Fault Ride Through Study Assumptions

Additional Information for the Christchurch Region

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1.0	28/03/2025	Initial Release
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	Position
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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 Christchurch Region (Grid Zone 10) for the technical studies required to demonstrate compliance with the FRT requirements stipulated in EIPC Clause 8.25A(3).

The Christchurch region includes: Ashley, Islington, Kaiapoi, Norwood, Southbrook, Bromely, Culveden and Waipara. 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 Christchurch region, which is shown geographically and as a single line diagram in Figure 1-1 and Figure 1-2.

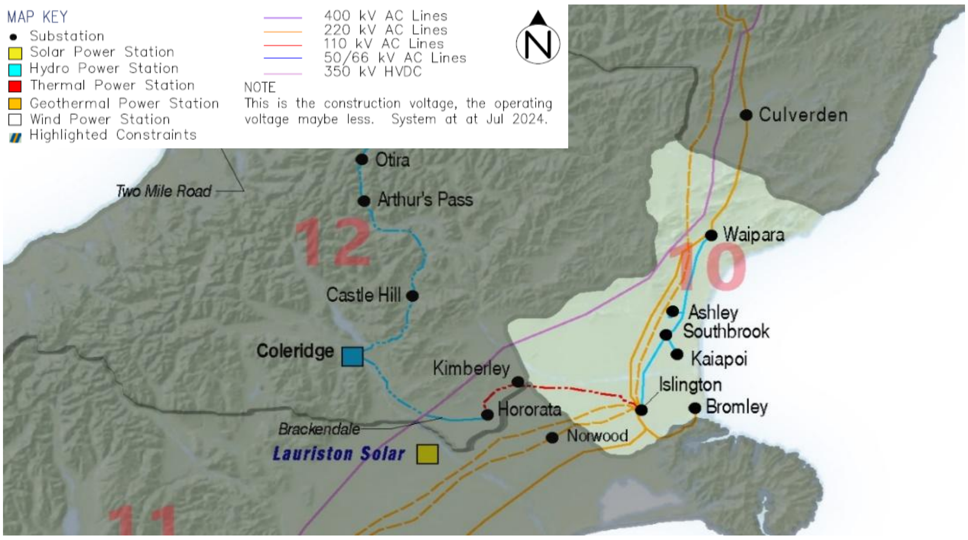

Figure 1-1 (above): Geographic representation of Christchurch Region (Grid Zone 10)

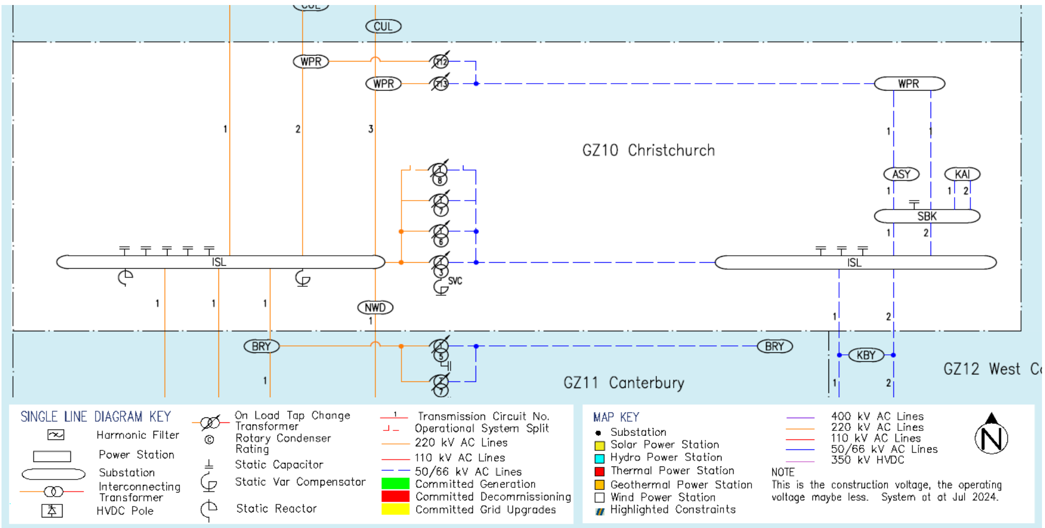

Figure 1-2: Single line diagram of Christchurch Region (Grid Zone 10)

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[1]
- Special protection schemes

[1] PSCAD network model will be provided by the SO upon request

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 base the study on the winter/summer peak and light load summer scenarios provided in the Electricity Market Information (EMI) dataset. 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 and all current controls, and
- any associated controls or equipment to be installed in the facility.
- Any control strategies that are designed to assist in riding through system fault used in IBRs

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 Christchurch Region.

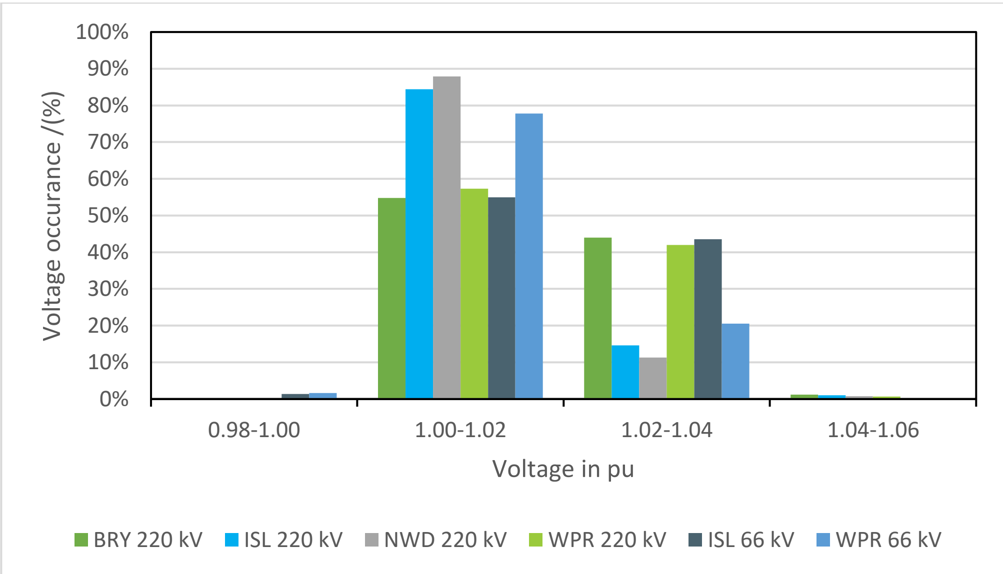

Figure 3-1: Voltage profile of BRY 220 kV, ISL 220kV, NWD 220kV, WPR 220kV, ISL 66 kV and WPR 66 kV from Jan to Dec 2024

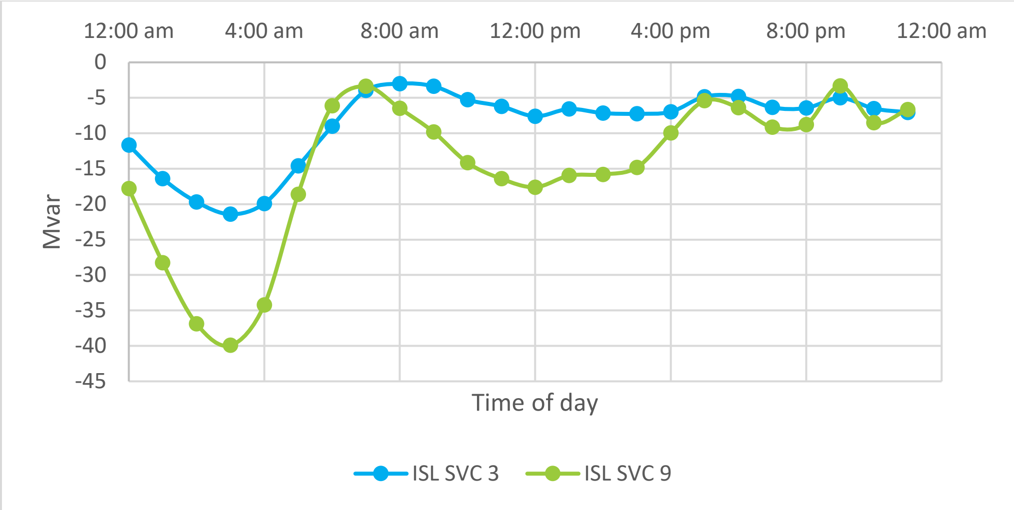

Figure 3-2: Average daily operation of the Islington Static Var Compensators from Jan to Dec 2024

The above graph indicates that 220kV voltage at Islington, Norwood and Waipara buses were mostly between 1.00-1.02pu. Further, this shows that the remainder of the region operated above 1.0pu throughout the year. It should be noted that these voltges are with the operation of the Islington Static Var Compensators (SVCs). Figure 3-2 outlines the average reactive power output of the ISL SVCs throughout 2024 in each hour. This indicates that voltages could be higher than voltages depicted in Figure 3-1 during an outage of either SVC, particularly ISL SVC 9. 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 66kV 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): WPR, CUL

PCC Group B (220kV): ISL, BRY, NWD

PCC Group C (66kV): WPR, ASY, KAI, SBK, ISL

PCC Group D (66kV): BRY, NWD

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, and B while Table 3-2 outlines the outages to be considered during the studies based on 66kV PCC groups C, and D as defined in section 3.4.

For 66kV PCC connections, you must also include the outage group associated with the nearest 220kV bus.

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

PCC Group A	PCC Group B
ISL-WPR-CUL-KIK circuit 2*	ISL-KIK circuit 1
ISL-TKB circuit 1	ISL-WPR-CUL-KIK circuit 2*
ISL-KIK circuit 1	ISL-TKB circuit 1
ISL-ASB circuit 1	ISL-ASB circuit 1
ISL-NWD circuit 1	ASB-BRY circuit 1
ISL SVC 9	BRY-ISL circuit 1
WPR T12	ISL-NWD circuit 1
	LIV-NWD circuit 1
	LIV-WTK circuit 1
	BRY T5
	ISL T6
	ISL SVC9

* ISL-WPR-CUL-KIK circuit 2 is a single circuit with WPR and CUL connected as Tee connections

Table 3-2: Outages under 66 kV PCC groups C and D

PCC Group C	PCC Group D
ISL-NWD circuit 1	ISL-TKB circuit 1
ISL-TKB circuit 1	BRY-ISL circuit 1
ISL-ASB circuit 1	ASB-ISL circuit 1
ISL-KIK circuit 1	ISL-NWD circuit 1
ISL-WPR-CIL-KIK circuit 2	LIV-NWD circuit 1
ISL T6	BRY T5
WPR T12	NWD T1
ISL SVC 9	ISL SVC 9
ISL SVC 3	
ISL-SBK 66kV circuit 1	
SBK-ASY 66kV circuit 1	
SBK-WPR 66kV circuit 1	
SBK-KAI 66kV circuit 1*	
ISL-KBY-HOR 66kV circuit 1	

* required only for connections at KAI

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 condcuted 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 * ISL-WPR-CUL-KIK circuit 2 is a single circuit with WPR and CUL connected as Tee connections

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.

It is to be noted that only three of the four ISL 220/66 kV transformers may be energised at any time. It is recommended that ISL T8 be set out of service during studies with the remaining three ISL transformers in service as ISL T8 is the largest of the four.

Highbank generation should be considered unable to provide reactive support.

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

The only significant generation plant in the region is the 52 MW Lauriston Solar Farm in Ashburton. It should be noted that dynamic models are not included for any IBR generation in this region in the EMI case. You may consult SO to check for the availability of those models at the time of the study.

There is a significant amount of hydro generation to the south, particularly from Tekapo (TKB) and Ohau (OHA, OHB, OHC). These units are highly dispatchable, you can scale them as required. If further generation is needed, the hydro generation at Benmore can be used. An outage of a Tekapo generator should be considered during the maximum fault level studies.

6 Relevant External Conditions

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

7 Fault Conditions

The studies to be documented are not simply be the product of all various faults, outages and system conditions identified below. 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. To clear the fault, remove faulted circuits from the system after the designated fault clearance time mentioned in the next section (7.2).

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 specific faults specified in section 7.1 above, 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 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 66kV 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 66kV or lower voltage connections within PCC groups C, or D, 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.

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

PCC Group A	PCC Group B
ISL-WPR-CUL-KIK circuit 3*	ISL-KIK circuit 1
ISL-NWD circuit 1	ISL-WPR-CUL-KIK circuit 3*
ISL-KIK circuit 1	ISL-TKB circuit 1
KIK-STK circuit 1	ISL-ASB circuit 1
ISL-TKB circuit 1	ASB-BRY circuit 1
ISL-ASB circuit 1	BRY-ISL circuit 1
WPR T13	ISL-NWD circuit 1
	LIV-NWD circuit 1
	BRY T7
	ISL T7

* ISL-WPR-CUL-KIK circuit 2 is a single circuit with WPR and CUL connected as Tee connections

Table 7-2: Fault cases to be studied under the 66 kV PCC groups; C and D

PCC Group C	PCC Group D
ISL-NWD circuit 1	ASB-BRY circuit 1
ISL-TKB circuit 1	BRY-ISL circuit 1
ISL-ASB circuit 1	ASB-ISL circuit 1
ISL-KIK circuit 1	ISL-NWD circuit 1
ISL-WPR-CUL-KIK circuit 3*	ISL-KIK circuit 1
ISL T7(66kV side)	ISL-TKB circuit 1
WPR T13 (66kV side)	LIV-NWD circuit 1
ISL-SBK 66kV circuit 2	ISL-WPR-CUL-KIK circuit 3*
SBK-ASY 66kV circuit 1	NWD T2 (66kV side)
SBK-WPR 66kV circuit 1	BRY T7**(66kV side)
SBK-KAI 66kV circuit 1*	
ISL-KBY-HOR 66kV circuit 2	
SVC 3 (While SVC 9 is on outage)	
SVC 9 (While SVC 3 is on outage)	

* ISL-WPR-CUL-KIK circuit 2 is a single circuit with WPR and CUL connected as Tee connections

** only for connections at BRK 66kV side

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

There is a potential for over-voltage situations under trough load conditions in this part of the network if the Albany SVC is unavailable, thus these scenario could be studied with the ALB SVC out of service . Further, 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 Northland region. We recommend that you simulate an over-voltage scenario using a summer trough case.

Appendix: Site Codes

Abbreviation	Full Name
ASB	Ashburton
ASY	Ashley
BRY	Bromley
CUL	Culverden
ISL	Islington
KAI	Kaiapoi
KIK	Kikiwa
LIV	Livingstone
NWD	Norwood
SBK	Southbrook
TKB	Tekapo B
TWZ	Twizel
WPR	Waipara

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