Otago Network

Spare Capacity and Load Characteristics Report

EECA

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ERGO CONSULTING

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1. Executive Summary

Transpower maintains/manages the transmission network in New Zealand and supplies the Otago region (as described in this report) via six GXP's.

Two Electrical Distribution Businesses (EDB's), Aurora Energy Ltd and OtagoNet Ltd then take supply from Transpower and distribute the electricity to end customers in the region.

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 Sites for the Otago region. The Load Sites involve existing consumers/plant that use fossil fuel and which could potentially be converted to using electricity, resulting in an overall lower carbon footprint.

EECA contracted Ergo to determine the following (for the Otago 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 Load Sites.

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

1.1 Network Spare Capacity

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

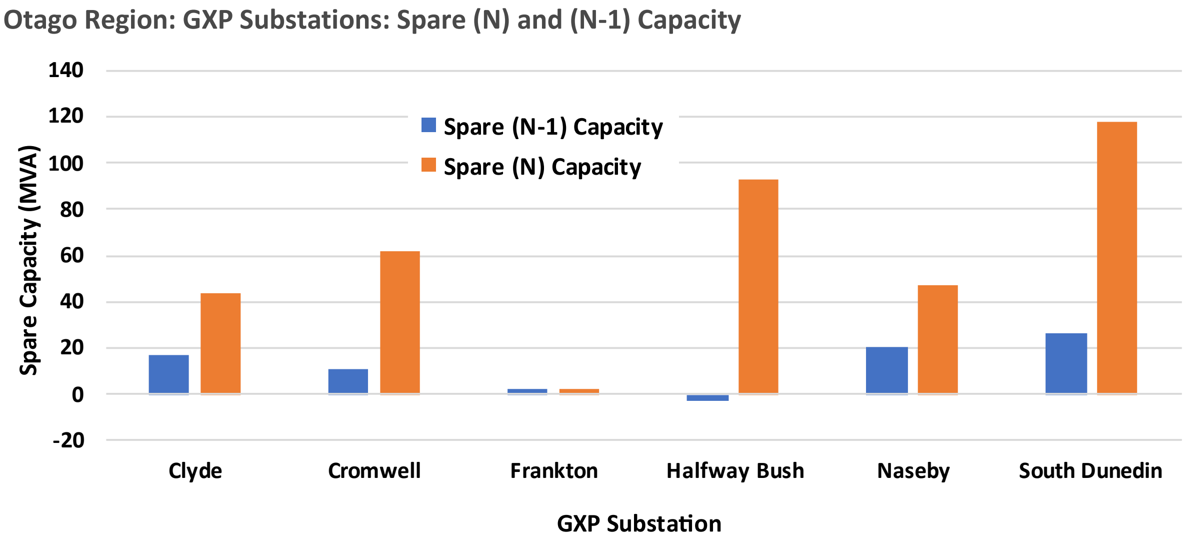


Figure 1 Summary: Approximate (N) and (N-1) spare capacity at GXP substations

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

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

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

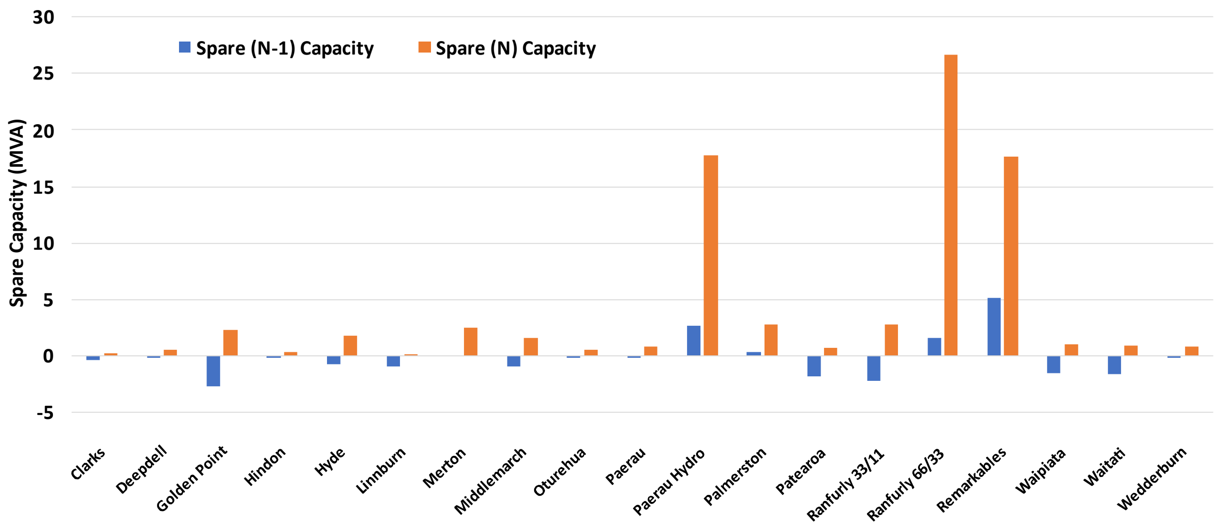


Figure 2 Summary: Approximate (N) and (N-1) spare capacity at OtagoNet's zone substations

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

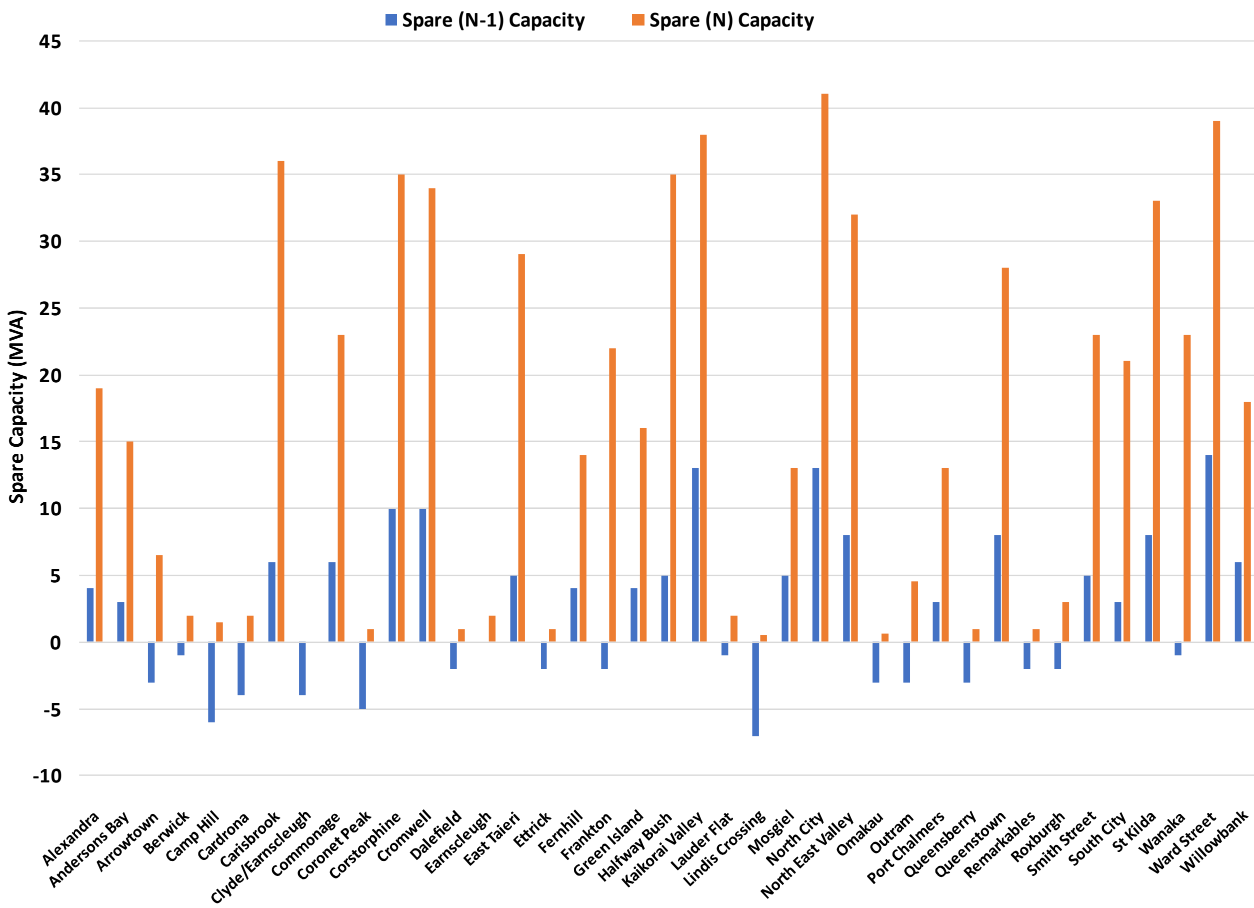


Figure 3 Summary: Approximate (N) and (N-1) spare capacity at Aurora Energy's zone substations

1.2 Load Characteristics

The substation load characteristics are documented in detail in the main body of the report (and the supplementary document 22132-RPT-0006) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

GXP substations:

- *Clyde GXP* – Loading is highly influenced by intermittent embedded generation with a winter peak.
- *Cromwell GXP* – Mix of residential, commercial and industrial loads. Winter peaking with a traditional daily morning and evening peak.
- *Frankton GXP* – Mix of residential and commercial. Winter peaking with a traditional daily morning and evening peak.
- *Halfway Bush GXP* – Mix of residential, commercial and light industrial loads. Winter peaking but is influenced by embedded generation in the area.
- *Naseby GXP* – Loading is dominated by the large industrial load at Macrae's mine, providing a relatively flat demand curve. Intermittent embedded hydro generation in the area also influences the GXP loading.
- *South Dunedin GXP* – Mix of residential, commercial and industrial loads. Winter peaking with a relatively flat daytime load profile.

Zone Substations:

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

1.3 EECA Load Sites

The following table shows EECA's Load Sites together with:

- The peak electrical power requirements of the Load Site.
- The distribution zone substation to which the Load Site would connect.
- The transmission substation/GXP which supplies the relevant zone substation.
- Ergo's estimate of the capital cost to increase the capacity of the relevant transmission assets (lines and substations).
- Ergo's estimate of the capital cost to install the necessary distribution assets to supply the Load Site.
- The cost efficiency associated with the Load Site 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 only 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: Load Sites vs transmission/distribution capital cost estimates

Table 1 Summary of Load Sites and estimated capital costs

No.	Load Site Name	Load (MW)	Transmission Details		Distribution		TOTAL	Cost Efficiency ($M/MW)	Complexity of Connection	Refer to notes
			GXP Substation	Upgrade Costs ($M)	Zone Substation	Upgrade Costs ($M)	Upgrade Costs ($M)			
1	Dunstan Hospital	0.11	Clyde	$0.00	Clyde/Earnscleugh	$0.00	$0.00	$0.00	Minor	1
2	Fulton Hogan Cromwell Ashphalt Plant	9.60	Cromwell	$0.00	Cromwell	$7.26	$7.26	$0.76	Moderate	
3	Cromwell EV Charging Station (3.8MW option)	3.80	Cromwell		Cromwell	$1.10	$1.10	$0.29	Moderate	
4	Cromwell Pool	0.07	Cromwell		Cromwell	$0.00	$0.00	$0.00	Minor	1
5	Cromwell College	0.16	Cromwell		Cromwell	$0.00	$0.00	$0.00	Minor	1
6	Mt. Aspiring College	0.15	Cromwell		Wanaka	$0.00	$0.00	$0.00	Minor	1
7	Southern Lakes Laundries	0.90	Frankton	$0.00	Frankton	$0.10	$0.10	$0.11	Minor	
8	Lakes Leisure	0.11	Frankton		Frankton	$0.00	$0.00	$0.00	Minor	1
9	Queenstown Primary School	0.14	Frankton		Queenstown	$0.00	$0.00	$0.00	Minor	1
10	Oceana Gold Macraes	4.80	Halfway Bush	$0.00	Golden Point	$2.10	$2.10	$0.44	Moderate	
11	Fulton Hogan Logan Point Quarry	4.80	Halfway Bush		Ward St	$1.70	$1.70	$0.35	Moderate	
12	Fulton Hogan Dunedin Bitument Plant	2.59	Halfway Bush		Ward St	$0.90	$0.90	$0.35	Moderate	
13	Goodman Fielder Dunedin	1.18	Halfway Bush		Kaikorai Valley	$0.05	$0.05	$0.04	Minor	
14	Greggs Coffee	2.72	Halfway Bush		Ward St/North City	$0.90	$0.90	$0.33	Moderate	
15	Graymont Makareao	7.84	Halfway Bush		Palmerston	$6.60	$6.60	$0.84	Moderate	
16	Lion Emerson's Brewery	0.83	Halfway Bush		Ward St	$0.56	$0.56	$0.67	Minor	
17	Keep it Clean Dunedin	4.06	Halfway Bush		Green Island	$1.38	$1.38	$0.34	Moderate	
18	Keep it Clean Silverstream	4.25	Halfway Bush		Mosgiel	$1.30	$1.30	$0.31	Moderate	
19	Moana Pool	0.28	Halfway Bush		Smith Street	$0.00	$0.00	$0.00	Minor	1
20	Mercy Hospital	0.37	Halfway Bush		Halfway Bush	$0.00	$0.00	$0.00	Minor	1
21	Balaclava School	0.02	Halfway Bush		Kaikorai Valley	$0.00	$0.00	$0.00	Minor	1
22	Brockville School	0.04	Halfway Bush		Kaikorai Valley	$0.00	$0.00	$0.00	Minor	1
23	Kaikorai School	0.12	Halfway Bush		Halfway Bush	$0.00	$0.00	$0.00	Minor	1
14	Logan Park High School	0.30	Halfway Bush		Ward Street	$0.00	$0.00	$0.00	Minor	1
15	Otago Boys High School Hostel	0.16	Halfway Bush		Smith Street	$0.00	$0.00	$0.00	Minor	1
16	Ravensbourne School	0.02	Halfway Bush		Ward Street	$0.00	$0.00	$0.00	Minor	1
17	Taieri College	0.35	Halfway Bush		East Taieri	$0.00	$0.00	$0.00	Minor	1
18	Wakari Hospital	0.22	Halfway Bush		Halfway Bush	$0.00	$0.00	$0.00	Minor	1
19	Alsco Dunedin	1.92	South Dunedin	$0.00	North City	$0.05	$0.05	$0.03	Minor	4
20	Otago Polytechnic Dunedin Campus	1.53	South Dunedin		North City/Ward St	$1.06	$1.06	$0.69	Moderate	
21	Dunedin Energy Centre	7.16	South Dunedin		North City	$0.18	$0.18	$0.03	Moderate	3
22	Dunedin Hospital	2.31	South Dunedin		North City	$0.05	$0.05	$0.02	Minor	4
23	University of Otago Dunedin Campus (1.56MW option)	1.56	South Dunedin		North City	$0.05	$0.05	$0.03	Minor	3
24	University of Otago Dunedin Campus (2.86MW option)	2.86	South Dunedin		North City	$0.66	$0.66	$0.23	Moderate	4
25	Lion Speights Brewery	4.54	South Dunedin		South City	$0.58	$0.58	$0.13	Moderate	
26	Preens Drycleaners Dunedin	1.96	South Dunedin		South City/St Kilda	$1.78	$1.78	$0.91	Moderate	
27	Burns House	0.17	South Dunedin		North City	$0.00	$0.00	$0.00	Minor	1
28	Tainui School	0.12	South Dunedin		Andersons Bay	$0.00	$0.00	$0.00	Minor	1
	TOTAL (scenario a) =>	67.0	TOTAL =>	$0.0	TOTAL (scenario a) =>	$27.60	$ 27.60			
	TOTAL (scenario b) =>	65.4			TOTAL (scenario b) =>	$28.13	$ 28.13			

Notes

1. Table doesn't include distribution transformer or switchgear costs for Load Sites (details provided in body of report). Estimated between $40k - $120k.
2. Load Site is likely to cause GXP to exceed (N-1) security limit of which an existing SPS in the region will permit. However, load growth in time will result in the incoming lines/GXP to be upgraded.
3. Cost included only in scenario a - Dunedin Energy Centre decarbonises itself, meaning that the loads of Alsco Dunedin and Dunedin Hospital, as well as 1.3MW of the University of Otago Dunedin Campus do not need to be considered.
4. Cost included only in scenario b - Dunedin Energy Centre does not decarbonise, meaning that the loads of Alsco Dunedin, Dunedin Hospital, and the University of Otago Dunedin Campus do need to be considered, while that of Dunedin Energy Centre does not.

Disclaimer: The Load Site 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 for final budgeting purposes in order to connect the respective Load Sites. For the larger Load Sites Ergo recommend proceeding with a Concept Design Report (CDR) to improve the accuracy of the respective cost estimate.

2. Introduction

The consumers in the Otago Region are supplied with electricity via electrical networks that are owned by the following Electrical Distribution Businesses (EDB):

- OtagoNet Ltd – 19 zone substations
- Aurora Energy Ltd - 39 zone substations

The franchise areas of the EDBs are shown in Figure 4. The Otago Region discussed in this report only includes the northern section of OtagoNet's franchise area. The southern section of OtagoNet's franchise area was included in the Southland Region's report[3].

The Energy Efficiency & Conservation Authority (EECA) is running a flagship program that is called Energy Transition Accelerator (ETA)[4]. 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 Otago Region.

Ergo previously developed a similar report for the Southland, South Canterbury and Wests Coast regions[3,5,6]

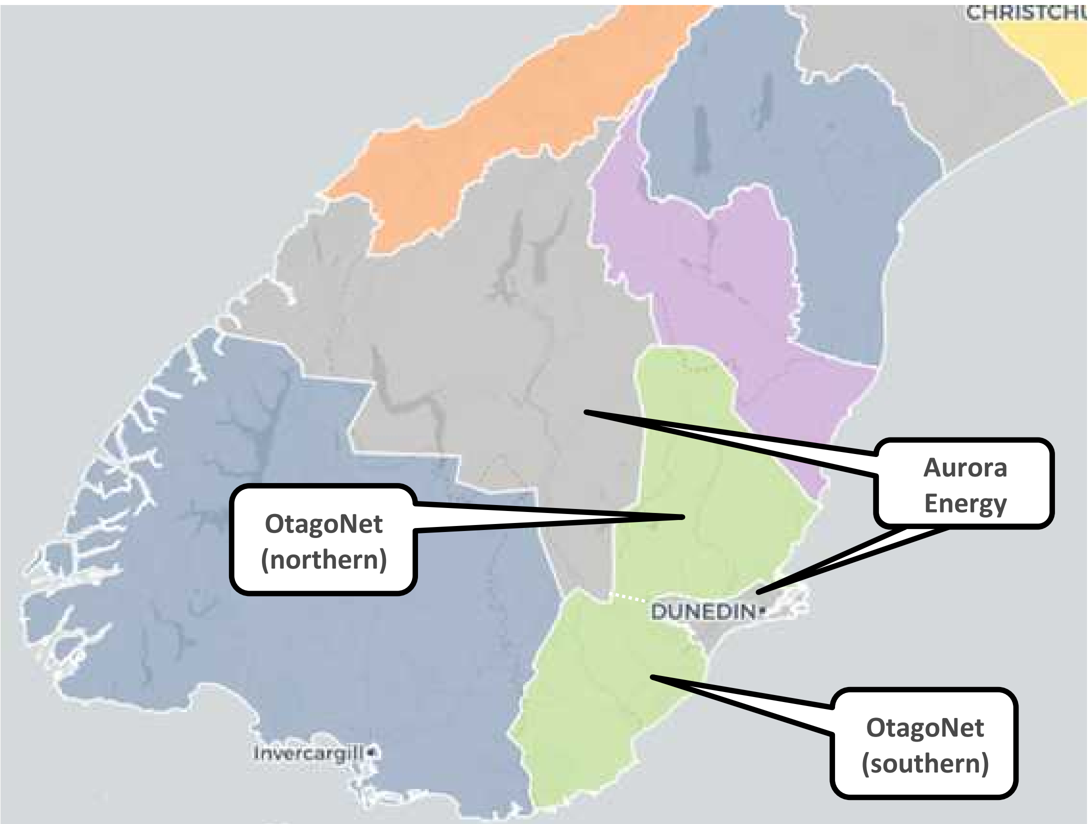


Figure 4 Electrical Distribution Business (EDB) franchise areas[7]

[3] 21177-RPT-0001 [G] Southland Electrical Network - Spare Capacity and Load Characteristics.
[4] https://www.eeca.govt.nz/co-funding/energy-transition-accelerator/
[5] 22108-RPT-0001 [F] South Canterbury Electrical Network - Spare Capacity and Load Characteristics.
[6] 22132-RPT-0001 [A] West Coast Electrical Network - Spare Capacity and Load Characteristics.
[7] 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 Otago Region. This included reviewing both the GXP's and local distribution zone substations along with their associated lines/cables within the Otago Region.

In addition to the above, EECA provided a number of Load Sites 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 2022 Planning Report.
- OtagoNet's 2022 Disclosures and Asset Management Plan.
- Aurora Energy's 2022 Disclosures and Asset Management Plan.
- SCADA substation loading data provided by OtagoNet and Aurora Energy.
- GXP metering data extracted from the Electricity Authority's website8.
- Network diagrams provided by OtagoNet and Aurora Energy.
- Geographic Information System (GIS) asset and location data provided by OtagoNet and Aurora Energy. This was mostly supplied in the form of *.kmz files.

[8] https://www.emi.ea.govt.nz/Wholesale/Datasets

4. Otago Network

The following sections describe (at a high level), the locations of the relevant substations and lines. For the purposes of this document the franchise areas supplied by OtagoNet and Aurora Energy are referred to as the Otago Region.

4.1 Transmission/GXP Substations

The following Figure 5 illustrates the relevant transmission substations (GXPs) within the Otago Region, which include the following:

- Clyde GXP.
- Cromwell GXP.
- Frankton GXP.
- Halfway Bush GXP.
- Naseby GXP.
- South Dunedin GXP.

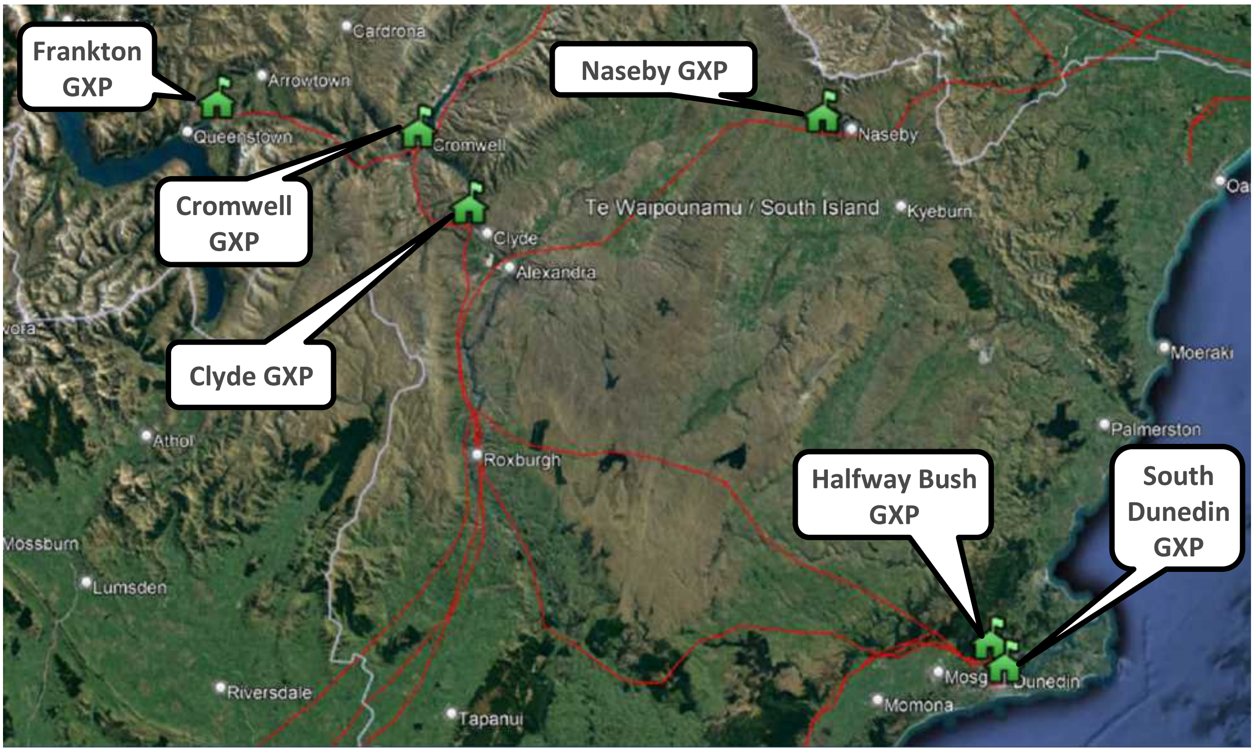


Figure 5 Transmission/GXP substations (red lines are Transpower's transmission lines)

The transmission network in the Otago Region is also shown diagramatically in Figure 6 and Figure 7. The network is comprised of 220 kV and 110 kV transmission circuits. The region has substantial hydro generation, much of which is consumed locally. Transmission capacity into the region is largely driven by the local hydrology: during wet periods, significant amounts of power are exported to the Waitaki Valley, while during dry periods power may need to be imported.

Figure 6 Transmission/GXP substations[9]

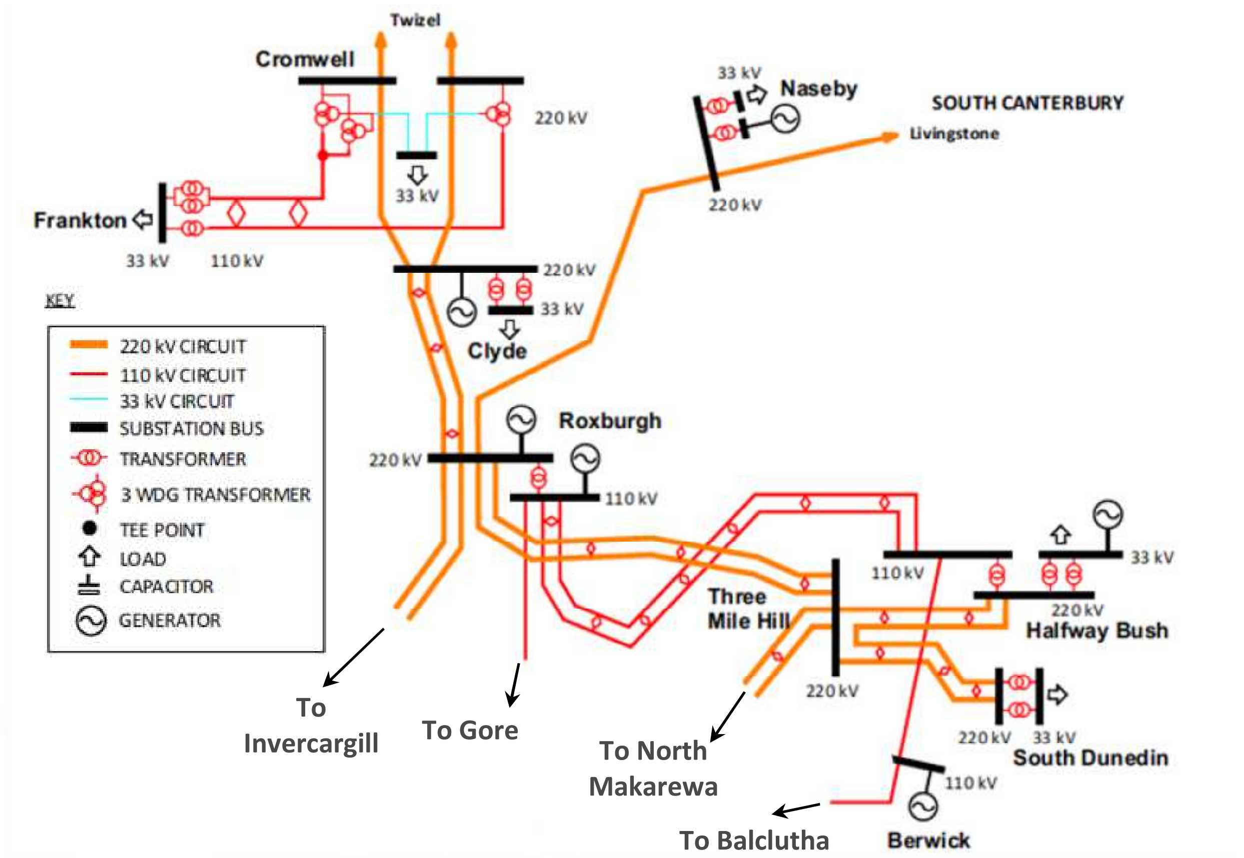


Figure 7 Existing transmission/GXP substations[9]

[9] 2022 Transmission Planning Report.

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 two relevant EDB's – OtagoNet and Aurora Energy. 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[10]

Table 2 Overview of substation numbers for each EDB investigated

EDB Name	Number of Zone Substations	Number of GXPs
OtagoNet	18[11]	3[11]
Aurora Energy	39	5

4.2.1 OtagoNet

The following Figure 8 shows the zone substations on OtagoNet's network diagrammatically. The substations include:

- Clarks 33/11kV zone substation
- Deepdell 33/11kV zone substation
- Falls Dam 33/11kV zone substation
- Golden Point 33/11kV zone substation
- Hindon 33/11kV zone substation
- Hyde 33/11kV zone substation
- Linnburn 33/11kV zone substation
- Merton 33/11kV zone substation
- Middlemarch 33/11kV zone substation
- Oturehua 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
- Ranfurly 33/11 33/11kV zone substation
- Ranfurly 66/33 33/11kV zone substation
- Remarkables 33/22kV zone substation
- Waipiata 33/11kV zone substation
- Waitati 33/11kV zone substation
- Wedderburn 33/11kV zone substation

[10] Both OtagoNet and Aurora Energy take supply from the Halfway Bush GXP

[11] Connections at Balclutha GXP are not considered in this report and therefore not reflected in the substations/GXPs listed.

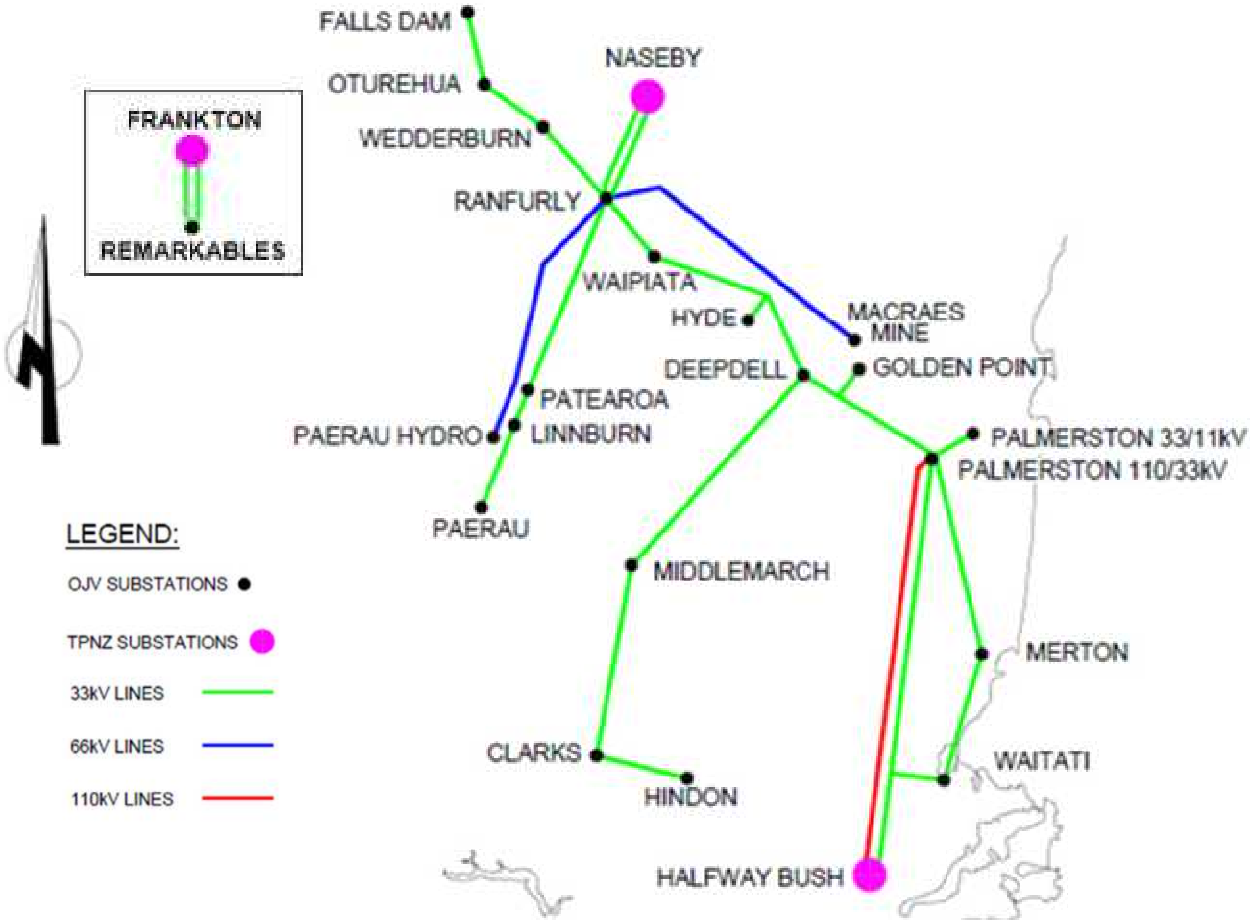


Figure 8 OtagoNet: Northern Zone Substation Geospatial Sub-transmission and Distribution Diagram[12]

4.2.2 Aurora Energy

The following Figure 9 through Figure 11 show the zone substations on Aurora Energy's network diagrammatically. The substations include:

- Alexandra 33/11kV zone substation
- Andersons Bay 33/11kV zone substation
- Arrowtown 33/11kV zone substation
- Berwick 33/11kV zone substation
- Camp Hill 33/11kV zone substation
- Cardrona 66/11kV zone substation
- Carisbrook 33/11kV zone substation
- Clyde/Earnscleugh 33/11kV zone substation
- Commonage 33/11kV zone substation
- Coronet Peak 33/11kV zone substation
- Corstorphine 33/11kV zone substation
- Cromwell 33/11kV zone substation
- Dalefield 33/11kV zone substation
- Earnscleugh 33/11kV zone substation

[12] https://powernet.co.nz/disclosures/otagonet/asset-management-plan/

- East Taieri 33/11kV zone substation
- Ettrick 33/11kV zone substation
- Fernhill 33/11kV zone substation
- Frankton 33/11kV zone substation
- Green Island 33/11kV zone substation
- Halfway Bush 33/11kV zone substation
- Kaikorai Valley 33/11kV zone substation
- Lauder Flat 33/11kV zone substation
- Lindis Crossing 66/11kV zone substation
- Mosgiel 33/11kV zone substation
- North City 33/11kV zone substation
- North East Valley 33/11kV zone substation
- Omakau 33/11kV zone substation
- Outram 33/11kV zone substation
- Port Chalmers 33/11kV zone substation
- Queensberry 66/11kV zone substation
- Queenstown 33/11kV zone substation
- Remarkables 33/11kV zone substation
- Roxburgh 33/11kV zone substation
- Smith Street 33/11kV zone substation
- South City 33/11kV zone substation
- St Kilda 33/11kV zone substation
- Wanaka 66/11kV zone substation
- Ward Street 33/11kV zone substation
- Willowbank 33/11kV zone substation

Figure 9 Aurora Energy's Dunedin (Halfway Bush and South Dunedin GXPs) Zone Substation Sub-transmission Diagram[13]

[13] https://www.auroraenergy.co.nz/disclosures/asset-management-plan/

Figure 10 Aurora Energy's Queenstown (Frankton GXP) Zone Substation Sub-transmission Diagram[13]

Figure 11 Aurora Energy's Central Otago (Cromwell/Clyde GXP) Zone Substation Sub-transmission Diagram[13]

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)[14]. 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 are 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 Transpower GXPs discussed in this report are considered connection assets and therefore decisions around their security classifications lie with their end customers (i.e. OtagoNet or Aurora Energy). For those substations that are supplied via dedicated incoming lines, the lines are also considered to be connection assets. The remaining lines that are not dedicated to a single substation are interconnection 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

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

mains borne ripple injection equipment to manage the load drawn by consumer's hot water cylinders. 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[15]. 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 Load Sites 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.

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

6. Spare Capacity – Transmission Substations

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

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

- The Cromwell and Frankton GXPs are supplied via two banks of 220/110/33 kV transformers at Cromwell that are Tee-connected to the 220 kV Clyde–Cromwell–Twizel–1 and 2 circuits. The 33 kV winding of the transformers supply the Cromwell 33 kV grid exit point while the 110 kV winding supplies the Frankton GXP via a pair of 110 kV Cromwell–Frankton circuits and two banks of 110/33 kV transformers at Frankton. A Clyde–Cromwell–Twizel circuit outage removes one of the Cromwell 220/110/33 kV transformers, the associated 110 kV Cromwell–Frankton circuit, and the associated Frankton transformer bank. Issues impacting the supply capacity to the Cromwell and Frankton areas are:
  - The Cromwell 33 kV cable rating limits the (N-1) capacity to the Cromwell 33 kV GXP and is expected to become a constraint from 2028.
  - The 110 kV Cromwell–Frankton circuits and Frankton 110/33 kV supply transformer ratings limit the (N-1) capacity to the Frankton 33 kV grid exit point. The two constraints are both expected to become constraints from 2022 (a special protection scheme allows unconstrained load pre-contingency and trips load if assets are overloaded post-contingency).
  - The lack of 220 kV and 110 kV buses at Cromwell increases the amount of assets taken out of service during a Clyde–Cromwell–Twizel circuit or Cromwell transformer outage, increasing the likelihood that a second outage will cause a loss of supply at Cromwell and Frankton.
  - During periods of high generation export from the Southland region towards the Waitaki Valley coupled with high load, a Clyde–Cromwell–Twizel circuit or a Cromwell transformer outage causes voltage steps in excess of 5%. It may also cause voltage collapse in the Cromwell and Frankton areas. This issue is partially caused by the lack of 220 kV and 110 kV buses at Cromwell.
- The 110 kV Gore–Roxburgh–1 circuit is rated at 63/77 MVA (summer/winter) and operates in parallel with the 220 kV Invercargill–Roxburgh–1 and 2 circuits which are part of the grid backbone. With low generation in the Southland region (predominantly Manapouri), a 220 kV Invercargill–Roxburgh circuit outage may cause the 110 kV Gore–Roxburgh circuit to overload. Early in 2022 a temporary emergency grid reconfiguration was used due to manage exceptionally low hydro storage and inflows at Manapouri, to avoid overloading the Gore-Roxburgh circuit.

Figure 12 below illustrates Transpower's view of a possible 2037 configuration for the Otago Region's transmission network. It includes:

- Replacement of the 220/33kV transformers and 33kV switchboard at the Clyde GXP.
- Replacement of the 220/33kV transformers at the Halfway Bush GXP.
- Replacement of the outdoor 33kV switchyard at the Cromwell GXP with an indoor 33kV switchboard/room.
- Thermal upgrade and/or variable line rating on the Cromwell-Frankton 110kV circuits.
- Replacement/upgrade of the 110/33kV transformers at the Frankton GXP.

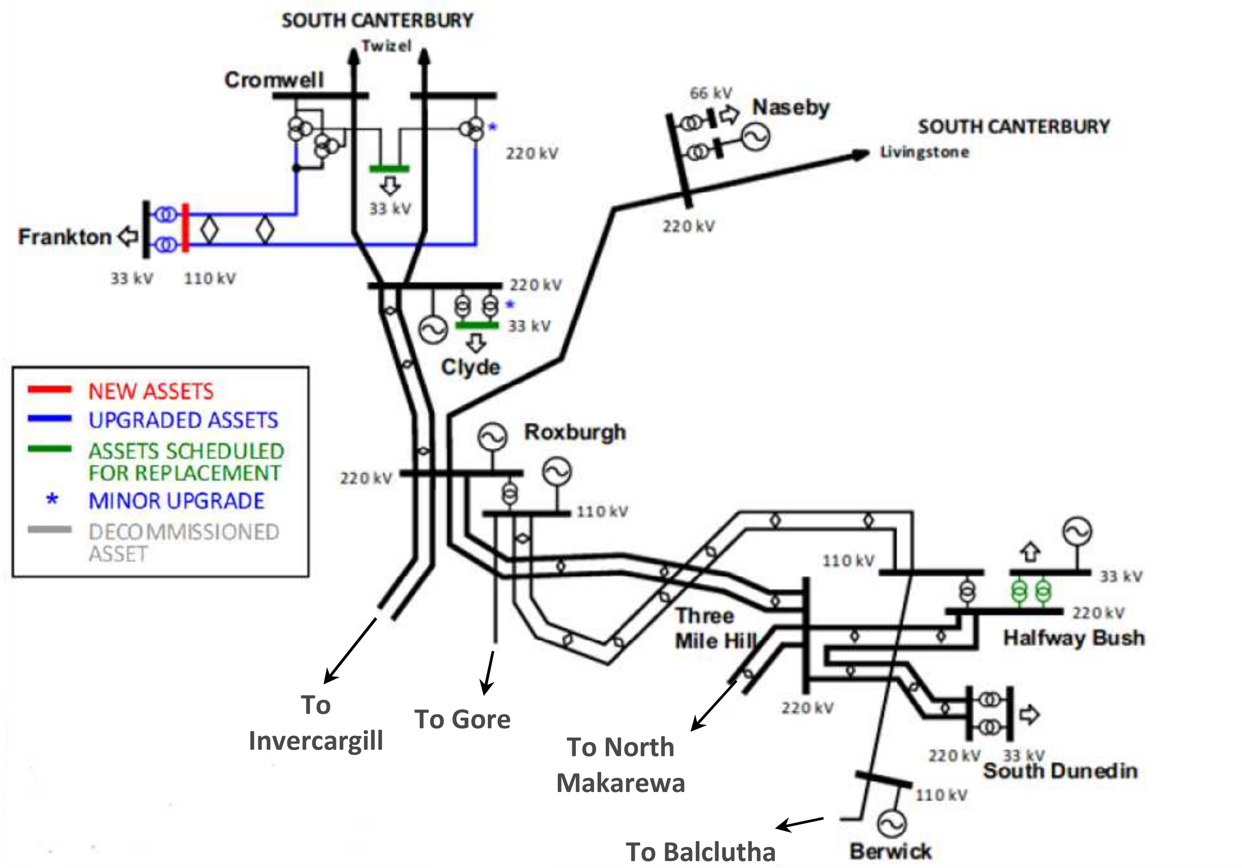


Figure 12 Existing transmission/GXP substations together with future proposed upgraded/new assets[9]

6.1 Demand Forecast

The following Table 3 illustrates Transpower's forecast demand at the transmission substations in the Otago Region from its 2022 Annual Planning Report[9]. The forecast predicts the demand growing at an average of 1.3% per annum over the next fifteen years which is lower than the national average.

Table 3 Transpower demand forecast (Active Power)

No.	Substation/GXP	Power Factor	Demand (MW)										
			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1	Clyde	0.96	13	13	13	14	14	14	15	15	16	16	16
2	Cromwell	1	44	45	46	48	49	50	52	53	54	55	56
3	Frankton	1	78	81	83	86	89	91	94	97	99	102	104
4	Halfway Bush[1]	0.99	127	128	129	130	130	131	132	133	133	134	135
5	Naseby	0.97	33	33	34	34	35	36	36	37	37	38	38
6	South Dunedin	0.99	82	82	83	83	83	83	83	83	83	83	83
		TOTAL	377	382	388	395	400	405	412	418	422	428	432

1. Halfway Bush has a leading power factory.

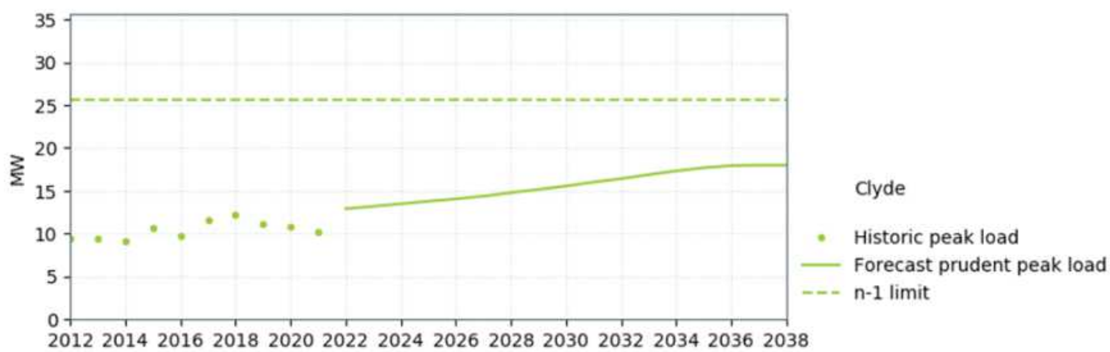
Ergo notes that Transpower's load forecasts are prudent (10% probability of exceedance) which may explain some of the differences between forecasted 2022 load and actual 2022 load in the sections below.

6.1.1 Clyde GXP

Transpower's demand forecast (refer Table 3) indicates that the Clyde GXP was expected to have a 2022 peak demand of 13MW at 0.96pf. This contrasts with the historical SCADA data that indicates that, in 2022 the Clyde GXP experienced a peak load of 18.9 MVA. However, this peak occurred during maximum export of 18.8 MW of generation (onto the South Island Grid) and the peak off-take load during 2021 was 11.1 MW.

The Clyde GXP is equipped with 2 x 60MVA, 220/33kV transformers (nominal capacity). The substation has an (N-1) capacity of 27/27MVA (summer/winter)[16].

The following graph compares Clyde GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR).



Note: Any difference in the supply capacity on the graph (in MW) and the asset rating (in MVA) is due to load power factor and impedance.

[16] The transformers' capacity is limited by a LV cable limit followed by a bus section rating; with these limits resolved, the (N-1) capacity will be 65/68 MVA (summer/winter).

Aurora take supply at 33kV from the Clyde GXP and supply the Alexandra, Clyde, Manuherikia, Ida Valley and Teviot Valley areas. In recent times the Clyde GXP has experienced a decline in peak demand whilst the embedded generation has increased due to the embedded hydro generation at Teviot, Ettrick and Earnscleugh. Going forward the demand is forecast to increase due to proposed developments.

The following Figure 13 illustrates Clyde's 2022 loading in comparison to its substation capacity. The substation is supplied via 220kV lines that are a major backbone to the South Island transmission system, have significant ratings and are thus not included on the graphs.

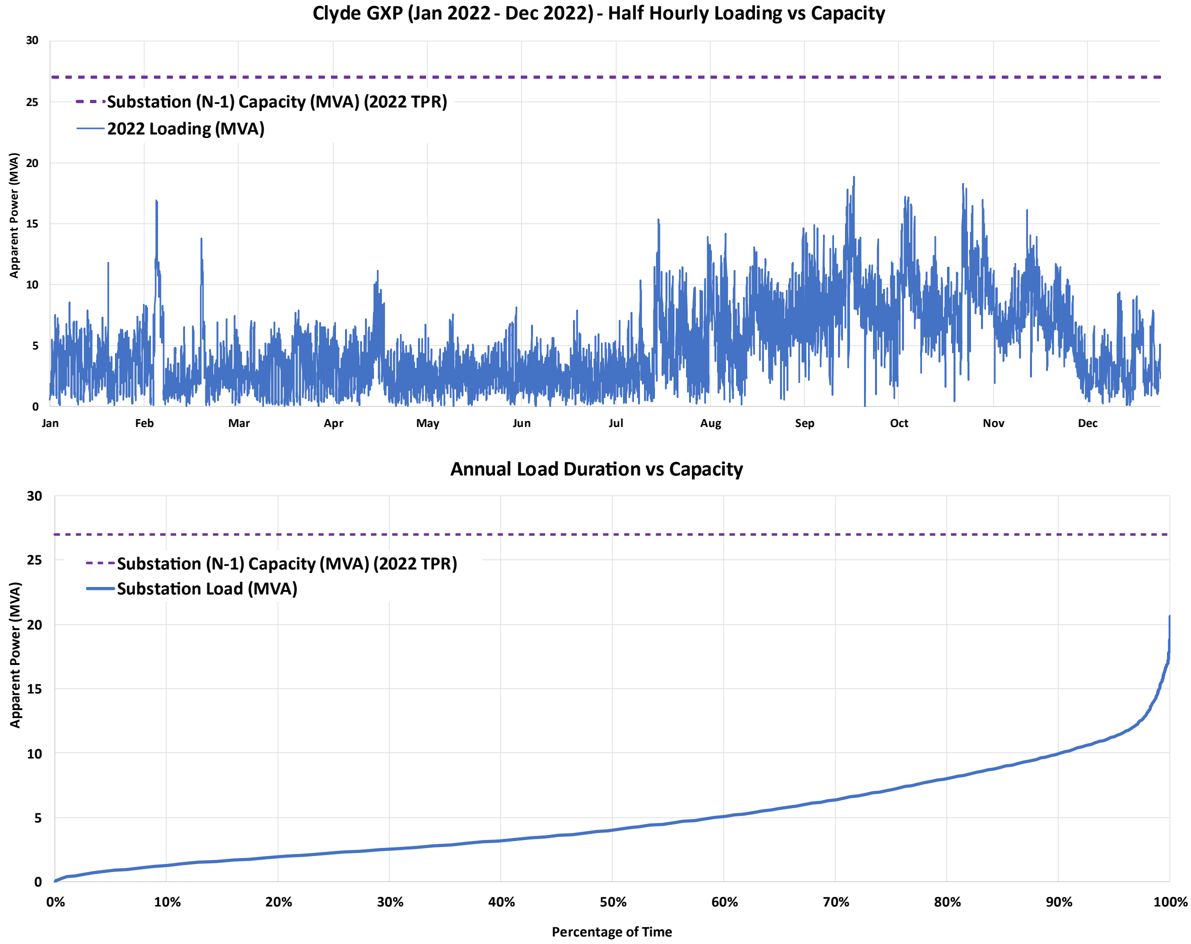


Figure 13 Clyde GXP: 2022 Loading: Substation capacity

6.1.2 Cromwell GXP

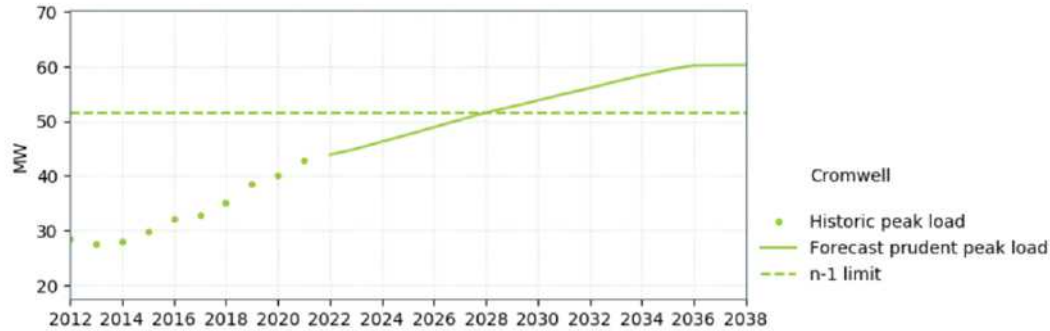
Transpower's demand forecast (refer Table 3) indicates that the 33kV supply at the Cromwell GXP was expected to have a 2022 peak demand of 44MW at unity power factor. This value reflects the historical SCADA data that indicates the 33kV supply at the Cromwell GXP experienced a peak load of 46.5MVA during the 2022 year.

The Cromwell GXP is equipped with three 220/110/33kV three winding transformers. Two of the transformers are operated in parallel (i.e. as a single transformer) and have a collective 33kV winding rating of 2 x 36.4MVA = 72.8MVA, however are limited to 28.4MVA each (56.8MVA total) due to their 33kV cables. The third transformer has 33kV winding rating of 50MVA (limited to 48MVA by its 33kV cables). Transpower has advised that the 33kV capacities at Cromwell GXP are 105MVA (N) and 48/54MVA (summer/winter) (N-1).

The Cromwell 33 kV GXP supplies Aurora's network which in turn supplies Cromwell and the Upper Clutha area (Wanaka, Cardrona and Hawea areas). Aurora's network supplies domestic, commercial and light industrial consumers within the urban areas. Also, rural consumers with significant irrigation loads and two major ski fields (Cardrona and Treble Cone). Aurora's supply to the Upper Clutha region is via two long 66kV overhead lines that are fed from the 33kV supply at the Cromwell GXP using two 33/66kV auto-transformers (N-1 winter rating of 34MVA).

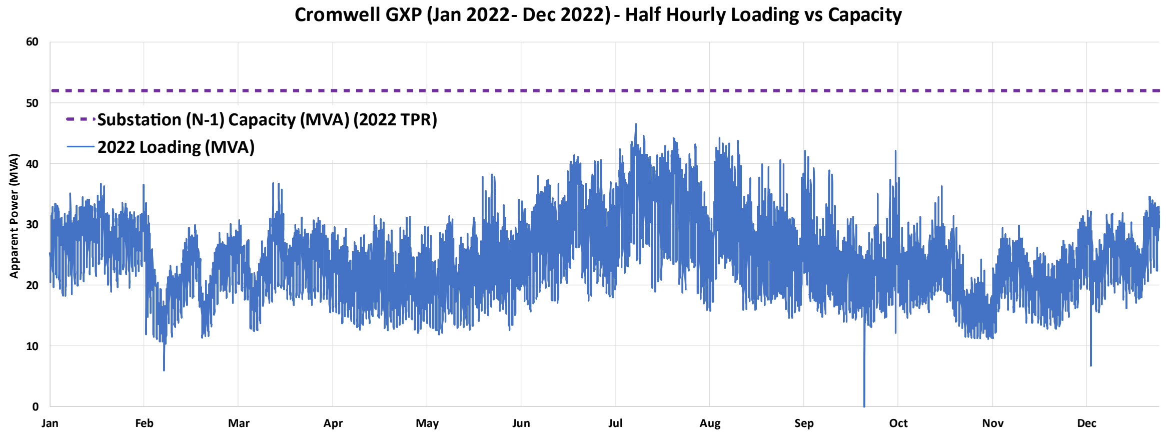
Transpower has advised that the 110kV capacities at Cromwell GXP are 197MVA (N) and 99MVA (N-1). The 110kV winding supplies the Frankton GXP via the Cromwell-Frankton 110kV double circuit overhead line.

The following graph compares Cromwell GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR).



Note: Any difference in the supply capacity on the graph (in MW) and the asset rating (in MVA) is due to load power factor and impedance.

The following Figure 14 illustrates Cromwell's 2022 33kV loading in comparison to its substation capacity.



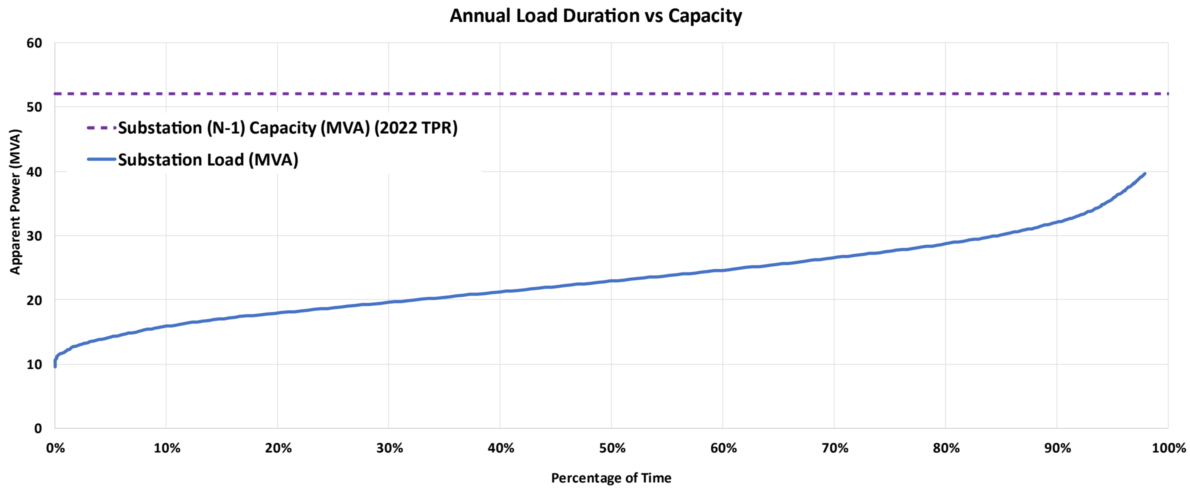


Figure 14 Cromwell GXP: 2022 Loading: Substation capacity

6.1.3 Frankton GXP

Transpower's demand forecast (refer Table 3) indicates that the Frankton GXP was expected to have a 2022 peak demand of 78MW at unity power factor. This contrasts with the historical SCADA data that indicates that during 2022 the Frankton GXP experienced a peak load of 71.6MVA, although we note that the Covid epidemic had a significant impact on tourism into the Queenstown area, which may have influenced the 2022 winter period.

The Frankton load is supplied by:

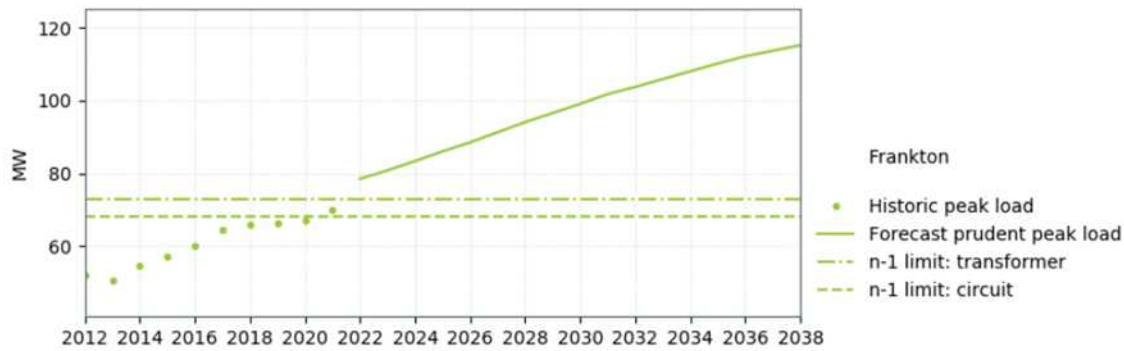
- Two 110 kV circuits from Cromwell, each rated at 63/77 MVA (summer/winter)
- Two 110/33 kV supply transformers rated at 66 MVA[17] and 85 MVA, providing:
  - A total nominal installed capacity of 151 MVA.
  - An (N-1) capacity of 79/83 MVA (summer/winter).

The peak load on the Frankton GXP is forecast to exceed the network's (N-1) supply capacity in the winter of 2022.

Frankton GXP presently has an (N) capacity of 80 MW, which is defined by the voltage stability limit. Transpower has advised that the system operator will not allow load at Frankton to exceed the voltage stability limit.

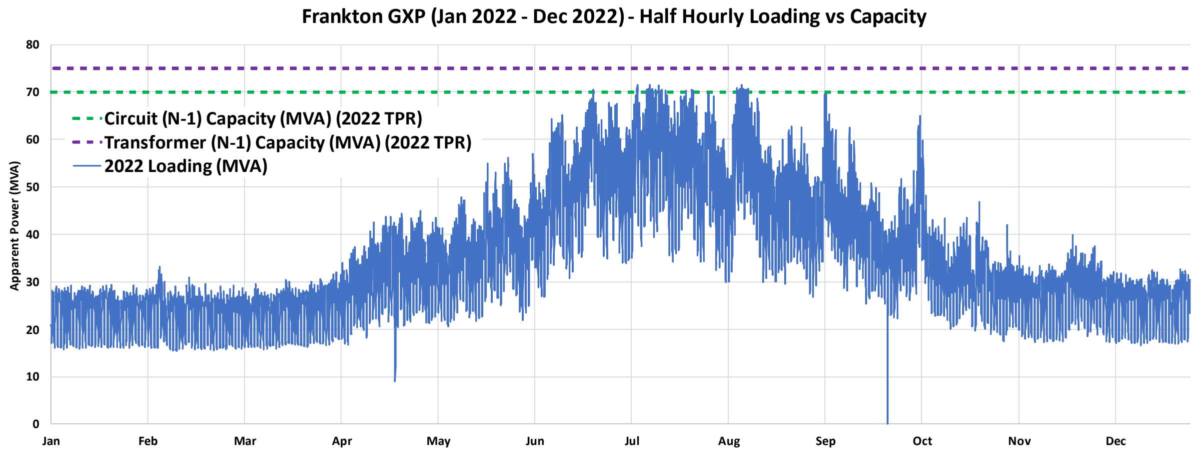
[17] Consists of two transformers connected in parallel, operated as a single unit, providing a total nominal installed capacity of 66 MVA.

The following graph compares Frankton GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR).



Note: Any difference in the supply capacity on the graph (in MW) and the asset rating (in MVA) is due to load power factor and impedance.

The following Figure 15 illustrates Frankton GXP's 2022 loading in comparison to its substation capacity. Also included is the incoming 110kV overhead line capacity, although care should be taken interpreting line capacity as it does not consider upstream transmission constraints, the power supplied to other GXP substations and voltage constraints.



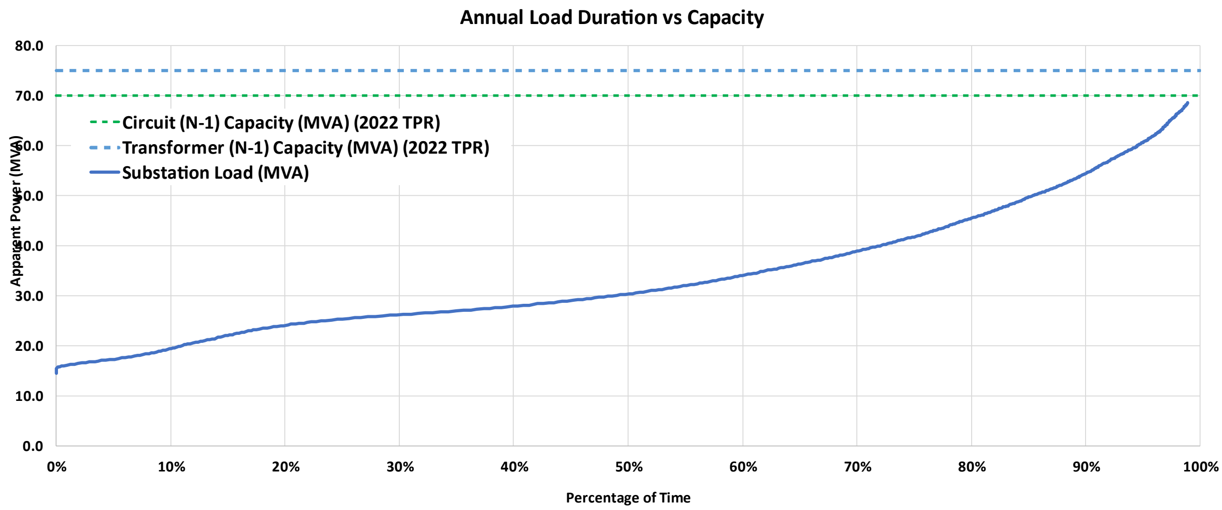


Figure 15 Frankton GXP: 2022 Loading: Substation capacity: Incoming 110kV line capacity

6.1.4 Halfway Bush GXP

Transpower's demand forecast (refer Table 3) indicates that the Halfway Bush GXP was expected to have a 2022 peak demand of 127MW at 0.99pf. This contrasts with the historical SCADA data that indicates that, during 2022, the Halfway Bush GXP experienced a peak load of 110.4MVA.

The Halfway Bush GXP is equipped with two 220/33 kV transformers rated at 100 MVA and 120 MVA, that provide:

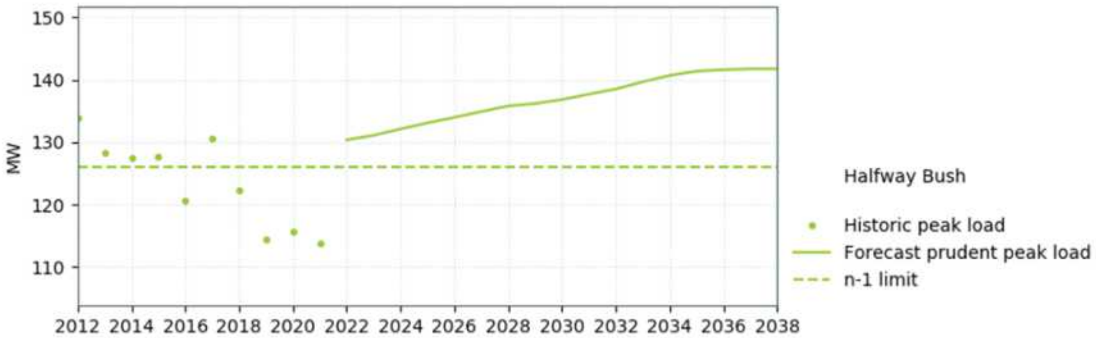
- A total nominal installed capacity of 220 MVA.
- An (N-1) capacity of 124/131 MVA (summer/winter)

The 33kV system at the Halfway Bush GXP supplies the subtransmission networks of both Aurora and OtagoNet. Figure 8 shows OtagoNet owns a 110kV and a 33kV circuit between Halfway Bush and Palmerston. Historically, these two circuits were owned by Transpower, both operated at 110kV and supplied Transpower's 110/33kV Palmerston GXP. OtagoNet purchased the lines in order to re-liven the lines at 33kV to deliver reliable supply to its Palmerston, Merton and Waitati substations.

There is a significant amount of generation embedded in Aurora's network (38 MW of hydro and 36 MW of wind) that is connected to the Halfway Bush 33 kV grid exit point. Assuming no contribution from the embedded generators, the peak load at Halfway Bush has already exceeded the (N-1) capacity.

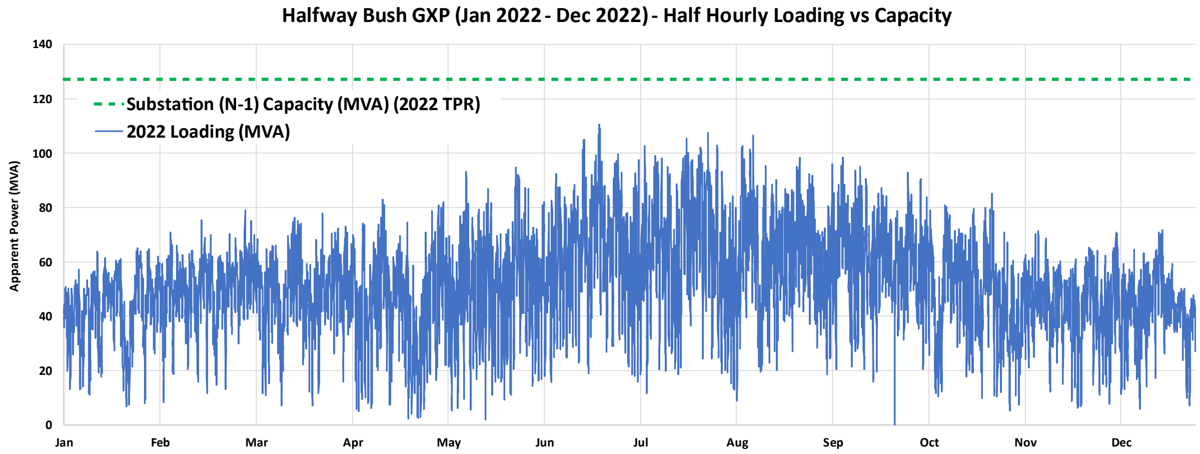
Aurora's network (that is supplied from Halfway Bush) supplies residual, commercial and light industrial consumers in the northern portion of Dunedin city and the townships to the west and north-east of the city. OtagoNet's network supplies residential and commercial consumers in the townships of Palmerston, Merton and Waitati and rural consumers in the surrounding areas. Consumers include farmers and sawmills.

The following graph compares Halfway Bush GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR).



Note: Any difference in the supply capacity on the graph (in MW) and the asset rating (in MVA) is due to load power factor and impedance.

The following Figure 16 illustrates Halfway Bush GXP's 2022 loading in comparison to its substation capacity.



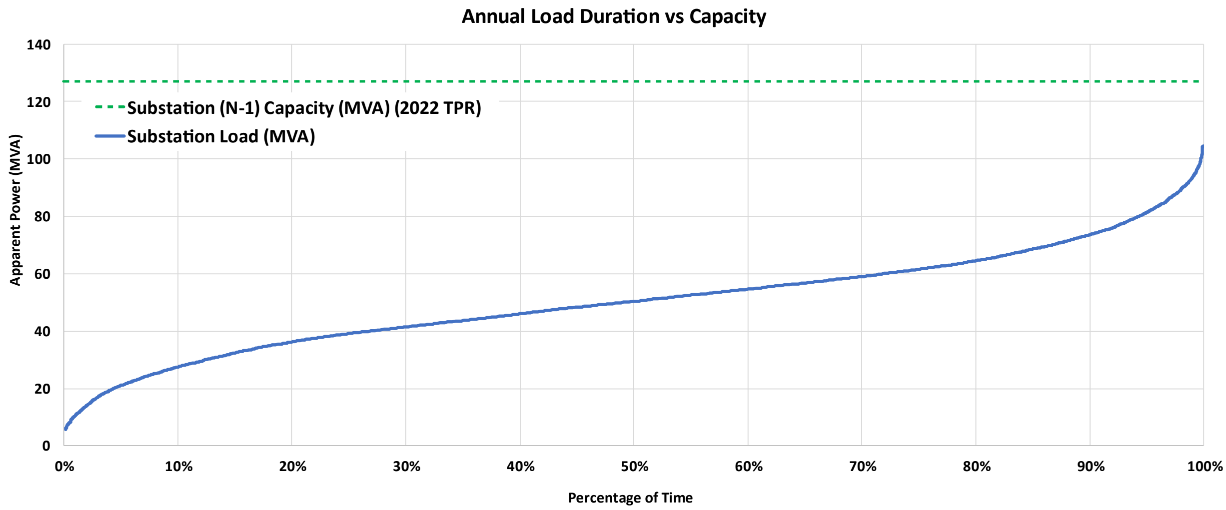


Figure 16 Halfway Bush GXP: 2022 Loading: Substation capacity

6.1.5 Naseby GXP

Transpower's demand forecast (refer Table 3) indicates that the Naseby GXP was expected to have a 2022 peak demand of 33MW at 0.97pf. This value contrasts with the historical SCADA data that indicates that during 2022 the Naseby GXP experienced a peak load of 32.3MVA.

The Naseby 33kV bus is supplied via two 220/33 kV transformers resulting in a total nominal capacity of 80 MVA. Transpower's 2022 Transmission Planning Report indicates that the transformers and associated substation equipment have a summer/winter rating of 53/54 MVA (summer/winter).

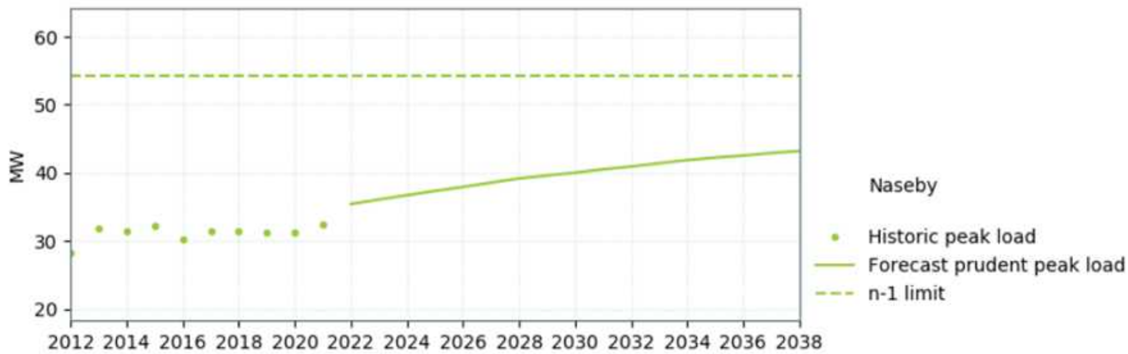
The Naseby GXP is supplied via two incoming 220 kV lines with summer/winter ratings of 610/671MVA.

OtagoNet takes supply from the GXP at Naseby and supplies a number of small number of zone substations together with a large industrial consumer (Macraes mine with a peak load of ≈25MW). The Patearoa/Paerau hydro power stations are embedded in OtagoNet's network and inject ≈12MW onto the network during periods of peak output.

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

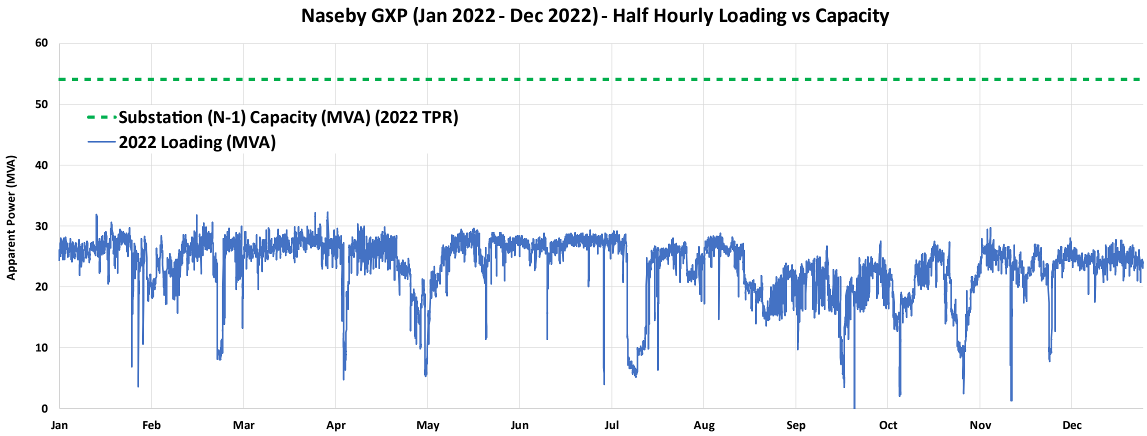
- ≈18 MVA of spare (N-1) substation capacity (across the entire year) is available at the Naseby GXP.

The following graph compares Naseby GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR).



Note: Any difference in the supply capacity on the graph (in MW) and the asset rating (in MVA) is due to load power factor and impedance.

The following Figure 17 illustrates the Naseby GXP's 2022 loading in comparison to its substation capacity. Also included is the incoming 220kV line capacity which should be interpreted with care as the capacity does not consider upstream transmission constraints, loading from other GXPs and voltage constraints.



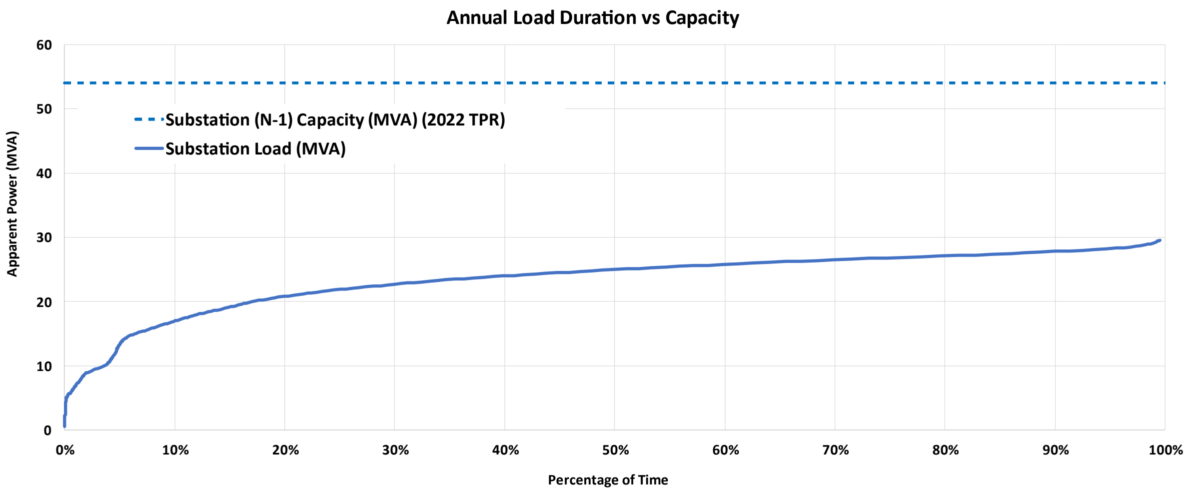


Figure 17 Naseby GXP: 2022 Loading: Substation capacity: Incoming 220kV line capacity

6.1.6 South Dunedin GXP

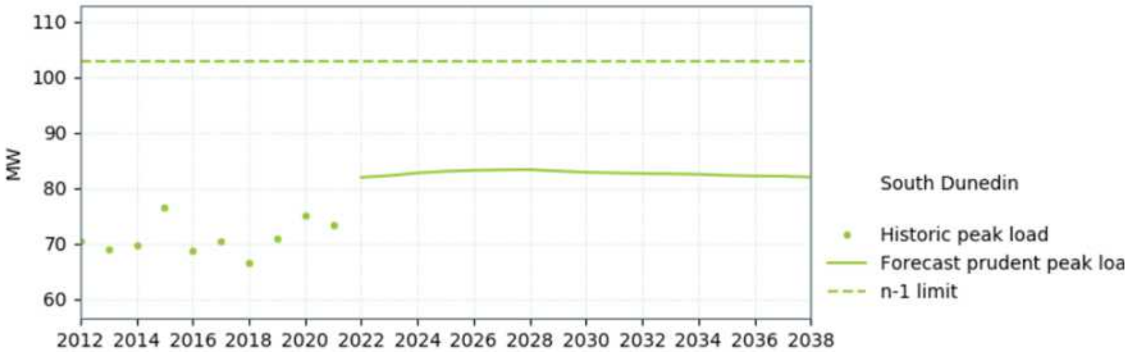
Transpower's demand forecast (refer Table 3) indicates that the South Dunedin GXP was expected to have a 2022 peak demand of 82MW at 0.99 power factor. This contrasts with the historical SCADA data that indicates that during 2022 the South Dunedin GXP experienced a peak load of 73.1MVA.

The South Dunedin GXP substation is equipped with 2 x 100MVA, 220/33kV transformers (nominal capacity). The transformers have a summer/winter rating of 108/108 MVA (summer/winter), resulting in an (N-1) rating of 108MVA.

The South Dunedin GXP is supplied via two incoming 220 kV lines with summer/winter ratings of 202/247MVA, which are presently being upgraded.

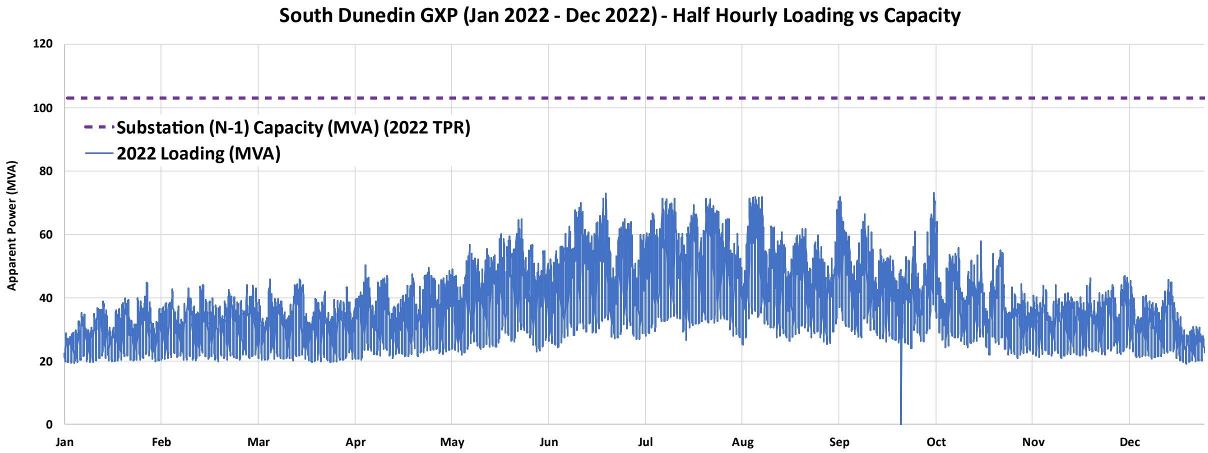
Aurora takes supply from the South Dunedin GXP, at 33kV, and supplies the southern portion of the Dunedin City. The consumers supplied include domestic, commercial and industrial.

The following graph compares South Dunedin GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR).



Note: Any difference in the supply capacity on the graph (in MW) and the asset rating (in MVA) is due to load power factor and impedance.

The following Figure 18 illustrates Dunedin South GXP's 2022 loading in comparison to its substation capacity. Also included is the incoming 220kV line capacity, although care should be taken interpreting line capacity as the line may be well loaded with other GXP loads, and does not consider voltage constraints or upstream transmission constraints.



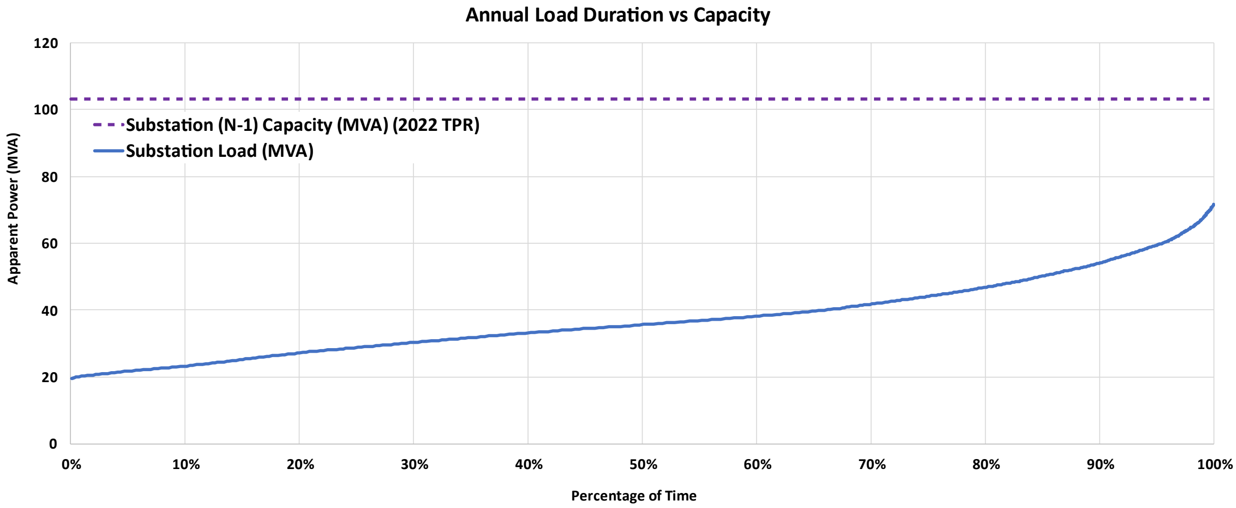


Figure 18 South Dunedin GXP: 2022 Loading: Substation capacity: 220kV line capacity

6.2 Summary - Spare Capacity based on Transpower's 2022 Forecast

The following Figure 19 summarises the approximate, all year, (N-1) and (N) spare capacities at each GXP based on:

- The substation capacity disclosed in Transpower's 2022 Transmission Planning Report
- The 2022 forecast load provided in Transpower's 2022 Transmission Planning Report (refer to Table 3).

Negative values are only possible for (N-1) capacities and indicate that there is no spare (N-1) capacity. The negative amount indicates the capacity increase that is required to achieve a secure firm capacity at the substation. It should be noted that the actual 2021 loading data indicates that the actual loads were lower than the forecast 2022 loads. This could be for various reasons and Ergo has not investigated this in detail.

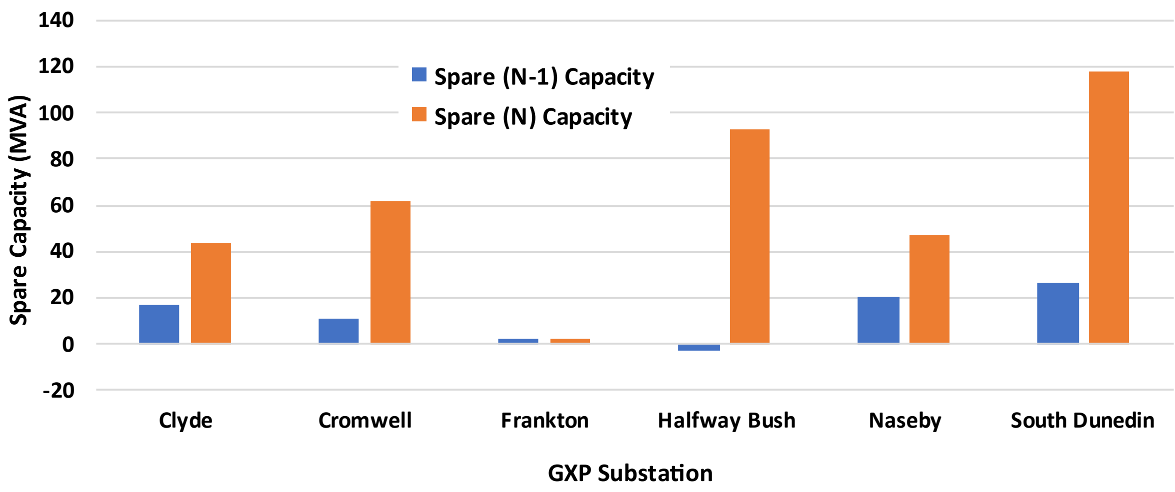


Figure 19 - Summary: GXP Spare Capacity based on Transpower's 2022 Load Forecast

It should be noted that the spare capacities are based on the values disclosed by Transpower.

We note the following:

- The negative values in Figure 19 indicate that there is no capacity and consumer load cannot be supplied (for (N) and (N-1) conditions).
- Figure 19 infers that there are relatively high levels of spare (N-1) capacity at Clyde, Naseby and South Dunedin.
- Transpower has advised that the spare capacities of Frankton and Cromwell are not cumulative, i.e. the GXPs cannot both supply their (N) capacity at the same time. This means that if large loads are expected to connect to both Frankton and Cromwell GXPs, they may need to be considered in parallel to ensure security of supply at each GXP.

7. Spare Capacity – Zone Substations

In determining the (N) and (N-1) spare capacities for the zone substation, Ergo reviewed the EDB 2022 disclosure data and the historical substation loading data for 2021.

Actual historical loading data was provided by OtagoNet and Aurora Energy.

7.1 OtagoNet

Table 4 OtagoNet: Spare capacity for each Zone Substation

No.	Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
		Disclosure Data	Historical Data[18]	Disclosure Data	Historical Data
1	Clarks	0.20	0.2	-0.3	-0.3
2	Deepdell	0.55	0.4	-0.2	-0.3
3	Golden Point	2.30	2.1	-2.7	-2.9
4	Hindon	0.35	0.4	-0.2	-0.2
5	Hyde	1.80	-1.4	-0.7	-3.9
6	Linnburn	0.10	0.1	-0.9	-0.9
7	Merton	2.50	0.9	0.0	-1.6
8	Middlemarch	1.60	1.4	-0.9	-1.1
9	Oturehua	0.55	0.1	-0.2	-0.6
10	Paerau	0.80	0.8	-0.2	-0.3
11	Paerau Hydro	17.70	N/A	2.7	N/A
12	Palmerston	2.80	2.8	0.3	0.3
13	Patearoa	0.70	0.6	-1.8	-1.9
14	Ranfurly 33/11	2.70	2.4	-2.3	-2.6
15	Ranfurly 66/33	23.50	N/A	-26.5	N/A
16	Remarkables	17.60	21.0	5.1	8.5
17	Waipiata	1.00	0.8	-1.5	-1.7
18	Waitati	0.90	0.4	-1.6	-2.1
19	Wedderburn	0.80	0.8	-0.2	-0.2

[18] N/A reflects sites that loading data was not provided for.

7.2 Aurora Energy

Table 5 Aurora Energy: Spare capacity for each Zone Substation

No.	Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
		Disclosure Data	Historical Data [19]	Disclosure Data	Historical Data
1	Alexandra	19.00	18.5	4.0	3.5
2	Andersons Bay	15.00	15.7	3.0	3.7
3	Arrowtown	6.50	5.0	-3.0	-4.5
4	Berwick	2.00	1.2	-1.0	-1.8
5	Camp Hill	1.50	1.7	-6.0	-5.8
6	Cardrona	2.00	0.6	-4.0	-5.4
7	Carisbrook	36.00	38.1	6.0	8.1
8	Clyde/Earnscleugh	0.00	0.1	-4.0	-3.9
9	Commonage	23.00	22.2	6.0	5.2
10	Coronet Peak	1.00	0.7	-5.0	-5.3
11	Corstorphine	35.00	N/A	10.0	N/A
12	Cromwell	34.00	41.6	10.0	17.6
13	Dalefield	1.00	0.5	-2.0	-2.5
14	Earnscleugh	2.00	N/A	0.0	N/A
15	East Taieri	29.00	31.7	5.0	7.7
16	Ettrick	1.00	0.8	-2.0	-2.2
17	Fernhill	14.00	13.5	4.0	3.5
18	Frankton	22.00	20.9	-2.0	-3.1
19	Green Island	16.00	14.9	4.0	2.9
20	Halfway Bush	35.00	41.4	5.0	11.4
21	Kaikorai Valley	38.00	38.3	13.0	13.3
22	Lauder Flat	2.00	1.9	-1.0	-1.1
23	Lindis Crossing	0.50	0.7	-7.0	-6.8
24	Mosgiel	13.00	8.8	5.0	0.8
25	North City	41.00	41.0	13.0	13.0
26	North East Valley	32.00	31.8	8.0	7.8
27	Omakau	0.60	0.3	-3.0	-3.3
28	Outram	4.50	N/A	-3.0	N/A
29	Port Chalmers	13.00	16.5	3.0	6.5
30	Queensberry	1.00	0.2	-3.0	-3.8
31	Queenstown	28.00	22.9	8.0	2.9
32	Remarkables	1.00	0.6	-2.0	-2.4
33	Roxburgh	3.00	2.3	-2.0	-2.8
34	Smith Street	23.00	19.9	5.0	1.9
35	South City	21.00	9.0	3.0	-9.0
36	St Kilda	33.00	32.4	8.0	7.4

[19] N/A reflects sites that loading data was not provided for.

No.	Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
		Disclosure Data	Historical Data [19]	Disclosure Data	Historical Data
37	Wanaka	23.00	22.0	-1.0	-2.0
38	Ward Street	39.00	34.3	14.0	9.3
39	Willowbank	18.00	17.6	6.0	5.6

7.3 Summary

7.3.1 OtagoNet

7.3.1.1 (N-1) Capacity Summary

The following Figure 20 illustrates the approximate (N-1) spare capacities at OtagoNet's zone substations, for the disclosed 2021 peak demand estimates[20]. 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 specific zone substations in Section 8.

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. The significant number of negative values in Figure 20 indicates very few substations have (N-1) spare capacity, which is driven by the fact that most of OtagoNet's zone substations are equipped with a single transformer bank.

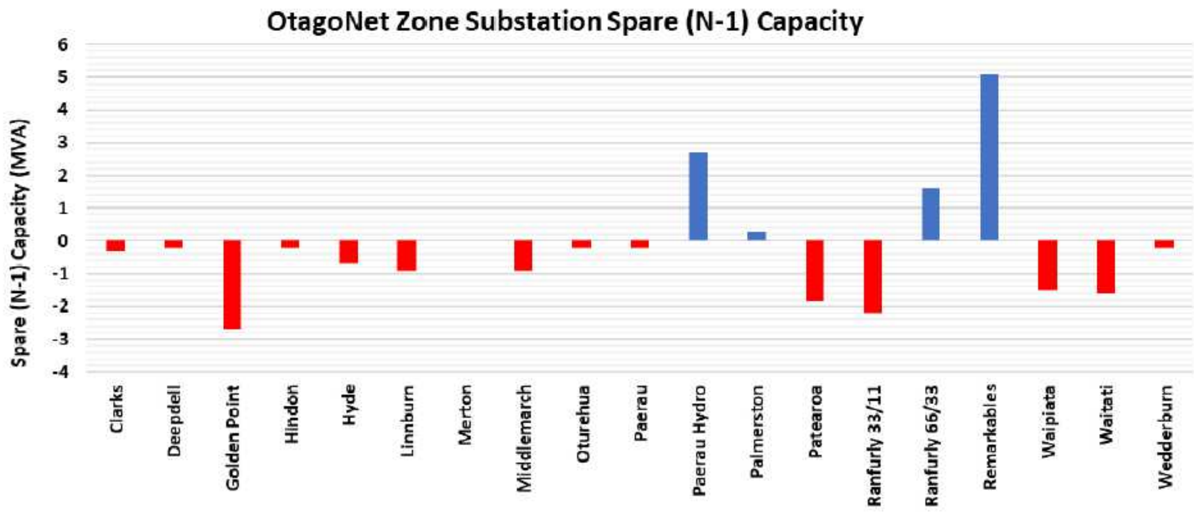


Figure 20 Summary: Approximate (N-1) spare capacity at OtagoNet's zone substations

[20] OtagoNet's 2022 information disclosure (https://powernet.co.nz/disclosures/otagonet/).

7.3.1.2 (N) Capacity Summary

The following Figure 21 illustrates the approximate (N) spare capacities at OtagoNet'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 OtagoNet.

The spare capacities shown do not include any upstream or downstream conductor or other equipment thermal constraints, which may be discussed for specific zone substations in Section 8.

Figure 21 indicates that the Ranfurly 66/33kV auto-transformers have significant spare (N) capacity. This is also the case with the power transformers at the Remarkables 33/22kV zone substation and the Paerau hydro station.

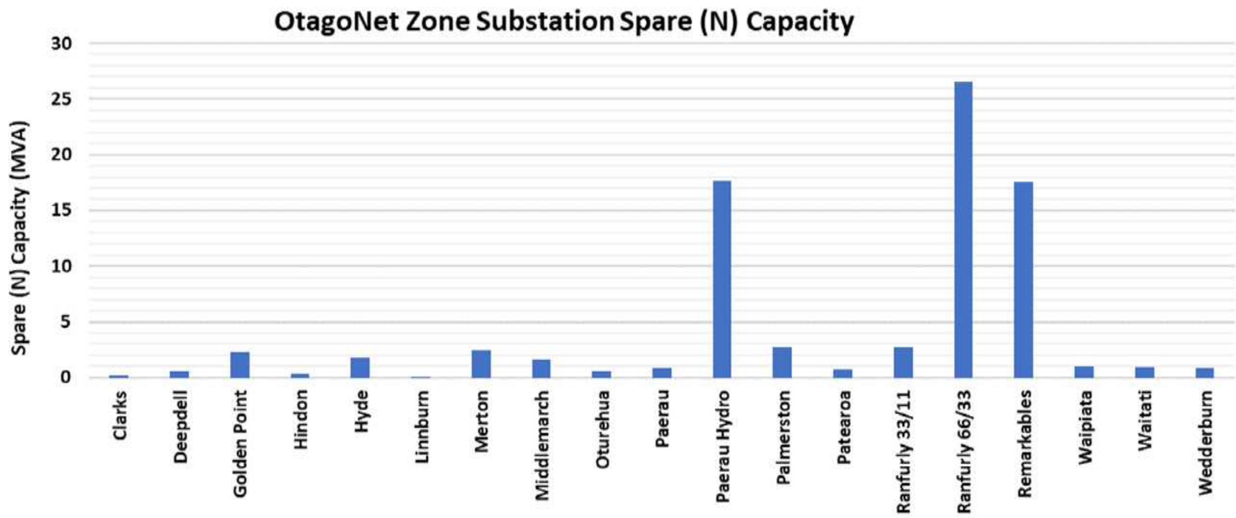


Figure 21 Summary: Approximate (N) spare capacity at OtagoNet's zone substations

7.3.2 Aurora Energy

7.3.2.1 (N-1) Capacity Summary

The following Figure 22 illustrates the approximate (N-1) spare capacities at Aurora'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 Aurora Energy.

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 8.

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.

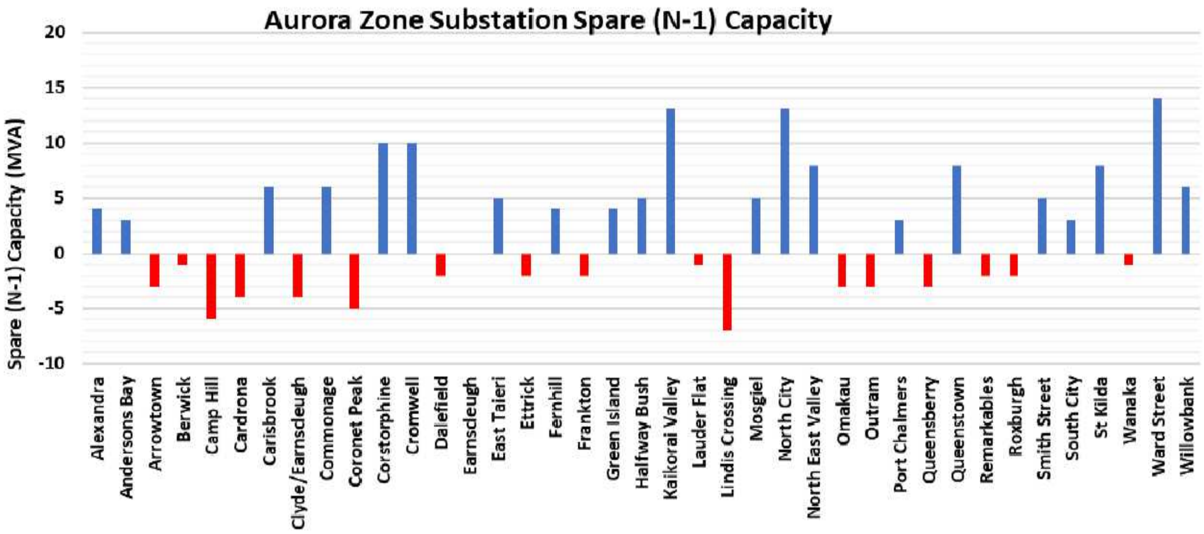


Figure 22 Summary: Approximate (N-1) spare capacity at Aurora Energy's zone substations

7.3.2.2 (N) Capacity Summary

The following Figure 23 illustrates the approximate (N) spare capacities at Aurora's zone substations, for the disclosed peak demand estimates[21]. Again, it should be noted that these have been calculated based on the transformer ratings disclosed by Aurora Energy.

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 8. Figure 23 indicates that there is a significant volume of spare (N) capacity at Aurora's substations, although we note that many of them are in urban/CBD locations where (N-1) security of supply would be a standard requirement.

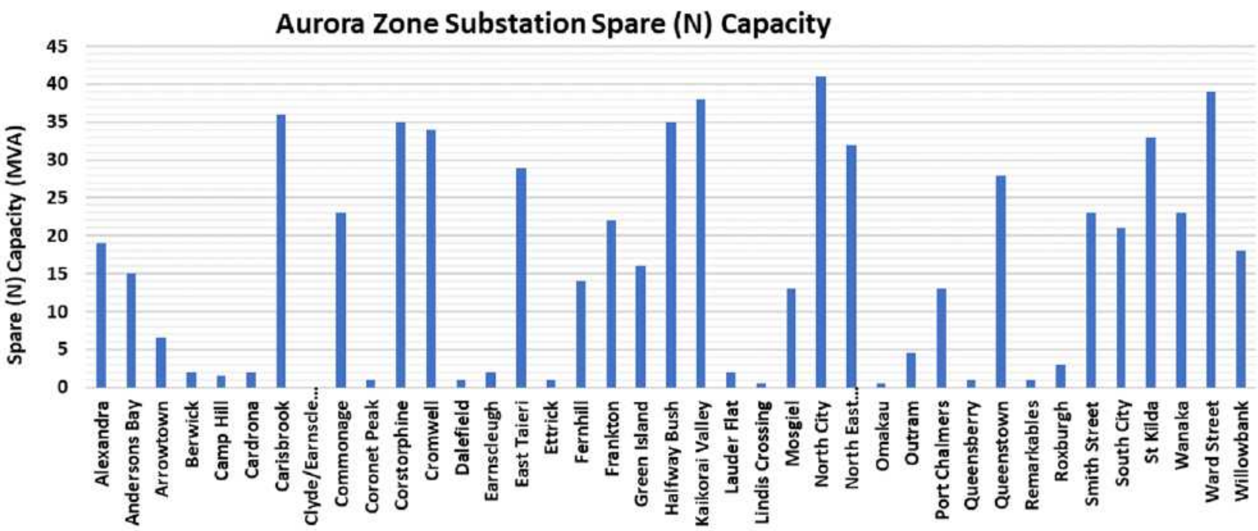


Figure 23 Summary: Approximate (N) spare capacity at Aurora Energy's zone substations

[21] Aurora Energy's 2022 information disclosure (https://www.auroraenergy.co.nz/disclosures/information-disclosures/).

8. Connection Options

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

- Transpower GXP substations (shaded blue colour in diagrams).
- The OtagoNet and Aurora Energy zone substations (shaded yellow in diagrams).

The purpose of this section is to provide a high-level assessment regarding the feasibility of connecting the Load Sites 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 Load Sites are progressed further, Ergo recommends more detailed engineering assessments are undertaken in consultation with Transpower and OtagoNet / Aurora Energy. 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 Load Sites uses a top down approach where the Load Site 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 the relevant EDB 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 Load Site 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 2021 loading data provided by Transpower, OtagoNet and Aurora Energy). 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 of individual Load Sites are considered in isolation of the adjacent Load Sites. We have not considered the scope and costs associated with connecting multiple Load Sites at this stage.
- The Load Site loads will have unity power factor which is reasonable considering the preliminary nature of the assessment.
- Unless otherwise stated, we have assumed the existing incoming sub-transmission line/cable capacities exceed the capacity of the existing zone substation(s) they supply.
- Unless capacity information is available, we assumed 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 information.
- Cost estimates have a Class 5[22] 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 wide corridor 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 Load Sites (for example, MV switchboards/cabling and LV switchboards/cables within the respective Load Site 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 Load Site 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

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

be used for final budgeting purposes in order to connect the respective Load Sites. For the larger Load Sites Ergo recommend proceeding with a Concept Design Report (CDR) to improve the accuracy of the respective cost estimate.

8.3 Clyde GXP

The EECA Load Sites include:

- Dunstan Hospital (0.11 MVA)

The geographic location of the Load Site is shown on the following map in relation to the local transmission and distribution substations.

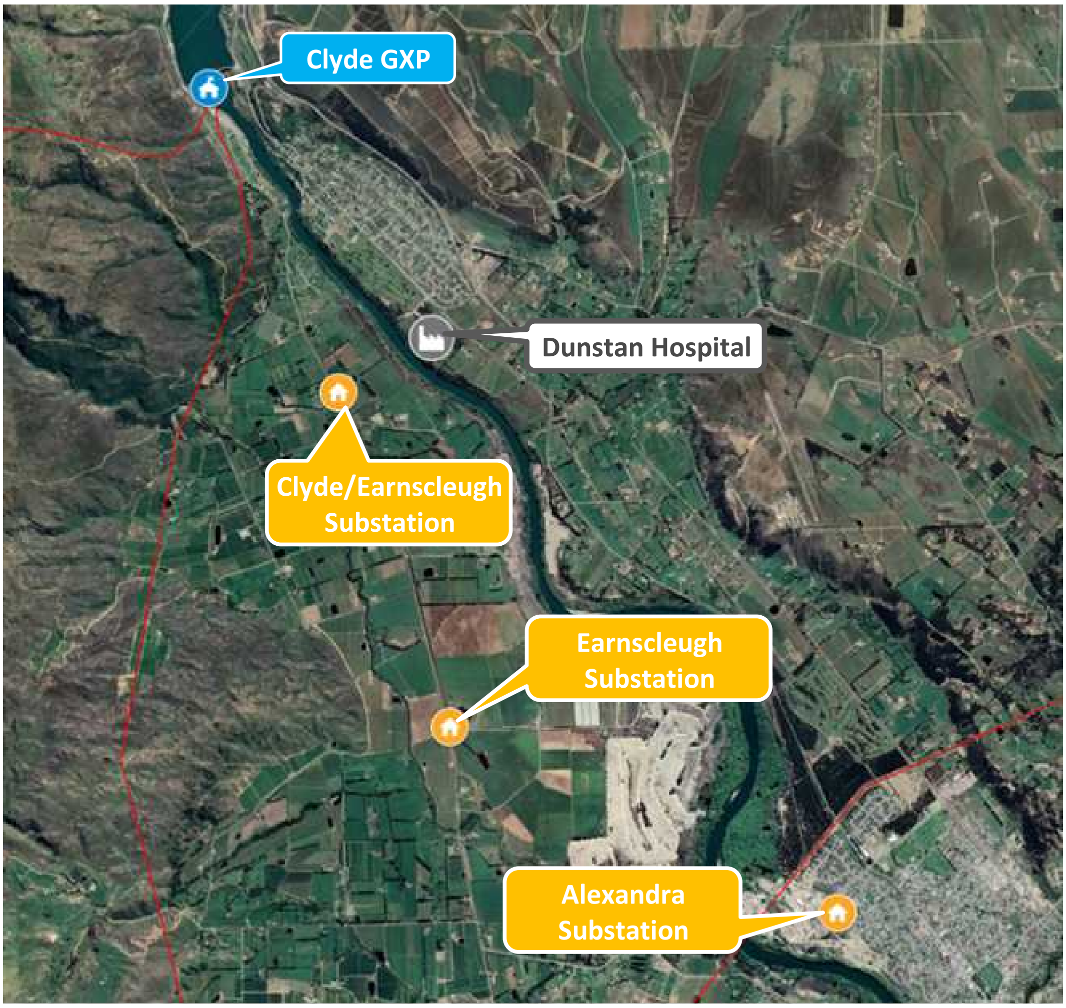


Figure 24 Clyde GXP: EECA Load Sites vs local substations

8.3.1 Clyde GXP Upgrade

The proposed loads connecting to Clyde GXP are not expected to exceed the GXP's (N-1) capacity. Therefore, a GXP upgrade is not considered.

8.3.2 Dunstan Hospital

DUNSTAN HOSPITAL		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	0.11 MW	Clyde

Existing Electrical Supply to the Plant

Dunstan Hospital is presently fed from Aurora Energy's Clyde/Earnscleugh zone substation (via the CE190 11 kV feeder). The plant is ≈1 km (straight line) from Clyde/Earnscleugh substation.

The hospital presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

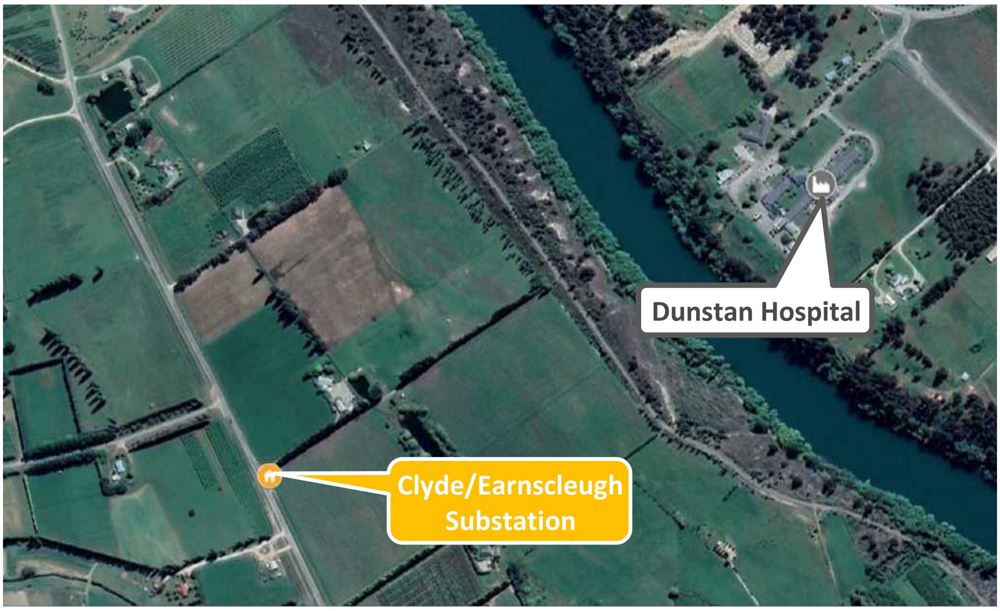


Figure 25 Dunstan Hospital geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

There is presently no (N-1) or (N) spare capacity at Clyde/Earnscleugh substation. Aurora states in their disclosures that Clyde/Earnscleugh substation will be decommissioned following the transfer of load to the new Dunstan substation in RY26. Ergo expects that given the size of this load, the only cost to connect this additional load once Dunstan substation is commissioned would be that associated with distribution transformers/cabling on site.

Aurora also states that the network has been reinforced to provide backup supply from Alexandra substation to Clyde/Earnscleugh. Based on the network GIS, it may be possible to perform network switching to provide backfeed to the Clyde/Earnscleugh feeder CE195 (which runs in the road next to the load site) via Alexandra feeder AX168. Again, Ergo expects that the cost to connect the load would be that associated with distribution transformers/cabling on site.

Capital Cost Estimate

There are no upgrade costs expected for this site, other than the installation of a distribution transformer which could be ≈$50k.
Does not include the costs for any switchgear or cabling on the plant site.

DUNSTAN HOSPITAL
Timeframe to Establish New Electrical Infrastructure
Estimated to take 3 - 6 months. To Plan, Design, Procure, Construct and Commission the works. Excludes the work required to establish the Load Site. Excludes land acquisition and consenting, if required.

8.3.3 Effect of all Load Sites Connecting to Clyde GXP

The following Figure 26 illustrates the Clyde 2022 load profile together with the Dunstan Hospital. Also shown in Figure 26 is:

- The cumulative sum of the loads (Combined Load), which forecasts that the maximum load on the Clyde GXP would not increase due to diversity of the loads.
- The Clyde GXP's (N-1) limit of 27 MVA (discussed in Section 6.1.1) is not expected to be exceeded.

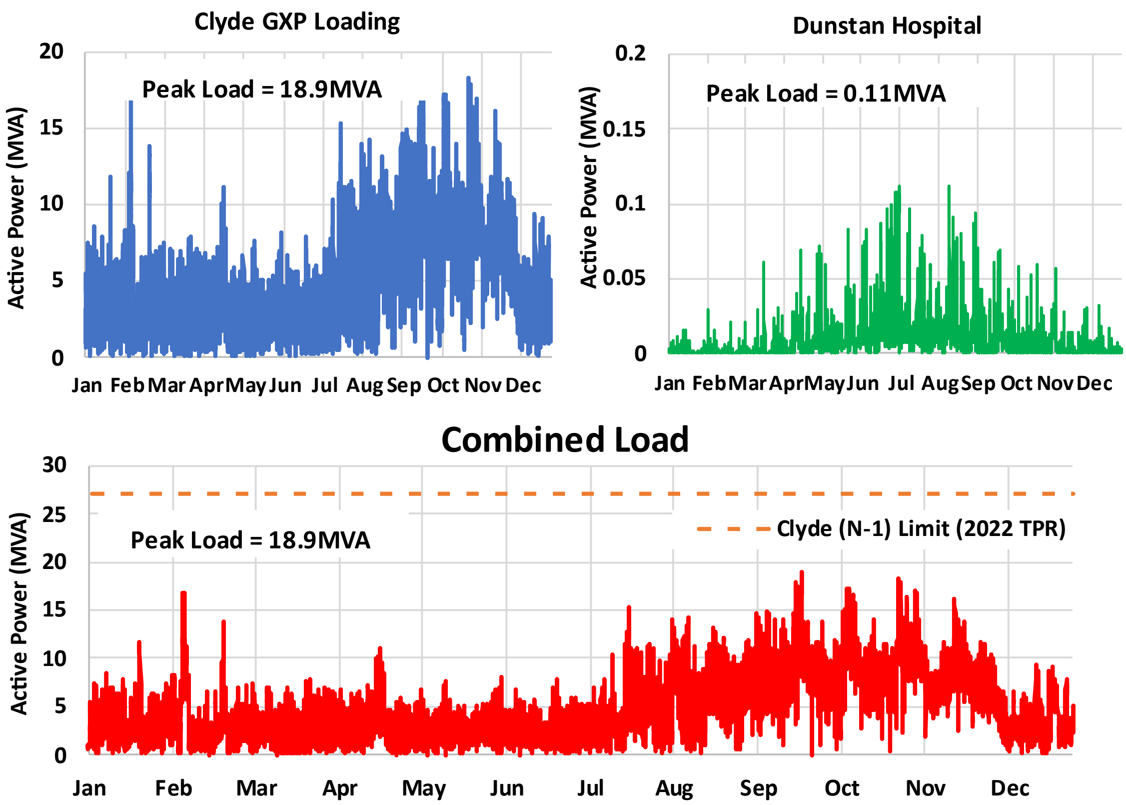


Figure 26 Loading Profiles: Clyde GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.4 Cromwell GXP

The EECA Load Sites include:

- Fulton Hogan Cromwell Asphalt Plant (9.6 MVA)
- Cromwell EV Charging Station (1.5 MW to 3.8 MW)
- Cromwell Pool (0.07 MVA)
- Cromwell College (0.16 MVA)
- Mt Aspiring College (0.15 MVA)

The geographic locations of the Load Sites are shown on the following map in relation to the local transmission and distribution substations.

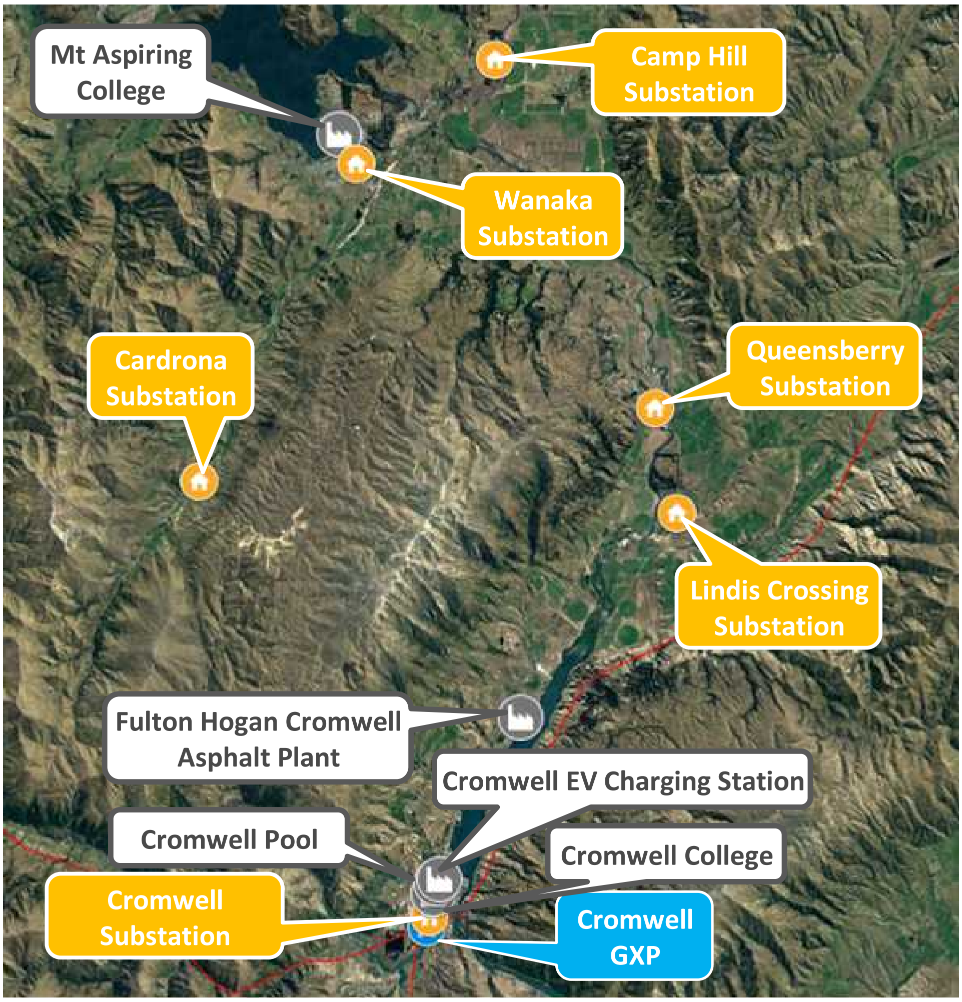


Figure 27 Cromwell GXP: EECA Load Sites vs local substations

8.4.1 Cromwell GXP Upgrade

Transpower's demand forecast indicates that Cromwell GXP will exceed its (N-1) capacity by 2028, however presently the GXP has 11 MVA of spare (N-1) capacity and 62 MVA of spare (N) capacity. The (N) and (N-1) capacity are presently limited by a 33kV cable limit.

Additionally, the 2022 Transmission Planning Report notes that there are existing voltage step/stability issues at Cromwell GXP for an outage of the 220 kV Clyde-Cromwell-Twizel circuit, or loss of a Cromwell transformer.

Transpower are presently working with Aurora Energy to investigate a longer-term solution to the capacity constraints at Cromwell GXP. Solutions at Cromwell GXP are likely to affect Frankton GXP as well. Transpower identifies the following options relevant to the Cromwell GXP:

- Replace Cromwell GXP's 33 kV bus with a 66 kV or 110 kV switchyard to ease (N-1) constraints at Cromwell GXP (long term),
- Implement variable line ratings and/or thermally upgrade the Cromwell-Frankton lines (medium term),
- Transpower, Aurora Energy, and PowerNet are working to resolve the voltage issues. They have agreed to install two new transformers at Frankton.

Transpower does not provide indicative costs for any of these solutions in their Transmission Planning Report 2022.

8.4.2 Fulton Hogan Cromwell Asphalt Plant

FULTON HOGAN CROMWELL ASPHALT PLANT		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	9.6 MW	Cromwell

Existing Electrical Supply to the Plant

The Fulton Hogan Cromwell Asphalt plant is presently fed from Aurora Energy's Cromwell zone substation (via the CM823 11 kV feeder). The plant is ≈11.5 km (straight line) from Cromwell substation. The CM823 feeder is presently loaded at a maximum of 3.27 MVA, and is a mixture of underground cabling and overhead conductors.

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

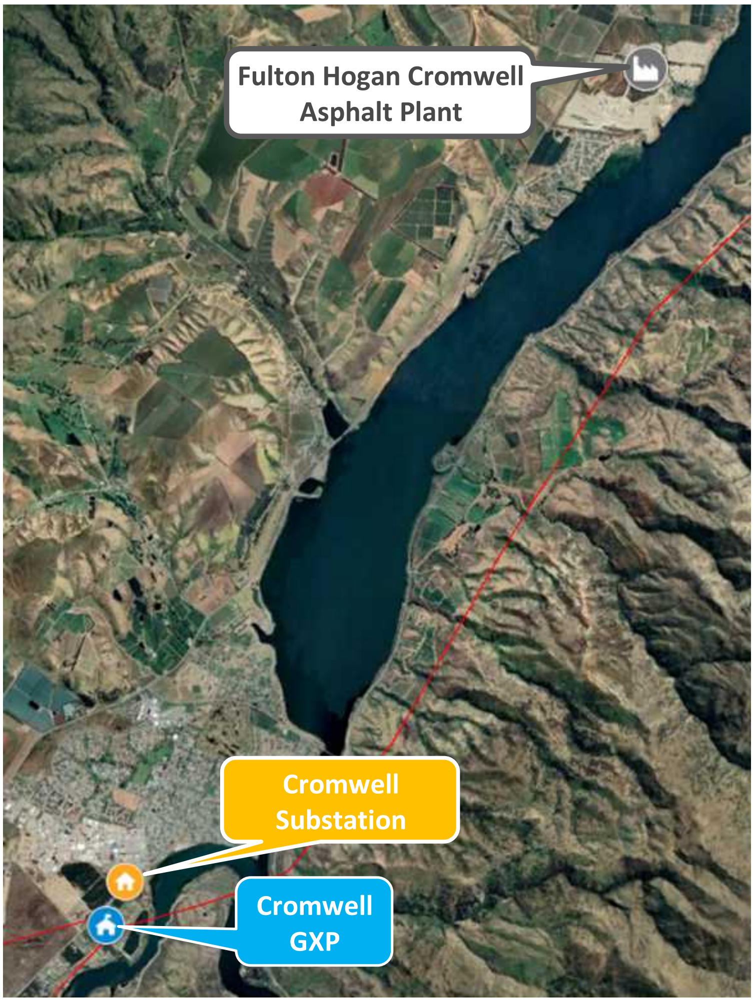


Figure 28 Fulton Hogan Cromwell Asphalt Plant geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Cromwell GXP and Cromwell zone substation have sufficient (N-1) capacity to accommodate the additional load of 9.6 MW. However, the CM823 feeder would not be able to supply the additional load.

FULTON HOGAN CROMWELL ASPHALT PLANT
Based on this, Ergo is of the view two new dedicated 11kV feeders to the site would be required. This could be supplied from the Cromwell substation and, for some of the route, due to the urban topography, would likely require underground cabling. A suitable route is likely to require ≈3.3 km of underground cabling and ≈12.5 km of overhead conductor. Due to the overall length of the feeder, it is likely that voltage support in the form of a STATCOM may be required at the site.
Capital Cost Estimate

Table 6 Fulton Hogan Cromwell Asphalt Plant: Capital cost estimate to supply the Load Site

Transmission => (N)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	2.00	$0.20
Distribution	Double underground 11kV cable	3.30	$2.31
Distribution	Double overhead 11kV line	12.50	$3.75
Distribution	11kV STATCOM	1.00	$1.00
		TOTAL	**$7.26**

Does not include the costs for any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 18 - 24 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.4.3 Cromwell EV Charging Station

CROMWELL EV CHARGING STATION		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
Charging station for electric cars	1.5 MW to 3.8 MW	Cromwell
Existing Electrical Supply to the Plant		

The following Figure 29 illustrates a potential location for the charging station on Barry Ave, near the northern fringe of Cromwell and SH8B. The proposed location is also close to a number of eateries and accommodation. The Cromwell substation feeder CM823 runs underground adjacent to Barry Ave. The CM823 feeder is presently loaded at a maximum of 3.27 MVA, and is a mixture of underground PILC and XLPE cabling.

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

Figure 29 Cromwell EV Charging Station geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Cromwell GXP and Cromwell zone substation have sufficient (N-1) capacity to accommodate the additional load of 3.8 MW. However, the CM823 feeder is unlikely to be able to supply the additional load. The CM823 feeder may be able to supply the load in the short-term (1.5 MW), which would require replacement of the 95 mm^2 Al PILC sections of cable (≈2.1 km of cable replacement).

Based on this, Ergo is of the view a new dedicated 11kV feeder to the site would be required for the full 3.8 MW of proposed load. This could be supplied from the Cromwell substation and, due to the urban topography, would likely require underground cabling. A suitable route is likely to require ≈2.5 km of underground cabling.

Capital Cost Estimate

Table 7 Cromwell EV Charging Station: Capital cost estimate to supply the Load Site

Short-term –1.5 MW total load

Transmission => (N)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Single underground 11kV cable	2.10	$0.84
		TOTAL	**$0.84**

Long-term –3.8 MW total load

Transmission => (N)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	2.50	$1.00
		TOTAL	**$1.10**

Does not include the costs for any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 18 months for either option.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.4.4 Small Opportunities

Below is a summary of the "small" Load Sites that were provided by EECA but due to their size, are unlikely to have a material effect on the distribution or transmission network. The costs provided are estimates to provide distribution transformers to supply the site.

Table 8 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Feeder	Zone sub (N-1) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Cromwell Pool	Cromwell	CM823	10	3.27	0.07	50
Cromwell College	Cromwell	CM823	10	3.27	0.16	80
Mt. Aspiring College	Wanaka	WK2756	-1	4.38	0.15	80

Each Load Site is estimated to take 3 - 6 months to plan, design, procure, construct and commission the works.

Estimates exclude:

- The work required to establish the Load Site.
- Land acquisition and consenting, if required.

8.4.5 Combined Load on Cromwell Zone Substation

A number of the loads on Cromwell GXP are expected to connect to Cromwell zone substation. These loads are Fulton Hogan Cromwell Asphalt Plant, and Cromwell EV charging station, along with with "small" loads Cromwell Pool and Cromwell College. The sum of peaks of these loads is 13.63 MVA, which the zone substation doesn't have (N-1) capacity for, however does have (N) capacity for, before considering the diversity between loads. The EV charging station has been assumed as a flat load, and with only one other large load (the Asphalt plant), diversity between loads is not present beyond that resulting from the two small loads, which would be inconsequential.

The costs estimated in the above sections per load opportunity are not expected to be shared by the loads, as they are relatively individual solutions (e.g. relate to feeders in different areas, or distribution transformers). Shared costs may only relate to overall zone substation upgrades:

- By exceeding the (N-1) capacity of the zone substation, transformer upgrades may be triggered, which could result in costs of ~$1.5M per transformer.
- Another issue Ergo anticipates with these concurrent load additions to the zone substation is if there is not enough physical space in the zone substation for the 3x additional 11 kV feeder breakers required for the Fulton Hogan Cromwell Asphalt Plant and the EV charging station. In this case, a switchroom upgrade/replacement may be triggered, at a cost of ~$4M.

8.4.6 Combined Load of Small Opportunities

Summing the maximum values of the "small" loads on Cromwell GXP gives a combined load of 0.38 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 30), with a maximum load of 0.37 MVA, with a diversity factor of 0.97.

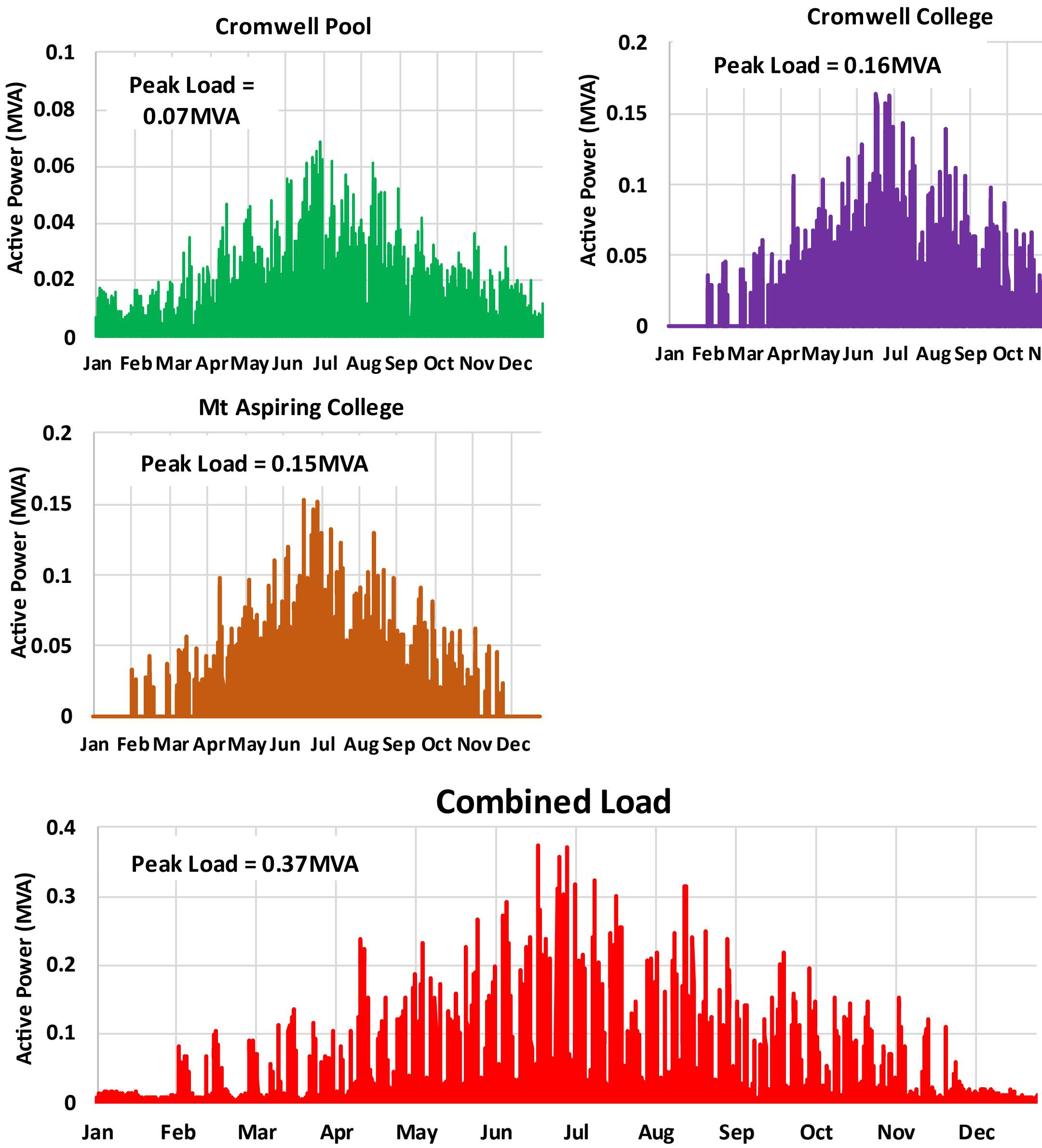


Figure 30 Loading Profiles: Cromwell GXP "small" Load Site Profiles: Combined Load (sum of all profiles)

8.4.7 Effect of all Load Sites Connecting to Cromwell GXP

The following Figure 31 illustrates the Cromwell 2022 load profile together with the load profiles of all the Load Sites within the Cromwell GXP region.[23] Also shown in Figure 31 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Cromwell GXP would increase to 58.5 MVA, a difference of 12.0 MVA. Given that the independent sum of the individual loads is 60.3 MVA there is a diversity factor of 0.97 between the loads.
- Based on Ergo's analysis, the Cromwell GXP's (N-1) limit is expected to be (slightly) exceeded for short periods of time throughout the year.
- It is possible that in the year studied, during the winterpeak, the embedded generation local to Cromwell (Roaring Meg, for which public generation information is not available) may have been supplying up to its 4 MW capacity[24], effectively decreasing the peak winter load. If in future years, the local generation at Roaring Meg or other local embedded generators is lower than it has been historically, then it could be expected that the (N-1) limit of Cromwell GXP could be further exceeded.

[23] The Combined Load graph includes a constant 3.8 MW Cromwell Charging Station load but the graph for this Load Site is not presented.

[24] Capacity is as per the Aurora Energy 2022 Asset Management Plan

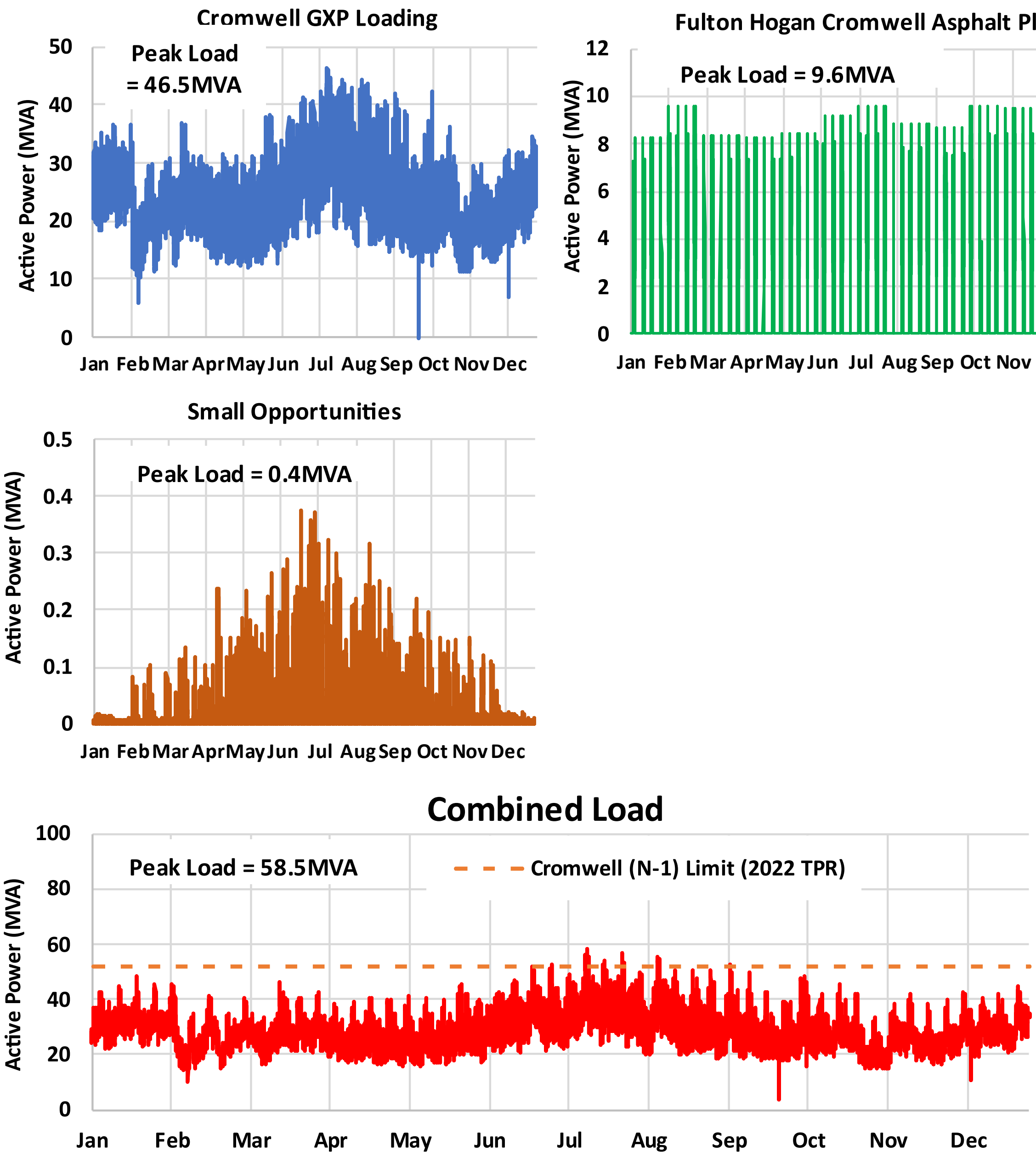


Figure 31 Loading Profiles: Cromwell GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.5 Frankton GXP

The EECA Load Sites include:

- Southern Lakes Laundries (0.9 MVA)
- Lakes Leisure (0.11 MVA)
- Queenstown Primary School (0.14 MVA)

The geographic locations of the Load Sites are shown on the following map in relation to the local transmission and distribution substations.

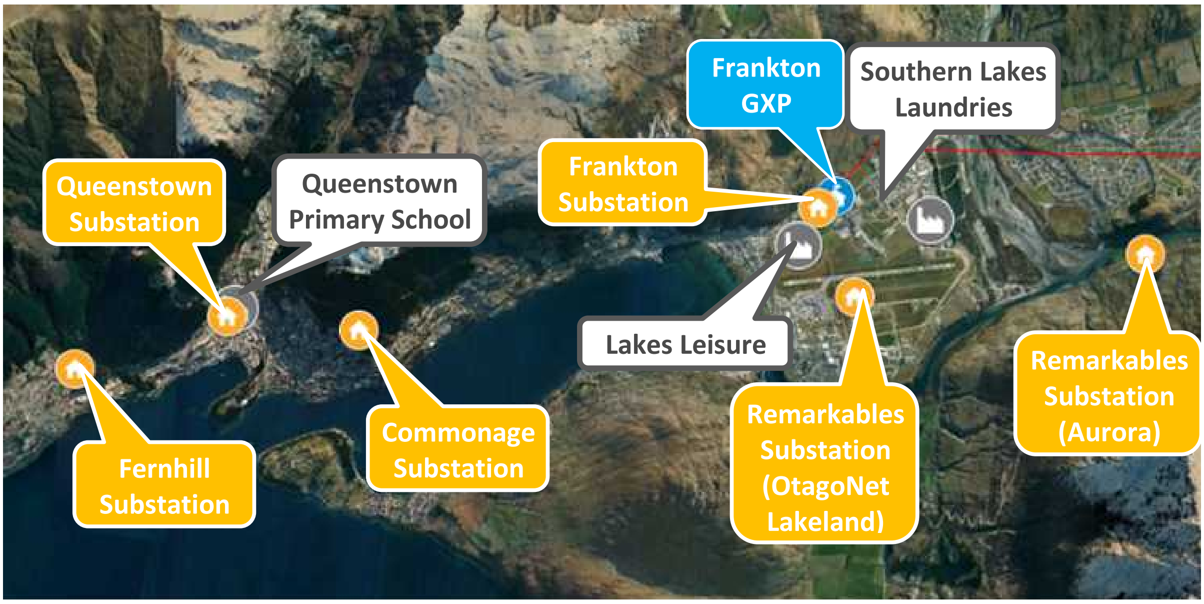


Figure 32 Frankton GXP: EECA Load Sites vs local substations

8.5.1 Frankton GXP Upgrade

Transpower's demand forecast indicates that Frankton GXP has exceeded its (N-1). The main constraint for this is the incoming lines. The 2022 Transmission Planning Report notes that as there is no 110 kV bus at Frankton, meaning that a fault on one of the following 220 kV lines/transformers would also take the Cromwell-Frankton 110kV line and connected supply transformer at Frankton out of service:

- Clyde-Cromwell-Twizel 220kV line
- Cromwell-Frankton 110kV line
- Cromwell transformer
- Frankton transformer

Additionally, the Transmission Planning Report 2022 notes the following:

- There are existing voltage step/stability issues at the Frankton GXP for an outage of the 220 kV Clyde-Cromwell-Twizel circuit, or loss of a Cromwell transformer; and
- A special protection scheme (SPS) has been commissioned for Frankton to allow the GXP to supply up to 120 MW, pre-contingency.

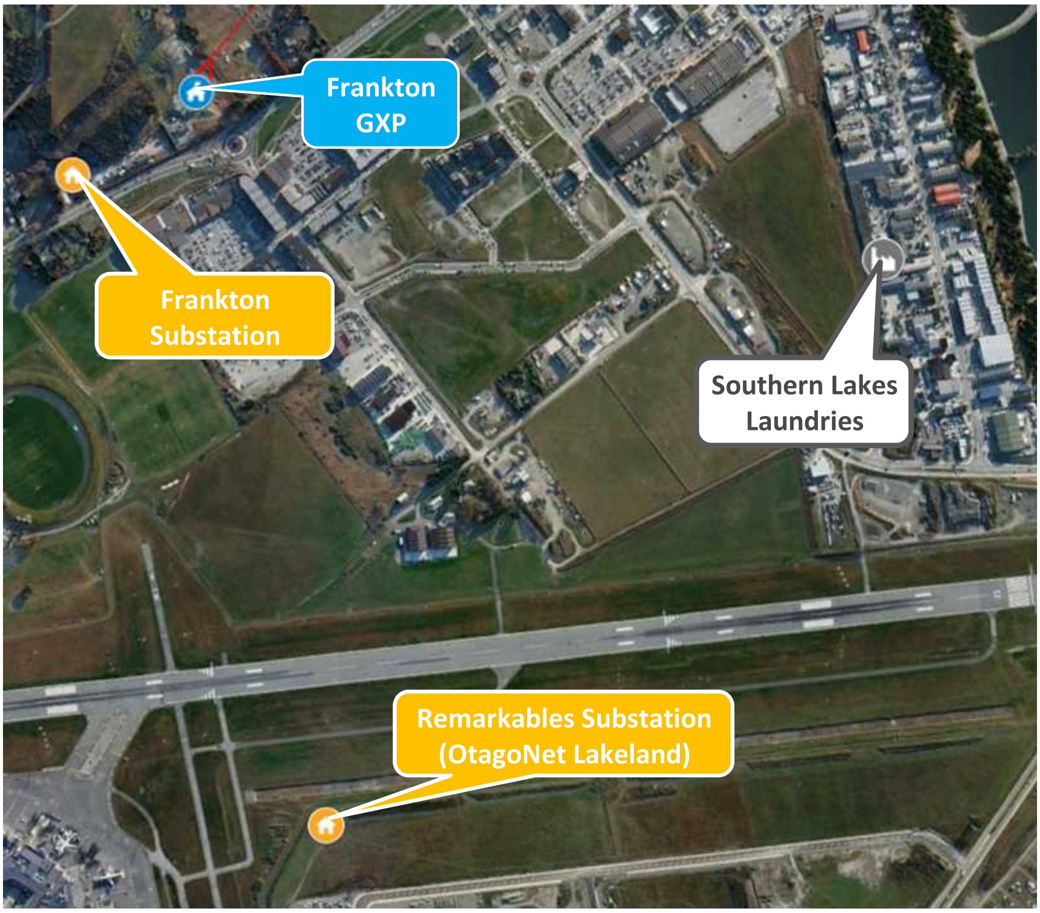
Transpower are presently working with Aurora Energy as well as PowerNet to investigate a longer-term solution to the capacity constraints at Frankton GXP. Solutions at Frankton GXP are likely to affect Cromwell GXP as well. Transpower identifies the following options relevant to the Frankton GXP:

- Implement variable line ratings and/or thermally upgrade the Cromwell-Frankton lines (medium term)
- Replacement of the Frankton GXP transformers (long term)
- Transpower, Aurora Energy, and PowerNet are working to resolve the voltage issues. They have agreed to install two new transformers at Frankton by winter 2025, which will resolve the existing 80 MW voltage stability limit. Aurora Energy, PowerNet, and Transpower are also considering upgrades on the Cromwell-Frankton line.

Transpower does not provide indicative costs for any of these solutions in their 2022 Transmission Planning Report.

On the basis the proposed Load Sites are relatively small (from a GXP perspective) and unlikely to justify the type of investment required at a GXP level to maintain (N-1) capacity, it has been assumed that (N) security at the Frankton GXP, utilising the SPS, is acceptable (for some periods of the year) to connect loads at Frankton GXP. Therefore, Ergo has not estimated the costs of transmission upgrades in this area.

8.5.2 Southern Lakes Laundries

SOUTHERN LAKES LAUNDRIES		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	0.9 MW	Frankton
Existing Electrical Supply to the Plant		
The Southern Lakes Laundries plant is presently supplied by Lakeland Network's (a part of OtagoNet) Remarkables zone substation (via the RMK8 22 kV feeder). The plant is ≈0.7 km (straight line) from Remarkables Lakeland substation. The RMK8 22 kV feeder is presently loaded at a maximum of 3.0 MVA, and is underground cabling. The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.  Figure 33 Southern Lakes Laundries geographic location in relation to the surrounding zone substations		
Supply Option(s) for New Load		
Remarkables substation and Frankton GXP have sufficient (N) spare capacity to accommodate the additional load of 0.9 MW. Lakeland (OtagoNet) have advised that to connect the proposed load,		

SOUTHERN LAKES LAUNDRIES
112m of HV cable would need to be laid between the street RMU and the plant. This would also involve installation of a new distribution transformer and an RMU upgrade.
Capital Cost Estimate

Table 9 Southern Lakes Laundries: Capital cost estimate to supply the Load Site

Transmission =>	**(N)**	**Subtransmission =>**	**(N)**	**Distribution =>**	**(N)**
Network Asset		**Equipment**		**Number and Capital Cost ($M)**	
Distribution		Single underground 22kV cable		0.11	$0.05
Distribution		Distribution switches - RMU		1.00	$0.05
				TOTAL	**$0.10**

Does not include the costs of any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure
Estimated to take 6 – 12 months. To Plan, Design, Procure, Construct and Commission the works. Excludes the work required to establish the Load Site. Excludes land acquisition and consenting, if required.

8.5.3 Small Opportunities

Below is a summary of the “small” Load Sites that were provided by EECA but due to their size, are unlikely to have a material effect on the distribution or transmission network. The costs provided are estimates to provide distribution transformers to supply the site.

Table 10 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Feeder	Zone sub (N-1) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Lakes Leisure	Frankton	FK7783	-2	4.11	0.11	80
Queenstown Primary School	Queenstown	QT5272	8	1.89	0.14	80

Each Load Site is estimated to take 3 - 6 months to plan, design, procure, construct and commission the works.

Estimates exclude:

- The work required to establish the Load Site.
- Land acquisition and consenting, if required.

8.5.4 Combined Load of Small Opportunities

Summing the maximum values of the “small” loads on Frankton GXP gives a combined load of 0.23 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 34), with a maximum load of 0.26 MVA, with a diversity factor of 0.90.

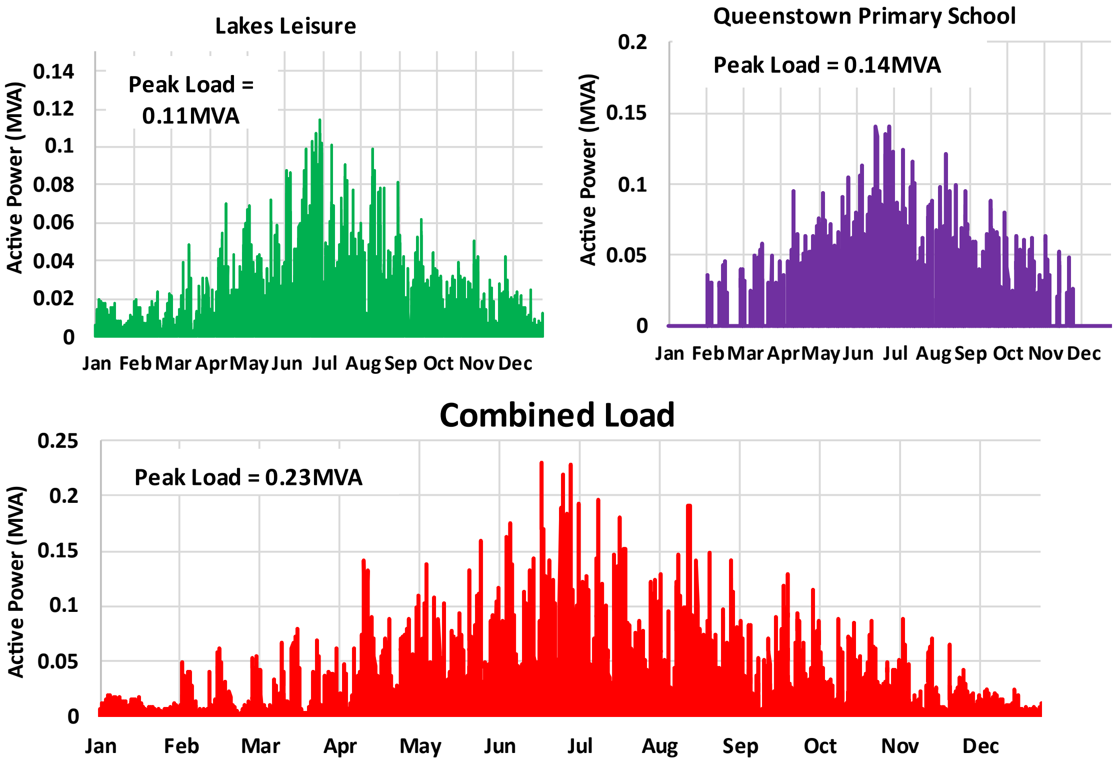


Figure 34 Loading Profiles: Frankton GXP “small” Load Site Profiles: Combined Load (sum of all profiles)

8.5.5 Effect of all Load Sites Connecting to Frankton GXP

The following Figure 35 illustrates the Frankton 2022 load profile together with the load profiles of all the Load Sites within the Frankton GXP region. Also shown in Figure 35 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Frankton GXP would increase to 71.7 MVA, a difference of 0.1 MVA. Given that the independent sum of the individual loads is 72.7 MVA there is a diversity factor of 0.99 between the loads.
- Based on Ergo's analysis, the Frankton GXP's (N-1) circuit limit is expected to be (slightly) exceeded for short periods of time throughout the year.

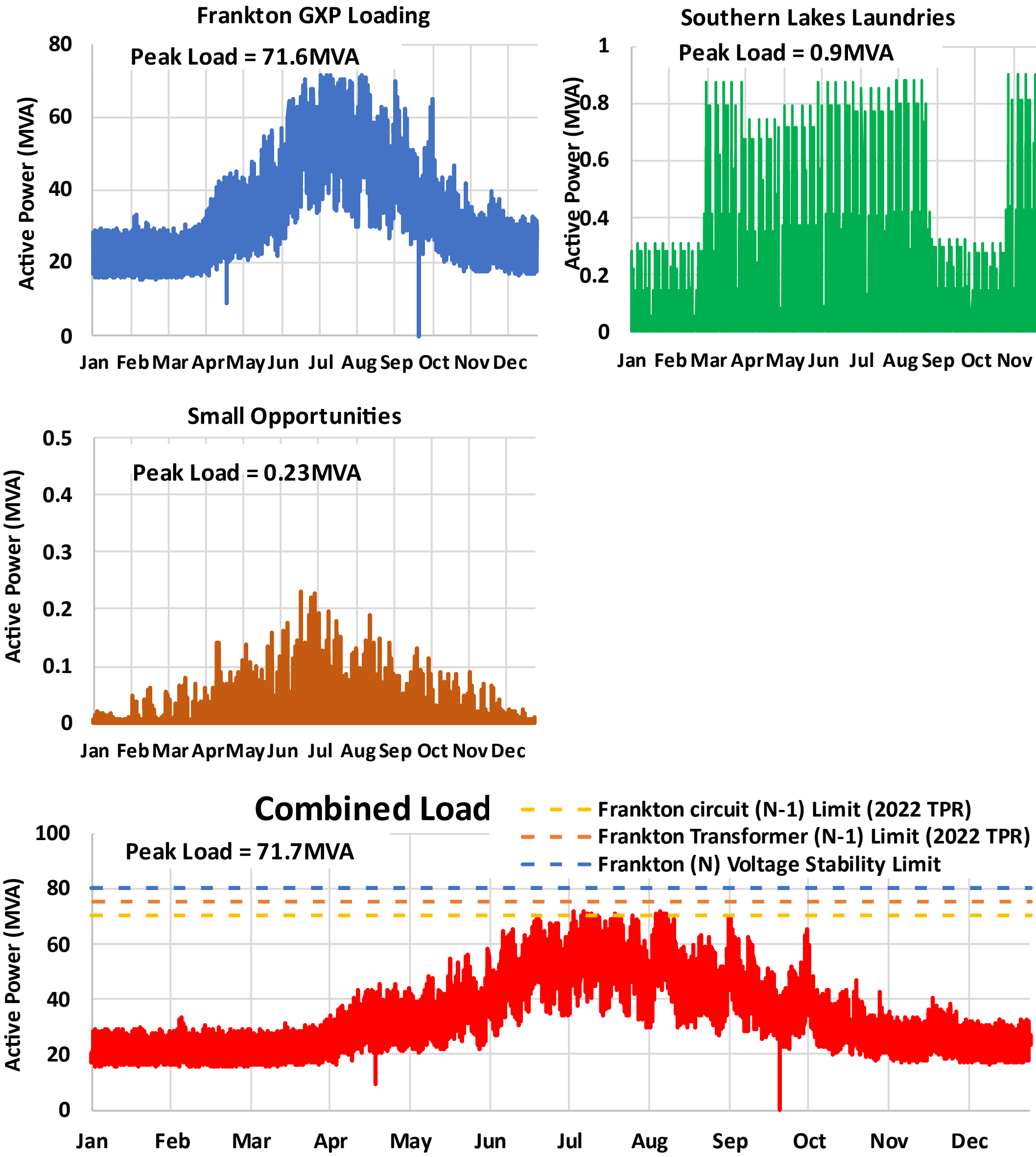


Figure 35 Loading Profiles: Frankton GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.6 Halfway Bush GXP

The EECA Load Sites include:

- Oceana Gold Macraes (4.8 MW)
- Fulton Hogan Logan Point Quarry (4.8 MVA)
- Fulton Hogan Dunedin Bitumen Plant (2.59 MVA)
- Goodman Fielder Dunedin (1.18 MVA)
- Gregg's Coffee (2.72 MW)
- Graymont Makareao (7.84 MVA)
- Lion Emerson's Brewery (0.83 MVA)
- Keep It Clean Dunedin (4.06 MVA)
- Keep It Clean Silverstream (4.25 MVA)
- Moana Pool (0.28 MVA)
- Mercy Hospital (0.37 MVA)
- Balaclava School (0.02 MVA)
- Brockville School (0.04 MVA)
- Kaikorai School (0.12 MVA)
- Logan Park High School (0.3 MVA)
- Otago Boys High School Hostel (0.16 MVA)
- Ravensbourne School (0.02 MVA)
- Taieri College (0.35 MVA)
- Wakari Hospital (0.22 MVA)

The geographic locations of the Load Sites are shown on the following maps in relation to the local transmission and distribution substations.

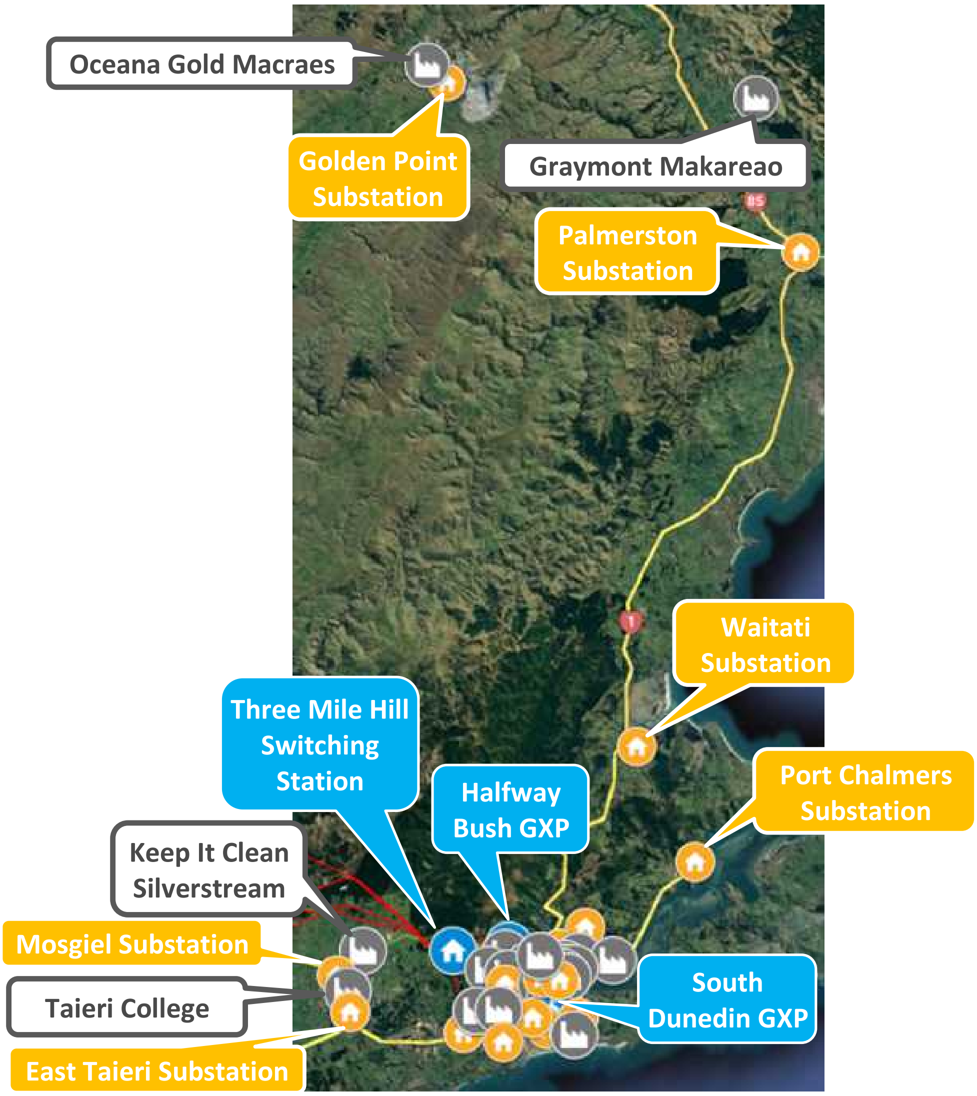


Figure 36 Halfway Bush GXP: EECA Load Sites vs local substations

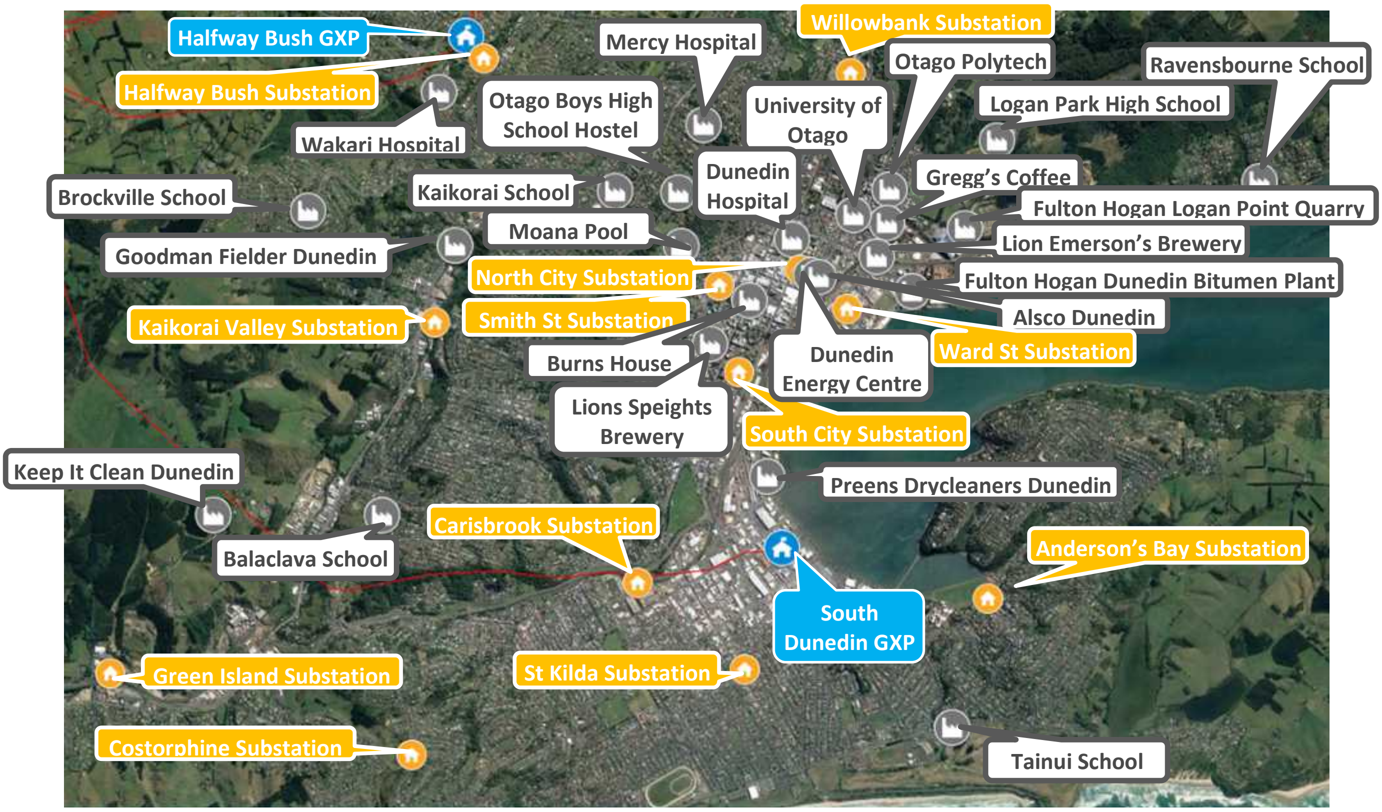


Figure 37 Halfway Bush GXP: EECA Load Sites vs local substations: Dunedin enlarged (loads are shared between Halfway Bush and South Dunedin GXPs)

8.6.1 Halfway Bush GXP Upgrade

Transpower's Transmission Planning Report 2022 indicates that, ignoring embedded generation, Halfway Bush GXP has in the past exceeded its (N-1) capacity. Transpower states in the planning report that there are no plans to upgrade the GXP as embedded generation is assumed to be sufficient to provide the zone substation with enough capacity/security.

When considering the combined Load Site loadings on the GXP, the GXP could marginally (in July) exceed its (N-1) capacity for a short period of time. However, on the basis the transformers are relatively new at Halfway Bush and its unlikely all Load Sites would connect, Ergo has not considered the costs of upgrading this GXP. Furthermore, a viable option to prevent exceeding Halfway Bush's (N-1) capacity would be to transfer some of the existing or new loads onto the South Dunedin GXP.

8.6.2 Oceana Gold Macraes

OCEANA GOLD MACRAES		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler	4.8 MW	Halfway Bush
Existing Electrical Supply to the Plant		
The Oceana Gold Macraes plant is presently supplied by OtagoNet's Ranfurly zone substation, at 66 kV. There is a substation on site, privately owned/operated by Oceana Gold Macraes. Two 66/33 kV 12.5/25 MVA transformers at Ranfurly step the voltage up to 66 kV, which then connects to the existing Oceana Gold plant and Patearoa generation station. The line to the site, owned by OtagoNet, is a combination of Dog and Lutetium conductors. There are three 66/11 kV transformers on site at Oceana Gold Macraes, two parallel 7.5 MVA transformers and a third 20/25 MVA transformer. Ergo understands that the existing 66 kV line to Oceana Gold is nearing its capacity, with approximately 4 MVA of spare capacity, and there are significant voltage issues on the present Macraes 66 kV bus during the operation of the mine which is a 24/7 operation. The site presently has (N-1) security for transmission and (N-1) security for sub-transmission. Distribution is provided by Oceana.		

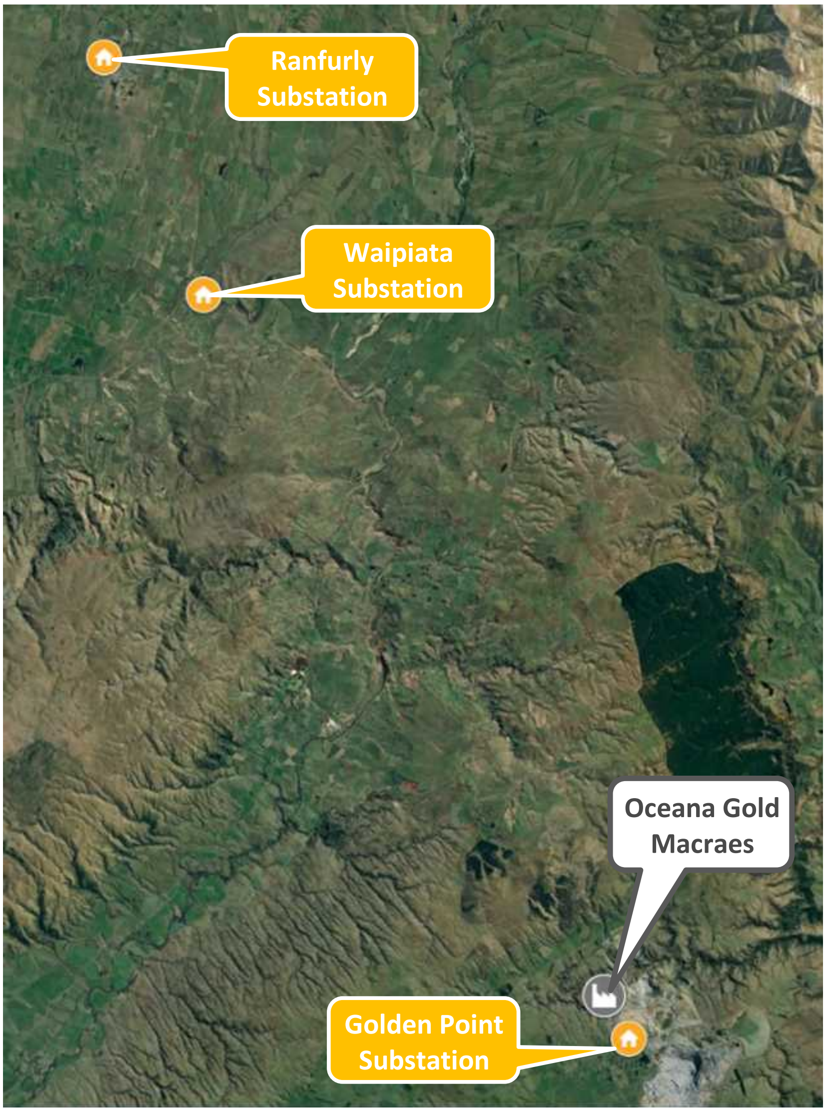


Figure 38 Oceana Gold Macraes geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Due to the voltage and load constraints of the existing 66 kV line supplying the Oceana Gold plant, it would not be able to supply the proposed additional 4.8 MVA.

Ergo is of the view that the additional load could instead be supplied via the Golden Point substation, which is connected to the Halfway Bush GXP via 48 km (unknown to Ergo conductor) double circuit to Palmerston substation and ≈30 km of Raven conductor between Palmerston and Golden Point substations. Due to the lengths of the lines, capacitive support would be required at Golden Point Substation. The GXP has ample (N-1) capacity for this load.

Ergo notes that presently the Golden Point substation is standby only and the transformer is due for replacement. Included in the costing is replacement of the transformer, an additional 11 kV feeder circuit breaker, capacitive support (with dedicated CBs), and cabling to the site.

OtagoNet have advised that there would likely be constraints on the load that could be drawn at Golden Point when only one Halfway Bush-Palmerston 33 kV line is in service. Similarly, there would be constraints on the load able to be drawn at Golden Point in the case that supply from Naseby GXP is lost, resulting in some other zone substations being transferred onto Halfway Bush GXP. It is also noted that there are upgrade projects planned to tap Merton and Waitati zone substations 33 kV supplies off the Halfway Bush-Palmerston 33 kV lines, after which the volt drop on the Halfway Bush-Palmerston 33 kV lines will decrease.

Capital Cost Estimate

Table 11 Oceana Gold Macraes: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	33kV circuit breaker (ZSS)	2.00	$0.30
Subtransmission	33kV Capacitor Bank	1.00	$0.40
Distribution	Small supply transformer (ZSS)	1.00	$0.50
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	2.00	$0.80
		TOTAL	**$2.10**

Does not include the costs to install any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 18 - 24 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

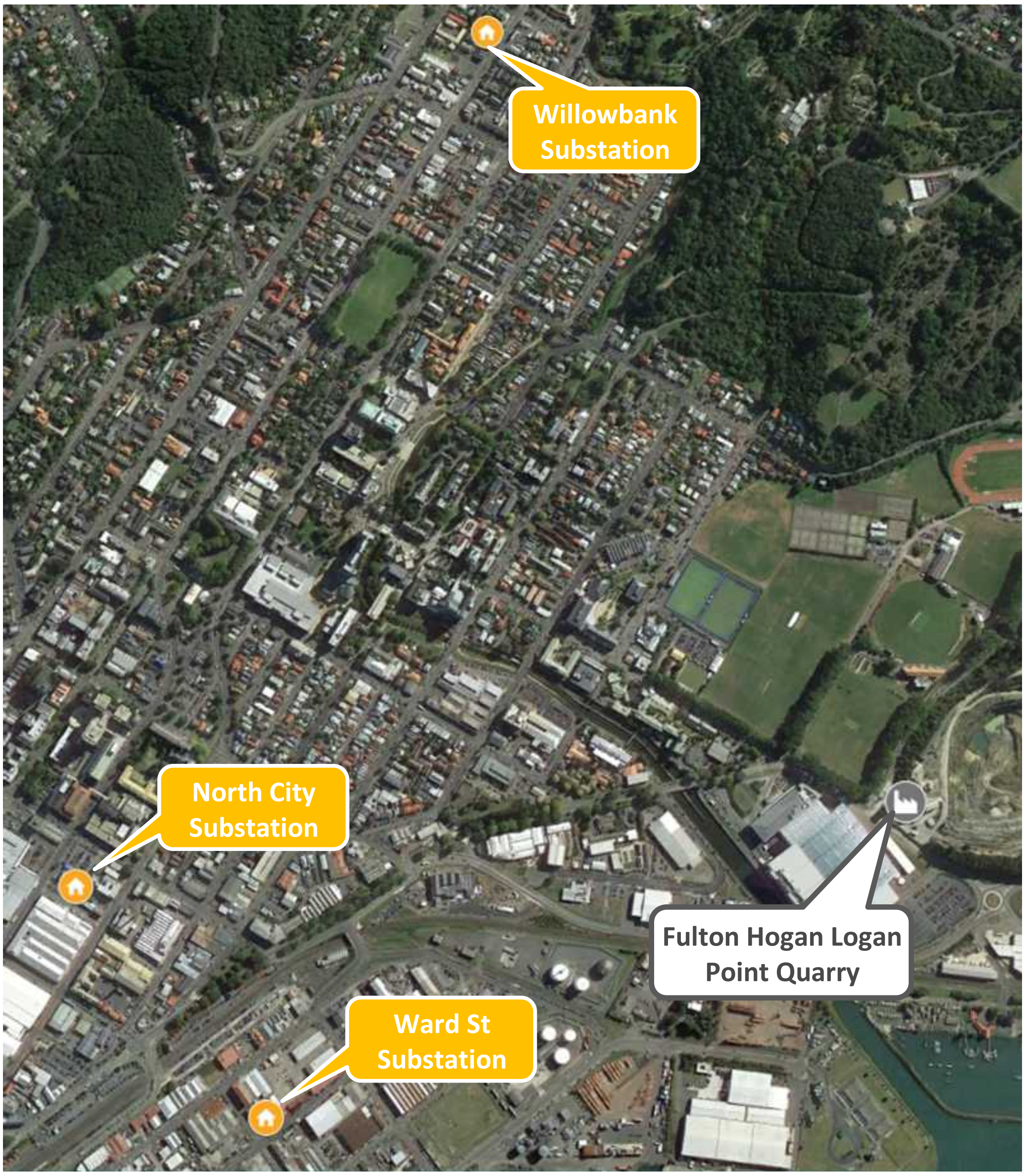
Excludes land acquisition and consenting, if required.

8.6.3 Fulton Hogan Logan Point Quarry

		FULTON HOGAN LOGAN POINT QUARRY
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler	4.8 MW	Halfway Bush
Existing Electrical Supply to the Plant		

The Fulton Hogan Logan Point Quarry is presently supplied by Aurora Energy's Ward St zone substation (via the WS4 6.6kV feeder). The plant is ≈1.1 km (straight line) from Ward St substation and ~1.3 km (straight line) from North City substation. The WS4 feeder is presently loaded at a maximum of 2.09 MVA, and is a mixture of underground cabling (mostly PILC) and overhead cables (copper).

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.



FULTON HOGAN LOGAN POINT QUARRY

Figure 39 Fulton Hogan Logan Point Quarry geographic location in relation to the surrounding zone substation

Supply Option(s) for New Load

Ward St substation and Halfway Bush GXP have sufficient (N-1) spare capacity to accommodate the additional load of 4.8 MW. However the WS4 feeder is unlikely to be able to supply the additional load.

Based on this, Ergo is of the view a new dedicated 11kV rated (6.6 kV operating) supply to the site would be required. This could be supplied from the Ward St substation and due to the urban topography, would likely require underground cabling. A suitable cable route is likely to require ≈2 km of underground cabling.

Capital Cost Estimate

Table 12 Fulton Hogan Logan Point Quarry: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	2.00	$1.60
		TOTAL	**$1.70**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.6.4 Fulton Hogan Dunedin Bitumen Plant

FULTON HOGAN DUNEDIN BITUMEN PLANT		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler	2.59 MW	Halfway Bush
Existing Electrical Supply to the Plant		
The Fulton Hogan Dunedin Bitumen plant is presently supplied by Aurora Energy's Ward St zone substation (via the WS10 6.6 kV feeder). The plant is ≈0.6 km (straight line) from Ward St zone substation. The WS10 feeder is presently loaded at a maximum of 1.43 MVA, and is a mixture of underground cabling (PILC) and overhead cables (copper and Dog). The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.		

Figure 40 Fulton Hogan Dunedin Bitumen Plant geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load
Ward St substation and Halfway Bush GXP have sufficient (N-1) spare capacity to accommodate the additional load of 2.59 MW. However the WS4 feeder is unlikely to be able to supply the additional load. Based on this, Ergo is of the view a new dedicated 11kV rated (6.6 kV operating) supply to the site would be required. This could be supplied from the Ward St substation and due to the urban topography, would likely require underground cabling. A suitable cable route is likely to require ≈1 km of underground cabling.

Capital Cost Estimate

Table 13 Fulton Hogan Dunedin Bitumen Plant: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	1.00	$0.80
		TOTAL	**$0.90**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.6.5 Goodman Fielder Dunedin

GOODMAN FIELDER DUNEDIN		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler	1.18 MW	Halfway Bush
Existing Electrical Supply to the Plant		

The Goodman Fielder Dunedin plant is presently supplied by Aurora Energy's Kaikorai Valley zone substation (via the KV6 6.6 kV feeder). The plant is ≈0.6 km (straight line) from Kaikorai Valley zone substation. The KV6 feeder is presently loaded at a maximum of 0.92 MVA, and is underground cabling (PILC).

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

GOODMAN FIELDER DUNEDIN

Figure 41 Goodman Fielder Dunedin geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Kaikorai Valley substation and Halfway Bush GXP have sufficient (N-1) spare capacity to accommodate the additional load of 1.18 MW. The KV6 feeder is likely to be able to supply the additional load given its present loading. Therefore, no network upgrades are expected to connect additional load at the Goodman Fielder Dunedin Plant other than to install an additional RMU at the site

Capital Cost Estimate

Table 14 Goodman Fielder: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Distribution switches - RMU	1.00	$0.05
		TOTAL	**$0.05**

Does not include the costs to install any distribution transformers/switchgear on the plant site

Timeframe to Establish New Electrical Infrastructure

Estimated to take 6 - 12 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.6.6 Gregg's Coffee

GREGG'S COFFEE		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler and high temperature heat pump	2.72 MW	Halfway Bush
Existing Electrical Supply to the Plant		
The Gregg's Coffee plant is presently supplied by Aurora Energy's Ward St and North City zone substations (via the WS5 and NC12 6.6 kV feeders). The plant is ≈0.8 km (straight line) from both Ward St and North City zone substations. The WS5 feeder is presently loaded at a maximum of 2.82 MVA, and is underground cabling (PILC). The NC12 feeder is presently loaded at a maximum of 1.52 MVA, and is underground cabling (PILC). Ergo notes that by having supply from both North City and Ward St zone substations, Gregg's Coffee could potentially be supplied by either Halfway Bush or South Dunedin GXP. The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N-1) security for distribution.  Figure 42 Gregg's Coffee geographic location in relation to the surrounding zone substations		
Supply Option(s) for New Load		
Ward St substation and Halfway Bush GXP, as well as North City Substation and South Dunedin GXP have sufficient (N-1) spare capacity to accommodate the additional load of 2.72 MW. However, the WS5 and NC12 feeders are unlikely to be able to supply the additional load.		

Based on this, Ergo is of the view a new dedicated 11kV rated (6.6 kV operating) supply to the site would be required. This could be supplied from the Ward St substation and due to the urban topography, would likely require underground cabling. A suitable cable route is likely to require ≈1 km of underground cabling.

Capital Cost Estimate

Table 15 Gregg's Coffee: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	1.00	$0.80
		TOTAL	**$0.90**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.6.7 Graymont Makareao

GRAYMONT MAKAREAO		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler	7.84 MW	Halfway Bush
Existing Electrical Supply to the Plant		

The Graymont Makareao plant is presently supplied by OtagoNet's Palmerston zone substation (via the PAL 1 11kV feeder). The plant is ≈11 km (straight line) from Palmerston zone substation. The PAL 1 feeder is a mixture of overhead conductors, with a maximum loading of 1.05 MVA.

The site presently has (N-1) security for transmission, (N) security for sub-transmission (limited by the final 2.3 km of line supplying Palmerston zone substation being a single circuit), and (N) security for distribution.

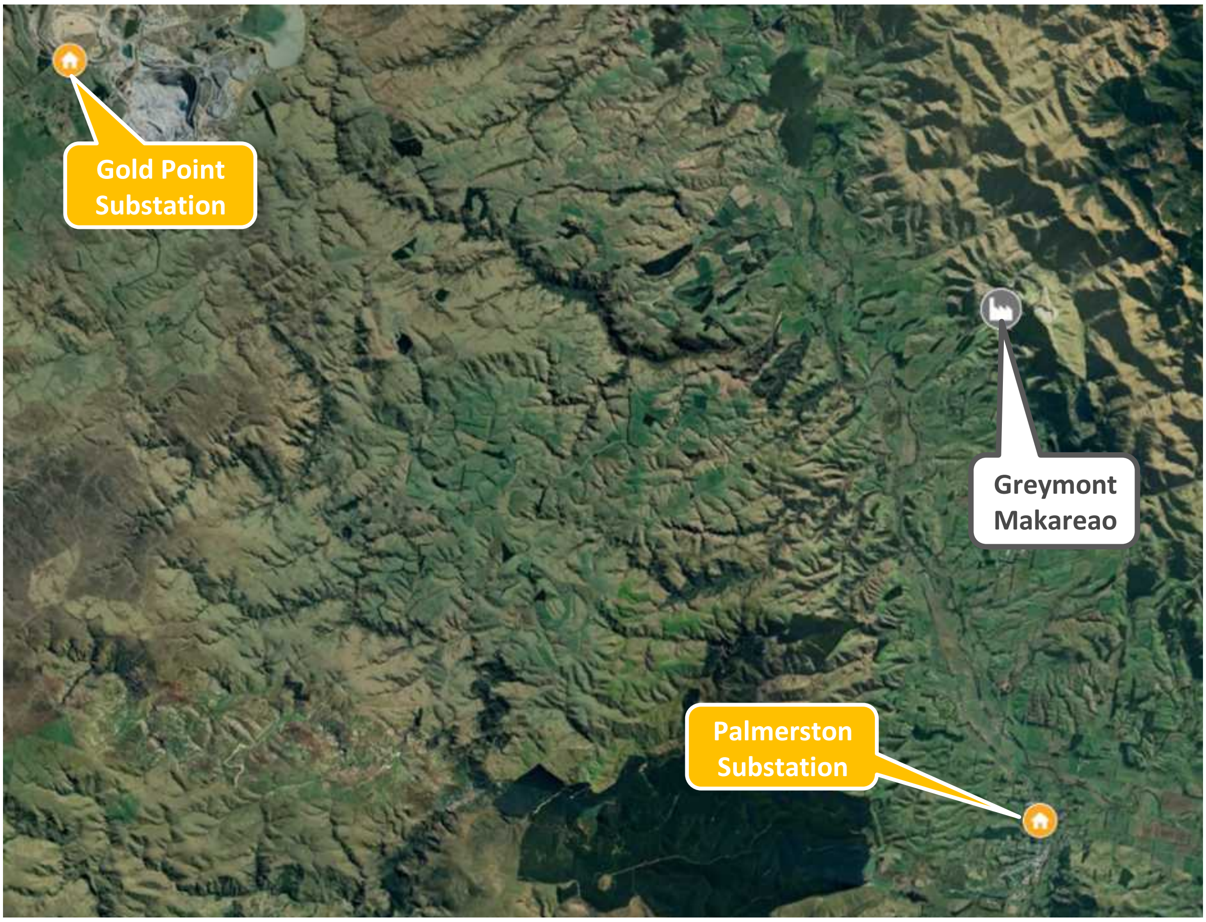


Figure 43 Greymont Makareao geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The Halfway Bush GXP has sufficient (N-1) spare capacity to accommodate the additional load of 7.84 MW. However the Palmerston zone substation, as well as the feeder which presently supplies the site, do not have enough capacity.

We expect the supply of 7.84 MW of new load to require the following:

- Installation of two 11 kV feeders from Palmerston substation to supply the load, including ~13 km of overhead conductor to the site
- Replacement of the Palmerston zone substation 33/11 kV transformer
- A 3MVAr switched capacitor bank.

OtagoNet have advised that should this supply upgrade proceed, there would be consideration of moving the existing Palmerston zone substation to the ex-Transpower Palmerston site, due to space constraints at the existing OtagoNet Palmerston site. This would involve a rebuild (outdoor to indoor) of both the 33kV and 11kV switchboards, along with the works described above.

OtagoNet have also advised that there would likely be constraints on the load that could be drawn at Palmerston when only one Halfway Bush-Palmerston 33 kV line is in service. Similarly, there would be constraints on the load able to be drawn at Palmerston in the case that supply from Naseby GXP is lost, resulting in some other zone substations being transferred onto Halfway Bush GXP. It is also noted that there are upgrade projects planned to tap Merton and Waitati zone substations 33 kV supplies off the Halfway Bush-Palmerston 33 kV lines, after which the volt drop on the Halfway Bush-Palmerston 33 kV lines will decrease.

Capital Cost Estimate

Table 16 Graymont Makareao: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Medium supply transformer (ZSS)	1.00	$1.00
Distribution	Medium switchroom (ZSS)	1.00	$3.00
Distribution	Single overhead 11kV line	13.00	$2.60
Distribution	11kV Capacitor Bank	1.00	$0.30
		TOTAL	**$6.60**

Does not include the costs to install any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 18 - 24 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.6.8 Lion Emerson's Brewery

LION EMERSON'S BREWERY		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler and high temperature heat pump	0.83 MW	Halfway Bush
Existing Electrical Supply to the Plant		
The Lion Emerson's Brewery plant is presently supplied by Aurora Energy's Ward st zone substation (via the WS7 6.6 kV feeder). The plant is ≈0.5 km (straight line) from Ward st zone substation. The WS7 feeder is presently loaded at a maximum of 1.87 MVA, and is a mixture of different types of underground cables (PILC and XLPE). The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.		

Figure 44 Lion Emerson's Brewery geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load
The Ward St substation and Halfway Bush GXP both have sufficient (N-1) spare capacity to accommodate the additional load of 0.83 MW. Ergo expects that the ~0.7 km of 35 mm^2 Al XLPE, 130 mm^2 Al PILC, and 160 mm^2 Al PILC would need to be replaced with a larger cable to allow the WS7 feeder to supply the additional 0.83 MW of load.

Capital Cost Estimate

Table 17 Lion Emerson's Brewery: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Single underground 11kV cable (CBD)	0.70	$0.56
		TOTAL	**$0.56**

Does not include the costs to install any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 6 - 12 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.6.9 Keep It Clean Dunedin

KEEP IT CLEAN DUNEDIN		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler and high temperature heat pump	4.06 MW	Halfway Bush
Existing Electrical Supply to the Plant		

The Keep It Clean Dunedin plant is presently supplied by Aurora Energy's Green Island zone substation (via the GI7 6.6kV feeder). The plant is ≈1.5 km (straight line) from Green Island zone substation, and ~2.3 km (straight line) from Kaikorai Valley zone substation. The GI7 feeder is presently loaded at a maximum of 1.87 MVA, and is a mixture of different types of underground cables (PILC and XLPE).

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

KEEP IT CLEAN DUNEDIN

Figure 45 Keep It Clean Dunedin geographic location in relation to the surrounding zone substation

Supply Option(s) for New Load

Halfway Bush GXP has sufficient (N-1) spare capacity, and Green Island substation has sufficient (N) capacity to accommodate the additional load of 4.06 MW. However, the GI7 feeder is unlikely to be able to supply the additional load.

Based on this, Ergo is of the view a new dedicated 11kV rated (6.6 kV operating) supply to the site would be required. This could be supplied from either the Green Island substation, or the nearby Kaikorai Valley substation (which does have sufficient (N-1) capacity for the load) and due to the urban topography, would likely require underground cabling. A suitable cable route is likely to require ≈3.2 km of underground cabling from Green Island substation, or ≈3.5 km of underground cabling from Kaikorai Valley substation.

Ergo understands that Aurora Energy are presently investigating two options to connect Keep It Clean Dunedin. These include reconductoring a portion of the existing feeder to the site, or installing a new feeder. Until confirmation of either option, the costs of the above proposed solution are assumed as a conservative estimate.

Capital Cost Estimate

Table 18 Keep It Clean Dunedin: Capital cost estimate to supply the Load Site (Green Island substation connection)

Transmission => (N-1)	Subtransmission => (N)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	3.20	$1.28
		TOTAL	**$1.38**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.6.10 Keep It Clean Silverstream

KEEP IT CLEAN SILVERSTREAM		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler	4.25 MW	Halfway Bush
Existing Electrical Supply to the Plant		
The Keep It Clean Silverstream plant is presently supplied by Aurora Energy's Mosgiel zone substation (via the MG1 or MG6 11 kV feeder)[25]. The plant is ≈2 km (straight line) from Mosgiel zone substation. The MG1 feeder is presently loaded at a maximum of 4.1 MVA, and is a mixture of Dog conductor and 185 mm2 Al PILC cables. The MG6 feeder is presently loaded at a maximum of 3.08 MVA, and is a mixture of sizes of overhead copper conductors. The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.		

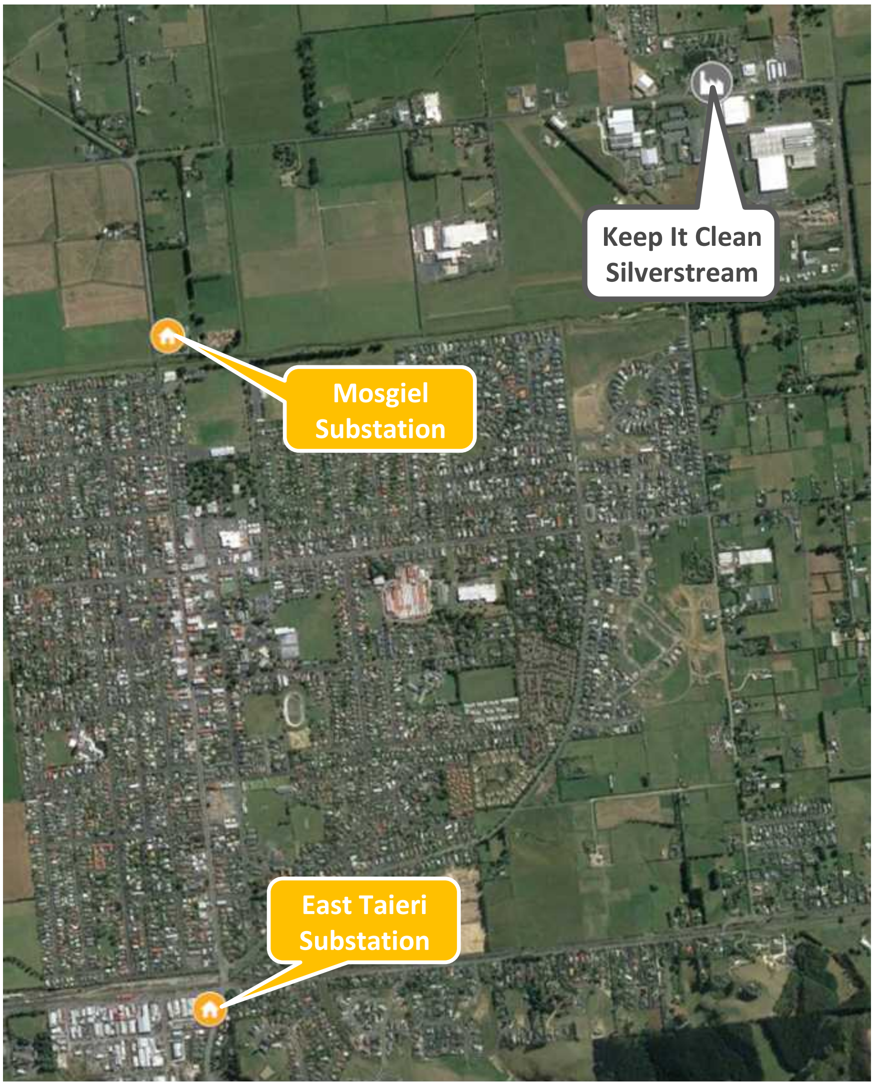


Figure 46 Keep It Clean Silverstream geographic location in relation to the surrounding zone substations

[25] Depending of the exact location of the Keep It Clean plant within Silverstream Industrial Park

Supply Option(s) for New Load

Halfway Bush GXP has sufficient (N-1) spare capacity, and Mosgiel substation has sufficient (N) capacity to accommodate the additional load of 4.06 MW. However, the MG1 and MG6 feeders are unlikely to be able to supply the additional load. It is noted that by exceeding the (N-1) capacity of Mosgiel substation, substation upgrades may be triggered to maintain security of supply.

Based on this, Ergo is of the view a new dedicated 11kV supply to the site would be required. This could be supplied from Mosgiel substation. As the route is rural, overhead conductor is assumed acceptable for this connection. A suitable route is likely to require ≈3 km of overhead line from Mosgiel substation.

Ergo notes that Aurora Energy is presently investigating 2x existing feeders which supply an existing plant (not operating) which may be able to be utilised for Keep It Clean Silverstream. Until confirmation of this option, the costs of the above proposed solution are assumed as a conservative estimate.

Capital Cost Estimate

Table 19 Keep It Clean Silverstream: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	3.00	$1.20
		TOTAL	**$1.30**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 28 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.6.11 Small Opportunities

Below is a summary of the “small” Load Sites that were provided by EECA but due to their size, are unlikely to have a material effect on the distribution or transmission network. The costs provided are estimates to provide distribution transformers to supply the site

Table 20 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Feeder	Zone sub (N-1) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Moana Pool	Smith Street	SS6	5	1.54	0.28	130
Mercy Hospital	Halfway Bush	HB10	5	2	0.37	130
Balaclava School	Kaikorai Valley	KV4	13	2.89	0.02	40
Brockville School	Kaikorai Valley	KV5	13	2.12	0.04	40
Kaikorai School	Halfway Bush	HB12	5	1.2	0.12	80
Logan Park High School	Ward Street	WS6	14	0.77	0.30	130
Otago Boys High School Hostel	Smith Street	SS9	5	1.67	0.16	80
Ravensbourne School	Ward Street	WS4	14	2.09	0.02	40
Taieri College	East Taieri	ET7	5	2.36	0.35	130
Wakari Hospital	Halfway Bush	HB5	5	0.54	0.22	130

8.6.12 Combined Load on Ward St Zone Substation

A number of the loads on Halfway Bush GXP are expected to connect to Ward St zone substation. These loads are Fulton Hogan Logan Point Quarry, Fulton Hogan Dunedin Bitumen Plant, Gregg’s Coffee, and Lion Emerson’s Brewery, along with “small” loads Logan Park High School and Ravensbourne School. The sum of peaks of these loads is 11.27 MVA, which the zone substation has (N-1) capacity for, even before considering the diversity between loads.

The costs estimated in the above sections per load opportunity are not expected to be shared by the loads, as they are relatively individual solutions (e.g. relate to feeders in different areas, or distribution transformers). Shared costs may only relate to overall zone substation upgrades:

- An issue Ergo anticipates with these concurrent load additions to the zone substation is if there is not enough physical space in the zone substation for the 3x additional 11 kV/6.6 kV feeder breakers required for Fulton Hogan Logan Point Quarry, Fulton Hogan Dunedin Bitumen Plant, and Gregg’s Coffee. In this case, zone substation upgrades may be triggered, at a potential cost of ~$4M.

8.6.13 Combined Load of Small Opportunities

Summing the maximum values of the "small" loads on Halfway Bush GXP gives a combined load of 1.88 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 47), with a maximum load of 1.8 MVA, with a diversity factor of 0.95.

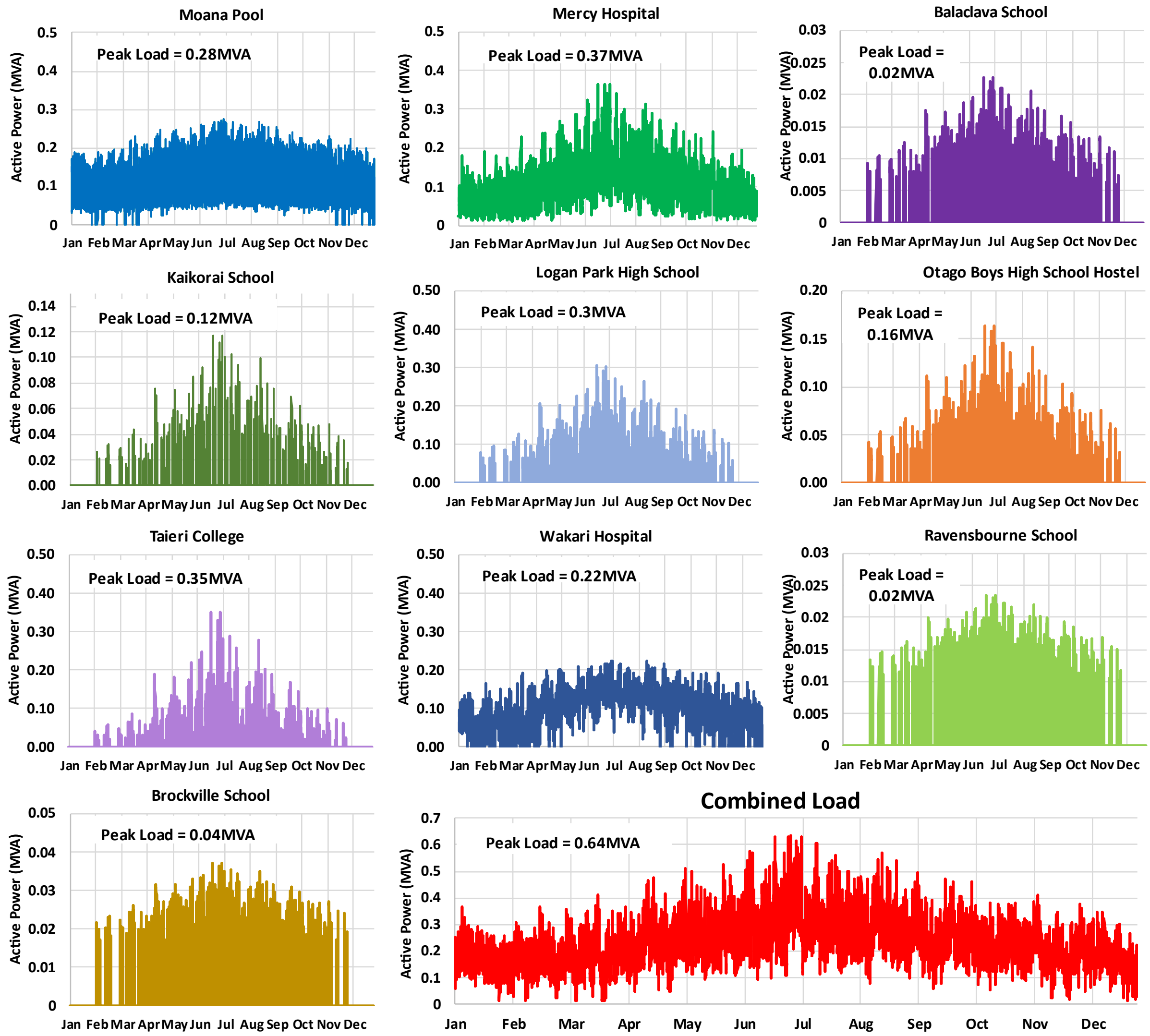


Figure 47 Loading Profiles: Halfway Bush GXP "small" Load Site Profiles: Combined Load (sum of all profiles)

8.6.14 Effect of all Load Sites Connecting to Halfway Bush GXP

The following Figure 48 illustrates the Halfway Bush 2022 load profile together with the load profiles of all the Load Sites within the Halfway Bush GXP region. Also shown in Figure 48 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Halfway Bush GXP would increase to 125.3 MVA, a difference of 14.9 MVA. Given that the independent sum of the individual loads is 145.3 MVA there is a diversity factor of 0.86 between the loads.
- Based on Ergo's analysis, the Halfway Bush GXP's (N-1) limit is not expected to be exceeded.
- Ergo notes that in the year studied, during the winter peak in June-July, often Manawa's embedded Waipori generation stations are collectively supplying up to ~80 MW of generation, effectively decreasing the peak. If in future years, the local generation at Waipori or other local embedded generators is lower than it has been historically, then it could be expected that the (N-1) limit of Halfway Bush GXP could be exceeded.

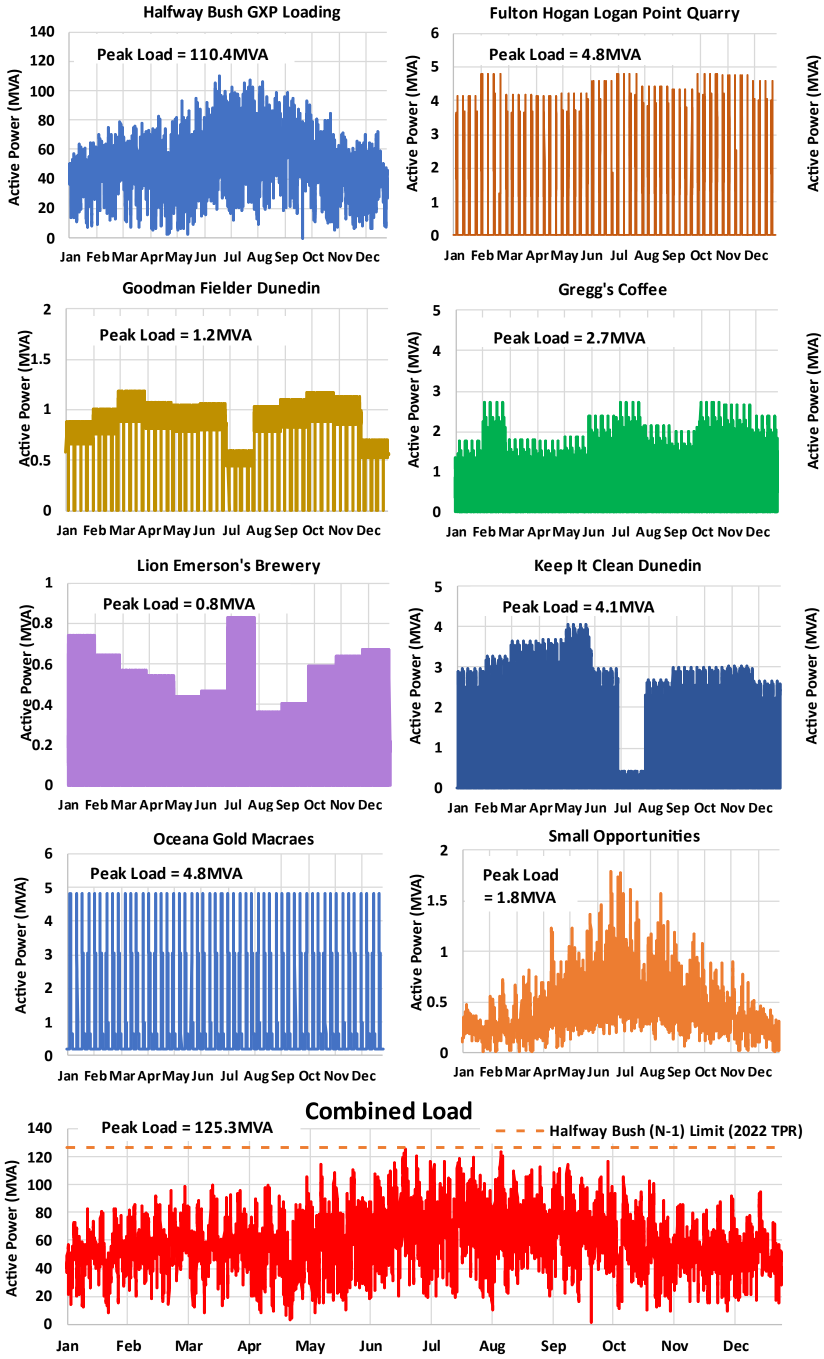


Figure 48 Loading Profiles: Halfway Bush GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.7 Naseby GXP

While one of the Load Sites identified by EECA, Oceana Gold Macraes, is near to Naseby GXP, it is not expected that it will connect to Naseby GXP, but instead will connect to Halfway Bush GXP. See Section 8.6.2. Thus the upgrade of the Naseby GXP or Zone Substations is not considered.

8.8 South Dunedin GXP

The EECA Load Sites include:

- Alsco Dunedin (1.92 MVA) (Dunedin Energy Centre)
- Otago Polytechnic Dunedin Campus (1.53 MVA)
- Dunedin Energy Centre (7.16 MW) (scenario a only)
- Dunedin Hospital (2.31 MW) (Dunedin Energy Centre)
- University of Otago Dunedin Campus (1.56 MVA)
- University of Otago Dunedin Campus (1.3 MVA) (Dunedin Energy Centre)
- Lion Speights Brewery (4.54 MW)
- Preens Drycleaners Dunedin (1.96 MW)
- Tainui School (0.12 MW)
- Burns House (0.17 MVA)

The geographic locations of the Load Sites are shown on the following map in relation to the local transmission and distribution substations.

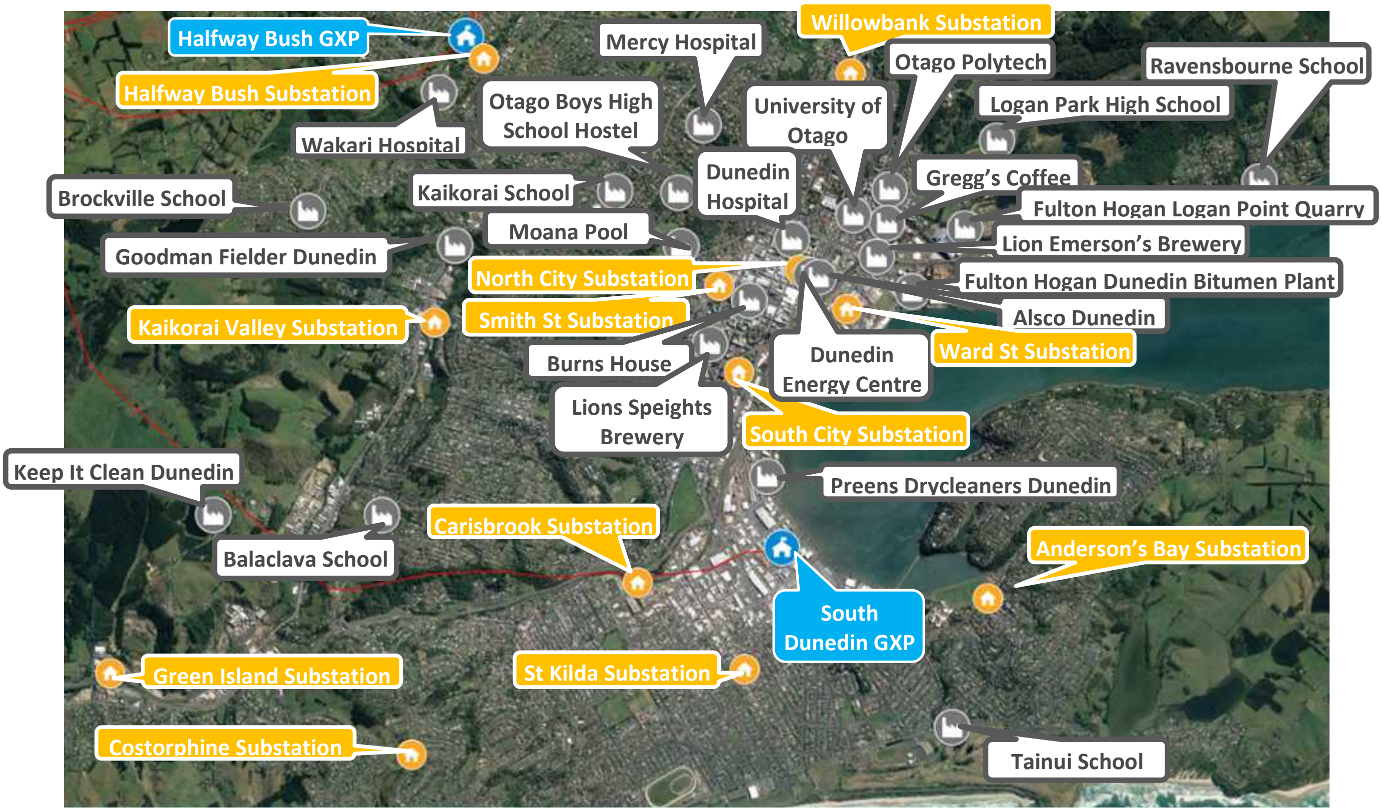


Figure 49 South Dunedin GXP: EECA Load Sites vs local substations: Dunedin enlarged (loads are shared between Halfway Bush and South Dunedin GXPs)

8.8.1 South Dunedin GXP Upgrade

Transpower's 2022 Transmission Planning Report does not indicate any plans to upgrade South Dunedin GXP. Furthermore, even with all of the proposed Load Sites connecting, the GXP is still expected to have spare (N-1) capacity for future demand growth. As a result, Ergo has not considered the upgrade of South Dunedin GXP.

South Dunedin GXP has sufficient spare (N-1) capacity to supply all of the proposed Load Sites.

8.8.2 Alsco Dunedin

ALSCO DUNEDIN		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler and high temperature heat pump	1.92 MW	South Dunedin
Existing Electrical Supply to the Plant		

Alsco Dunedin is near the North City zone substation. The site appears to currently only have an LV connection. However, there is two 6.6kV (rated to 11kV) feeders from North City running down Hanover St and another 6.6kV (rated to 11kV) from Ward St zone substation running down Leith St.

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

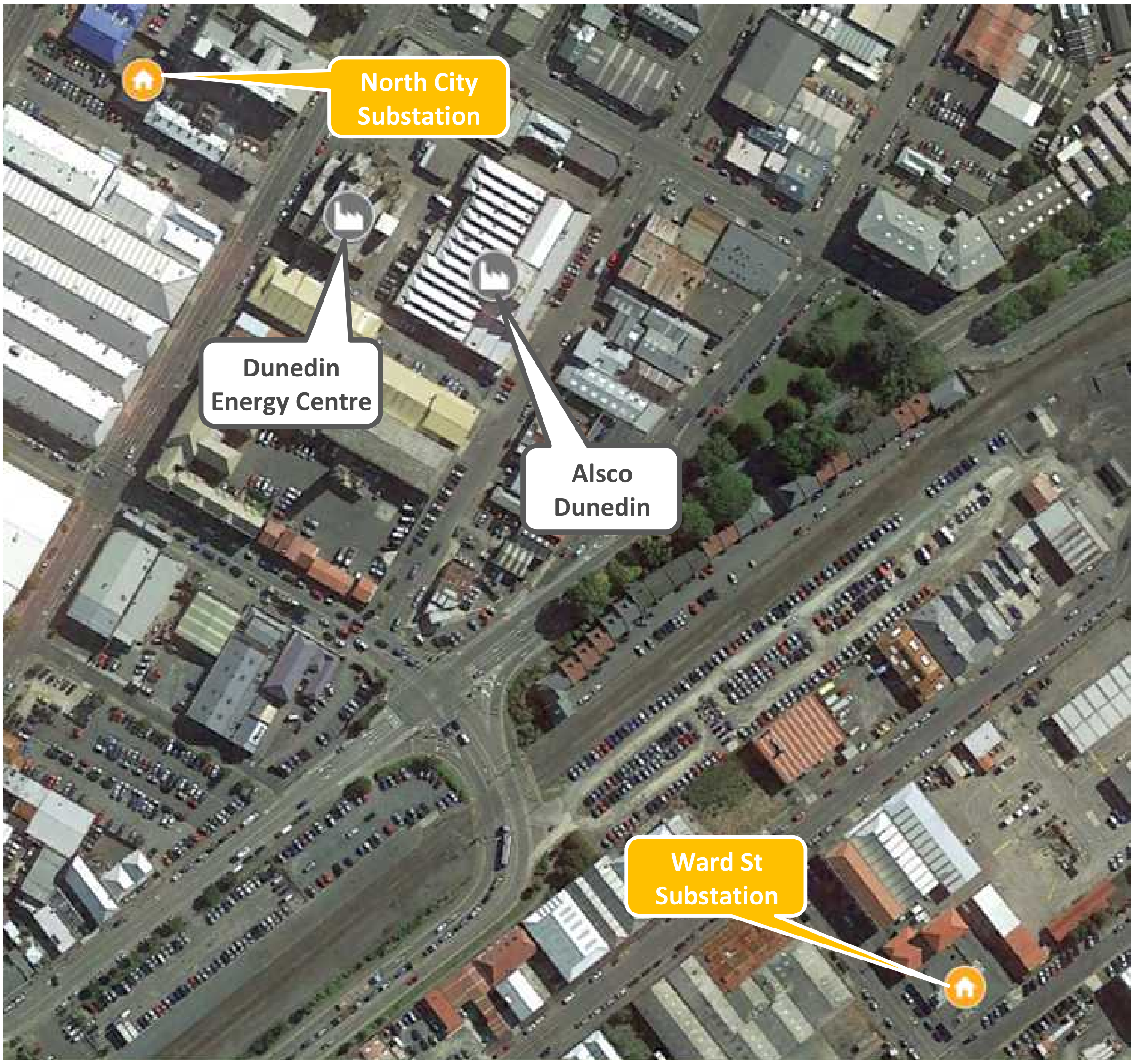


Figure 50 Alsco Dunedin geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load
Of the three 6.6kV (11kV rated) feeders traversing near the site, NC12 (a mix of $130mm^2$ and 160^2 mm Cu PILC cable) appears to be relatively lightly loaded (peak of ≈1.5MVA) and capable of supplying the additional load. North City zone substation and South Dunedin GXP also have sufficient spare (N-1) capacity to supply the load. Therefore, the supply could require: - Installation of an 11kV RMU on NC12 on Hanover St.

Capital Cost Estimate

Table 21 Alsco Dunedin: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Distribution switches - RMU	1.00	$0.05
		TOTAL	**$0.05**

Does not include the costs for any cabling into or distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure
Estimated to take 6 - 12 months. To Plan, Design, Procure, Construct and Commission the works. Excludes the work required to establish the Load Sites. Excludes land acquisition and consenting, if required.

8.8.3 Otago Polytechnic Dunedin Campus

OTAGO POLYTECHNIC DUNEDIN CAMPUS		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	1.53 MW	Halfway Bush
Existing Electrical Supply to the Plant		

Otago Polytechnic is currently supplied from two 6.6kV (rated at 11kV) feeders from both North City zone substation and Ward St zone substation which are in turn supplied from South Dunedin GXP and Halfway Bush GXP respectively.

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N-1) security for distribution.

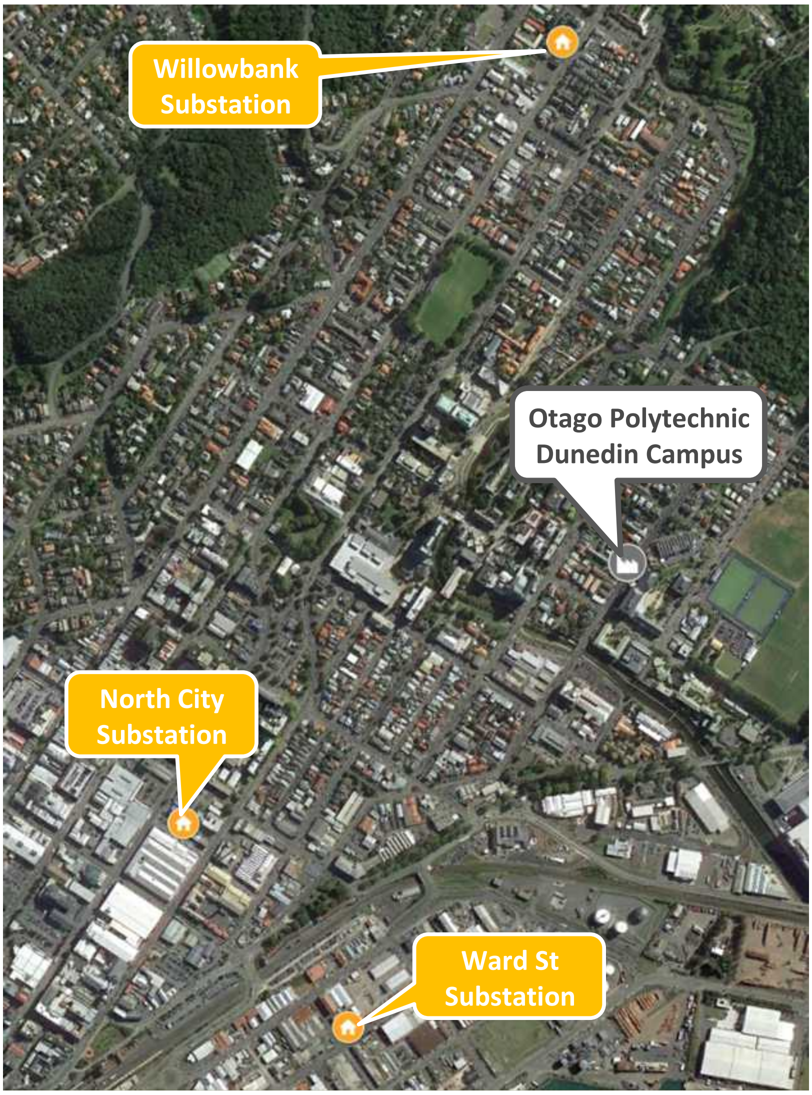


Figure 51 Otago Polytechnic Dunedin Campus geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The two 6.6kV (11kV rated) feeders, NC6 and WS5 are relatively highly loaded and therefore are unlikely to be able to supply the additional load. However, there is sufficient spare (N-1) capacity at both Ward St and North City zone substations. Furthermore, both South Dunedin GXP and Halfway Bush GXP could supply the additional load.

Based on the above, Ergo expects the new supply would require a new ≈1.2km 6.6kV (11kV rated) underground feeder would be required from North City zone substation. North City is chosen on the basis it is closer and is supplied by South Dunedin GXP which has more spare capacity.

Capital Cost Estimate

Table 22 Otago Polytechnic: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	1.20	$0.96
		TOTAL	**$1.06**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 - 18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.8.4 Dunedin Energy Centre

		DUNEDIN ENERGY CENTRE
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boiler	7.16 MW	Halfway Bush

Existing Electrical Supply to the Plant

The Dunedin Energy Centre is adjacent to the North City zone substation which in turn is supplied by South Dunedin GXP. The site currently has a single 6.6kV (11kV rated) supply (for the hospital laundry) from North City.

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.

Figure 52 Dunedin Energy Centre geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Both South Dunedin GXP and North City zone substation have sufficient spare (N-1) capacity to supply the additional load. Due to the size of the load, it is assumed a dedicated high capacity 6.6kV (11kV rated) supply would be required to supply the load.

This would likely require:

- A new 6.6kV (11kV rated) 630A rated circuit breaker at North City zone substation

- ≈100m of underground 6.6kV (11kV rated) high capacity cabling from North City to the Dunedin Energy Centre
- A 6.6kV (11kV rated) 630A RMU at the site.

Capital Cost Estimate

Table 23 Dunedin Energy Centre: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	0.10	$0.08
		TOTAL	**$0.18**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker.

Timeframe to Establish New Electrical Infrastructure

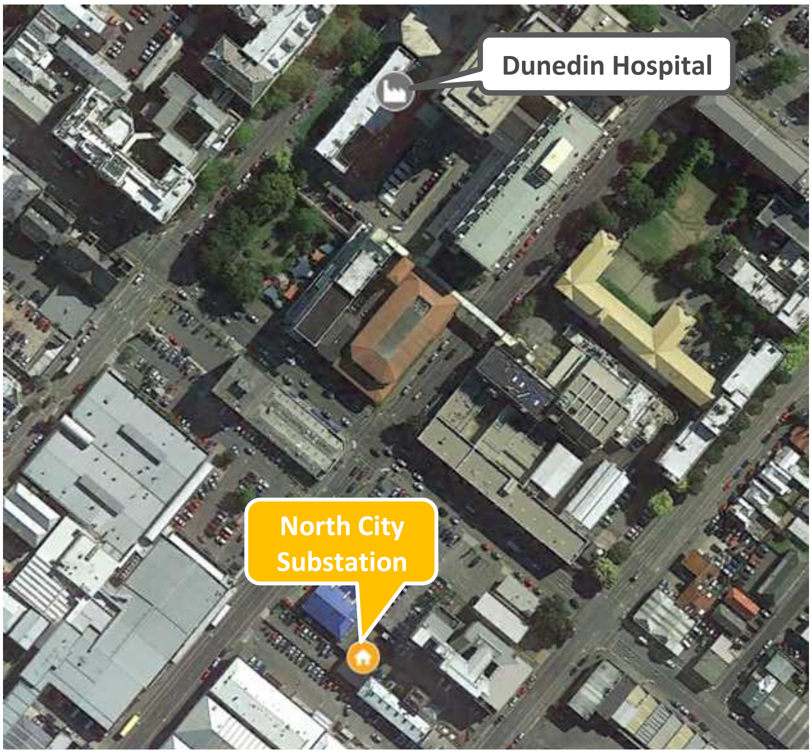
Estimated to take 12 - 18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.8.5 Dunedin Hospital

DUNEDIN HOSPITAL		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boiler and high temperature heat pump	2.31 MW	South Dunedin
Existing Electrical Supply to the Plant		
Dunedin Hospital is currently supplied by two 6.6kV (11kV rated) feeders from North City zone substation, NC4 and NC8. There is also a switched back-up (normally open) supply from Ward Street zone substation, WS1 – essentially providing (N-2) security. North City and Ward St substations are supplied from South Dunedin GXP and Halfway Bush GXP respectively. The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (switched N-2) security for distribution.  Figure 53 Dunedin Hospital geographic location in relation to the surrounding zone substations		
Supply Option(s) for New Load		
Both South Dunedin GXP and Halfway Bush GXP which supply North City and Ward Street substations respectively could supply the additional load. The peak loading on NC4 is ≈1.2MVA and NC8 is ≈1.0MVA. WS1 is typically switched out (i.e. no loading) with a small period through the year in service (likely due to outages at North City). NC4 appears to be 240mm^2 AL PILC cable and NC8 a mix of 240mm^2 AL PILC and 160mm^2 Cu PILC. WS1 appears to be 300mm^2 AL PILC cable.		

Based on the above, Ergo suspects the additional load could be supplied by connecting the additional HTHP and electric boilers to each side of the existing 6.6kV buses on the switchgear at the site, resulting in an additional load of 1.45MVA and 0.99MVA on NC4 and NC8 respectively. This could exceed the (N-1) capacity of the supplies from North City. However, a switched (N-1) security supply could be provided from the back-up supply from Ward Street. To ensure this can supply both sides of the switchboard bus at the hospital, in the event of an outage on NC4 or NC8, a new 11kV RMU could be installed at the site.

Capital Cost Estimate

Table 24 Dunedin Hospital: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N-1)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Distribution switches - RMU	1.00	$0.05
		TOTAL	**$0.05**

Does not include the costs for any distribution transformers/switchgear on the plant site.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 6 - 12 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.8.6 University of Otago Dunedin Campus

UNIVERSITY OF OTAGO DUNEDIN CAMPUS		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	1.56 MW or 2.86 MW	South Dunedin
Existing Electrical Supply to the Plant		

The University of Otago Dunedin Campus is currently supplied by North City zone substation via three 6.6kV (rated to 11kV) feeders, NC7, NC11 and NC14. North City is supplied from South Dunedin GXP.

The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution (at each point of supply).

Figure 54 University of Otago Dunedin Campus geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Option A – 1.56MW

The additional 1.56MVA could likely be supplied from the NC14 feeder. NC14 appears to consist of 240mm^2 AL and 160mm^2 Cu PILC cable and currently has a peak loading of ≈2.2MVA. Therefore, the connection would likely require a new RMU to be installed at the site.

South Dunedin has sufficient space capacity to supply the additional load.

Option B – 2.86MW

It is unlikely any of the three North City feeders currently supplying the university could supply an additional 2.86MVA. Therefore, the supply of the additional load would likely require installation of an additional feeder from North City.

This would require:

- A new 6.6kV (11kV rated) circuit breaker at North City zone substation
- ≈700m of underground 6.6kV (11kV rated) cabling from North City to a location on the campus
- A 6.6kV (11kV rated) RMU at the site.

Capital Cost Estimate

Table 25 University of Otago Dunedin Campus (Option A): Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	Distribution switches - RMU	1.00	$0.05
		TOTAL	**$0.05**

Table 26 University of Otago Dunedin Campus (Option B): Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	Equipment	Number and Capital Cost ($M)	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	0.70	$0.56
		TOTAL	**$0.66**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker.

Timeframe to Establish New Electrical Infrastructure

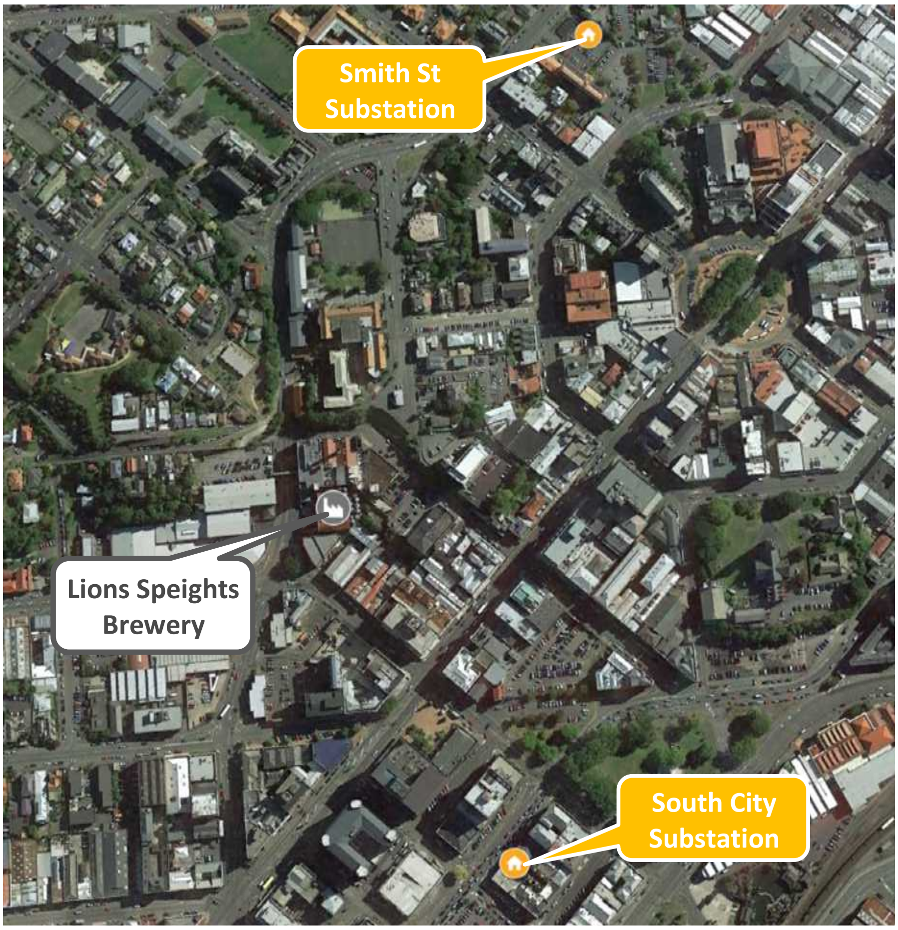
Estimated to take 6 – 12 months (Option A) or 12 - 18 months (Option B).

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Sites.

Excludes land acquisition and consenting, if required.

8.8.7 Lions Speights Brewery

		LIONS SPEIGHTS BREWERY
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler and high temperature heat pump	4.54 MW	South Dunedin
Existing Electrical Supply to the Plant		
The Speights Brewery is currently supplied from a 6.6kV (rated to 11kV) feeder supplied from South City zone substation which is in turn supplied from South Dunedin substation. There is also one other 6.6kV (rated to 11kV) feeder that traverse the site from Smith St zone substation. The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.  Figure 55 Lions Speights Brewery geographic location in relation to the local GXP substation		
Supply Option(s) for New Load		
Due to the size of the proposed load, it is unlikely any of the existing feeders traversing the site could supply the additional load. Therefore, it is likely the connection would require: - A new 6.6kV (11kV rated) circuit breaker at Smith St zone substation. Smith St is chosen as it has sufficient spare (N-1) capacity.		

- ≈550m of underground 6.6kV (11kV rated) cabling from Smith St zone substation to the Speights site.
- A 6.6kV (11kV rated) RMU at the site.

Capital Cost Estimate

Table 27 Lion Speights Brewery: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	0.60	$0.48
		TOTAL	**$0.58**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12-18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.8.8 Preens Drycleaners Dunedin

PREENS DRYCLEANERS DUNEDIN		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boiler and high temperature heat pump	1.96 MW	South Dunedin
Existing Electrical Supply to the Plant		
The Preens Drycleaners site is currently supplied by a 6.6kV (11kV rated) feeder from South City zone substation, SC14. There is also a back-up supply (normally open) from St Kilda, SK1. Both South City zone substation and St Kilda are supplied from South Dunedin GXP. The site presently has (N-1) security for transmission, (N-1) security for sub-transmission, and (N) security for distribution.  Figure 56 Preens Drycleaners Dunedin geographic location in relation to the local GXP substation		
Supply Option(s) for New Load		
Due to the size of the proposed load and the existing loading on the two feeders supplying the site (SC14 has a peak load of ≈1.8MVA and SK1 ≈2.6MVA), it is unlikely the existing infrastructure could supply the additional load. Therefore, it is likely the connection would require:		

- A new 6.6kV (11kV rated) circuit breaker at St Kilda substation. St Kilda is chosen over South City as it has sufficient spare (N-1) capacity.
- ≈2km of underground 6.6kV (11kV rated) cabling from St Kilda zone substation to the Load Site.
- A 6.6kV (11kV rated) RMU at the site.

Capital Cost Estimate

Table 28 Preens Drycleaners: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable (CBD)	2.10	$1.68
		TOTAL	**$1.78**

Does not include the costs to install any distribution transformers/switchgear on the plant site and assumes there is sufficient space in the substation building to install a compatible circuit breaker.

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12-18 months.

To Plan, Design, Procure, Construct and Commission the works.

Excludes the work required to establish the Load Site.

Excludes land acquisition and consenting, if required.

8.8.9 Small Opportunities

Below is a summary of the “small” Load Sites that were provided by EECA but due to their size, are unlikely to have a material effect on the distribution or transmission network. The costs provided are estimates to provide distribution transformers to supply the site.

Table 29 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Feeder	Zone sub (N-1) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Burns House	North City	NC9	13	0.66	0.17	80
Tainui School	Andersons Bay	AB6	3	2.48	0.12	80

8.8.10 Combined Load on North City Zone Substation

A number of the loads on South Dunedin GXP are expected to connect to North City zone substation. These loads are Alsco Dunedin (scenario b only), Otago Polytechnic Dunedin Campus, Dunedin Energy Centre (scenario a only), Dunedin Hospital (scenario b only), and University of Otago Dunedin Campus (both scenarios), along with “small” load Burns House.

The sum of peaks of the scenario a loads is 10.25 MVA, which the zone substation has (N-1) capacity for, even before considering the diversity between loads.

The sum of peaks of the scenario b loads is 8.62 MVA, which the zone substation has (N-1) capacity for, even before considering the diversity between loads.

The costs estimated in the above sections per load opportunity are not expected to be shared by the loads, as they are relatively individual solutions (e.g. relate to feeders in different areas, or distribution transformers). Shared costs may only relate to overall zone substation upgrades:

- The only issue Ergo anticipates with these concurrent load additions to the zone substation is if there is not enough physical space in the zone substation for the 1x additional 11 kV/6.6 kV feeder breaker required for Dunedin Energy Centre in scenario a, or the 2x additional 11 kV/6.6 kV feeder breakers required for Otago Polytechnic Dunedin Campus and University of Otago Dunedin Campus in scenario b. In this case, zone substation upgrades may be triggered, at a potential cost of ~$4M.

8.8.11 Combined Load of Small Opportunities

Summing the maximum values of the "small" loads on South Dunedin GXP gives a combined load of 0.29 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 57), with a maximum load of 0.27 MVA, with a diversity factor of 0.95.

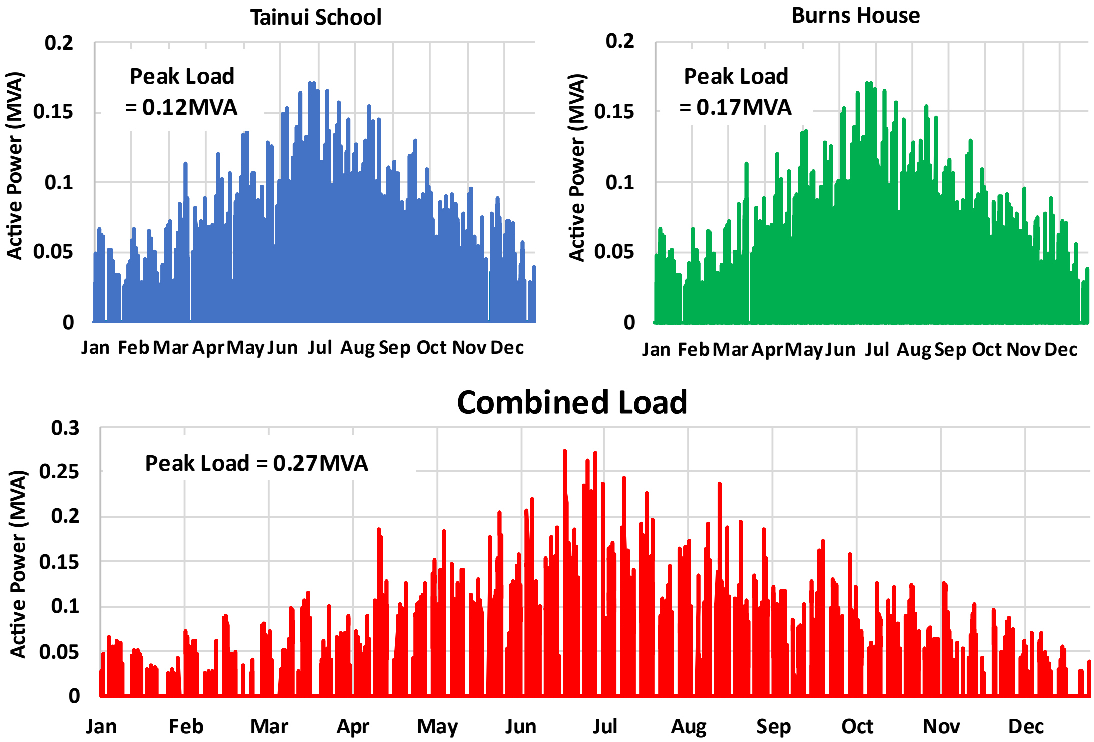


Figure 57 Loading Profiles: South Dunedin GXP "small" Load Site Profiles: Combined Load (sum of all profiles)

8.8.12 Effect of all Load Sites Connecting to South Dunedin GXP

The following Figure 58 and Figure 59 illustrates the South Dunedin 2022 load profile together with the load profiles of all the Load Sites within the South Dunedin GXP region, for:

- Scenario A – Where the Dunedin Energy Centre electrifies and as a result, Alsco Dunedin, Dunedin Hospital and University of Otago Dunedin Campus continue to utilise process heat from the energy centre.
- Scenario B – Where Alsco Dunedin, Dunedin Hospital and University of Otago Dunedin electrify themselves.

Also shown in Figure 58 and Figure 59 is:

- For Scenario A:
    - The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the South Dunedin GXP would increase to 82.4 MVA, a difference of 9.3 MVA. Given that the independent sum of the individual loads is 90.1 MVA there is a diversity factor of 0.91 between the loads.
    - The South Dunedin GXP's (N-1) limit of 108 MVA (discussed in Section 6.1.6) is not expected to be exceeded.
- For Scenario B:
    - The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the South Dunedin GXP would increase to 83.3 MVA, a difference of 10.2 MVA. Given that the independent sum of the individual loads is 88.5 MVA there is a diversity factor of 0.94 between the loads.
    - The South Dunedin GXP's (N-1) limit of 108 MVA (discussed in Section 6.1.6) is not expected to be exceeded.

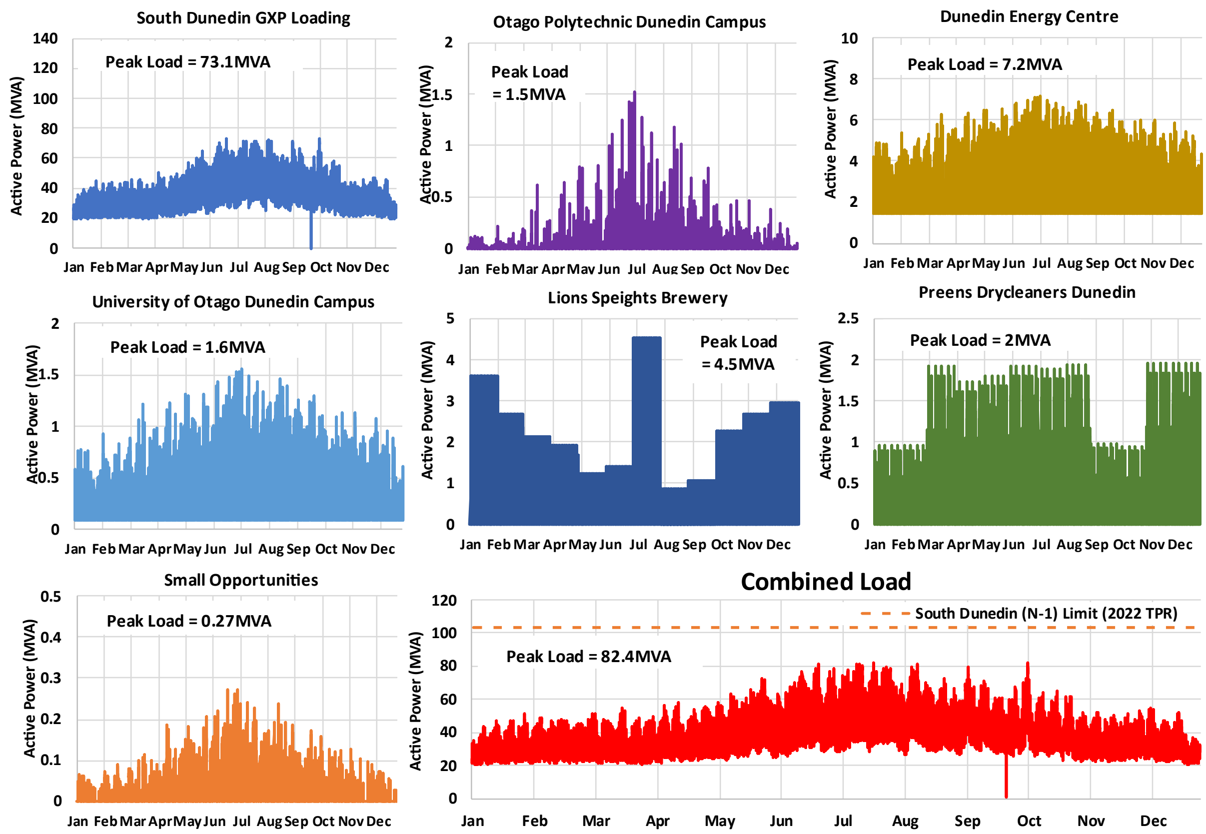


Figure 58 Loading Profiles: South Dunedin GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles) (Scenario A)

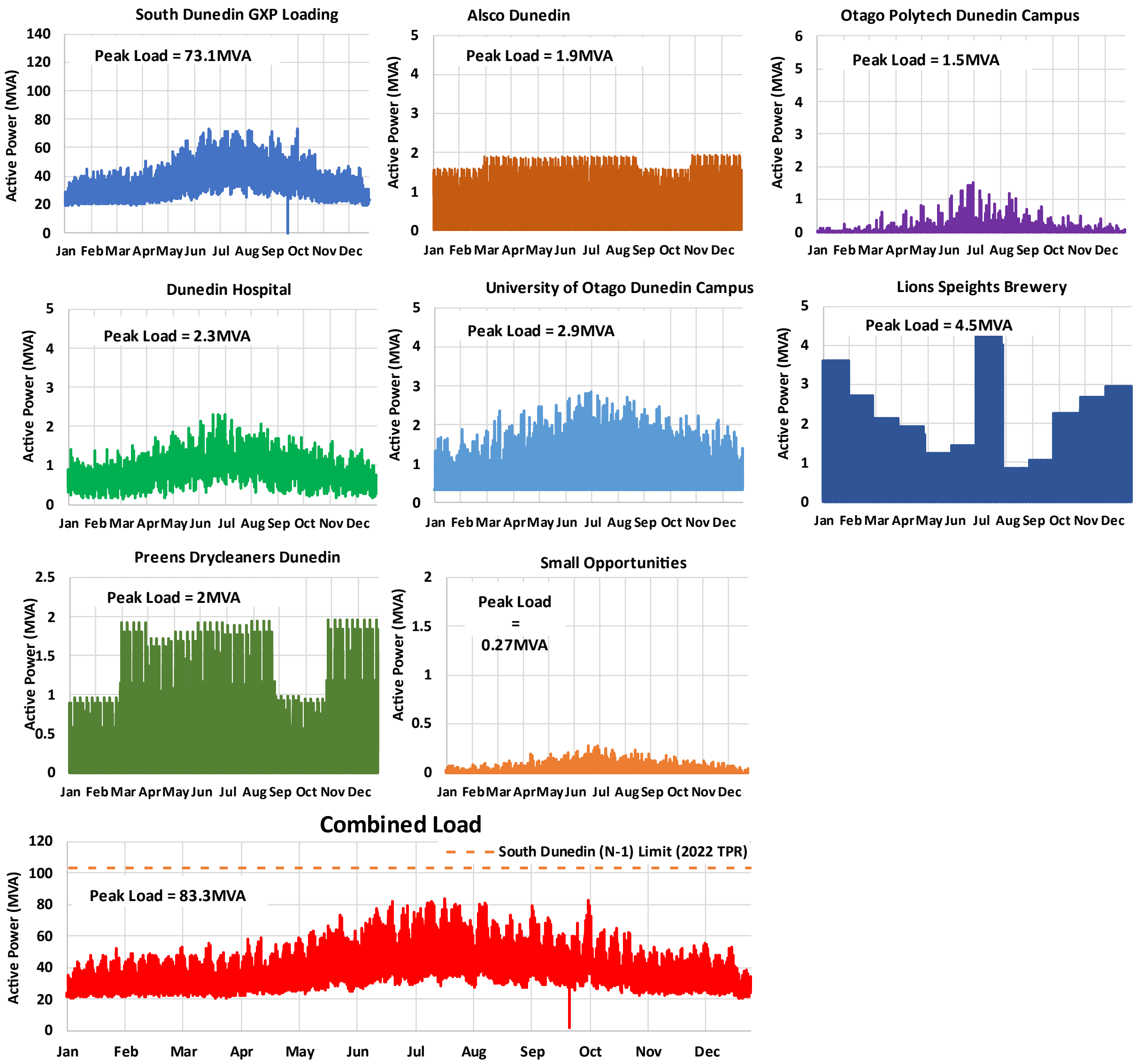


Figure 59 Loading Profiles: South Dunedin GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles) (Scenario B)

9. Conclusions

9.1 Network Spare Capacity

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

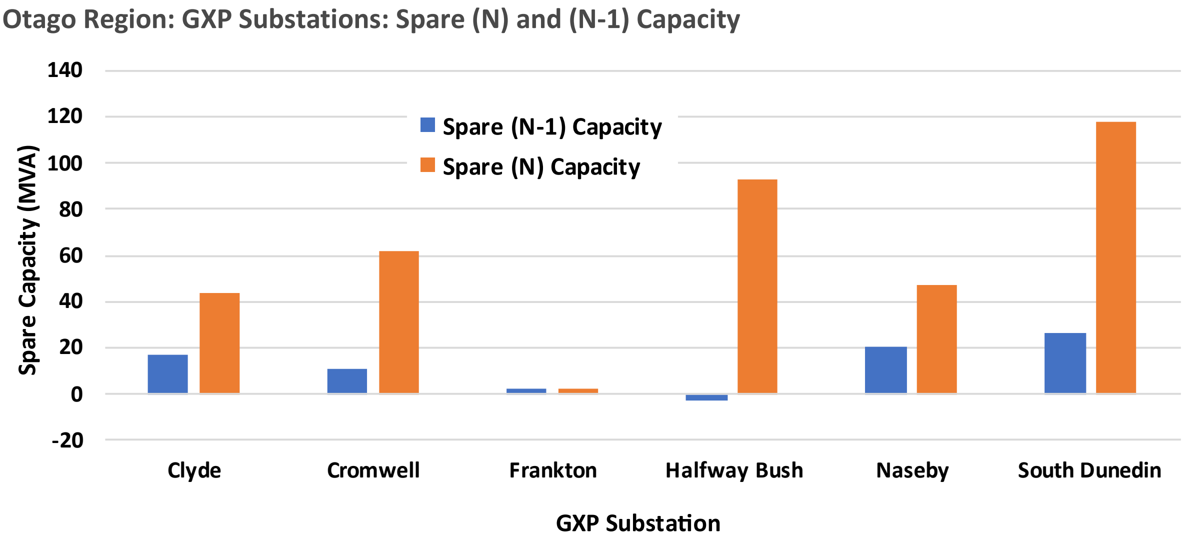


Figure 60 Summary: Approximate (N) and (N-1) spare capacity at GXP substations

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

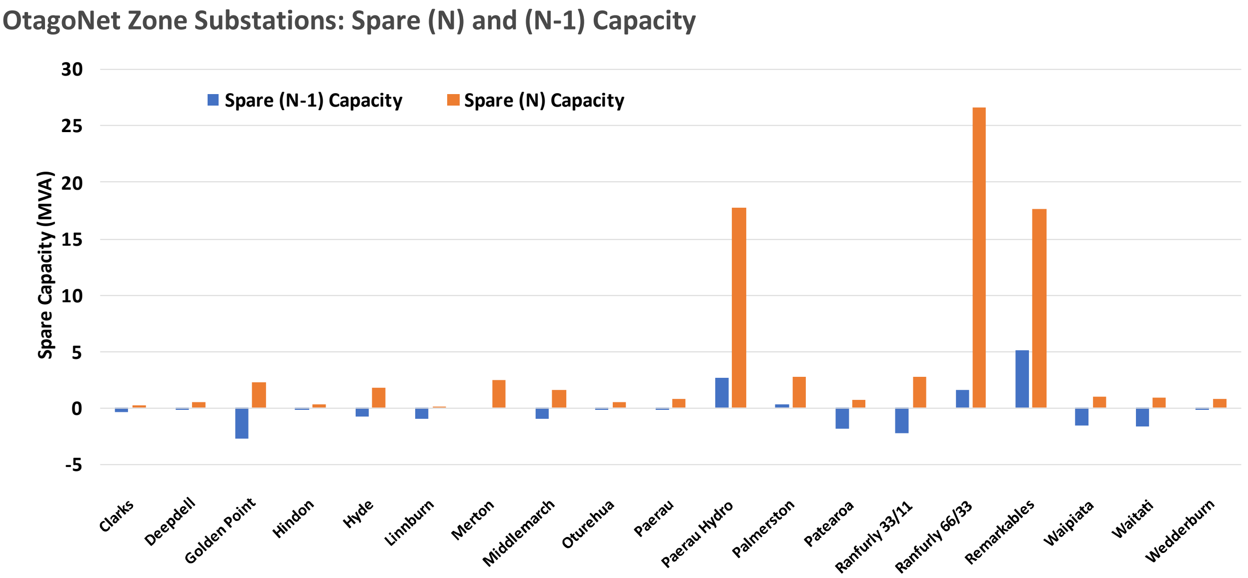


Figure 61 Summary: Approximate (N) and (N-1) spare capacity at OtagoNet's zone substations

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

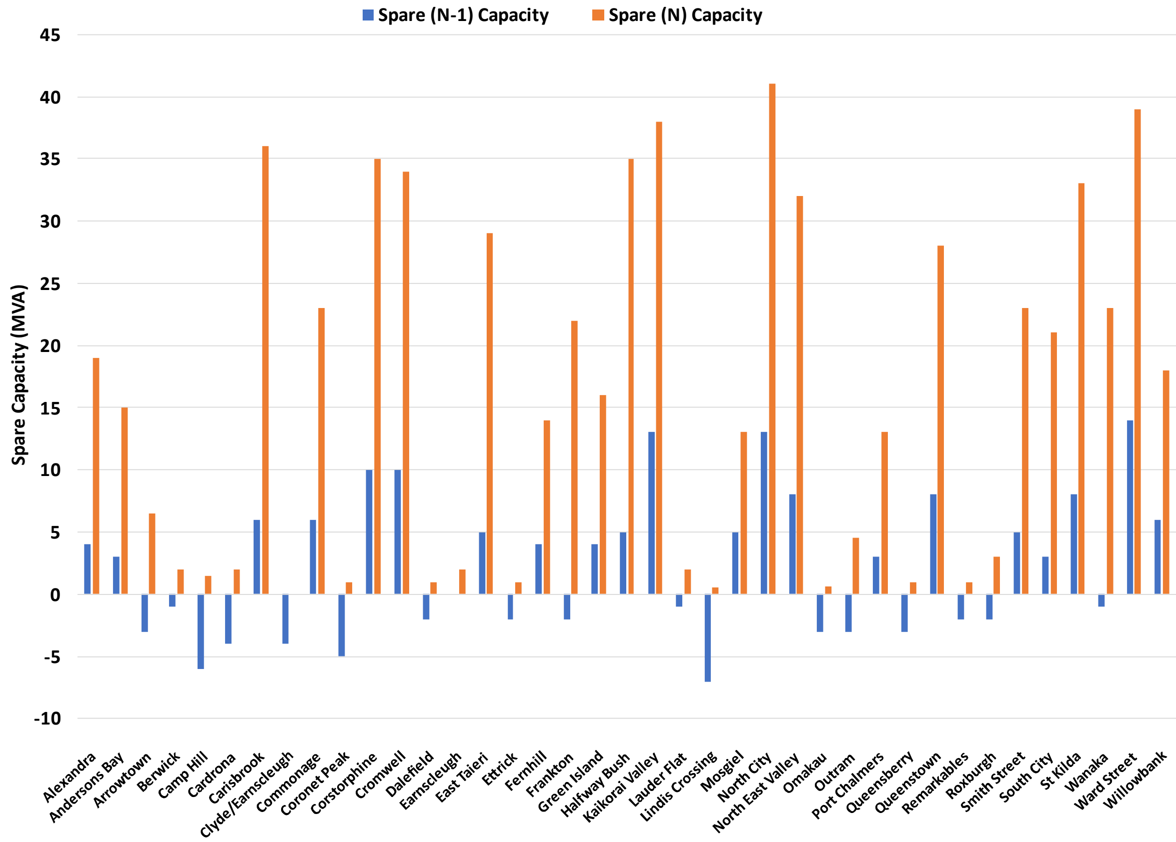


Figure 62 Summary: Approximate (N) and (N-1) spare capacity at Aurora Energy's zone substations

9.2 Load Characteristics

The substation load characteristics are documented in detail in the main body of the report (and the supplementary document 22132-RPT-0006) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

GXP substations:

- *Clyde GXP* – Loading is highly influenced by intermittent embedded generation with a winter peak.
- *Cromwell GXP* – Mix of residential, commercial and industrial loads. Winter peaking with a traditional daily morning and evening peak.
- *Frankton GXP* – Mix of residential and commercial. Winter peaking with a traditional daily morning and evening peak.
- *Halfway Bush GXP* – Mix of residential, commercial and light industrial loads. Winter peaking but is influenced by embedded generation in the area.
- *Naseby GXP* – Loading is dominated by the large industrial load at Macrae's mine, providing a relatively flat demand curve. Intermittent embedded hydro generation in the area also influences the GXP loading.
- *South Dunedin GXP* – Mix of residential, commercial and industrial loads. Winter peaking with a relatively flat daytime load profile.

Zone Substations:

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

9.3 EECA Load Sites

The following table shows EECA's Load Sites together with:

- The peak electrical power requirements of the Load Site.
- The distribution zone substation to which the Load Site would connect.
- The transmission substation/GXP which supplies the relevant zone substation.
- Ergo's estimate of the capital cost to increase the capacity of the relevant transmission assets (lines and substations).
- Ergo's estimate of the capital cost to install the necessary distribution assets to supply the Load Site.
- The cost efficiency associated with the Load Site 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[26], which is only suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details)

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

Summary: Load Sites vs transmission/distribution capital cost estimates

Table 30 Summary of Load Sites and estimated capital costs

No.	Load Site Name	Load (MW)	Transmission Details		Distribution		TOTAL	Cost Efficiency ($M/MW)	Complexity of Connection	Refer to notes
			GXP Substation	Upgrade Costs ($M)	Zone Substation	Upgrade Costs ($M)	Upgrade Costs ($M)			
1	Dunstan Hospital	0.11	Clyde	$0.00	Clyde/Earnscleugh	$0.00	$0.00	$0.00	Minor	1
2	Fulton Hogan Cromwell Ashphalt Plant	9.60	Cromwell	$0.00	Cromwell	$7.26	$7.26	$0.76	Moderate	
3	Cromwell EV Charging Station (3.8MW option)	3.80	Cromwell		Cromwell	$1.10	$1.10	$0.29	Moderate	
4	Cromwell Pool	0.07	Cromwell		Cromwell	$0.00	$0.00	$0.00	Minor	1
5	Cromwell College	0.16	Cromwell		Cromwell	$0.00	$0.00	$0.00	Minor	1
6	Mt. Aspiring College	0.15	Cromwell		Wanaka	$0.00	$0.00	$0.00	Minor	1
7	Southern Lakes Laundries	0.90	Frankton	$0.00	Frankton	$0.10	$0.10	$0.11	Minor	
8	Lakes Leisure	0.11	Frankton		Frankton	$0.00	$0.00	$0.00	Minor	1
9	Queenstown Primary School	0.14	Frankton		Queenstown	$0.00	$0.00	$0.00	Minor	1
10	Oceana Gold Macraes	4.80	Halfway Bush	$0.00	Golden Point	$2.10	$2.10	$0.44	Moderate	
11	Fulton Hogan Logan Point Quarry	4.80	Halfway Bush		Ward St	$1.70	$1.70	$0.35	Moderate	
12	Fulton Hogan Dunedin Bitument Plant	2.59	Halfway Bush		Ward St	$0.90	$0.90	$0.35	Moderate	
13	Goodman Fielder Dunedin	1.18	Halfway Bush		Kaikorai Valley	$0.05	$0.05	$0.04	Minor	
14	Greggs Coffee	2.72	Halfway Bush		Ward St/North City	$0.90	$0.90	$0.33	Moderate	
15	Graymont Makareao	7.84	Halfway Bush		Palmerston	$6.60	$6.60	$0.84	Moderate	
16	Lion Emerson's Brewery	0.83	Halfway Bush		Ward St	$0.56	$0.56	$0.67	Minor	
17	Keep it Clean Dunedin	4.06	Halfway Bush		Green Island	$1.38	$1.38	$0.34	Moderate	
18	Keep it Clean Silverstream	4.25	Halfway Bush		Mosgiel	$1.30	$1.30	$0.31	Moderate	
19	Moana Pool	0.28	Halfway Bush		Smith Street	$0.00	$0.00	$0.00	Minor	1
20	Mercy Hospital	0.37	Halfway Bush		Halfway Bush	$0.00	$0.00	$0.00	Minor	1
21	Balaclava School	0.02	Halfway Bush		Kaikorai Valley	$0.00	$0.00	$0.00	Minor	1
22	Brockville School	0.04	Halfway Bush		Kaikorai Valley	$0.00	$0.00	$0.00	Minor	1
23	Kaikorai School	0.12	Halfway Bush		Halfway Bush	$0.00	$0.00	$0.00	Minor	1
14	Logan Park High School	0.30	Halfway Bush		Ward Street	$0.00	$0.00	$0.00	Minor	1
15	Otago Boys High School Hostel	0.16	Halfway Bush		Smith Street	$0.00	$0.00	$0.00	Minor	1
16	Ravensbourne School	0.02	Halfway Bush		Ward Street	$0.00	$0.00	$0.00	Minor	1
17	Taieri College	0.35	Halfway Bush		East Taieri	$0.00	$0.00	$0.00	Minor	1
18	Wakari Hospital	0.22	Halfway Bush		Halfway Bush	$0.00	$0.00	$0.00	Minor	1
19	Alsco Dunedin	1.92	South Dunedin	$0.00	North City	$0.05	$0.05	$0.03	Minor	4
20	Otago Polytechnic Dunedin Campus	1.53	South Dunedin		North City/Ward St	$1.06	$1.06	$0.69	Moderate	
21	Dunedin Energy Centre	7.16	South Dunedin		North City	$0.18	$0.18	$0.03	Moderate	3
22	Dunedin Hospital	2.31	South Dunedin		North City	$0.05	$0.05	$0.02	Minor	4
23	University of Otago Dunedin Campus (1.56MW option)	1.56	South Dunedin		North City	$0.05	$0.05	$0.03	Minor	3
24	University of Otago Dunedin Campus (2.86MW option)	2.86	South Dunedin		North City	$0.66	$0.66	$0.23	Moderate	4
25	Lion Speights Brewery	4.54	South Dunedin		South City	$0.58	$0.58	$0.13	Moderate	
26	Preens Drycleaners Dunedin	1.96	South Dunedin		South City/St Kilda	$1.78	$1.78	$0.91	Moderate	
27	Burns House	0.17	South Dunedin		North City	$0.00	$0.00	$0.00	Minor	1
28	Tainui School	0.12	South Dunedin		Andersons Bay	$0.00	$0.00	$0.00	Minor	1
	TOTAL (scenario a) =>	67.0	TOTAL =>	$0.0	TOTAL (scenario a) =>	$27.60	$ 27.60			
	TOTAL (scenario b) =>	65.4			TOTAL (scenario b) =>	$28.13	$ 28.13			

Notes

1. Table doesn't include distribution transformer or switchgear costs for Load Sites (details provided in body of report). Estimated between $40k - $120k.
2. Load Site is likely to cause GXP to exceed (N-1) security limit of which an existing SPS in the region will permit. However, load growth in time will result in the incoming lines/GXP to be upgraded.
3. Cost included only in scenario a - Dunedin Energy Centre decarbonises itself, meaning that the loads of Alsco Dunedin and Dunedin Hospital, as well as 1.3MW of the University of Otago Dunedin Campus do not need to be considered.
4. Cost included only in scenario b - Dunedin Energy Centre does not decarbonise, meaning that the loads of Alsco Dunedin, Dunedin Hospital, and the University of Otago Dunedin Campus do need to be considered, while that of Dunedin Energy Centre does not.

Disclaimer: The Load Site 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 for final budgeting purposes in order to connect the respective Load Sites. For the larger Load Sites Ergo recommend proceeding with a Concept Design Report (CDR) to improve the accuracy of the respective cost estimate.

Appendix 1 Glossary

CT	Current transformer
CYD	Clyde GXP
CML	Cromwell GXP
DG	Distributed generator
DUN	Aurora Energy Ltd
EDB	Electrical Distribution Business
EIPC	Electricity Industry Participation Code
ENA	Electricity Network Association
ESA	Electricity Supply Authority
FKN	Frankton GXP
GXP	Grid exit point substation
HWB	Halfway Bush GXP
kV	Kilovolts
MW	Megawatts
MVArs	Mega volt amps reactive
MVA	Mega volt amps
NSY	Naseby GXP
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)
OTP	OtagoNet Ltd
SCADA	Supervisory control and data acquisition
SDN	South Dunedin GXP

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 31 Cost estimate classification matrix[27]

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 Load Sites and do not consider the connection of multiple Load Sites.

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