TRANSPOWER

Fault Ride Through Study Assumptions

Additional Information for the Southland Region

Version: 1.2

Date: 22/06/2026

Version	Date	Change
1.0	08/08/2025	Initial Release
1.1	23/04/2026	Update to circuit names in Table 3-1 following commissioning of KIW bus
1.2	22/06/2026	Updated section 3.2

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IMPORTANT

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1 Introduction

Fault Ride-Through (FRT) is the ability of a generating unit to stay connected to the electrical grid during and following a fault disturbance, and then to restore its power output to pre-fault levels. This document provides additional information and system assumptions relevant to the Southland Region (Grid Zone 14) for the technical studies required to demonstrate compliance with the FRT requirements stipulated in EIPC.

The Southland region includes: Clyde, Roxburgh, Three Mile Hill, Halfway Bush, South Dunedin, Berwick, Balclutha, Gore, Brydone, Edendale, Invercargill, North Makarewa, Tiwai and Manapouri. For a list of site code abbreviations relevant to this region, see the appendix. The contents of this document apply to any asset that will be connected within the Southland region, which is shown geographically and as a single line diagram in Figure 1-1 and Figure 1-2.

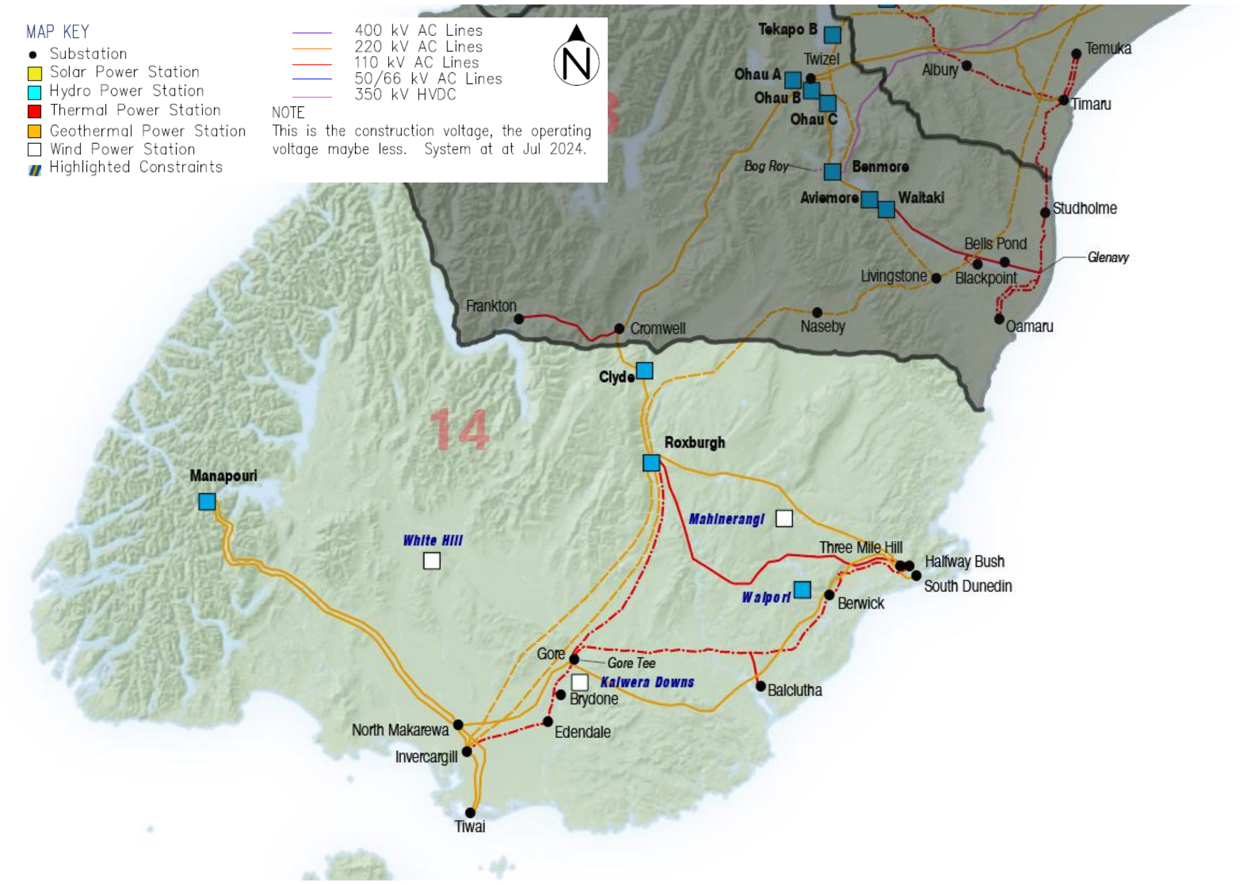

Figure 1-1 (above): Geographic representation of Southland Region (Grid Zone 14)

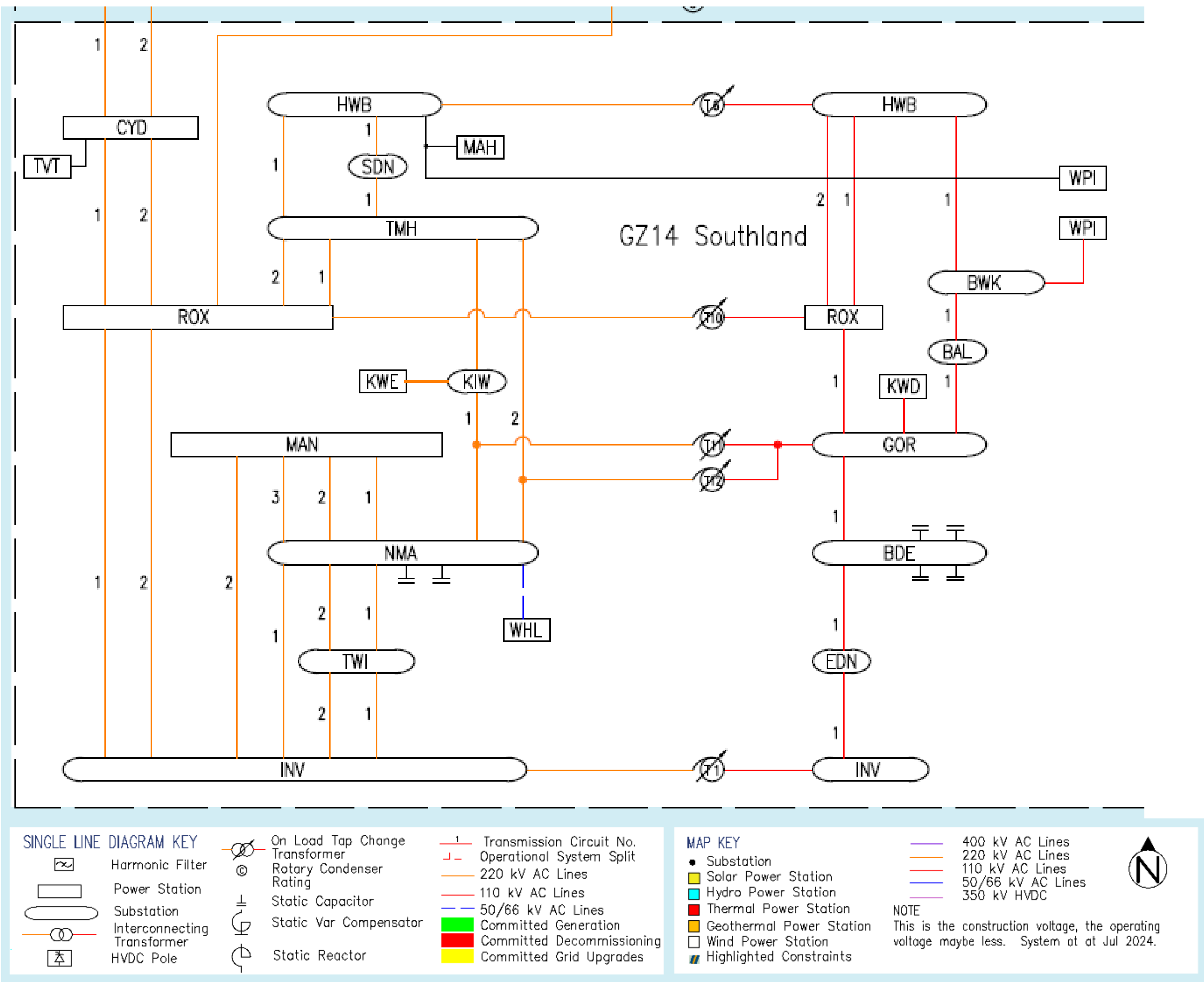

Figure 1-2: Single line diagram of Southland Region (Grid Zone 14)

This document includes region-specific information and historical voltage trends to support you to complete your studies with accurate region-specific system conditions. You will also find an appropriate set of planned outages and corresponding generation dispatches, as well as information on any changing system conditions in the region, including the commissioning or de-commissioning of both transmission and generation assets.

Note that planned outages (section 3.5) and fault locations (section 7.3) to be studied will depend on the point of common coupling (PCC) groups. These have been introduced based on the location of the stations, with each station within the region assigned to a specific PCC group. You can find these outlined in section 3.4.

If your asset has not started commissioning one year after the System Operator has received and accepted a technical study, you may need to repeat it to reflect further changes to the power system that could affect the asset's fault ride through capability.

1.1 Additional documents

Transpower's GL-EA-953 document outlines the general requirements for a new generating station's connection studies, including the FRT study. The System Operator expects the Asset Owner to be familiar with that document as it outlines relevant information such as steps for model and study case preparation, as well as study scope and assessment criteria.

The following Transpower documents are also relevant to this assessment:

- 2024 System Security forecast
- Transpower EA EMI DIgSILENT NIPS case
- PSCAD Electromagnetic Transients (EMT) network model
- Special protection schemes

2 FRT Study Purpose

The System Operator expects an FRT study to have the following outcomes:

- The generating units meet all the assessment criteria whilst riding through post-fault voltage excursions within the envelopes prescribed by the Code.
- The fault ride through strategies are detailed.
- Any non-compliant, or potentially non-compliant, behaviours are identified and explained.
- There is confirmation that no protection or control settings at the generating station would result in a breach of the fault ride through requirements. If there is any shortfall of asset capability to meet the Code requirements, you shall discuss it with the System Operator.

3 System Conditions

3.1 System model

You should perform the FRT assessment based on the latest available design parameters of your asset.

- If you modify any controller parameter after submitting the FRT report, i.e. during or after the EIPC Compliance tests, then you must also provide the System Operator with updated parameters.
- If there is a material change in the settings that would significantly alter the FRT performance, you may need to update and resubmit the study to the System Operator.

3.1.1 Minimum and maximum short circuit level conditions

It is acceptable to use the winter/summer peak and light load summer scenarios provided in the Electricity Market Information (EMI) dataset to prepare the maximum and minimum short circuit level study scenarios. The LoadSeason triggers 'At regional night trough S EXP' and 'At regional night trough W EXP' (for summer and winter respectively) may also be used in the absence of a light load summer scenario for the study year in question. As a minimum, the studies should be carried out for the planned commissioning year. Your study should also include any significant future local changes if the EMI case contains that relevant data.

3.2 Network model

The network model used for the connecting assets in the FRT study should include an accurate representation of:

- all generation units
- generator transformers
- the internal collector network
- the grid-connected transformer
- all controllers for Inverter Based Resources, including the Plant controller, and Inverter controller. These models should include representation of any Phase Lock Loop (PLL) controls, all current controls and should model the control strategies used
- any other equipment to be installed in the facility that affects fault ride through behaviour.

This model must align with the available single-line diagram submitted in the Asset Capability Statement (ACS). An aggregated generating station model is acceptable for wind, solar and battery generating stations that shall include a collector system equivalent network model, as long as the model accurately reflects the performance expected of the station (see section 4.2).

Calculate the Effective Short Circuit Ratio (ESCR) at the PCC under the lowest short circuit system conditions using the latest EMI study case, the lowest short circuit system conditions are likely to be during an outage.

For synchronous generators you will need to undertake fault ride through studies with PowerFactory RMS simulations.

For Inverter Based Resources (IBR) you will need to undertake fault ride through studies with PowerFactory RMS simulations as an initial screening to cover all generation scenarios, fault types and asset operation conditions agreed with System Operator. You must then undertake a PSCAD EMT study to assess a selection of study cases identified in the screening process as agreed with System Operator.

3.3 System Voltages

Figure 3-1 demonstrates the grid voltage profiles over the period January to December 2024 in the Southland Region.

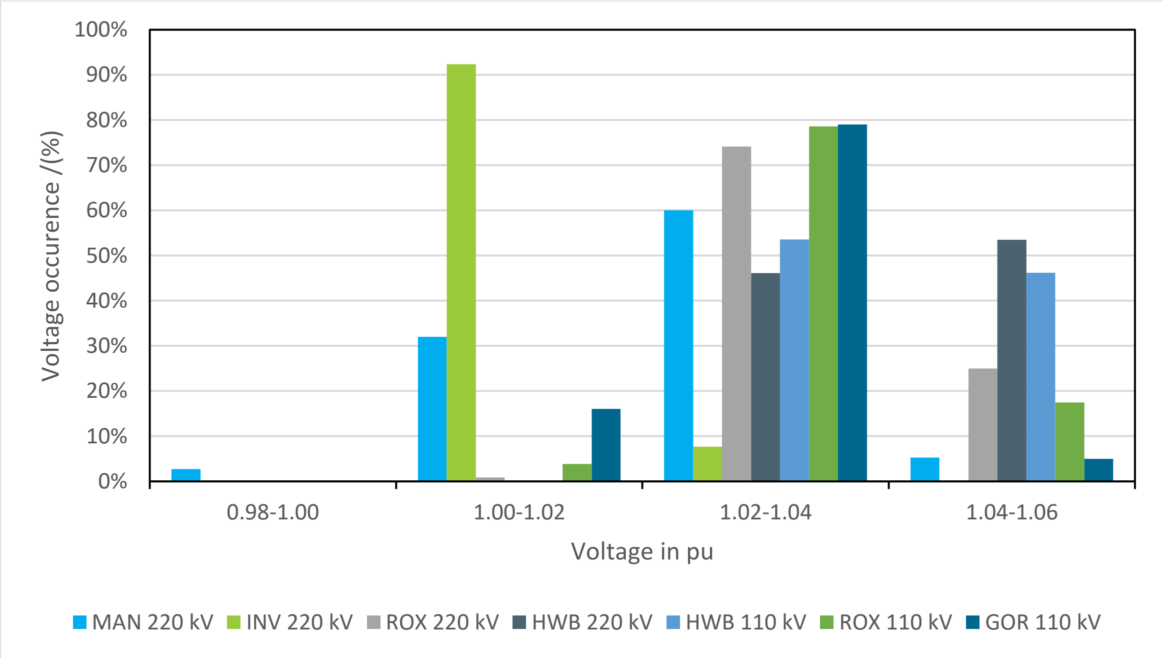

Figure 3-1: Voltage profile of MAN 220kV, INV 220kV, ROX 220kV, HWB 220 kV, HWB 110kV, ROX 110 kV and GOR 110 kV from Jan to Dec 2024

The above graph indicates that 220kV voltage in Southland region varies between 1.00-1.06 pu with the 110 kV buses typically operating between 1.02-1.06 pu. It is to be noted that this region is well equipped with reactive power compensation devices to regulate the voltage. The nominal rating of each capacitor at NMA is 50 MVArs and normally only one is in service. Thus, one NMA capacitor should be in service for studies with trough load conditions. Asset Owners should perform fault ride through studies with voltage targets for the region within these ranges, highlighting any impact the new connection may have on the local voltage.

3.4 PCC groups classification

The System Operator has grouped 220kV and 110kV stations within the region as follows. This should help streamline the outages and fault locations to be studied based on the PCC. Accordingly, an asset connecting to any voltage level at these stations will belong to a particular PCC group.

PCC Group A (220kV): CYD, ROX, TVT (off CYD 220)

PCC Group B (220kV): TMH, HWB, SDN, MAH (off HWB 220), WPI (off HWB 220)

PCC Group C (220kV): MAN

PCC Group D (220kV): NMA, INV, TWI, WHL 66 kV

PCC Group E (110kV): HWB, ROX, BWK, WPI

PCC Group F (110kV): GOR, BAL, KWD (off GOR 110)

PCC Group G (110kV): BDE, EDN, INV

3.5 Transmission circuit outages

Planned outages are regular occurrences on the grid and the fault ride through study must include assessment of performance during outages. The System Operator expects outages to result in reduced system strength at the point of connection, which can make the fault ride though more difficult to achieve. We will maintain N-1 security during planned or forced outages, and this may require special protection schemes (SPS) or pre-contingent constraints. The generation dispatch used in the outage studies should not result in unacceptable overloading of any circuit for a further contingency. If you need advice on any relevant special protection schemes (SPS), operational measures or on specific circuit overload capabilities, contact the System Operator.

You should consider the outages in Table 3-1 and Table 3-2 below during your FRT assessment. Table 3-1 outlines the outages to be considered during the studies based on 220kV PCC groups A, B and C, while Table 3-2 outlines the outages to be considered during the studies based on 110kV PCC groups D, E and F as defined in section 3.4.

For 110kV PCC connections, you must also include the outage group associated with the nearest 220kV bus.

Table 3-1: Outages under 220kV PCC groups A, B, C and D

PCC Group A	PCC Group B	PCC Group C	PCC Group D
CML-CYD-TWZ-1 220 kV tee circuit	ROX-TMH-1 220 kV circuit	INV-MAN-2 220 kV circuit	INV-MAN-2 220 kV circuit
CYD-ROX-1 220 kV circuit	GOR-NMA-TMH-1 220 kV tee circuit	MAN-NMA-1 220 kV circuit	MAN-NMA-1 220 kV circuit
NSY-ROX-1 220 kV circuit	HWB-TMH-1 220 kV circuit	INV-NMA-1 220 kV circuit	NMA-TWI-1 220 kV circuit
INV-ROX-1 220 kV circuit	HWB-SDN-1 220 kV circuit	INV-TWI-1 220 kV circuit	KIW-GOR-NMA-1 220 kV circuit
ROX-TMH-1 220 kV circuit	SDN-TMH-1 220 kV circuit	INV-ROX-1 220 kV circuit	KIW-TMH-1 220 kV circuit
ROX T10 220/110 kV interconnecting transformer	NSY-ROX-1 220 kV circuit	GOR-NMA-TMH-1 220 kV tee circuit	INV-TWI-1 220 kV circuit
INV-MAN-2 220 kV circuit	HWB T6 220/110 kV interconnecting transformer	One TWI pot line*	INV-ROX-1 220 kV circuit
	GOR-NMA-TMH-1 220 kV tee circuit	NMA-TWI-1 220 kV circuit	INV-NMA-1 220 kV circuit
		MAN bus split open	INV T1 220/110 kV interconnecting transformer
		NMA C1 capacitor*	GOR T11 220/110 kV interconnecting transformer
			One TWI pot line*

* Only during trough load conditions

Table 3-2: Outages under 110kV PCC groups E, F and G

PCC Group E	PCC Group F	PCC Group G
ROX T10 220/110 kV interconnecting transformer	INV T1 220/110 kV interconnecting transformer	INV T1 220/110 kV interconnecting transformer
HWB T6 220/110 kV interconnecting transformer	GOR T11 220/110 kV interconnecting transformer	GOR T11 220/110 kV interconnecting transformer
GOR-ROX-1 110 kV circuit	BAL-BWK-1 110 kV circuit	BDE-EDN-1 110 kV circuit
HWB-ROX-1 110 kV circuit	GOR-ROX-1 110 kV circuit	EDN-INV-1 110 kV circuit
BWK-HWB-1 110 kV circuit	BAL-GOR-1 110 kV circuit	BDE-GOR-1 110 kV circuit
BWK-WPI-1 110 kV circuit*	BDE-GOR-1 110 kV circuit	BDE capacitor **
BAL-BWK-1 110 kV circuit	BDE-EDN-1 110 kV circuit	GOR-ROX-1 110 kV circuit
BAL-GOR-1 110 kV circuit	EDN-INV-1 110 kV circuit	BAL-GOR-1 110 kV circuit
GOR T11 220/110 kV interconnecting transformer		
BAL capacitor **		

* Only for WPI
** Only during trough load conditions

The outages detailed above are expected to identify any problematic network configurations up to the post-fault N-1-1 condition. However, the Asset Owner remains responsible for identifying any onerous outage scenarios that result in an inability to ride through a system fault. To this end, you may choose to carry out a wider range of outage studies.

3.5.1 EMT studies

EMT studies should be conducted for a range of outages, with a focus on the most critical scenarios, typically the most onerous will be outages that result in the lowest short circuit ratios at the PCC. Outages in Table 3-1 and Table 3-2 can be used for screening through the SCR, in some cases not all the outages will need to be studied in the EMT case.

4 Local Conditions

4.1 Local network model

The network topology for Transpower assets is depicted in the EMI study case. Where there is a complex local network that can affect the study results, Asset Owners should acquire this data from the network owner and add this to the study. An equivalent representation of a local network may be sufficient.

A significant local network would, for example, be a network connected between the nearest Transpower asset and the generation site, or a network that could provide a parallel or alternative export path during any potential operation of the generation. A local network with generation that also feeds into a common connection at a Transpower asset may also need to be included.

The 2024 EMI case is set with constant impedance modelling in the transient studies, this is an optimistic assumption for the load itself. It is prudent to perform fault ride through studies with less optimistic load modelling (such as modelling the real power load component as constant current, or modelling both real and reactive load components as 50% constant current, 50% constant impedance) as a sensitivity.

The following assumptions can be used for this region:

- The Halfway Bush T6 Reverse Power Protection scheme is operational, normally disabled.
- The Gore Circuit Overload Protection Scheme is operational, normally disabled.
- Capacitors are available at Balclutha, Brydone.
- The Gore bus split is assumed to be normally closed.
- Tiwai Smelter assumed to be not retiring.
- Only one NMA capacitor should be dispatched

The Gore Circuit Overload Protection Scheme (GOR COPS) does not have any externally published information, so is summarised below.

GOR COPS is normally enabled when the GOR 110 kV bus is split and a NMA-GOR-TMH 220 kV circuit, or GOR 220/110 kV transformer (or both associated circuit and transformer) are removed from service.

The purpose of GOR COPS is to avoid overloading the EDN-INV-1 circuit in future when the GOR 110 kV bus is split. EDN-INV-1 overloads may otherwise occur as a consequence of a NMA-GOR-TMH 220 kV circuit or GOR 220/110 kV transformer trip.

Two 220/110 kV transformers are to be connected in a double tee configuration off the NMA-TMH-1 and NMA-TMH-2 circuits. The GOR 110 kV bus is to be re-arranged so that it may be run split.

- BAL-GOR-1 and GOR-ROX-1 will be connected to one side of the split GOR 110 kV bus.

- The two 220/110 kV transformers, BDE-GOR-1 and the GOR 110/33 kV supply transformers will be connected to the other side of the split GOR 110 kV bus.

4.2 Generator model

The high-level details for modelling the generation facility are available in the GL-EA-953 guideline. If you use an aggregated model instead of modelling individual units, you must demonstrate that the aggregated model accurately represents the characteristics of the entire facility at the connection point. To this end, you must provide any relevant underlying assumptions.

4.2.1 Active power output of the generating unit/ station

The Asset Owner should conduct an FRT study at both 80%, and 100% of the maximum continuous output (MCO) of the generation. However, Inverter based generation is also expected to be studied at 20% of its MCO with all inverters are in service. Asset Owner can limit the EMT studies to two most onerous generation outputs.

The System Operator expects you to identify and study any power output conditions below maximum generation that may be onerous for FRT studies. A simple example of this would be a site with more than one connection to the grid, where, during an outage, the output through one or more of those connections may surpass its output under intact conditions, despite the total station output being lower.

If a facility has more than one operating mode, then you must study the FRT performance of the facility in all its configurations. For example, battery or hybrid connections must include import, export and idling modes.

4.2.2 Reactive power output of the generating unit/station

You must identify the reactive power capability at the connection point for the expected grid voltage range. To demonstrate successful fault ride through, studies should include the expected operation as well as identify the most onerous pre-fault reactive power dispatch conditions for both lagging and leading power factors.

Further, for a synchronous generating station, you should carry out sensitivity studies to assess the performance of generating units when operating near their under-excitation and over-excitation limits.

All nearby generating stations should be dispatched to manage their respective target bus voltages within an acceptable operating range, typically between 0.98- 1.05pu. Bus voltage profiles provided in Figure 3-1 (see section 3.3 above) serve as a starting point to configure the study cases. Fault ride through studies should include a voltage of 1.00p.u. at the point of connection. You should also perform sensitivity studies at the most common voltage levels expected at the PCC to reflect the existing operating voltage range as shown in Figure 3-1, allowing for any impact of the new connection.

5 Other Generation

Manapouri is the most significant plant to be considered during the studies in the connections of this region. The generation scenario provided at MAN in the EMI case files is not the most onerous condition for the fault ride through scenarios for the lower South Island. Manapouri can operate with multiple units at 125 MW output.

The hydro units connected at Manapouri, Roxburgh and Clyde are highly dispatchable. You can scale these as required.

Asset Owner should consider following dispatch scenarios if electrically close to Manapouri.

Sensitivity studies for the most onerous transient stability solutions should consider 6 Manapouri units running at 125 MW with high wind (75% KWD and WHL wind generation) both peak and trough load conditions.

The filters at Tiwai typically export 119 Mvar but this often reduces to 82 Mvar, in this case the net reactive power load at Tiwai can reach an import of 200 Mvar. As a sensitivity for PCC groups A, C, D and G, this higher reactive power load at Tiwai should be considered as a worst case where the critical clearing time margin is less than 40ms.

6 Relevant External Conditions

The System Operator requires Asset Owners to ensure that permanent splits are enabled during the studies. These are outlined in the Appendix A: grid configuration - SSF 2024.

7 Fault Conditions

The studies to be documented are not simply the product of all various faults, outages and system conditions identified in this document. FRT study should identify and focus on the most difficult fault ride through conditions.

7.1 Fault types

The study can demonstrate fault ride through capability with three-phase balanced faults to ground and single-phase to ground faults with zero impedance. It is also necessary to study the line-line-ground fault for inverter based resources. To clear the fault, remove faulted circuits from the system after the designated fault clearance time mentioned in the next section (7.2). Studies should also include failed auto-reclose scenarios. Auto-reclose is enabled by default on 220kV transmission lines and will re-close onto 3 phase faults. Default reclose times of 1 second should be applied.

Further, the System Operator suggests that you detail the fault duration and retained voltage at the PCC as stipulated in section 6.6.4.1 in GL-EA-953. This will help to demonstrate fault ride through performance in compliance with Code clause 8.25A. To reflect these PCC voltage levels and longer fault durations, you can apply faults at various distances along circuits or at lower voltage levels. If necessary, use fault impedances to represent more remote faults.

In case of impedance faults, we recommendyou use only a reactance value (i.e. use a zero-resistance value). Remember to document the type of fault, duration and fault impedance (if any) in your FRT study report.

7.2 Fault clearance times

For the faults specified in Table 7-1 and Table 7-2 below, use the following durations:

- **220kV faults**: 120ms; while the close in end to a circuit fault is likely to clear earlier than 120ms, this is the currently designed guaranteed clearance time and should be applied at both ends.
- **110kV faults**: although target clearance time is 120ms for Zone 1, the EIPC Benchmark Agreement design fault clearance time allows 200ms for 110kV circuits. Therefore, we recommend you use 200ms fault clearance time for the 110kV circuit faults.
- **66 kV faults:** EIPC Benchmark Agreement design fault clearance time allows 200ms
- **33 kV faults:** fault clearance times can be assumed as up to 1000ms.

For impedance faults (see below), you can determine the fault duration by the relevant section of the fault ride through envelope under test (as per Code obligations). The System Operator advises you to apply the longer duration faults on the MV busbar (33kV) as distribution feeders would typically have a longer time duration.

7.3 Fault locations

We have listed the faults to be studied under each 220kV and 110kV PCC groups in Table 7-1 and Table 7-2 respectively. Asset Owner remains responsible for identifying the onerous fault locations that result in an inability to ride through a system fault under each PCC group.

For 110kV or lower voltage connections within PCC groups D, E or F, you should also include the faults associated with the nearest 220kV bus (PCC group). For example, if a new connection belongs to PCC group A, you should study faults under PCC group A in Table 7-1. However, for a new connection at BWK 110kV bus, you should study the faults under the PCC group B in Table 7-1 in addition to faults under PCC group E in Table 7-2.

Table 7-1: Fault cases to be studied under each 220kV PCC groups; A, B, C and D

PCC Group A	PCC Group B	PCC Group C	PCC Group D
CML-CYD-TWZ-2 220 kV tee circuit	ROX-TMH-2 220 kV circuit	INV-MAN-2 220 kV circuit	INV-MAN-2 220 kV circuit
CYD-ROX-2 220 kV circuit	GOR-NMA-TMH-2 220 kV tee circuit	MAN-NMA-2 220 kV circuit	MAN-NMA-2 220 kV circuit
NSY-ROX-1 220 kV circuit	HWB-TMH-1 220 kV circuit	INV-NMA-1 220 kV circuit	NMA-TWI-2 220 kV circuit
INV-ROX-2 220 kV circuit	HWB-SDN-1 220 kV circuit	INV-TWI-2 220 kV circuit	GOR-NMA-TMH-2 220 kV tee circuit
ROX-TMH-2 220 kV circuit	SDN-TMH-1 220 kV circuit	INV-ROX-2 220 kV circuit	INV-TWI-2 220 kV circuit
ROX T10 220/110 kV interconnecting transformer	HWB T6 220/110 kV interconnecting transformer	GOR-NMA-TMH-2 220 kV tee circuit	INV-ROX-2 220 kV circuit
INV-MAN-2 220 kV circuit	NSY-ROX-1 220 kV circuit	NMA-TWI-2 220 kV circuit	GOR T12 220/110 kV interconnecting transformer
INV-NMA-1 220 kV circuit		Double circuit fault at MAN-NMA-1 and MAN-NMA-2 220 kV circuits *	INV T1 220/110 kV interconnecting transformer

		Double circuit fault at MAN-NMA-3 and INV-MAN-2 220 kV circuits *	INV-NMA-1 220 kV circuit
		NMA capacitor C3	NMA capacitor C3

* These faults should only be considered for intact network conditions, not during outage conditions

Table 7-2: Fault cases to be studied under each 110kV PCC groups; E, F and G

PCC Group E	PCC Group F	PCC Group G
ROX T10 220/110 kV interconnecting transformer	INV T1 220/110 kV interconnecting transformer	INV T1 220/110 kV interconnecting transformer
HWB T6 220/110 kV interconnecting transformer	GOR T12 220/110 kV interconnecting transformer	GOR T12 220/110 kV interconnecting transformer
GOR-ROX-1 110 kV circuit	GOR-ROX-1 110 kV circuit	BDE-EDN-1 110 kV circuit
HWB-ROX-2 110 kV circuit	BAL-GOR-1 110 kV circuit	EDN-INV-1 110 kV circuit
BWK-HWB-1 110 kV circuit	BDE-GOR-1 110 kV circuit	BDE-GOR-1 110 kV circuit
BWK-WPI-1 110 kV circuit	BDE-EDN-1 110 kV circuit	BDE capacitor *
BAL-BWK-1 110 kV circuit	BAL-BWK-1 110 kV circuit	GOR-ROX-1 110 kV circuit
BAL-GOR-1 110 kV circuit		BAL-GOR-1 110 kV circuit
GOR T12 220/110 kV interconnecting transformer		

* Only during trough load conditions

The assessment should also simulate faults with the outages defined in section 3.4 to confirm the FRT performance during outage conditions.

You should select fault locations on the circuits, at both ends of the circuit, not at intermediate points.

FRT studies should also include failed auto-reclose scenarios. Auto-reclose is enabled by default on 220kV transmission lines and will re-close onto 3 phase faults. Default reclose times of 1 second should be applied.

The System Operator expects you to specify islanding protection separately; no islanding analysis is expected in these studies.

7.3.1 EMT studies

EMT studies should be a subset of the RMS studies carried out. The selection of fault cases should include the most onerous cases identified in the RMS studies and be sufficiently comprehensive to demonstrate the expected FRT capability. A minimum of three distinct fault types must be studied to ensure a robust assessment of system performance.

If EMT results show significant differences to RMT results, the scope of EMT studies should be expanded to provide sufficient evidence that the required FRT performance will be achieved.

7.4 Over-voltage simulations

Over-voltage situations are unusual for the lower South Island. These are typically associated with the unexpected loss of significant load. Therefore, you could study over-voltage ride through by simulating load shedding within the Southland region (without a frequency event). We recommend that you simulate an over-voltage scenario using a summer trough case.

Appendix: Site Codes

Abbreviation	Full Name
BAL	Balclutha
BWK	Berwick
CYD	Clyde
EDN	Edendale
GOR	Gore
HWB	Halfway Bush
INV	Invercargill
KWD	Kaiwera Downs Windfarm
MAH	Mahinerangi Wind Farm
MAN	Manapouri
NMA	North Makarewa
ROX	Roxburgh
SDN	South Dunedin
TMH	Three Mile Hill
TVT	Treviot
TWI	Tiwai
WHL	White Hill
WPI	Waipori

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