thus, Volt-VAR and Volt-Watt may need coordination with other congestion management controls, receiving instructions or signals from remote devices or control centres.

2.3.2 Power Factor Control Mode

In this mode, the generator varies reactive power in direct proportion to real power output, maintaining a fixed power factor.

- Weak Network: The generator absorbs reactive power to limit voltage rise caused by generation export into high impedance areas. Voltage variation is mitigated in proportion to the generation output.
- Strong Network: In areas where voltage is less responsive to generation export, the fixed power factor may need to be slightly positive (reactive power injection) or unity to match the local network load's reactive power demand. This is not strictly a form of voltage control, as the generation merely contributes proportionally to supplying network load.

2.3.3 Reactive Power Control Mode

Reactive power mode requires the generator controller to output (absorb or inject) a fixed quantity of reactive power regardless of voltage or real power output. This mode is not expected to be implemented frequently.

2.4 Voltage Control Coordination

Reactive power injection and absorption by a generation plant help manage voltage, particularly in limiting variations and exceedances caused by generation output. However, excessive or improper reactive power use incurs additional costs (increased losses, reduced thermal capacity, and reactive power sourcing). Optimal deployment must be coordinated with other network voltage management devices.

2.4.1 Operational Requirements and Flexibility

The generating plant must contribute to overall network voltage management within its scope and dynamic range, following the instructed operational mode, setpoints, and control parameters. When operating in voltage control mode, the plant’s impact on network voltage must be coordinated with other grid voltage management devices. It should be capable of controlling voltage within its dynamic range and limits to smoothly achieve new setpoints.

Requirements will change with network conditions such as loading, generation, and re-configuration. Generators must have an established capability range, with deployment via operating instructions subject to change as per the operating agreement.

2.4.2 Instability and Oscillation Mitigation

Generation in voltage control mode must not conflict with other devices, causing instability, oscillation, or hunting. Control mode and settings may need adjustment to accommodate changes in network configuration, impedance, loading, or generation. New operating instructions may be issued as required.

2.4.3 Effective Voltage Management

Studies during the application and design phases should cover anticipated future operating states, including different network loading levels and reconfigurations, to ensure stable and effective voltage management across all scenarios. These studies inform the initial voltage management mode and setpoints implemented during commissioning.

The plant controller should implement all normal control functions (proportional, integral), dead-bands, and timing delays for key parameters to coordinate with other network voltage management devices. Voltage control modes refer to steady-state voltage management (over minutes or longer). The plant should also dynamically contribute maximum possible injection to sustain network voltage during momentary excursions and then return to the control setpoints.

2.5 Voltage Variation Due to Intermittency

Special consideration is required for intermittent generation due to its potential for frequent and rapid changes in export, affecting network loading and voltage.

Note: Intermittency may also pose challenges to the energy balance of the broader electricity system. While this issue falls outside the scope of this network standard, it's noteworthy that both challenges stem from generation size and the necessity to restrict change rates due to intermittency.

2.5.1 Challenges of Intermittent Generation

In network voltage management, rapid changes in generation export, such as from passing cloud cover, can cause transient voltage fluctuations, particularly in weak network areas. Tap-changing devices (OLTC and regulators) typically correct voltage over time but have inherent time delays that can lead to power quality issues for nearby consumers. Frequent export variations increase device operation, raising maintenance, reducing lifespan, and increasing costs.

Intermittent generation relies exclusively on inverters, making voltage control or fixed reactive power modes essential to mitigate output-induced voltage variations. Inverters respond quickly and are better suited than tap- changing devices for managing rapid voltage changes. However, using reactive power in voltage control modes can cause excessive flows and coordination challenges with other voltage management devices.

2.5.2 Limitations and Considerations in Reactive Power Deployment

The +/- 33 % reactive power deployment limit aims to manage reactive power flow, reducing losses, capacity constraints, and costs. Effective scheme design must prevent conflicts between voltage management devices despite varying generation and network conditions. If inverter reactive power capabilities prove insufficient, alternative measures like reducing installed capacity or enhancing spatial diversity (e.g., spacing out wind or solar installations) may be necessary. Local storage options could offer additional benefits such as arbitrage and congestion management.

2.5.3 Design Guidelines for Addressing Voltage Fluctuations

Electricity distributors typically manage voltage by gradually decreasing it across network circuits (feeders). Substation bus voltage is maintained near the upper operating limit using OLTC devices, decreasing with distance while staying above the lower limit at the line's end. Therefore, setting a fixed POC voltage for generation can lead to unnecessary reactive power use, potentially conflicting with other devices if within operating limits.

To manage voltage fluctuations from intermittency, ideally, a control scheme should absorb reactive power proportionally to generation output (+33% to -33%). Long-term integration control would gradually return output to zero reactive power, allowing tap-change devices to resume voltage management.

Design limits for intermittent voltage fluctuation include:

- Limit tap changer operations to an average of 20 per day.
- Ensure voltage changes due to intermittency (e.g., wind fluctuations, solar cloud cover) do not exceed 2 % pu per minute at the POC.
- Limit total voltage variation from 100 % to 25 % export to 3 %, using allowable reactive power responses.

Studies during application and design should ensure stable coordinated voltage management across the network. Voltage fluctuation due to intermittency is a power quality issue distinct from harmonics or flicker, requiring consideration of factors like inverter Volt-VAR functionality, albeit with limitations described earlier.

2.6 Fault Ride Through

The grid and network occasionally experience faults or disturbances that cause temporary, severe voltage drops at generation plant terminals. Many faults can be cleared by protection systems, after which voltage levels return to normal. It's crucial that generators can withstand transient faults, continuing to supply energy to prevent system collapse.

After a fault clears, generators connected to less interconnected networks may find themselves in isolated network islands. In such cases, anti-islanding protection must promptly disconnect generation (see section 2.8). Balancing the fault ride-through requirement for sustained connection against the need for rapid disconnection for anti-islanding is essential. Both responses are based on local voltage measurements, as the plant lacks visibility into wider network conditions.

A specific fault ride-through study should be conducted for each connection as part of technical assessments. Network Waitaki must review and accept this study. During system events, Power Quality Monitoring (PQM) results should be compared with technical study findings in post-event investigations. Generator owners must implement any recommended system modifications.

Generation asset owners must ensure their plants remain stable and connected during voltage fluctuations within the fault ride-through envelope in Figure 3. Table 4 provides modelling data points.

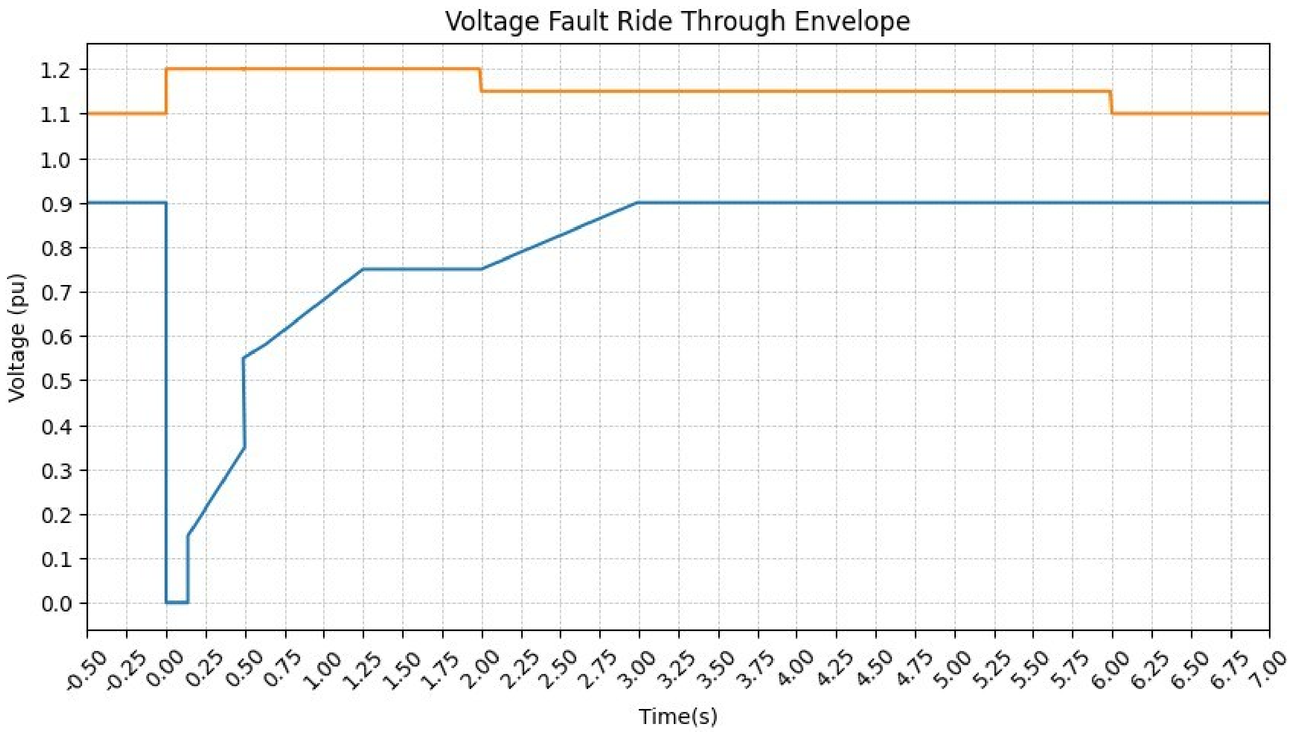

Figure 3: Voltage Fault Ride Through Requirement

Generators must also comply with any requirements of the System Operator in relation to Part 8 of the Code. (Refer Part 8, Section 8.25A of the Code).

Table 4 Voltage Fault Ride Through envelope data points

Time(s)	LVRT	HVRT
-0.50	0.90	1.10
0.00	0.00	1.20
0.14	0.15	1.20
0.50	0.35	1.20
0.50	0.35	1.20
0.63	0.58	1.20
1.25	0.75	1.20
2.00	0.75	1.15
3.00	0.90	1.15
6.00	0.90	1.10
7.00	0.90	1.10

2.7 Fault Current Contribution

Following a grid or network fault lasting up to 6 seconds, connected generators must comply with the following requirements:

- Inject reactive power to oppose the change in voltage, up to the maximum transient reactive capability of the generation plant.
- Continue injecting real power proportionate to pre-fault levels, adjusted for fault impedance and voltage.
- Inverter-based generators must provide total fault current injection (vector sum of real and reactive) of at least 100% of the rated inverter output.
- Rotating machine-based generators should sustain short-term fault current exceeding six times the rated continuous current.

Inverter-based generation plants must ensure a maximum fault current contribution equivalent to 100% of continuous rated current. 'Transient reactive capability' refers to short-term capability, distinct from steady-state voltage control. Inverter-based generators should support reactive output up to their full current rating during short-circuit faults if necessary.

2.8 Islanding

Islanding occurs when upstream equipment clears a fault, disconnecting a section of the network (referred to as an island) from the main grid. This risk is higher in distribution networks with single radial circuits. In contrast, interconnected grids reduce the likelihood of islands forming.

Due to lower fault current contribution from inverter-based generation, parts of the network may remain energised during faults until anti-islanding protection detects and isolates any generation. Timely operation of anti-islanding protection is crucial for public and worker safety.

Generator plants must:

- Disconnect from the network within two seconds of islanding.

- Incorporate a two-minute delay before injecting active power into the Network Waitaki network after re-energisation following a fault or loss of supply.
- Never energise disconnected network parts under any circumstances.

For utility scale distributed generation near the grid, consultation with Transpower is necessary to identify grid protection requirements, including anti-islanding measures as a backup to fault current protection, due to the insufficient fault current generation capability of inverter-based systems.

2.9 Synchronising

The Generation Asset Owner must ensure proper synchronisation of generators with the Network Waitaki network, bearing liability for damages due to out-of-sync closures. They must also anticipate Network Waitaki's ability to re- energise the network after any supply loss, planned or unplanned.

Additionally, the Generator Asset Owner is responsible for coordinating operational procedures for synchronisation before reconnection. It is crucial for Network Operations Centre (NOC) personnel to participate in all commissioning meetings and discussions related to generator synchronisation and commissioning.

2.10 Stability

2.10.1 Short Circuit Ratio (SCR)

The short-circuit ratio measures a power system's ability to supply short-circuit current during faults. System strength, as defined by AEMO[1], ensures stable voltage waveforms post disturbances. It's proportional to fault level and inversely to Inverter-Based Resource (IBR) penetration.

Inverter-based sources like wind, solar PV, and battery storage require adequate system strength for reliability. The SCR of a generation plant, determined at the connection point, influences:

- Voltage performance and system stability
- Protection system coordination
- Voltage recovery post-disturbance
- Harmonic distortion

The SCR is calculated by dividing the networks lowest short-circuit level at the point of connection by the rated output of the generating plant (expressed in MW or MVA):

$$SCR = \frac{\mathrm{S3}_{\emptyset\mathrm{FL\ at\ POC}}}{S_{GEN}}$$

where

$\mathrm{S3}_{\emptyset\mathrm{FL\ at\ POC}}$ denotes the minimum three-phase fault level at the POC.

and

[1] AEMO 2020, System strength in the NEM explained, https://www.aemo.com.au/-/media/files/electricity/nem/system-strength-explained.pdf?la=en

S_{GEN} denotes the generating plant rated output in either MW or MVA.

Technical studies should determine maximum and minimum short-circuit levels at the connection and inverter control points. Network connections with SCR ≤ 3 require Electromagnetic Transient (EMT) studies to assess operational impacts. Network Waitaki may request EMT studies for SCR values > 3 to address stability concerns.

2.10.2 Ratio of Reactance (X) to Resistance (R)

The X/R ratio, defining reactance (X) to resistance (R) ratio in a network, offers insights into power system behaviour during faults. Both X and R are crucial for stability assessment. During power system faults, the X/R ratio affects fault current buildup and decay rates.

Table 5 outlines key criteria for evaluating the X/R ratio. A higher ratio signifies more reactance than resistance, resulting in slower fault current changes. Conversely, a lower ratio indicates more resistance relative to reactance, leading to faster fault current responses.

Table 5: X/R ratio – General Criteria

	High: X/R >10	**Medium: 3<X/R≤10**	**Low: X/R≤3**
Fault Current	rise slowly due to the predominance of reactance	balance between reactance and resistance	rise rapidly due to the dominance of resistance
Fault Duration	prolonged, potentially delaying system recovery.	moderate fault current response characteristics	shorter fault durations, potentially reducing stress on
Fault Recovery	might take longer	typically, manageable for most networks	faster system recovery
Protection Consideration	coordinated accordingly to prevent equipment damage	consideration still necessary for protection coordination	excessive fault currents may pose challenges for protective devices and equipment insulation, requiring careful coordination and design

2.11 Congestion Management

Congestion arises when exported generation levels exceed network operational limits, potentially causing thermal overload or voltage breaches. Our policies for distributed generation and congestion management facilitate increased capacity, enabling connected generation to surpass forecasted export limits. Effective real- time operational management is crucial for mitigating congestion risks. For more details, refer to our complete Congestion Management Policy.

2.11.1 Operational Congestion Management

Operational congestion management optimises network utilisation by dynamically addressing network configuration, capacity, and loading variables. Effective and highly automated interfaces between generation plant controls, network devices, and our network operations centre are essential for implementing operational congestion management.

Utility scale generators must establish basic communication and automated control functionality during commissioning to manage immediate and potential future congestion requirements, even if initial operation is expected to be unconstrained under normal network conditions.

Given the evolving nature of operational generation control in the distribution industry, specific communication and control requirements will be determined during detailed design. These requirements will be tailored to each generation plant based on operational maturity and anticipated network congestion, with adjustments expected as centralised control systems advance.

SCADA system visibility of key generation and network parameters is mandatory for all utility scale generation. Control functionality, including the ability to issue operational instructions (e.g., analogue limits or set points) from our network operations centre and automatically apply them to generation control systems, is necessary to manage potential network congestion.

Real-time dynamic adjustment of limits or set points allows continued generation export during certain network events, typically at reduced levels, avoiding disconnection scenarios unless operational instructions cannot be applied promptly enough.

2.11.2 Types of Congestion and Management Strategies

Congestion can occur locally at the point of connection (POC) or remotely anywhere on the network or grid. Voltage congestion typically occurs at the POC, but thermal constraints can arise throughout the network or grid.

Localised congestion can often be managed using automated schemes equipped with local sensing and control capabilities. For instance, voltage congestion at the generation plant's POC can be mitigated locally.

However, such schemes operate independently of the network operations centre and address only specific points of congestion. They may not effectively handle all potential events or scenarios across the wider network or grid. Therefore, automated measures controlled from the operations centre remain essential to enforce limits when necessary.

2.11.3 Mitigation Techniques for Congestion

Local congestion, particularly voltage, can be mitigated directly using reactive power (Volt/VAR) controlled by the generation control system. However, network voltage management requires coordinating multiple devices influenced by external variables beyond the control system's visibility. Moreover, the use of reactive power must be constrained to prevent excessive losses or costs, limiting its effectiveness in mitigating voltage congestion. When reactive power alone is insufficient, Volt-Watt response (a voltage-triggered runback scheme) can be employed.

Thermal congestion can sometimes be managed through localised control schemes, provided they have visibility into congestion-related parameters, network state, and triggering events via local point-to-point communications. This approach is typical when generation is near constrained assets, utilising automated runback and special protection schemes. However, these schemes only address specific congestion points, necessitating communication with a network operations centre to manage events beyond their local visibility.

Dynamic or variable ratings can mitigate thermal congestion by adjusting asset capacities dynamically. While less effective for solar generation due to minimum line rating conditions coinciding with peak solar output, it can prove more beneficial for wind and other forms of generation. Proposed dynamic rating schemes must comply with our standards and demonstrate effective mitigation of asset overload risks. Such schemes typically require remote monitoring of environmental variables, network states, and reliable communication systems to manage data and communication failures effectively, ensuring fallback controls and fail-safes are in place. Additionally, generators must reduce output in a controlled and stable manner if environmental conditions constrain their output.

2.11.4 Future Directions in Congestion Management

Network Waitaki plans to implement advanced distribution management in our network operations centre, enhanced by extensive network visibility through monitoring and real-time communications. This will enable dynamic congestion management, allowing us to set generation export limits to maximise network export capacity under various scenarios and conditions. However, this implementation is expected to take several years.

Distributed generation exceeding 10 MW, whether individually or collectively, can cause congestion on grid assets. This will be managed by the System Operator through market mechanisms. Generation under 10 MW is considered embedded and will be managed through the congestion management policy, which will allocate limited capacity among competing generators, following the "last on, first off" principle.

2.12 Power Quality

Network Waitaki is responsible for maintaining acceptable power supply quality for its customers. No load or generation plant should produce power quality pollution that damages network assets or disrupts supply to other customers. Generation plant owners, especially those with inverter-based systems, must follow the EEA Power Quality Guidelines and comply with AS/NZS 61000 standards.

2.12.1 Harmonic Emissions

The Generation Asset Owner must provide the anticipated emissions of the generation plant. These emissions will affect the network. Emitted currents will be introduced into the POC impedance to evaluate voltage impacts concerning standards and anticipated allocations for the generation plant.

2.12.2 Harmonics Allocation and Assessment Requirements

Network Waitaki must maintain harmonics within acceptable limits to prevent potential damage to customer equipment connected to its network. Transpower currently uses NZECP36 to determine Network Waitaki's harmonic allocation per GXP. To ensure compliance, Network Waitaki calculates the available harmonic allocation at the Point of Connection (POC) for each generation plant.

The Generation Asset Owner is responsible for ensuring and demonstrating that their generation plant operates within the specified harmonic voltage and current allocations as outlined in technical studies. This involves providing data on harmonic voltage and current injection from the generating plant, ensuring that the site's expected voltage and current harmonics align with their allocated limits.

If Network Waitaki's Power Quality Monitoring (PQM) results reveal that harmonics introduced by the generating plant are adversely impacting the network, the Generating Asset Owner must take corrective measures.

Network Waitaki plans to adopt the harmonic limit allocation methodology specified in AS/NZS 61000-3-6 for new generating plants, as outlined in the EEA Power Quality Guidelines. This adoption requires Transpower to provide harmonic allocations in accordance with AS/NZS 61000-3-6, which is not expected to occur soon.

2.12.3 Voltage Fluctuation and Flicker Assessment Requirements

The Generation Asset Owner must ensure and demonstrate that their generation plant operates within the allocated voltage flicker limits as specified by the EEA Power Quality Guidelines and AS/NZS 61000-3-7.

2.12.4 Generation Plant PQ Monitoring Setup

Network Waitaki requires a Power Quality Meter (PQM) in the generation plant design to monitor power supply. The Generation Asset Owner must provide for the installation of the PQM at the most practical point near the POC. Table 6 lists the appropriate PQM (Class A) for the applicable monitoring frequency range.

Table 6: PQ monitoring setup

	Monitoring Frequency Range	
Component	**Up to 9 kHz**	**9 kHz and higher**
PQM Instrument	Approved Network Waitaki Power Quality Meter	
PQM VT	Standard VT	Resistive Voltage Sensor
PQM CT	Standard CT	Rogowski Coil
Communications Modem	Approved Network Waitaki Communications Modem and Aerial	

2.12.5 Baseline Power Quality Data Capture Prior to Connection

Upon executing a Memorandum of Agreement between the Generation Asset Owner and Network Waitaki for generation connection, Network Waitaki will install Power Quality Monitoring (PQM) equipment at the relevant zone substation. This data will serve as the baseline Power Quality reference before the generation plant connects to the network. A minimum of one month's recording is required.

2.12.6 Post-Export Power Quality monitoring

After approval for connection and power export to the Network Waitaki network, Network Waitaki will use the PQM results to monitor the generating plant's performance. If network irregularities occur post-connection or if the generated power fails to meet technical requirements, the Generation Asset Owner must make necessary adjustments. Additionally, if new information indicates potential adverse effects of the generating plant on other connected parties, Network Waitaki reserves the right to require modifications to the Generation Asset Owner's connection and operational protocols.

2.13 Network Waitaki Ripple Control Interference Mitigation

The Generation Asset Owner must ensure that their generating plant does not interfere with Network Waitaki's ripple control system. During commissioning, it is crucial to demonstrate that the plant does not disrupt the ripple control signal within the designated area. If interference is detected, the Generation Asset Owner must promptly halt operations to prevent network disruption and resolve the issue before reconnecting.

The Generation Asset Owner should collaborate with Network Waitaki's Network Development Team to ensure that the operation of the generating plant does not affect operation of the ripple control plant, or propagation of the ripple control signal.

2.14 Earthing Requirements

The Generator Asset Owner must ensure the generating plant complies with all relevant regulatory requirements and Network Waitaki standards for adequate earthing. Network Waitaki will review the earthing design.

2.15 Fault Level Requirements

Power network primary assets are rated for specific fault levels. Generation plants must not exceed these ratings. Network Waitaki will provide Generation Asset Owners with current network fault level information.

If a generation plant increases fault levels beyond those rated for Network Waitaki's primary assets and protection equipment, the Generation Asset Owner must implement fault level reduction measures. The costs associated with these mitigation measures are the responsibility of the Generation Plant Asset Owner.

3 PROTECTION REQUIREMENTS

3.1 General

Network Waitaki must maintain a reliable distribution and subtransmission network. This section specifies Network Waitaki's minimum protection requirements for generation plants. The required level of protection varies based on each plant's specifics. The Generation Asset Owner must collaborate with Network Waitaki to develop an acceptable protection design and scheme that:

- Ensures primary and backup protection systems meet Network Waitaki's sensitivity standards.
- Establishes sufficient protection grading coverage.

The generation plant's protection system must be centralised to swiftly detect and isolate all internal faults.

3.2 Connection Point Protection Relay

The Connection Point Protection Relay (CPPR) must be placed as close as possible to the connection point to safeguard the Network Waitaki network from hazardous conditions originating at the generating plant. The CPPR shall:

- Coordinate multiple generating units using a single Generation Plan Circuit Breaker (GPCB).
- Enable unified protection functions for all generating units connected to a single GPCB.
- Provide protection functions as specified in the connection-specific protection study.
- Prevent the generating plant from exporting power to the Network Waitaki network when the CPPR is offline.
- Activate the isolation device at the connection point or within the generating system(s).
- Ensure the safety of the Network Waitaki network, personnel, and the public.

3.3 Protection Philosophy & Protection Operating Speed

Liaise with the Network Development team to establish the protection requirements and clearing times. Generating plant protection must ensure safe disconnection of generators during fault events. Generation Asset Owners must provide specific details on aligning protection and control with the philosophy, prioritising maximum protection speed.

3.4 Minimum Protection Requirements for Generation Plant Connection

Table 7 specifies minimum protection requirements for connecting a generation plant to the Network Waitaki network. Depending on the plant's location and interface, additional protections may be required at Network Waitaki's discretion. All plants must connect through a Network Waitaki-owned circuit breaker (Connection Point Circuit Breaker - CPCB).

The Generator Asset Owner is responsible for ensuring adequate protection of their equipment. They must establish processes to maintain continuous operation of their DC system, supporting the protection system even when plant equipment is offline.

Symbol codes in Table 7 and Table 8 shall be interpreted as follows:

M – Mandatory Requirement

O – Optional, not specifically required but not prohibited

P – Prohibited - shall not be used /installed

C – Conditional requirement or depend on ‘Network Connection Study’

RS – Rotating synchronous generation

RI – Rotating asynchronous generation, with or without rotor circuit inverters

IB – Inverter-based

Table 7: Minimum Protection for the Network Waitaki side

Network Type		Distribution (11 kV)			Sub transmission (33/66/110kV)		
Requirement (ANSI code)	**Ref**	**RS**	**RI**	**IB**	**RS**	**RI**	**IB**
Connection Point CB (CPCB)	R01	M	M	M	M	M	M
CPCB OC (51/67) Protection	R02	M	M	M	M	M	M
CPCB EF (50N/67N/50G/67G) Protection	R03	M	M	M	M	M	M
CPCB NVD (59N) Protection	R04	M	M	M	M	M	M
CPCB Under-frequency (81U) Protection	R05	M	M	M	M	M	M
CPCB Over-frequency (81O) protection	R06	M	M	M	M	M	M
CPCB Rate of Change of Frequency (81R) protection	R07	O	O	O	O	O	O
CPCB Line Differential (87L) Protection	R08	O	O	O	M	M	M
CPCB Inter-Trip	R09	C	C	C	C	C	C
CPCB Local Backup (P2) protection	R10	O	O	O	C	C	C
Auto Reclose (79) on CPCB	R11	P	P	P	P	P	P
Deadline Check	R12	M	M	M	M	M	M

3.5 Protection Requirements for the Generation Plant

Table 8 lists the general protection requirement for a connection of a generation plant onto the Network Waitaki network. These requirements may be modified with the agreement of Network Waitaki Planning team.

Table 8: Suggested Protection for Generation Plant side

Network		Distribution (11 kV)			Sub transmission (33/66kV/110 kV)		
Requirement (ANSI code)	**Ref**	**RS**	**RI**	**IB**	**RS**	**RI**	**IB**
Protection Report	R13	M	M	M	M	M	M
Generator plant circuit breaker (GPCB)	R14	M	M	M	M	M	M
Undervoltage (27) Protection Overvoltage (59) Protection Under-frequency (81U) Protection Over-frequency (81O) Protection	R15	M	M	M	M	M	M
Active Anti-islanding Protection[2]	R16	O	O	M	O	O	M
Co-ordination with other assets	R17	M	M	M	M	M	M
NVD (59N) Protection	R18	M	M	M	M	M	M
Synchronising Check (25) before closing (GPCB)	R19	M	M	M	M	M	M
Prevent closing GPCB onto dead bus/line	R20	M	M	M	M	M	M
OC (51) Protection	R21	M	M	M	M	M	M
EF (50N) Protection	R22	M	M	M	M	M	M
Local Protection within Generation Plant [R19]	R23	M	M	M	M	M	M
Protection Maintenance Plan	R24	M	M	M	M	M	M
Auto Reclose (79) on GPCB	R26	P	P	P	P	P	P
Generator Pole slip	R28	M			M		
Backup (CB Fail) for CPCB	R29	M	M	M	M	M	M
Inverter Integrated Protection	R30			M			M
Rate of Change of Frequency (81R) Protection	R31	O	O	O	O	O	O
Vector Shift (96) Protection	R32	O	O	O	O	O	O
DC system	R33	M	M	M	M	M	M

4 OPERATIONAL AND COMMUNICATION REQUIREMENTS

4.1 Operational Requirements

Requirement 1: The Generation Asset Owner must ensure a 24-hour plant controller is always available and reachable by Network Waitaki's Network Operations Centre (NOC) via phone.

Requirement 2: The Generation Asset Owner must provide technical details for the generating plant, including configured protection settings and circuit breaker test results, as well as information on the run-back/curtailment scheme and any inter-tripping scheme in use.

[2] The generator protection scheme must be capable of disconnecting from the network during islanded cases. If Network Waitaki deems that other protection elements are not satisfactory to meet this, Network Waitaki at its sole discretion may require this on a case-by-case basis

Requirement 3: Network Waitaki's NOC reserves the right to disconnect the generation plant in the following circumstances:

- Ensuring public safety and the safety of service providers working on the network feeder.
- Preserving the integrity and safety of Network Waitaki's electricity network.
- Minimising disruption to other connected customers.

Requirement 4: Network Waitaki may request an outage from the Generation Asset Owner through an established process.

Requirement 5: Generation Asset Owners may request a network outage or change from Network Waitaki by contacting the Network Operations Centre 10 days in advance

Requirement 6: Network Waitaki requires the establishment of operational procedures for:

- Contact details for planned or unplanned activities, events, and emergencies.
- Isolation of generating plant to facilitate safe work by Network Waitaki contractors on the network at the generation plant connection point.
- Standard protocols for re-energising after an outage, either on the Network Waitaki network or originating at the generation plant.

Requirement 7: The Generation Asset Owner's plant must not be treated as standby generation.

4.2 Coordination between Generation Plant and Network Waitaki Network Operation

The Network Waitaki distribution network utilises automatic reclosing schemes on main feeder overhead lines. Upon detecting a network supply loss, the generation plant must disconnect within the specified recloser dead time to avoid potential plant damage.

Once system voltage is restored at the Network Waitaki Point of Connection (POC) and meets protection limits for at least 120 seconds in terms of voltage and frequency, the generation plant may initiate reconnection with the Network Waitaki network. Automatic control equipment must ensure synchronisation of frequency, voltage, and phase with the Network Waitaki network before reconnection.

4.3 SCADA Requirements

Network Waitaki's NOC requires real-time operational visibility of each Generating Plant Circuit Breaker (GPCB) linking the Generation Asset Owner's plant to Network Waitaki's electricity distribution network. Each GPCB must provide the operational data points listed in Table 9, utilising the communication methods specified in section 4.4.

Table 9: SCADA operational data points

Data Point	Unit of Measure
CB open, closed, tripped, racked status	Binary
CB protection flag statuses	Binary
CB health status (heartbeat)	-
Line voltage (L1, L2, L3)	kV
Phase voltage (Ph1, Ph2, Ph3, N)	kV
Line current (L1, L2, L3)	Ampere
Real Power import (-) and export (+) with direction	MW (signed)
Reactive Power import (-) and export (+) with direction	Mvar (signed)
Curtailment indicator	Binary
Curtailment setpoint	MW

Any event in the distribution system, such as switching or activation of protection functions, must be time- stamped at the source device. These time-stamped events should then be sent to Network Waitaki's SCADA system via the Edge Device. Generation Asset Owners must synchronise their equipment clocks with a Network Waitaki approved GPS device to ensure accurate time-stamping. All communications between the generation plant and Network Waitaki's network must comply with cybersecurity requirements detailed in section 4.4.

4.4 Telecommunications and Cybersecurity Requirements

4.4.1 Communications Link Establishment

A communications link must connect each generation plant's GPCB to Network Waitaki's network via Network Waitaki's Edge Device. Network Waitaki's Engineering team will select Edge Device equipment and communication technologies based on:

- Proximity of the Generation Asset Owner's GPCB to existing Network Waitaki communication assets.
- Availability of communication mediums (Fibre, Cellular, RF, Microwave) near the GPCB.
- Requirements for installing fixed-position power quality monitoring equipment at the CPCB and expected data exchange volumes with Network Waitaki's SCADA system.

If a generation site has multiple GPCBs, Network Waitaki's Edge Device may interface with a central data concentrator owned by the Generation Asset Owner, subject to Network Waitaki's approval and design provisions for accommodating Network Waitaki's primary and secondary communications equipment.

4.4.2 Communications Mediums

The communications link between the GPCB and Network Waitaki's Edge Device shall:

- Be optically isolated using fibre-optic cable or an opto-isolator near the Edge Device.
- Use cables and connectors installed in compliance with industry best practices.

4.4.3 Communications Mechanisms

The Generation Asset Owner must provide one or more of the following communication mechanisms for Network Waitaki's Edge Device:

- DNP3 over Serial (TIA-232 or TIA-485)
- DNP3 over IP (Ethernet/Fibre Optic)
- SCADA communication via fibre or radio (as decided by Network Waitaki's Engineering Team).

Network Waitaki reserves the right to disconnect any communication link immediately upon suspicion of malicious activities or security breaches.

4.4.4 Physical Equipment Security

Network Waitaki's Edge Device(s) must be installed within an enclosure that:

- Protects against adverse weather, humidity, heat, and dust.
- Is located in a secure facility or compound to prevent unauthorised access.
- Is lockable and controlled by Network Waitaki's lock-and-key system.
- Includes physical access monitoring with alerts sent to Network Waitaki's Network Operations Centre via SCADA.
- Provides adequate battery backup to maintain function of the device for 24 hours after loss of mains power.

4.4.5 Cybersecurity Responsibilities of the Generation Asset Owner

The Generation Asset Owner must inform Network Waitaki of:

- Cybersecurity breaches that could impact operational electrical environments or communication equipment.
- Vulnerability advisories affecting operational environments or communication equipment, along with their risk management strategies.
- Both Network Waitaki and the Generation Asset Owner must make reasonable efforts to inform each other about planned works or incidents related to telecommunications, GPCB, or edge equipment.

5 GENERATION PLANT ELECTRICAL CONNECTION INTERFACE

Generation plants connecting to the Network Waitaki network must link via a Network Waitaki switching station located at or adjacent to the plant. The station must meet these minimum requirements:

- Network Waitaki-owned switchgear with circuit breakers (CBs) or a switchboard equipped with CBs.
- Network Waitaki Supervisory Control and Data Acquisition (SCADA) system with communication capabilities.
- Network Waitaki Power Quality (PQ) monitoring equipment.

Considerations should address ownership and demarcation. The main circuit breaker should be positioned as close as possible to the existing circuit route. Compliance with operational requirements from the Network Waitaki Network Operations Centre is essential.

5.1 Network Waitaki Connection Point Circuit Breaker

All generation plants are obligated to connect through a Network Waitaki-owned connection point circuit breaker (CPCB). Figure 4 illustrates the CPCB and GPCB with the connecting link between them. The CPCB must be appropriately rated for voltage, maximum load current, and fault current rating.

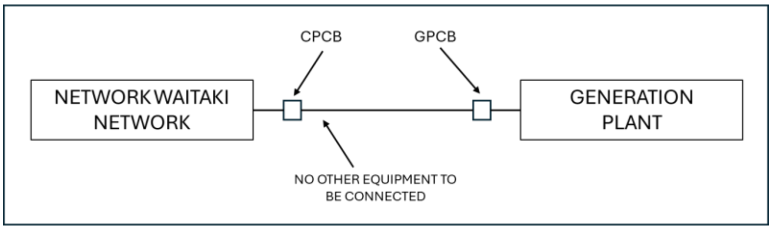

Figure 4: Connection Point Circuit Breaker

5.2 Preferred Subtransmission Connection Configuration

This section specifies the preferred connection configurations for subtransmission at 33 kV, 66 kV, or 110 kV. Any deviation from these configurations in generation plant connection designs requires approval from the Network Waitaki Network Development manager.

5.2.1 New Subtransmission Feeder at Grid Exit Point (GXP)

Generation Asset Owners need to engage Transpower if their proposed generation plant connection is directly to Transpower owned assets at Grid Exit Point (GXP). No advice will be provided in this instance.

5.2.2 New Subtransmission Feeder at Network Waitaki Owned Bus

Two connection options are offered for linking to Network Waitaki's bus at the substation. Figure 5 shows the subtransmission feeder alongside the generation plant owned by the asset owner, whereas Figure 6 depicts Network Waitaki's dedicated feeder. The latter option offers potential for future load or generation expansions.

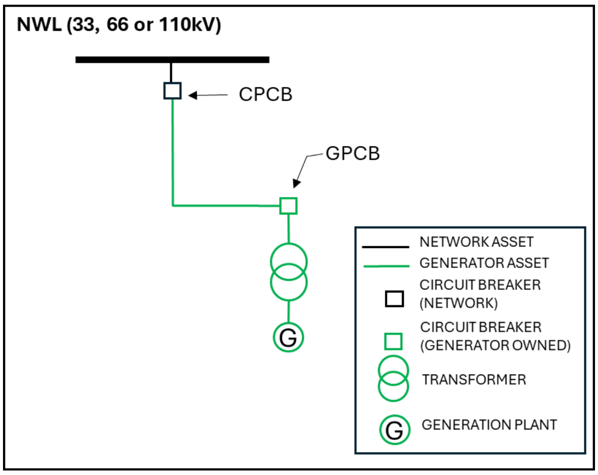

Figure 5: Dedicated subtransmission feeder (Owned by Generation Asset Owner)

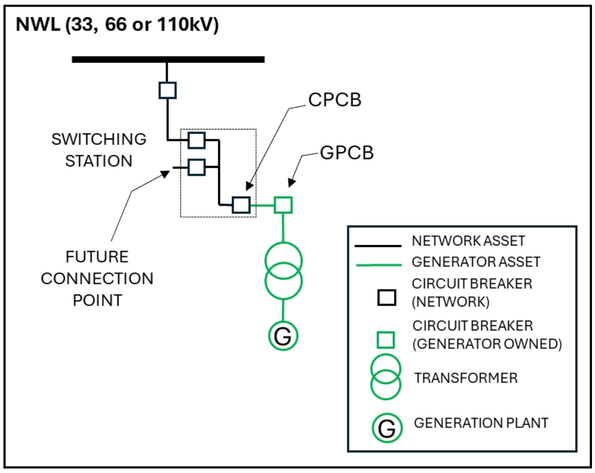

Figure 6: Subtransmission feeder (Owned by Network Waitaki)

5.2.3 Connection to existing subtransmission circuits

Figure 7 and Figure 8 depict the in-out connections of two network topologies, each featuring either an indoor or outdoor switching station.

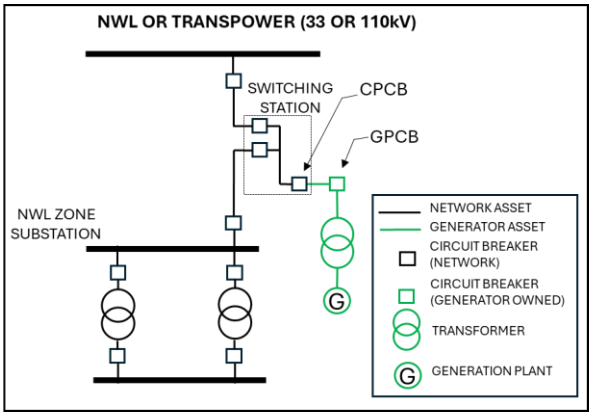

Figure 7: In-out from radial subtransmission feeder

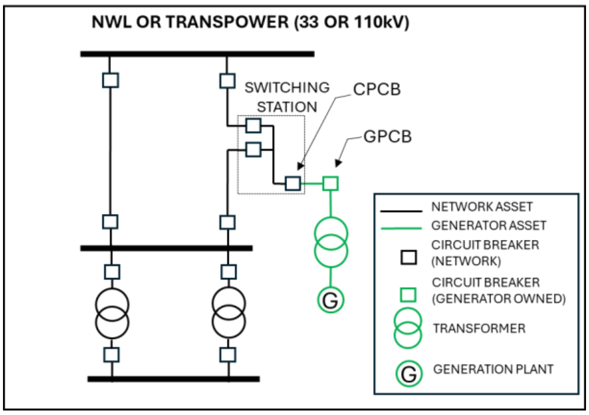

Figure 8: In-out from meshed subtransmission feeder

Figure 9 depicts double in-out connections from two circuits with normally open bus-section.

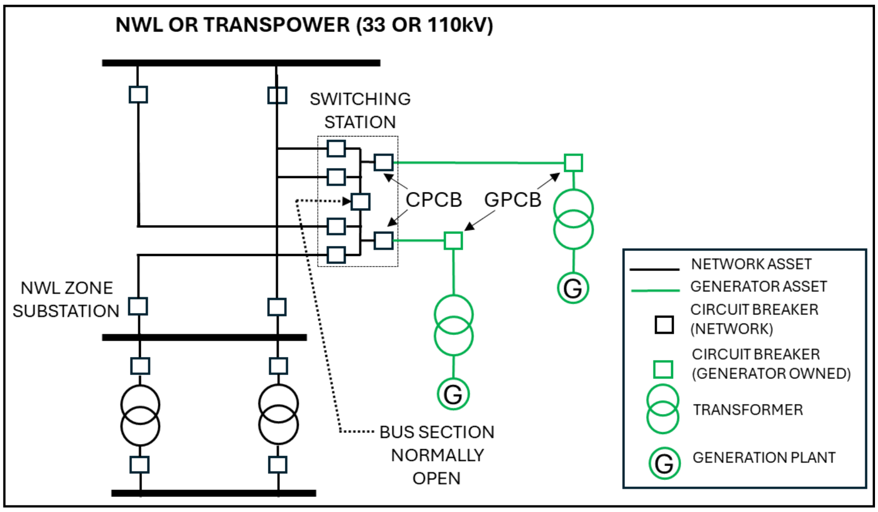

Figure 9 : Double in-out from meshed subtransmission feeder

The Generation Asset Owner is responsible for:

- Consulting the Network Waitaki Standard for approved switchgear.
- Ensuring availability of low voltage (LV) supply to the switching station.

5.3 Preferred Distribution Connection Configuration

This section specifies the preferred connection configurations for distributing at 11 kV. Any deviation from these configurations in distribution generation connection design requires approval from Network Waitaki.

5.3.1 Connection to Existing Distribution Feeders

Connecting to existing distribution feeders must not compromise supply security for current customers. When establishing these connections, prioritise protection and communication. Network Waitaki recommends that all generation plants connect to the distribution network via a three-way switchboard or switchgear.

Figure 10 illustrates a connection through a distribution switching station, which safely isolates a feeder section while enabling the plant to maintain export capabilities. If a three-way switchboard is not feasible, negotiate a tee-off connection with Network Waitaki (Figure 11), ensuring security, protection, and communication requirements are met.

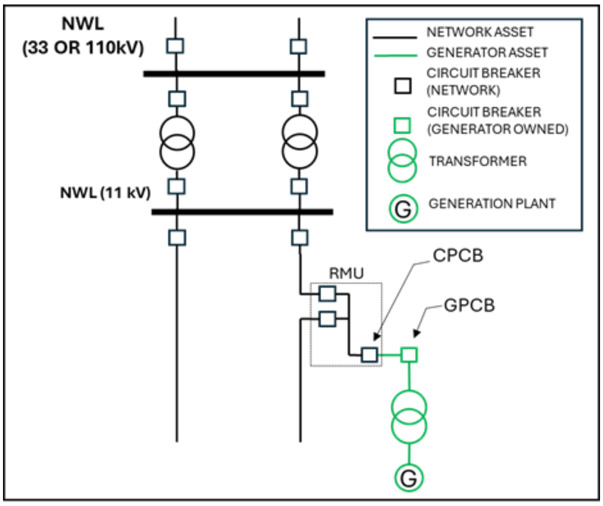

Figure 10: Distribution in-out from radial circuit

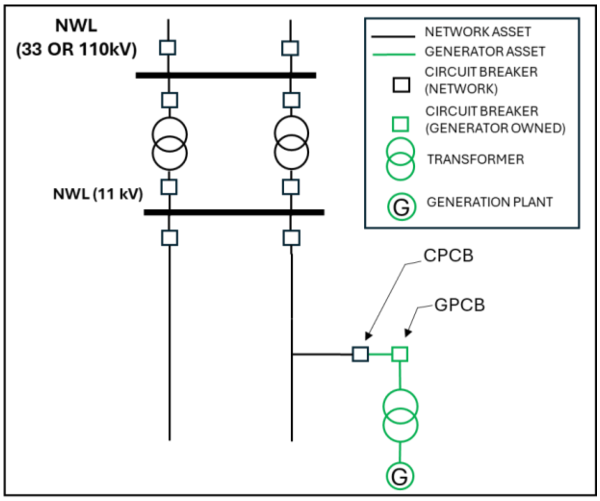

Figure 11: Distribution tee-off from radial circuit

5.3.2 New Distribution Feeder to Network Waitaki Zone Substation.

A new distribution feeder from a zone substation can be owned by either Network Waitaki or the Generator Asset Owner, as shown in Figure 12 and Figure 13, respectively.

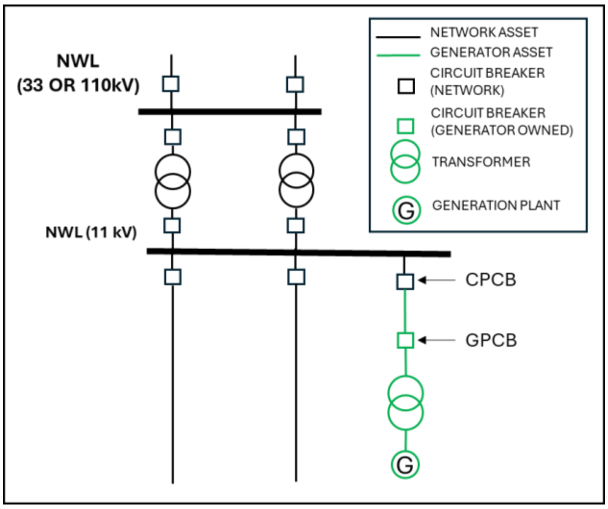

Figure 12: Distribution feeder
(Owned by Generation Asset owner)

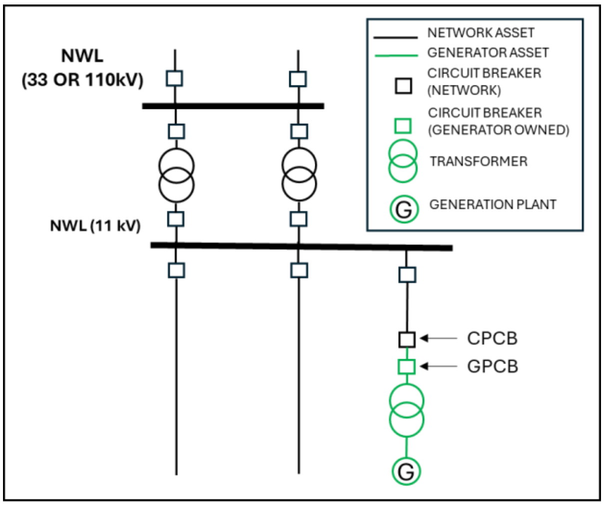

Figure 13: Distribution feeder

(Owned by Network Waitaki)

6 NETWORK IMPACT ASSESSMENT STUDIES

The Generation Asset Owner must engage a credentialed consulting engineer to conduct network impact studies and deliver a formal report as agreed with Network Waitaki. This report must include documentation, modelling evidence, and results demonstrating compliance with technical and protection requirements.

The Distributed Generation Connection Application follows these key stages within the Capital Works Project process:

- High Level Report (HLR)
- Network Impact Assessment Studies
- Concept Design
- Detailed Design
- Delivery/Commissioning

These studies should assess the impact on the Network Waitaki network and at the GXP, including necessary changes to Transpower assets to meet Network Waitaki's contractual obligations. Areas covered include power quality, protection coordination, voltage management, and GXP metering. Findings will be shared with Transpower.

Network Waitaki mandates that the consulting engineer nominated by the Generation Asset Owner conduct steady-state and dynamic modelling analyses. Network Waitaki will provide subtransmission and/or distribution models in Digsilent Powerfactory file format, along with network/feeder single-line diagrams and current network loadings. Conductor ratings used in the model be approved by the Network Waitaki.

Network Waitaki will provide derating factors applied to feeders in response to the Request for Information (RFI). Network Waitaki reserves the right to request additional modelling information and may require a post-commissioning Power Systems Model be supplied by the Generation Asset Owner in an agreed format.

6.1 Generation Plant Details

The Generation Asset Owner should provide comprehensive details of their generation plant. If necessary, Network Waitaki and the Generation Asset Owner will enter into a non-disclosure agreement. The detailed phases of the studies require the following generation plant information:

- Generator unit brand/model/type
- Step-up transformer nameplate details
- GPCB details (generation plant isolation device)
- Compliance with AS/NZS 4777 standards, where applicable
- Generator capability curve
- Control modes and strategy
- Single line diagram of the generation plant, including location, network configuration, demarcations, and monitoring points.

Refer to Appendix B – Generation Plant Details Checklist.

6.2 Steady-State Analysis

6.2.1 Voltage, Thermal and Contingent Event Constraints

The assessment ensures that the generating plant does not thermally overload conductors or transformers and does not cause any under or over-voltages. The study should consider various operating conditions, as shown in Table 10, accounting for a range of active and reactive power injections. It should record network parameters, including active and reactive power flows, to demonstrate no violations.

Table 10: Voltage, Thermal and Contingent Events Constraints - Operating Conditions

	Peak network load	Minimum midday network load	Off-peak (Not required for solar generation)
Current Network (No DG)	☑	☑	☑
Network with DG (with and without BESS where applicable)	☑	☑	☑
Loss of a power transformer (i) at GXP and/or (ii) at the zone substation	☑	☑	☑
Loss of an upstream or downstream circuits	☑	☑	☑

Acceptance criteria:

- No thermal exceedances of circuit current carrying capacities
- Voltages managed to acceptable pre-connection levels

6.2.2 Rapid Voltage Change

The voltage fluctuation at the POC varies with changes in generation export, from maximum (full sun/wind) to minimum (partial/no sunlight/wind) and during sudden loss of the generation plant. The focus should be on the magnitude and rate of voltage change at the POC, PCC, and relevant upstream buses before voltage correction by power transformers or voltage regulators.

The study should consider the various operating conditions listed in Table 11, accounting for a range of active and reactive power injections. It should also record network parameters, including active and reactive power flows, to ensure no violations occur.

Table 11: Rapid Voltage Change - Operating Conditions

	Peak network load	Minimum midday network load	Off-peak (Not required for solar generation)
Full to partial sunlight (cloud cover) or wind	☑	☑	☑
Sudden loss of DG (no P and Q injection)	☑	☑	☑

Acceptance criteria:

- As per Indicate Planning Levels for Rapid Voltage Changes in AS/NZS TR IEC 61000.3.7:2012.

6.2.3 Fault level Study

Fault level study to identify the fault contribution from the generating plant highlighting any equipment fault current rating exceedances on either the network or grid.

Acceptance criteria:

- No fault current rating exceedances of network and grid equipment

6.2.4 Stability

Calculate the SCR at the PCC and the point where the inverter is looking to control. The SCR shall be determined at both the normal system maximum and the contingent system minimum short circuit levels at the point where the inverter control system is connected to and controlling. The method of calculation is outlined in section 2.10.1 of this document. Weak network sections, with SCRs typically at or below 3, will require Electromagnetic Transient (EMT) studies to assess their impact on the network's ability to return to normal operation following a disturbance or fault.

Calculate the X/R ratio at the POC which provide an insight on how quickly the fault current builds up and decays. Refer to section 2.10.2.

6.2.5 Curtailment

Obtain interconnectivity scenarios from Network Waitaki to analyse generation constraints for all potential network configurations. This analysis will inform active power set-points for generation curtailment. This is particularly important during unplanned outages when parts of the network experience load rejection. The studies will provide the NOC with clear guidance on generation dispatch for any planned outages.

6.2.6 Harmonic and Flicker Studies

The Generation Asset Owner to determine the emissions of their generation plant. Request the harmonic headroom available and do an assessment of any exceedances as well as mitigation strategy.

6.2.7 Grid Impact

Assess Grid Impact as per the Transpower Questionnaire (TP GXP Impact Studies for DER) and provide commentary on the analysis and findings. Note that this assessment determines if either a further assessment or/and a Transpower Application is required.

6.3 Dynamic Analysis

When performing dynamic studies, the consulting engineer must consider the following:

- Maximum and minimum fault levels (network and generation plant)
- Maximum and minimum network loading
- Proximity to existing generation plants (if applicable)
- Fault ride-through response

- Generation stability (demonstrating reactive power capability at various active power set points)
- Voltage control and its impact on regulation (including control modes, deadband, and ramp rate)
- The impact of proposed generation plant power control modes on Network Waitaki network voltage during transient events

Generation Plant Controller parameters:

a) Voltage and power control modes
b) Ramp rates for real and reactive power export
c) Reactive capability across the active power range
d) Anti-islanding

6.4 Protection Studies

The report will include the following studies.

6.4.1 Protection Scheme and Settings Design

- Protection relay specifications
- Generation plant protection setting
- Protection R & I diagram
- Upstream Network Waitaki protection device settings and coordination proof
- Protection CT and VT accuracy

6.4.2 Generation Curtailment Scheme (if applicable)

Provide details on curtailment schemes (run-back schemes) design, including:

- Logic table
- Trigger elements (e.g., switching status, CT monitoring)
- Single Line Diagram (SLD)
- Communication componentry
- Communication delays
- Communication path resilience.

7 SYSTEM OPERATOR NOTIFICATION

Generation asset owners operating plants of 1 MW or larger must promptly notify the Transpower System Operator and comply with all applicable code obligations in Part 8 and Part 13 of the Code. Adherence to Transpower's GL-EA-953 Connection Study Guide for Connecting New Generation Stations is required, including results from both steady state and dynamic modelling.

8 TESTING AND COMMISSIONING REQUIREMENTS

The generation plant commissioning must be processed through Network Operations Control. Submit test plans and the commissioning plan to Network Waitaki at least 8 weeks in advance.

For generation plants of 10 MW or higher, the Transpower System Operator requires the timely submission of a Commissioning Plan, an Engineering Test Methodology, and associated Test

Plans. This provides an opportunity to optimise the submissions. Refer to Transpower's GL-EA-404 Generation Commissioning and Decommissioning Requirements.

8.1 Responsibilities and Testing Process

- The Generation Asset Owner is responsible for all testing activities and associated costs.
- Testing must include changes in active and reactive power, ramp rates to demonstrate stable and predictable plant performance, benchmarked against dynamic studies.
- Testing activities must be overseen by a competent engineer or technician appointed by the Generation Asset
- Owner, subject to Network Waitaki's agreement.
- Network Waitaki or its representative may request access to witness testing activities.
- Testing consists of three phases: pre-commissioning (stage 1), commissioning (stage 2), and post-commissioning
- (stage 3).
- Objectives of testing include verifying compliance with Network Waitaki requirements, ensuring no adverse effects on the network, and preventing damage to network assets or customer supply.
- Test results from each stage must be accepted (not approved) by Network Waitaki before progressing to the next stage.
- A compliance test report summarising all test results related to Network Impact and Protection Studies must be submitted. It should include final approved as-built drawings, protection settings, and control parameters.
- Compliance remains an ongoing obligation for the Generation Asset Owner throughout the generation plant's life cycle.
- Network Waitaki reserves the right to withhold final connection approval until concerns regarding design, commissioning, or other commercial or technical aspects are resolved.

8.2 Documentation Requirements Prior to Commissioning

The following documentation must accompany the Commissioning Plan:

- Metering unit test results, compliant with Part 10 of the Code
- Multiple earth neutral (MEN) ohm test or earth grid results (where applicable)
- Earth grid test results
- Generation livening Test Report
- Compliance sign-off for the generation plant
- Information for CoC inspector (name, electrical license number)
- Specification document detailing standards and regulations certified by the CoC inspector (e.g., Electricity (Safety) Regulations 2010 and Associated Standards AS/NZS 3000:2007)

8.3 Pre-commissioning Testing and Documentation Requirements

Pre-commissioning testing allows offline testing of the generation plant to demonstrate stable and predictable control behaviour for set point changes. The following expectations are outlined for pre-commissioning testing:

- Submission of protection settings details and completed final protection studies to Network Waitaki.
- Submission of pre-commissioning test plans detailing specific tests and equipment.
- Agreement between Network Waitaki and the Generation Asset Owner on the pre-commissioning test plans.
- Application for a Network Waitaki release request by selected Contractors (contact NOC for advice).
- Submission of pre-commissioning test results to Network Waitaki for review.
- Provision of signed as-built SLD and R&I drawings to Network Waitaki.
- Confirmation of the complete protection system's serviceability and appropriateness.
- Completion of Generation Asset Owner requirements as specified in the protection study report.
- Inclusion of anti-islanding protection testing and certification for photovoltaic inverters.

8.4 Commissioning Testing and Documentation Requirements

Commissioning (online) testing must meet the following requirements:

- Generator Asset Owners must submit test plans to Network Waitaki at least 8 weeks before commissioning. These plans should clearly state the purpose of each test.
- Submission of active power export levels to Network Waitaki's connections planner and NOC.
- Provision of signed as-built SLD and R&I drawings to Network Waitaki if changes have been made post-connection testing.
- Confirmation by the Generation Asset Owner that the protection and SCADA system is fully operational, correctly set, and tested.
- Provision of 24-hour telephone contacts for Network Waitaki's NOC.
- Ensuring SCADA interfaces with NOC and compliance with cybersecurity requirements.

8.5 Post-commissioning Testing and Documentation Requirements

After initial connection, Network Waitaki will grant conditional approval for connection, pending post-commissioning monitoring. The following tasks must be completed:

- Submission of a completed Commissioning Test Report for review and acceptance.
- Commissioning Test Report should demonstrate how the model aligns with test results of each test, including appropriate commentary.
- Ensuring availability of all associated protection equipment.
- Immediate notification to Network Waitaki NOC of any protection failures.
- Prohibition of changes to generator protection or central protection without prior written approval from Network Waitaki.
- Monitoring of plant settings post-commissioning as agreed.
- Assisting Network Waitaki with Power Quality investigation and mitigation if necessary.
- Continued power quality monitoring by Network Waitaki.
- Responsibility of Generation Asset Owner for energisation, operation, and maintenance of the generation plant.

Network Waitaki will review and accept the Commissioning Test Report upon resolution of all concerns, marking commissioning completion. Network Waitaki will assess harmonic emissions from the generation plant. The developer must provide Network Waitaki with a post-commissioning power systems model of the plant.

9 DISPENSATIONS

In instances where a dispensation or deviation from this standard becomes necessary, it must be supported by a comprehensive business and technical justifications. Deviations from the standard will undergo rigorous review processes and require approval on a case-by-case basis by the relevant Network Waitaki Electrical Technical Authority, ensuring that each deviation is thoroughly evaluated for its potential impact on both operational and technical factors of the network. Only deviations demonstrating a clear and justifiable need, along with appropriate mitigation strategies for any associated risks, will be considered for approval.

10 MAINTENANCE AND OPERATION

The maintenance and operation of the generating plant must adhere to the following:

- The generating plant must fully comply with all applicable legislative requirements, including New Zealand's relevant regulations, standards, guidelines, and codes of practice.
- Compliance remains an ongoing obligation for the Generation Asset Owner throughout the generation plant's life cycle.
- Maintenance and operating reports must be promptly provided to Network Waitaki upon request.
- Network Waitaki retains the right to conduct inspections of the generating plant, with reasonable notice and at Network Waitaki's expense. Access to the generating plant site and network isolation points is necessary for maintenance and testing purposes.
- Any modifications to the connection, such as the installation of additional inverters, upgrades, extensions, augmentations, or alterations, including operational or protection settings at the generating plant, require prior approval from Network Waitaki. Such modifications may necessitate additional network studies and incur extra costs. Any changes to the electrical installation must be carried out by a registered and qualified electrician authorised for such work.
- The generating plant's connection and operating principles may be adjusted at Network Waitaki's discretion in the following circumstances:
    - If the generating plant causes power quality issues.
    - Upon discovery of new information indicating that the generating plant may adversely affect Network Waitaki's obligations to other connected parties.
- The Generation Asset Owner is obligated to inform Network Waitaki of both scheduled and unscheduled protection or communication outages or failures.
- In the event of an audit or investigation revealing non-compliance with the Connections Contract, Network Waitaki will notify the Generation Asset Owner in writing. A non-compliant generating plant will be disconnected and cannot be reconnected until the Generation Asset Owner mitigates the issue and demonstrates compliance through testing.
- All costs associated with the maintenance and operation of the generating plant are the responsibility of the Generation Asset Owner.

In a functional Distribution Network, several types of network faults, including three-phase to ground, phase to phase, and single-phase faults, can occur, leading to voltage variations that impact the generating plant's operation. Additionally, scheduled Distribution Network maintenance may cause interruptions or outages for the generating plant. To minimise downtime and reduce interruptions, it is crucial to effectively coordinate maintenance schedules.

11 APPENDICES

11.1 Appendix A – Application Process

Developers interested in connecting Distributed Generation (DG) to our network should consult Clause 11 of Part 2 in Schedule 6.1 of Part 6 of The Code for guidance. Additionally, Network Waitaki's Utility-Scale Distributed Generation Process guide, which can be found on our website, provides a step-by-step process.

Connections are categorised based on their potential impact at the proposed connection point, considering factors such as load flow, network voltage stability, protection, and power quality. Note that while the size of the generation plant matters, it's not the sole determining factor.

This document details the minimum equipment standards required for connecting any new generation plant, and additional standards for plants with high potential impact.

The Generation Asset Owner's initial application must include all necessary details for Network Waitaki to conduct a network assessment, as per Clause 12 of Part 2 in Schedule 6.1 of Part 6 of The Code. This assessment considers:

- Thermal rating of network assets
- Fault level at the point of connection (POC)
- Short circuit ratio (SCR), an indicator of stability
- Existing generation plants within Network Waitaki's network area.