Southland Electrical Network

Spare Capacity and Load Conversion Opportunity Report

EECA

21177 / 21177-RPT-0001 / Revision I / 16-Jan-2023

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Revision details

Revision	Details
A	Preliminary draft – containing GXP spare capacity and load characteristics – for discussion
B	Updated report with connection options for opportunities adjacent to North Makarewa
C	Updated report with draft zone substation loading data
D	Updated report with capital cost estimates to supply LCOs
E	Updated following Transpower and EECA feedback
F	Updated to incorporate further scenarios provided by EECA
G	Minor updates and split report to include supplementary information in separate document 21177-RPT-0002
H	Minor updates following review from WM Advisory
I	Issued in final with reference to Edendale supply options memo

Table of Contents

List of Tables

List of Figures

1. Executive Summary

Transpower maintains/manages the transmission network in New Zealand and supplies the lower South Island (as described in this report) via nine GXP's.

PowerNet Limited (PowerNet) maintains/manages the electrical networks that are owned by the following Electrical Distribution Businesses (EDB):

- The Power Company Limited (TPC)
- Electricity Invercargill Limited (EIL)
- OtagoNet Joint Venture Limited (OJV)

The Energy Efficiency & Conservation Authority (EECA) is running a flagship program that is called Energy Transition Accelerator (ETA)[1]. The program is targeted at large energy-using businesses and public sector organisations that are committed to reducing carbon emissions.

As part of the ETA program, EECA has developed a set of Load Conversion Opportunities (LCO) for the Southland Region. The LCO's involve existing consumers/plant that use fossil fuel and which could potentially be converted to using electricity.

EECA contracted Ergo to determine the following (for the Southland Region):

- The existing spare supply capacity at the major electrical substations.
- The load characteristics at the major electrical substations.
- A capital cost estimate to supply electricity to each of the LCO's

The purpose of the LCO cost analysis is to provide options for investment that will provide significant reduction in the use of fossil fuels.

[1] https://www.eeca.govt.nz/co-funding/energy-transition-accelerator/

1.1 Network Spare Capacity

The following figure illustrates the approximate (N) and (N-1) spare capacity at the Transpower GXP substations in the Southland Region based on Transpower disclosed information.

Southland Region: GXP Substations: Spare (N) and (N-1) Capacity

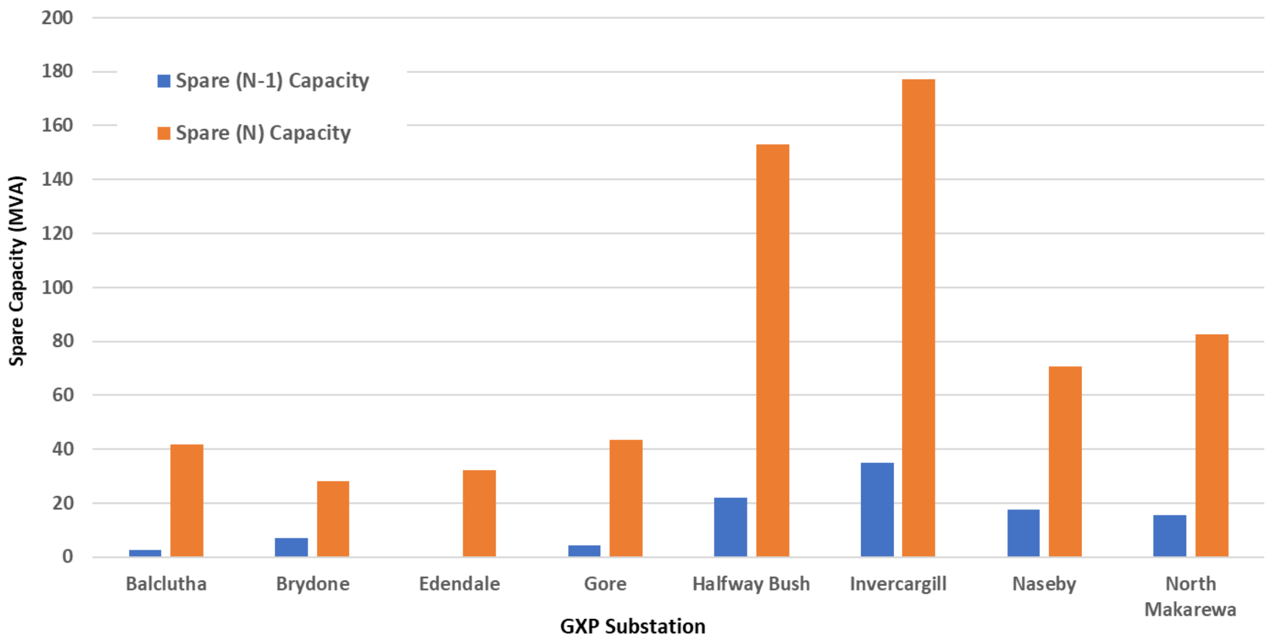


Figure 1 Summary: Approximate (N) and (N-1) spare capacity at GXP substations

The following figures illustrate the (N) and (N-1) spare capacity at the EDB Zone Substations in the Southland Region based on EDB disclosures.

The Power Company Zone Substations: Spare (N) and (N-1) Capacity

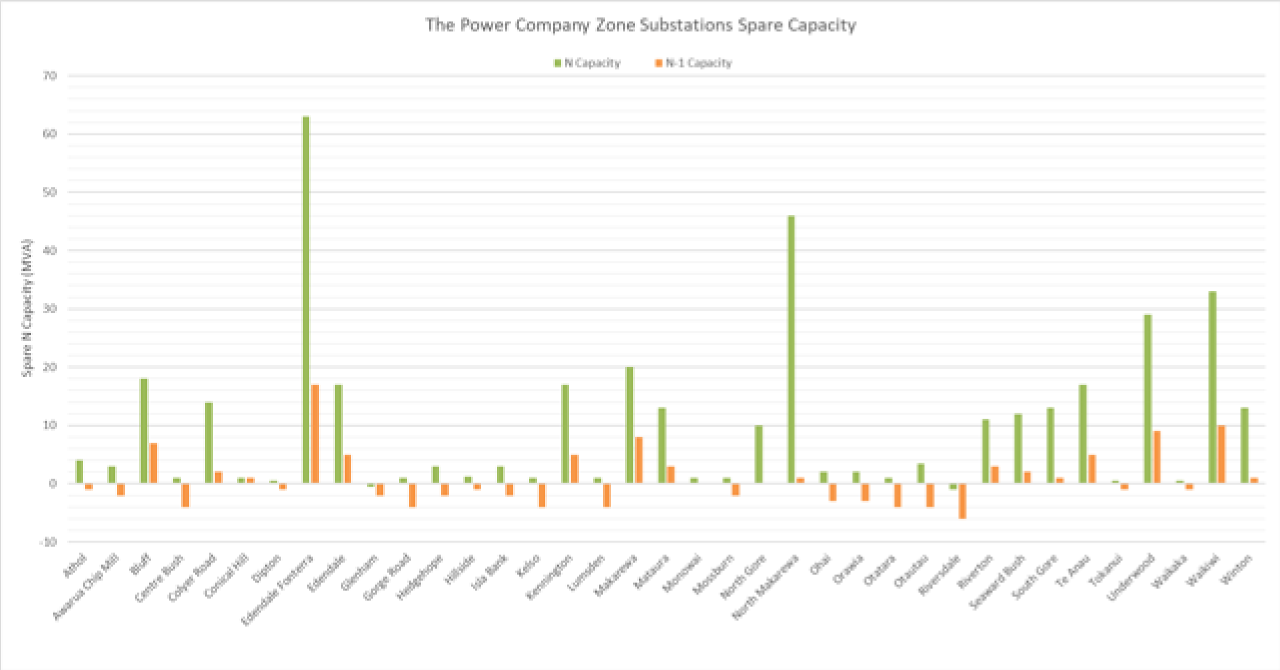


Figure 2 Summary: Approximate (N) and (N-1) spare capacity at The Power Company zone substations

Electricity Invercargill Zone Substations: Spare (N) and (N-1) Capacity

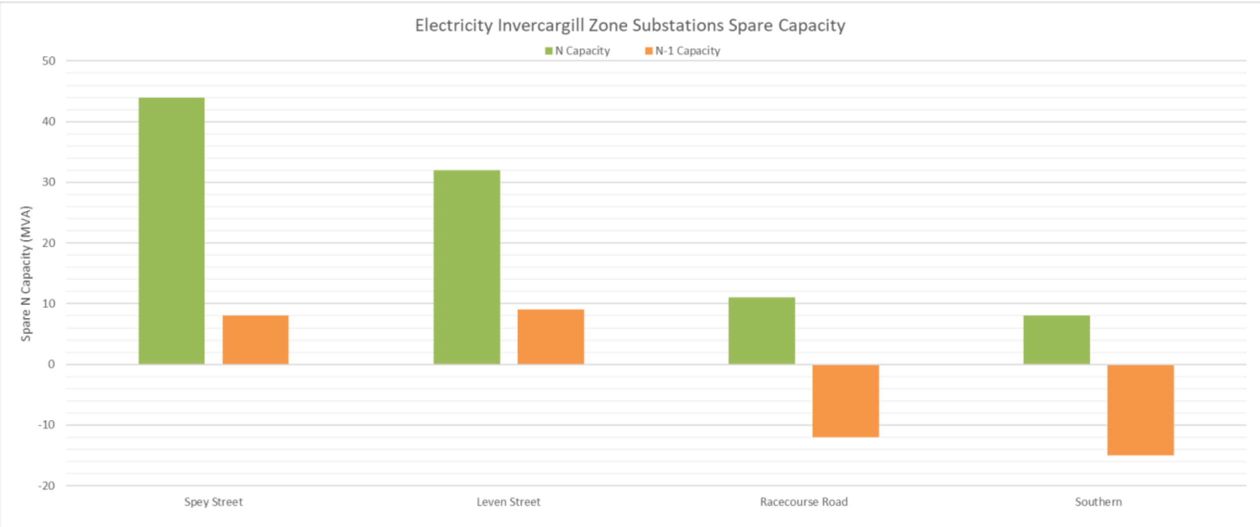


Figure 3 Summary: Approximate (N) and (N-1) spare capacity at Electricity Invercargill zone substations

OtagoNet Zone Substations: Spare (N) and (N-1) Capacity

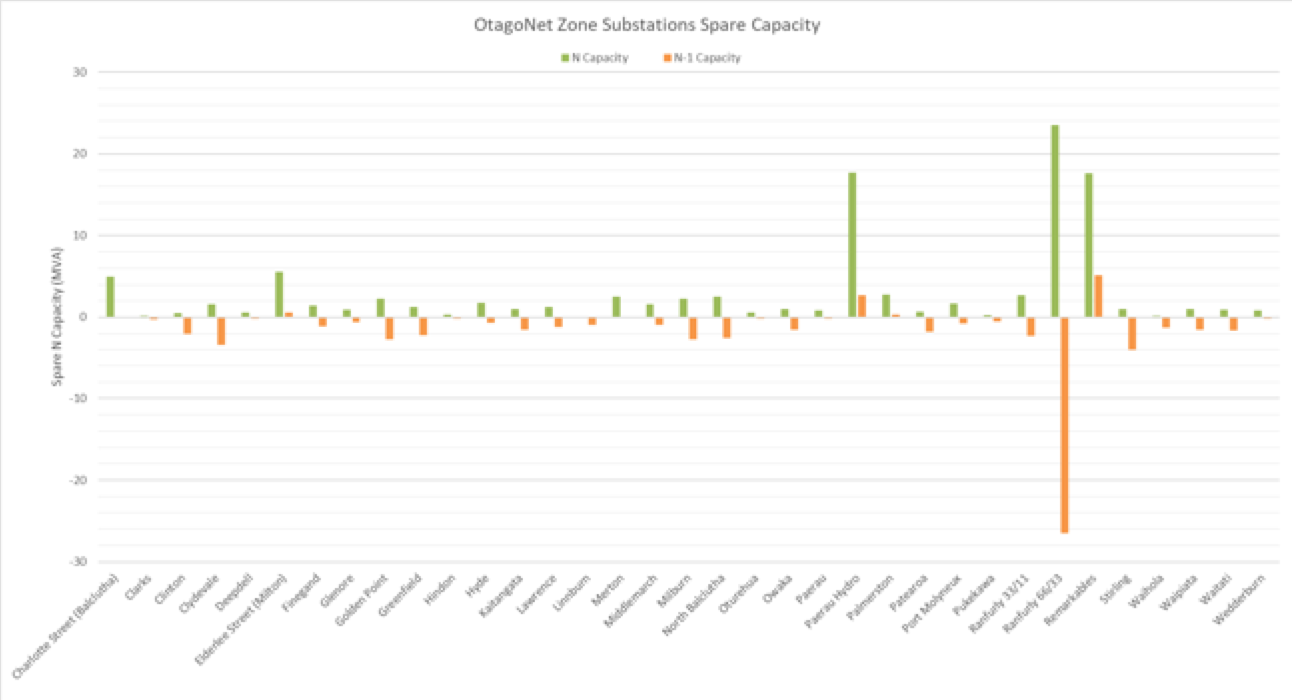


Figure 4 Summary: Approximate (N) and (N-1) spare capacity at OtagoNet zone substations

1.2 Load Characteristics

The substation load characteristics are documented in detail in the main body of the report (and the supplementary report 21177-RPT-0001) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

- **GXP substations:**
  - *Balclutha*. A typical mix of residential and commercial/industrial loads. The load tends to peak in the mornings and evenings and is lower during weekends.
  - *Brydone*. Predominantly commercial/industrial, with significant variations in load occurring at different times of the day due to changes industrial processing or distributed generation.
  - *Edendale*. Predominately based on the dairy industry with a significant reduction during June/July during which the industry has its major shutdowns.
  - *Gore.* Predominantly residential load, with the load peaking in the mornings/evenings and very lightly loaded in the early hours of the morning. Some evidence of load reduction during weekends.
  - *Halfway Bush.* The load profile is affected significantly by the intermittent power injected by the Mahinerangi wind farm, and thus not particularly predictable.
  - *Invercargill.* A typical mix of residential and commercial/industrial loads. The load tends to peak in the mornings and evenings and is lower during weekends.
  - *Naseby*. Predominantly industrial, with significant variations in load occurring at different times of the day/week due to changes industrial processing.
  - *North Makarewa*. The load profile is affected significantly by the intermittent power injected by the White Hill windfarm, and thus not particularly predictable.

- *Tiwai.* The load profile is very constant as the substation supplies an aluminium smelter.

- **Zone Substations**:

  The load characteristics of the zone substations vary widely depending on the connected consumers/generators.

1.3 EECA Load Conversion Opportunities (LCO)

The following table shows EECA's Load Conversion Opportunities (LCO) together with:

- The peak electrical power requirements of the LCO.
- The distribution zone substation to which the LCO would connect.
- The transmission substation which supplies the relevant zone substation.
- Ergo's estimate of the capital cost to significantly increase the capacity of the relevant transmission substation.
- Ergo's estimate of the capital cost to install the necessary distribution assets to supply the LCO.
- The cost efficiency associated with the LCO in terms of $M/MW.
- The 'complexity' of connection based on the level of upgrades required.

The costs are preliminary and Ergo is of the view that they have an accuracy of Class 5[2], which is suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details).

[2] Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries, AACE International Recommended Practice No. 18R-97.

Summary: LCO’s vs transmission/distribution capital cost estimates

Table 1 Summary of LCO's and estimated capital costs

			Transmission			Distribution		TOTAL	Cost Efficiency		
No.	Opportunity Name	Load (MW)	GXP Substation	Substation Costs (M$)	Line Costs (M$)	Zone Substation	Costs ($M)	Costs ($M)	($M/MW)	Complexity of Connection	Refer to notes
1	Silver Fern Farms Finegand	8.0		$7.50	$0.00 [4]	Finegand	$5.15	**$12.65**	**$1.58**	Major	2
2	Balclutha Hospital	5.1	Balclutha	$0.00 [4]		Charlotte St	$3.50	**$3.50**	**$0.69**	Moderate	2
3	Balclutha Swimming Pool	0.6				Charlotte St	$0.20	**$0.20**	**$0.33**	Minor	
4	Great Southern Milton	0.9				Elderlee St	$0.20	**$0.20**	**$0.22**	Minor	
5	Fonterra Edendale	85.0	Edendale	$13.00	$16.00	New	$25.50	**$54.50**	**$0.64**	Major	1,2,3
6	Blue Sky Meats	4.1		$0.00 [4]	$0.00 [4]	Edendale	$3.70	**$3.70**	**$0.90**	Minor	2
7	Alliance Mataura	4.0	Gore	$0.00	$0.00 [4]	Mataura	$0.12	**$0.12**	**$0.03**	Minor	2
8	Silver Fern Farm Waitane	1.0				South Gore	$0.10	**$0.10**	**$0.10**	Minor	
9	Mataura Valley Milk	15.0		$7.00	$0.00 [4]	South Gore	$17.70	**$24.70**	**$1.65**	Major	2,3
10	Open Country Dairy Awarau	23.5	Invercargill	$0.00	$0.00 [4]	Coyler Rd	$15.80	**$15.80**	**$0.67**	Moderate	2,3
11	Southland Hospital	6.1				Seaward Bush	$3.10	**$3.10**	**$0.51**	Moderate	2
12	South Pacific Meats	4.0				Colyer Rd	$2.46	**$2.46**	**$0.62**	Moderate	2
13	Peacehaven Village	2.4				Southern	$0.71	**$0.71**	**$0.30**	Minor	
14	Southern Inst of Technologoy	1.9				Spey St	$0.35	**$0.35**	**$0.18**	Minor	
15	Ascot Park Hotel	1.6				Racecourse Rd	$0.57	**$0.57**	**$0.36**	Minor	
16	ITL Stadium Southland	0.9				Spey St	$0.99	**$0.99**	**$1.10**	Minor	
17	Downers Roading Invercargill	1.4				Bluff	$0.40	**$0.40**	**$0.29**	Minor	
18	Invercargill Prison	1.3				Leven Street	$0.40	**$0.40**	**$0.31**	Minor	
19	Prime Range Meats	1.2				Waikiwi	$1.15	**$1.15**	**$0.96**	Minor	
20	Great Southern Invercargill	0.9				Waikiwi	$1.08	**$1.08**	**$1.20**	Minor	
21	Winton Feedstock	0.6				Leven	$0.26	**$0.26**	**$0.43**	Minor	
22	Kelvin Hotel	0.4				Spey St	$0.18	**$0.18**	**$0.45**	Minor	
23	Alliance Lorneville	23.0	North Marakewa	$0.50	$0.00 [4]	Underwood	$15.60	**$16.10**	**$0.70**	Moderate	2,5
24	Fiordland Hotel	0.1		$0.00 [4]	$0.00 [4]	Te Anau	$0.08	**$0.08**	**$0.62**	Minor	
25	SDCF Swimming Pool	0.6				Te Anau	$0.20	**$0.20**	**$0.32**	Minor	
	TOTAL =>	**193.7**	**TOTAL =>**	**$28.0**	**$16.0**	**TOTAL =>**	**$99.50**	**$143.50**			

1 Fonterra Edendale is supplied directly from the Edendale GXP

2 Does not include the on-site distribution transformers & switchgear, which should be accounted for (Ergo does noth have this detail).

3 One or more zone substations would be required.

4 No upgrade of the existing transmission substation/lines is expected (given the LCO's identified)

5 Minor GXP Upgrades required only, therefore classified as "Moderate"

Disclaimer: The LCO supply investigations and capital cost estimates outlined in this report are preliminary and are only suitable for screening purposes. The capital cost estimates should not be used be used for final budgeting purposes in order to connect the respective LCO’s.

2. Introduction

PowerNet Limited (PowerNet) maintains/manages the electrical networks that are owned by the following Electrical Distribution Businesses (EDB):

- The Power Company Limited (TPC) – 37 zone substations
- Electricity Invercargill Limited (EIL) – 4 zone substations
- OtagoNet Joint Venture Limited (OJV) – 35 zone substations

The networks supply electricity to consumers in the Southland Region of the South Island in the franchise areas shown in Figure 5.

The Energy Efficiency & Conservation Authority (EECA) is running a flagship program that is called Energy Transition Accelerator (ETA)[3]. The program is targeted at large energy-using businesses and public sector organisations that are committed to reducing carbon emissions.

As part of the ETA program, EECA contracted Ergo to determine the existing spare supply capacity and the load characteristics at the major electrical substations within the Southland Region, from which PowerNet take supply. The exact scope of Ergo's work is discussed in more detail in Section 3.

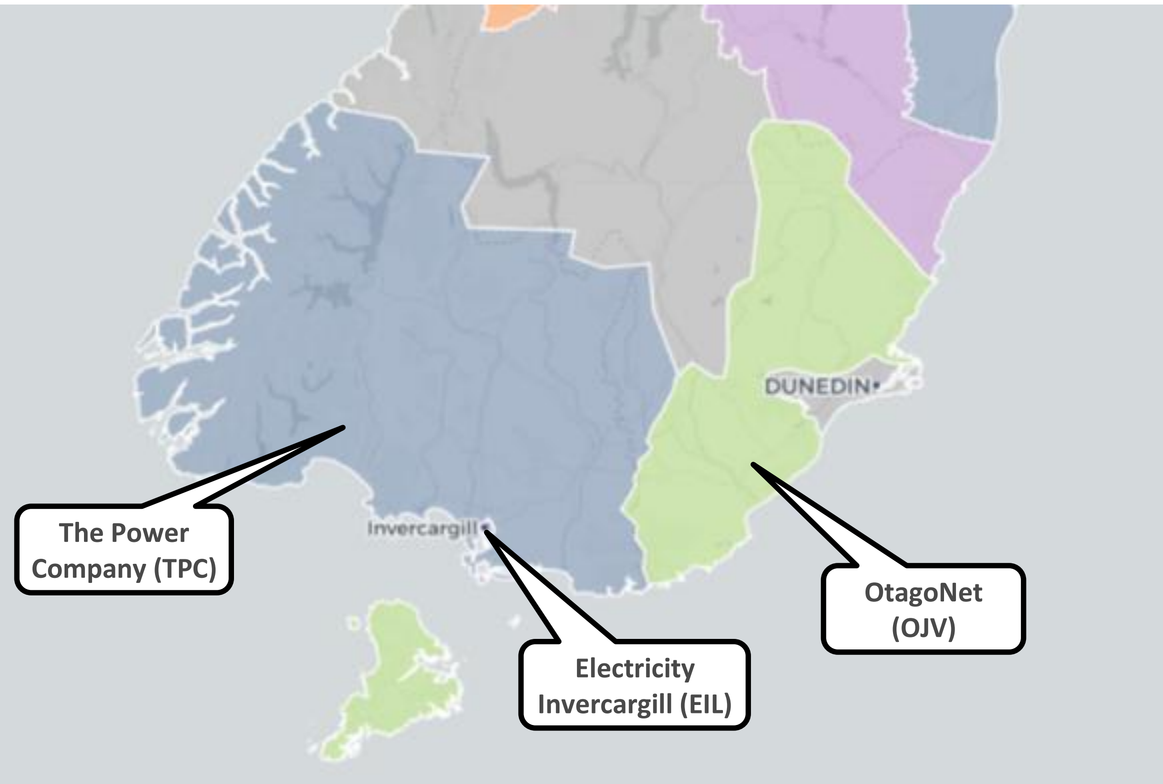


Figure 5 Electrical Distribution Business (EDB) franchise areas[4]

[3] https://www.eeca.govt.nz/co-funding/energy-transition-accelerator/
[4] https://www.ena.org.nz/lines-company-map/

3. Scope of Work

The scope requested of Ergo was to assess the existing capacity (both (N-1) and (N) security) and supply characteristics (peak and average supply and seasonality information) for the major electrical infrastructure in the Southland region. This included reviewing both the GXP's and local distribution zone substations along with their associated lines/cables within the Southland region.

In addition to the above, EECA provided a number of Load Conversion Opportunities (LCO's) in which Ergo were asked to assess:

1) Whether the existing electrical infrastructure was likely able to supply the additional load, and
2) If upgrades were required, outline option(s) and estimate capital costs for the necessary electrical infrastructure upgrades from both a transmission and distribution perspective.

Ergo's assessments and analysis were based on the following information sources:

- Transpower's 2021 Planning Report
- The Power Company's 2021 Disclosures and Asset Management Plan
- Electricity Invercargill's 2021 Disclosures and Asset Management Plan
- OtagoNet Joint Venture's 2021 Disclosures and Asset Management Plan
- SCADA substation loading data provided by both Transpower and PowerNet for a 12-month period
- Network diagrams provided by PowerNet
- Geographic Information System (GIS) asset and location data provided by PowerNet

4. Southland Network

The following sections describes (at a high level), the locations of the relevant substations and lines. For the purposes of this document TPC/EIL/OJV's franchise supply area is referred to as the Southland Region. Note also that the Tiwai GXP[5] has been included, but it directly supplies the New Zealand Aluminium Smelter (NZAS) and TPC/EIL/OJV does not take supply from this transmission substation.

4.1 Transmission/GXP Substations

The following Figure 6 illustrates the relevant transmission substations (GXPs) within the Southland Region, which include the following:

- Balclutha GXP.
- Brydone GXP.
- Edendale GXP.
- Gore GXP.
- Halfway Bush GXP.
- Invercargill GXP.
- Naseby GXP.
- North Makarewa GXP.
- Tiwai GXP.

Note that Figure 6 does not include all the GXPs in the lower South Island and only includes the GXP substations that TPC/EIL/OJV takes supply from (plus Tiwai and Brydone GXP's which directly supply customers). GXP's further North in the Otago region that are supplied by other EDB's have been excluded.

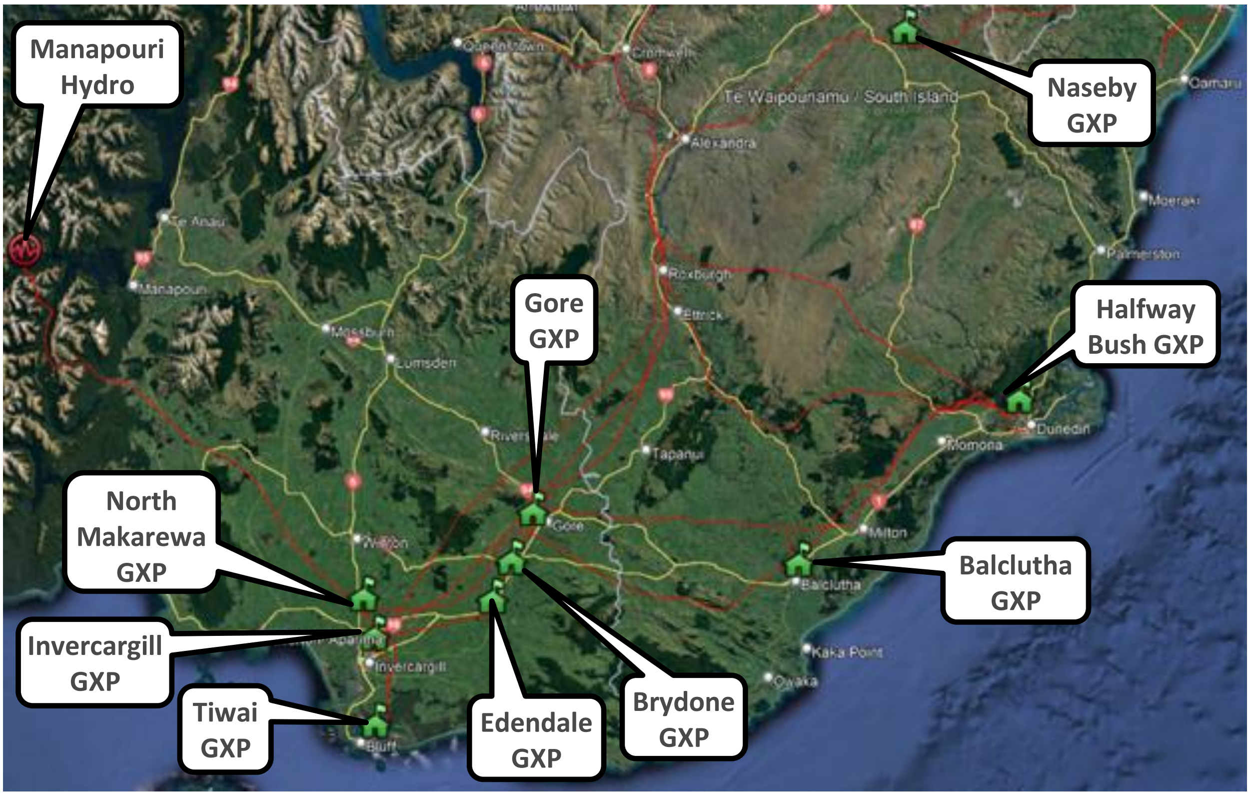


Figure 6 Transmission/GXP substations (red lines are Transpower's transmission lines, yellow lines are roads)

[5] GXP is an abbreviation for grid exit point substation.

The transmission network in the Southland Region is also shown diagramatically in Figure 7 and Figure 8.

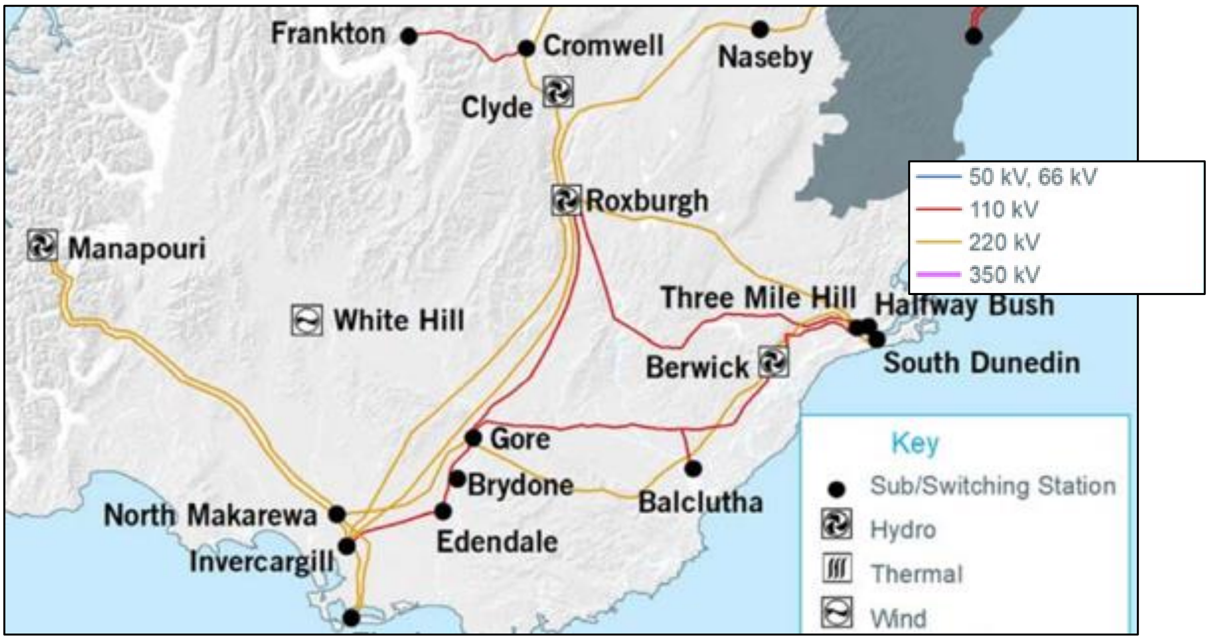


Figure 7 Transmission/GXP substations[6]

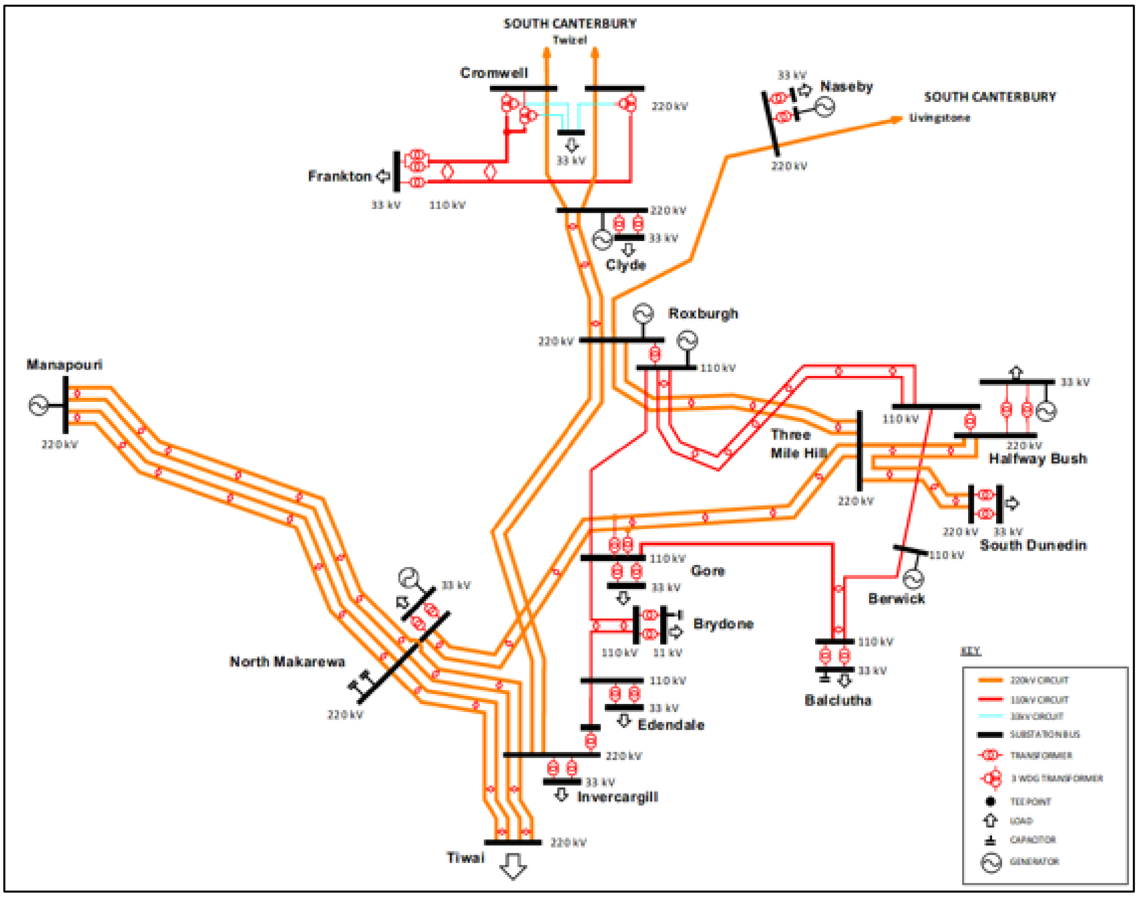


Figure 8 Existing transmission/GXP substations[6]

[6] https://www.transpower.co.nz//Transmission Planning Report 2021.

4.2 Zone Substations

Zone substations are categorised by the Electrical Distribution Business (EDB) that owns and operates the network. As mentioned earlier, in the area investigated, there are three relevant EDB's – The Power Company, Electricity Invercargill, and OtagoNet. Table 2 below gives an overview of the number of Zone Substations managed by each investigated EDB, and the number of Transpower GXPs they take power from.

Table 2 Overview of substation numbers for each EDB investigated

EDB Name	Three-letter acronym	Number of Zone Substations	Number of GXPs
The Power Company	TPC	37	4
Electricity Invercargill	EIL	4	2
OtagoNet	OJV	35	3

4.2.1 The Power Company

The following Figure 9 shows zone substations on The Power Company's network diagrammatically. The substations include:

- Athol 66/11kV zone substation
- Awarua Chip Mill 33/11kV zone substation
- Bluff 33/11kV zone substation
- Centre Bush 33/11kV zone substation
- Colyer Road 33/11kV zone substation
- Conical Hill 33/11kV zone substation
- Dipton 33/11kV zone substation
- Edendale Fonterra 33/11kV zone substation
- Edendale 33/11kV zone substation
- Glenham 33/11kV zone substation
- Gorge Road 33/11kV zone substation
- Hedgehope 33/11kV zone substation
- Hillside 33/11kV zone substation
- Isla Bank 33/11kV zone substation
- Kelso 33/11kV zone substation
- Kennington 33/11kV zone substation
- Lumsden 33/11kV zone substation
- Makarewa 33/11kV zone substation
- Mataura 33/11kV zone substation
- Monowai 66/11kV zone substation
- Mossburn 66/33/11kV zone substation
- North Gore 33/11kV zone substation
- North Makarewa 66/33/11kV zone substation
- Ohai 66/11kV zone substation
- Orawia 66/11kV zone substation
- Otatara 33/11kV zone substation
- Otautau 66/11kV zone substation
- Riversdale 33/11kV zone substation

- Riverton 33/11kV zone substation
- Seaward Bush 33/11kV zone substation
- South Gore 33/11kV zone substation
- Te Anau 66/11kV zone substation
- Tokanui 33/11kV zone substation
- Underwood 33/11kV zone substation
- Waikaka 33/11kV zone substation
- Waikiwi 33/11kV zone substation
- Winton 66/11kV zone substation

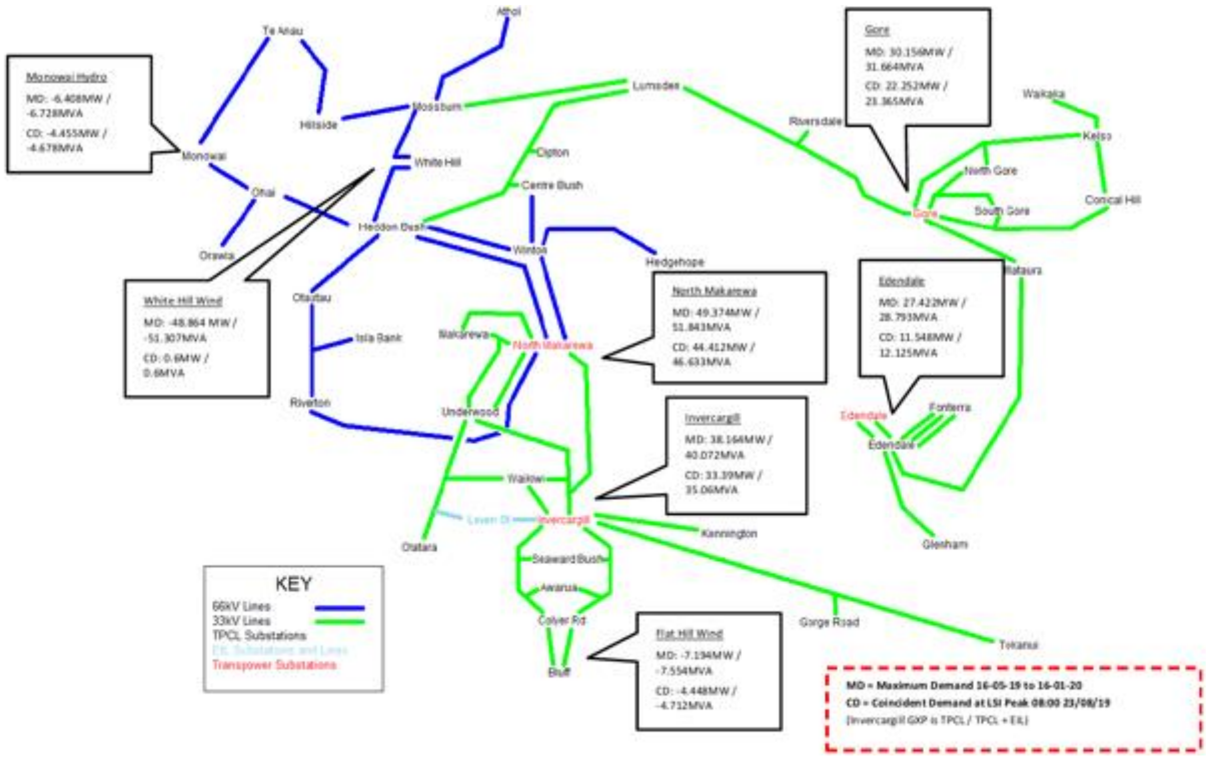


Figure 9 The Power Company Zone Substation Sub-transmission Diagram[7]

[7] https://powernet.co.nz/wp-content/uploads/2021/07/2021-31_AM-PLN-000_Asset-Management-Plan_TPCL_30_03_2021_Signed.pdf

4.2.2 Electricity Invercargill

The following Figure 10 shows zone substations on Electricity Invercargill's network diagrammatically. The substations include:

- Spey Street 33/11kV zone substation
- Leven Street 33/11kV zone substation
- Racecourse Road 33/11kV zone substation
- Southern 33/11kV zone substation

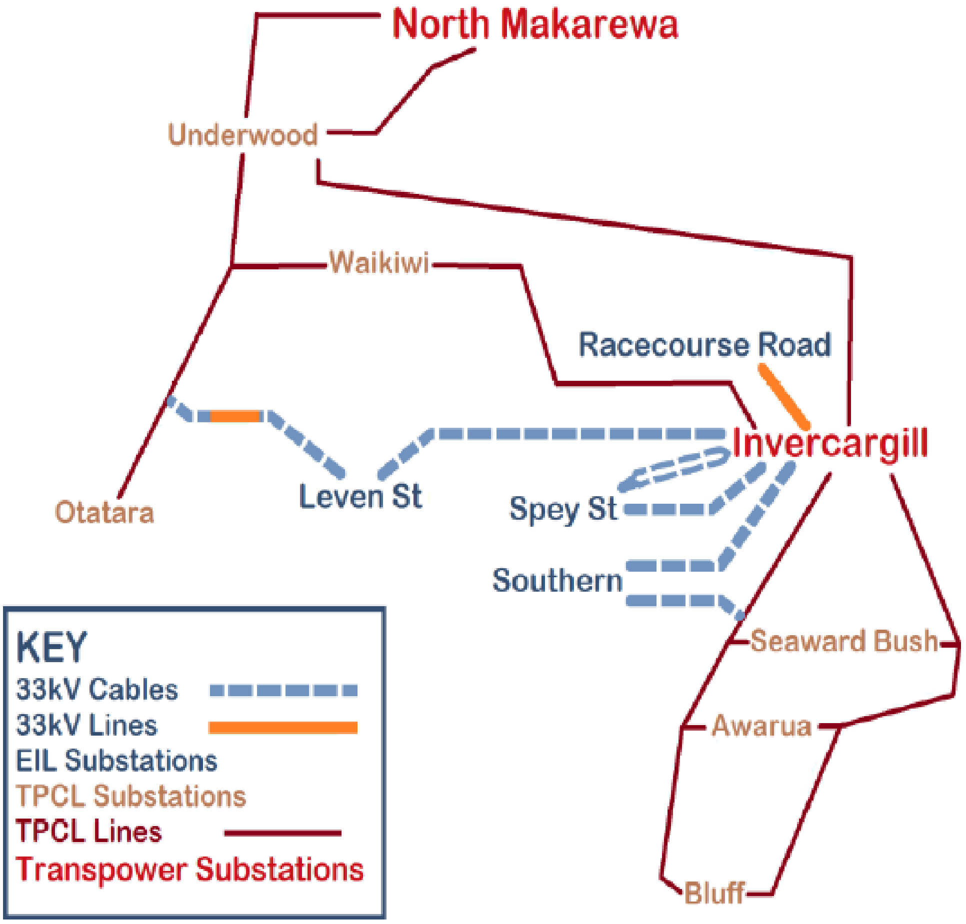


Figure 10 Electricity Invercargill Zone Substation Sub-transmission Diagram[8]

[8] https://powernet.co.nz/wp-content/uploads/2021/07/2021-2031-EIL-Asset-Management-Plan-2021-03-29-Final.pdf

4.2.3 OtagoNet

The following Figure 11 shows zone substations on OtagoNet's network diagrammatically. The substations include:

- Southern 33/11kV zone substation
- Charlotte Street (Balclutha) 33/11kV zone substation
- Clarks 33/11kV zone substation
- Clinton 33/11kV zone substation
- Clydevale 33/11kV zone substation
- Deepdell 33/11kV zone substation
- Elderlee Street (Milton) 33/11kV zone substation
- Finegand 33/11kV zone substation
- Glenore 33/11kV zone substation
- Golden Point 33/11kV zone substation
- Greenfield 33/11kV zone substation
- Hindon 33/11kV zone substation
- Hyde 33/11kV zone substation
- Kaitangata 33/11kV zone substation
- Lawrence 33/11kV zone substation
- Linnburn 33/11kV zone substation
- Merton 33/11kV zone substation
- Middlemarch 33/11kV zone substation
- Milburn 33/11kV zone substation
- North Balclutha 33/11kV zone substation
- Oturehua 33/11kV zone substation
- Owaka 33/11kV zone substation
- Paerau 33/11kV zone substation
- Paerau Hydro 33/11kV zone substation
- Palmerston 33/11kV zone substation
- Patearoa 33/11kV zone substation
- Port Molyneux 33/11kV zone substation
- Pukekawa 33/11kV zone substation
- Ranfurly 33/11 33/11kV zone substation
- Ranfurly 66/33 33/11kV zone substation
- Remarkables 33/11kV zone substation
- Stirling 33/11kV zone substation
- Waihola 33/11kV zone substation
- Waipiata 33/11kV zone substation
- Waitati 33/11kV zone substation
- Wedderburn 33/11kV zone substation

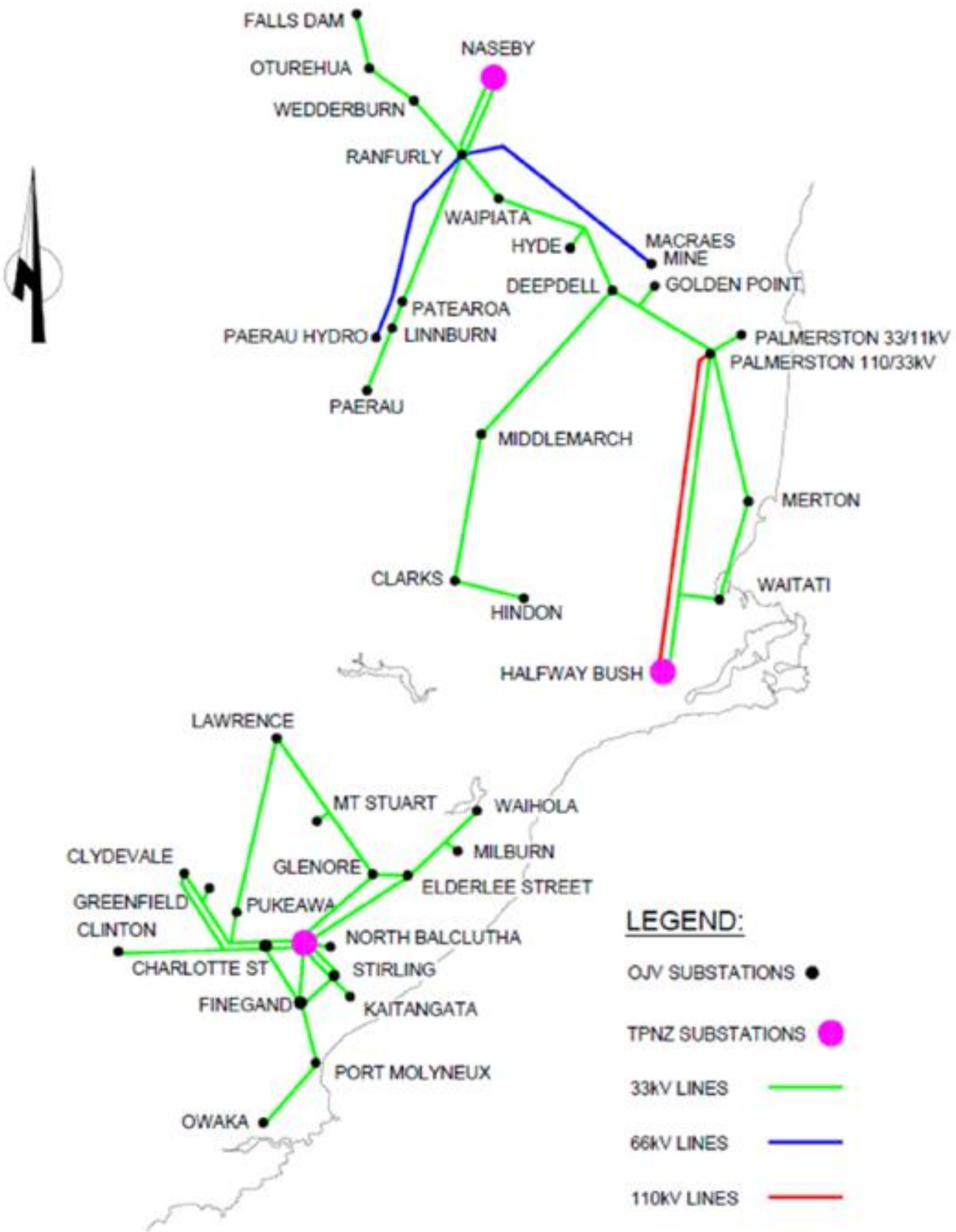


Figure 11 OtagoNet Zone Substation Sub-transmission Diagram[9]

[9] https://powernet.co.nz/wp-content/uploads/2021/10/2021-2031-OJV-Asset-Management-Plan.pdf

5. (N) and (N-1) Security Classifications

Both Transpower and the EDB's develop and operate their networks in accordance with a set of reliability standards. In the context of Transpower it is required to meet the grid reliability standards that are outlined in the Electricity Industry Participation Code (EIPC)[10]. In contrast, EDBs are required to publish a network security criteria, which is used to plan/develop its network.

In both cases, these standards are usually quantified in terms of the following terminology:

- (N) security: The network is designed and operates such that it will be unable to supply load in the event of a single asset failure (i.e. a line, transformer or other primary assets). This is equivalent to a single-engine airplane, which in the event of engine failure will result in the aircraft crashing.
- (N-1) security: The network is designed and operates such that it can continue to supply load uninterrupted in the event of a single asset failure. Again, can be compared with an aircraft, but in this case with two engines, which in the event of single engine failure will not crash.

The decision around whether to develop/operate a network supply with (N) or (N-1) security is typically driven by the size and criticality of the load versus the investment costs.

Typically, in New Zealand, this results in the following:

- Transmission GXP substations and lines being designed and operated with (N-1) security of supply.
- Distribution zone substations designed and operated as follows:
    - Loads ≥ 12MW designed and operated with (N-1) security of supply.
    - Loads <12MW designed and operate with (N) security of supply.

Transpower is required to provide (N-1) for "core grid" (i.e. 220kV and >150MVA loads) interconnected assets (i.e. transmission lines that supply multiple GXP substations). For "non-core grid" assets (i.e. <220kV and <150MVA loads), the decision to supply (N-1) is still made by Transpower but must be economically justified.

For connection assets that are dedicated to a single consumer the decision regarding security is made by the consumer/customer. The customer can be an industrial consumer, but in most cases is an EDB and usually (N-1) security of supply is specified. However, for GXPs that supply small consumer load or where a large industrial customer does not want to pay for (N-1) security, an (N) security connection is not uncommon.

The nine Southland Transpower points of supply discussed in this report are considered connection assets and therefore decisions around their security classifications lie with their end customers (i.e. PowerNet or directly connected customers as is the case with Brydone and Tiwai). The incoming lines are all considered interconnection assets other than the North Makarewa to Tiwai 220kV circuits which are connection assets.

The distribution networks owned/operated by EDBs generally supply multiple consumers and thus, in most cases, EDBs have to make security of supply decisions on behalf of their consumers. These decisions are based on the EDB's disclosed network security criteria, that have been ratified by their respective board of directors.

Both Transpower and EDBs have taken advantage of technology to make the above mentioned standards more flexible, by managing consumer demand where possible. Initially this involved the use of mains borne ripple injection equipment to manage the load drawn by consumer's hot water cylinders.

[10] https://www.ea.govt.nz/code-and-compliance/the-code/

But more recently this has involved, for example, special protection systems (SPS) that, in the event of the loss of specific network equipment will shed specific consumer loads and also the development of a market for interruptible load[11]. There are examples of this at both transmission and distribution levels. This has allowed Transpower and EDB's to operate some sections of their networks well beyond their (N-1) limits, whilst still maintaining sufficient security of supply to the majority of their consumers.

There is potential to significantly reduce the costs associated with electrical network upgrades if LCO's can be designed to:

- Operate during times of minimum network loading (typically late in the evening and early in the morning) such that they do not significantly increase existing peak network loading.
- Swiftly and safely disconnecting from the relevant electrical network during periods of peak loading.

6. Spare Capacity – Transmission Substations

The following sections document the spare capacity that is individually available on the nine GXP's that take supply from within the Southland Region.

Transpower has identified the following "*core grid issues*" that result from increasing electrical demand in the Southland Region including:

- Exacerbation of the existing Gore–Roxburgh 110kV circuit constraint under low Southland generation conditions. This constraint occurs when generation in the Southland Region (i.e. Manapouri and Waipori) is low, and an outage of a 220 kV Invercargill-Roxburgh circuit has potential to cause overloading on the Gore-Roxburgh 110kV circuit. The capacity of the 110 kV Gore–Roxburgh 1 circuit is relatively small (63/77 MVA rating during summer/winter), and operates in parallel with the 220 kV Invercargill–Roxburgh 1 and 2 circuits which are part of the major South Island transmission grid backbone. Presently the constraint is managed by constraining on generation in the Southland Region. Furthermore, due to the expected closure of the NZAS smelter (beyond 2024), Transpower is not actively investigating solutions to the constraint.
- Exacerbation of the transmission capacity issues into the Southland Region but relief for export constraints on lower South Island generation (i.e. Manapouri and Waipori). For this reason, the Livingstone-Naseby-Roxburgh 220kV circuits were recently upgraded (conductors changed from simplex to duplex). This project was completed in April 2022.
- Potentially requiring the reconductoring of the Invercargill-Edendale-Brydon-Gore 110kV circuits. Transpower's documents indicate a cost of NZ$16M to undertake this work.

Figure 12 below illustrates Transpower's plans for new/upgraded transmission/substation assets in the Southland Region. They include the above-mentioned line upgrade projects, coupled with a possible new GXP at Milton, which is discussed in Section 6.1.1.

6.1 Demand Forecast

The following Table 3 illustrates Transpower's forecast demand at the transmission substations in the Southland Region. Note that:

- Halfway bush has a leading power factor, which is primarily due to the 33kV capacitor banks that are installed on Aurora Energy Ltd's network to facilitate the connection of Tilt Renewable's Mahinerangi Wind Farm.

[11] https://www.transpower.co.nz/system-operator/electricity-market/instantaneous-reserve.

- The forecast includes an assumed ≈200MW of new demand at Tiwai after the NZAS/Meridian smelter closes. In reality this "*replacement load*" may not only connect to Tiwai and could connect to a number of the existing or new grid exit points.

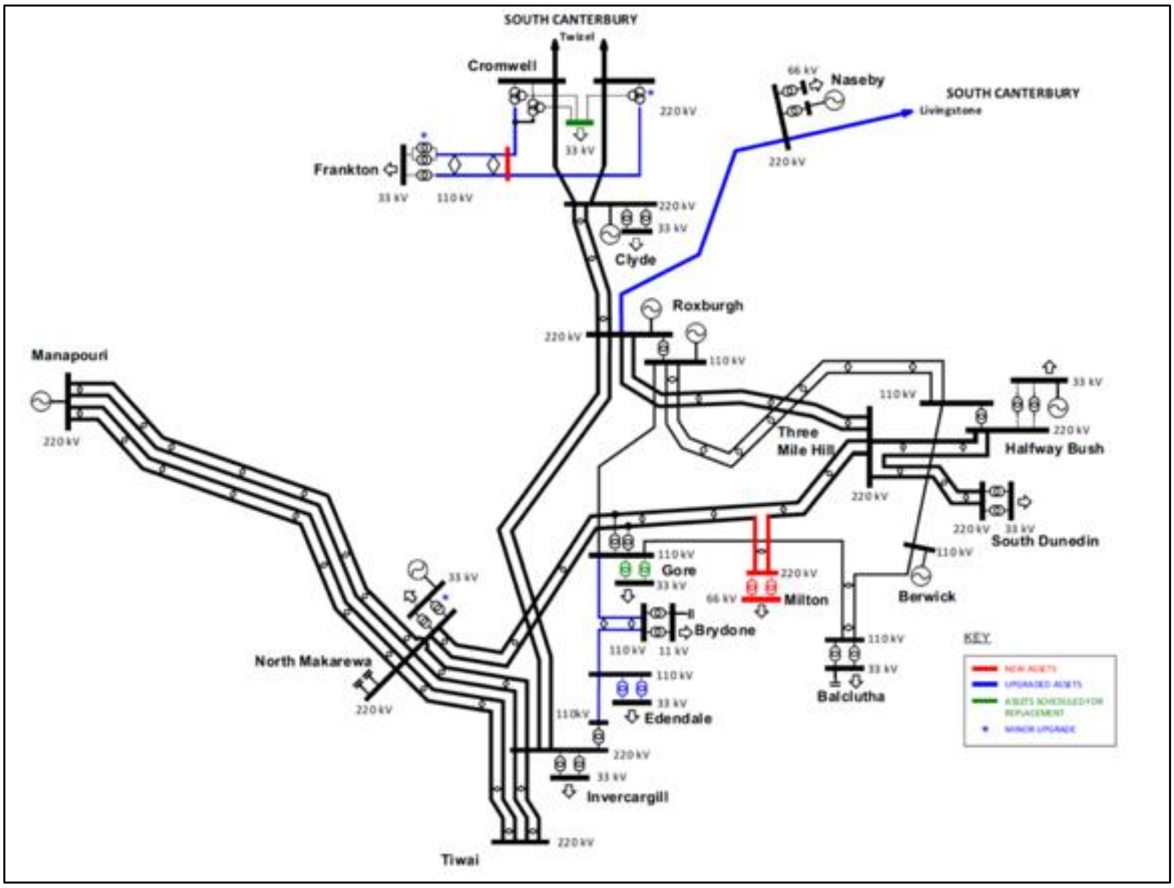


Figure 12 Existing transmission/GXP substations together with future proposed upgraded/new assets[6]

Table 3 Transpower demand forecast (Active Power)

No.	Substation / GXP	Power Factor	Demand (MW)											
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1	Balclutha	0.99	36	36	37	37	38	38	39	40	40	41	41	45
2	Brydone	0.8	11	11	11	11	11	12	12	12	12	12	13	14
3	Edendale	0.95	34	34	34	35	35	35	36	36	36	36	36	37
4	Gore	0.98	34	36	35	36	36	37	37	37	38	38	38	41
5	Halfway Bush	0.99	108	108	109	110	111	112	113	114	114	115	116	121
6	Invercargill	0.99	106	108	110	113	115	118	120	122	125	127	129	141
7	Naseby	0.99	35	36	36	37	37	38	38	39	39	40	40	43
8	North Makarewa	0.99	51	52	53	54	55	56	57	58	59	60	61	65
9	Tiwai	0.97	580	580	580	680	100	200	200	200	200	200	200	200
		TOTAL	**995**	**1001**	**1005**	**1113**	**538**	**646**	**652**	**658**	**663**	**669**	**674**	**707**

6.1.1 Balclutha GXP

Transpower's demand forecast (refer Table 3) indicates that the Balclutha GXP was expected to have a 2021 peak demand of 36MW at 0.99pf. This contrasts with the historical SCADA data that indicates that, during 2020, the Balclutha GXP experienced a peak load of 29.1MVA.

OtagoNet owns and operates the distribution network in the Balclutha area which supplies a dairy factory and a meat processing plant in addition to other smaller process heat users.

The Balclutha GXP load is supplied by 2 x 110/33kV transformers with a total nominal capacity of 60MVA. Transpower's 2021 Planning Report indicates that the transformers and associated substation equipment have an (N-1) capacity of 37/39MVA (summer/winter).[12]

The Balclutha GXP is supplied via the following two 110 kV circuits:

- Balclutha–Gore 110kV (BAL-GOR-1) rated at 51/62 MVA (summer/winter)
- Balclutha–Berwick 110kV (BAL-BWK-1) rated at 51/62 MVA (summer/winter)

Beyond the substation capacity constraint, the next constraint is overloading of the above incoming 110kV lines in the event of an outage on either BAL-GOR-1 or BAL-BWK-1. We note that the Berwick GXP is an injection point for Trustpower's Waipori hydro power station and does not supply any consumer loads.

Figure 13 illustrates Balclutha's 2020 loading in comparison to its substation capacity and incoming (N-1) 110kV line capacity.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- ≈3 MVA of spare (N-1) substation capacity (across the entire year) at the Balclutha GXP.
- ≈20 MVA of spare (N-1) capacity (across the entire year) on the 110kV transmission system that supplies the Balclutha GXP.[13]

Section 8.3 shows and discusses EECA's load conversion opportunities (LCO) surrounding the Balclutha GXP.

Transpower's documents indicate they are in discussions, with OtagoNet and other stakeholders, regarding options to enhance the Balclutha supply network in the future (and the timing). Also, that the options being considered include:

- A special protection scheme to automatically shed load post contingency.
- Replacing the existing 110/33kV supply transformers.
- A new grid exit point supplied from the existing North Makarewa–Three Mile Hill 220 kV line that passes through the Balclutha region. This substation is referred to as the Milton GXP in Transpower's plans.

[12] Ergo understands that Transpower has undertaken detailed investigations of the substation equipment and load profiles to arrive at the (N-1) capacity values. The (N-1) values are generally higher that the nominal ratings of the individual transformers but in some cases are lower due to other equipment rating constraints (for example, incomer cables or current transformer ratings).

[13] This conclusion is based on the information that is available to Ergo and the exact capacity would need to be confirmed by Transpower. Particularly the available line capacity which is difficult to assess without undertaking detailed powerflow studies.

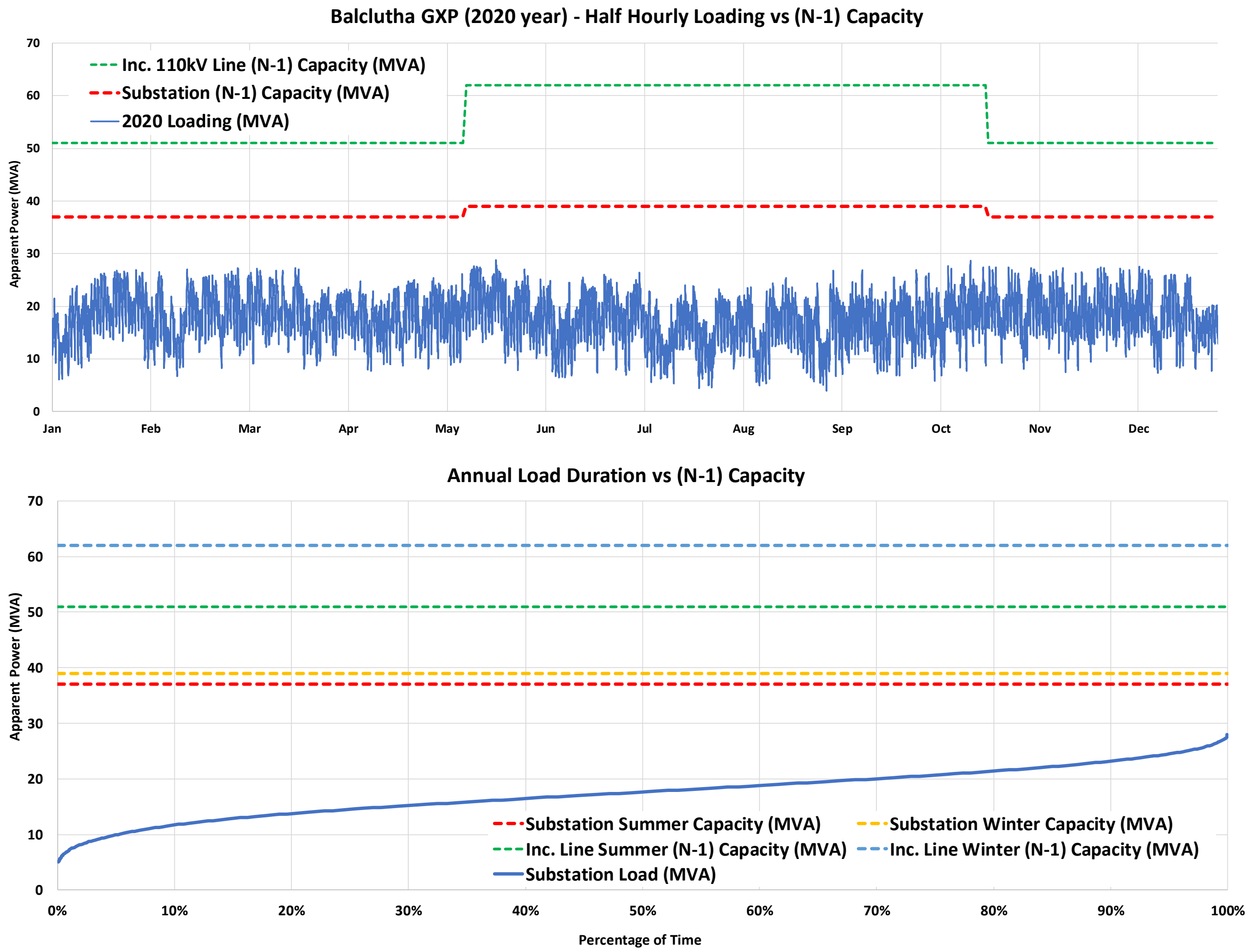


Figure 13 Balclutha GXP: 2020 Loading: Substation capacity: Incoming 110kV line capacity

6.1.2 Brydone GXP

Transpower's demand forecast (refer Table 3) indicates that the Brydone GXP was expected to have a 2021 peak demand of 11MW at 0.80pf (i.e. 13.8MVA). This contrasts with the historical SCADA data that indicates that, during 2020, the Brydone GXP experienced a peak load of 12.0MVA.

The Brydone GXP load is supplied by 2 x 110/11kV transformers, each with a nominal capacity of 25MVA. The Electricity Authority's PowerFactory model[14] indicates that the transformers and associated substation equipment have a summer/winter rating of 21MVA/21MVA rating.

Brydone GXP and Edendale GXP are supplied via the following three 110 kV circuits:

- Edendale–Invercargill 1 rated at 51/62 MVA (summer/winter)
- Brydone–Gore 1 rated at 51/62 MVA (summer/winter)
- Brydone–Edendale 1 rated at 51/62 MVA (summer/winter)

The combined peak load at Brydone and Edendale is ≈46MVA, which is relatively close to exceeding the (N-1) summer capacity of the Brydone–Gore 1 and Edendale–Invercargill 1 110kV circuits.

[14] https://www.emi.ea.govt.nz/Wholesale/Datasets/Transmission/PowerSystemAnalysis.

Figure 14 illustrates Brydone's 2020 loading in comparison to its substation capacity and the 110kV (N-1) supply capacity. The 110kV (N-1) supply capacity available at Brydone is based on subtracting the Edendale peak demand from the summer/winter 110kV line ratings.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- ≈7 MVA of spare (N-1) substation capacity (across the entire year) at the Brydone GXP. However, access to this capacity is constrained by the spare capacity on the supply from the upstream 110kV transmission system (discussed in the next bullet).
- ≈6 MVA of spare (N-1) capacity (across the entire year) on the 110kV transmission system[15] that supplies the Brydone GXP.[16]

There are no EECA load conversion opportunities close to the substation.

Transpower's documents indicate they are in discussions, with The Power Company and other stakeholders, regarding options to enhance the supply to the Brydone (and Edendale) region. Also, that the level of investment required will depend on the following:

- If a minor increase in electrical demand eventuates, the existing 2 x 25MVA, 110/11kV transformers could supply the demand, but would be limited to the available 110kV line capacity.
- If a large step increase in electrical demand emerges, the 110 kV Invercargill–Edendale–Brydone–Gore circuits would need to reconductored. Transpower's estimate to reconductor the 110kV lines is NZ$16M.

15 For example, the 110kV lines that supply the substation.

16 This conclusion is based on the information that is available to Ergo and the exact capacity would need to be confirmed by Transpower. Particularly the available line capacity which is difficult to assess without undertaking detailed powerflow studies.

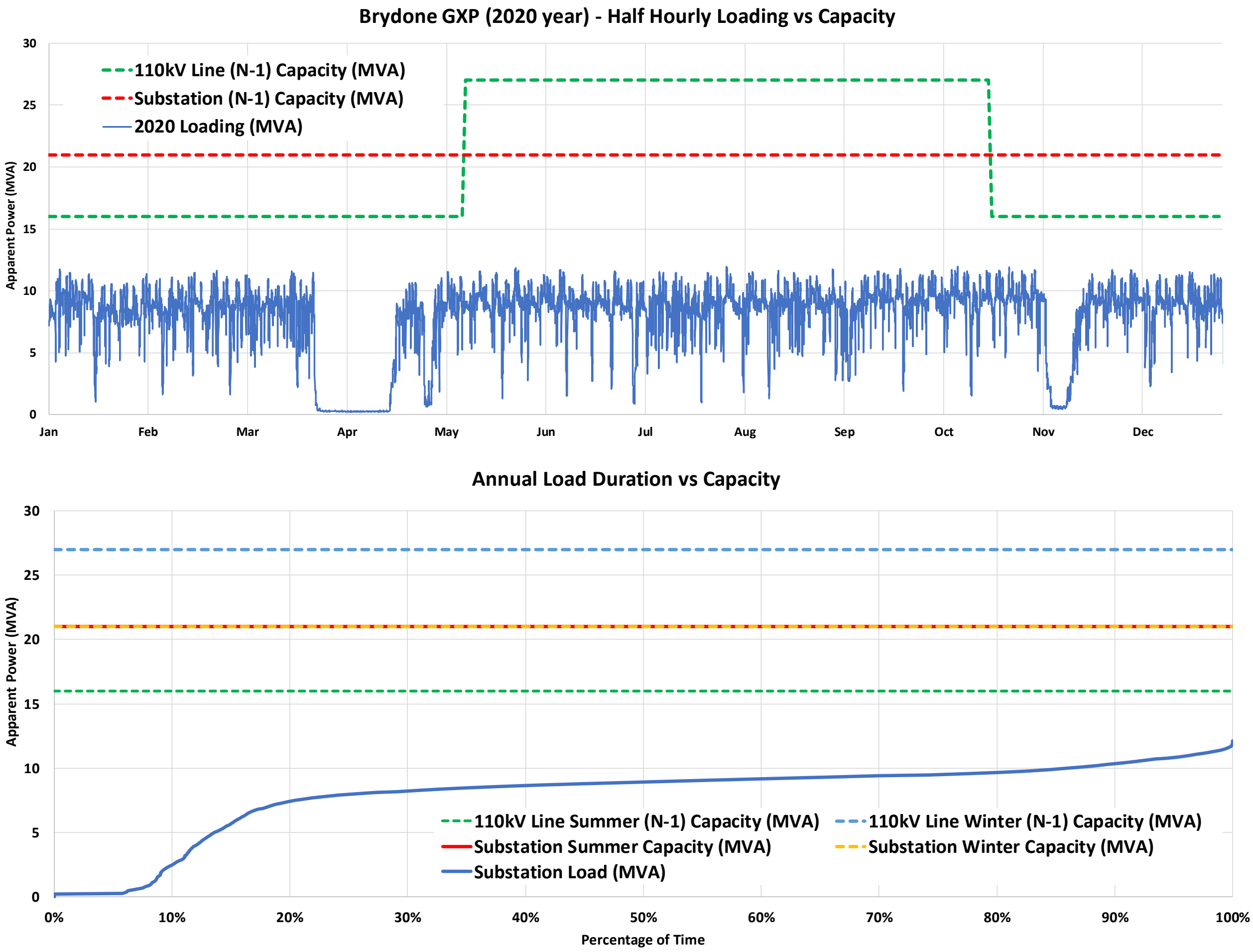


Figure 14 Brydone GXP: 2020 Loading: Substation capacity: 110kV line capacity

6.1.3 Edendale GXP

Transpower's demand forecast (refer Table 3) indicates that the Edendale GXP was expected to have a 2021 peak demand of 34MW at 0.95pf during 2020 (i.e. 35.8MVA). This aligns relatively closely with the historical SCADA data that indicates that, during 2020, the Edendale GXP experienced a peak load of 34.6MVA.

The Power Company owns and operates the distribution network in the Edendale area which predominantly supplies the Fonterra Edendale dairy factory.

The Edendale GXP is supplied via two 110/33 kV transformers, serves Fonterra's Edendale dairy plant and the local rural load. The 110kV supply to Edendale is via the Edendale–Invercargill, Brydone–Edendale and Brydone–Gore circuits.

The 2 x 110/33kV Edendale transformers have a total nominal capacity of 60MVA. Transpower's 2021 Planning Report indicates that the transformers and associated substation equipment have an (N-1) capacity of 34/36 MVA (summer/winter).

As discussed previously in Section 6.1.2, the Edendale GXP and Brydone GXP are supplied via the following three 110 kV circuits:

- Edendale–Invercargill 1 rated at 51/62 MVA (summer/winter)
- Brydone–Gore 1 rated at 51/62 MVA (summer/winter)
- Brydone–Edendale 1 rated at 51/62 MVA (summer/winter)

The combined peak load at Edendale and Brydone is ≈46MVA, which is relatively close to exceeding the (N-1) summer capacity of the Brydone–Gore 1 and Edendale–Invercargill 1 110kV circuits.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- No spare (N-1) substation capacity (across the entire year) at the Edendale GXP.
- ≈6 MVA of spare (N-1) capacity (across the entire year) on the 110kV transmission system that supplies the Edendale GXP.[17]

Section 8.4 shows and discusses EECA's load conversion opportunities surrounding the Edendale GXP.

As discussed previously in Section 6.1.2, Transpower's documents indicate they are in discussions, with The Power Company and other stakeholders, regarding options to enhance the supply to the Edendale (and Brydone) region. Also, that the level of investment required will depend on the following:

- If a minor increase in electrical demand eventuates, the existing 2 x 25MVA, 110/11kV transformers at Brydone could supply the demand, but would be limited to the available 110kV line capacity.
- If a large step increase in electrical demand emerges, the 110 kV Invercargill–Edendale–Brydone–Gore circuits would need to reconductored. Transpower's estimate to reconductor the 110kV lines is NZ$16M.

[17] This conclusion is based on the information that is available to Ergo and the exact capacity would need to be confirmed by Transpower. Particularly the available line capacity which is difficult to assess without undertaking detailed powerflow studies.

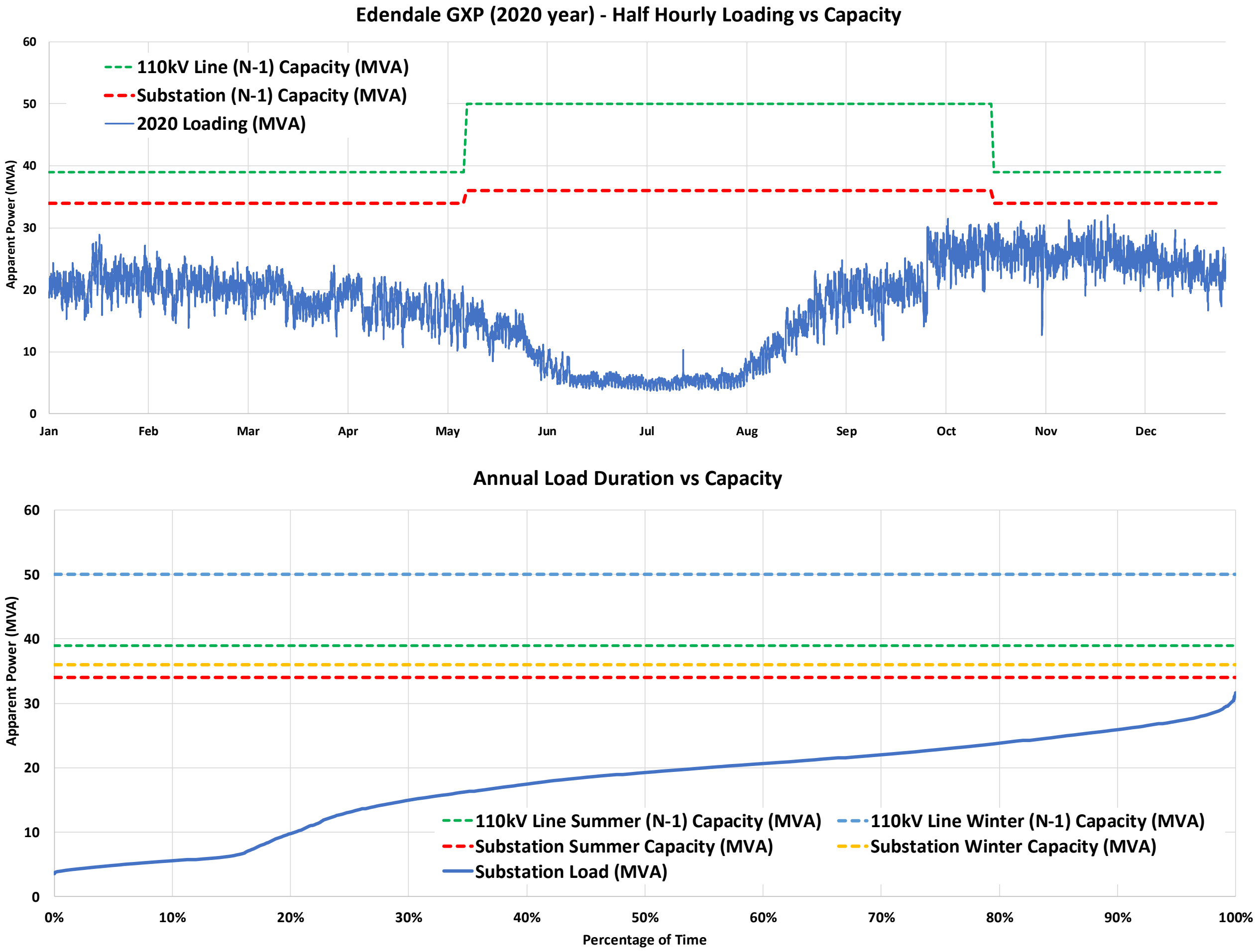


Figure 15 Edendale GXP: 2020 Loading: Substation capacity: 110kV line capacity

6.1.4 Gore GXP

Transpower's demand forecast (refer Table 3) indicates that the Gore GXP was expected to have a 2021 peak demand of 34MW at 0.98pf (i.e. 34.7MVA). This aligns relatively closely with the historical SCADA data that indicates that, during 2020, the Gore GXP experienced a peak load of 32.8MVA.

The Gore GXP is supplied via two 110/33 kV transformers and serves rural farms, the towns of Tapanui and Gore, the village of Waikaka, and a meat processing plant.

The 2 x 110/33kV Gore transformers have a total nominal capacity of 60MVA. Transpower's 2021 Planning Report indicates that the transformers and associated substation equipment have an (N-1) capacity of 37/39 MVA (summer/winter).

The 110kV supply to the Gore GXP is mostly via the existing 150/210/219MVA and 150/215/225MVA 220/110/11kV interconnecting transformers at the substation. These transformers are lightly loaded and able to cope with a significant increase in load.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- ≈4 MVA of spare (N-1) substation capacity (across the entire year) at the Gore GXP.

- Significant capacity (across the entire year) on the 220kV transmission system that supplies the Gore GXP.[18]

Section 8.5 shows and discusses EECA's load conversion opportunities surrounding the Gore GXP.

Transpower's documents indicate they are in discussions with The Power Company regarding the impending loss of (N-1) substation capacity at the Gore GXP, and it has proposed the following options:

- Installing a transformer overload protection scheme on the existing 110/33kV supply transformers.
- Replacing/upgrading the existing 110/33kV transformers with two higher-rated units. Transpower also indicate that the existing transformers are scheduled for replacement due to their condition.

[18] This conclusion is based on the information that is available to Ergo and the exact capacity would need to be confirmed by Transpower. Particularly the available line capacity which is difficult to assess without undertaking detailed powerflow studies.

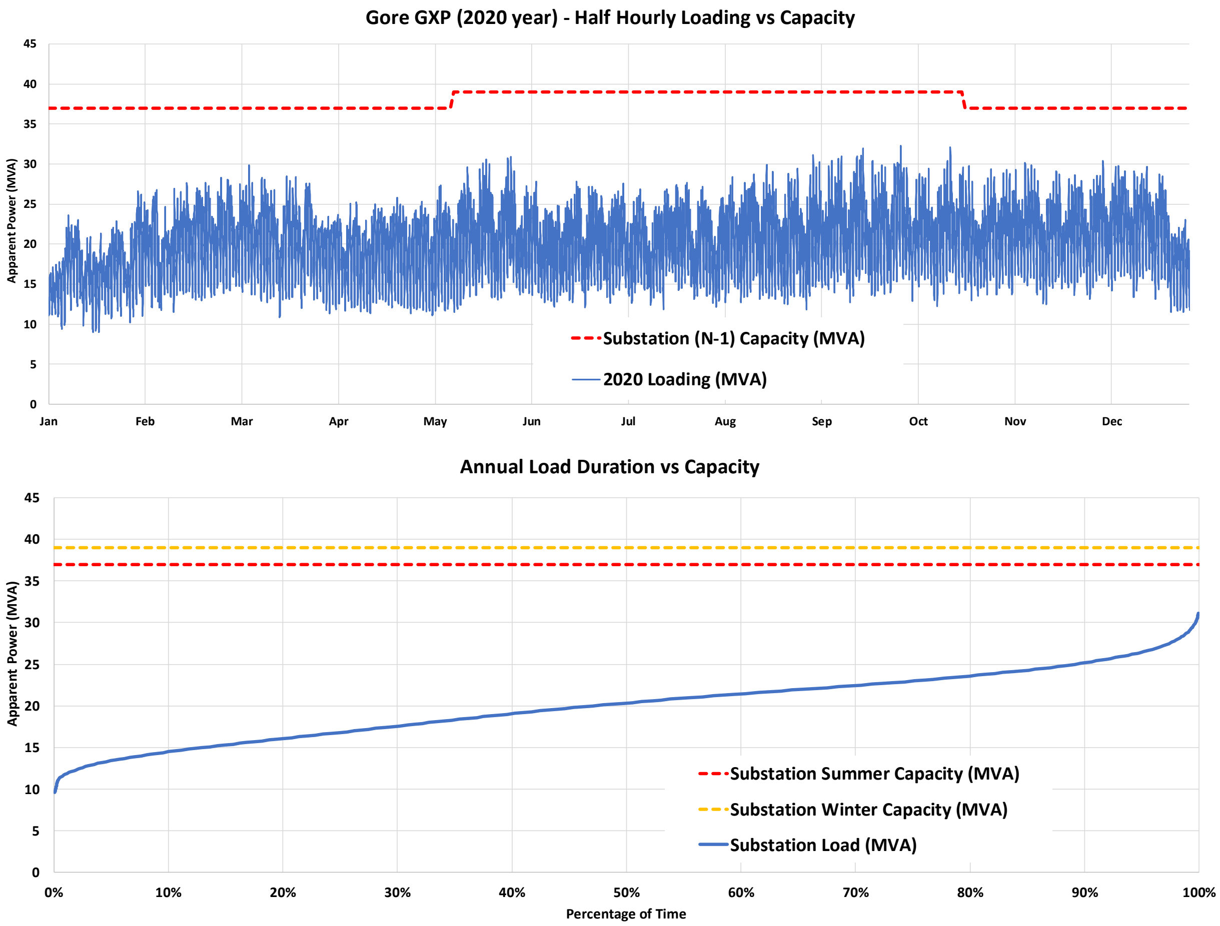


Figure 16 Gore GXP: 2020 Loading: Substation capacity

6.1.5 Halfway Bush GXP

Transpower's demand forecast (refer Table 3) indicates that the Halfway Bush GXP was expected to have a 2021 peak demand of 108MW at 0.99pf (i.e. 109.1MVA). The historical SCADA data indicates that, during 2020, the Halfway Bush GXP experienced a peak load of 97.9MVA, but this increased significantly to 120.4MVA in 2021.

The Halfway Bush 33kV bus is supplied via two 220/33 kV transformers with a total nominal capacity of 200 MVA. Transpower's 2021 Planning Report indicates that the transformers and associated substation equipment have an (N-1) capacity of 124/131 MVA (summer/winter).

There is a significant amount of embedded generation (42 MW of hydro and 37 MW of wind) on the Halfway Bush 33 kV grid exit point. This means that the substation loadings can vary significantly. It also means that, assuming no contribution from the embedded generators, the peak load at the Halfway Bush GXP exceeds the (N-1) winter capacity of the two 220/33 kV supply transformers.

The Halfway Bush GXP is supplied via two incoming 220 kV lines with summer/winter ratings of 333/370MVA. These 220kV lines are relatively lightly loaded and the spare capacity well exceeds that of the Halfway Bush GXP.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- ≈22 MVA of spare (N-1) substation capacity (across the entire year) at the Halfway Bush GXP, provided the embedded generation is operational.
- Significant capacity (across the entire year) on the 220kV transmission system that supplies the Gore GXP. [19]

There are no EECA load conversion opportunities close to the substation.

Transpower's documents indicate that it (and the EDBs that take supply from Halfway Bush) expect the embedded generation at the Halfway Bush 33 kV will be available and sufficient to provide security to the load for the foreseeable future and thus there are no plans to upgrade the supply capacity at the Halfway Bush GXP.

[19] This conclusion is based on the information that is available to Ergo and the exact capacity would need to be confirmed by Transpower. Particularly the available line capacity which is difficult to assess without undertaking detailed powerflow studies.

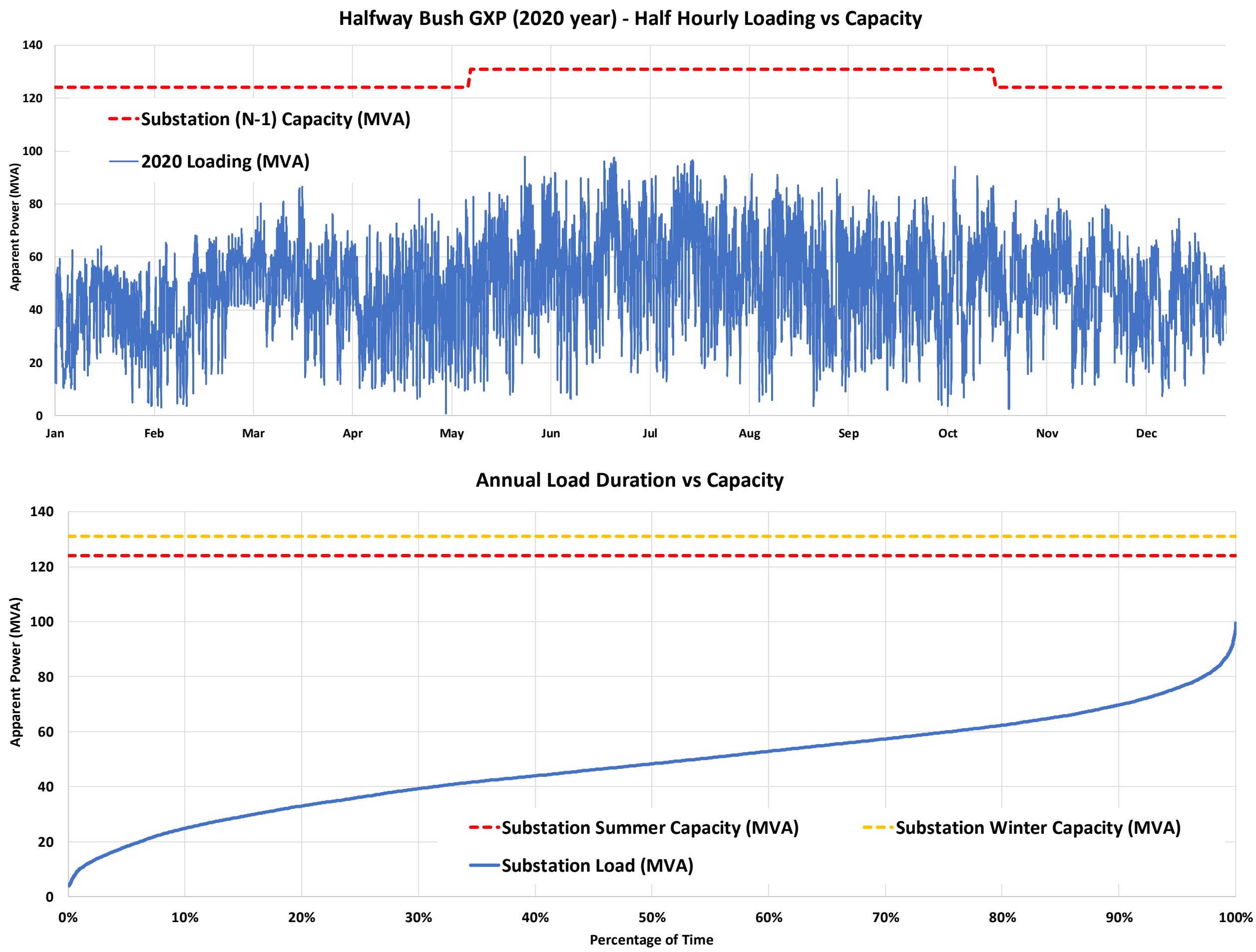


Figure 17 Halfway Bush GXP: 2020 Loading: Substation capacity

6.1.6 Invercargill GXP

Transpower's demand forecast (refer Table 3) indicates that the Invercargill GXP was expected to have a 2021 peak demand of 106MW at 0.99pf (i.e. 107.0MVA). This closely aligns with the historical SCADA data that indicates, during 2020, the Invercargill GXP experienced a peak load of 107.9MVA. The distribution network supplies the Invercargill region, which includes two dairy factories (i.e. Open Country Dairy) and other smaller process heat users.

The Invercargill 33kV bus is supplied via two 220/33 kV transformers with a total nominal capacity of 240 MVA. Transpower's 2021 Planning Report indicates that the transformers and associated substation equipment have an (N-1) capacity of 142/142 MVA (summer/winter).[20]

The Invercargill GXP is supplied via four incoming 220 kV lines each with ratings that well exceed 300MVA. The spare capacity on the 220kV lines well exceeds that of the Invercargill substation.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- Provided the embedded generation is operational there is ≈35 MVA of spare (N-1) substation capacity (across the entire year) at the Invercargill GXP.

20 Transpower's documents indicate the transformers' capacity is limited by circuit breakers and current transformers to 142 MVA followed by 33 kV incomer cables to 154 MVA. With these limits resolved, the rating will be limited to 155/162 MVA (summer/winter).

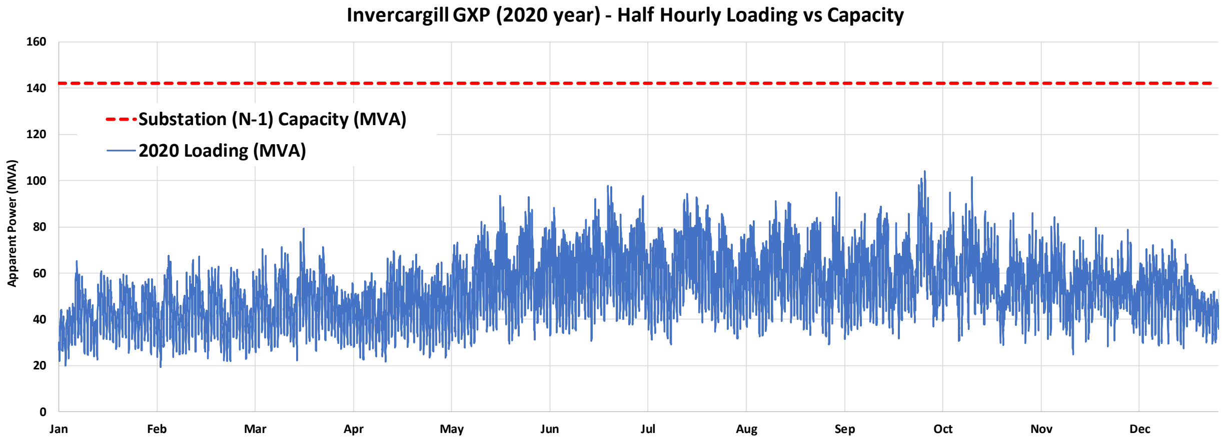
- Significant capacity (across the entire year) on the 220kV transmission system that supplies the Invercargill GXP. [21]

Section 8.6 shows and discusses EECA's load conversion opportunities surrounding the Invercargill GXP.

Transpower's documents indicate that:

- There is significant headroom at the Invercargill GXP before it expects the substation's (N-1) capacity will be exceeded and thus no investment is currently planned.
- Increased electrical demand in the Southland Region will exacerbate the transmission capacity issues into the region but will relieve export constraints on the lower South Island generation.
- If the electrical demand increases significantly, it will discuss the available options with The Power Company.

[21] This conclusion is based on the information that is available to Ergo and the exact capacity would need to be confirmed by Transpower. Particularly the available line capacity which is difficult to assess without undertaking detailed powerflow studies.



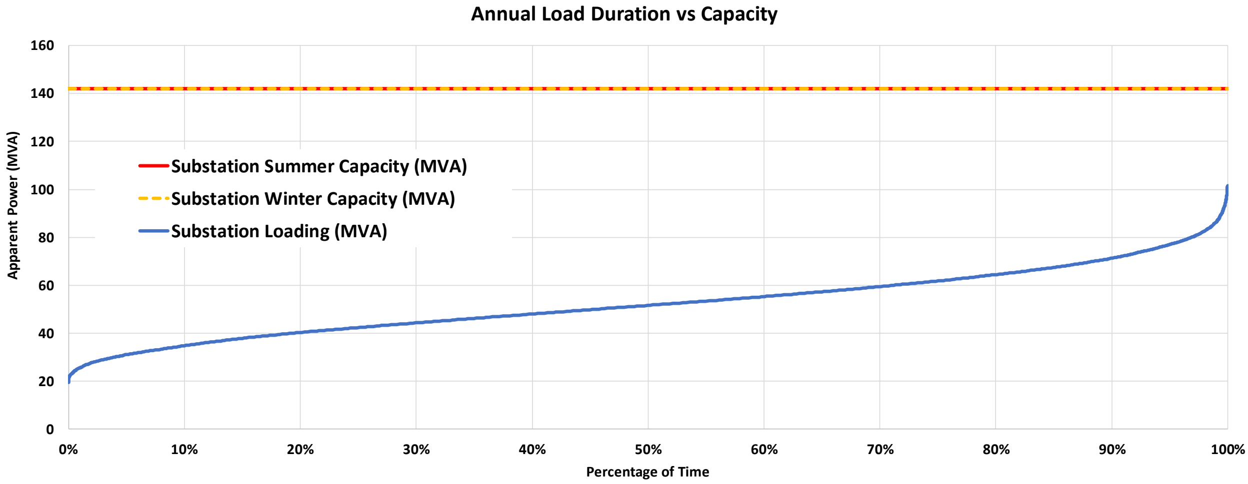


Figure 18 Invercargill GXP: 2020 Loading: Substation capacity

6.1.7 Naseby GXP

Transpower's demand forecast (refer Table 3) indicates that the Naseby GXP was expected to have a 2021 peak demand of 35MW at 0.99pf (i.e. 35.4MVA). This contrasts with the historical SCADA data which indicates that, during 2020, the Naseby GXP experienced a peak load of 30.4MVA.

The Naseby 33kV bus is supplied via two 220/33 kV transformers with a total nominal capacity of 40 MVA. The Electricity Authority's PowerFactory model[22] indicates that the transformers and associated substation equipment have a summer/winter rating of 53/55 MVA (summer/winter).

The Naseby is supplied via two incoming 220 kV lines with summer/winter ratings of 202/247MVA, which are presently being upgraded (refer to the introductory section of Section 6 and Figure 12).

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

- ≈18 MVA of spare (N-1) substation capacity (across the entire year) is available at the Naseby GXP.
- The upgrade of the incoming 220kV lines to the Naseby substation will mean that the Naseby GXP will not be constrained by line ratings.

There are no EECA load conversion opportunities close to the substation.

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22 https://www.emi.ea.govt.nz/Wholesale/Datasets/Transmission/PowerSystemAnalysis.

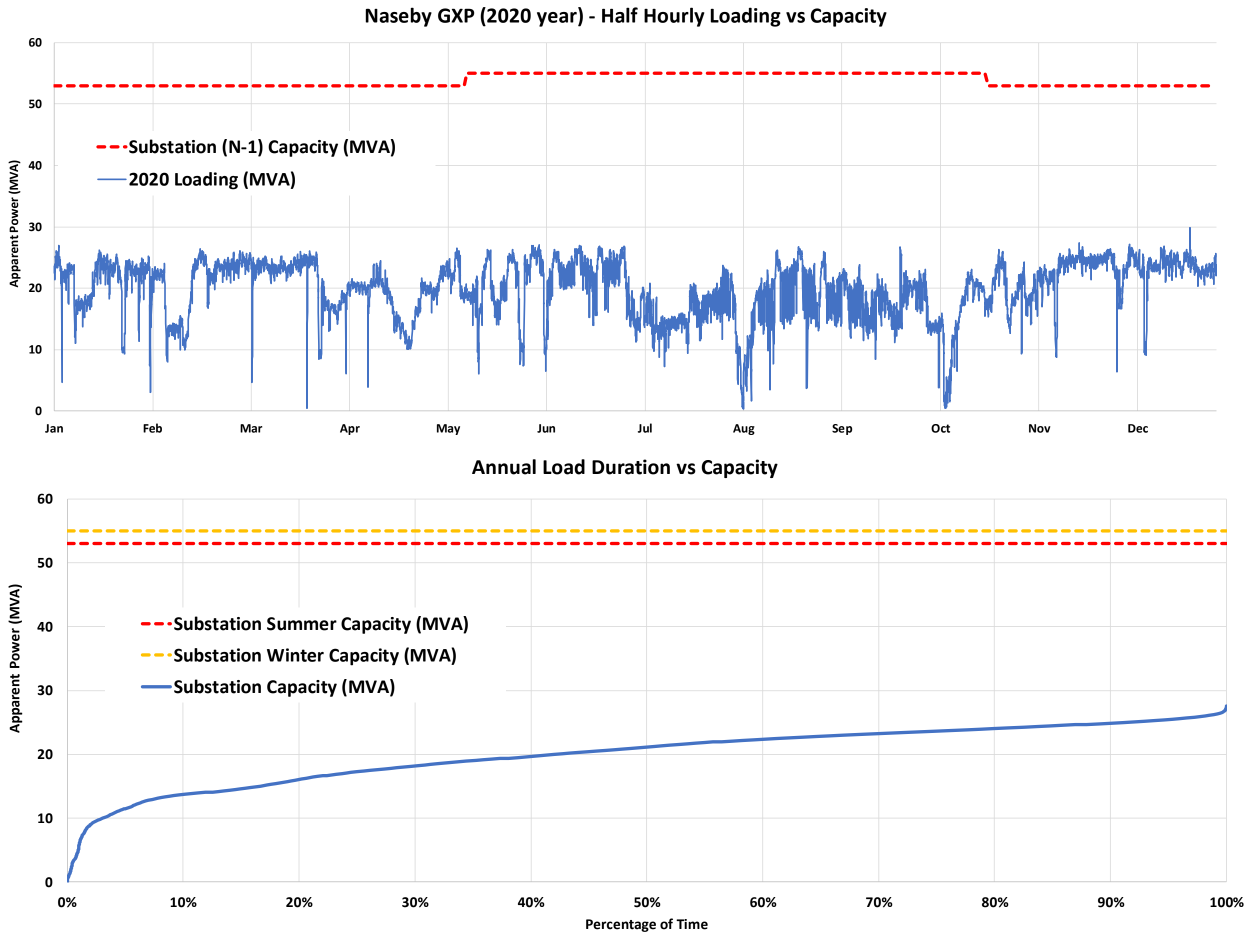

Figure 19 Naseby GXP: 2020 Loading: Substation capacity

6.1.8 North Makarewa GXP

Transpower's demand forecast (refer Table 3) indicates that the North Makarewa GXP was expected to have a 2021 peak demand of 51MW at 0.99pf (i.e. 51.5MVA). This aligns well with the historical SCADA data which indicates that, during 2020, the North Makarewa GXP experienced a peak load of 51.4MVA.

The North Makarewa GXP supplies The Power Company's distribution system, which in turn, supplies rural farms, small towns, villages, small industrial plants and a coal mine. The 33kV bus is supplied via two 220/33 kV transformers with a total nominal capacity of 120 MVA.[23] Transpower's 2021 Planning Report indicates that the transformers and associated substation equipment have an (N-1) capacity of 67/67 MVA (summer/winter).[24]

The North Makarewa is supplied via eight incoming 220 kV lines and is a major transmission hub and thus the surrounding 220kV network is not a constraint.

Given the above information it does appear, to Ergo, that if one considers Transpower's demand forecast there is currently:

23 Note that The Power Company owns two 33/66kV power transformers at the North Makarewa GXP that step up the 33kV voltage to 66kV and supply its 66kV distribution network.

24 Transpower's documents indicate the transformers' capacity is limited by cables and disconnectors and if replaced/resolved the substation capacity would increase to 76/79 MVA (summer/winter).

- ≈16 MVA of spare (N-1) substation capacity (across the entire year) is available at the North Makarewa GXP. Although, we note that the GXP includes the White Hill windfarm which has the potential to reduce the GXP loading.

Transpower's documents indicate that:

- There is currently around 10 MW of headroom at the North Makarewa grid exit point before it expects the substations (N-1) capacity to be exceeded. Also, that they are working with The Power Company regarding the upgrade of the existing equipment that is limiting the substation capacity, in conjunction with planned major refurbishment work at the substation.
- If a substantial increase in demand occurs a larger investment would likely be required, and this could include upgrading the existing transformers and converting the North Makarewa grid exit point to 66 kV.
- Assuming no local generation at White Hill windfarm, it forecasts that the transformers' (N-1) summer capacity will be exceeded by approximately 1 MW in 2033 increasing to 19 MW in 2036.

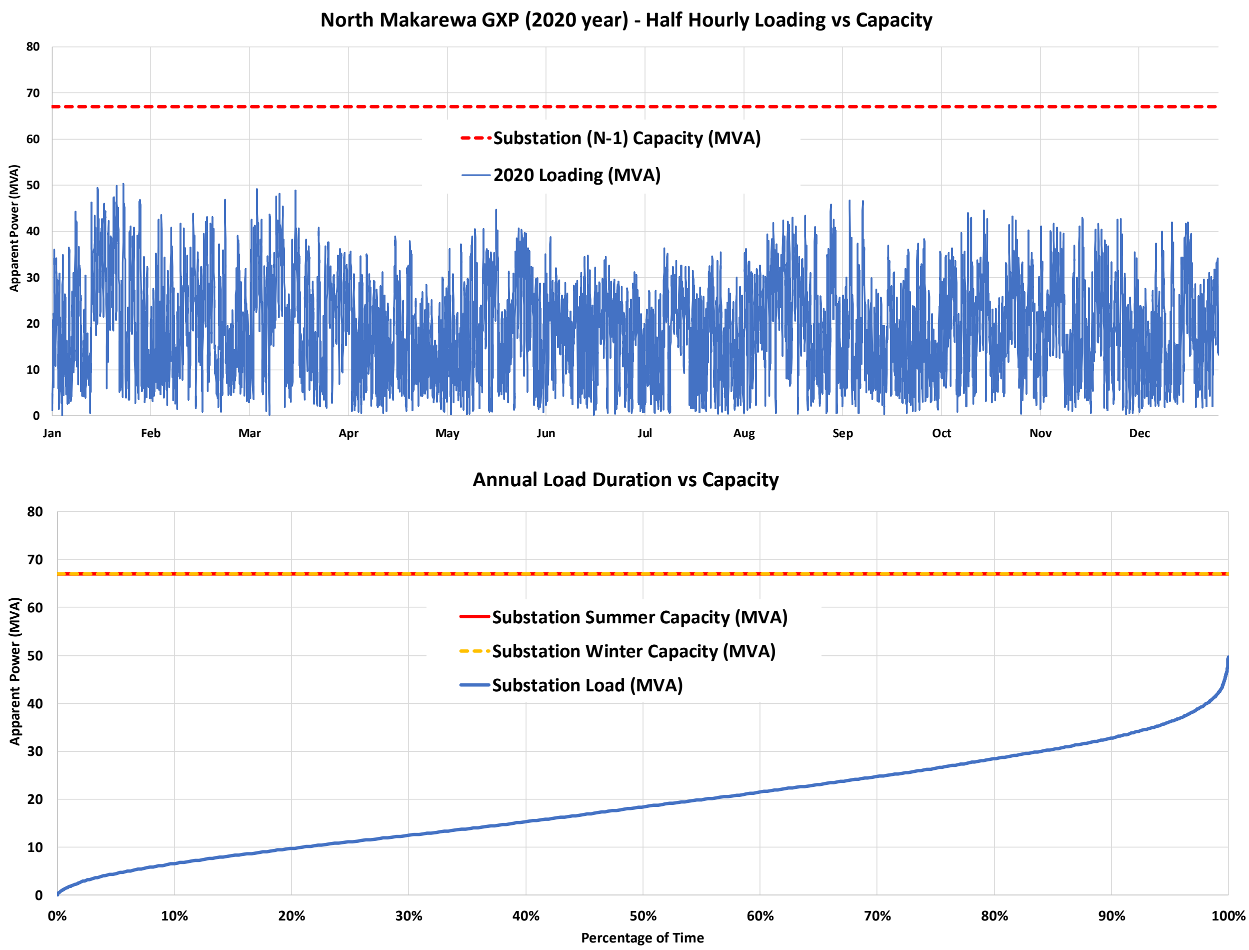

Figure 20 North Makarewa GXP: 2020 Loading: Substation capacity

6.1.9 Tiwai GXP

Transpower's demand forecast (refer Table 3) indicates that the Tiwai GXP was expected to have a 2021 peak demand of 580MW at 0.97pf (i.e. 598MVA). This contrasts with the historical SCADA data which indicates that, during 2020, the Tiwai GXP experienced a peak load of 632MVA.

Ergo understands that the NZAS smelter owns the step down transformers at the Tiwai GXP and we have not been able to establish the transformer sizes/capacities.

The Tiwai GXP is supplied by the following four 220kV circuits:

- INV-TWI-1 and INV-TWI-2 each with summer/winter ratings of 383MVA/466MVA.
- NMA-TWI-1 and NMA-TWI-2 each with summer/winter ratings of 385MVA/467MVA.

In theory this means that the (N-1) rating of the 220kV supply network into the Tiwai GXP involves the sum of the three lowest circuit capacities (i.e. one 220kV circuit out of service). This translates to an (N-1) summer/winter capacity of 1152MVA/1399MVA. Having said this Ergo expects that the delivery of this amount of power into the Tiwai substation is unlikely due to upstream transmission constraints.

Due to the lack of firm information available regarding the Tiwai GXP assets we have not presented the Tiwai load vs the substation/line capacities.

There are no EECA load conversion opportunities close to the substation.

6.2 Summary - Spare Capacity based on Transpower's 2021 Forecast

The following Figure 21 summarises the approximate, all year, (N-1) and (N) spare capacities at each GXP based on the substation capacity and the 2021 forecast load provided in Transpower's 2021 Transmission Planning Report, as discussed in the sections above.

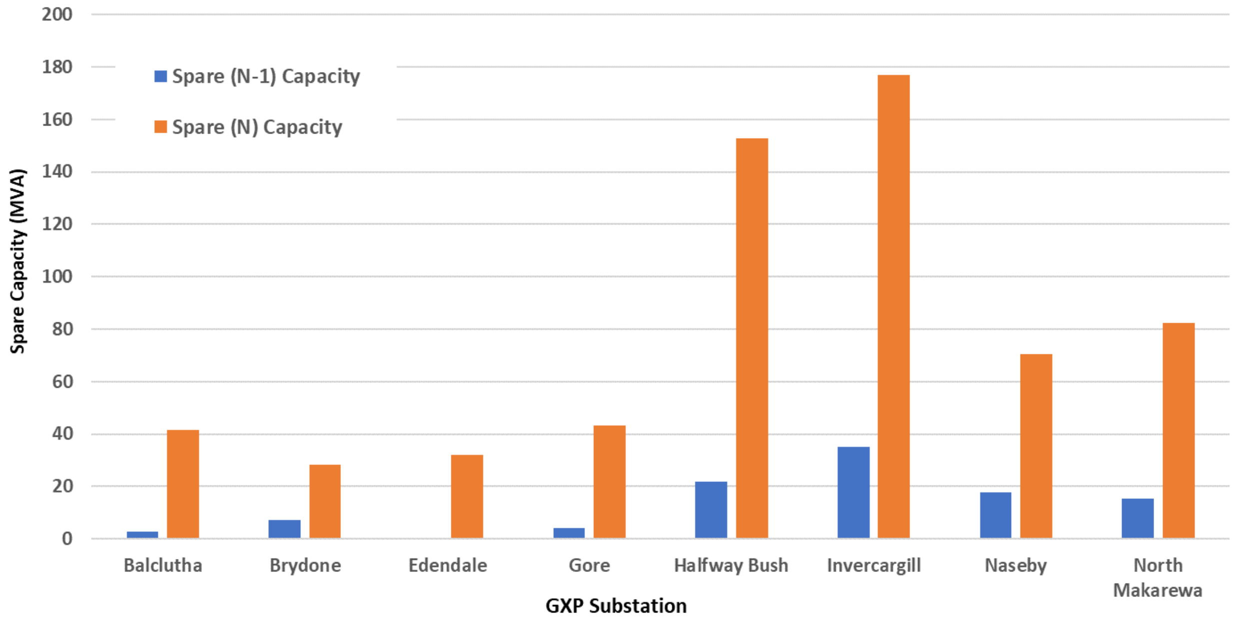

Figure 21 - Summary: GXP Spare Capacity based on Transpower's 2021 Load Forecast

It should be noted that the capacities have been calculated based on the transformer bay ratings disclosed by Transpower and the spare capacities do not include any upstream transmission constraints, which would need to be confirmed by Transpower.

7. Spare Capacity – Zone Substations

In determining the (N) and (N-1) spare capacities for the zone substation, Ergo reviewed both the EDB 2021 disclosure data and the historical substation loading data for 2020, supplied by PowerNet.

7.1 The Power Company

Table 4 TPC Spare capacity for each Zone Substation

Substation Name	Spare (N) Capacity		Spare (N-1) Capacity (MVA)	
	Disclosure Data	Historical Data[25]	Disclosure Data	Historical Data
Athol	4	3.6	-1	-1.4
Awarua Chip Mill	3	2.92	-2	-2.08
Bluff	18	19.47	7	8.47
Centre Bush	1	0.97	-4	-4.03
Colyer Road	14	14.39	2	2.39
Conical Hill	1	2.87	1	2.87
Dipton	0.5	0.06	-1	-1.44
Edendale Fonterra[26]	63	0	17	0
Edendale	17	16.39	5	4.39
Glenham	-0.5	-0.08	-2	-1.58
Gorge Road	1	1.43	-4	-3.57
Hedgehope	3	3.38	-2	-1.62
Hillside	1.25	1.35	-1	-0.9
Isla Bank	3	2.62	-2	-2.38
Kelso	1	0.6	-4	-4.4
Kennington	17	16.56	5	4.56
Lumsden	1	1.41	-4	-3.59
Makarewa	20	19.65	8	7.65
Mataura	13	13.92	3	3.92
Monowai	1	0.91	0	-0.09
Mossburn	1	0.66	-2	-2.34
North Gore	10	9.94	0	-0.06
North Makarewa[26]	46	0	1	0
Ohai	2	2.11	-3	-2.89
Orawia	2	1.77	-3	-3.23
Otatara	1	0.85	-4	-4.15
Otautau	3.5	3.51	-4	-3.99
Riversdale	-1	-0.7	-6	-5.7
Riverton	11	10.72	3	2.72
Seaward Bush	12	12.33	2	2.33

[25] Negative values indicate the relevant power transformer is likely overloaded from time to time. EDBs often disclose capacity in terms of the transformers ONAN capacity, but transformers can often be overloaded for short periods or have an ONAF capacity (i.e. fan cooled). The exact transformer ratings are very specific.

[26] No historical data supplied

Substation Name	Spare (N) Capacity		Spare (N-1) Capacity (MVA)	
	Disclosure Data	Historical Data[25]	Disclosure Data	Historical Data
South Gore	13	13.27	1	1.27
Te Anau	17	17.64	5	5.64
Tokanui	0.5	0.19	-1	-1.31
Underwood	29	28.43	9	8.43
Waikaka	0.5	-0.01	-1	-1.51
Waikiwi	33	33.59	10	10.59
Winton	13	12.77	1	0.77

7.2 Electricity Invercargill

Table 5 EIL Spare capacity for each Zone Substation

Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
	Disclosure Data	Historical Data	Disclosure Data	Historical Data
Spey Street	44	46.46	8	10.46
Leven Street	32	30.23	9	7.23
Racecourse Road	11	6.73	-12	-16.27
Southern	8	11.07	-15	-11.93

7.3 OtagoNet

Table 6 OJV Spare capacity for each Zone Substation

Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
	Disclosure Data	Historical Data[25]	Disclosure Data	Historical Data
Charlotte Street (Balclutha)	5	4.8	0	-0.2
Clarks	0.2	-2.86	-0.3	-3.36
Clinton	0.5	0.06	-2	-2.44
Clydevale	1.6	1.28	-3.4	-3.72
Deepdell	0.55	0.41	-0.2	-0.34
Elderlee Street (Milton)	5.6	5.5	0.6	0.5
Finegand	1.4	1.13	-1.1	-1.37
Glenore	0.9	0.81	-0.6	-0.69
Golden Point	2.3	2.08	-2.7	-2.92
Greenfield	1.3	2.79	-2.2	-0.71
Hindon	0.35	0.4	-0.2	-0.15
Hyde	1.8	-1.37	-0.7	-3.87
Kaitangata	1	0.9	-1.5	-1.6
Lawrence	1.3	1.11	-1.2	-1.39
Linnburn	0.1	0.07	-0.9	-0.93

Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
	Disclosure Data	Historical Data[25]	Disclosure Data	Historical Data
Merton	2.5	0.92	0	-1.58
Middlemarch	1.6	1.43	-0.9	-1.07
Milburn	2.3	2.39	-2.7	-2.61
North Balclutha	2.5	1.61	-2.5	-3.39
Oturehua	0.55	0.12	-0.2	-0.63
Owaka	1	0.59	-1.5	-1.91
Paerau	0.8	0.75	-0.2	-0.25
Paerau Hydro[27]	17.7	0	2.7	0
Palmerston	2.8	2.77	0.3	0.27
Patearoa	0.7	0.63	-1.8	-1.87
Port Molyneux	1.7	1.83	-0.8	-0.67
Pukekawa	0.25	0.24	-0.5	-0.51
Ranfurly 33/11	2.7	2.37	-2.3	-2.63
Ranfurly 66/33[27]	23.5	0	-26.5	0
Remarkables	17.6	20.95	5.1	8.45
Stirling	1	-1.29	-4	-6.29
Waihola	0.2	0.2	-1.3	-1.3
Waipiata	1	0.84	-1.5	-1.66
Waitati	0.9	0.44	-1.6	-2.06
Wedderburn	0.8	0.83	-0.2	-0.17

[27] No historical data provided.

7.4 Summary

7.4.1 The Power Company

7.4.1.1 (N-1) Capacity Summary

The following Figure 22 illustrates the approximate (N-1) spare capacities at The Power Company's zone substations, for the disclosed 2021 peak demand estimates[28]. It should be noted that these have been calculated based on the transformer ratings disclosed by The Power Company.

The spare capacities shown do not include any upstream or downstream lines, cables or other equipment thermal constraints, which may be discussed for selected zone substations in Section 0.

The negative (N-1) ratings represent either a single bank transformer or that the N-1 rating is already exceeded at times throughout the year.

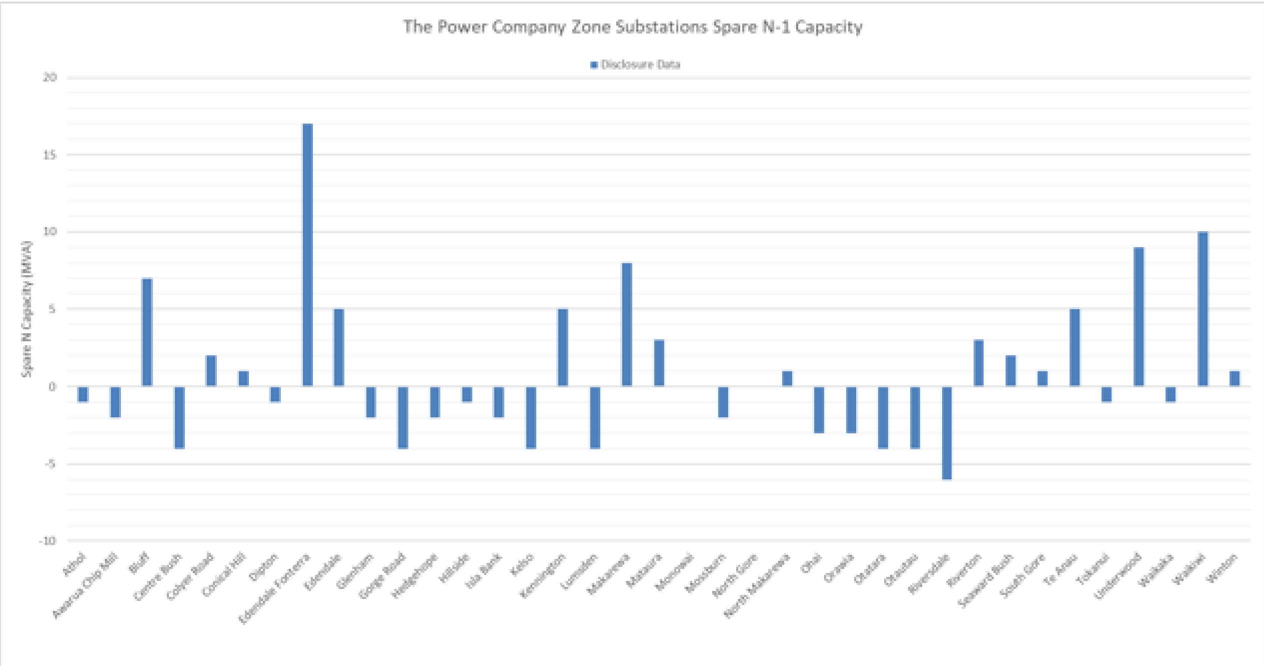

Figure 22 Summary: Approximate (N-1) spare capacity at The Power Company zone substations

7.4.1.2 (N) Capacity Summary

The following Figure 23 illustrates the approximate (N) spare capacities at The Power Company's zone substations, for the disclosed peak demand estimates. Again, it should be noted that these have been calculated based on the transformer ratings disclosed by The Power Company.

The spare capacities shown do not include any upstream or downstream conductor or other equipment thermal constraints, which may be discussed for selected zone substations in Section 0.

[28] The Power Company's 2021 information disclosure (https://powernet.co.nz/disclosures/).

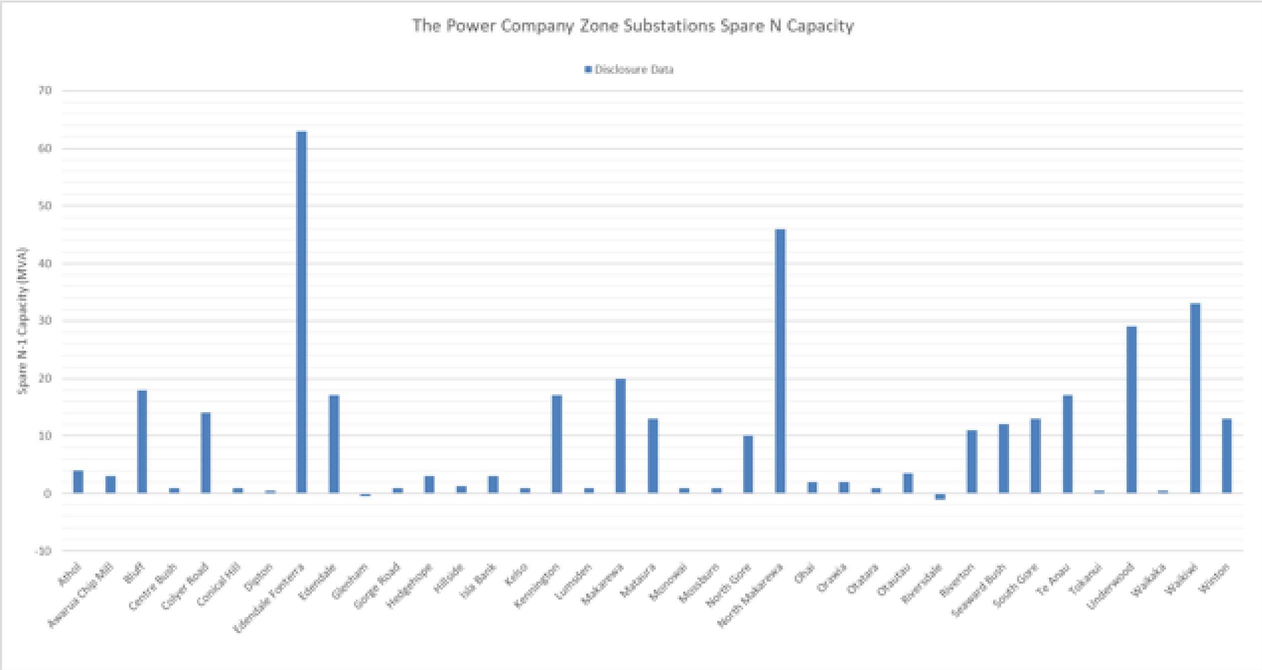

Figure 23 Summary: Approximate (N) spare capacity at The Power Company zone substations

7.4.2 Electricity Invercargill

7.4.2.1 (N-1) Capacity Summary

The following Figure 24 illustrates the approximate (N-1) spare capacities at Electricity Invercargill's zone substations, for the disclosed peak demand estimates. It should be noted that these have been calculated based on the transformer ratings disclosed by Electricity Invercargill.

The spare capacities shown do not include any upstream or downstream conductor or other equipment thermal constraints, which may be discussed for selected zone substations in Section 0.

The negative (N-1) ratings represent either a single bank transformer or that the (N-1) rating is already exceeded at times throughout the year.

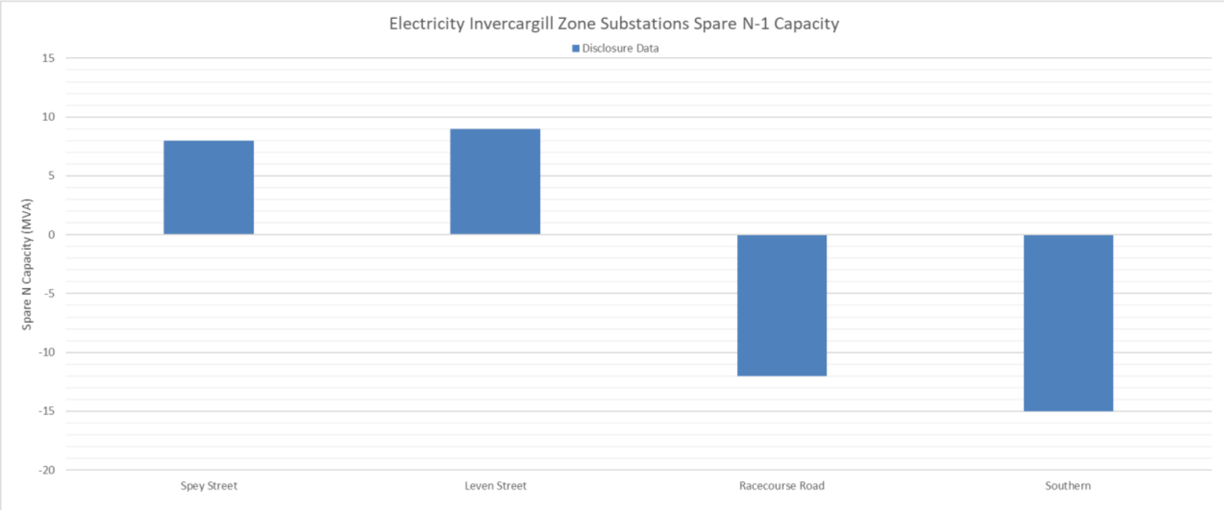

Figure 24 Summary: Approximate (N-1) spare capacity at Electricity Invercargill zone substations

7.4.2.2 (N) Capacity Summary

The following Figure 25 illustrates the approximate (N) spare capacities at Electricity Invercargill's zone substations, for the disclosed peak demand estimates[29]. Again, it should be noted that these have been calculated based on the transformer ratings disclosed by Electricity Invercargill.

The spare capacities shown do not include any upstream or downstream lines, cables or other equipment thermal constraints, which may be discussed for selected zone substations in Section 0.

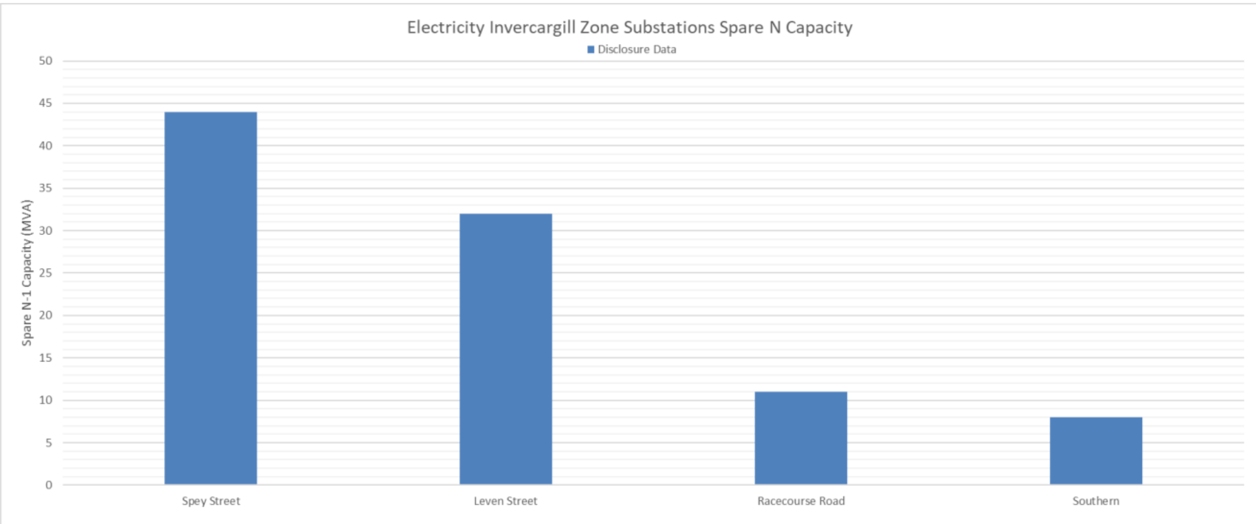

Figure 25 Summary: Approximate (N) spare capacity at Electricity Invercargill zone substations

[29] Electricity Invercargill's 2021 information disclosure (https://powernet.co.nz/disclosures/).

7.4.3 OtagoNet

7.4.3.1 (N-1) Capacity Summary

The following Figure 26 illustrates the approximate (N-1) spare capacities at OtagoNet's zone substations, for the disclosed peak demand estimates[30]. It should be noted that these have been calculated based on the transformer ratings disclosed by OtagoNet.

The spare capacities shown do not include any upstream or downstream lines, cables or other equipment thermal constraints, which may be discussed for selected zone substations in Section 0.

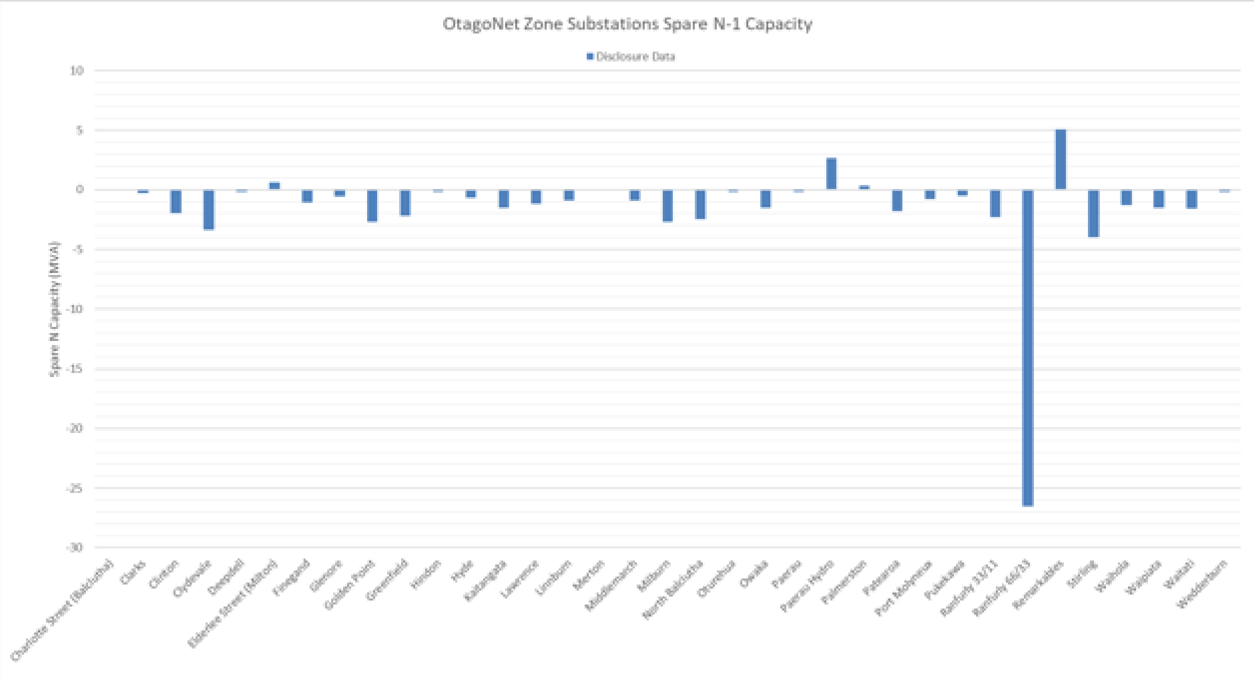

Figure 26 Summary: Approximate (N-1) spare capacity at OtagoNet zone substations

[30] OtagoNet 2021 information disclosure (https://powernet.co.nz/disclosures/).

7.4.3.2 (N) Capacity Summary

The following Figure 27 illustrates the approximate (N) spare capacities at OtagoNet's zone substations, for the disclosed peak demand estimates[31]. It should be noted that these have been calculated based on the transformer ratings disclosed by OtagoNet.

The spare capacities shown do not include any upstream or downstream conductor or other equipment thermal constraints, which may be discussed for selected zone substations in Section 0.

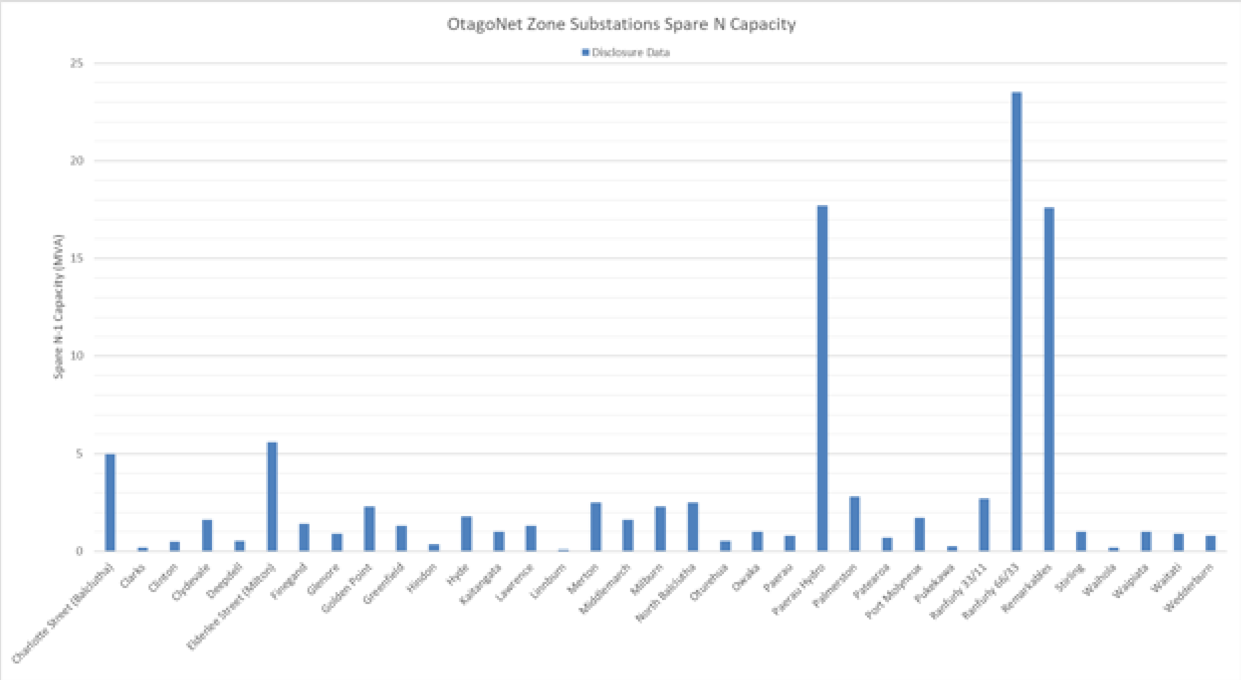

Figure 27 Summary: Approximate (N) spare capacity at OtagoNet zone substations

[31] OtagoNet 2021 information disclosure (https://powernet.co.nz/disclosures/).

8. Connection Options

The following sections describe the potential connection options for EECA's load conversion opportunities (LCO). For simplicity Ergo has categorised (and discusses) the connection options for the LCO's in terms of the local substations, as follows:

- Transpower GXP substations (shaded blue colour in diagrams).
- The Power Company/OtagoNet/Electricity Invercargill zone substations (shaded yellow in diagrams).

The purpose of this section is to provide a high-level assessment to the feasibility of connecting the LCO to the existing electrical infrastructure (both transmission and distribution) and where upgrades would be needed, provide an indication of potential scope, capital costs and timeframes.

The assessments made have involved a desk-based assessment using the various information provided to Ergo. Where information was not available, we have used engineering judgement. If the LCO's are progressed further, Ergo recommends more detailed engineering assessments are undertaken in consultation with both Transpower and PowerNet. This would likely entail powerflow modelling, optioneering and concept designs to provide more refined cost estimates.

8.1 Assessment Methodology

The assessment of each individual LCO uses a bottom down approach where the LCO peak load is used to determine whether there appears to be spare capacity at:

- The incoming transmission lines
- The GXP substation
- The sub-transmission lines feeding the nearby zone substation
- The nearby zone substation
- The adjacent 11kV or 22kV feeder

The spare capacity across each asset type has been determined using the information provide by Transpower and PowerNet or in the absence of information, assumptions made based on the asset type/voltage and typical capacity expectations.

Once the load implications across the supply network are understood, Ergo has been able to determine the implications of connecting that load i.e. the necessary infrastructure upgrades. Ergo has used a building block approach to the costing of the necessary upgrades where typical assets have a unit rate associated with them.

In terms of upgrades, these can typically be classified as:

- **Minor** – The "as designed" electrical system can likely connect the LCO with minor distribution level changes and without the need for substantial infrastructure upgrades costs
- **Moderate** – The "as designed" electrical system requires some infrastructure upgrades including new connections into the local zone substation and/or upgrades at the local zone substation or sub-transmission network
- **Major** – The "as designed" electrical system requires substantial upgrades at both the transmission and distribution level, likely requiring significant investment

8.2 Engineering Assumptions:

Specific engineering assumptions in this section include:

- We have used the spare capacities of both the GXP and Zone substations based on the publicly disclosed loading and capacity information (instead of the 2020 loading data provided by Transpower and PowerNet). Ergo's view is that these are typically more conservative than the actual loading and are therefore appropriate for this sort of high level assessment
- We have assumed the existing site security should be maintained (unless otherwise stated). For example, if the site currently presently has (N-1) security, we have recommended infrastructure upgrades to maintain this.
- The upgrades and costs an individual LCOs are considered in isolation of the adjacent LCOs. We have not considered the scope and costs associated with implementing multiple LCO's at this stage .
- The LCO loads will have unity power factor which is reasonable considering the preliminary nature of the assessment.
- Unless otherwise stated, the existing incoming 33kV line/cable capacities exceed the capacity of the existing substation they supply.
- Existing 33kV and 11kV feeders are capable of supplying up to 12 MVA and 4.5 MVA respectively which is generally accepted as a conservative capacity limit in the absence of detailed asset/conductor/cable details.
- Cost estimates have a Class 5[32] accuracy - suitable for concept screening. Appendix 2 outlines accuracy of the cost estimates and the general assumptions.
- Cost estimates exclude land purchase, easements and consenting. These costs are difficult to estimate without undertaking a detailed review of the available land (including a site visit) and the local council rules in relation to electrical infrastructure. For example, the upgrade of existing overhead lines or new lines/cables across private land does require utilities to secure easements to protect their assets. Securing easements can be a very time consuming and costly process. For this reason, Ergo's estimates for new electrical circuits are generally based on assuming they are installed in road reserve and involve underground cables in urban locations and overhead lines in rural locations. We note that, as a general rule, 110kV and 220kV lines cannot be installed in road reserve due to width requirements. In some locations the width of the road reserve is such that 66kV and 33kV lines cannot be installed. This issue only becomes transparent after a preliminary line design has been undertaken.
- Cost estimates only include the incumbent network operator's distribution/transmission equipment and do not include onsite equipment that may be required to supply the LCO's (for example, MV switchboards/cabling and LV switchboards/cables within the respective LCO sites are not included).
- The time estimates provided are based on Ergo's experience. These can vary significantly depending on the scope of the project and the appetite for expediting. These should be used as a guide only.

Disclaimer: The LCO supply investigations and capital cost estimates outlined in this report are preliminary and are only suitable for screening purposes. The capital cost estimates should not be used be used for final budgeting purposes in order to connect the respective LCO's.

[32] Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries, AACE International Recommended Practice No. 18R-97.

8.3 Balclutha GXP

The EECA LCO's include:

- Silver Fern Farms Finegand (8.0 MW)
- Balclutha Hospital (5.1 MW)
- Balclutha Swimming Pool (0.60 MW)

The geographic location of the LCO's are shown on the following map in relation to the local transmission and distribution substations.

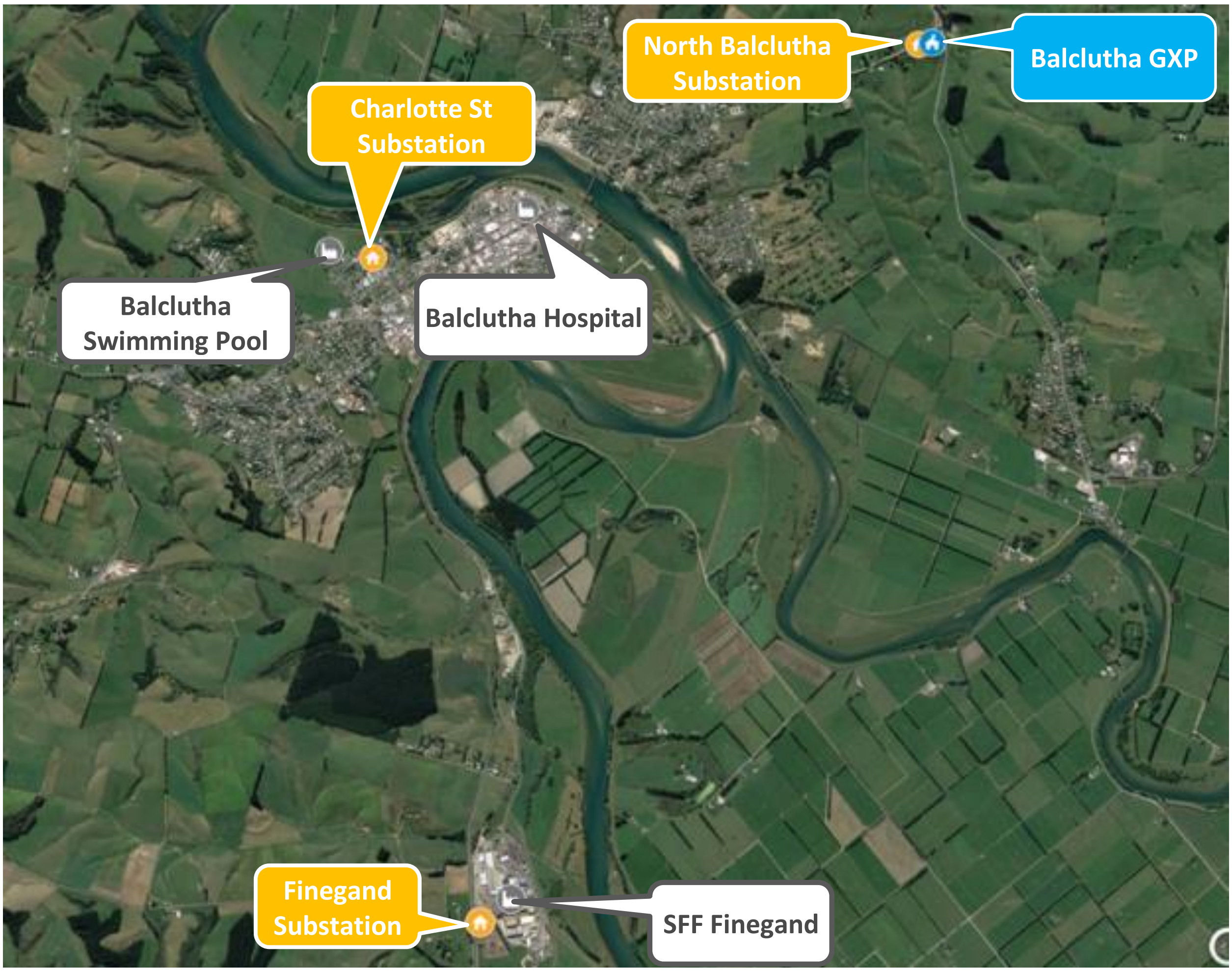

Figure 28 Balclutha: EECA load conversion opportunities vs local substations

8.3.1 Balclutha GXP Upgrade

Balclutha GXP is near it's (N-1) capacity with ≈3MVA of spare capacity at the substation and ≈20MVA on the incoming 110kV circuits.

If additional capacity was required, this could be achieved by upgrading the two existing 110/33kV 37/39 MVA (summer/winter rating) transformers with transformers capable of supplying the full incoming line capacity of ≈51/62 MVA, providing an additional 14 MVA and 23 MVA summer and winter capacity at the GXP respectively.

Balclutha has a relatively new 33kV indoor switchboard/switchroom so it is assumed the additional load could be supplied via two new 33kV panels within the existing switchroom.

Ergo's capital cost estimates for the option presented are outlined in the following Table 7.

Table 7 Balclutha GXP: Capital cost estimate for upgrading the Balclutha GXP[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	Medium supply transformer (GXP)	2.00	$7.00
Sub-transmission	33kV circuit breaker bay	2.00	$0.50
		TOTAL	**$7.50**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

8.3.2 Silver Ferns Finegand

This LCO is confirmed as an electrode boiler requiring an additional 8 MW. The Finegand plant is currently supplied as follows:

- Directly via a single 33kV circuit from the Balclutha GXP. Ergo understands the 33/11kV transformers (supplied via the 33kV circuit) are owned by Silver Fern Farms and we do not have the details of these transformers (or the transformer loading).
- At 11kV via OtagoNet's close-in existing, 33/11kV, Finegand zone substation. The substation is equipped with a single 2.5MVA, 33/11kV transformer that has three 11kV feeders, and is supplied via a single 33kV circuit from the Balclutha GXP. Ergo understands that one of the 11kV feeders supplies Finegand, whilst the remaining two 11kV feeders supply other consumers.

In order to supply an additional 8 MW, Ergo propose the upgrade of the existing Finegand substation to a capacity of 12MVA. Given the size/nature/age of the existing substation we expect the upgrade to include a rebuild of the substation and to include the following:

- A new 12MVA, 33/11kV power transformer.
- A new switchroom to accommodate switchgear and control equipment.
- A new indoor 33kV circuit breaker.
- A new indoor 11kV switchboard with 1 x incoming circuit breaker and 5 x feeder circuit breakers.

Ergo's capital cost estimates for the option presented above are outlined in the following Table 8. Note that this estimate does not include the costs to upgrade the Balclutha GXP (discussed in Section 8.3.1).

Table 8 Silver Ferns Finegand: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	33kV circuit breaker (ZSS)	1.00	$0.15
Distribution	Medium supply transformer (ZSS)	1.00	$1.00
Distribution	11kV circuit breaker (ZSS)	6.00	$0.60
Distribution	Medium switchroom (ZSS)	1.00	$3.00
Distribution	Single underground 11kV cable	1.00	$0.40
		TOTAL	**$5.15**

[33] Given the preliminary nature of the costs they are considered to be Class 5 estimates as discussed in Appendix 2.

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

8.3.3 Balclutha Hospital

This LCO requires an additional 5.1 MW, is ≈1.0km from OtagoNet's Charlotte St zone substation (refer to Figure 29) and is presently fed via an 11kV overhead line. The Charlotte St substation presently has no spare (N-1) capacity and the two incoming 33kV lines from Balclutha GXP may not be capable of supplying the additional load at (N-1) as the existing, no diversity, peak load on these feeders appears to be ≈16 MVA. While, according to Transpower, the GXP currently only has approximately 3 MVA (N-1), the peak loading appears to be through the summer and spring periods while Ergo understands Balclutha Hospital's peak energy use (and assumed peak loads) would be through winter. Therefore, it is likely the LCO could utilise existing GXP capacity.

Therefore, we expect the supply could involve:

- Re-conductoring of the two existing 33kV circuits to a higher rated conductor (≈5.0km).
- An upgrade of the two 33/11kV 5MVA transformers to two new 12 MVA transformers.
- A new indoor 11 kV circuit breaker, which we have assumed can be accommodated in the existing switchroom.
- A new 11kV cable from the Charlotte St zone substation to the hospital, running down Charlotte St (≈1.0km).

Figure 29 Balclutha Hospital geographic location in relation to the Charlotte substation

Ergo's capital cost estimates for the option presented are outlined in the following Table 9. Note that this estimate does not include the costs to upgrade the Balclutha GXP (discussed in Section 8.3.1), or any distribution transformers/switchgear on the hospital site. Note that this estimate does not include the costs to upgrade the Balclutha GXP (discussed in Section 8.3.1).

Table 9 Balclutha Hospital: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Sub-transmission	Double overhead 33kV line (reconductor)	5.00	$1.00
Distribution	Medium supply transformer (ZSS)	2.00	$2.00
Distribution	11kV circuit breaker bay	1.00	$0.10
Distribution	Single underground 11kV cable	1.00	$0.40
		TOTAL	**$3.50**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 18 - 24 months.

8.3.4 Balclutha Swimming Pool

This LCO requires an additional 0.6 MW which is currently supplied via an 11kV feeder from Charlotte St zone substation which is lightly loaded and would likely be capable of supplying the additional load.

Figure 30 Balclutha Swimming Pool geographic location in relation to the Charlotte substation

While Charlotte St zone substation has no remaining (N-1) capacity, the additional load is minimal and OtagoNet's AMP does state that some Charlotte St load can be transferred to maintain (N-1). Therefore, it is likely the additional load could be supplied through the existing 11kV network with no major infrastructure upgrades are required. However, we expect the LCO would require the installation of a large new distribution transformer.

Ergo recommends overlaying the proposed Balclutha Swimming Pool demand profile with the existing load profile of Charlotte St zone substation to confirm the impact on the zone substations peak demand.

Ergo's capital cost estimates for supply of the additional load are outlined in the following Table 10.

Table 10 Balclutha Swimming Pool: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	750kVA distribution tx	1.00	$0.20
		TOTAL	**$0.20**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 4 months.

8.3.5 Great Southern Milton

This LCO requires an additional 0.9 MW which is currently supplied via a lightly loaded 11kV feeder from OtagoNet's Elderlee St zone substation (≈1.2km apart). Elderlee St zone substation is fed via two 33kV circuits from Balclutha GXP.

Figure 31 Great Southern Milton geographic location in relation to the Elderlee Street substation

While Elderlee St zone substation has only 0.6 MVA remaining (N-1) capacity, this at worst case, would be exceeded less than 3% of the time. Therefore, it is likely the additional load could be supplied through the existing connection and no major infrastructure upgrades are required. However, supply of the LCO is expected to require the installation of a large new distribution transformer.

Ergo recommends overlaying the proposed Great Southern Milton demand profile with the existing load profile of Elderlee St zone substation to confirm the impact on the zone substations peak demand.

Ergo's capital cost estimates for supply of the additional load are outlined in the following Table 11.

Table 11 Great Southern Milton: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	750kVA distribution tx	1.00	$0.20
		TOTAL	**$0.20**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 4 months.

8.4 Edendale GXP

The EECA LCO's include:

- Fonterra Edendale (85MW)
- Blue Sky Meats (4.1MW)

The geographic location of the LCO's are shown on the following map in relation to the local transmission and distribution substations.

Figure 32 Edendale: EECA load conversion opportunities vs local substations

8.4.1 Edendale GXP Upgrade

Edendale GXP is near it's (N-1) capacity with no spare capacity at the substation, and ≈6MVA of spare (N-1) capacity on the 110kV lines that supply the substation (this is discussed in more detail in Section 6.1.3).

If significant additional capacity is required, the 110 kV Invercargill–Edendale–Brydone–Gore circuits would need to be upgraded. Transpower's estimate to reconductor these 110kV lines is NZ$16M.

Also, the Edendale GXP would need to be upgraded. Given the wider EECA LCO requirements Ergo has assumed this would involve following:

- The replacement of the existing 110/33kV transformers with 2 x 100MVA units.
- Extension of the existing 33kV switchroom (or new building).
- Eight new indoor 33kV circuit breakers.

Ergo's capital cost estimates for the option presented are outlined in the following Table 12.

Table 12 Edendale GXP: Capital cost estimate for upgrading the Edendale GXP[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	110kV line upgrades	1.00	$16.00
Transmission	Large supply transformer (GXP)	2.00	$9.00
Transmission	Switchroom extension	1.00	$2.00
Transmission	33kV circuit breaker bay	8.00	$2.00
		TOTAL	**$29.00**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 36 - 48 months.

8.4.2 Fonterra Edendale

Fonterra Edendale presently has a peak load of approximately 25MW and is supplied via 3 x 33kV, ≈0.5km, underground cables from the Edendale GXP. The supply of the 85MW LCO would require a significant upgrade to the Edendale GXP, which is discussed in Section 8.4.1. Ergo is not clear regarding exactly what Fonterra's requirements would be on its Edendale site, but we have assumed that the following additional sub-transmission/distribution equipment would need to be installed:

- Six, 0.5km, 33kV cables from the Edendale GXP to the Fonterra site.
- Three new 33/11kV substations, each equipped with 2 x 30MVA, feeder fed transformers, and 11kV switchboards (9 x 11kV circuit breakers).

Ergo's capital cost estimates for the option presented are outlined in the following Table 13.

Table 13 Fonterra Edendale: Capital cost estimate to supply LCO with (N-1) security[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Sub-transmission	Double underground 33kV cable	1.50	$1.50
Sub-transmission	Medium zone substation	3.00	$24.00
		TOTAL	**$25.50**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 36 - 48 months.

The above costs assume that Fonterra require a secure (N-1) supply to its Edendale plant, as do the other consumers that take supply from the Edendale GXP (i.e. PowerNet). Acceptance of (N) security of supply would reduce upgrade costs. The existing Edendale GXP substation has a total (N) capacity of 2 x 34MVA = 68MVA (refer to Section 6.1.3). This means that if the peak Fonterra Edendale plant increases its demand by 85MW the existing Edendale GXP would need to be upgraded. Furthermore, the supply of the 85MW Fonterra load would exceed the (N) capacity of the existing 110kV lines that supply the Edendale GXP substation and the lines would need to be upgraded (Section 8.3.1 discusses the 110kV line upgrades). Given the above facts, the transmission costs would not be significantly less than that outlined in Section 8.4.1, and could be 10-20% less. However, the costs of the 33kV and 11kV upgrades outlined in Table 13 would reduce if Fonterra accepted (N) security on the 33kV supply to its Edendale factory. Ergo has assumed the following would need to be installed to supply the additional Fonterra load:

- Three new, 0.5km, 33kV cables from the Edendale GXP to the Fonterra site.
- Three new 33/11kV substations, each equipped with 1 x 30MVA, feeder fed transformers, and 11kV switchboards (7 x 11kV circuit breakers).

Ergo's capital cost estimates for the (N) supply option presented above are outlined in the following Table 14.

Table 14 Fonterra Edendale: Capital cost estimate to supply LCO with (N) security at 33kV[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Sub-transmission	Single underground 33kV cable	1.50	$0.90
Sub-transmission	Small zone substation	3.00	$15.00
		TOTAL	**$15.90**

In terms of timeframes, again Ergo estimates the above works, excluding consenting times, would take around 36 - 48 months.

There may be an opportunity to supply a portion of Fonterra Edendale's proposed 85MW, provided Fonterra accept (N) security-of-supply and in the event of a 110/33kV transformer, or 110kV line outage the additional Fonterra load is shed/disconnected. This would typically involve the installation of a special protection system (SPS). Taking into account power factor the maximum load that could be supplied from the existing Edendale GXP is ≈60MW, which means that Fonterra Edendale could increase its demand by ≈25MW to 50MW provided an SPS was installed. Again, the costs of the 33kV and 11kV upgrades outlined in Table 14 would reduce further with (N) security on the 33kV supply to the Edendale factory and Ergo has assumed the following would need to be installed to supply the additional Fonterra load:

- One new, 0.5km, 33kV cable from the Edendale GXP to the Fonterra site.
- A single new 33/11kV substation, equipped with 1 x 30MVA, feeder fed transformer, and an 11kV switchboard.
- A special protection system.

Ergo's capital cost estimates for the partial (N) supply option presented above are outlined in the following Table 15.

Table 15 Fonterra Edendale: Capital cost estimate to supply a portion of the LCO with (N) security at 33kV[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	Special protection system (GXP)	1.00	$0.50
Sub-transmission	Single underground 33kV cable	0.50	$0.30
Sub-transmission	Medium zone substation	1.00	$8.00
		TOTAL	**$8.80**

In terms of timeframes, again Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

Further analysis on the Edendale supply options can be found in the subsequent Memo 21177-EE-MEM-0001 in Appendix 3

8.4.3 Blue Sky Meats

Blue Sky Meats is supplied at 11kV via The Power Company's Edendale zone substation. The Edendale zone substation has a spare (N-1) capacity of approximately 17MVA. While according to Transpower, the GXP currently has no spare (N-1), the peak loading is through the months of Oct – Dec while Ergo understands Blue Sky Meat's peak energy use (and assumed peak loads) would be between Feb and May. Therefore, it is likely the LCO could utilise existing GXP capacity.

From the perspective of the existing zone substation capacity, the supply of the LCO of 4.1MW would be possible. However, the distance between the two sites is approximately 13km (via the line/road route) and Ergo expects that the supply of 4.1MW via the existing 11kV network would not be possible. In order to supply LCO Ergo expect the following to be required:

- A new 11kV feeder circuit breaker at the Edendale zone substation.
- A new 13km, 11kV feeder constructed from the Edendale zone substation out to the Blue Sky Meats site. Ergo has assumed the feeder consists of 11kV overhead line and 2km underground cable.
- The installation of a 4MVA voltage regulator or a 2.25MVAr, 11kV capacitor bank close-in to the Blue Sky Meats plant. This would be required as a 13km, 11kV overhead line would result in delivery voltages of ≈90% of nominal voltage, which would not be acceptable. Ergo has assumed a switched capacitor bank is installed that is switched in 0.75MVAr steps (this requires further study).

Ergo's capital cost estimates for the option presented are outlined in the following Table 16.

Table 16 Blue Sky Meats: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single overhead 11kV line	11.00	$2.20
Distribution	Single underground 11kV cable	2.00	$0.80
Distribution	3 x 0.75MVAr switched capacitor	1.00	$0.60
		TOTAL	**$3.70**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 12 – 18 months.

8.5 Gore GXP

The EECA LCO's include:

- Alliance Mataura (4MW)
- Silver Fern Farms Waitane (1MW)
- Mataura Valley Milk (15MW)

The geographic location of the LCO's are shown on the following map in relation to the local transmission and distribution substations.

Figure 33 Gore: EECA load conversion opportunities vs local substations

8.5.1 Gore GXP Upgrade

The Gore GXP 33kV currently has an (N-1) rating of 37/39 MVA (summer/winter) and approximately 4 MVA of spare (N-1) substation capacity.

Increasing the capacity available on the Gore GXP 33kV would require the existing power transformers to be upgraded (previous discussed in Section 6.1.4). Given EECA's LCOs, Ergo recommend the upgrade of the existing transformers with two new 60MVA, 220/33kV transformer banks.

Ergo's capital cost estimates for the option presented are outlined in the following Table 17.

Table 17 Gore GXP: Capital cost estimate for upgrading the Invercargill GXP[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	Medium supply transformer (GXP)	2.00	$7.00
		TOTAL	**$7.00**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

8.5.2 Alliance Mataura

Alliance Mataura is presently supplied from The Power Company's Mataura zone substation, which in turn, is supplied from the Gore GXP. The Mataura zone substation has a spare (N-1) capacity of approximately 3MVA. The supply of the additional 4MW load conversion opportunity from the zone substation should be possible as the zone substation has a transfer capacity of 2MVA if required. There are three relatively high capacity 11kV lines (Mink or Cockroach conductors) installed between the Mataura substation and the roads that traverse close to the site. The supply of the additional 4MW of load should be possible via the existing lines. Although, we expect some additional 11kV cable would need to be installed from the lines into the Mataura site, as well reconfiguration of the existing 11kV network.

Ergo's capital cost estimates for the option presented above are outlined in the following Table 18. Note that this estimate does not include the costs to upgrade the Gore GXP (discussed in Section 8.3.1), or the installation of distribution transformers/switchgear on the Alliance site.

Table 18 Alliance Mataura: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Single underground 11kV cable	0.30	$0.12
		TOTAL	**$0.12**

In terms of timeframes, Ergo estimates the above works, would take around 2 - 4 months.

8.5.3 Silver Fern Farms Waitane

Silver Ferns is presently supplied from The Power Company's South Gore zone substation, which in turn is supplied from the Gore GXP. South Gore zone substation has a spare (N-1) capacity of approximately 1MVA and thus the supply of the additional 1MW load conversion opportunity from the zone substation should be possible. There is a double circuit 11kV line installed on the road past the Silver Fern's site (from the South Gore substation). One of the 11kV circuits has a relatively large conductor (Mink) whilst the second circuit has a small conductor (7/2.34Cu). It does appear, to Ergo, that the Silver Ferns Waitane plant is supplied via the larger 11kV circuit and the supply of an additional 1MW of load should be possible. However, we expect some reconfiguration/upgrade of the existing 11kV supply equipment may be required.

Ergo's capital cost estimates for the option presented are outlined in the following Table 19. Note that this estimate does not include the costs to upgrade the Gore GXP (discussed in Section 8.3.1), or the installation of distribution transformers/switchgear on the Silver Fern Farms site.

Table 19 Silver Fern Farms Waitane: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Network reconfiguration/upgrade	1.00	$0.10
		TOTAL	**$0.10**

In terms of timeframes, Ergo estimates the above works, would take around 2 - 4 months.

8.5.4 Mataura Valley Milk

Mataura Valley Milk (MVM) is presently supplied via 2 x 300mm^2, 11kV, underground cables from the South Gore zone substation. The South Gore zone substation has a spare (N-1) capacity of approximately 1MVA and thus the supply of the additional 15MW LCO from the existing zone substation would not be possible.

Ergo expect the most economic option to supply the additional 15MW of load would involve a 33kV connection to the Gore GXP together with the installation of a new 33/11kV substation on the MVM site. We expect that the factory would require a secure (N-1) supply consisting of two independent 33kV circuits and two 15MVA, 33/11kV transformers. One of the 33kV circuits, to the MVM site, could involve the diversion of an existing 33kV overhead line that traverses approximately 1.5km to the south of the MVM site. This existing 33kV line connects the South Gore substation to the Conical Hill substation. As well as diverting the existing 33kV line, it would need to be extended (via 33kV underground cable) from the South Gore substation to the Gore GXP. The second 33kV circuit, to the MVM site, would need to be via a 9km underground cable from the Gore GXP out to the MVM site. The substation on the MVM site would need to include a 33kV switchboard with the following 33kV circuit breakers:

- Two incoming "line circuit breakers" (circuits from Gore GXP)
- Two transformer circuit breakers
- A single outgoing "line circuit breaker" (circuit to Conical Hill)
- A bus-section breaker

Two additional 33kV circuit breakers would also need to be installed at the Gore GXP.

Ergo's capital cost estimates for the option presented above are outlined in the following Table 20. Note that this estimate does not include the costs to upgrade the Gore GXP (discussed in Section 8.3.1), or the installation of distribution transformers/switchgear on the MVM site.

Table 20 Mataura Valley Milk: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	33kV circuit breaker bay	2.00	$0.50
Sub-transmission	Medium zone substation	1.00	$8.00
Sub-transmission	Double underground 33kV cable	5.00	$5.00
Sub-transmission	Single underground 33kV cable	7.00	$4.20
		TOTAL	**$17.70**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

8.6 Invercargill GXP

The EECA LCO's include:

- Open Country Dairy Awarau (23.5 MW)
- Southland Hospital (6.1 MW)
- South Pacific Meats (4.0 MW)
- Peacehaven Village (2.4 MW)
- Southern Institute of Technology (1.9MW)
- Ascot Park Hotel (1.6 MW)
- Downers Road Invercargill (1.4MW)
- Invercargill Prison (1.3 MW)
- Prime Range Meats (1.2 MW)
- Great Southern Invercargill (0.9 MW)
- Stadium Southland (0.9 MW)
- Winton Feedstock (0.6 MW)
- Kelvin Hotel (0.4 MW)

The geographic location of the LCO's are shown on the following map in relation to the local transmission and distribution substations.

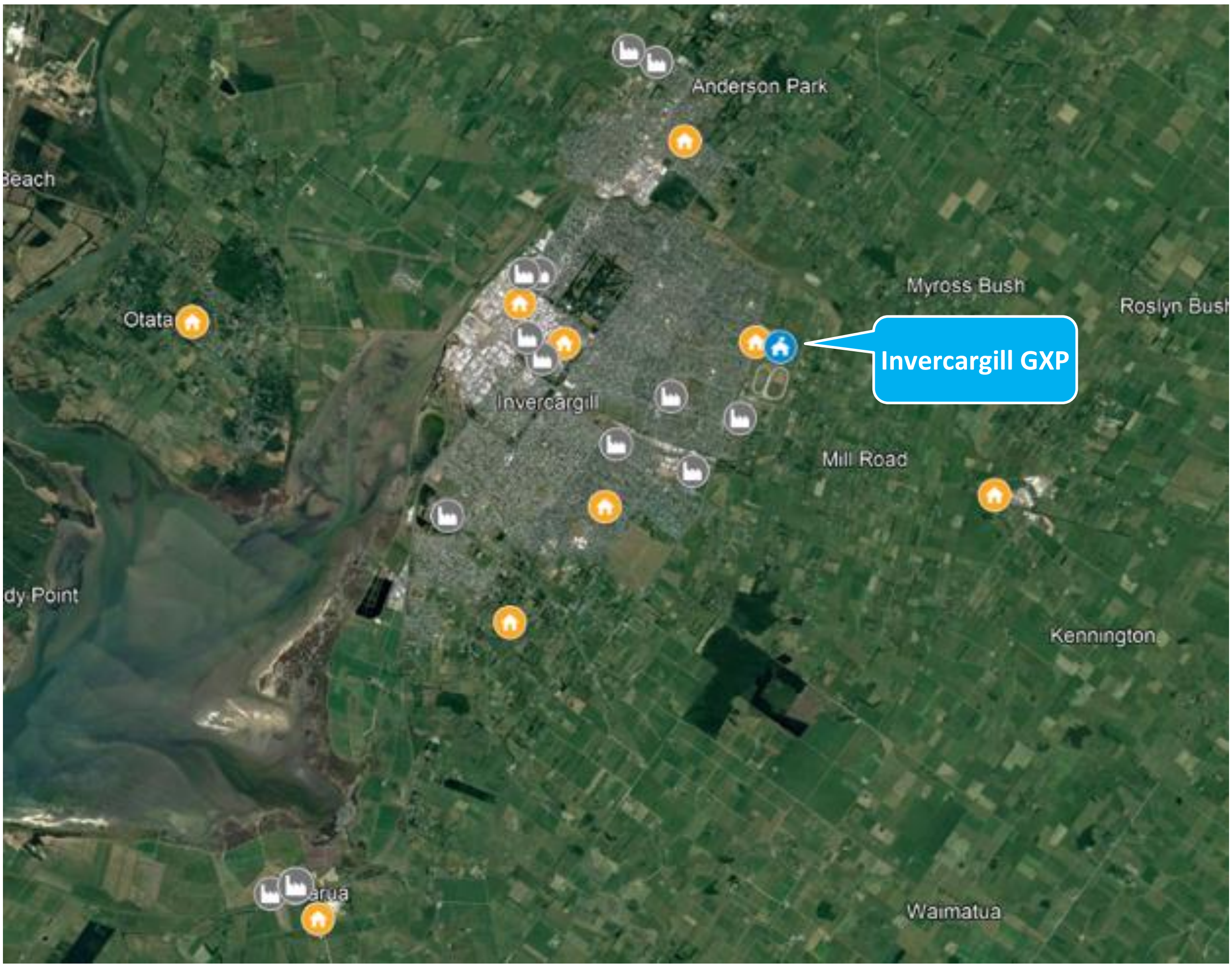

Figure 34 - Invercargill GXP, local zone substations and LCOs (excludes Bluff area further South)

8.6.1 Invercargill GXP Upgrade

The Invercargill GXP 33kV currently has an (N-1) rating of 142/142 MVA (summer/winter) which Transpower documents indicate is limited by circuit breakers and current transformers (assumed to be the 33kV incomers) followed by the 33kV incoming cables. If these assets were uprated, Transpower indicate the (N-1) rating would be 155/162 MVA (summer/winter).

These changes would increase the existing spare capacity from ≈30 MVA to ≈43 MVA (across the entire year) which would be sufficient to supply all ten of the indicated LCO's (which require 40.3MW/MVA)

Based on the above, Ergo's recommended option to increase the supply capacity at Invercargill GXP would be to replace the two 33kV incomer circuit breakers and cables (each assumed to be 100m in length).

Ergo's capital cost estimates for the option presented are outlined in the following Table 21.

Table 21 Invercargill GXP: Capital cost estimate for upgrading the Invercargill GXP[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Sub-transmission	Single underground 33kV cable	0.20	$0.10
Sub-transmission	33kV circuit breaker bay	2.00	$0.50
		TOTAL	**$0.60**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 12 - 18 months.

8.6.2 Open Country Dairy – Awarua

This LCO requires an additional 23.5 MW. Open County Dairy is currently supplied with 33 kV and 11 kV via The Power Company's Colyer substation. Colyer Road substation is fed by two 33kV circuits (predominantly overhead lines) from the Invercargill GXP.

Due to the size of the load, it is expected the new load would require a standalone new 33kV supply from Invercargill GXP with a new 33/11 kV 25MVA transformer installed at the Open Country Dairy site (the existing electrode boiler is supplied via an existing 33/11 kV, 10 MVA, transformer at the site).

Open Country Dairy Awarua is ≈12km from Invercargill GXP. The existing 33kV overhead lines supplying the Awarua area run an angled route between the two sites which results in the routes being largely rural. It is assumed a similar line path could be followed with a line length estimated to be ≈15km.

Based on the above, we expect the supply could involve:

- Two new indoor 33kV circuit breaker bays at Invercargill GXP
- A new double circuit 33kV overhead/cable supply from Invercargill GXP to the Open Country Dairy site (≈15km). Ergo has assumed that 12km would be via overhead line and 3km via underground cable.
- Two new 33/11 kV 25MVA transformers and indoor 11kV switchgear (assumed to be a medium sized zone substation.

Ergo's capital cost estimates for the option presented are outlined in the following Table 22. Note that this estimate does not include the costs to upgrade the Invercargill GXP (discussed in Section 8.6.1), or the installation of distribution transformers/switchgear on the Awarua dairy site.

Table 22 Open Country Dairy - Awarua: Capital cost estimate for an (N-1) supply to the LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	33kV circuit breaker bay	2.00	$0.50
Zone Substation	Medium zone substation	1.00	$8.00
Distribution	Double underground 33kV cable	3.00	$3.00
Distribution	Double overhead 33kV line	12.00	$4.80
		TOTAL	**$15.80**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

The above connection option assumes that Open Country Dairy require (N-1) security of supply. If a supply with (N) security is acceptable we expect the network upgrades would include the following:

- One new indoor 33kV circuit breaker bay at Invercargill GXP
- A new single circuit 33kV overhead/cable supply from Invercargill GXP to the Open Country Dairy site (≈15km). Ergo has assumed that 12km would be via overhead line and 3km via underground cable.
- A new 33/11 kV 25MVA transformer and indoor 11kV switchgear (assumed to be a small sized zone substation.

Ergo's capital cost estimates for an (N) supply are outlined in the following Table 23. Again, we note that this estimate does not include the costs to upgrade the Invercargill GXP (discussed in Section 8.6.1), or the installation of distribution transformers/switchgear on the Awarua dairy site.

Table 23 Open Country Dairy - Awarua: Capital cost estimate for an (N) supply to the LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	33kV circuit breaker bay	1.00	$0.25
Zone Substation	Small zone substation	1.00	$5.00
Distribution	Single underground 33kV cable	3.00	$1.80
Distribution	Single overhead 33kV line	12.00	$3.00
		TOTAL	**$9.80**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

There is also the potential to supply a portion of the LCO at a lower cost using the existing spare capacity available at PowerNet's Colyer zone substation which is indicated to have ≈14MW of (N) spare capacity (refer to Table 4). This spare capacity could be accessed provided PowerNet and the other consumers supplied from the Coyler substation accept (N) security of supply, or if the additional load is tripped/disconnected in the event of one of an outage of one of the Coyler 33/11kV transformers or the incoming 33kV lines. The supply of 14MW into the Open Country Dairy site would likely require the installation of additional 11kV switchgear at the Colyer zone substation coupled with additional underground 11kV cables from Coyler to the dairy site.

Ergo's capital cost estimates for a partial (N) supply are outlined in the following Table 26. Again, we note that this estimate does not include the costs for the installation of distribution transformers/switchgear on the Awarua dairy site.

Table 24 Open Country Dairy - Awarua: Capital cost estimate for partially supplying the LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	11kV circuit breaker (ZSS)	4.00	$0.40
Distribution	Special protection system (ZSS)	1.00	$0.25
Distribution	Single underground 11kV cable	1.60	$0.64
		TOTAL	**$1.29**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 9 - 12 months.

8.6.3 Ministry of Health – Southland Hospital

This LCO requires an additional 6.1 MW. Southland Hospital is currently supplied via an 11kV supply from Seaward Bush zone substation which has a spare capacity of ≈2 MVA. Seaward Bush is supplied through two 33 kV overhead feeder circuits (equipped with Cockroach conductors[34]) from the Invercargill GXP which would be capable of supplying the additional load.

Therefore, it is expected Southland Hospital would require a new standalone 11kV supply from Seaward Bush substation. Additionally, the two 33/11 kV transformers would likely need to be upgraded to 15 MVA each.

Based on the above, we expect the supply could involve:

- Two new 33/11 kV 15MVA transformers at Seaward Bush substation.
- A new 11kV indoor circuit breaker.
- A new single circuit, large capacity, 11kV underground cable from Seaward Bush substation to Southland Hospital, running west down Stirrat St from the substation and then Northward up Elles Road to the hospital (a total distance of ≈2.5km).

Ergo's capital cost estimates for the option presented above are outlined in the following Table 25. Note that this estimate does not include the costs of installation of distribution transformers/switchgear on the hospital site.

Table 25 Southland Hospital: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Medium supply transformer (ZSS)	2.00	$2.00
Distribution	11kV circuit breaker bay	1.00	$0.10
Distribution	Single underground 11kV cable	2.50	$1.00
		TOTAL	**$3.10**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 12 - 18 months.

[34] https://www.prysmiancable.co.nz/documents/bohc-catalogue.pdf/

8.6.4 South Pacific Meats (AFFCO) - Awarua

This LCO requires an additional 4.0 MW. South Pacific Meats is currently supplied with 11 kV via The Power Company's Colyer Road substation. Colyer Road substation is fed by two 33kV circuits (predominantly overhead lines) from the Invercargill GXP and has ≈2MVA of spare N-1 Capacity.

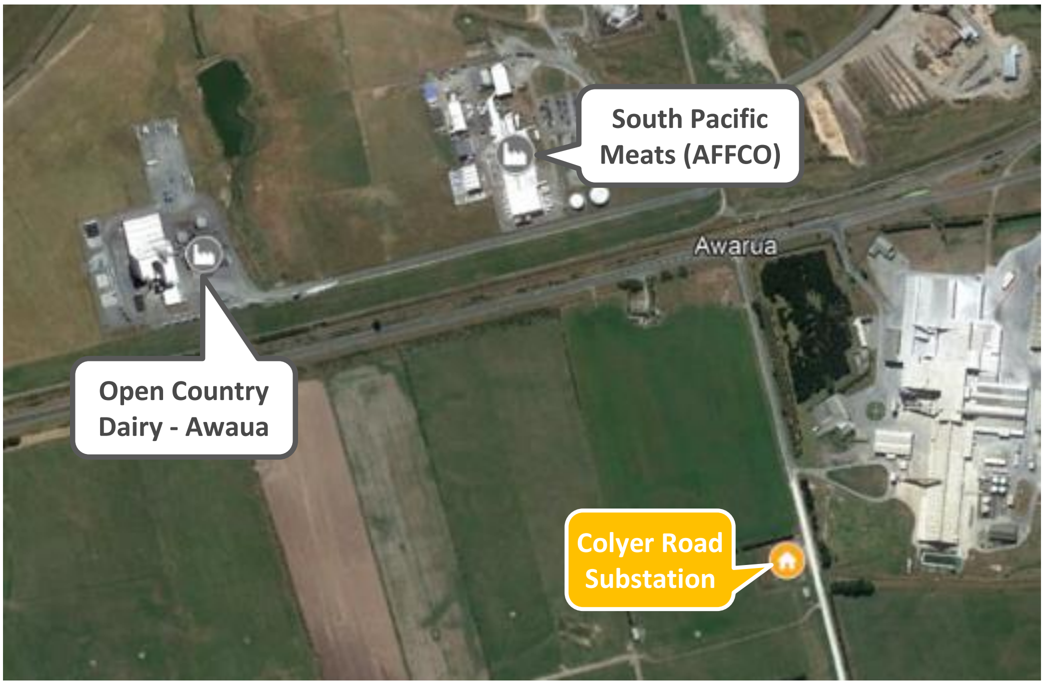

Figure 35 South Pacific Meats location in relation to Colyer Road Substation and Open Country Dairy

Therefore, it is expected South Pacific Meats would require a new standalone 11kV supply from Colyer substation. Additionally, the two 33/11 kV transformers would likely need to be upgraded to 15 MVA each.

Based on the above, we expect the supply could involve:

- Two new 33/11 kV 15MVA transformers at Colyer Road substation.
- A new 11kV indoor circuit breaker.
- A new single circuit 11kV underground cable from Colyer Road substation to South pacific meats, running North up Colyer Road from the substation and then Westward down Bluff highway to the South Pacific Meats (a total distance of ≈0.9km).

Ergo's capital cost estimates for the option presented above are outlined in the following Table 25. Note that this estimate does not include the costs associated with the installation of distribution transformers/switchgear on the LCO site.

Table 26 South Pacific Meats: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Medium supply transformer (ZSS)	2.00	$2.00
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	0.90	$0.36
		TOTAL	**$2.46**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 18 - 24 months.

8.6.5 Presbyterian Support – Peacehaven Village

This LCO requires an additional 2.3 MW. Peacehaven is currently supplied via an 11kV supply from Southern zone substation which has a spare capacity of ≈8 MVA. Southern is supplied through a single 33 kV feeder from Invercargill GXP.

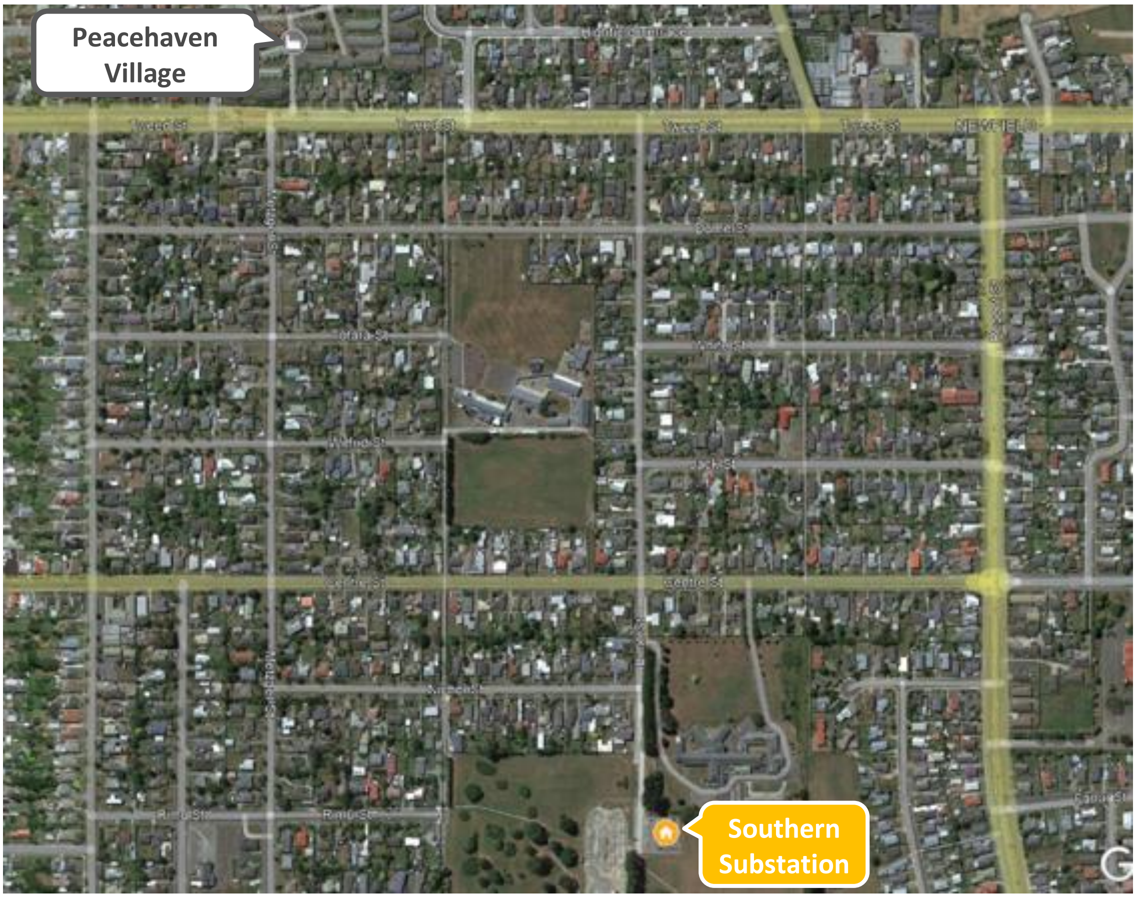

Figure 36 Peacehaven geographic location in relation to the Southern substation

Due to the size of the new load and the existing 11kV cable being highly loaded (peak of 7.1 MVA), it is likely the additional load would require a standalone 11kV feed from Southern zone substation.

Based on the above, we expect the supply could involve:

- A new 11kV indoor circuit breaker at Southern zone substation.
- A new single circuit 11kV underground cable from Southern substation to Peacehaven Village, running Northward up Lime St from the substation, Westward up Tweed St and then Northward up Miller St to the Peacehaven Village (a total distance of ≈1.4km).
- An 11kV ring main unit (RMU - distribution switch) at Peacehaven Village.

Ergo's capital cost estimates for the option presented are outlined in the following Table 27. Note that this estimate does not include the installation of distribution transformers on the Peacehaven Village site.

Table 27 Peacehaven Village: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	11kV circuit breaker bay	1.00	$0.10
Distribution	Single underground 11kV cable	1.40	$0.56
Distribution	Distribution switches - RMU	1.00	$0.05
		TOTAL	**$0.71**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 12 - 18 months.

8.6.6 Southland Institute of Technology

This LCO requires an additional 1.9 MW. The Southern Institute of Technology appears to be supplied via an 11kV feeder from Spey Street zone substation which has a spare (N-1) capacity of ≈8MVA summer/winter. Spey St is supplied via two 33 kV feeder's from Invercargill GXP.

Figure 37 Southern Institute of Technology geographic location in relation to the Spey St substation

The 11kV feeder (Spey 9) supplying the Southern Institute of Technology appears to be heavily loaded (peak of 4.7 MVA).

Based on the above, it appears to Ergo, the LCO could be supplied via one the following options:

- **Option 1:** Transfer existing load from the 11kV supply to an adjacent lightly loaded feeder to enable sufficient headroom to connect the LCO.
- **Option 2**: The installation of another 11kV circuit breaker and underground circuit (≈0.5km) from Spey St Substation heading southward down Jed St, westward down Tay St to the Southern Institute of Technology campus. This does rely on there being sufficient room in the existing switchroom to install the circuit breaker. However, a fall back option could involve the installation of an RMU in an existing 11kV feeder to supply the LCO, which would involve a cost of a similar order.

Ergo's capital cost estimates for the two options are outlined in the following Table 28. Note that this estimate does not include the costs for the installation of distribution transformers/switchgear that will likely be required on the institute's site.

Table 28 Southern Institute of Technology: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost (M$)			
		Option 1		Option 2	
Zone Substation	11kV Circuit breaker bay	0.00	$0.00	1.00	$0.10
Distribution	Single underground 11kV cable	0.00	$0.00	0.50	$0.20
Distribution	Distribution switches - RMU	0.00	$0.00	1.00	$0.05
		TOTAL	**$0.00**		**$0.35**

The following delivery timeframes are provided as indication (exclusive of consenting lead times):

- Option 1 – 3 months
- Option 2 – 12 – 18 months

8.6.7 ILT - Ascot Park Hotel

This LCO requires an additional 1.6 MW. Ascot Park Hotel is currently supplied via a lightly loaded 11kV feeder from Racecourse Road zone substation which has a spare capacity of ≈11MVA on its single operational transformer (i.e. N security). Racecourse Road does have a second transformer but it appears, to Ergo, this is normally offline. Racecourse Road is supplied through a single 33 kV feeder from Invercargill GXP which should be capable of supplying the additional load.

Figure 38 Ascot Park Hotel geographic location in relation to the Racecourse Road substation

Based on the above, it is Ergo's view that the additional 1.6 MW could be supplied to the LCO via the existing connection arrangement. Also, the fact that we expect distribution transformers/switchgear would need to be installed on the Ascot Park Hotel site to supply the new LCO equipment (Ergo does not have these details). In the absence of specific details Ergo has assumed that a RMU and four distribution transformers would be required to supply the LCO equipment.

Ergo's capital cost estimates for the option presented are outlined in the following Table 29.

Table 29 Ascot Hotel: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Distribution switches - RMU	1.00	$0.05
Distribution	500kVA distribution tx	4.00	$0.52
		TOTAL	**$0.57**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.6.8 ILT Stadium Southland

This LCO requires an additional 0.9 MW. Stadium Southland is currently supplied via an 11kV feeder (with an existing peak load of 4.1 MVA) from Spey Street zone substation which has a spare (N-1) capacity of ≈8MVA summer/winter. Spey St is supplied through by two 33 kV feeder's from Invercargill GXP.

Figure 39 Stadium Southland geographic location in relation to the Spey Street substation

Based on the above, it appears to Ergo, the LCO could be supplied via one the following options:

- **Option 1:** Transfer existing load from the 11kV supply to an adjacent lightly loaded feeder to enable sufficient headroom to connect the Stadium Southland.
- **Option 2**: The installation of another 11kV circuit breaker and underground circuit from Spey St Substation heading northward up Jed St, eastward along Yarrow Street, southward down Isabella Street with a distribution switch at the Stadium southland (≈2.1km).

Ergo's capital cost estimates for the two options are outlined in the following Table 30. Note that this estimate does not include the costs to for the installation of distribution transformers/switchgear that may be required on the stadium's site.

Table 30 Stadium Southland: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost (M$)			
		Option 1		Option 2	
Zone Substation	11kV Circuit breaker bay	0.00	$0.00	1.00	$0.10
Distribution	Single underground 11kV cable	0.00	$0.00	2.10	$0.84
Distribution	Distribution switches - RMU	0.00	$0.00	1.00	$0.05
		TOTAL	**$0.00**		**$0.99**

The following delivery timeframes are provided as indication (exclusive of consenting lead times):

- Option 1: 3 months
- Option 2: 12 – 18 months

8.6.9 Downers Roading Invercargill

This LCO requires an additional 1.4 MW. Downer's Roading is supplied via an 11kV feeder from Bluff zone substation which has a spare (N-1) capacity of ≈2.5/8.5 MVA summer/winter. Bluff zone substation is supplied by two 33 kV feeder's from Invercargill GXP which run via Colyer Road zone substation.

While Ergo hasn't been able to confirm the specific feeder supplying Downer Roading, two of the three 11kV feeders appear to be capable of supplying the additional load.

Figure 40 Downer Roading geographic location in relation to the Bluff substation

Based on the above, it appears to Ergo, the LCO could be supplied via one the following options:

- **Option 1:** Transfer the existing load from the 11kV supply to an adjacent lightly loaded feeder to enable sufficient headroom to connect the LCO.
- **Option 2**: The installation of another 11kV circuit breaker and underground circuit (≈2.1km) from Bluff Substation heading south-eastward down ocean beach road (SH1) and across the rail tracks at a desirable location with a distribution switch at the LCO.

Assuming that supply Option 1 is possible Ergo expect that some additional distribution switchgear and transformers would be required. In the absence of specific details Ergo has assumed that a RMU and two distribution transformers would be required to supply the LCO equipment.

Ergo's capital cost estimates for option 1 presented are outlined in the following Table 31.

Table 31 Downers Roading: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Distribution switches - RMU	1.00	$0.05
Distribution	750kVA distribution tx	2.00	$0.40
		TOTAL	**$0.40**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.6.10 Invercargill Prison

This LCO requires an additional 1.3 MW. Invercargill Prison appears to be supplied via two 11kV feeders from Leven Street zone substation which has a spare (N-1) capacity of ≈9 MVA. The two feeder's supplying the prison, LEV12 and LEV13 have a current peak load of 2.2 MVA and 3.6 MVA respectively. Leven St is supplied through by a single 33 kV feeder from Invercargill GXP.

Figure 41 Leven Street geographic location in relation to the Leven St substation

Based on the above and the minimal proposed load increase, it is Ergo's view that the additional 1.3 MW could be supplied to the LCO via the existing connection arrangement. We expect some distribution transformers/switchgear would need to be installed on the prison site to supply the new LCO equipment (Ergo does not have these details). In the absence of specific details Ergo has assumed that a RMU and two distribution transformers would be required to supply the LCO equipment.

Ergo's capital cost estimates for the option presented are outlined in the following Table 32.

Table 32 Invercargill Prison: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Distribution switches - RMU	1.00	$0.05
Distribution	750kVA distribution tx	2.00	$0.40
		TOTAL	**$0.40**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.6.11 Prime Range Meats

This LCO requires an additional 1.2 MW. Prime Range Meats appears to be supplied via an 11kV feeder from Waikiwi zone substation which has a spare (N-1) capacity of ≈10MVA. The feeder supplying the LCO appears to have a peak load of 3.7 MVA. Waikiwi substation is normally supplied by a single 33 kV feeder from Invercargill GXP with a second feed available from North Makarewa via Underwood zone substation.

Figure 42 Prime Range Meats geographic location in relation to the Waikiwi substation

Based on the above, it appears to Ergo, the LCO could be supplied via one the following options:

- **Option 1:** Transfer existing load from the 11kV supply to an adjacent lightly loaded feeder to enable sufficient headroom to connect the Prime Range Meats.
- **Option 2**: The installation of another 11kV circuit breaker and underground circuit (≈2.5km) from Waikiwi Substation heading northward up Munro St, westward along Bainfield Rd, northward up SH6 and westward down West Plains Road with a distribution switch at the LCO.

Ergo's capital cost estimates for the two options are outlined in the following Table 33. Note that this estimate does not include the costs for the installation of distribution transformers/switchgear that may be required on the Prime Range Meats site.

Table 33 Prime Range Meats: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost (M$)			
		Option 1		Option 2	
Zone Substation	11kV Circuit breaker bay	0.00	$0.00	1.00	$0.10
Distribution	Single overhead 11kV line	0.00	$0.00	0.00	$0.00
	Single underground 11kV cable	0.00	$0.00	2.50	$1.00
	Distribution switches - RMU	0.00	$0.00	1.00	$0.05
		TOTAL	**$0.00**		**$1.15**

The following delivery timeframes are provided as indication (exclusive of consenting lead times):

- Option 1: 3 months
- Option 2: 12 – 18 months

8.6.12 Great Southern Invercargill

This LCO requires an additional 0.9 MW. Great Southern Invercargill appears to be supplied via an 11kV feeder from Waikiwi zone substation which has a spare (N-1) capacity of ≈10MVA. The feeder supplying the LCO has a peak load of 3.7 MVA. Waikiwi substation is normally supplied by a single 33 kV feeder from Invercargill GXP with a second feed available from North Makarewa via Underwood zone substation. The overhead 11kV line that supplies the site has a relatively small capacity conductor (19/1.365Cu) and thus Ergo is of the view that the supply of the LCO using the existing line would not be possible.

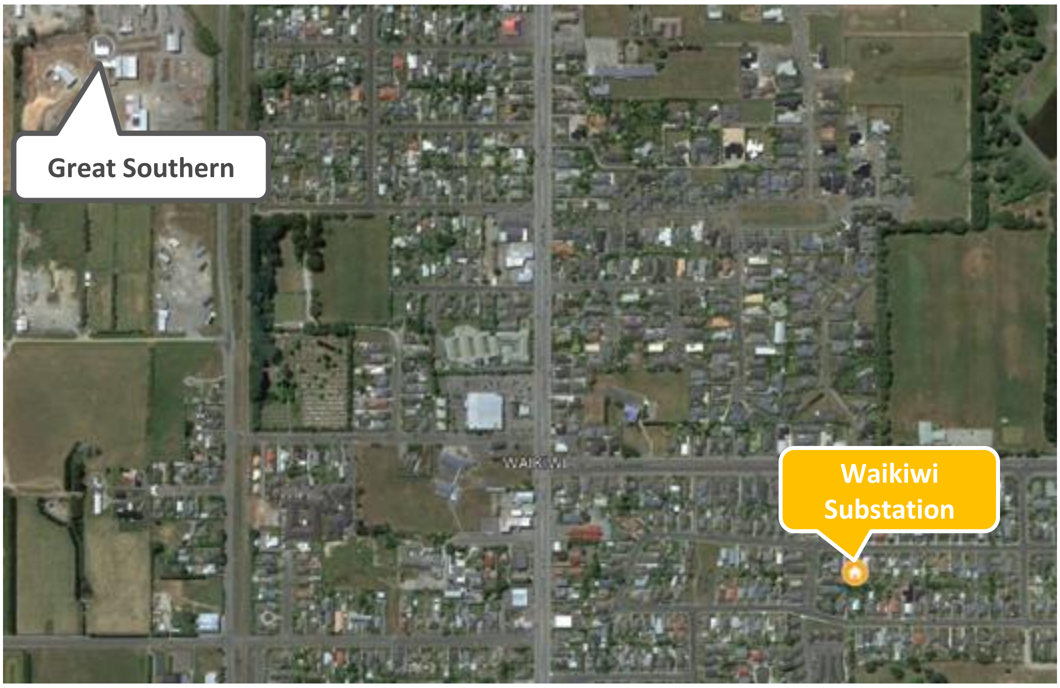

Figure 43 Great Southern Invercargill geographic location in relation to the Waikiwi substation

Ergo has looked at the loadings on the four 11kV feeders out of the Waikiwi substation and WAI6 is relatively lightly loaded and could potentially supply the LCO.

Based on the above, it appears to Ergo, the LCO could be supplied via one the following options:

- **Option 1:** Upgrade of a 1km section of existing 11kV line (along Western Plains Rd and Gloucester Street) that connects to a higher capacity 11kV line (Cricket conductor) in Durham Street.
- **Option 2**: The installation of a 1.8km underground cable heading south-eastward (along Western Plains Rd, Gloucester Street, Durham Street and Banfield Road) close-in to the Waikiwi zone substation in order to connect into the WAI6 feeder.

Ergo has assumed that Option 2 would be required to supply the LCO and our capital cost estimates for the option presented are outlined in the following Table 34. However, we note that we expect distribution transformers/switchgear would need to be installed on the LCO site to supply the new plant (Ergo does not have these details). In the absence of specific details Ergo has assumed that a RMU and two distribution transformers would be required to supply the LCO equipment.

Table 34 Great Southern Invercargill: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Single underground 11kV cable	1.80	$0.72
Distribution	Distribution switches - RMU	2.00	$0.10
Distribution	500kVA distribution tx	2.00	$0.26
		TOTAL	**$1.08**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.6.13 CRT Farmlands – Winton Feedstock

This LCO requires an additional 0.6 MW. Winton Feedstock appears to be supplied via an 11kV feeder from Leven Street zone substation which has a spare (N-1) capacity of ≈9 MVA. The feeder's supplying LCO is LEV13 which has a peak load of 3.6 MVA. Leven St is supplied through by a single 33 kV feeders from Invercargill GXP.

Figure 44 CRT Farmlands - Winton Feedstock geographic location in relation to the Leven Street substation

Based on the above, it is Ergo's view that the additional 0.6 MW could be supplied to the LCO via the existing connection arrangement. However, we note that we expect distribution transformers/switchgear would need to be installed on the CRT Farmlands site to supply the new LCO equipment (Ergo does not have these details).

In the absence of specific details Ergo has assumed that a RMU and two distribution transformers would be required to supply the LCO equipment.

Ergo's capital cost estimates for the option presented are outlined in the following Table 35.

Table 35 Winton Feedstock: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Distribution switches - RMU	1.00	$0.05
Distribution	500kVA distribution tx	2.00	$0.26
		TOTAL	**$0.26**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.6.14 Kelvin Hotel

This LCO requires an additional 0.4 MW. Kelvin Hotel appears to be supplied via an 11kV feeder (Ergo was unable to confirm the feeder details) from Spey Street zone substation which has a spare (N-1) capacity of ≈6/14 MVA summer/winter. Spey St is supplied through by two 33 kV feeder's from Invercargill GXP.

Figure 45 Kelvin Hotel geographic location in relation to the Spey St substation

Based on the above and the minimal proposed load increase and the fact the majority of Spey feeders have spare capacity (excluding Spey 14 which has a peak of 4.7 MVA), it is Ergo's view that the additional 0.4 MW could be supplied to the LCO via the existing connection arrangement. However, we do expect the installation of an RMU and 500kVA distribution transformer as outlined in the following Table 36.

Table 36 Kelvin Hotel: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Distribution switches - RMU	1.00	$0.05
Distribution	500kVA distribution tx	1.00	$0.13
		TOTAL	**$0.18**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.7 North Makarewa GXP

The EECA LCO's include:

- Alliance Lorneville (23 MW)
- Fiordland Hotel (0.13MW)
- Southland District Council Fiordland (SDCF) Community Swimming Pool (0.62MW)

The geographic location of the LCO's are shown on the following Figure 46 and Figure 47 in relation to the local transmission and distribution substations.

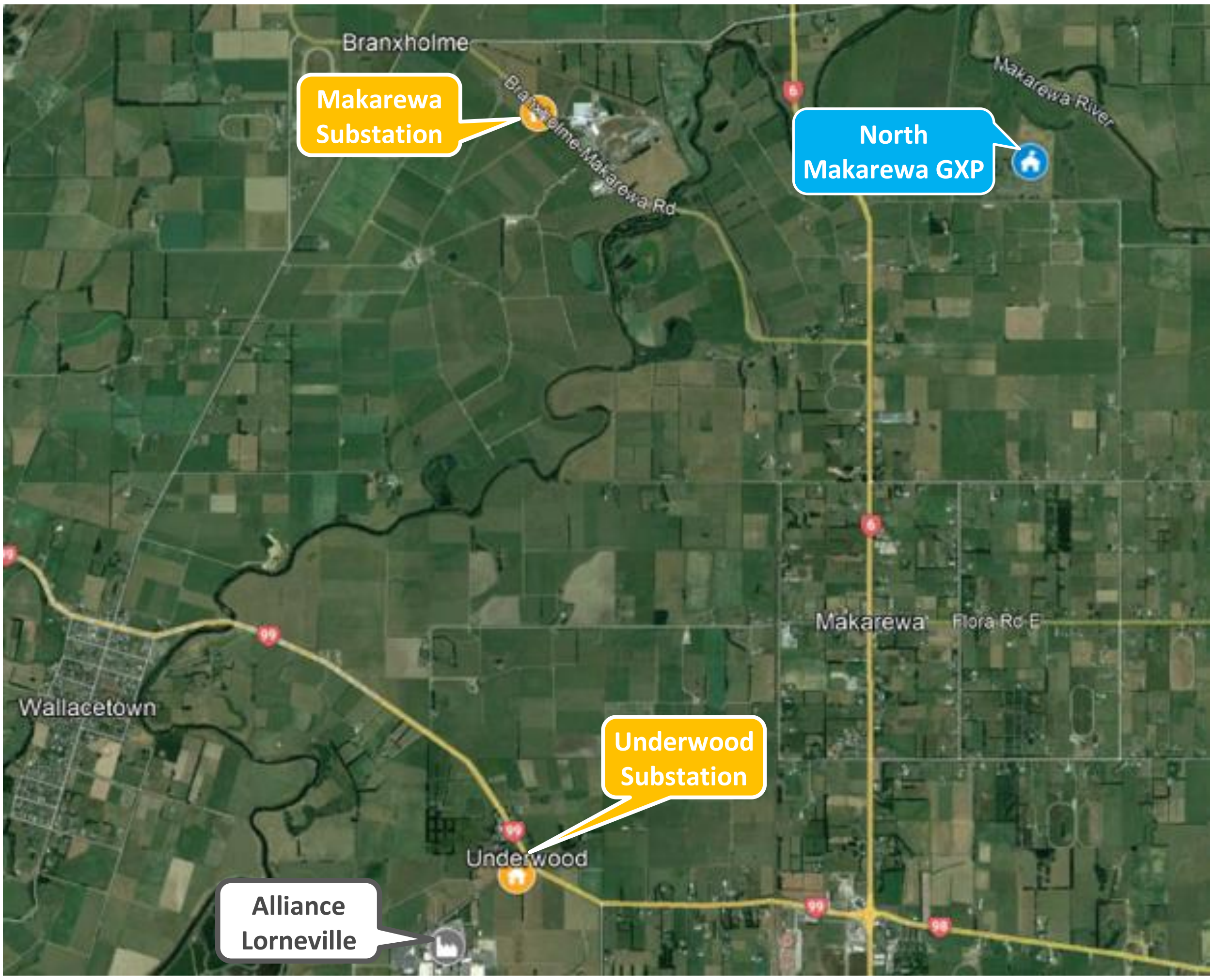

Figure 46 North Makarewa: Alliance Lorneville opportunity vs local substations

Figure 47 North Makarewa: SDCF Community Swimming Pool and Fiordland Hotel load conversion opportunities vs local substations

8.7.1 North Makarewa GXP Upgrade

North Makarewa GXP currently has ≈16MVA of spare capacity at the substation across the entire year. Due to the GXP being supplied by eight incoming 220kV lines, the surrounding 220kV network is not an immediate constraint. Additionally, Transpower documents indicate that the existing 67/67 MVA summer/winter (N-1) rating of the substation is based on cables and disconnectors at the site. If these were replaced/resolved, the substation capacity would increase to 76/79 MVA.

Based on the above, it appears to Ergo, the GXP could be upgraded via one the following options:

- **Option 1:** Replace the constraining cables and disconnectors, increasing the (N-1) rating of the GXP to 76/79 MVA summer/winter and increasing the spare capacity to 24/27 MVA summer/winter.
- **Option 2**: Replace the existing 220/33kV 60 MVA transformers with 220/33kV 80 MVA supply transformers.

Ergo's capital cost estimates for Option 1 and 2 presented above are outlined in the following Table 37

Table 37 North Makarewa GXP: Capital cost estimate for upgrading the Makarewa GXP[33]

Network Asset	Equipment	Number and Capital Cost (M$)			
		Option 1		Option 2	
Transmission	Medium supply transformer (GXP)	0.00	$0.00	2.00	$7.00
Sub-transmission	33kV circuit breaker bay	0.00	$0.00	2.00	$0.50
Sub-transmission	Upgrade cables and disconnectors	0.00	$0.50	0.00	$0.00
		TOTAL	**$0.50**		**$7.50**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around:

- Option 1: 12 – 18 months
- Option 2: 24 – 36 months

8.7.2 Alliance Lorneville

This LCO involves a significant load of 23 MW. The plant is located close-in to The Power Company's Underwood zone substation, which only has a spare capacity of 9 MW. The supply of 23 MW is expected to require additional sub-transmission circuits to be constructed from the North Makarewa GXP to the Alliance Lorneville site. However, the North Makarewa GXP only has spare (N-1) capacity of 16MVA (refer to Section 6.1.8) so an upgrade of the North Makarewa GXP, as per Option 1 discussed in Section 8.7.1 would be required.

In addition, we expect the supply would involve the following:

- Expansion of The Power Company's Underwood zone substation to include the addition of the following:
    - 2 x 35 MVA transformers.
    - A new 33kV switchboard (5 circuit breakers).
    - A new 11kV switchboard (9 circuit breakers).
    - A new switch-room and ancillary equipment.
- Two new 33kV circuits from North Makarewa GXP to the LCO site, which have been assumed to consist of 50% overhead line and 50% underground cable.
- Two new 33kV circuit breakers at the North Makarewa GXP.

Ergo's capital cost estimates for the option presented are outlined in the following Table 38.

Table 38 Alliance Lorneville: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	33kV circuit breaker bay	2.00	$0.50
Zone Substation	Large zone substation	1.00	$10.00
Distribution	Double overhead 33kV line	4.00	$1.60
	Double underground 33kV cable	4.00	$4.00
		TOTAL	**$15.60**

We also note that The Power Company's 2021 AMP[35] indicates that the Underwood power transformers are in need of refurbishment/replacement, and that the first Underwood transformer would be replaced in 2021 followed by the second unit in 2022.

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 24 - 36 months.

[35] https://powernet.co.nz/disclosures/the-power-company/asset-management-plans/

8.7.3 Fiordland Hotel

The Fiordland Hotel is supplied via an 11kV feeder from The Power Company's Te Anau, 66/11kV, zone substation, which in turn is supplied from the North Makarewa GXP. This substation has a spare capacity of approximately 5MVA and the supply of the small LCO of 0.13MW via the existing 11kV network should be possible.

Ergo's capital cost estimates for the option presented are outlined in the following Table 39.

Table 39 Fiordland Hotel: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	200kVA distribution tx	1.00	$0.08
		TOTAL	**$0.08**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 2 - 4 months.

8.7.4 Southland District Council Fiordland (SDCF) Community Swimming Pool

The SDCF Community Swimming Pool is supplied via an 11kV feeder from The Power Company's Te Anau, 66/11kV, zone substation, which in turn is supplied from the North Makarewa GXP. This substation has a spare capacity of approximately 5MVA and the supply of the small LCO of 0.62MW via the existing 11kV network should be possible.

Ergo's capital cost estimates for the option presented are outlined in the following Table 40.

Table 40 SDCF Community Swimming Pool: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	750kVA distribution tx	1.00	$0.20
		TOTAL	**$0.20**

In terms of timeframes, Ergo estimates the above works, excluding consenting times, would take around 3 - 6 months.

8.8 LCO Coordination Efficiencies

Ergo has evaluated the supply of the LCO's from a scope and cost perspective independently and in most cases it is unlikely there would be cost efficiencies in coordinating LCO's to share the infrastructure upgrade costs at either the GXP or local zone substation. This is primarily driven by the fact there are no two LCOs that trigger an upgrade of the same GXP or zone substation. However, the concept of coordinating upgrades to share the investment costs could be beneficial in certain scenarios and should be explored as alternative LCO's arise.

For the purpose of demonstrating this, Ergo has provided the example below (which we believe is the best example within the supplied LCOs).

8.8.1 Open Country Dairy and South Pacific Meats - Awarua

The Open County Dairy and South Pacific Meats LCO's are within 400m of each. If both opportunities proceeded, this would result in 27.5MW of additional load. These LCO's could be supplied via a new double circuit 33kV supply from Invercargill GXP (no GXP upgrades would be required) with a new 30 MVA 33/11kV zone substation situated near the two LCOs with 11kV feeders supplying both sites (assumed to be three double circuit 11kV cables supplying Open Country Dairy and one 11kV single circuit cable supplying South Pacific Meats).

Ergo's capital cost estimates for the option presented are outlined in the following Table 41.

Table 41 Open Country Dairy and South Pacific Meats combined: Capital cost estimate to supply LCO[33]

Network Asset	Equipment	Number and Capital Cost ($M)	
Transmission	33kV circuit breaker bay	2.00	$0.50
Zone Substation	Medium zone substation	1.00	$8.00
Distribution	Double underground 33kV cable	3.00	$3.00
Distribution	Double overhead 33kV line	12.00	$4.80
Distribution	Double underground 11kV cable	0.60	$0.42
Distribution	Single underground 11kV cable	0.20	$0.08
		TOTAL	**$16.80**

The estimated $16.8M to supply the two LCO's is $1.46M less than the estimate to supply the LCO's individually (discussed in Sections 8.6.2 and 0).

9. Conclusions

9.1 Network Spare Capacity

The following Figure 48 illustrates the (N) and (N-1) spare capacity at the Transpower GXP substations in the Southland Region.

Southland Region: GXP Substations: Spare (N) and (N-1) Capacity

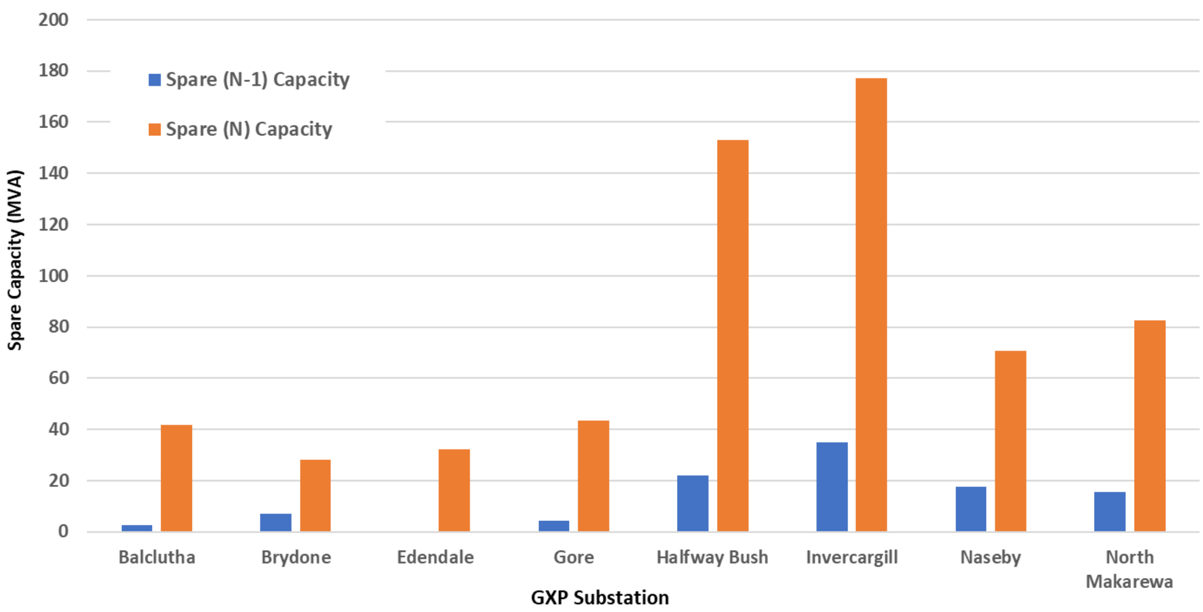

Figure 48 Summary: Approximate (N) and (N-1) spare capacity at GXP substations

The following figures illustrate the (N) and (N-1) spare capacity at the EDB Zone Substations in the Southland Region. These figures are based off the maximum loadings and the EDB 2021 disclosures.

The Power Company Zone Substations: Spare (N) and (N-1) Capacity

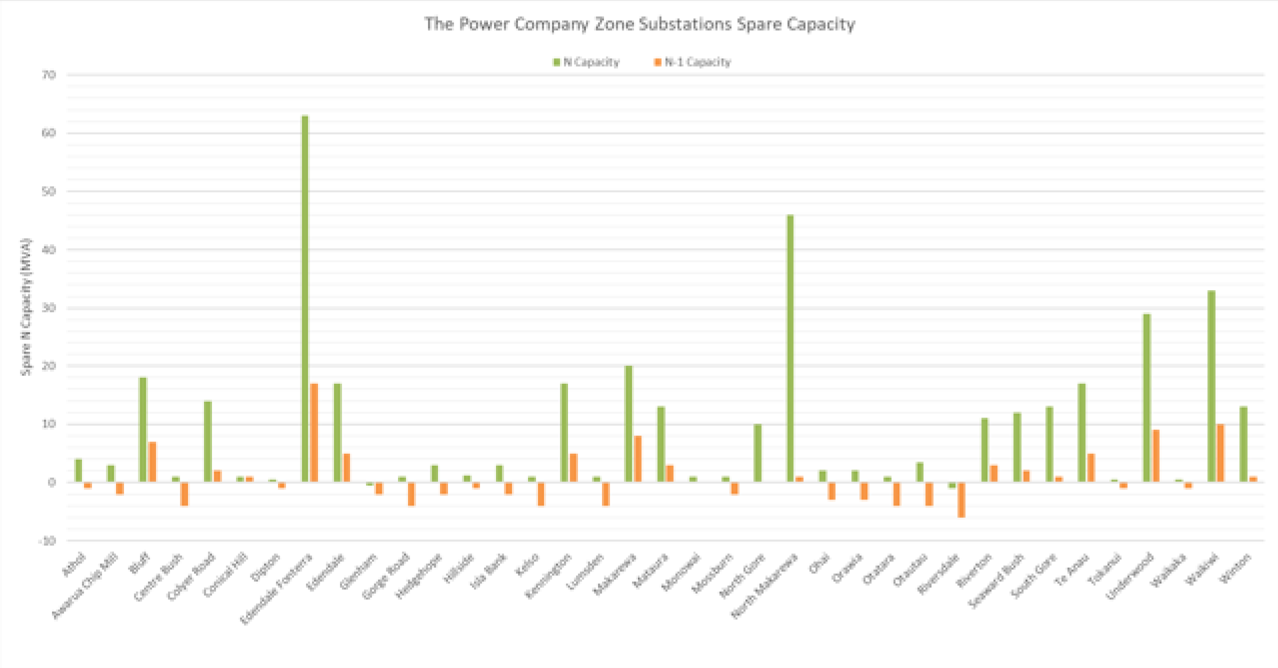

Figure 49 Summary: Approximate (N) and (N-1) spare capacity at The Power Company zone substations

Electricity Invercargill Zone Substations: Spare (N) and (N-1) Capacity

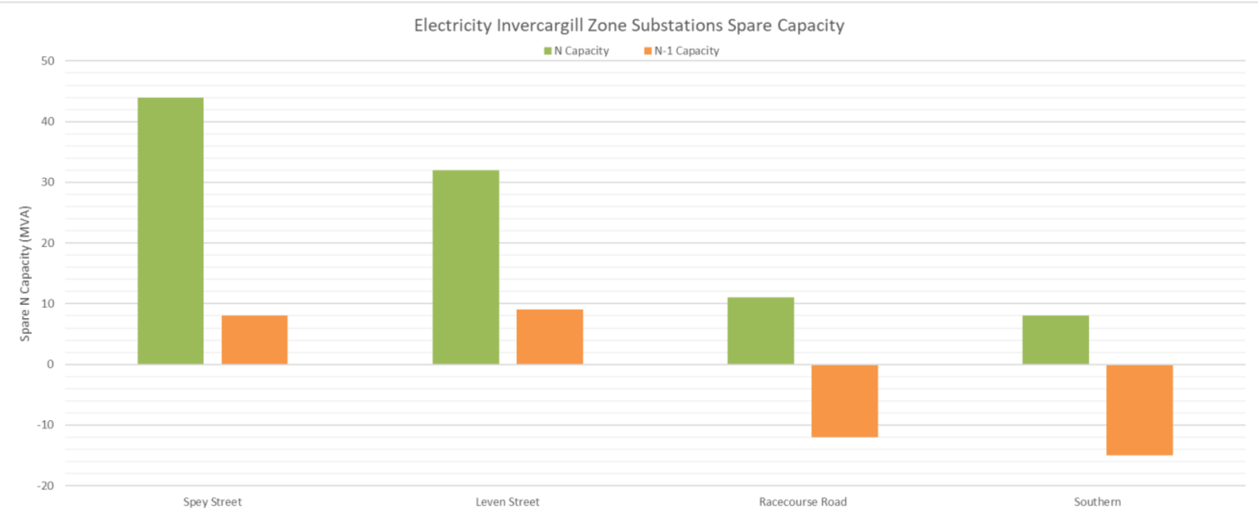

Figure 50 Summary: Approximate (N) and (N-1) spare capacity at Electricity Invercargill zone substations

OtagoNet Zone Substations: Spare (N) and (N-1) Capacity

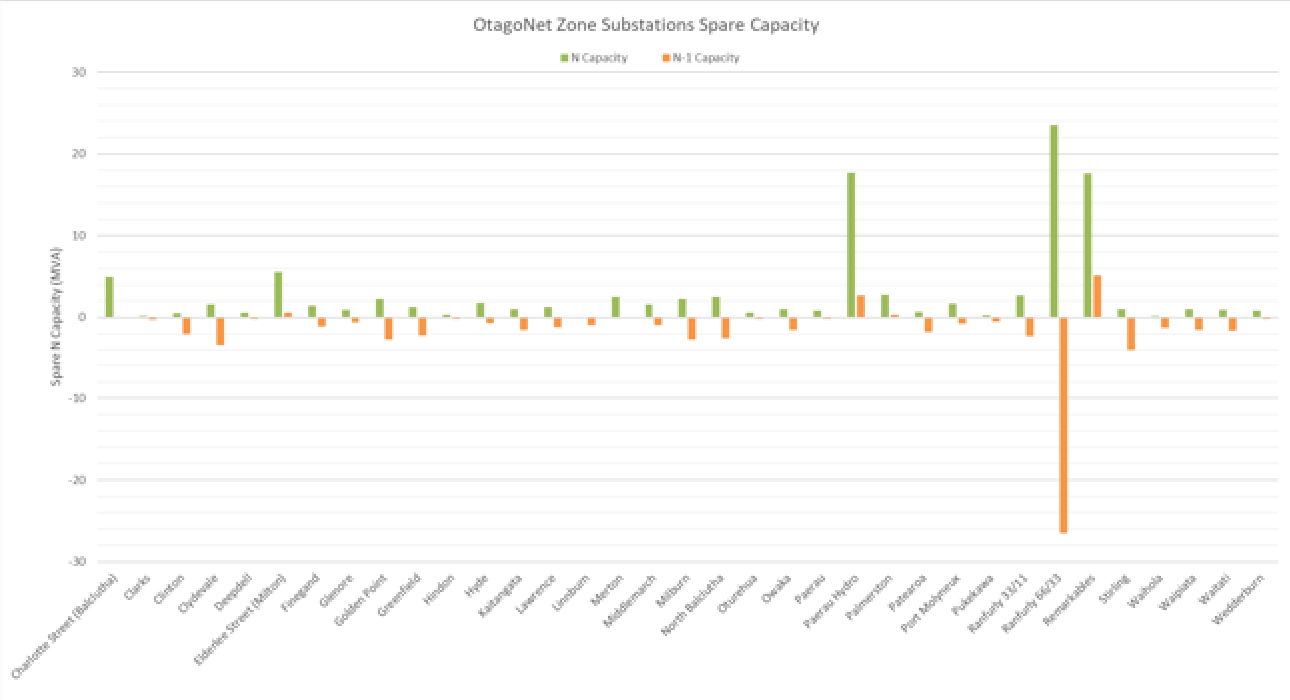

Figure 51 Summary: Approximate (N) and (N-1) spare capacity at OtagoNet zone substations

9.2 Load Characteristics

The substation load characteristics are documented in detail in the main body of the report (and the supplementary document 21177-RPT-0002) vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

- **GXP substations:**
  - *Balclutha*. A typical mix of residential and commercial/industrial loads. The load tends to peak in the mornings and evenings and is lower during weekends.
  - *Brydone*. Predominantly commercial/industrial, with significant variations in load occurring at different times of the day due to changes industrial processing or distributed generation.
  - *Edendale*. Predominately based on the dairy industry with a significant reduction during June/July during which the industry has its major shutdowns.
  - *Gore.* Predominantly residential load, with the load peaking in the mornings/evenings and very lightly loaded in the early hours of the morning. Some evidence of load reduction during weekends.
  - *Halfway Bush.* The load profile is affected significantly by the intermittent power injected by the Mahinerangi wind, and thus not particularly predictable.
  - *Invercargill.* A typical mix of residential and commercial/industrial loads. The load tends to peak in the mornings and evenings and is lower during weekends.
  - *Naseby*. Predominantly industrial, with significant variations in load occurring at different times of the day/week due to changes industrial processing.

- *North Makarewa*. The load profile is affected significantly by the intermittent power injected by the White Hill windfarm, and thus not particularly predictable.
- *Tiwai.* The load profile is very constant as the substation supplies an aluminium smelter.

- **Zone Substations**:

  The load characteristics of the zone substations vary widely depending on the connected consumers/generators.

9.3 EECA Load Conversion Opportunities (LCO)

The following table shows EECA's Load Conversion Opportunities (LCO) together with:

- The peak electrical power requirements of the LCO.
- The distribution zone substation to which the LCO would connect.
- The transmission substation which supplies the relevant zone substation.
- Ergo's estimate of the capital cost to significantly increase the capacity of the relevant transmission substation.
- Ergo's estimate of the capital cost to install the necessary distribution assets to supply the LCO.
- The cost efficiency associated with the LCO in terms of $M/MW
- The 'complexity' of connection based on the level of upgrades required

The costs are preliminary and Ergo is of the view that they have an accuracy of Class 5[36], which is suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details)

Disclaimer: The LCO supply investigations and capital cost estimates outlined in this report are preliminary and are only suitable for screening purposes. The capital cost estimates should not be used be used for final budgeting purposes in order to connect the respective LCO's.

[36] Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries, AACE International Recommended Practice No. 18R-97.

Summary: LCO's vs transmission/distribution capital cost estimates

Table 42 Summary of LCO's and estimated capital costs

No.	Opportunity Name	Load (MW)	Transmission			Distribution		TOTAL	Cost Efficiency	Complexity of Connection	Refer to notes
			GXP Substation	Substation Costs (M$)	Line Costs (M$)	Zone Substation	Costs ($M)	Costs ($M)	($M/MW)		
1	Silver Fern Farms Finegand	8.0	Balclutha	$7.50	$0.00[4]	Finegand	$5.15	**$12.65**	**$1.58**	Major	2
2	Balclutha Hospital	5.1		$0.00[4]		Charlotte St	$3.50	**$3.50**	**$0.69**	Moderate	2
3	Balclutha Swimming Pool	0.6				Charlotte St	$0.20	**$0.20**	**$0.33**	Minor	
4	Great Southern Milton	0.9				Elderlee St	$0.20	**$0.20**	**$0.22**	Minor	
5	Fonterra Edendale	85.0	Edendale	$13.00	$16.00	New	$25.50	**$54.50**	**$0.64**	Major	1,2,3
6	Blue Sky Meats	4.1		$0.00[4]	$0.00[4]	Edendale	$3.70	**$3.70**	**$0.90**	Minor	2
7	Alliance Mataura	4.0	Gore	$0.00	$0.00[4]	Mataura	$0.12	**$0.12**	**$0.03**	Minor	2
8	Silver Fern Farm Waitane	1.0				South Gore	$0.10	**$0.10**	**$0.10**	Minor	
9	Mataura Valley Milk	15.0		$7.00	$0.00[4]	South Gore	$17.70	**$24.70**	**$1.65**	Major	2,3
10	Open Country Dairy Awarau	23.5	Invercargill	$0.00	$0.00[4]	Coyler Rd	$15.80	**$15.80**	**$0.67**	Moderate	2,3
11	Southland Hospital	6.1				Seaward Bush	$3.10	**$3.10**	**$0.51**	Moderate	2
12	South Pacific Meats	4.0				Colyer Rd	$2.46	**$2.46**	**$0.62**	Moderate	2
13	Peacehaven Village	2.4				Southern	$0.71	**$0.71**	**$0.30**	Minor	
14	Southern Inst of Technologo	1.9				Spey St	$0.35	**$0.35**	**$0.18**	Minor	
15	Ascot Park Hotel	1.5				Racecourse Rd	$0.57	**$0.57**	**$0.38**	Minor	
16	ITL Stadium Southland	0.9				Spey St	$0.99	**$0.99**	**$1.10**	Minor	
17	Downers Road Invercargill	1.4				Bluff	$0.40	**$0.40**	**$0.29**	Minor	
18	Invercargill Prison	1.3				Leven Street	$0.40	**$0.40**	**$0.31**	Minor	
19	Prime Range Meats	1.5				Waikiwi	$1.15	**$1.15**	**$0.77**	Minor	
20	Great Southern Invercargill	0.5				Waikiwi	$1.08	**$1.08**	**$2.16**	Minor	
21	Winton Feedstock	0.6				Leven	$0.26	**$0.26**	**$0.43**	Minor	
22	Kelvin Hotel	0.4				Spey St	$0.18	**$0.18**	**$0.45**	Minor	
23	Alliance Lorneville	23.0	North Marakewa	$0.50	$0.00[4]	Underwood	$15.60	**$16.10**	**$0.70**	Moderate	2,5
24	Fiordland Hotel	0.1		$0.00[4]	$0.00[4]	Te Anau	$0.08	**$0.08**	**$0.62**	Minor	
25	SDCF Swimming Pool	0.6				Te Anau	$0.20	**$0.20**	**$0.32**	Minor	
	TOTAL =>	**193.5**	**TOTAL =>**	**$28.0**	**$16.0**	**TOTAL =>**	**$99.50**	**$143.50**			

[1] Fonterra Edendale is supplied directly from the Edendale GXP
[2] Does not include the on-site distribution transformers & switchgear, which should be accounted for (Ergo does noth have this detail).
[3] One or more zone substations would be required.
[4] No upgrade of the existing transmission substation/lines is expected (given the LCO's identified)
[5] Minor GXP upgrades required only, therefore classified as 'moderate'

Appendix 1 Glossary

BAL	Balclutha substation
BDE	Brydone substation
DG	Distributed generator
EDB	Electrical Distribution Business
EDN	Edendale substation
ENA	Electricity Network Association
ESA	Electricity Supply Authority
GOR	Gore substations
GXP	Grid exit point substation
HWB	Halfway Bush substation
INV	Invercargill
kV	Kilovolts
LCO	Load conversion opportunity
NSY	Naseby substation
NMK	North Makarewa substation
MW	Megawatts
MVArs	Mega volt amps reactive
MVA	Mega volt amps
ONAN	Oil natural air natural (the methods used to cool the windings and body of the transformer)
ONAF	Oil natural air forced (the methods used to cool the windings and body of the transformer)

Appendix 2 Accuracy of Cost Estimates and Assumptions

The amount of time available and effort expended to prepare a capital cost estimate has a significant bearing on the expected accuracy range. Accordingly the accuracy of capital cost estimates should be based on the amount and quality of information available at the time the estimate is developed. The Association for the Advancement of Cost Engineering (AACE) has developed a framework for the accuracy of cost estimates as a project progresses, which is illustrated below.

Table 43 Cost estimate classification matrix[37]

ESTIMATE CLASS	*Primary Characteristics*	*Secondary Characteristic*		
	MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges at an 80% confidence level
Class 5 (Order of Magnitude)	***0% to 2%***	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	**L: -20% to -50%** **H: +30% to +100%**
Class 4 (Preliminary)	***1% to 15%***	Study or Feasibility	Equipment Factored or Parametric Models	**L: -15% to -30%** **H: +20% to +50%**
Class 3 (Early Budget)	***10% to 40%***	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	**L: -10% to -20%** **H: +10% to +30%**
Class 2 (Budget/Control)	***30% to 70%***	Control or Bid / Tender	Detailed Unit Cost With Forced Detailed Take-off	**L: -5% to -15%** **H: +5% to +20%**
Class 1 (Definitive/Construction)	***50% to 100%***	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	**L: -3% to -10%** **H: +3% to +15%**

Assumptions

Ergo is of the view that the capital cost estimates developed in this report are Class 5 and we note the following:

- Costs exclude land and/or land easements.
- Costs exclude planning/consenting.
- It is assumed there is sufficient space/land in switchrooms/switchyards to accommodate the new equipment.
- The estimates are based on the connection of individual load conversion opportunities (LCO) and do not consider the connection of multiple LCOs.
- The estimates consider the upgrade of the power supply to individual LCOs. For example, they do not consider the costs when multiple LCOs connect to the same substation.

[37] Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries, AACE International Recommended Practice No. 18R-97.

Appendix 3 Edendale Supply Options (Further Analysis)