North Canterbury

Spare Capacity and Load Characteristics Report

EECA

22132 / 22132-EE-RPT-0007 / Revision F/ 06-Nov-2023

INSPIRED. AGILE. GENUINE.

ERGO CONSULTING

Document history and status

Revision	Date	Author	Reviewed by	Approved by	Status
A	24-04-2023	Caitlin Bergervoet/Kane Morison	Richard Fairbairn	Kane Morison	Draft
B	29-05-2023	Caitlin Bergervoet	Kane Morison	Kane Morison	Revised
C	30-06-2023	Caitlin Bergervoet	Kane Morison	Kane Morison	Revised
D	06-07-2023	Caitlin Bergervoet	Richard Fairbairn	Kane Morison	Revised
E	10-07-2023	Caitlin Bergervoet	Richard Fairbairn	Kane Morison	Revised
F	06-11-2023	Caitlin Bergervoet	Richard Fairbairn	Kane Morison	Final

Revision details

Revision	Details
A	Draft for client review/comment
B	Updated for EECA/Orion/Mainpower/Transpower comments
C	Updated to include two stages for Darfield Dairy Factory
D	Updated to include additional N security supply for Darfield Dairy Factory
E	Minor updates to Darfield and Synlait stages
F	Issued in Final

Table of Contents

List of Tables

List of Figures

1. Executive Summary

Transpower maintains/manages the transmission network in New Zealand and supplies the North Canterbury region (as described in this report) via twelve GXP's, four of which have multiple points of supply (e.g. more than one voltage level supplied).

Two Electrical Distribution Businesses (EDB's), Mainpower Ltd and Orion 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.

Building on the ETA project is the EECA's Regional Energy Transition Accelerator (RETA)[2]. The RETA program aims to provide a regional view of opportunities and barriers to reducing emissions.

As part of the RETA program, EECA has developed a set of Load Sites for the North Canterbury 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 North Canterbury 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] Energy Transition Accelerator | EECA
[2] Regional Energy Transition Accelerator | EECA

1.1 Network Spare Capacity

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

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

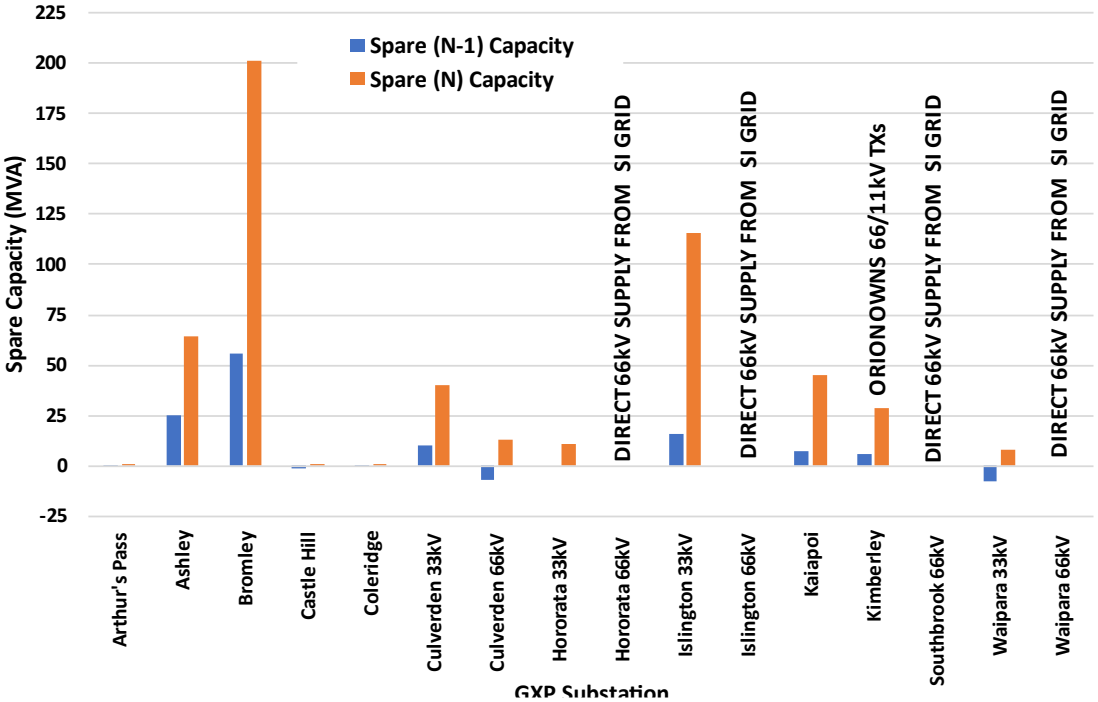


Figure 1 Summary: Approximate (N) and (N-1) spare capacity at GXP substations[3]

The following figures illustrate the (N) and (N-1) spare capacity at the EDB Zone Substations in the North Canterbury Region. These figures are based on the maximum loadings and the EDB 2022 disclosures.

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

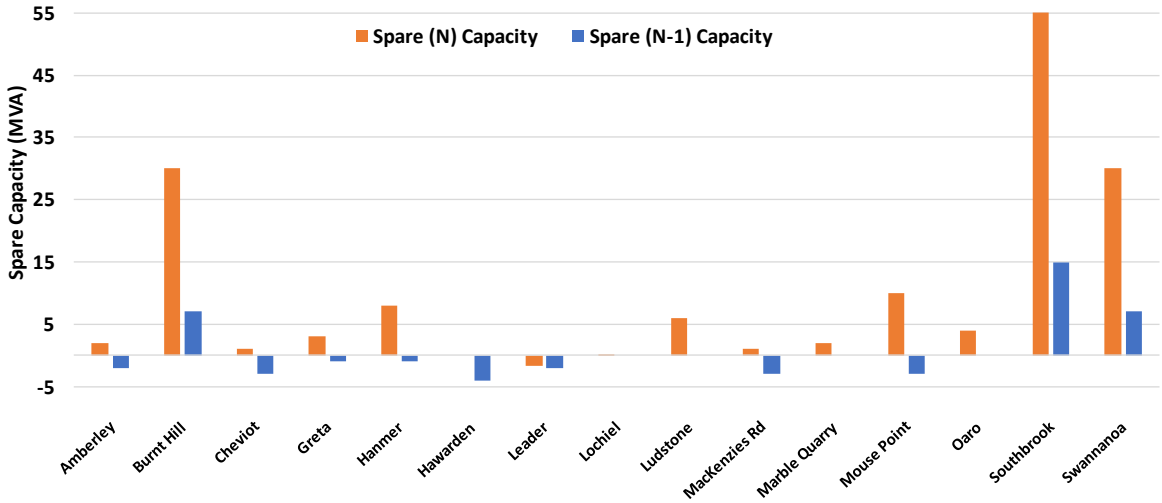


Figure 2 Summary: Approximate (N) and (N-1) spare capacity at Mainpower's zone substations[3]

[3] Some sites have negative values in these figures, indicating that either the site has one transformer (which results in negative (N-1) capacities), and/or that the transformer(s) at the site are overloaded from time to time.

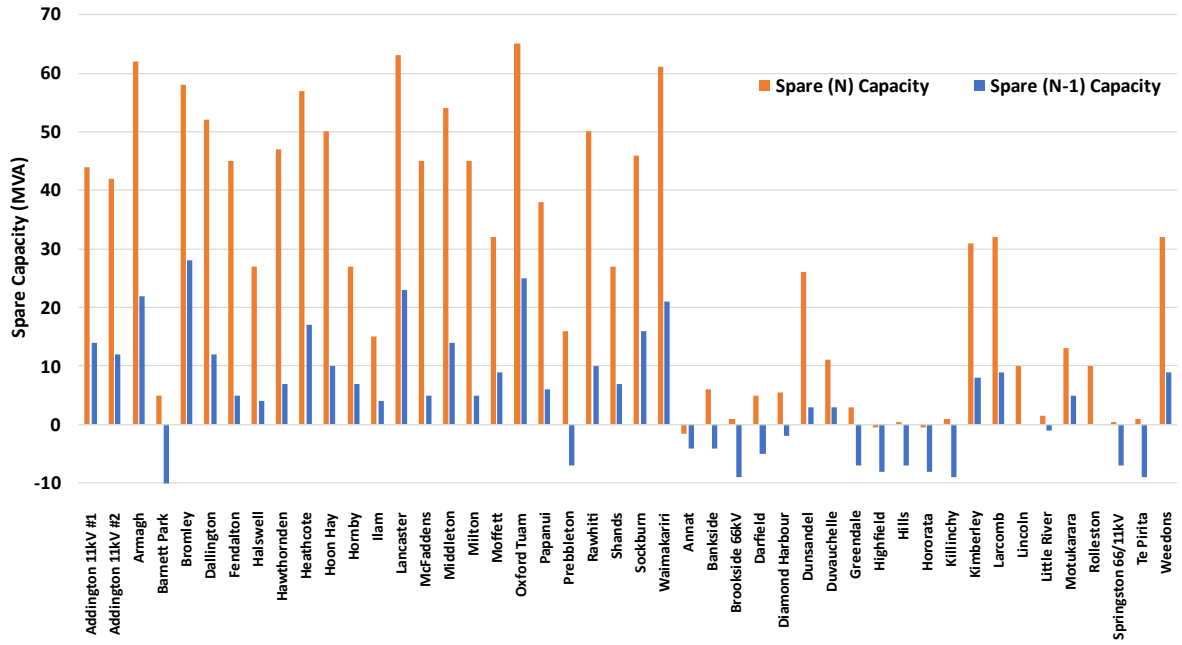


Figure 3 Summary: Approximate (N) and (N-1) spare capacity at Orion's zone substations[4]

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-0002) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

GXP substations:

- *Arthur's Pass GXP* – Very small GXP with a winter peak. GXP supplies the Arthurs Pass township with relatively flat daily load curves.
- *Ashley GXP* – Similar peak loading through both summer and winter due to continuous operation of the connected Daiken plant which is the majority of loading.
- *Bromley GXP* – GXP supplies large parts of Eastern Christchurch and therefore has a relatively conventional urban winter peak load profile with a morning and evening peak. Historical data indicates load was transferred from an adjacent GXP to Bromley for a period in October which is likely an anomaly.
- *Castle Hill GXP* – Very small GXP with a winter peak. GXP supplies the Castle Hill township.
- *Coleridge GXP* - Very small GXP with a winter peak. GXP supplies the Coleridge region.
- *Culverden GXP* – GXP supplies the Culverden, Hanmer and Kaikoura regions which is dominated by irrigation, dairy and holiday accommodation. The 33kV supply is summer peaking with the 66kV supply winter peaking (although relatively flat).
- *Hororata GXP* – GXP supplies area to the West of Christchurch with supply provided at both 33kV and 66kV. Summer peaking due to significant irrigation loading in the area.

[4] Some sites have negative values in these figures, indicating that either the site has one transformer (which results in negative (N-1) capacities), and/or that the transformer(s) at the site are overloaded from time to time.

- *Islington GXP* - GXP supplies Orion at both 33kV and 66kV which in turn supplies Christchurch City and the area's west of the city. Both are largely winter loading with a typical residential, commercial daily load profile with a morning and evening peak.
- *Kaiapoi GXP* – A mix of residential, commercial and industrial loading with winter peak.
- *Kimberley GXP* – Majority of load is Fonterra's Darfield dairy factory with some supply provided to the Darfield area. As a result, loading is relatively consistent from August – April with a flat daily load profile.
- *Southbrook GXP* – Load profile is a mix of irrigation (causing high summer peaks) and residential, commercial, industrial resulting in a typical winter loading profile with daily peaks in the mornings and evenings.
- *Waipara GXP* – Mix of rural and residential loading. Both summer (likely due to irrigation) and winter peaks are similar. Daily load profiles are dominated by morning and evening peaks for both summer and winter.

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[5], which is only suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details).

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.

[5] 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	G L Bowron Company Christchurch	6.36	Bromley	$0.00	Heathcote	$2.50	**$2.50**	**$0.39**	Moderate	2
2	Winstone Wallboards Christchurch	6.05	Bromley	$0.00	Heathcote	$2.50	**$2.50**	**$0.41**	Moderate	2
3	Alsco New Zealand Christchurch	2.04	Bromley	$0.00	Lancaster	$0.64	**$0.64**	**$0.31**	Moderate	2
4	Paua Co. Bromley	1.44	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
5	Ardex Christchurch	0.82	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
6	Woolston Foundry Christchurch	0.48	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
7	Castle Rock Orchards	0.46	Bromley	$0.00	Heathcote	$0.00	**$0.00**	**$0.00**	Minor	1
8	Aromaunga Baxter Flowers	0.33	Bromley	$0.00	Heathcote	$0.00	**$0.00**	**$0.00**	Minor	1
9	Te Aratai College	0.33	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
10	Taylors Manufacturing Christchurch	0.25	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
11	Shirley Boys High School	0.22	Bromley	$0.00	Rawhiti	$0.00	**$0.00**	**$0.00**	Minor	1
12	Scott Technology Christchurch	0.17	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
13	Shirley Intermediate School	0.12	Bromley	$0.00	Dallington	$0.00	**$0.00**	**$0.00**	Minor	1
14	Chisnallwood Intermediate School	0.12	Bromley	$0.00	Dallington	$0.00	**$0.00**	**$0.00**	Minor	1
15	Tekoa Range/Hanmer EV Charging Station (1.6MW option)	1.60	Culverden	$0.00	Hanmer	$1.60	**$1.60**	**$1.00**	Moderate	1
16	Kaikoura EV Charging Station (4.5MW option)	4.50	Culverden	$0.00	Ludstone	$4.48	**$4.48**	**$1.00**	Moderate	2
17	Kaikoura High School	0.12	Culverden	$0.00	Ludstone	$0.00	**$0.00**	**$0.00**	Minor	1
18	Canterbury Clay Bricks Darfield	2.30	Hororata	$0.00	Darfield	$2.30	**$2.30**	**$1.00**	Moderate	2,4
19	Gladfield Malt Dunsandel	1.98	Hororata	$0.00	Greendale	$1.38	**$1.38**	**$0.69**	Minor	1
20	Mitchell Bros Sawmillers Darfield	1.16	Hororata	$0.00	Darfield	$0.73	**$0.73**	**$0.63**	Moderate	2,4
21	Darfield EV Charging Station (2.3MW option)	2.30	Hororata	$0.00	Darfield	$0.78	**$0.78**	**$0.34**	Moderate	2,4
22	ANZCO Foods Rakaia	0.95	Hororata	$0.00	Killinchy	$0.66	**$0.66**	**$0.69**	Minor	
23	Meadow Mushrooms Giggs Farm	0.55	Hororata	$0.00	Greendale	$0.00	**$0.00**	**$0.00**	Minor	1
24	Synlait Milk Rakaia	45.96	Islington	$0.00	Dunsandel	$19.91	**$19.91**	**$0.43**	Moderate	2,3
25	Kraft Heinz Christchurch((N-1) security option)	7.29	Islington	$0.00	Shands Road	$6.32	**$6.32**	**$0.87**	Moderate	2
26	Goodman Fielder Christchurch	4.71	Islington	$0.00	Middleton	$0.42	**$0.42**	**$0.09**	Moderate	2
27	Air New Zealand Christchurch (biomass portion)	4.13	Islington	$0.00	Waimakariri	$1.70	**$1.70**	**$0.41**	Moderate	2
28	Valmont Christchurch	3.36	Islington	$0.00	Sockburn	$0.90	**$0.90**	**$0.27**	Moderate	2
29	Westland Milk Products Rolleston	2.65	Islington	$0.00	Weedons	$2.50	**$2.50**	**$0.94**	Moderate	2
30	Hexion Hornby	2.30	Islington	$0.00	Moffett	$1.62	**$1.62**	**$0.70**	Moderate	2
31	Lincoln University	1.64	Islington	$0.00	Springston	$0.00	**$0.00**	**$0.00**	Minor	1
32	Higgins Christchurch	1.95	Islington	$0.00	Hornby	$1.30	**$1.30**	**$0.67**	Minor	1
33	Silver Fern Farms Belfast	1.29	Islington	$0.00	Belfast	$0.00	**$0.00**	**$0.00**	Minor	1
34	NZ Defence Force Burnham	1.28	Islington	$0.00	Rolleston	$3.96	**$3.96**	**$3.09**	Moderate	2
35	St George's Hospital Inc.	1.24	Islington	$0.00	McFaddens	$2.88	**$2.88**	**$2.32**	Moderate	2
36	Kisco Foods Christchurch	1.15	Islington	$0.00	Middleton	$0.16	**$0.16**	**$0.14**	Moderate	2
37	Expol Christchurch	1.15	Islington	$0.00	Belfast	$0.48	**$0.48**	**$0.42**	Minor	2
38	Farmlands Rolleston	0.96	Islington	$0.00	Weedons	$0.00	**$0.00**	**$0.00**	Minor	1
39	Apparelmaster Christchurch	0.82	Islington	$0.00	Middleton	$0.00	**$0.00**	**$0.00**	Minor	1
40	Air New Zealand Christchurch	0.81	Islington	$0.00	Waimakariri	$0.00	**$0.00**	**$0.00**	Minor	1
41	Christchurch Womens Prison	0.81	Islington	$0.00	Moffett	$0.00	**$0.00**	**$0.00**	Minor	1
42	Hamilton Jet Christchurch	0.67	Islington	$0.00	Middleton	$0.00	**$0.00**	**$0.00**	Minor	1
43	Ag Research Lincoln	0.61	Islington	$0.00	Lincoln	$0.00	**$0.00**	**$0.00**	Minor	1
44	Tegal Foods Ltd Christchurch	0.60	Islington	$0.00	Sockburn	$0.00	**$0.00**	**$0.00**	Minor	1
45	Expol Rolleston	0.58	Islington	$0.00	Weedons	$0.00	**$0.00**	**$0.00**	Minor	1
46	Ara Institute of Canterbury Christchurch	0.57	Islington	$0.00	Oxford Tuam	$0.00	**$0.00**	**$0.00**	Minor	1
47	Christchurch Mens Prison	0.56	Islington	$0.00	Moffett	$0.00	**$0.00**	**$0.00**	Minor	1
48	Nova Trust Templeton	0.55	Islington	$0.00	Moffett	$0.00	**$0.00**	**$0.00**	Minor	1
49	Southern Cross Healthcare Christchurch	0.45	Islington	$0.00	Armagh	$0.00	**$0.00**	**$0.00**	Minor	1
50	Hillmorton Hospital	0.45	Islington	$0.00	Middleton	$0.00	**$0.00**	**$0.00**	Minor	1
51	Burnside High School	0.45	Islington	$0.00	Hawthornden	$0.00	**$0.00**	**$0.00**	Minor	1
52	Christchurch City Council Civic Offices	0.39	Islington	$0.00	Oxford Tuam	$0.00	**$0.00**	**$0.00**	Minor	1
53	Zealandia Horticulture Belfast*	0.35	Islington	$0.00	Belfast	$0.00	**$0.00**	**$0.00**	Minor	1
54	Coca Cola Europacific Partners Christchurch	0.35	Islington	$0.00	Heathcote	$0.00	**$0.00**	**$0.00**	Minor	1
55	Oderings Nurseries Spreydon	0.29	Islington	$0.00	Milton	$0.00	**$0.00**	**$0.00**	Minor	1
56	Rochester & Rutherford Hall	0.28	Islington	$0.00	Ilam	$0.00	**$0.00**	**$0.00**	Minor	1
57	Hornby High School	0.23	Islington	$0.00	Hornby	$0.00	**$0.00**	**$0.00**	Minor	1
58	Lincoln High School	0.23	Islington	$0.00	Lincoln	$0.00	**$0.00**	**$0.00**	Minor	1
59	Hellers Kaiapoi	2.15	Kaiapoi	$0.00	Kaiapoi	$1.62	**$1.62**	**$0.75**	Moderate	2
60	Kaiapoi EV Charging (6.1MW option)	6.10	Kaiapoi	$0.00	Kaiapoi	$1.18	**$1.18**	**$0.19**	Moderate	2
61	Island Horticulture	3.80	Kaiapoi	$0.00	Kaiapoi	$1.96	**$1.96**	**$0.52**	Moderate	2
62	Fonterra Darfield	58.82	Kimberley	$19.45	Kimberley	$7.14	**$26.59**	**$0.45**	Major	2,3
63	McAlpines Rangiora	1.21	Southbrook	$0.00	Southbrook	$0.30	**$0.30**	**$0.25**	Minor	5
64	Harris Meats	0.59	Waipara	$0.00	Cheviot	$1.20	**$1.20**	**$2.03**	Minor	1
	TOTAL =>	**198.4**	**TOTAL =>**	**$19.5**	**TOTAL =>**	**$73.11**	**$92.56**			

Notes

1 Doesn't include distribution transformer or switchgear costs for Load Sites (details provided in body of report). Estimated between $50k - $350k depending on size.
2 Assumes supply is taken from the EDB at either 33kV or 11kV. Costs will vary depending on size, security and site requirements
3 Proposed to take supply from the new Norwood GXP. Costs include stage 1, stage 1A, and stage 2.
4 Ergo have proposed to connect load to Kimberley instead of Hororata due to the Hororata 33kV constraint
5 Connection of this load to Southbrook is dependent on confirmation of capacity at Southbrook zone substation.

2. Introduction

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

- Mainpower Ltd– 15 zone substations
- Orion Ltd- 46 zone substations

The franchise areas of the EDBs are shown in Figure 4.

The Energy Efficiency & Conservation Authority (EECA) is running a flagship program that is called Energy Transition Accelerator (ETA)[6]. The program is targeted at large energy-using businesses and public sector organisations that are committed to reducing carbon emissions.

Building on the ETA project is the EECA's Regional Energy Transition Accelerator (RETA)[7]. The RETA program aims to provide a regional view of opportunities and barriers to reducing 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 North Canterbury.

Ergo previously developed a similar report for the Southland, South Canterbury, West Coast, and Otago regions.[8,9,10,11]

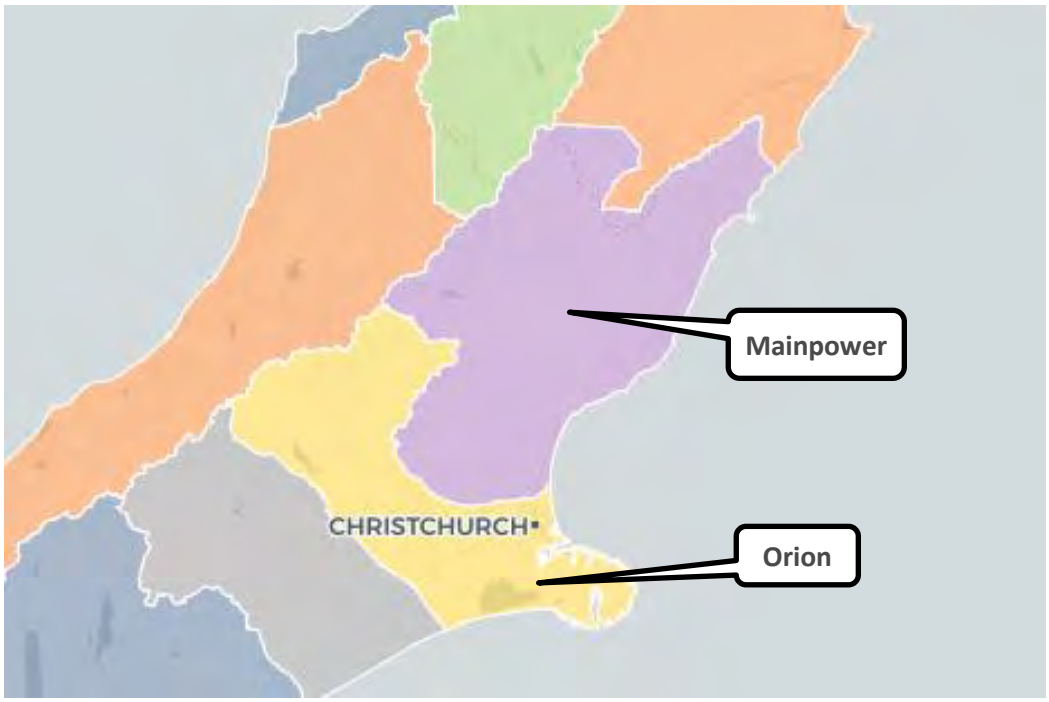


Figure 4 Electrical Distribution Business (EDB) franchise areas[12]

[6] Energy Transition Accelerator | EECA
[7] Regional Energy Transition Accelerator | EECA
[8] 21177-RPT-0001 [G] Southland Electrical Network - Spare Capacity and Load Characteristics.
[9] 22108-RPT-0001 [F] South Canterbury Electrical Network - Spare Capacity and Load Characteristics.
[10] 22132-RPT-0001 [D] West Coast Electrical Network – Spare Capacity and Load Characteristics.
[11] 22132-RPT-0005 [A] Otago Electrical Network – Spare Capacity and Load Characteristics.
[12] 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 North Canterbury Region. This included reviewing both the GXP's and local distribution zone substations along with their associated lines/cables within the North Canterbury 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.
- Mainpower's 2022 Disclosures and Asset Management Plan.
- Orion's 2022 Disclosures and Asset Management Plan.
- SCADA substation loading data provided by Mainpower and Orion.
- GXP metering data extracted from the Electricity Authority's website[13].
- Network diagrams provided by Mainpower and Orion.
- Geographic Information System (GIS) asset and location data provided by Mainpower and Orion. Electricity. This was mostly supplied in the form of *.kmz files.

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

4. North Canterbury Network

The following sections describes (at a high level), the locations of the relevant substations and lines. For the purposes of this document the franchise areas supplied by Mainpower and Orion are referred to as the North Canterbury Region.

4.1 Transmission/GXP Substations

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

- Arthurs Pass GXP.
- Ashley GXP.
- Bromley GXP.
- Castle Hill GXP.
- Coleridge.
- Culverden GXP (33kV and 66kV).
- Hororata GXP (33kV and 66kV).
- Islington GXP (33kV and 66kV).
- Kaiapoi GXP.
- Kimberley GXP (Orion takes supply at 66 kV).
- Southbrook GXP (66kV).
- Waipara GXP (33kV and 66kV).

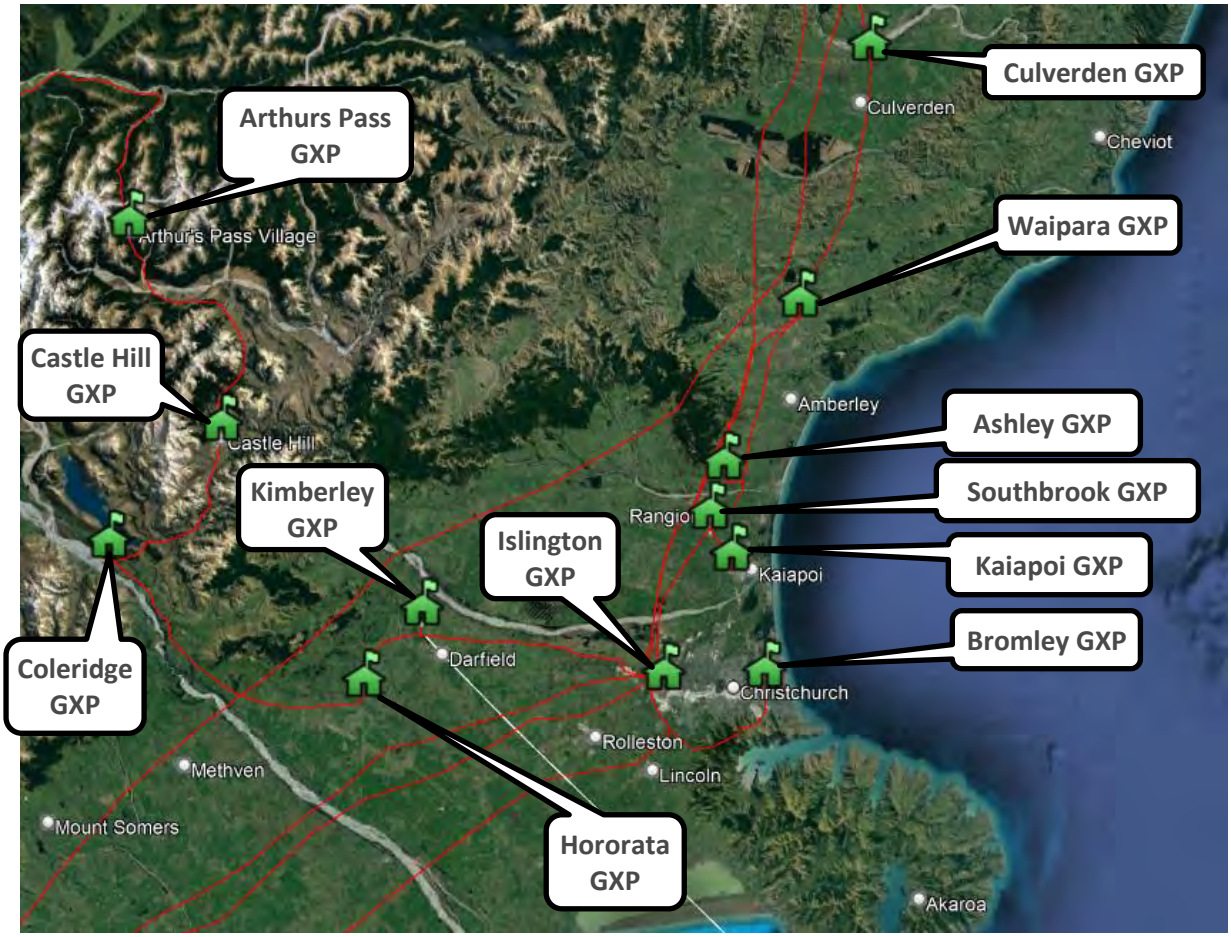


Figure 5 Transmission/GXP substations (red lines are Transpower's transmission lines)

The transmission network in the North Canterbury Region is also shown diagramatically in Figure 6 and Figure 7. The region has some of the South Island's highest load densities, but relatively low levels of local generation. As a result, most of Canterbury's electricity demand is supplied by generation located to the south of the region, via four 220 kV transmission circuits (three from Twizel and one from Livingstone). This transmission is essential for power flow into North Canterbury and onwards to the Nelson-Marlborough and West Coast regions of the South Island. Within the North Canterbury region, the transmission network comprises 220 kV and 66 kV transmission circuits, with five 220/66 kV interconnecting transformers (three at Islington and two at Waipara). GXP substations deliver power at vairous combinations of 11kV, 33kV and 66kV to Mainpower and Orion. Voltage support for the region (and grid backbone) is provided by the following reactive power sources:

- Static VAR compensators (SVC) at Islington.
- Capacitor banks at Islington, Bromley and Southbrook.

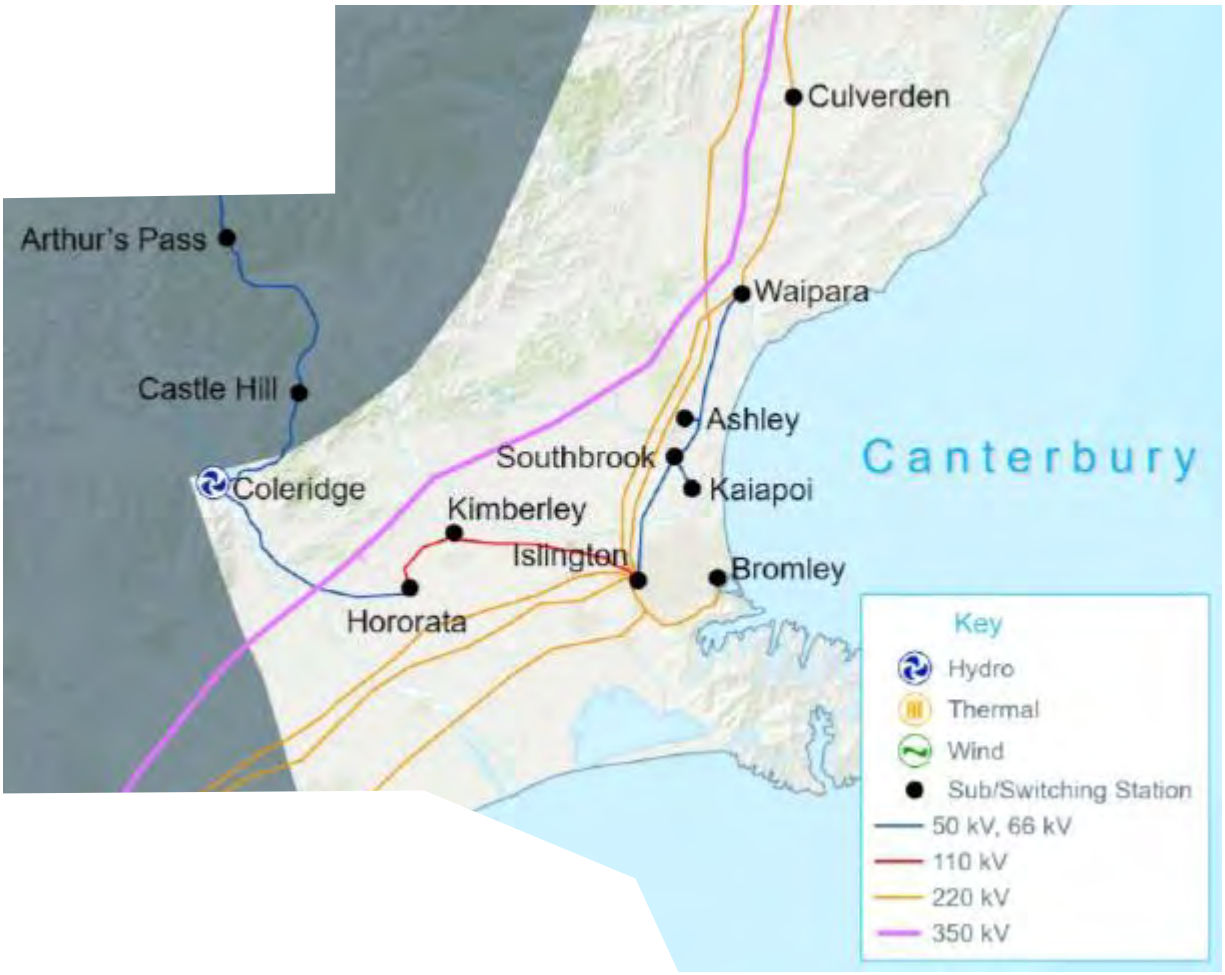


Figure 6 Transmission/GXP substations[14]

[14] Transmission Planning Report 2022

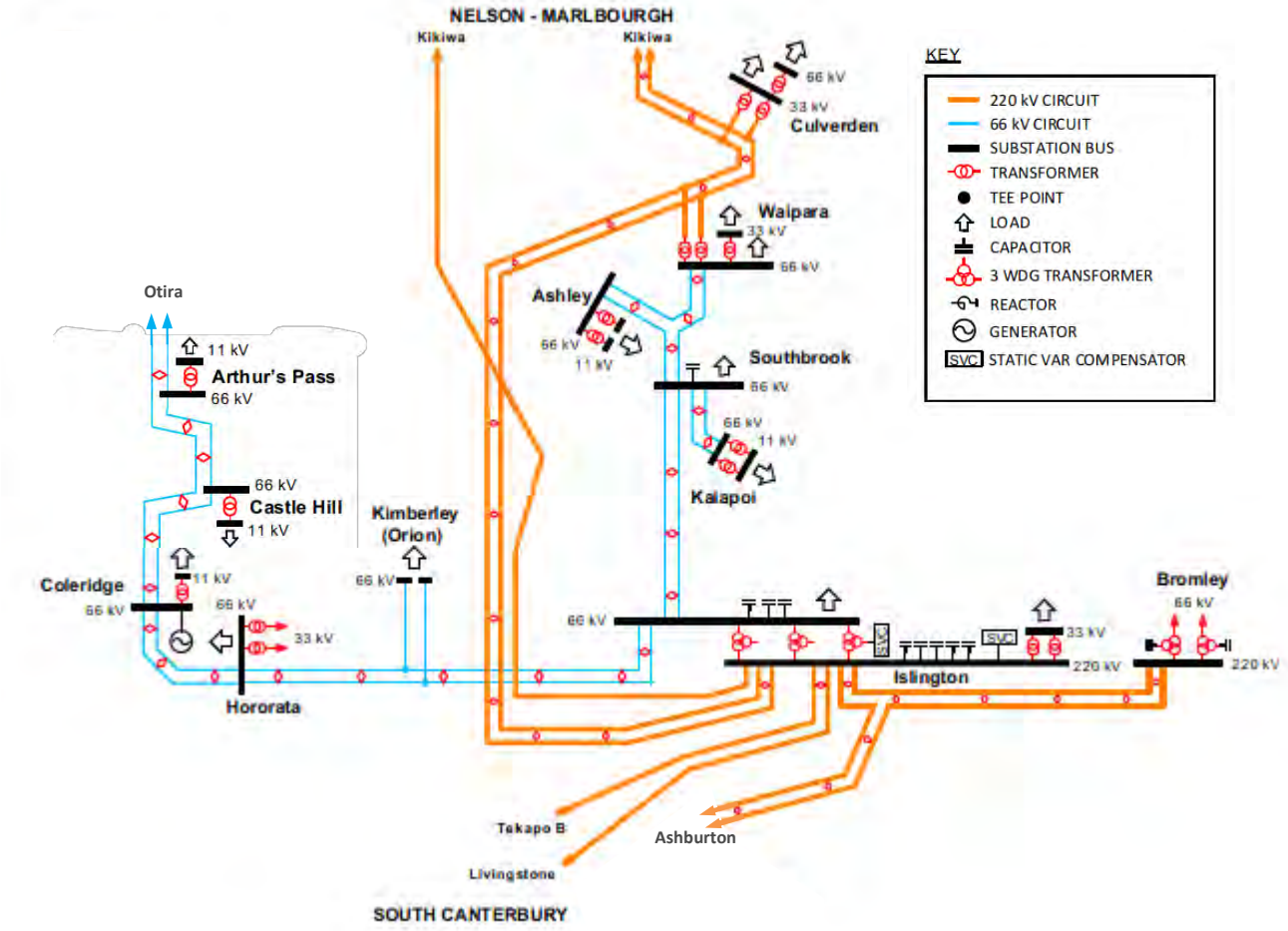


Figure 7 Existing transmission/GXP substations[14]

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 – Mainpower and Orion. Table 2 below gives an overview of the number of Zone Substations managed by each investigated EDB, and the number of Transpower GXPs they take power from.

Table 2 Overview of substation numbers for each EDB investigated

EDB Name	Participant Code	Number of Zone Substations	Number of GXPs	Existing Peak Demand (MW)	Energy Entering Network 2022 (GWh)
Mainpower	MPOW	17	5	~124	662
Orion	ORON	46	7	~650	3,458

4.2.1 Mainpower

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

- Amberley 33/11kV zone substation.
- Burnt Hill 66/11kV zone substation.
- Cheviot 66/11kV zone substation.
- Greta 66/11kV zone substation.
- Hanmer 33/11kV zone substation.
- Hawarden 33/11kV zone substation.
- Kaikōura 66/33kV zone substation.
- Leader 33/11kV zone substation.
- Lochiel 33/11kV zone substation.
- Ludstone 33/11kV zone substation.
- MacKenzies Rd 66/11kV zone substation.
- Marble Quarry 33/11kV zone substation.
- Mouse Point 33/11kV zone substation.
- Oaro 33/11kV zone substation.
- Rangiora North 33/11kV zone substation (to be decommissioned following completion of the Southbrook zone substation upgrade to 66/11kV).
- Southbrook 66/11kV zone substation.
- Swannanoa 33/11kV zone substation.

Figure 8 Mainpower: Northern Zone Substation Geospatial Sub-transmission Diagram[15]

4.2.2 Orion

The following Figure 9 and Figure 10 show the zone substations on Orion's network diagrammatically (Region A and Region B).[16] The substations include:

- Addington 11kV #1 66/11kV zone substation.
- Addington 11kV #2 66/11kV zone substation.
- Armagh 66/11kV zone substation.
- Barnett Park 66/11kV zone substation.
- Bromley 66/11kV zone substation.
- Dallington 66/11kV zone substation.
- Fendalton 66/11kV zone substation.
- Halswell 66/11kV zone substation.
- Hawthornden 66/11kV zone substation.
- Heathcote 66/11kV zone substation.
- Hoon Hay 66/11kV zone substation.
- Hornby 33/11kV zone substation.

[15] https://mainpower.co.nz/assets/documents/mainpower-amp2022
[16] https://www.oriongroup.co.nz/corporate/corporate-publications/asset-management-plans/

- Ilam zone substation (supplied via 2 x 66/11kV transformers located at Hawthornden).
- Lancaster 66/11kV zone substation.
- McFaddens 66/11kV zone substation.
- Middleton 66/11kV zone substation.
- Milton 66/11kV zone substation.
- Moffett 33/11kV zone substation.
- Oxford Tuam 66/11kV zone substation.
- Papanui 66/11kV zone substation.
- Prebbleton 33/11kV zone substation.
- Rawhiti 66/11kV zone substation.
- Shands 33/11kV zone substation.
- Sockburn 33/11kV zone substation.
- Waimakariri 66/11kV zone substation.
- Annat 33/11kV zone substation.
- Bankside 33/11kV zone substation.
- Brookside 66/11kV zone substation.
- Darfield 33/11kV zone substation.
- Diamond Harbour 33/11kV zone substation.
- Dunsandel 66/11kV zone substation.
- Duvauchelle 33/11kV zone substation.
- Greendale 66/11kV zone substation.
- Highfield 33/11kV zone substation.
- Hills 33/11kV zone substation.
- Hororata 33/11kV zone substation.
- Killinchy 66/11kV zone substation.
- Kimberley 66/11kV zone substation.
- Larcomb 66/11kV zone substation.
- Lincoln 33/11kV zone substation.
- Little River 33/11kV zone substation.
- Motukarara 33/11kV zone substation.
- Rolleston 33/11kV zone substation.
- Springston 33/11kV zone substation.
- Te Pirita 66/11kV zone substation.
- Weedons 66/11kV zone substation.

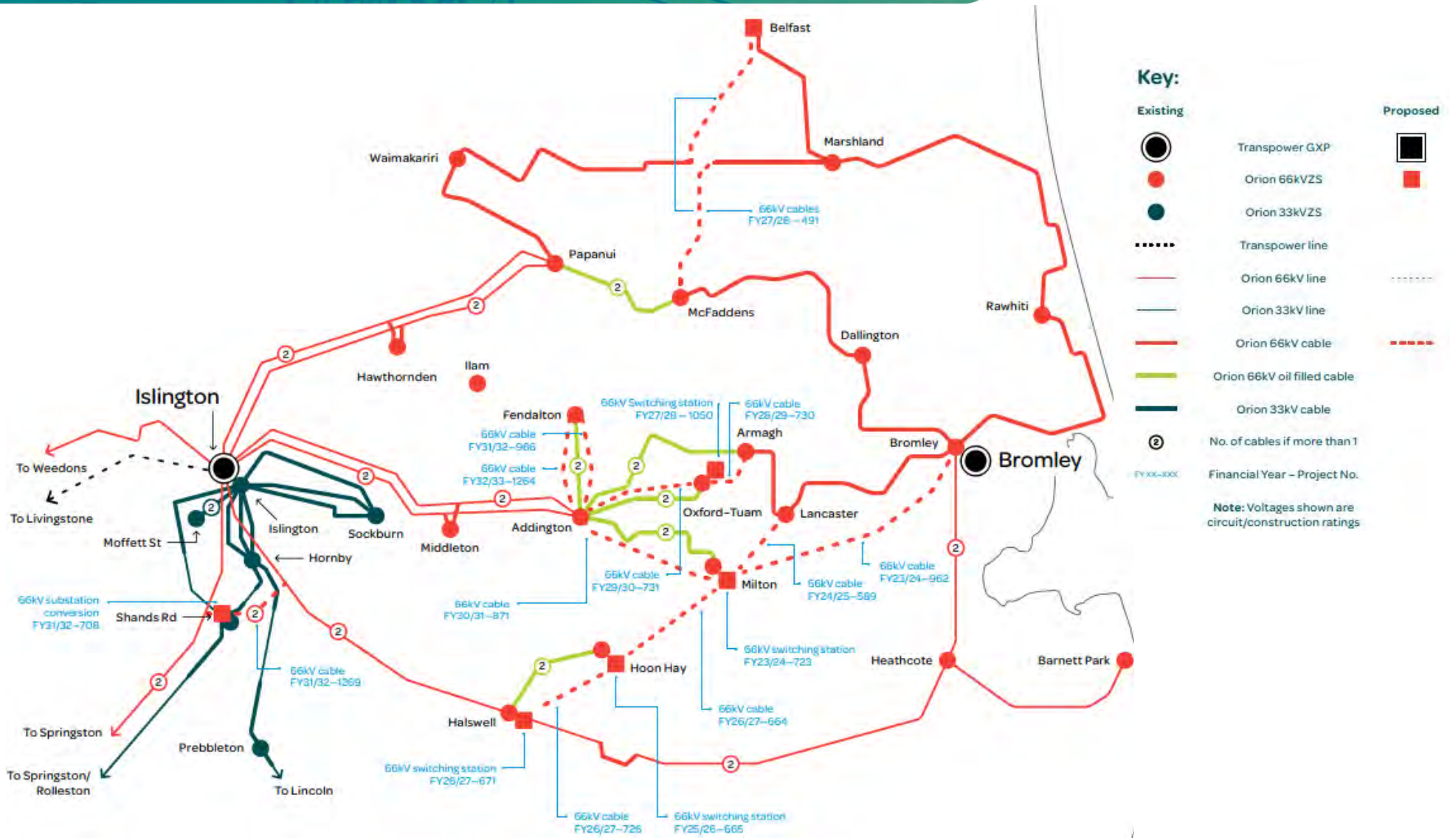


Figure 9 Orion: Region A: Zone Substation Geospatial Sub-transmission Diagram: Existing and proposed future

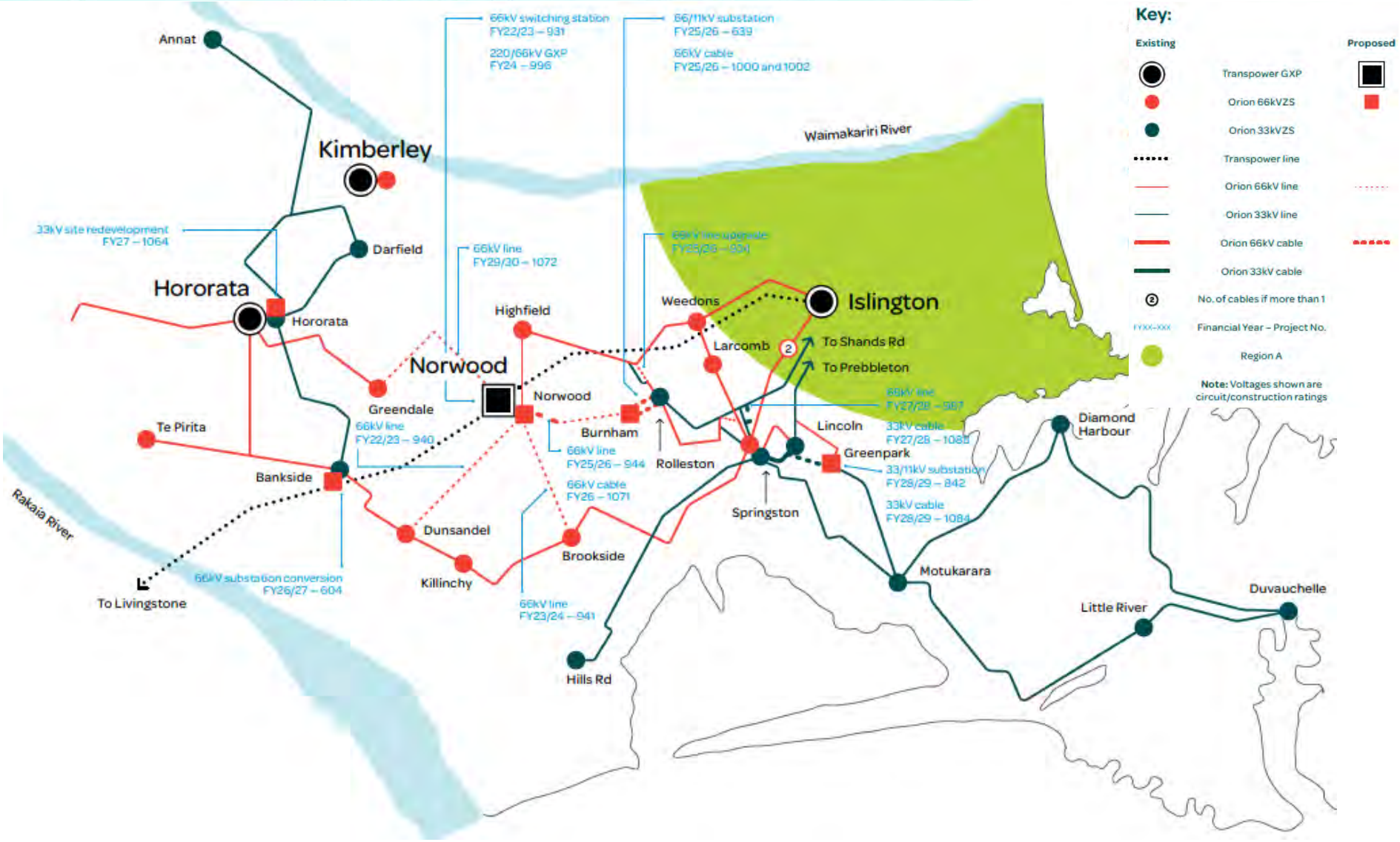


Figure 10 Orion: Region B: Zone Substation Geospatial Sub-transmission Diagram: Existing and proposed future

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)[17]. 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 are normally used simultaneously), which in the event of single engine failure will not crash.
- Switched (N-1) security or strategic spares: The network is designed and operates such that it can continue to supply load with an interruption in the event of a single asset failure. Interruptions in these cases could be as short as seconds to remotely switch, or hours to send an operator to manually switch the network, to drive a mobile substation to the site, or replace assets on site using spares which are kept relatively close. Again, can be compared with a single-engine aircraft, but in this case in the event of failure, a parachute is deployed.

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/or >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 points of supply discussed in this report are considered connection assets and therefore decisions around their security classifications lie with their end customers (i.e. Mainpower or Orion). 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.

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

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

Both Transpower and EDBs have taken advantage of technology to make the above mentioned standards more flexible, by managing consumer demand where possible. Initially this involved the use of mains borne ripple injection equipment to manage the load drawn by consumer's hot water cylinders. 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[18]. 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.

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 North Canterbury Region.

Transpower has identified the following "*wider region issues*" that result from increasing electrical demand in the North Canterbury Region including:

- Most of the Christchurch 66 kV load is supplied from the Bromley and Islington GXPs. The local EDB, Orion, can transfer significant load between the Bromley and Islington 66 kV buses, and in the future is proposing to undertake multiple load shifts between the two GXPs. Therefore, the five 220/66/11kV transformers at the Bromley and Islington GXPs can be considered together when considering the security of supply delivered to Orion's 66kV network.
  The three 220/66/11kV transformers at Islington collectively provide:
  - A nominal installed capacity of 657 MVA.
  - A (N-1) capacity of 504/532 MVA (summer/winter).

  From 2023 the existing system spare 220/66 kV transformer will be on hot standby (that is, energised but not loaded). When one of the three Islington "main" transformers are out-of-service, the spare can be switched in to provide switched (N-1) security. Ergo expects that in this particular case, there would be some interruption to supply <1 hour, to connect the hot spare transformer; with switching in the hot spare being automatic after ~2032 when a special protection scheme is planned for that purpose.
  The two 220/66 kV interconnecting transformers at Bromley provide:
  - A nominal installed capacity of 360 MVA.
  - A (N-1) capacity of 215/220 MVA (summer/winter).

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

From 2028 a contingency of a Bromley 220/66/11 kV transformer may overload the remaining Bromley transformer. In this event Orion can shift load to Islington to remove the overload at Bromley. The load at Islington will remain within the switched (N-1) capacity of the transformers.

- The Hororata and Kimberley GXPs are supplied from:
  - The Islington GXP, by two 66 kV Hororata–Kimberley–Islington circuits, each rated at 59/62 MVA (summer/winter).
  - The Coleridge GXP and the West Coast, by two 66 kV Coleridge–Hororata circuits, each rated at 30/37 MVA (summer/winter).

  Transpower has an agreement with Orion for the Hororata and Kimberley 66 kV buses to have a post contingent operating voltage band of between 0.9 and 1.05 p.u.
  With low Coleridge generation (three of the five units in service), and high load at Hororata and Kimberley, a Hororata–Kimberley–Islington 66kV circuit outage may cause:
  - The combined load to exceed the (N-1) thermal capacity of the remaining Hororata–Kimberley–Islington circuit from 2028.
  - Voltages on the Hororata and Kimberley 66 kV buses to drop below 0.9 p.u. from 2029.
  - The combined load to exceed the (N-1) thermal capacity of the remaining Hororata–Kimberley–Islington circuit with all Coleridge generation in service from 2036.
- The four 220 kV transmission circuit system that connects the Canterbury region to the South Canterbury region to the south includes:
  - The Tekapo B–Islington circuit, rated at 557/620 MVA (summer/winter)
  - The two Ashburton–Islington circuits, each rated at 694/764 MVA (summer/winter)
  - The Islington–Livingstone circuit, rated at 404/493 MVA (summer/winter).

  A new grid exit point (Norwood) will be connected to the Islington–Livingstone 220 kV circuit. The circuit rating is constrained by a section of low capacity line between Rangitata and Islington. In the event of a Tekapo B–Islington circuit outage, the low capacity section of the Islington–Livingstone line will overload from 2030.

Figure 11 below illustrates Transpower's view of a possible 2037 configuration for the North Canterbury Region's transmission network. It includes:

- A new 220/66kV GXP substation near Dunsandel that is referred to as Norwood to be commissioned in 2023.
- A new 220/66kV interconnecting transformer bank at the Islington GXP.
- A new 220/66kV interconnecting transformer bank at the Bromley GXP.
- A 93 MW wind generation station at Mount Cass connecting to the Waipara 66 kV bus.
- A 66kV capacitor bank at the Hororata GXP to support network voltages.
- Replacement of the Kaiapoi 11kV switchboard.
- Replacement of the Islington 220/66kV transformer (T3 and T7).
- Replacement of the 66/11kV transformers at the Arthurs Pass and Castle Hill GXPs.
- Reconductoring of the double circuit 66kV line that is diverted to the Ashley GXP.
- Reconductoring of the Islington-Southbrook double circuit 66kV line.
- Refurbishment of the Islington SVC 3.
- Refurbishment of the Islington SVC 9.
- Upgrade of the Islington-Kimberley double circuit 66kV line.
- Upgrade of the Islington-Livingstone 220 kV circuit (between Rangitata and Islington).

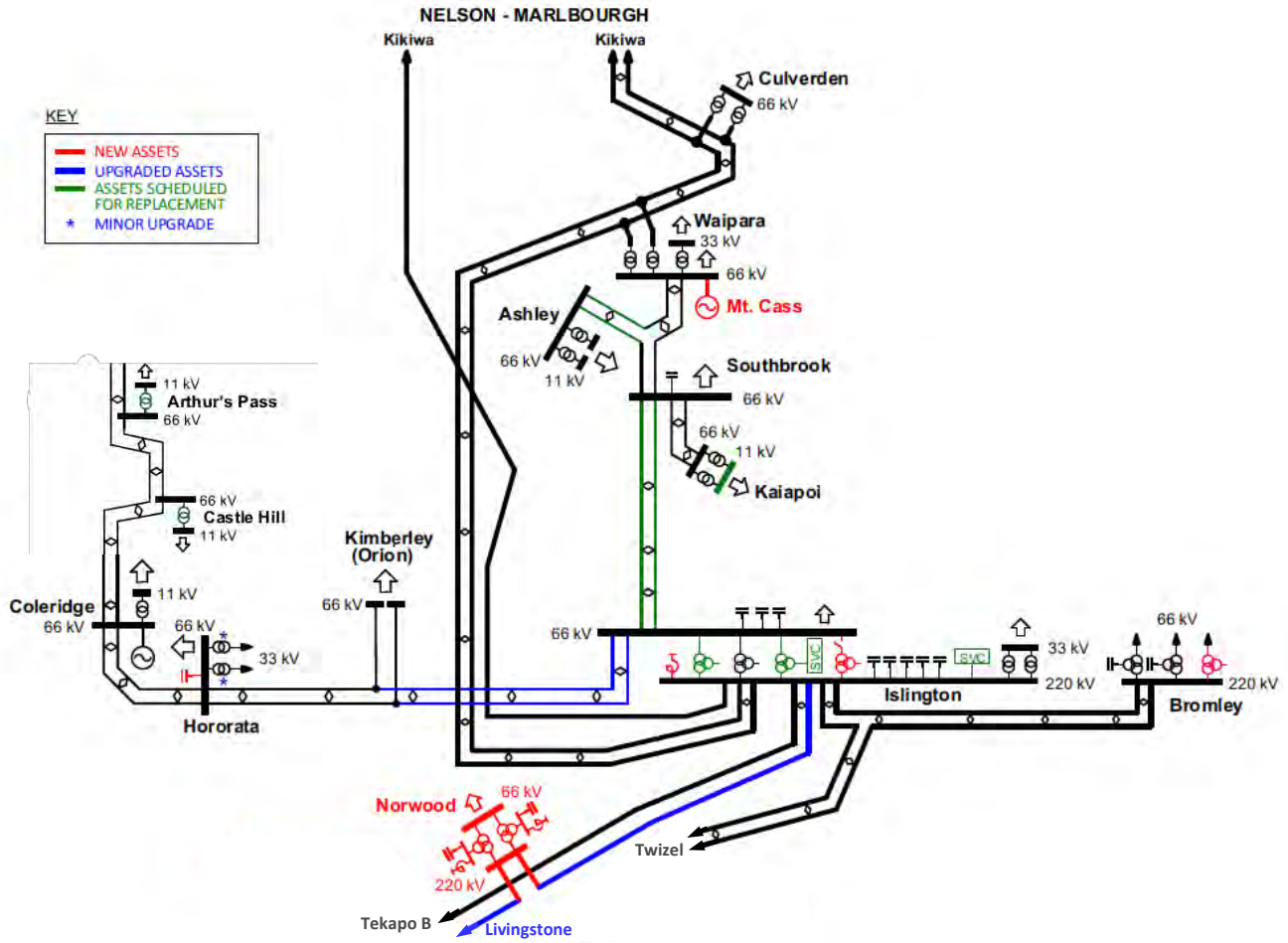


Figure 11 Existing transmission/GXP substations together with future proposed upgraded/new assets[14]

6.1 Demand Forecast

The following Table 3 illustrates Transpower's forecast demand at the transmission substations in the North Canterbury Region from its 2022 Annual Planning Report[14]. The forecast predicts the demand growing at an average of 2.3% per annum over the next fifteen years which is greater than the national average of 2.1%.

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	2037
1	Arthurs Pass	1.00	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.8
2	Ashley (Mainpower)	0.90	7	7	8	8	8	8	8	8	8	8	8	9
	Ashley (Daiken)	0.94	9	9	9	9	9	9	9	9	9	9	9	9
3	Bromley 66kV	0.99	159	165	167	169	214	220	261	263	266	269	219	251
4	Castle Hill	1.00	0.9	0.9	0.9	0.9	0.9	1	1	1	1.1	1.1	1.1	1.2
5	Coleridge	0.99	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.8	1	1.1	1.5
6	Culverden 33kV	0.96	20	20	21	21	21	22	22	22	23	23	23	25
	Culverden 66kV	1.00	7	7	7	8	8	8	8	8	9	9	9	10
7	Hororata 33kV	0.96	23	24	24	25	21	22	22	23	24	24	25	28
	Hororata 66kV	0.97	17	17	17	18	23	23	23	24	16	16	16	19
8	Islington 33kV	0.99	84	87	89	91	93	94	96	97	98	99	76	83
	Islington 66kV	1.00	453	464	477	485	435	443	368	378	387	398	489	525
9	Kaiapoi	1.00	31	29	30	31	31	32	33	33	34	35	35	39
10	Kimberley	0.97	17	17	17	17	18	18	18	18	19	19	19	21
11	Norwood	0.98		36	40	45	66	67	108	108	116	117	118	120
12	Southbrook 33kV	0.99	0	0	0	0	0	0	0	0	0	0	0	0
	Southbrook 66kV	0.98	56	60	62	64	66	69	71	73	76	78	81	92
13	Waipara 33kV	0.96	8	8	9	9	9	10	10	10	10	11	11	12
	Waipara 66kV	0.93	6	6	6	6	6	6	7	7	7	7	7	8
		TOTAL	899	958	985	1,008	1,030	1,053	1,066	1,083	1,104	1,125	1,148	1,255

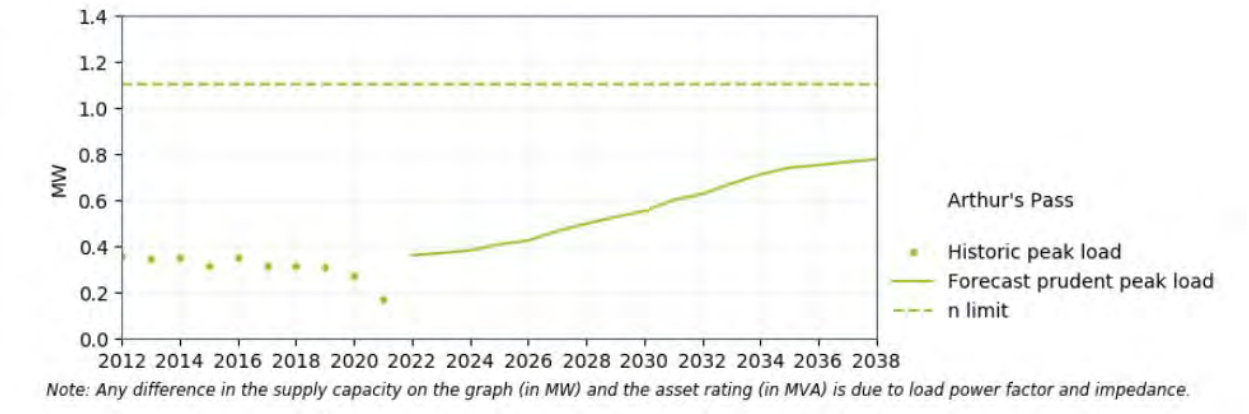
1. Bromley, Coleridge and Waipara have leading power factors.
2. The Norwood GXP substation is due to be commissioned prior by December 2023.
3. The forecast includes a number of planned load shifts as follows (due in part to the planned new Norwood GXP):
   - From Islington 66 kV to Bromley 66 kV: 39 MW in 2026 (Milton).
   - From Islington 66 kV to Bromley 66 kV: 34 MW in 2028 (Hoon Hay).
   - From Islington 66 kV to new Norwood GXP: 36 MW in 2023; 18 MW in 2026; 42 MW in 2028.
   - New Norwood GXP is expected to commission by December 2023, and this GXP peaks in summer season.
   - From Kaiapoi to Southbrook 66 kV: 4.1 MW in 2022.[19]
   - From Kaiapoi to Southbrook 66 kV: 1.9 MW in 2023.[19]
   - From 2022 all Southbrook load is taken at Southbrook 66 kV

6.1.1 Arthur's Pass GXP

Transpower's demand forecast (refer Table 3) indicates that the Arthur's Pass GXP was expected to have a 2022 peak demand of 0.4MW at unity power factor. This value contrasts with the historical SCADA data that indicates the Arthur's Pass GXP experienced a peak load of 0.3MVA during the 2022 year. The Arthur's Pass GXP is equipped with a single 66/11, 3MVA transformer that is constrained to 1.1MVA (due to a metering accuracy limit). There is a spare transformer on the site that would take 8 to 14 hours to put into service (in the event the existing transformer failed). The two 66kV circuits supplying the GXP are not afforded with circuit breakers (line circuit breakers at Coleridge and Otira) and thus a fault on any section of the Coleridge–Castle Hill–Arthur's Pass–Otira 66kV circuits results in a loss of supply to the Arthur's Pass load.

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

[19] Mainpower has advised Ergo that these load shifts to Southbrook GXP are not viable, due to the existing load and lack of feeder capacity at Southbrook substation, as well as the volt drops which occur when supplying the Kaiapoi area from Southbrook GXP.



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.

Orion takes supply from the GXP at 11kV and supplies the local Arthur's Pass township. The following Figure 11 illustrates Arthur's Pass 2022 loading in comparison to its substation capacity. The incoming 66kV lines are not included as they far exceed the substation's load.

There are no EECA Load Sites close to the substation.

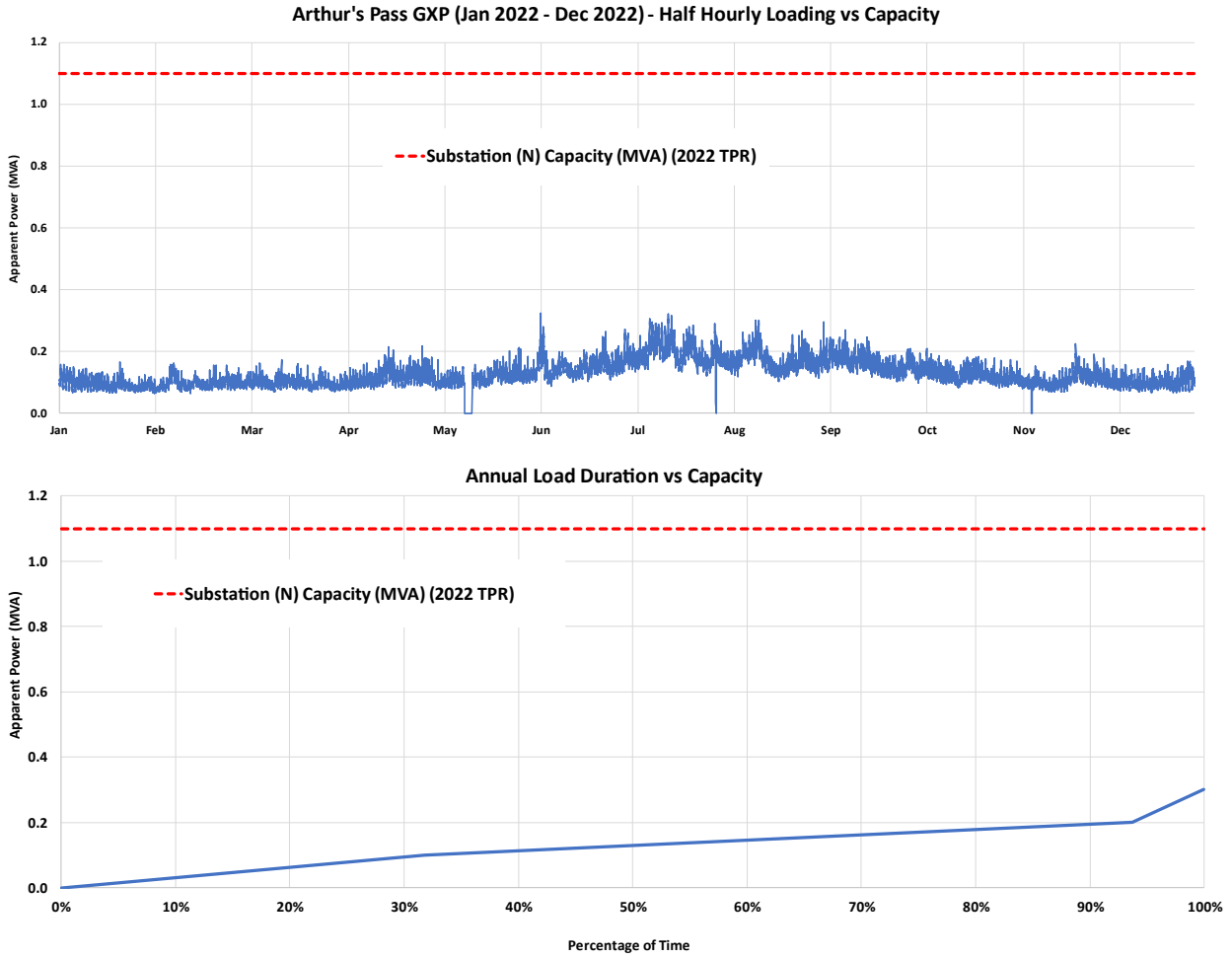


Figure 12 Arthur's Pass GXP: 2022 Loading: Substation capacity

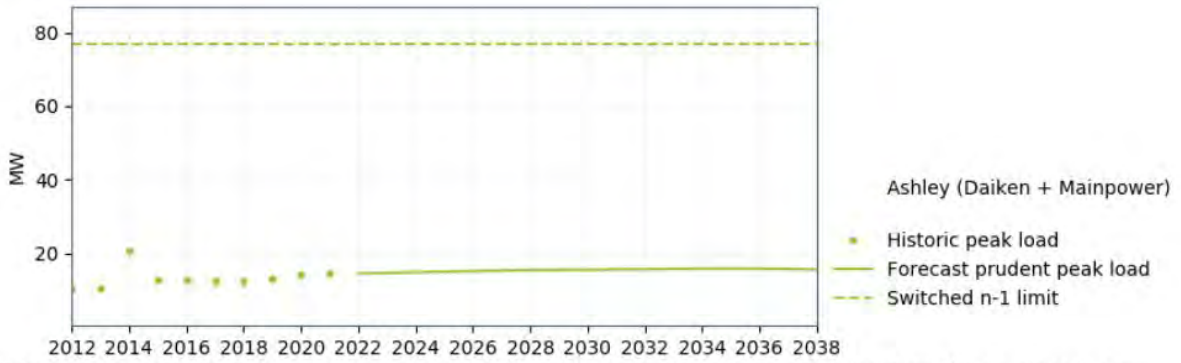
6.1.2 Ashley GXP

Transpower's demand forecast (refer Table 3) indicates that the Ashley GXP was expected to have a 2022 peak demand of approximately 16MW with a relatively low power factor. This aligns relatively well with the historical SCADA data that indicates that, in 2022 the Ashley GXP experienced a peak load of 16.5 MVA.

The Ashley GXP is equipped with two 66/11kV, 40MVA transformers (nominal capacity) which deliver a switched (N-1) capacity of 41 MW. Ergo notes that the two transformers have different neutral configurations and therefore cannot be operated in parallel.

The Ashley GXP supplies Mainpower's local 11kV distribution network, which includes the Daiken fibre-board mill. The Daiken plant is supplied via four 11kV feeders, has a peak load of 9MW and dominates the Ashley GXP's load. Ergo notes that the Daiken plant can only be supplied by one of the Ashley GXP transformers, and not the other, due to the differing neutral configurations.

The following graph compares Ashley GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR). There is a conflict between the transformer ratings and the following graph which Transpower has confirmed is an error (in the graphs).



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 13 illustrates Ashley's 2022 loading in comparison to its substation capacity.

There are no EECA Load Sites close to the substation.

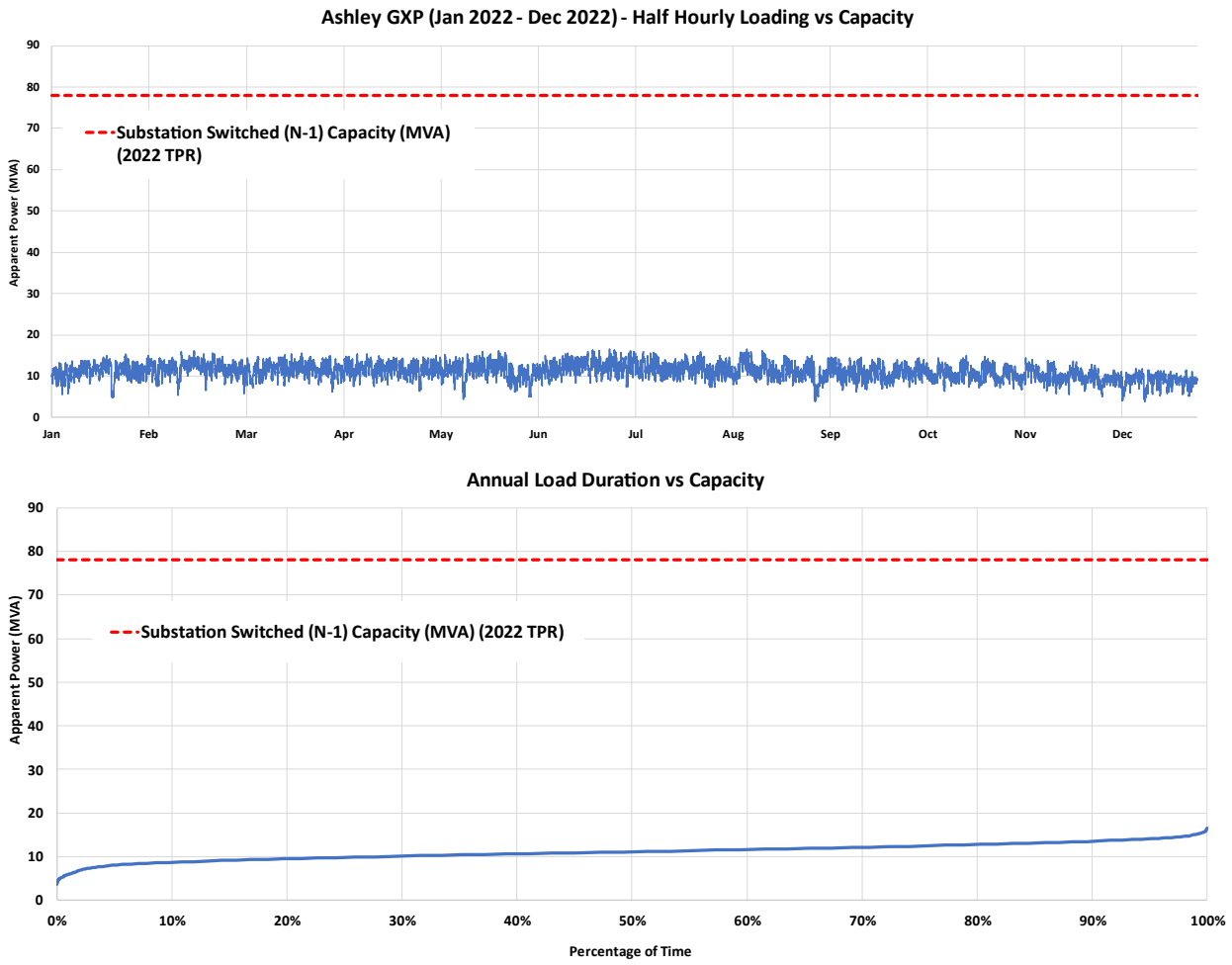


Figure 13 Ashley GXP: 2022 Loading: Substation capacity

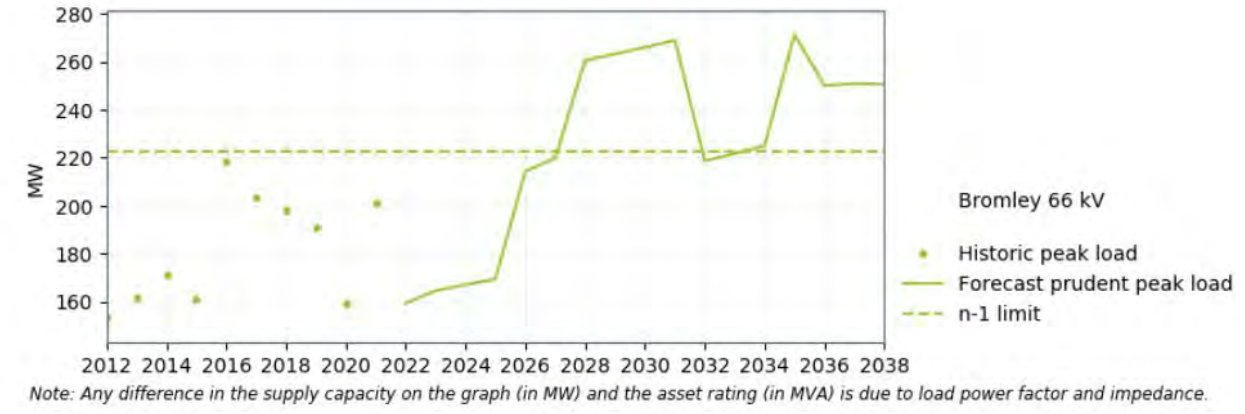
6.1.3 Bromley GXP

Transpower's demand forecast (refer Table 3) indicates that the Bromley GXP was expected to have a 2022 peak demand of 159MW at 0.99pf. This contrasts with the historical SCADA data that indicates that during 2022 the Bromley GXP experienced a peak load of 235MVA. Although, as discussed below, the historical data appears to include periods during which Bromley was used to back-feed substations that are normally supplied from an adjacent GXP (i.e. Islington).

The Bromley GXP is equipped with 2 x 180MVA, 220/66kV transformers (nominal capacity) that deliver (N-1) capacity of 215/220MVA (summer/winter).

The Bromley GXP supplies Orion's 66kV network that, in turn, supplies zone substations in the eastern suburbs of Christchurch.

The following graph compares Bromley 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 Bromley GXP's 2022 loading in comparison to its substation capacity. The loading graph in Figure 14 does include a number of unusually high periods of electrical demand that are likely due to the temporary supply of additional load (as shown in Section 6.1.9 the load on Islington GXP drops in October, coinciding with the additional load on the figure below). Ignoring these unusual periods the peak loading on the Bromley GXP appears to be around 160MW.

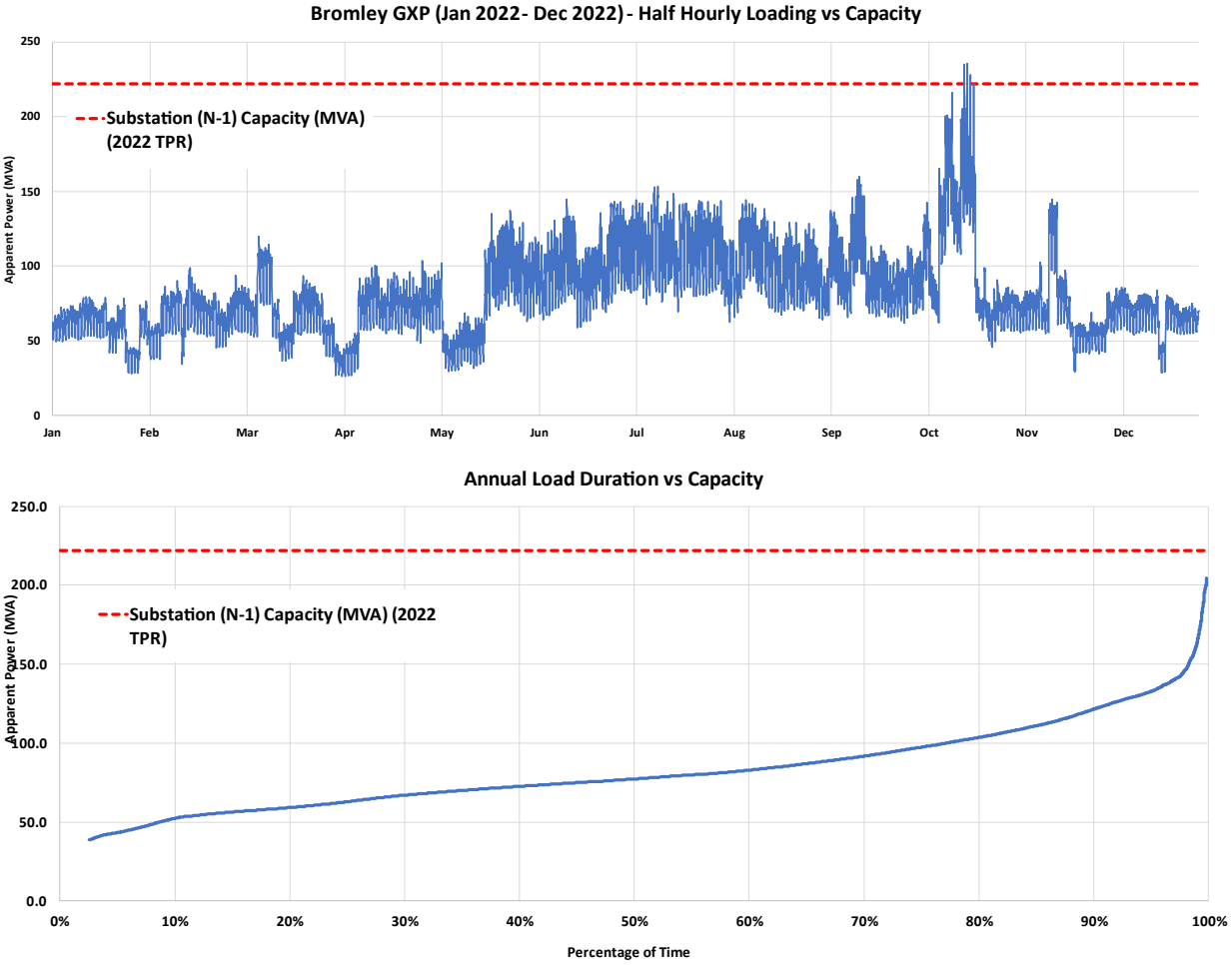


Figure 14 Bromley GXP: 2022 Loading: Substation capacity

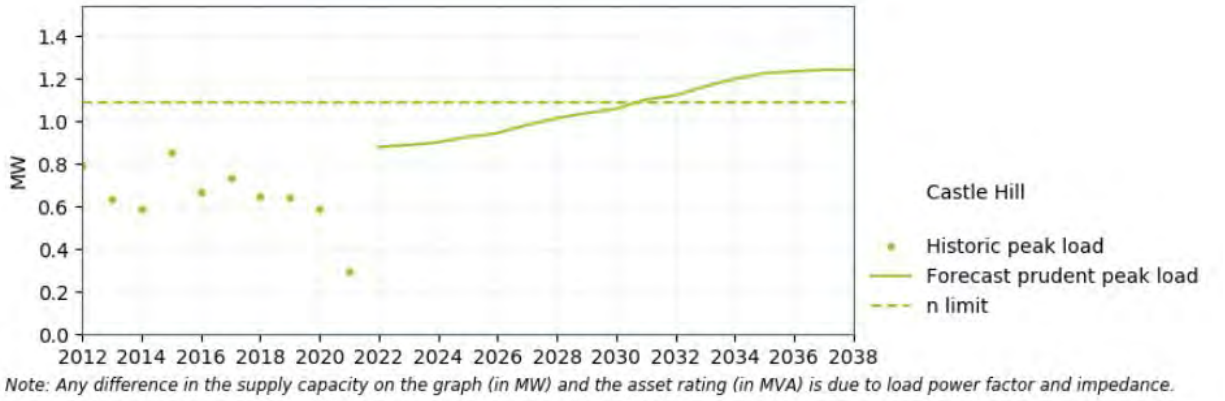
6.1.4 Castle Hill GXP

Transpower's demand forecast (refer Table 3) indicates that the Castle Hill GXP was expected to have a 2022 peak demand of 0.9MW at unity power factor. This contrasts with the historical SCADA data that indicates that, during 2022, the Castle Hill GXP experienced a peak load of 0.9MVA.

The Castle Hill GXP is equipped with a single 3.75MVA, 66/11kV transformer that is constrained to 1.1MVA (due to a metering accuracy limit). There is a spare transformer on the site that would take 8 to 14 hours to put into service (in the event the existing transformer failed). The two 66kV circuits supplying the GXP are not afforded with circuit breakers (line circuit breakers at Coleridge and Otira) and thus a fault on any section of the Coleridge–Castle Hill–Arthur's Pass–Otira 66kV circuits results in a loss of supply to the Castle Hill load.

Orion takes supply at 11kV from the GXP and distributes electricity to the local Castle Hill township and surrounds.

The following graph compares Castle Hill 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 Castle Hill GXP's 2022 loading in comparison to its substation capacity. The incoming 66kV line capacities are not included as they well exceed the substation capacity.

There are no EECA Load Sites close to the substation.

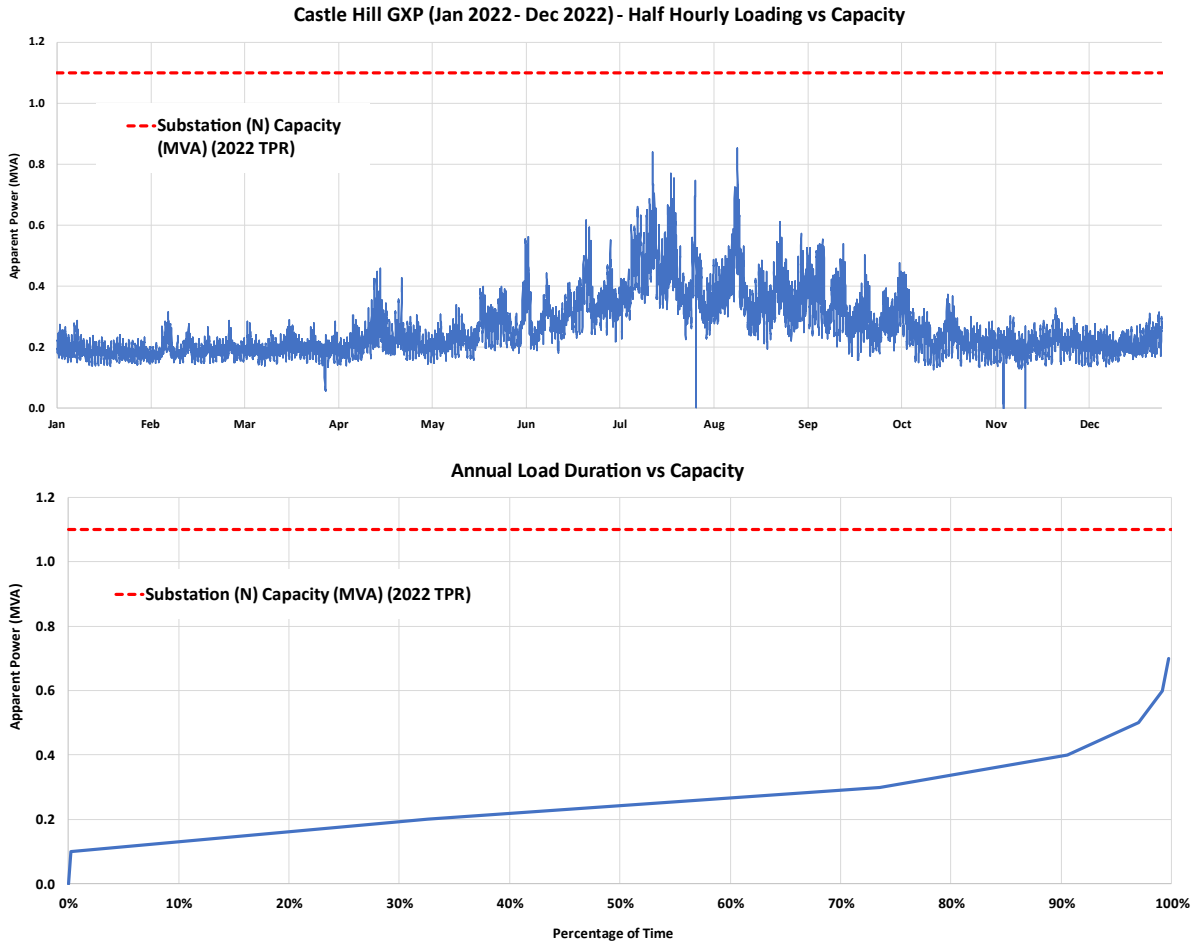


Figure 15 Castle Hill GXP: 2022 Loading: Substation capacity

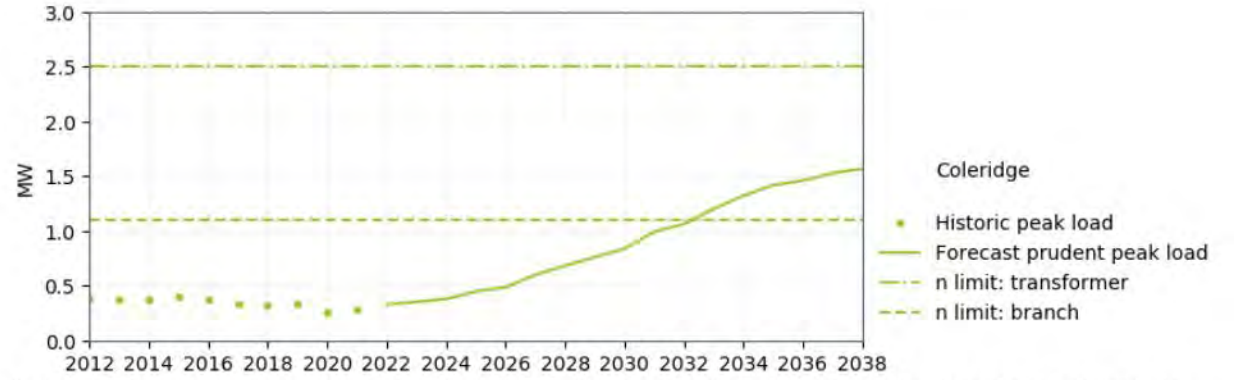
6.1.5 Coleridge GXP

Transpower's demand forecast (refer Table 3) indicates that the Coleridge GXP was expected to have a 2022 peak demand of 0.3MW at 0.99pf. This value closely resembles the historical SCADA data that indicates that during 2022 the Coleridge GXP experienced a peak load of 0.31MVA.

The Coleridge GXP is equipped with a single 2.5MVA, 66/11kV transformer that is constrained to 1.1MVA (due to a metering accuracy limit).

Orion takes supply at 11kV from the GXP and distributes electricity to the local Coleridge region.

The following graph compares Coleridge 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 the Coleridge GXP's 2022 loading in comparison to its substation and branch capacity.

There are no EECA Load Sites close to the substation.

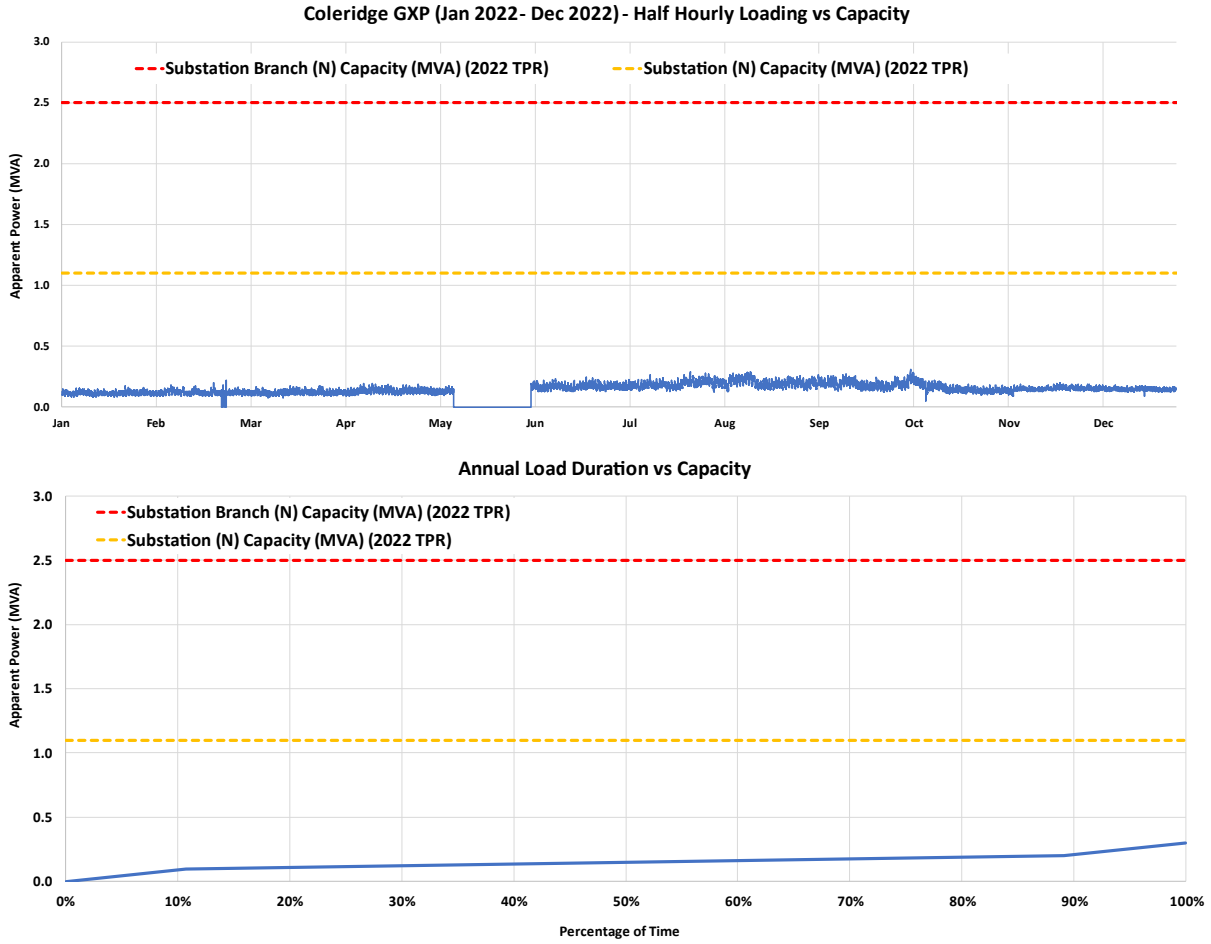


Figure 16 Coleridge GXP: 2022 Loading: Substation capacity

6.1.6 Culverden GXP (33kV and 66kV)

The Culverden 33kV GXP is equipped with two 220/33kV, 30MVA transformers (nominal capacity) that provide (N-1) capacity of 30/32MVA (summer/winter). The transformers also supply a single 20MVA, 33/66kV step-up transformer that supplies the Culverden 66kV GXP (one of Mainpower's 66kV feeders).

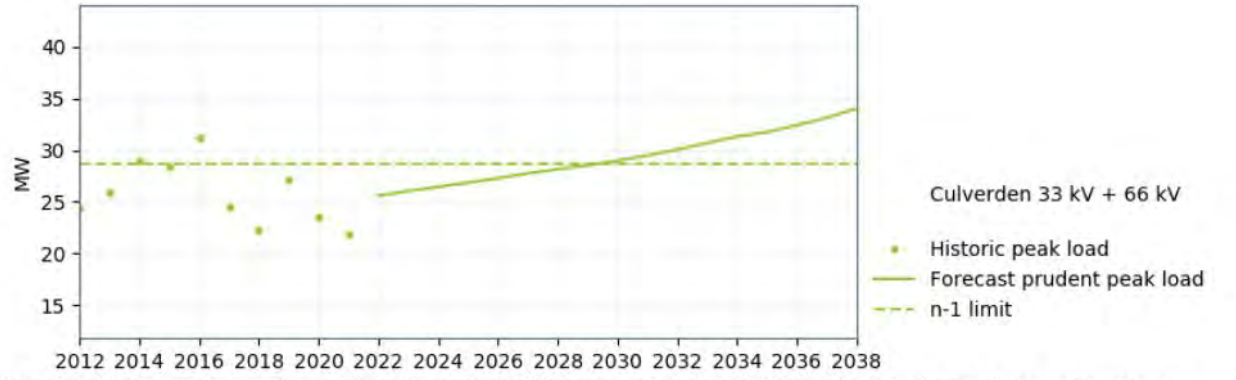
Transpower's demand forecast (refer Table 3) indicates that:

- The Culverden 33kV GXP was expected to have a 2022 peak demand of 20MW at 0.96pf, which aligns relatively well with the historical SCADA data that indicates that, during 2022, it experienced a peak load of 18.4MVA.
- The Culverden 66kV GXP was expected to have a 2022 peak demand of 7MW at unity power factor, which aligns relatively well with the historical SCADA data that indicates that, during 2022, it experienced a peak load of 9.0MVA.

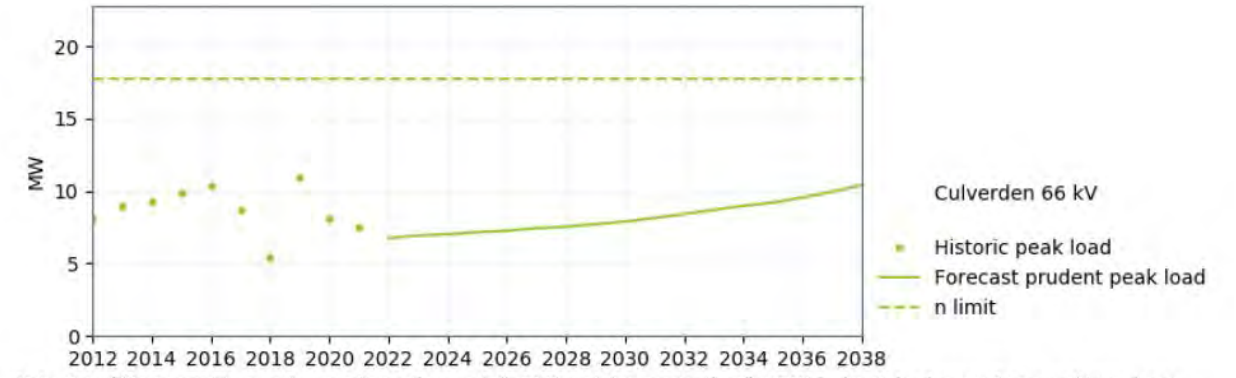
The Culverden GXP supplies Mainpower's distribution network which, in turn, supplies electricity to consumers in the Culverden, Hanmer and Kaikōura areas. Consumers supplied include irrigation schemes, dairy farms (primarily in the Culverden Basin), motels and holiday homes (i.e. Hanmer Springs).

Mainpower is currently investigating relocation of the Mouse Point zone substation site. This upgrade project is to rebuild the zone substation either on or near the existing GXP site.

The following graphs compare Culverden 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.



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 and Figure 18 illustrates the historical 2022 loading on the Culverden 33kV and 66kV GXPs in comparison to their substation capacity. The incoming 220kV line ratings are significantly higher and thus not included on the graphs. The loading graph clearly shows the effects of the summer irrigation and dairy loading on the GXPs.

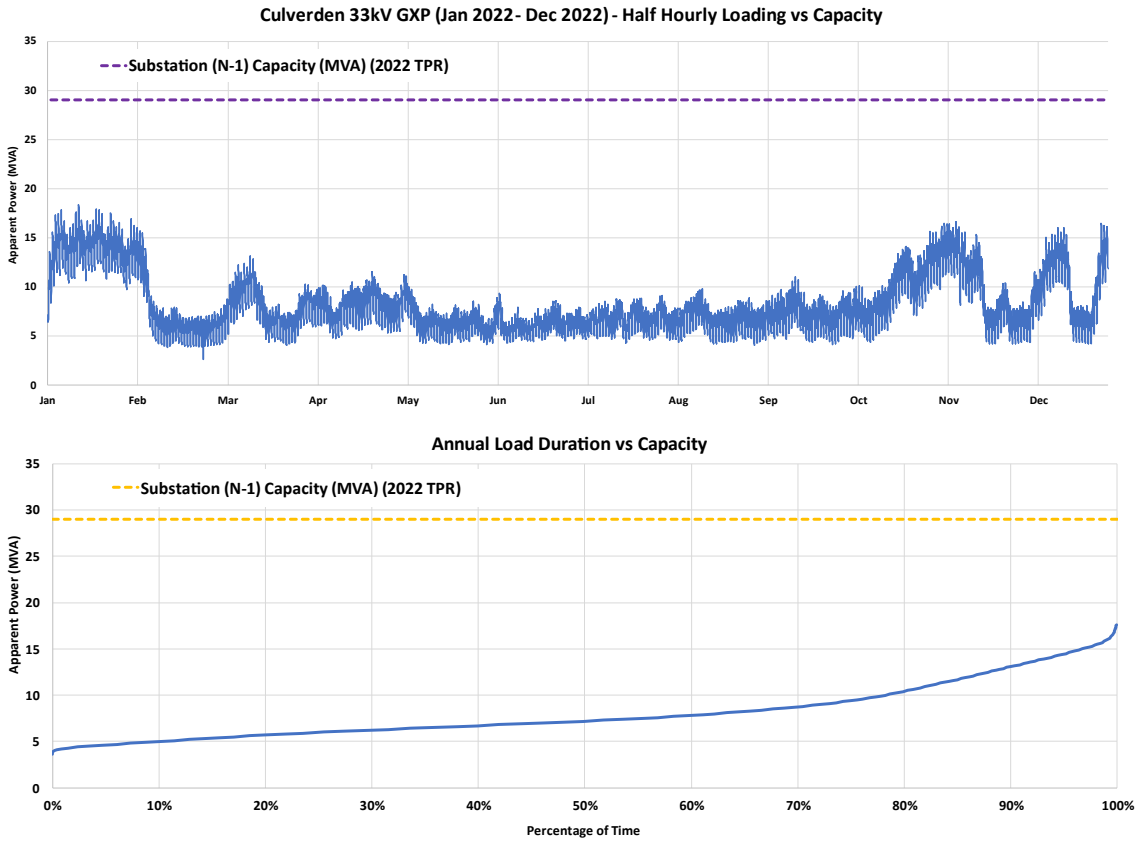


Figure 17 Culverden 33kV GXP: 2022 Loading: Substation capacity

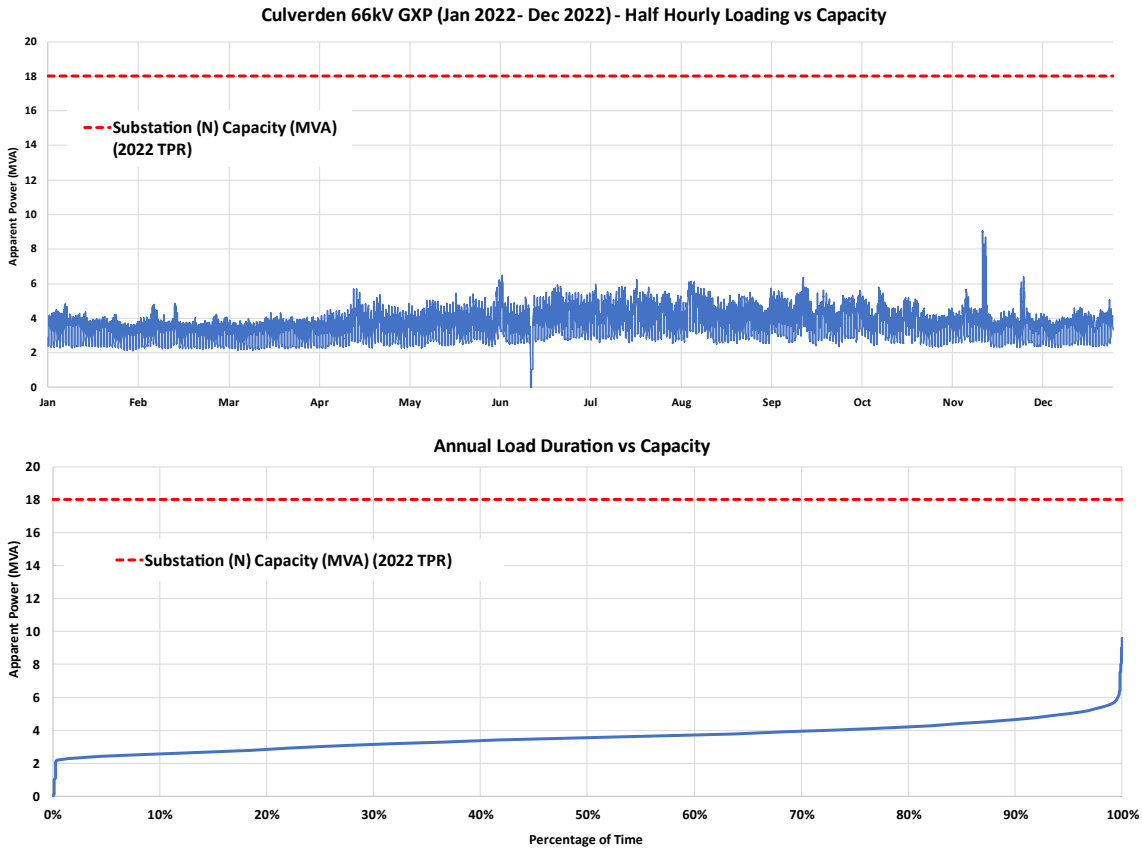


Figure 18 Culverden 66kV GXP: 2022 Loading: Substation capacity

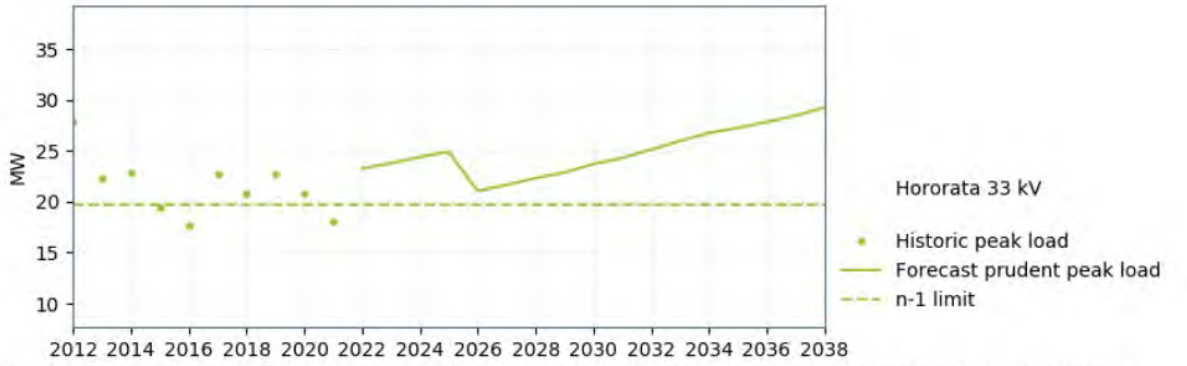
6.1.7 Hororata GXP (33kV and 66kV)

Transpower's demand forecast (refer Table 3) indicates that the Hororata 33kV GXP was expected to have a 2022 peak demand of 23MW at 0.96pf. This value aligns relatively well the historical SCADA data that indicates that during 2022 the Hororata 33kV GXP experienced a peak load of 20.2MVA. Transpower's demand forecast (refer Table 3) indicates that the Hororata 66kV GXP was expected to have a 2022 peak demand of 17MW at 0.97pf. This value contrasts with the historical SCADA data that indicates that during 2022 the Hororata 66kV GXP experienced a peak load of 36.3MVA.

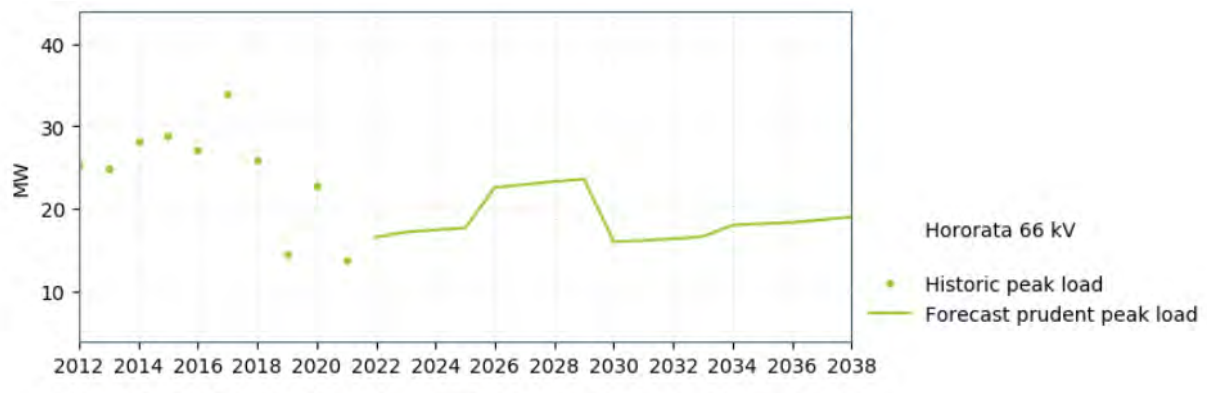
The Hororata GXP is equipped with two 66/33kV, 17MVA transformers (nominal capacity) that provide (N-1) capacity of 23/23MVA (summer/winter). Orion takes supply from the GXP at the 33 kV level, and at the 66 kV level. The Orion connection at 66 kV is a direct connection to the South Island grid, while the 33 kV connection is supplied via the 66/33 kV transformers at the GXP.

The GXP supplies Orion's 33kV and 66kV network, which in turn supply Orion's zone substations to the west of Christchurch City. Based on Transpower's forecast the existing peak load on the Hororata 33 kV bus already exceeds the (N-1) capacity of the supply transformers in summer primarily due to the high levels of irrigation load, in particular due to the loading from the Central Plains Water irrigation scheme. The GXP is also susceptible to large voltage excursions which cause sensitive customer loads to disconnect if a tripping occurs on either of the Islington to Kimberley to Hororata GXP lines. Any reductions of load will benefit the overall post-contingency voltage stability. Also, the GXP does not have a 66kV bus coupler and is thus exposed to single bus faults causing complete outages to the 66kV and 33kV Orion load and the connection through to the Coleridge GXP.

The following graphs compare Hororata 33kV and 66kV GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR). There is no supply capacity/limit shown on the Hororata 66 kV GXP graphs as the direct connection means that there are no transformers limiting the capacity (capacity of the 66 kV GXP is limited by transmission lines, which are not reported by Transpower in this case).



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 19 illustrates the Horarata GXP's 2022 loading in comparison to its substation capacity.

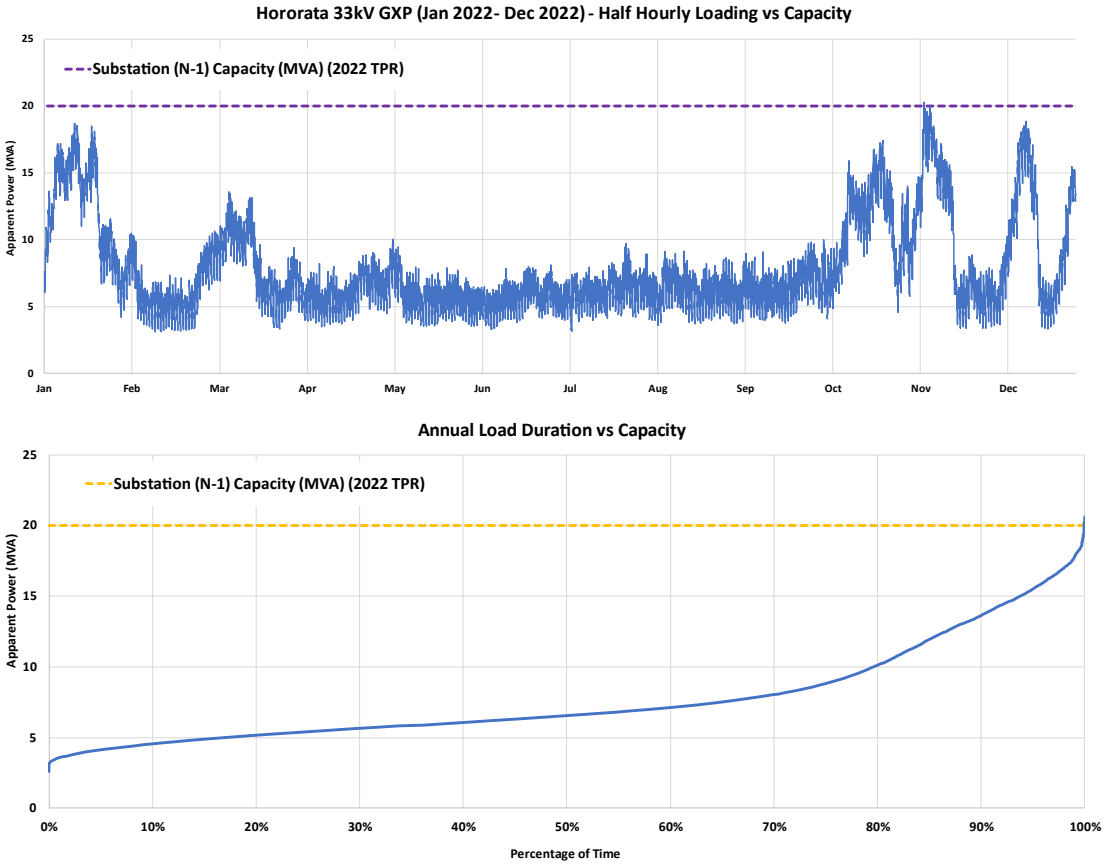


Figure 19 Horarata 33kV GXP: 2022 Loading: Substation capacity

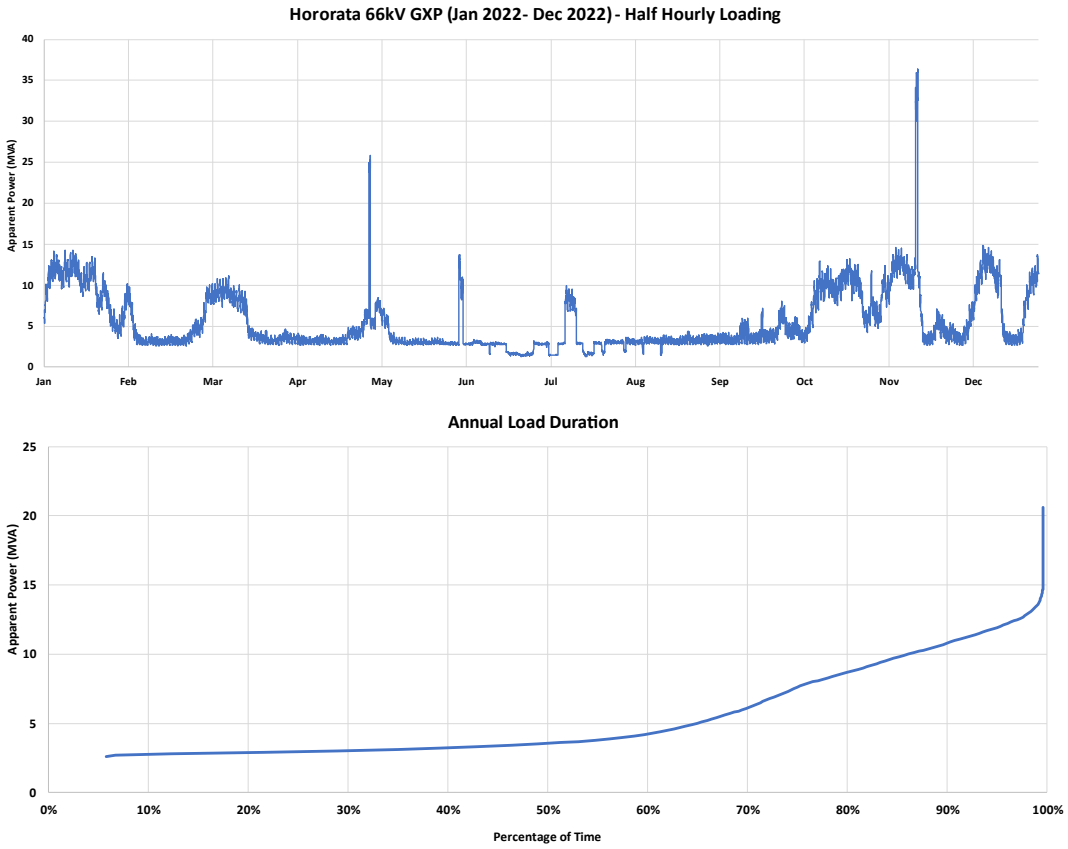


Figure 20 Hororata 66kV GXP: 2022 Loading

6.1.8 Islington 33kV GXP

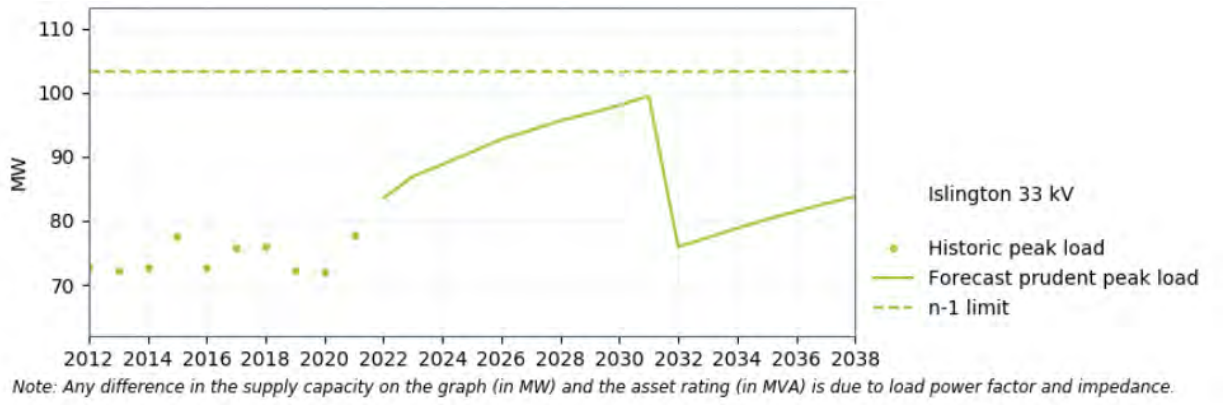
Transpower's demand forecast (refer Table 3) indicates that the Islington 33kV GXP was expected to have a 2022 peak demand of 84MW at 0.99pf. This value aligns relatively well the historical SCADA data that indicates that during 2022 the Islington 33 kV GXP experienced a peak load of 76.6MVA.

The Islington 33kV GXP is equipped with two 220/33kV, 100MVA transformers (nominal capacity) that provide (N-1) capacity of 107/107MVA (summer/winter).

The GXP supplies Orion's 33kV network, which in turn supplies Orion's 33/11kV zone substations that are located in the western suburbs/fringes of the Christchurch City.

Based on Transpower's forecast the peak load on the Islington 33 kV bus is not projected to exceed the (N-1) capacity of the supply transformers in the next 15 years.

The following graph compares Islington 33 kV 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 19 illustrates the Islington 33kV GXP's 2022 loading in comparison to its substation capacity. The incoming 220kV line ratings are significantly higher and thus not included on the graphs.

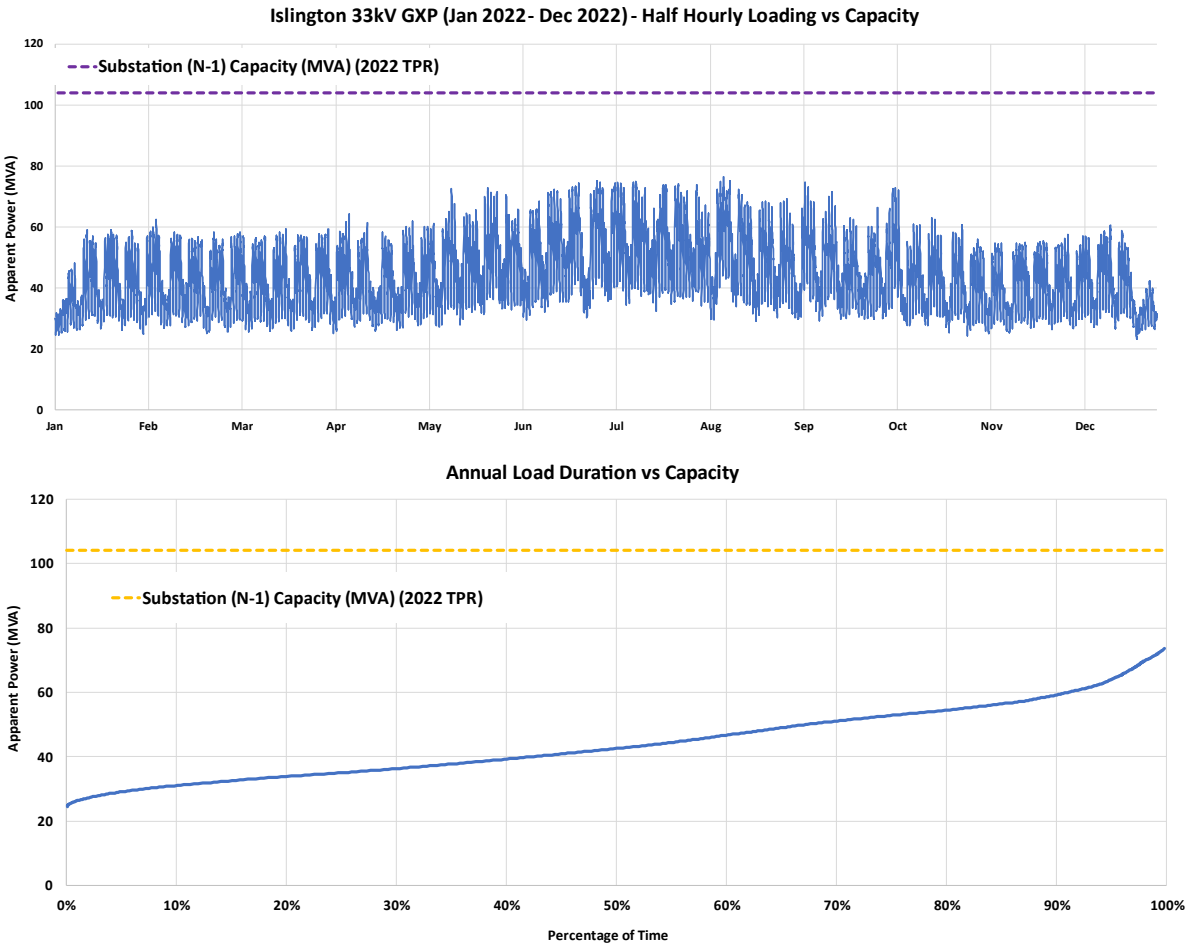


Figure 21 Islington 33kV GXP: 2022 Loading: Substation capacity

6.1.9 Islington 66kV GXP

Transpower's demand forecast (refer Table 3) indicates that the Islington 66kV GXP was expected to have a 2022 peak demand of 453MW at 1.00pf. This value aligns relatively well the historical SCADA data that indicates that during 2022 the Islington 66kV GXP experienced a peak load of 441MVA.

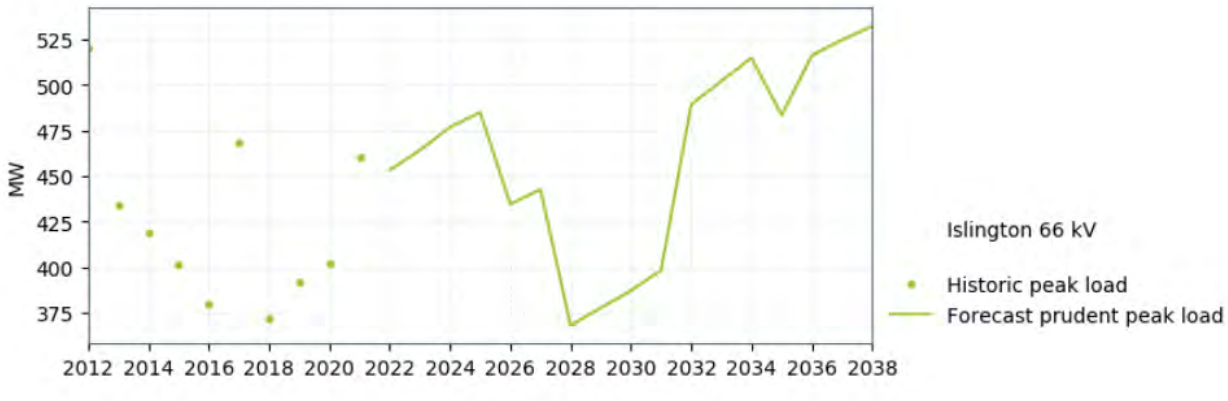
The Islington 66kV GXP is equipped with two 220/66/11kV, 200/200/60MVA interconnecting transformers and a 220/66/11kV, 257/250/60MVA interconnecting transformer (nominal capacity). They collectively provide the 66kV GXP supply with:

- A nominal installed capacity of 657 MVA.
- An (N-1) capacity of 504/532 MVA (summer/winter).

Ergo notes that the Islington 220/66/11 kV transformers, while supplying the local Islington load, also supply Southbrook, Hororata, and Kimberly GXPs via 66 kV circuits. As such, the available capacity at Islington 66 kV GXP cannot exclusively be assigned to the load local to Islington GXP itself.

The "*wider region issues*" paragraphs at the front of Section 6 discuss the security of the 66kV supply delivered from the Islington GXP (and the Bromley GXP).

The following graph shows Islington 66 kV GXP's historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR). There is no supply capacity/limit shown on the graphs as the direct connection means that there are no transformers limiting the capacity (capacity of the 66 kV GXP is limited by transmission lines, which are not reported on by Transpower in this case).



The following Figure 22 illustrates the Islington 66kV GXP's 2022 loading (metered supply to Orion's network). This loading cannot be directly compared to the (N-1) interconnecting transformer capacity stated above as it does not include the loading on the 66 kV lines which leave the GXP. The loading on the 220/66 kV interconnecting transformers would need to be determined via a load flow study. The ratings of the incoming lines are not shown in Figure 22 due to the complexity of the 220kV supply network and high line ratings.

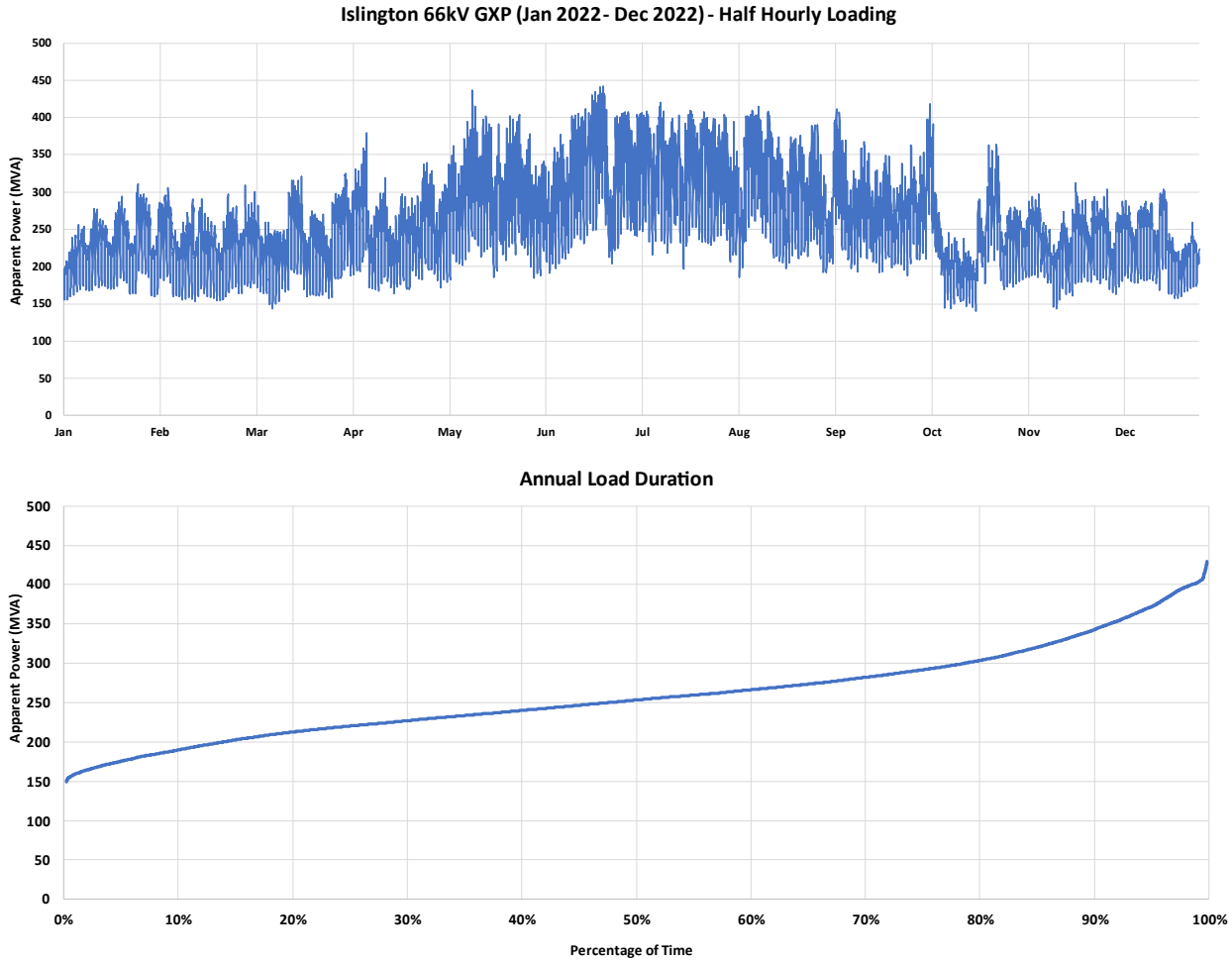


Figure 22 Islington 66kV GXP: 2022 Loading

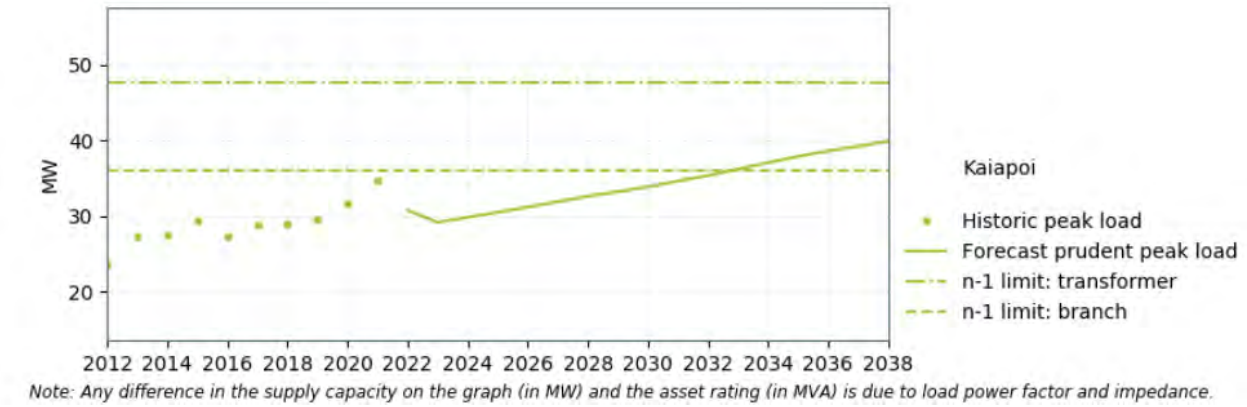
6.1.10 Kaiapoi GXP

Transpower's demand forecast (refer Table 3) indicates that the Kaiapoi GXP was expected to have a 2022 peak demand of 31MW at unity power factor. This value aligns relatively well the historical SCADA data that indicates that during 2022 the Kaiapoi GXP experienced a peak load of 30.2MVA.

The Kaiapoi GXP is equipped with two 66/11kV, 40MVA transformers (nominal capacity) that provide (N-1) capacity of 38/38MVA (summer/winter). The GXP capacity is presently limited by the existing 11 kV switchboard, which limits the transformers to 36 MW ("branch limit"). Transpower plans to commission a new 11 kV switchboard for the site in 2023-2024, which will allow the transformers to operate at full capacity.

The GXP supplies Mainpower's 11kV network that supplies consumers in the Kaiapoi region, including the Hellers Kaiapoi meat-processing plant and Sutton Tools. Based on Transpower's forecast the peak load on the Kaiapoi GXP will exceed the capacity of the supply transformers from 2033.

The following graph compares Kaiapoi 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 23 illustrates the Kaiapoi GXP's 2022 loading in comparison to its substation capacity.

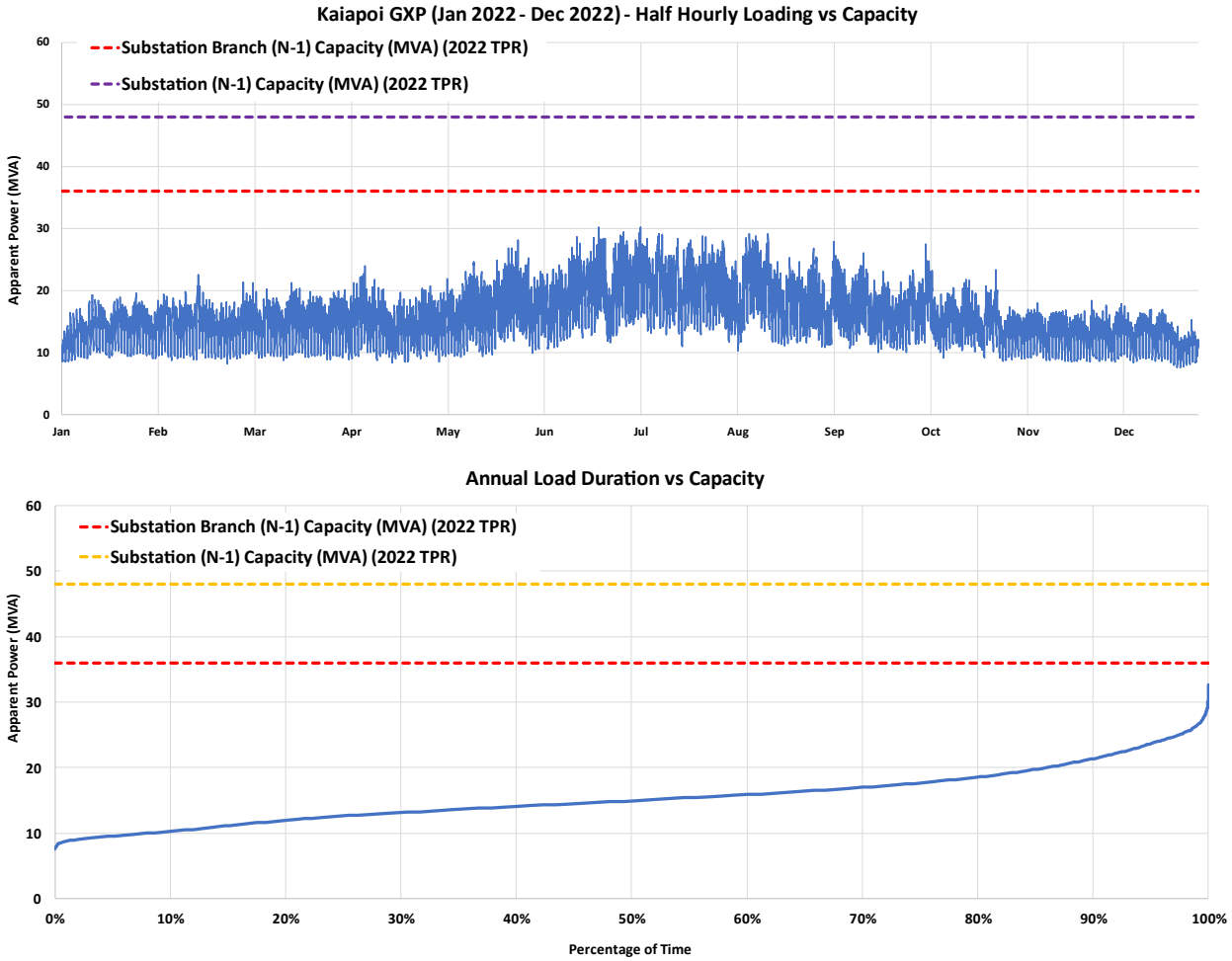


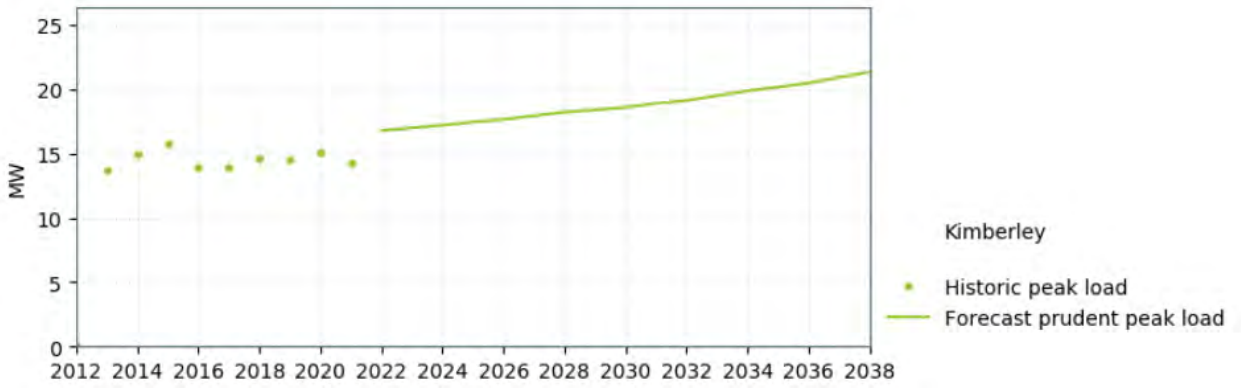
Figure 23 Kaiapoi GXP: 2022 Loading: Transformer and branch capacity

6.1.11 Kimberley GXP

Transpower's demand forecast (refer Table 3) indicates that the Kimberley GXP was expected to have a 2022 peak demand of 17MW at 0.97pf. This value contrasts with the historical SCADA data that indicates that during 2022 the Kimberley GXP experienced a peak load of 15.5MVA.

Orion takes supply at 66kV from Transpower at the Kimberley GXP and owns the 66/11kV transformers and the 11kV switchgear. The substation is equipped with two 66/11kV, 23MVA transformers (nominal capacity) that provide (N-1) capacity of 23MVA. The majority of the substation's load is due to Fonterra's Darfield dairy plant but includes supply to the Darfield township and rural consumers.

The following graph shows Transpower's demand forecast for the Kimberley GXP (sourced from Transpower's 2022 TPR).



The following Figure 24 illustrates the Kimberley GXP's 2022 loading. The dominance of the dairy factory's loading is clearly evident which results from the seasonal reduction in milk processing that occurs during the June/July winter period. The "*wider region issues*" paragraphs at the front of Section 6 discuss the constraints on the 66kV network that supplies the Kimberley and Hororata GXPs. Orion's Asset Management Plan indicates that the firm capacity available to the combined load on the Kimberley and Hororata GXPs is generally 70MW but would be limited to 40MW in the event that the Coleridge hydro station is not generating or providing reactive power.

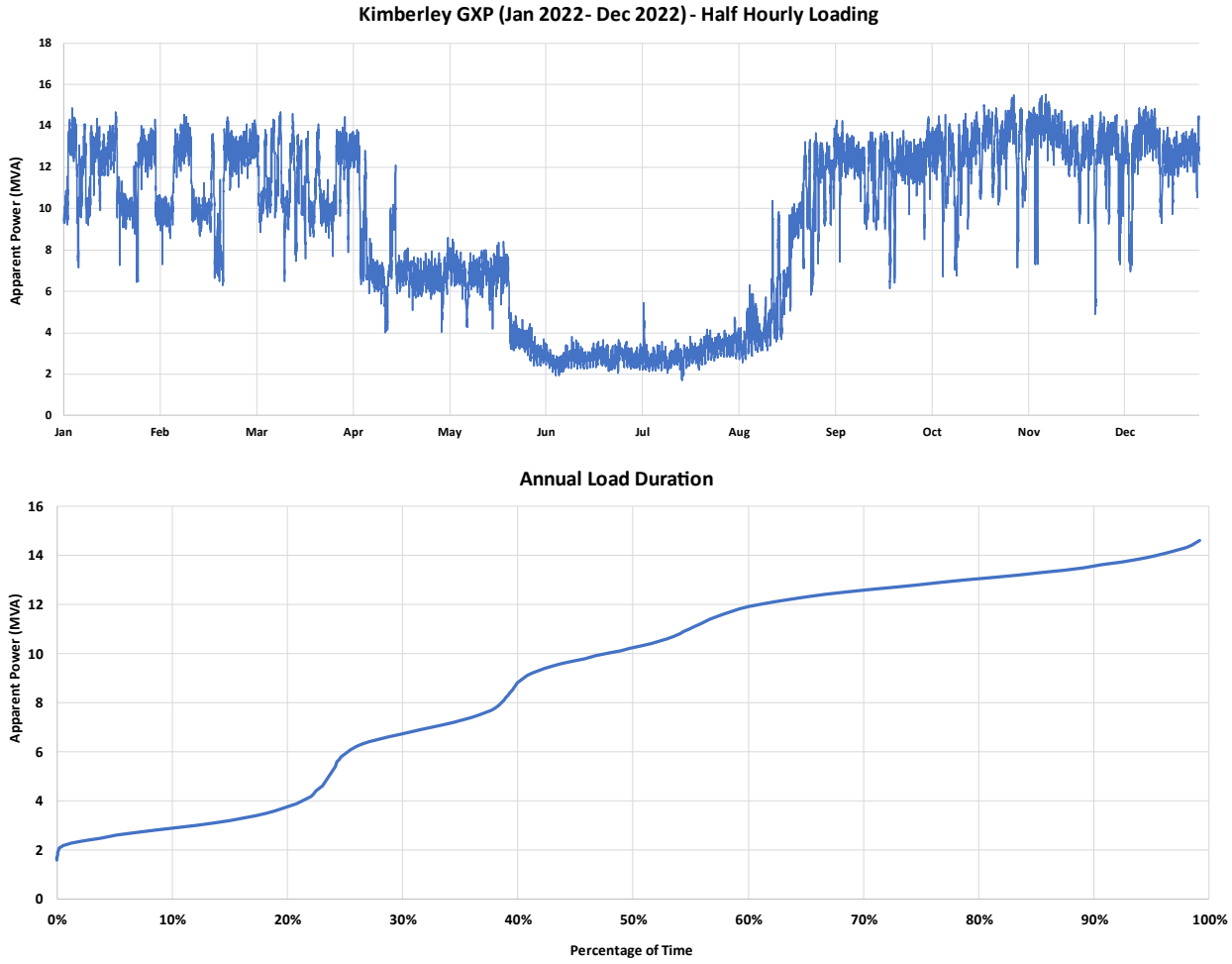


Figure 24 Kimberley GXP: 2022 Loading

6.1.12 Southbrook GXP

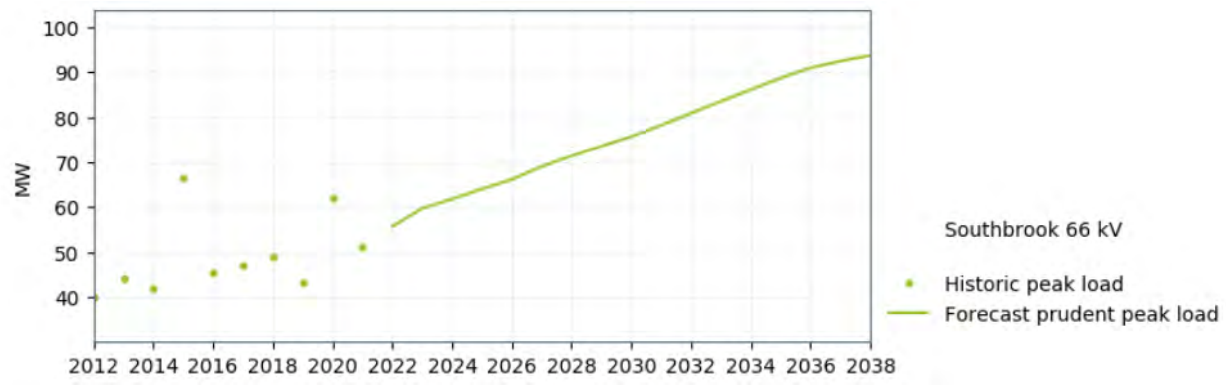
Transpower's demand forecast (refer Table 3) indicates that the Southbrook GXP was expected to have a 2022 peak demand of 56MW at 0.98pf. This value aligns relatively well the historical SCADA data that indicates that during 2022 the Southbrook GXP experienced a peak load of 49.7MVA.

Mainpower takes supply from the Southbrook GXP at 66kV, having completed a four-year project that involved rebuilding its Southbrook Zone Substation as a 66/11 kV zone substation and decommissioning the existing Southbrook and Rangiora North 33/11kV zone substations.[20]

The region supplied by the Southbrook GXP is characterised by flat, open plains used for a range of farming activities, combined with an increasing number of small to medium-sized lifestyle blocks. The electricity demand tends to peak during summer but can also occur during extreme winter events. Major loads supplied include McAlpines sawmill and Mitre 10 Megastore in Rangiora.

The following graph shows Transpower's demand forecast for Southbrook GXP (sourced from Transpower's 2022 TPR). There is no supply capacity/limit shown on the graphs as the direct connection means that there are no transformers limiting the capacity (capacity of the 66 kV GXP is limited by transmission lines, which are not reported on by Transpower in this case).

[20] Up-to-date the Southbrook GXP has been equipped with 2 x 30/40MVA, 66/33kV transformers. They will become redundant once the project is completed. Hence, Transpower's forecast in Table 3 has zero load on Southbrook 33kV GXP.



The following Figure 25 illustrates the Southbrook GXP's 2022 loading (combination of historical 33kV and 66kV loading).

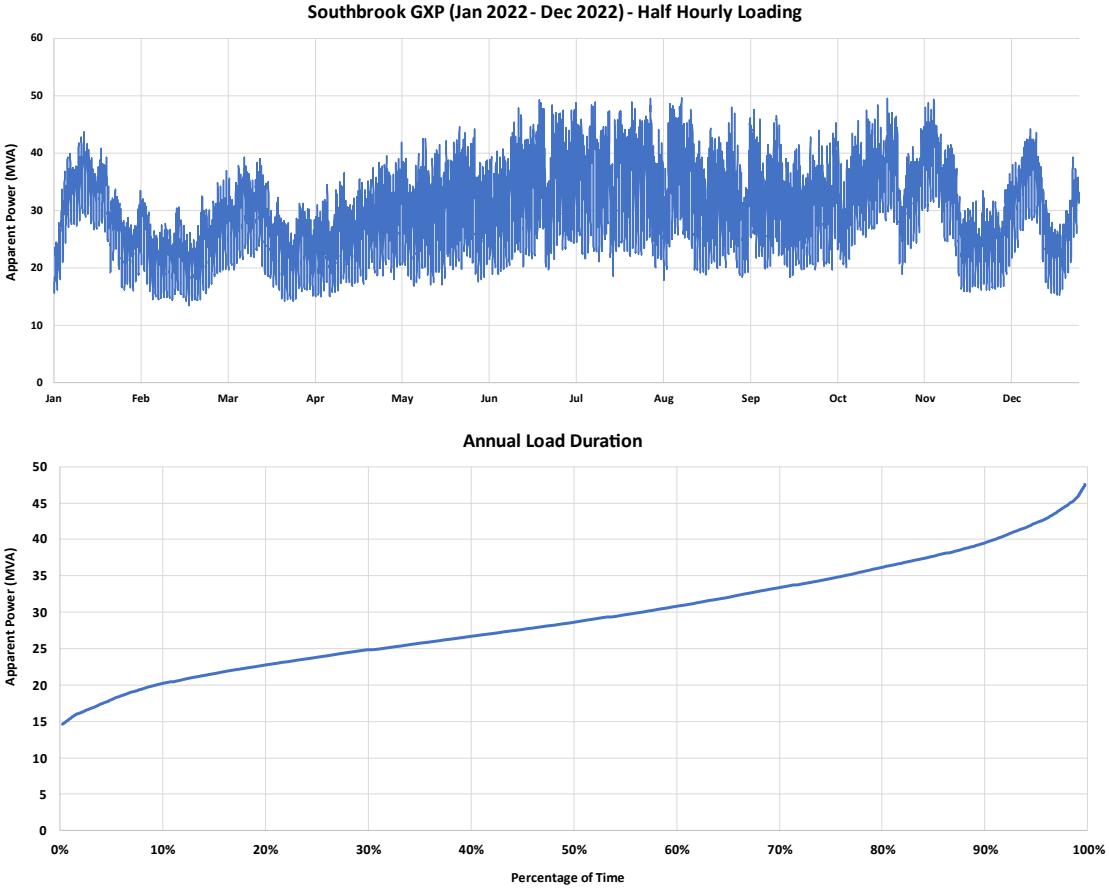


Figure 25 Southbrook GXP: 2022 Loading

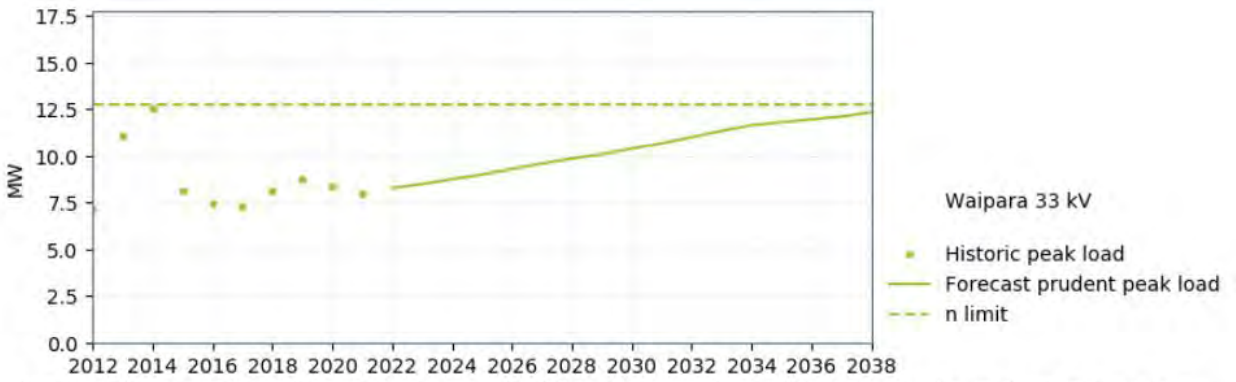
6.1.13 Waipara 33kV GXP

Transpower's demand forecast (refer Table 3) indicates that the Waipara 33kV GXP was expected to have a 2022 peak demand of 8MW at 0.96pf. This value aligns relatively well the historical SCADA data that indicates that during 2022 the Waipara 33kV GXP experienced a peak load of 8.3MVA.

The Waipara 33kV GXP is equipped with a single 66/33kV, 16MVA transformer (nominal capacity) that provides (N) capacity.

The GXP supplies Mainpower's 33kV network which, in turn, supplies its 33/11kV zone substations that supply the townships of Amberley and Hawarden, as well as the surrounding rural areas.

The following graph compares Waipara 33 kV 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 26 illustrates the Waipara 33kV GXP's 2022 loading in comparison to its substation capacity. The ratings of the incoming lines are not shown in Figure 22 due to the small size of the substation in comparison the 66kV network that supplies it.

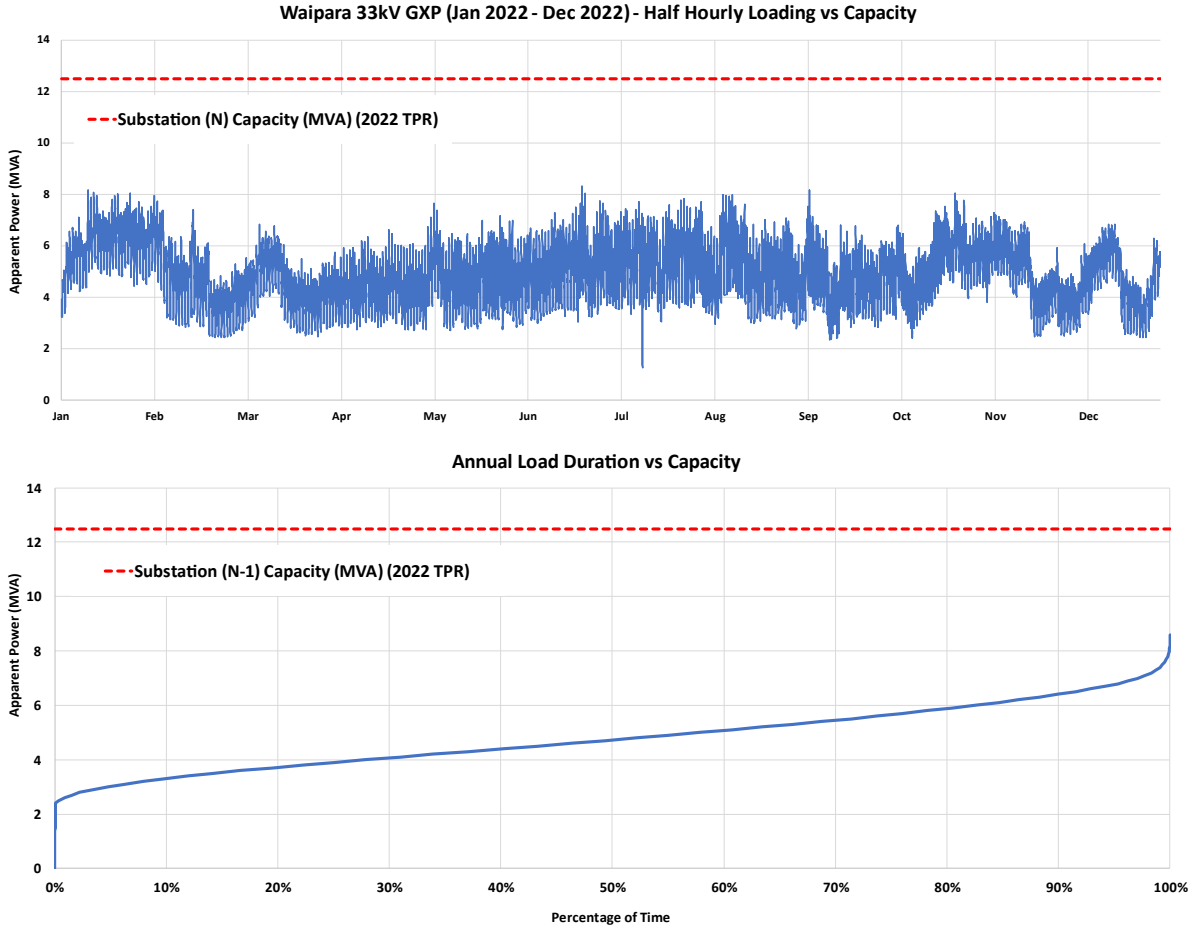


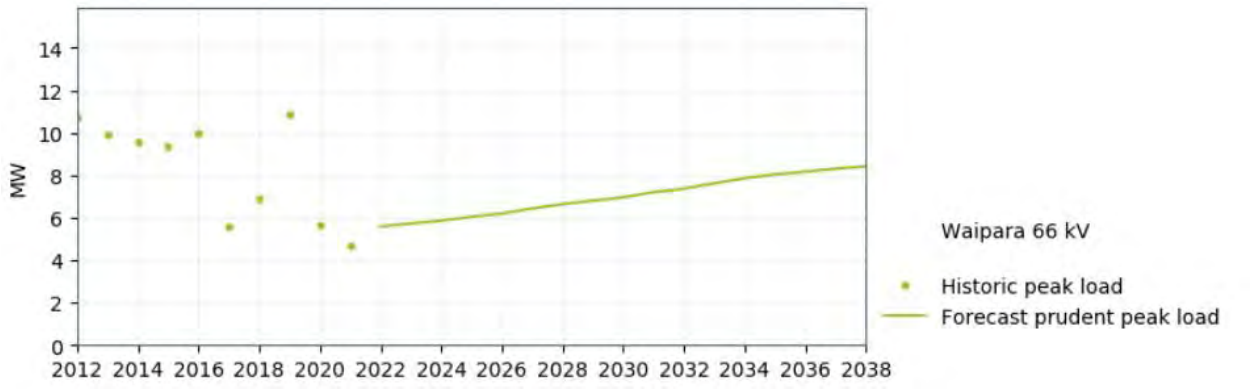
Figure 26 Waipara 33kV GXP: 2022 Loading: Substation capacity

6.1.14 Waipara 66kV GXP

Transpower's demand forecast (refer Table 3) indicates that the Waipara GXP was expected to have a 2022 peak demand of 6MW at 0.93pf. This value aligns well the historical SCADA data that indicates that during 2022 the Waipara GXP experienced a peak load of 7.3MVA (excluding temporary back-up periods).

The Waipara 66kV GXP is equipped with two 220/66kV, 80MVA transformers (nominal capacity) that delivers (N-1) capacity of 80/80MVA (summer/winter) onto the 66kV bus at Waipara. The Waipara 66kV bus supplies Mainpower's local 66kV network, the Waipara 33kV GXP and Transpower's double circuit 66kV line that connects to the Ashley, Kaiapoi and Islington GXPs to the south.

The following graph compares Waipara 66 kV GXP's supply capacity with the historical loading and Transpower's demand forecast (sourced from Transpower's 2022 TPR). There is no supply capacity/limit shown on the graphs as the direct connection means that there are no transformers limiting the capacity (capacity of the 66 kV GXP is limited by transmission lines, which are not reported on by Transpower in this case).



The following Figure 27 illustrates the historical 2022 load that was delivered into Mainpower's 66kV network from the Waipara 66kV. Note that the graphs illustrated in Figure 27:

- Exclude the load delivered to the Waipara 33kV GXP and Transpower's double circuit 66kV line.
- Includes periods of unusually high load that Ergo understand is due to Mainpower temporarily transferring load onto the GXP during network contingencies or periods of planned network maintenance.

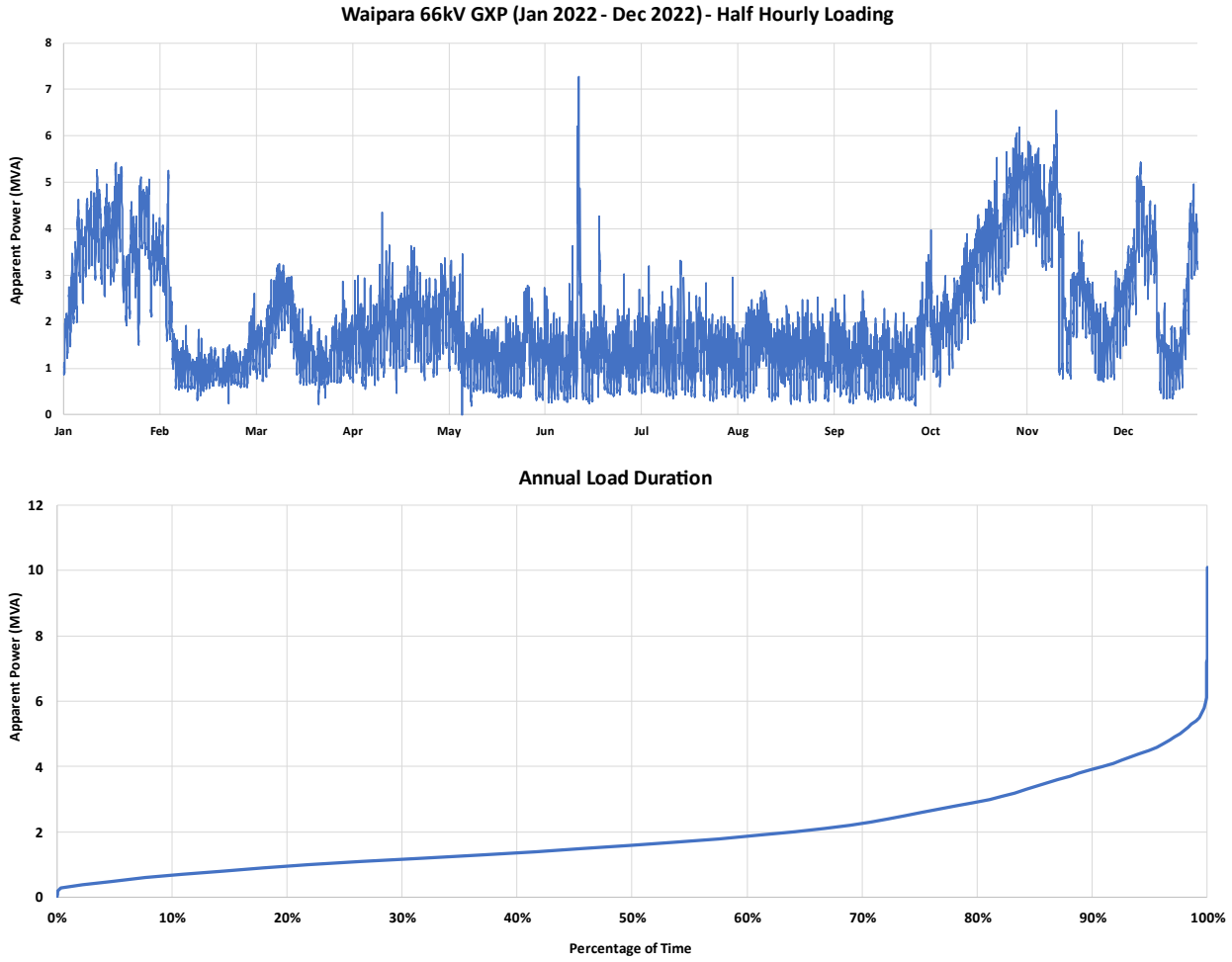


Figure 27 Waipara 66kV GXP: 2022 Loading

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

The following Figure 28 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 or disclosed in the asset management plan of the relevant EDB.
- 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.

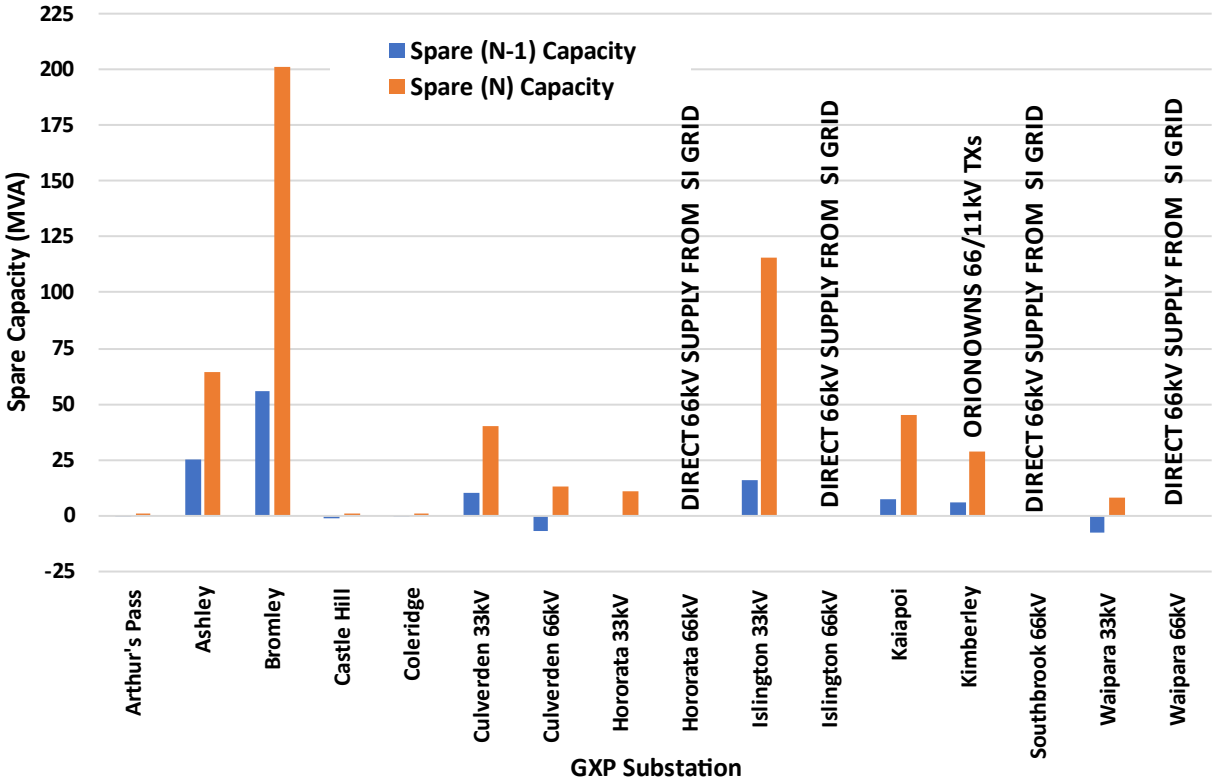


Figure 28 - Summary: GXP Spare Capacity based on Transpower's 2022 Load Forecast

It should be noted that the capacities have been calculated based on the transformer bay ratings disclosed by Transpower and information in the EDB asset management plans. Also, the spare capacities do not include any voltage constraints or upstream transmission constraints (where the transformers may not be the limiting factor for the capacity). Ergo has confirmed security ratings of GXPs and substations with the relevant EDB or Transpower where possible. We note the following:

- The negative values in Figure 28 indicate that there is no capacity and consumer load cannot be supplied (for (N) and (N-1) conditions).
- Figure 28 infers that there are relatively high levels of spare capacity at Ashley, Bromley and Islington, but we note that these values do not consider the transmission line constraints and voltage constraints.

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.

Actual historical 2021 loading data was provided by Orion, and actual 2022 loading data was provided by Mainpower.

7.1 Mainpower

Some of the Mainpower disclosed data (2022 AMP) values do not align with their recent historical loading data, which shows significantly less capacity for some zone substations. This is likely due to load growth during the 2022 year, after the publication of the AMP. For this reason, the lower capacity between disclosed and historical data is used in analysis for loads connecting to the Mainpower network.

Table 4 Mainpower: Spare capacity for each Zone Substation

No.	Substation Name	Spare (N) Capacity (MVA) [21]		Spare (N-1) Capacity (MVA) [22]	
		Disclosure Data	Historical Data	Disclosure Data	Historical Data
1	Amberley	2.00	1.2	-2.0	-2.8
2	Burnt Hill	30.00	31.9	7.0	8.9
3	Cheviot	1.00	0.8	-3.0	-3.2
4	Greta	3.00	2.5	-1.0	-1.5
5	Hanmer	8.00	7.2	-1.0	-1.8
6	Hawarden	0.00	0.4	-4.0	-3.6
7	Leader	-1.70	-1.1	-2.0	-1.4
8	Lochiel	0.20	0.1	0.0	-0.1
9	Ludstone	6.00	5.8	0.0	-0.2
10	MacKenzies Rd	1.00	No data	-3.0	No data
11	Marble Quarry	2.00	No data	0.0	No data
12	Mouse Point	10.00	18.2	-3.0	5.2
13	Oaro	4.00	No data	0.0	No data
14	Southbrook	55.00	42.2	15.0	2.2
15	Swannanoa	30.00	30.9	7.0	7.9

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

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

7.2 Orion

The Orion historical data contains many points where network switching or other load transfers were used throughout the network, and as such, many of the substations appear to have lower capacities in the historical data when compared to the disclosure data. For this reason, the disclosure data has been used for analysis of loads connecting to Orion's network.

Table 5 Orion: Spare capacity for each Zone Substation

No.	Substation Name	Spare (N) Capacity[23]		Spare (N-1) Capacity[24]	
		Disclosure Data	Historical Data	Disclosure Data	Historical Data
1	Addington 11kV #1	44.00	34.0	14.0	4.0
2	Addington 11kV #2	42.00	37.6	12.0	7.6
3	Armagh	62.00	46.2	22.0	6.2
4	Barnett Park	5.00	3.0	-10.0	-12.0
5	Bromley	58.00	49.5	28.0	19.5
6	Dallington	52.00	48.3	12.0	8.3
7	Fendalton	45.00	40.5	5.0	0.5
8	Halswell	27.00	24.0	4.0	1.0
9	Hawthornden	47.00	43.4	7.0	3.4
10	Heathcote	57.00	46.0	17.0	6.0
11	Hoon Hay	50.00	54.4	10.0	14.4
12	Hornby	27.00	21.7	7.0	1.7
13	Ilam	15.00	10.5	4.0	-0.5
14	Lancaster	63.00	49.2	23.0	9.2
15	McFaddens	45.00	41.8	5.0	1.8
16	Middleton	54.00	49.4	14.0	9.4
17	Milton	45.00	37.2	5.0	-2.8
18	Moffett	32.00	26.2	9.0	3.2
19	Oxford Tuam	65.00	58.3	25.0	18.3
20	Papanui	38.00	41.5	6.0	9.5
21	Prebbleton	16.00	14.2	-7.0	-8.8
22	Rawhiti	50.00	46.3	10.0	6.3
23	Shands	27.00	22.8	7.0	2.8
24	Sockburn	46.00	41.5	16.0	11.5
25	Waimakariri	61.00	56.8	21.0	16.8
26	Annat	-1.50	-1.1	-4.0	-3.6
27	Bankside	6.00	5.6	-4.0	-4.4
28	Brookside 66kV	1.00	-0.3	-9.0	-10.3
29	Darfield	5.00	4.7	-5.0	-5.3

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

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

No.	Substation Name	Spare (N) Capacity[23]		Spare (N-1) Capacity[24]	
		Disclosure Data	Historical Data	Disclosure Data	Historical Data
30	Diamond Harbour	5.50	4.6	-2.0	-2.9
31	Dunsandel	26.00	21.9	3.0	-1.1
32	Duvauchelle	11.00	10.4	3.0	2.4
33	Greendale	3.00	3.1	-7.0	-6.9
34	Highfield	-0.50	-0.6	-8.0	-8.1
35	Hills	0.50	0.2	-7.0	-7.3
36	Hororata	-0.50	-0.6	-8.0	-8.1
37	Killinchy	1.00	0.2	-9.0	-9.8
38	Kimberley	31.00	30.3	8.0	7.3
39	Larcomb	32.00	25.3	9.0	2.3
40	Lincoln	10.00	7.4	0.0	-2.6
41	Little River	1.50	1.3	-1.0	-1.2
42	Motukarara	13.00	12.0	5.0	4.0
43	Rolleston	10.00	5.8	0.0	-4.2
44	Springston 66/11kV	0.50	-1.8	-7.0	-9.3
45	Te Pirita	1.00	-0.1	-9.0	-10.1
46	Weedons	32.00	29.4	9.0	6.4

7.3 Summary

7.3.1 Mainpower

7.3.1.1 (N-1) Capacity Summary

The following Figure 29 illustrates the approximate (N-1) spare capacities at Mainpower's zone substations, for the disclosed 2022 peak demand estimates[25]. It should be noted that these have been calculated based on the transformer ratings disclosed by Mainpower.

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.

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.

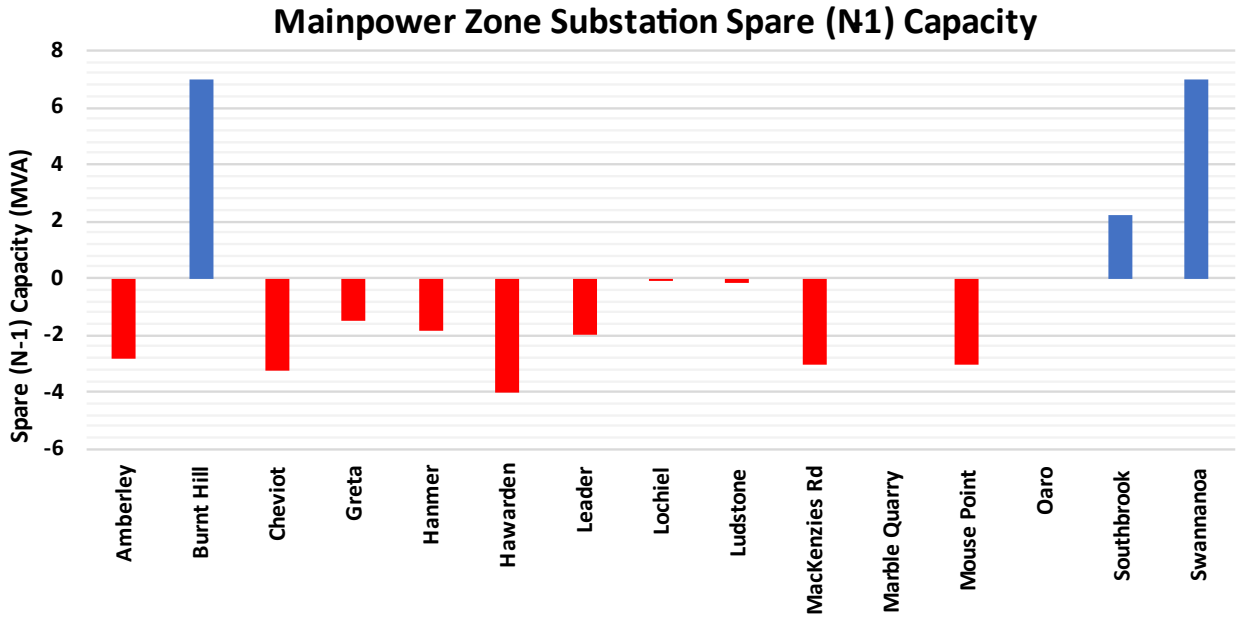


Figure 29 Summary: Approximate (N-1) spare capacity at Mainpower's zone substations

7.3.1.2 (N) Capacity Summary

The following Figure 30 illustrates the approximate (N) spare capacities at Mainpower'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 Mainpower.

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. Figure 30 indicates that the nominal capacity of the power transformers at Mainpower's Leader zone are

[25] Mainpower's 2022 information disclosure (https://mainpower.co.nz/about-us/disclosures/mainpower-disclosures/).

marginally exceeded during peak loading conditions. It is possible to expose power transformers to loadings that exceed the nominal capacity provided a detailed engineering study has been undertaken.

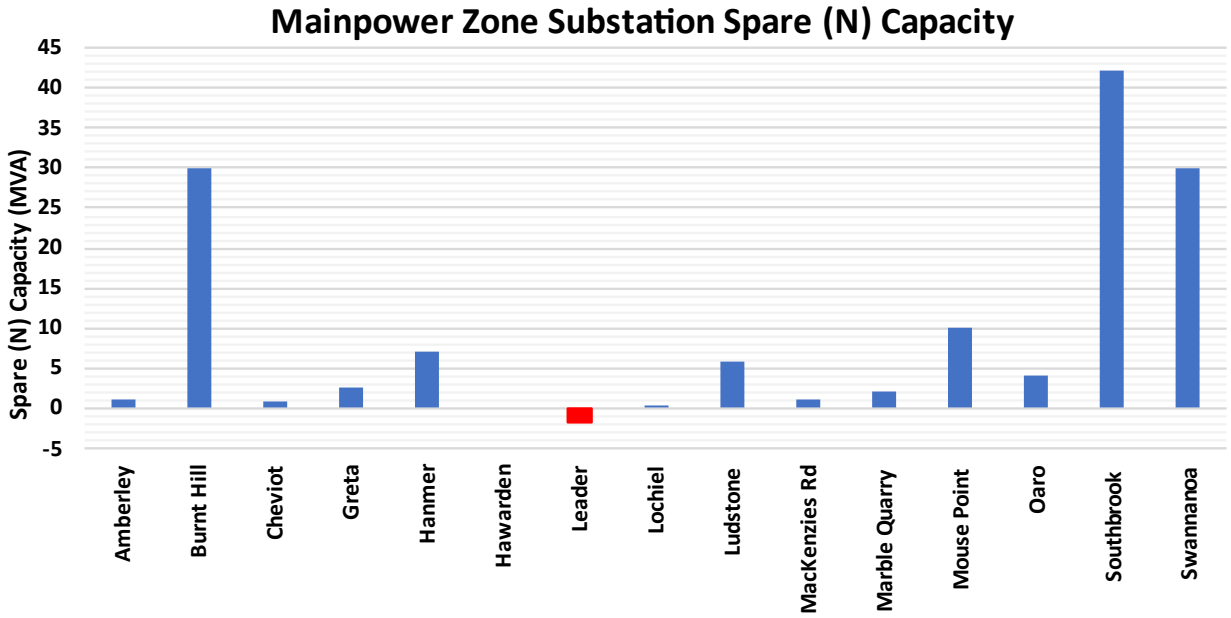


Figure 30 Summary: Approximate (N) spare capacity at Mainpower's zone substations

7.3.2 Orion

7.3.2.1 (N-1) Capacity Summary

The following Figure 31 illustrates the approximate (N-1) spare capacities at Orion'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 Orion[26].

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.

[26] Orion's 2022 disclosure data (https://www.oriongroup.co.nz/corporate/regulatory-disclosures/)

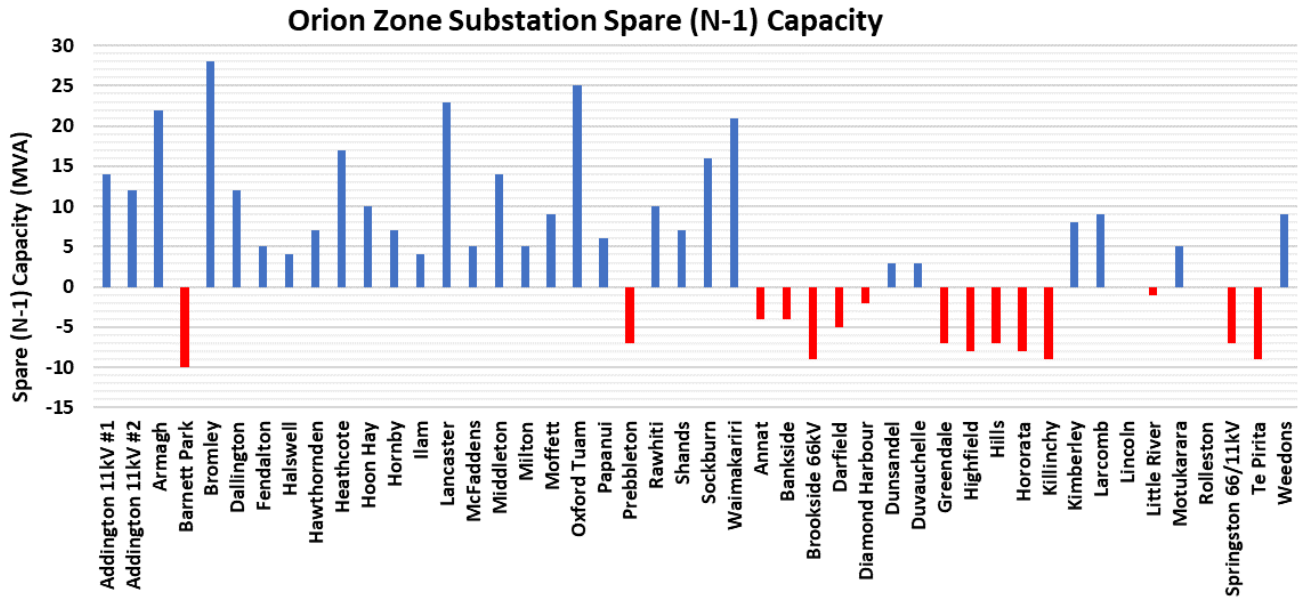


Figure 31 Summary: Approximate (N-1) spare capacity at Orion's zone substations

7.3.2.2 (N) Capacity Summary

The following Figure 32 illustrates the approximate (N) spare capacities at Orion'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 Orion Electricity.

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.

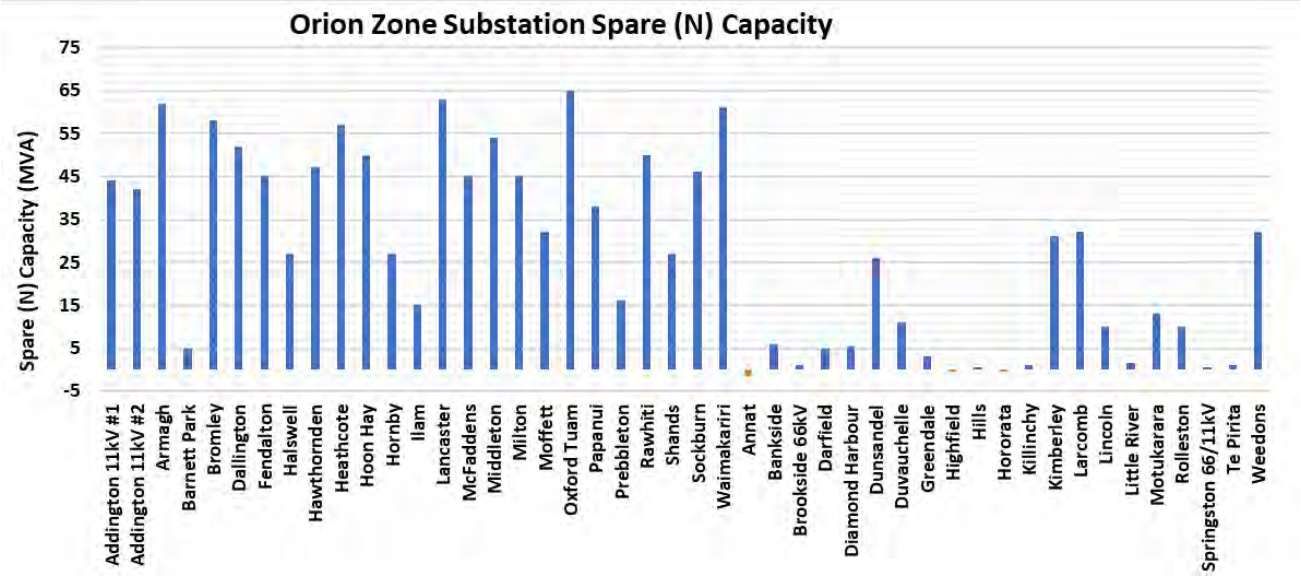


Figure 32 Summary: Approximate (N) spare capacity at Orion's zone substations

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 Mainpower and Orion zone substations (shaded yellow in diagrams).

The purpose of this section is to provide a high-level assessment to 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, including review by the relevant EDBs and Transpower. 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 Mainpower / Orion. 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, Mainpower and Orion). 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 provided a view of the potential impacts of multiple loads connected to the same GXP or zone substation, where applicable.
- 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[27] accuracy - suitable for concept screening. Appendix 2 outlines the 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 be used for final budgeting purposes in order to connect the respective 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.

8.3 Arthur's Pass GXP

None of the Load Sites identified by EECA are geographically close to the Arthur's Pass GXP. Hence, Ergo is of the view that the Arthur's Pass GXP is not a viable option for supplying any of the Load Sites, and thus we have not considered the upgrade of the GXP or any zone substations.

8.4 Ashley GXP

None of the Load Sites identified by EECA are geographically close to the Ashley GXP. Hence, Ergo is of the view that the Ashley GXP is not a viable option for supplying any of the Load Sites, and thus we have not considered the upgrade of the GXP or any zone substations.

8.5 Bromley GXP

The "Large" EECA Load Sites include:

- G L Bowron Company Christchurch (6.36 MVA)
- Winstone Wallboards Christchurch (6.05 MVA)
- Alsco New Zealand Christchurch (2.04 MVA)
- Paua Co. Bromley (1.44 MVA)

The "Small" Load Sites include (refer to Sections 8.5.6 and 8.5.8:

- Ardex Christchurch (0.82 MVA)
- Woolston Foundry Christchurch (0.48 MVA)
- Castle Rock Orchards (0.46 MVA)
- Coca Cola Europacific Partners Christchurch (0.35 MVA)
- Aromaunga Baxter Flowers (0.33 MVA)
- Te Aratai College (0.33 MVA)
- Taylors Manufacturing Christchurch (0.25 MVA)
- Shirley Boys High School (0.22 MVA)
- Scott Technology Christchurch (0.17 MVA)
- Shirley Intermediate School (0.12 MVA)
- Chisnallwood Intermediate School (0.12 MVA)

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

Figure 33 Bromley GXP: EECA Load Sites vs local substations: Christchurch Central/East enlarged (loads are shared between Islington and Bromley GXPs)

8.5.1 Bromley GXP Upgrade

As shown in Section 8.5.9, the (N-1) capacity of Bromley GXP is expected to be exceeded for a short period of time, due to the connection of the proposed loads. The Transmission Planning Report 2022 indicates that Orion and Transpower plan to manage this by transferring load between Islington GXP and Bromley GXP as required. With the commissioning of the new Norwood GXP, it is expected that Islington GXP will have increased capacity to accommodate load transferred from Bromley GXP.

In the long-term, Transpower is planning to install a third 220/66 kV supply transformer at Bromley. This is estimated to cost $12M. The date this upgrade will occur is unknown at this time, as it is still to be determined by Orion and Transpower.

8.5.2 G L Bowron Company Christchurch

G L BOWRON COMPANY CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	6.36 MW	Bromley

Existing Electrical Supply to the Plant

G L Bowron is presently supplied by Orion's Heathcote zone substation, which is supplied at 66 kV by Bromley GXP by overhead lines.
The plant is supplied by the Heathcote zone substation 3 feeder. The Heathcote 3 feeder is presently loaded at a maximum of 116 A (2.21 MVA). The Heathcote 3 feeder is a mixture of underground XLPE and PILC cables.
The plant is ≈1.4 km (straight line) from Heathcote substation.

Figure 34 G L Bowron Company Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Bromley GXP and Heathcote zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 6.36 MW. The lines feeding Heathcote substation have sufficient capacity to accommodate the additional load with (N-1) security.

G L BOWRON COMPANY CHRISTCHURCH

In order to connect the proposed load, Ergo expects that one new 11 kV feeder to the site from Heathcote zone substation would be required. This feeder would likely be underground cabled, matching the existing supply/urban topography.

Capital Cost Estimate

Table 6 G L Bowron Company Christchurch: 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)	3.00	$2.40
		TOTAL	**$2.50**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 – 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.

8.5.3 Winstone Wallboards Christchurch

WINSTONE WALLBOARDS CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	6.05 MW	Bromley
Existing Electrical Supply to the Plant		

Winstone Wallboards is presently supplied by Orion's Heathcote zone substation, which is supplied at 66 kV by Bromley GXP by overhead lines.
The plant is supplied by the Heathcote zone substation 15 feeder. The Heathcote 15 feeder is presently loaded at a maximum of 287 A (5.46 MVA). The Heathcote 15 feeder is a mixture of underground XLPE and PILC cables, with a short section of overhead conductor.
The plant is ≈2.2 km (straight line) from Heathcote substation.

Figure 35 Winstone Wallboards Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Bromley GXP and Heathcote zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 6.05 MW. The lines feeding Heathcote substation have sufficient capacity to accommodate the additional load with (N-1) security.

In order to connect the proposed load, Ergo expects that one new 11 kV feeder to the site from Heathcote zone substation would be required. This feeder would likely be underground cabled, matching the existing supply/urban topography.

Capital Cost Estimate

Table 7 Winstone Wallboards Christchurch: 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)	3.00	$2.40
		TOTAL	**$2.50**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 – 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.

8.5.4 Alsco New Zealand Christchurch

ALSCO NEW ZEALAND CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	2.04 MW	Bromley

Existing Electrical Supply to the Plant

Alsco New Zealand Christchurch is presently supplied by Orion's Lancaster zone substation, which is supplied at 66 kV by Bromley GXP via underground cable.
The plant is supplied by the Lancaster zone substation 5 feeder. The Lancaster 5 feeder is presently loaded at a maximum of 121 A (2.30 MVA). The Lancaster 5 feeder is a mixture of underground XLPE and PILC cables. The nearby Milton 23 feeder may also supply the site, and is loaded at 37 A (0.71 MVA). The Milton 23 feeder is a mixture of underground XLPE and PILC cables.
The plant is ≈1.2 km (straight line) from Lancaster substation, and ≈0.8 km (straight line) from Milton substation.

Figure 36 Alsco New Zealand Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Bromley GXP and Lancaster zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 2.04 MW, as does Milton zone substation. Ergo expects that in order to connect the

load, some cable replacements on the relevant feeders would be required: If connecting to Lancaster zone substation, the replacements would be of the 95mm^2 and 0.15in^2 Aluminium XLPE and 95mm^2 Aluminium PILC (total length ≈0.8 km); if connecting to Milton zone substation, the replacements would be of the 0.04in^2 Cu PILC (total length ≈0.2 km).

Ergo notes that, while Milton zone substation is presently fed by Islington zone substation, the Transmission Planning Report 2022 forecast states that the Milton load is expected to be switched from Islington GXP to Bromley GXP in 2026.

Capital Cost Estimate

Table 8 Alsco New Zealand Christchurch: 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)	0.80	$0.64
		TOTAL	**$0.64**

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.

8.5.5 Paua Co. Bromley

		PAUA CO. BROMLEY
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	1.44 MW	Bromley

Existing Electrical Supply to the Plant

Paua Co. Bromley is presently supplied by Orion's Bromley zone substation, which is supplied at 66 kV by Bromley GXP.
The plant is supplied by the Bromley zone substation 2572 feeder. The Bromley 2572 feeder is presently loaded at a maximum of 9.3 A (0.18 MVA). The Bromley 2572 feeder is a mixture of underground XLPE cables.
The plant is ≈0.5 km (straight line) from Bromley substation.

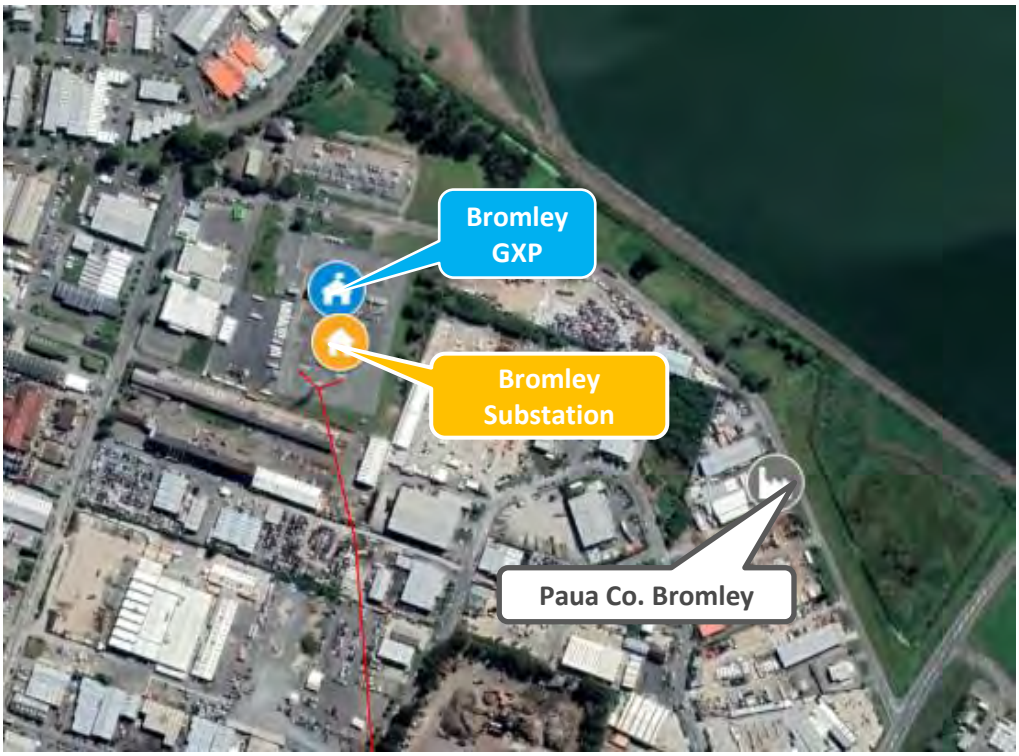


Figure 37 Paua Co. Bromley geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Bromley GXP and zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 1.44 MW. Ergo expects that the existing Bromley 2572 feeder has the capacity to supply the additional 1.44 MW of load. Therefore, it is expected that the main costs associated with this connection would be related to any required distribution transformers or site equipment.

Capital Cost Estimate
Ergo estimates that the cost for a Ring Main Unit (RMU) and 2x 750 kVA distribution transformers for this load would be ≈$0.40M. Does not include the costs of any switchgear/equipment on the plant site.
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.

8.5.6 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 an RMU and distribution transformer to supply the site.

Table 9 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Zone sub (N-1) spare capacity (MVA)	Zone sub (N) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Ardex Christchurch	Bromley	28	58	4.90	0.82	260
Woolston Foundry Christchurch	Bromley	28	58	3.28	0.48	130
Castle Rock Orchards	Heathcote	17	57	3.30	0.46	130
Coca Cola Europacific Partners Christchurch	Heathcote	17	57	3.30	0.35	130
Aromaunga Baxter Flowers	Heathcote	17	57	5.14	0.33	130
Te Aratai College	Bromley	28	58	5.46	0.33	130
Taylors Manufacturing Christchurch	Bromley	28	58	2.13	0.25	130
Shirley Boys High School	Rawhiti	10	50	6.13	0.22	130
Scott Technology Christchurch	Bromley	28	58	3.28	0.17	80
Shirley Intermediate School	Dallington	12	52	2.42	0.12	80
Chisnallwood Intermediate School	Dallington	12	52	4.53	0.12	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.

8.5.7 Combined Load on Zone Substations

8.5.7.1 Bromley

One of the large loads, plus five of the "small" loads on Bromley GXP are expected to connect to Bromley zone substation. The loads are Paua Co. Bromley, Ardex Christchurch, Woolston Foundry Christchurch, Te Aratai College, Taylor's Manufacturing Christchurch, and Scott Technology Christchurch. The sum of peaks of these loads is 3.48 MVA, which the zone substation does have (N-1) capacity for. Therefore, upgrades of Bromley zone substation are not considered.

8.5.7.2 Heathcote

Five of the loads on Bromley GXP are expected to connect to Heathcote zone substation. These are G L Bowron Company Christchurch, Winstone Wallboards Christchurch, and small loads Castle Rock Orchards, Coca Cola Europacific Partners Christchurch, and Aromaunga Baxter Flowers. The sum of peaks of these loads is 13.55 MVA, which Heathcote substation does have (N-1) capacity for. However, the (N-1) capacity of the lines between Bromley GXP and Heathcote zone substation may be exceeded. Orion has advised that to resolve this issue, the most likely solution would be a reconductoring of the relevant lines. Ergo has estimated this to be ~4.7 km double 66 kV line reconductoring, at 50% of the price of a new line, approximately $1.18M.

8.5.8 Combined Load of Small Opportunities

Summing the maximum values of the "small" loads on Bromley GXP gives a combined load of 3.65 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 38), with a maximum load of 2.8 MVA, with a diversity factor of 0.77.

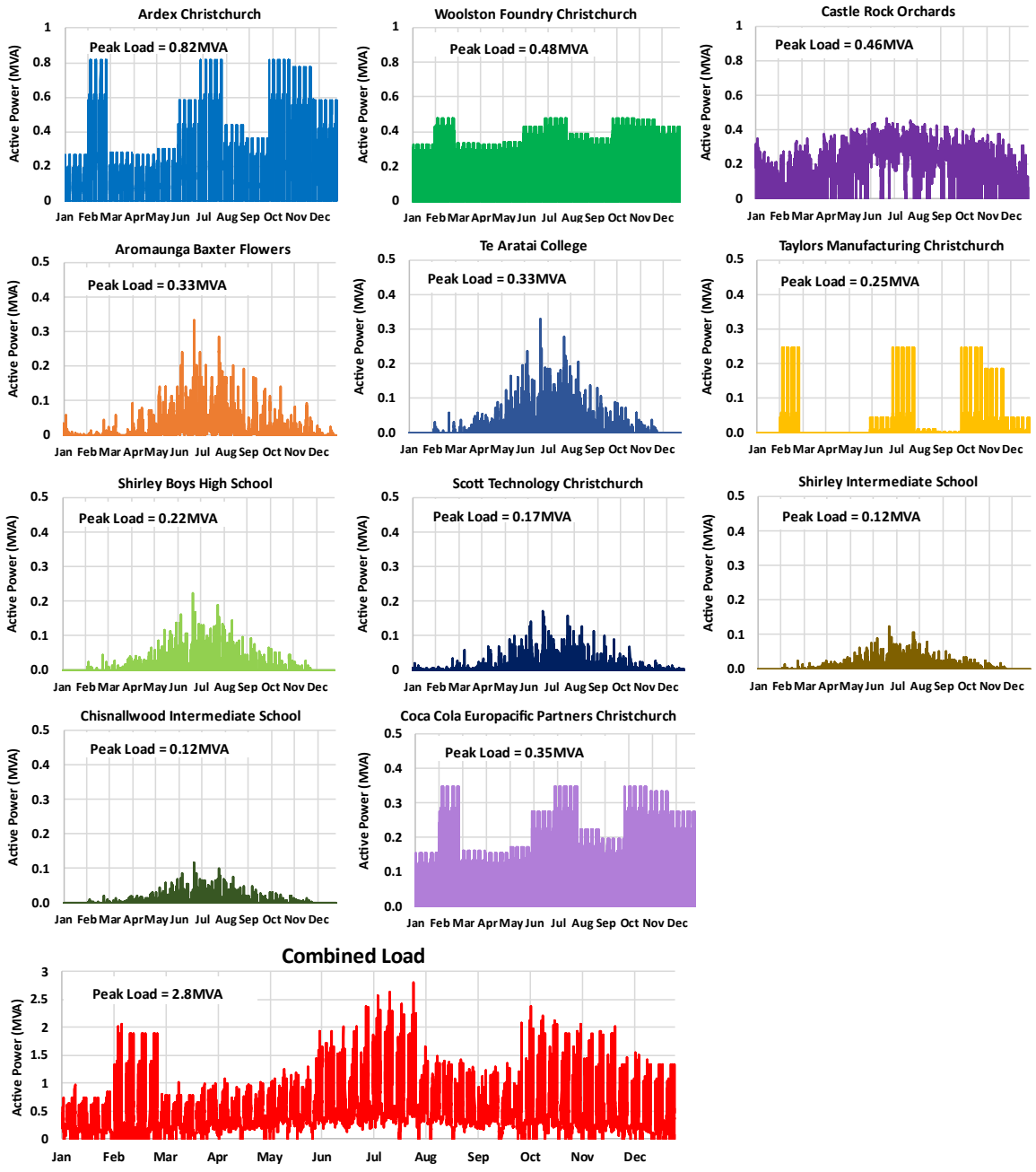


Figure 38 Loading Profiles: Bromley GXP "small" Load Site Profiles: Combined Load (sum of all profiles)

8.5.9 Effect of all Load Sites Connecting to Bromley GXP

The following Figure 39 illustrates the Bromley 2022 load profile together with the load profiles of all the Load Sites within the Bromley GXP region. Also shown in Figure 39 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Bromley GXP would increase to 246.2 MVA, a difference of 10.9 MVA. Given that the independent sum of the individual load peaks is 254.0 MVA there is a diversity factor of 0.97 between the loads.
- Based on Ergo's analysis, the Bromley GXP's (N-1) limit is not expected to be exceeded, assuming that the early/mid-October loading observed in the 2022 data was due to a temporary backup situation.

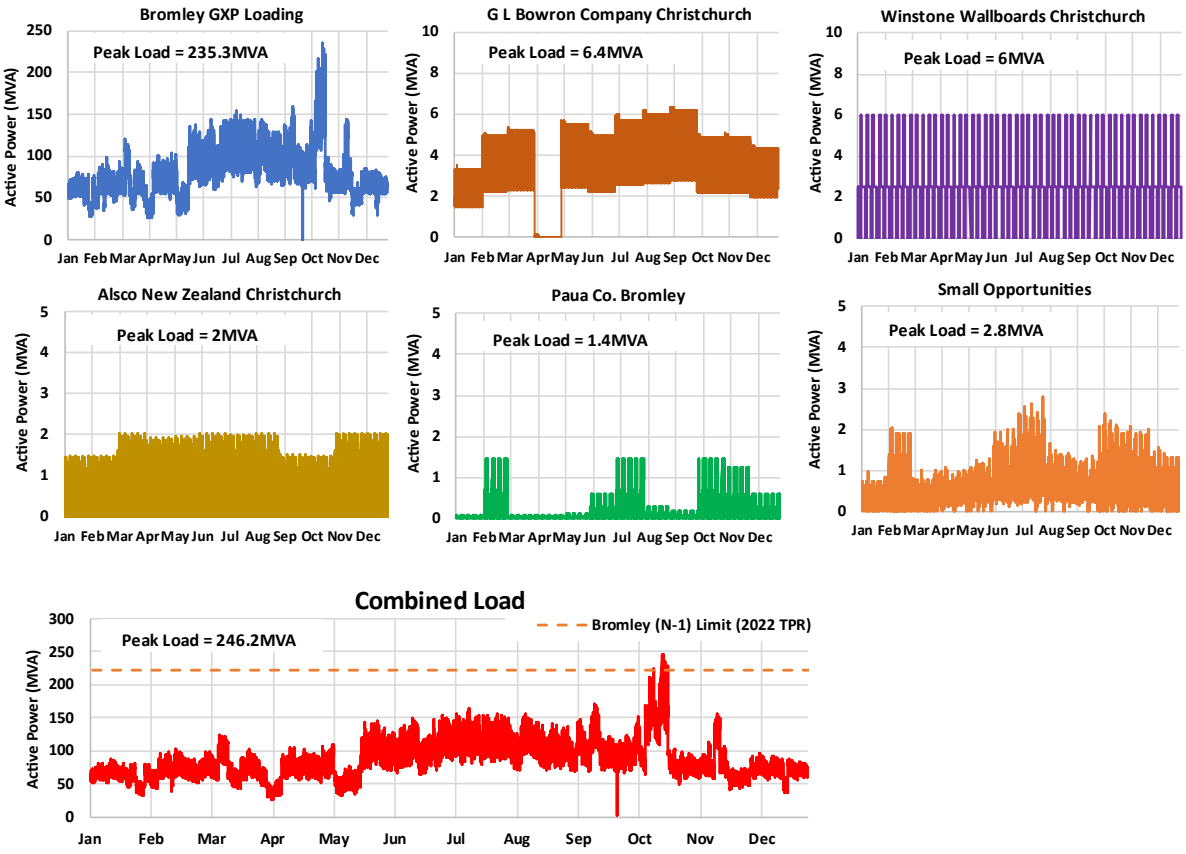


Figure 39 Loading Profiles: Bromley GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.6 Castle Hill GXP

None of the Load Sites identified by EECA are geographically close to the Castle Hill GXP. Hence, Ergo is of the view that the Castle Hill GXP is not a viable option for supplying any of the Load Sites, and thus we have not considered the upgrade of the GXP or any zone substations.

8.7 Coleridge GXP

None of the Load Sites identified by EECA are geographically close to the Coleridge GXP. Hence, Ergo is of the view that the Coleridge GXP is not a viable option for supplying any of the Load Sites, and thus we have not considered the upgrade of the GXP or any zone substations.

8.8 Culverden GXP

The EECA Load Sites include:

- Tekoa Range/Hanmer EV Charging Station (0.6 to 1.6 MVA)
- Kaikōura EV Charging Station (1.5 to 4.5 MVA)
- Kaikōura High School (0.12 MVA) (refer to Section 8.8.4)

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

It is noted that Ergo presently does not have access to Mainpower's network map or loading data outside of public disclosures at this time and therefore analysis for this GXP is at a high level only.

Figure 40 Culverden GXP: Local zone substations and Load Sites

Figure 41 Culverden GXP: Local zone substations and Load Sites: Kaikōura enlarged

8.8.1 Culverden GXP Upgrade

The spare capacity at Culverden GXP is not expected to be exceeded by the connecting Load Sites and as such, upgrades at Culverden GXP have not been considered.

8.8.2 Tekoa Range/Hanmer EV Charging Station

TEKOA RANGE/HANMER EV CHARGING STATION		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
Charging station for electric vehicles	0.6 to 1.6 MW	Culverden (33 kV)

Existing Electrical Supply to the Plant

Shown below is a potential location for the Tekoa Range/Hanmer EV charging station on SH7A near the intersection with SH7.

The area is chosen on the basis of its proximity to local attractions/activities while still being adjacent to the state highway.

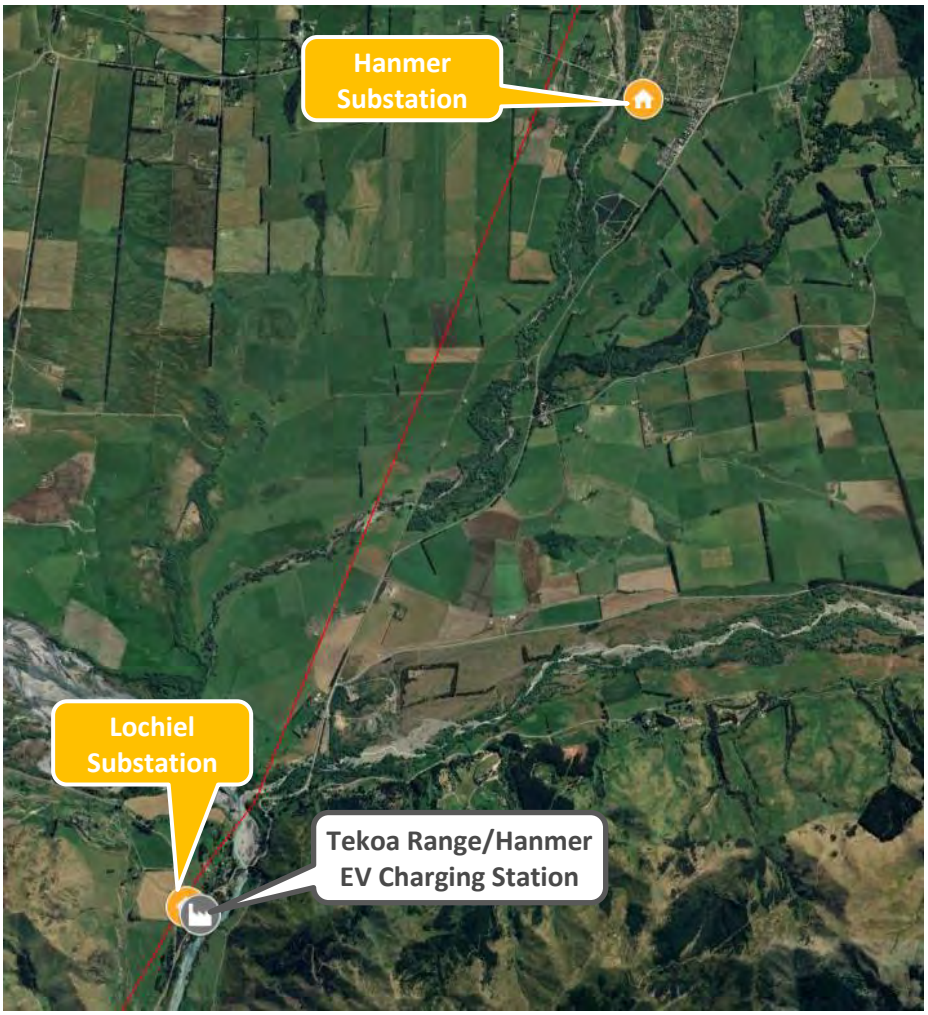


Figure 42 Tekoa Range/Hanmer EV Charging Station geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Culverden GXP has sufficient spare (N-1) capacity for the proposed additional 1.6 MW of load. Lochiel zone substation does not have capacity for this load; due to difficulties with reaching the site from Hanmer substation (river crossing), connection to Hanmer has not been considered.

TEKOA RANGE/HANMER EV CHARGING STATION

Ergo has considered connection to Lochiel substation, including replacement of the transformer and installation of an 11 kV switchroom, with lines to the site.

Capital Cost Estimate

Table 10 Tekoa Range/Hanmer EV Charging Station: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	Small supply transformer (ZSS)	1.00	$0.50
Distribution	Small switchroom (ZSS)	1.00	$1.50
Distribution	Single overhead 11kV line	0.50	$0.10
		TOTAL	**$1.60**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 24-36 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.

8.8.3 Kaikōura EV Charging Station

KAIKŌURA EV CHARGING STATION		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
Charging station for electric vehicles	1.5 to 4.5 MW	Culverden (66 kV)

Existing Electrical Supply to the Plant

Shown below is a potential location for the Kaikōura EV charging station, near accommodation as well as some local eateries. The area is presently fed by Culverden GXP, via Ludstone zone substation, which has 4x feeders supplying the Kaikōura township and surrounding areas.
The site is ≈0.8 km (straight line) from Ludstone zone substation.

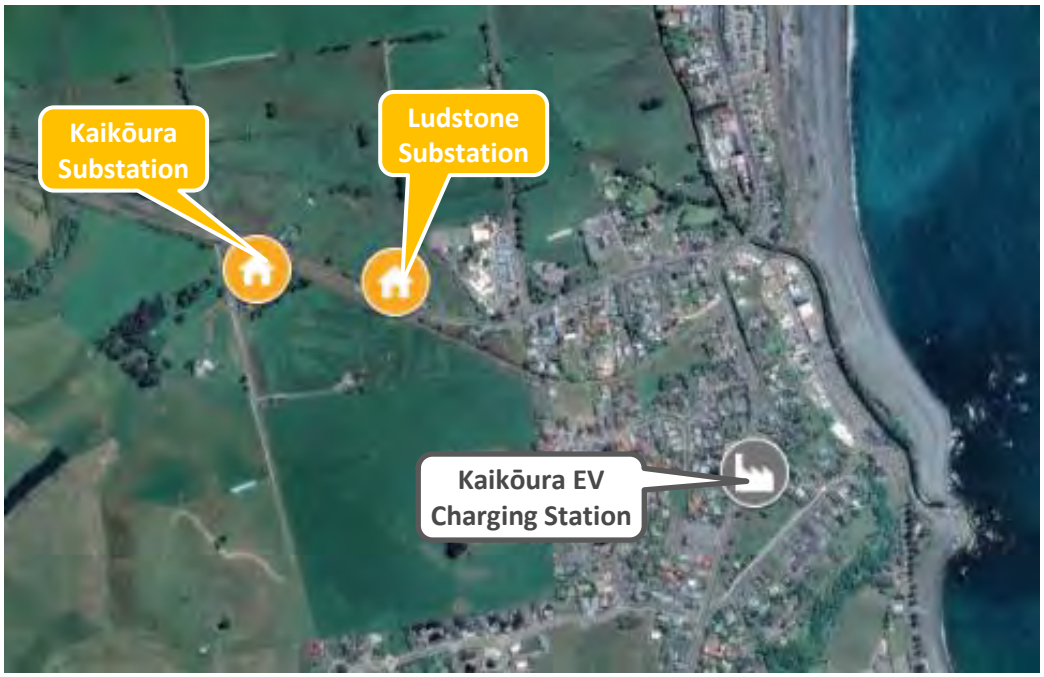


Figure 43 Kaikōura EV Charging Station geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The Culverden GXP has sufficient spare capacity to supply the proposed additional 1.5 to 4.5 MW of load. The Kaikōura 33/11 kV zone substation build project is planned to commence after the end of the present planning period, that is, after 2033. Presently the Kaikōura substation is a 66/33 kV substation only. Mainpower has advised that addition of load this size would necessitate a substation upgrade at Ludstone zone substation, and has indicated that they have received several other connection requests for large loads at the substation, which limit the substation spare capacity further.

Kaikōura is approximately 75 km from the Culverden GXP, and so it is expected that adding as much as 4.5 MW of additional load may cause voltage drop issues at the substation. Ergo understands that Mainpower has plans to upgrade the existing Cheviot-Kaikōura line to 66 kV, which will negate some of the voltage issues at the site. Ergo has additionally included the cost for a capacitor bank at Ludstone substation.

Ergo expects, due to the size of the load and existing loading of Ludstone substation, that the supply would require a dedicated feeder to the site. Due to the urban topography, it is expected that this new feeder would require underground cabling.

Capital Cost Estimate

Table 11 Kaikōura EV Charging Station: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	Large supply transformer (ZSS)	2.00	$3.00
Subtransmission	33kV Capacitor Bank	1.00	$0.40
Distribution	Large switchroom (ZSS)	1.00	$4.00
Distribution	Single underground 11kV cable	1.20	$0.48
		TOTAL	**$4.48**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 24-36 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 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 an RMU and distribution transformer to supply the site.

Table 12 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Zone sub (N-1) spare capacity (MVA)	Zone sub (N) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Kaikōura High School*	Ludstone	0	6	0.00	0.12	Ludstone

*GIS and feeder loading data for Mainpower’s network are unavailable at this stage, and so are unknown in analysis

Each Load Site is estimated to take 12-24 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.

8.8.5 Effect of all Load Sites Connecting to Culverden GXP

The following Figure 44 illustrates the Culverden 2022 load profile together with the load profiles of all the Load Sites within the Culverden GXP region. The EV charging stations are represented as flat loads in the absence of a firm load profile. Also shown in Figure 44 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Culverden GXP would increase to 24.5 MVA.
- Based on Ergo's analysis, the Culverden GXP's (N-1) limit is not expected to be exceeded.

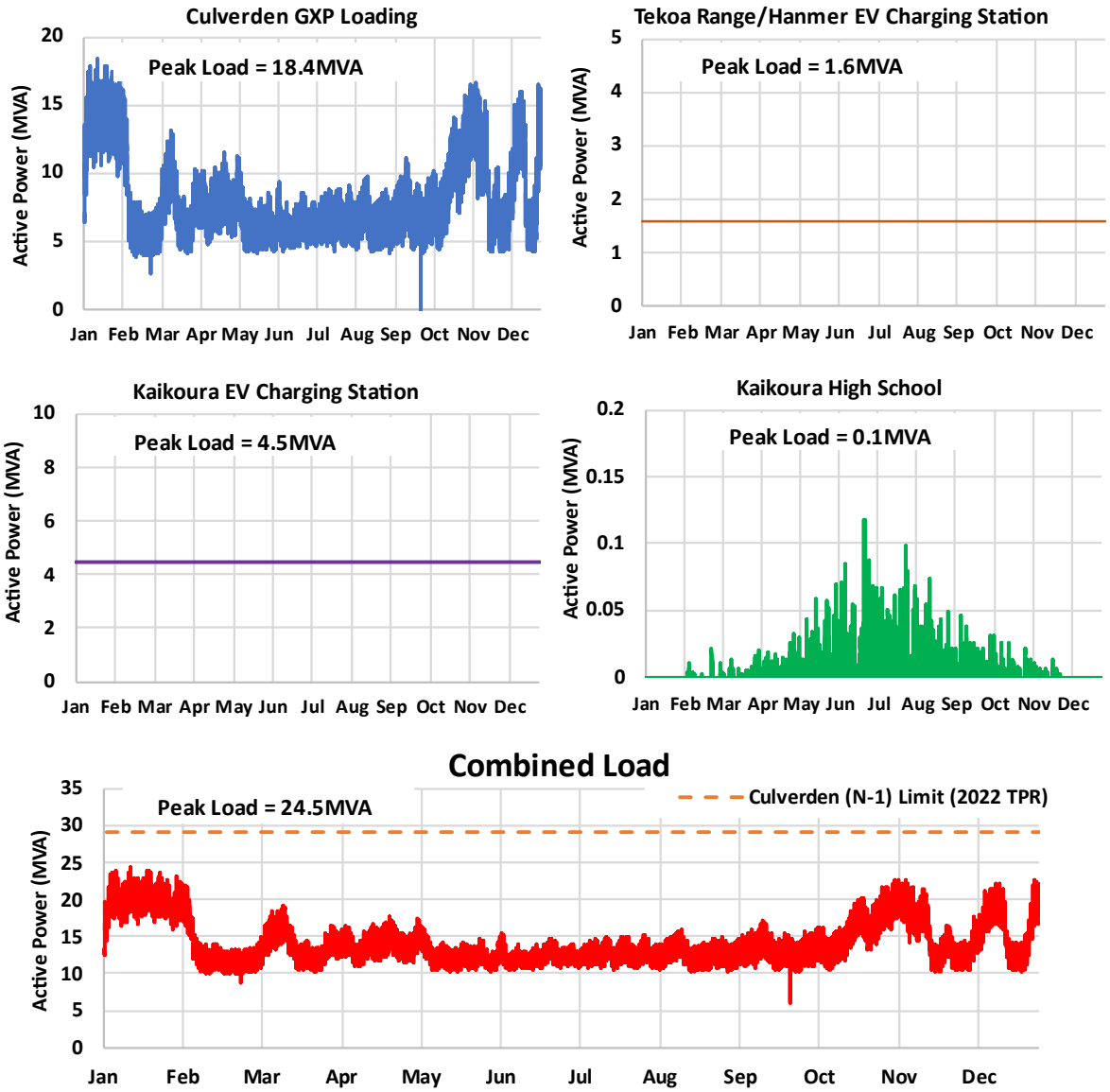


Figure 44 Loading Profiles: Culverden GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.9 Hororata GXP

The EECA Load Sites include:

- Canterbury Clay Bricks Darfield (2.30 MVA)
- Gladfield Malt Dunsandel (1.98 MVA)
- Mitchell Bros Sawmillers Darfield (1.16 MVA)
- Darfield EV Charging Station (0.9 to 2.3 MVA)
- ANZCO Foods Rakaia (0.95 MVA)
- Meadow Mushrooms Giggs Farm (0.44 MVA) (refer to Section 8.9.7)

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

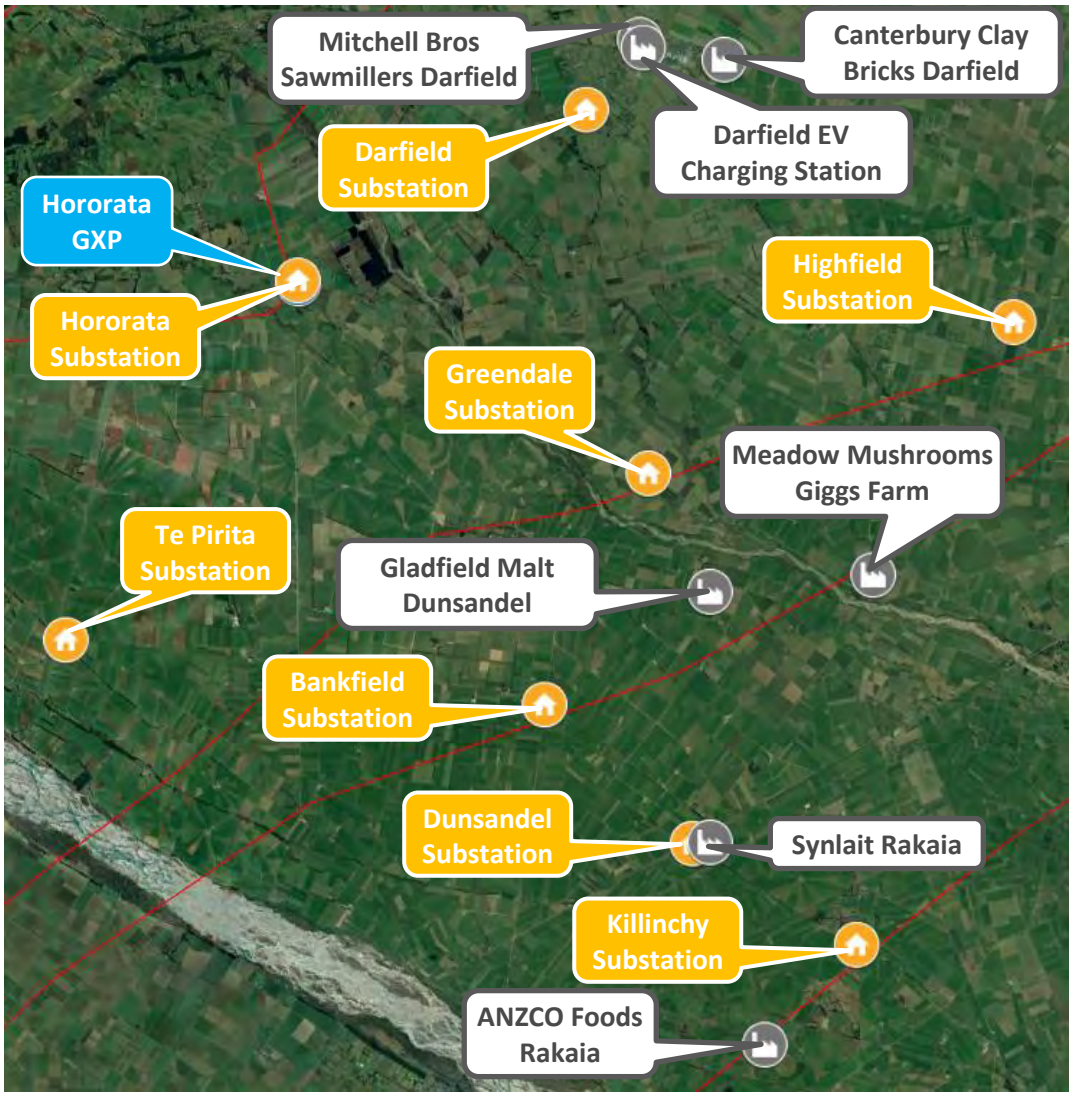


Figure 45 Hororata GXP: Local zone substations and Load Sites

Note: As an alternative approach to upgrading the Hororata GXP (for relatively small individual Load Sites), Ergo have proposed, where we believe feasible and economic, connecting some of the Load Sites to Kimberley GXP due to its existing spare capacity and relative proximity to the Darfield township. This includes:

- Canterbury Clay Bricks Darfield
- Mitchell Bro's Sawmillers Darfield
- Darfield EV Charging Station

For the purpose of this report, the Load Sites remain under the original GXP they were proposed by EECA and we have not updated the "Combined" load profiles for each GXP to reflect this change.

8.9.1 Hororata GXP Upgrade

As shown in Section 8.9.9, the (N-1) capacity of Hororata GXP (33kV) is expected to be exceeded due to the connection of all the proposed Load Sites. The constraint on the 33kV GXP is the two 23MVA transformers at the site. Transpower doesn't provide any details of planned upgrades at the site.

Orion has advised that their preference would be to transfer the local Hororata 11 kV load (presently fed off the 33 kV bus) to be fed from the 66 kV GXP.
In the longer term (financial years 26-27), Orion plans to redevelop the Hororata site – splitting the existing 33 kV connections between a new indoor 33 kV switchboard and a new 66 kV rated (33 kV operating) outdoor bus. The upgrade would also include the installation of a 66 kV tie from Hororata to the new Norwood GXP. The costs associated with this upgrade are not detailed at this time.

8.9.2 Canterbury Clay Bricks Darfield

CANTERBURY CLAY BRICKS DARFIELD		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	2.30 MW	Hororata

Existing Electrical Supply to the Plant

Canterbury Clay Bricks Darfield is currently supplied by an 11kV feeder (114) from Darfield Zone substation which is in turn supplied from Hororata GXP.

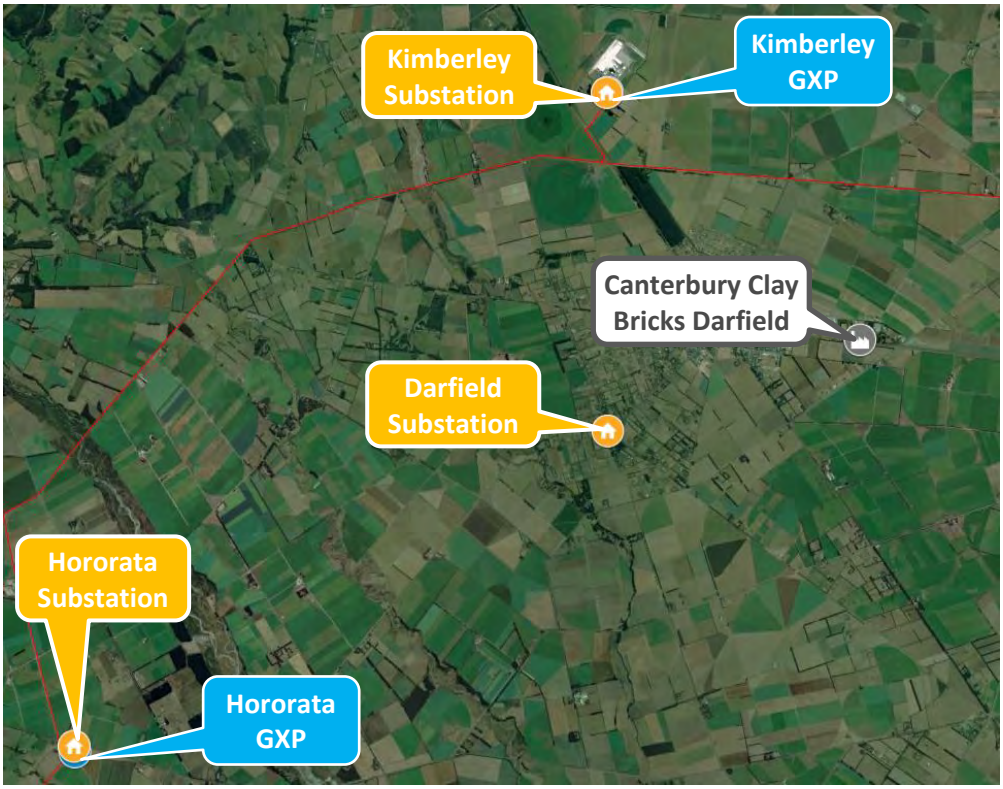


Figure 46 Canterbury Clay Bricks Darfield geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The existing feeder (114) has a current peak load of ≈2.2MVA and as a result, the existing conductors are unlikely able to supply the additional load. Darfield zone substation does have sufficient spare capacity to supply the additional load. However, as Hororata GXP (33kV) has no spare capacity, Ergo expects the additional supply would be better to come from Kimberley zone substation to the North.

Based on this, Ergo expects the supply would require a new 11kV feeder from the Kimberley zone substation, running down SH73 to the site. This would likely consist of ≈4km of overhead line and ≈2km of underground cable (through the urban area of Darfield).

In the long term, this additional load may be supplied by the redeveloped/relocated Darfield zone substation (renamed to Creyke Rd zone substation). This relocation is planned for financial years 30-31. While more detailed information on the proposed new substation is unknown, Ergo has

assumed that the costs associated with connecting to it (relating to a new or dedicated 11 kV feeder) will be approximately the same as the Kimberley connection.

Capital Cost Estimate

Table 13 Canterbury Clay Bricks Darfield: 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 overhead 11kV line	4.00	$1.00
Distribution	Single underground 11kV cable	2.00	$1.20
		TOTAL	**$2.30**

Does not include the costs of any 11kV distribution transformers/switchgear on the plant site.

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.

8.9.3 Gladfield Malt Dunsandel

GLADFIELD MALT DUNSANDEL		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	1.98 MW	Hororata

Existing Electrical Supply to the Plant

Gladfield Malt Dunsandel is currently supplied by an 11kV feeder (111) from Greendale Zone substation which is in turn supplied from Hororata GXP (66kV).

Figure 47 Gladfield Malt Dunsandel geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Greendale zone substation currently has sufficient spare (N) capacity to supply the additional load, as does the Hororata GXP at 66kV. The existing 11kV feeder (111) has a current peak load of ≈2.0MVA and the existing conductors are likely able to supply the additional load. However, Orion expects that the additional load would cause voltage issues on the existing feeder. Ergo has not considered an (N-1) security option for this site, as considering the size of the load and the configuration of the existing network, it would be prohibitively expensive to upgrade the network.

Therefore, Ergo expects that the additional load could be supplied by a new feeder from Greendale zone substation. The new feeder would likely be comprised of overhead lines given the rural topography.

Capital Cost Estimate

Table 14 Gladfield Malt Dunsandel: 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 overhead 11kV line	5.10	$1.28
		TOTAL	**$1.38**

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

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.

8.9.4 Mitchell Bros Sawmillers Darfield

MITCHELL BROS SAWMILLERS DARFIELD		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	1.16 MW	Hororata

Existing Electrical Supply to the Plant

Mitchell Bros Sawmillers is currently supplied by an 11kV feeder (111) from Darfield Zone substation which is in turn supplied from Hororata GXP (33kV).

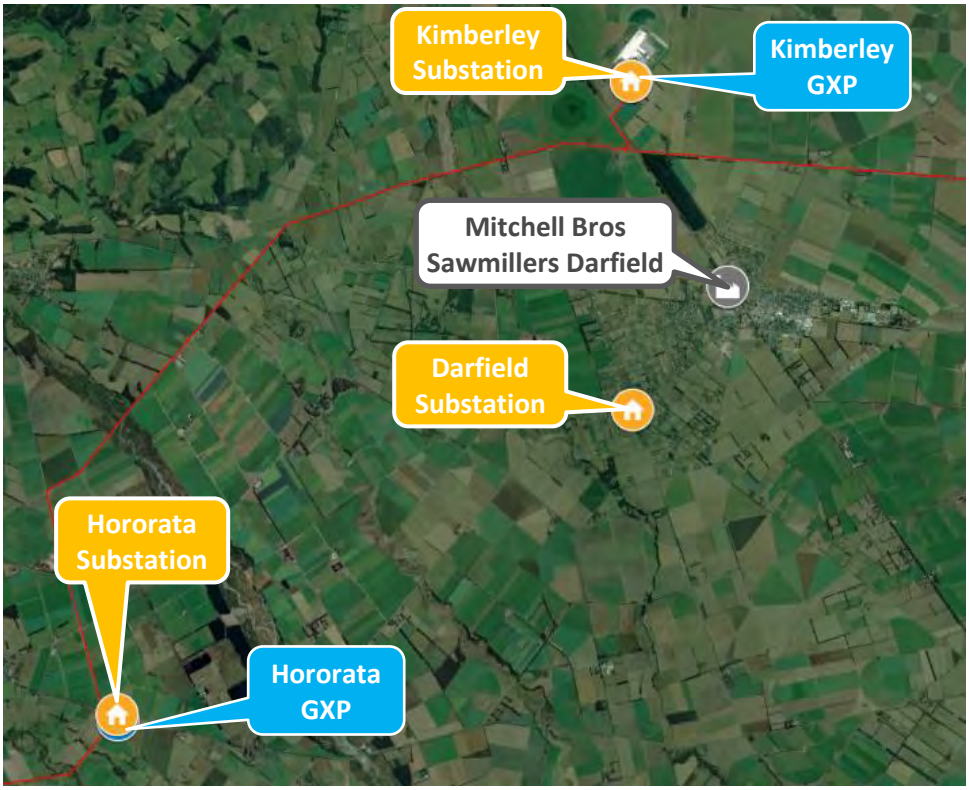


Figure 48 Mitchell Bros Sawmillers Darfield geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The existing feeder (111) has a current peak load of ≈2.1MVA and as a result, the existing conductors are likely able to supply the additional load. Darfield zone substation does have sufficient (N) spare capacity to supply the additional load. However, as Hororata GXP (33kV) has no spare capacity, Ergo expects the additional supply would be better to come from Kimberley zone substation to the North.

Based on this, Ergo expects the supply would require a new 11kV feeder from the Kimberley zone substation, running down SH73 to the site. This would likely consist of ≈2.5km of overhead line.

In the long term, this additional load may be supplied by the redeveloped/relocated Darfield zone substation (renamed to Creyke Rd zone substation). This relocation is planned for financial years 30-31. While more detailed information on the proposed new substation is unknown, Ergo has assumed that the costs associated with connecting to it (relating to a new or dedicated 11 kV feeder) will be approximately the same as the Kimberley connection.

Capital Cost Estimate

Table 15 Mitchell Bros Sawmillers Darfield: 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 overhead 11kV line	2.50	$0.63
		TOTAL	**$0.73**

Does not include the costs of any 11kV distribution transformers/switchgear on the plant site.

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.

8.9.5 Darfield EV Charging Station

DARFIELD EV CHARGING STATION		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
Charging station for electric vehicles	0.9 to 2.3 MW	Hororata

Existing Electrical Supply to the Plant

The proposed location of the Darfield EV Charging Station is currently supplied by an 11kV feeder (111) from Darfield Zone substation which is in turn supplied from Hororata GXP.

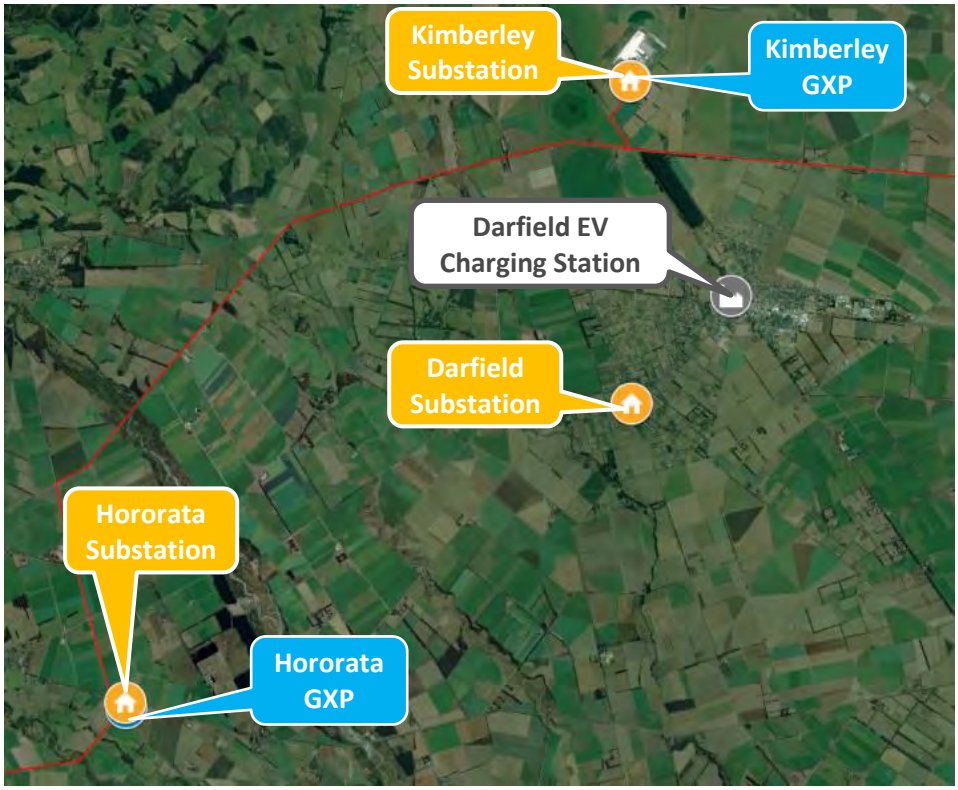


Figure 49 Darfield EV Charging Station geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The existing feeder (111) has a current peak load of ≈2.1MVA and as a result, the existing conductors are likely able to supply the additional load (up to 2.3MVA). Darfield zone substation does have sufficient spare capacity to supply the additional load. Darfield zone substation does have sufficient spare capacity to supply the additional load. However, as Hororata GXP (33kV) has no spare capacity, Ergo expects the additional supply would be better to come from Kimberley zone substation to the North.

Based on this, Ergo expects the supply would require a new 11kV feeder from the Kimberley zone substation, running down SH73 to the site. This would likely consist of ≈2.7km of overhead line.

In the long term, this additional load may be supplied by the redeveloped/relocated Darfield zone substation (renamed to Creyke Rd zone substation). This relocation is planned for financial years 30-31. While more detailed information on the proposed new substation is unknown, Ergo has

assumed that the costs associated with connecting to it (relating to a new or dedicated 11 kV feeder) will be approximately the same as the Kimberley connection.

Capital Cost Estimate

Table 16 Darfield EV Charging Station: 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 overhead 11kV line	2.70	$0.68
		TOTAL	**$0.78**

Does not include the costs of any 11kV distribution transformers/switchgear on the plant site.

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.

8.9.6 ANZCO Foods Rakaia

		ANZCO FOODS RAKAIA
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boilers and high temperature heat pump	0.95 MW	Hororata

Existing Electrical Supply to the Plant

ANZCO Foods Raikai is currently supplied by an 11kV feeder (114) from Killinchy substation which is in turn supplied from Hororata GXP (via Dunsandel).

Figure 50 ANZCO Foods Rakaia geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

The existing 11kV feeder (114) has a current peak load of ≈2.8MVA and the existing conductors are likely able to supply the additional load. Killinchy zone substation currently has sufficient spare (N) capacity to supply the additional load. However, Hororata 33kV GXP is currently constrained. Ergo has not considered an (N-1) security option for this site, as considering the size of the load and the configuration of the existing network, it would be prohibitively expensive to upgrade the network.

Therefore, Ergo expects the additional supply could only be supplied once the Norwood GXP has been commissioned and Killinchy (via Dunsandel) is tranferred onto the new GXP. Once this is complete, Ergo suspects the existing load could be supplied from the existing infrastructure. However, Orion expects that the additional load would cause voltage issues on the existing feeder. As such, the cost of a voltage regulator has been included for this site.

ANZCO FOODS RAKAIA
Capital Cost Estimate

Table 17 Darfield EV Charging Station: 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 Voltage Regulator	1.00 $0.40
Distribution	1000kVA distribution tx	1.00 $0.26
	TOTAL	**$0.66**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 3 – 6 months once the Norwood GXP been commissioned.

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.

8.9.7 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 an RMU and distribution transformers to supply the site.

Table 18 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Zone sub (N-1) spare capacity (MVA)	Zone sub (N) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Meadow Mushrooms Giggs Farm	Greendale*	-7	3	1.32	0.55	200

* It is expected that this load site would be supplied from Norwood GXP/zone substation upon the completion of the new substation

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.

8.9.8 Combined Load on Zone Substations

8.9.8.1 Greendale

Two of the loads on Hororata GXP are expected to connect to Greendale zone substation. The loads are Meadow Mushrooms Giggs Farm and Gladfield Malt Dunsandel. The sum of peaks of these loads is 2.52 MVA, which the zone substation does have (N) capacity for. Therefore, upgrades of Greendale zone substation are not considered.

8.9.9 Effect of all Load Sites Connecting to Hororata GXP

The following Figure 51 and Figure 52 illustrate the Hororata 2022 load profiles together with the load profiles of all the Load Sites within the Hororata GXP region. Also shown in Figure 51 and Figure 52 is:

- For Hororata 33 kV GXP:
  - The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Hororata 33 kV GXP would increase to 25.8 MVA, a difference of 5.6 MVA. Given that the independent sum of the individual load peaks is 25.97 MVA there is a diversity factor of 0.99 between the loads.
  - Based on Ergo's analysis, the Hororata 33 kV GXP's (N-1) limit is expected to be exceeded throughout the year.
- For Hororata 66 kV GXP:
  - The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Hororata 66 kV GXP would increase to 38.7 MVA, a difference of 2.4 MVA. Given that the independent sum of the individual load peaks is 39.8 MVA there is a diversity factor of 0.97 between the loads.

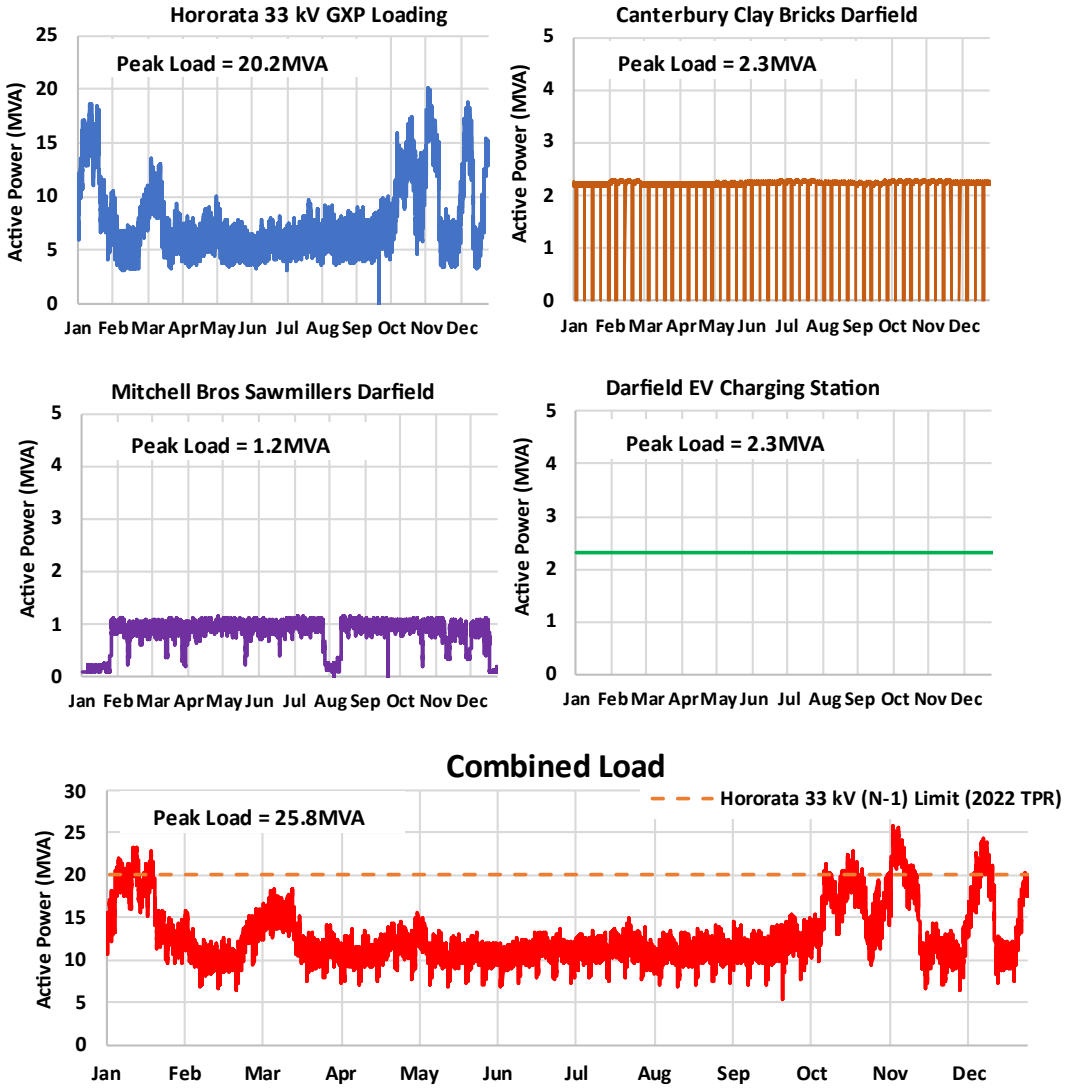


Figure 51 Loading Profiles: Hororata 33 kV GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

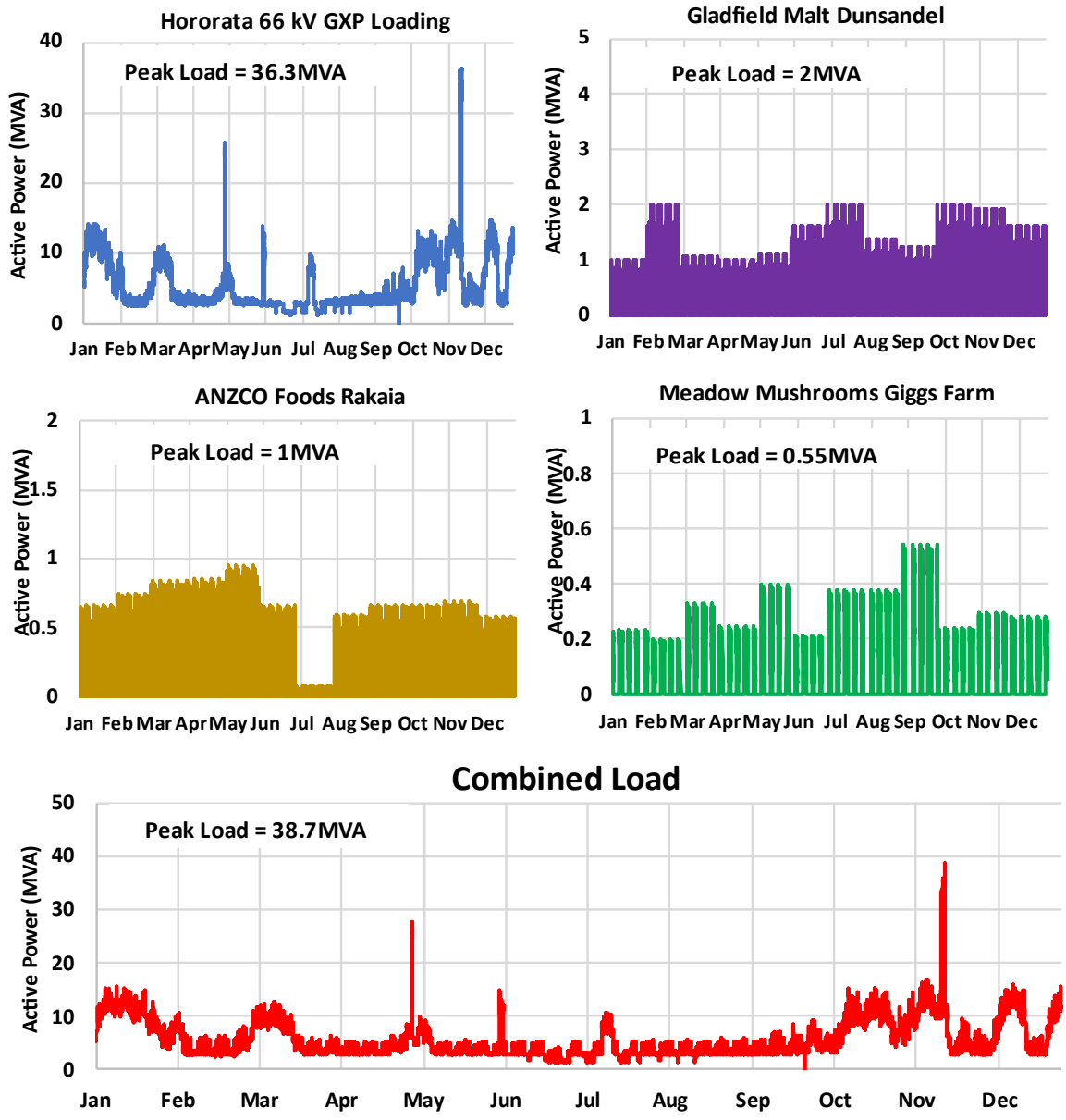


Figure 52 Loading Profiles: Horarata 66 kV GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.10 Islington GXP

The "Large" EECA Load Sites include:

- Synlait Milk Rakaia (16.55 MW (Boiler 2), 29.41 MW (Boilers 1 & 3)) (45.96 MW total)
- Kraft Heinz Christchurch (7.29 MVA)
- Goodman Fielder Christchurch (4.71 MVA)
- Air New Zealand Christchurch (biomass portion) (4.13 MVA)
- Valmont Christchurch (3.36 MVA)
- Westland Milk Products Rolleston (2.65 MVA)
- Hexion Hornby (2.30 MVA)
- Higgins Asphalt (1.95 MVA)
- Lincoln University (1.64 MVA)
- Silver Fern Farms Belfast (1.29 MVA)
- NZ Defence Force Burnham (1.28 MVA)
- St George's Hospital Inc. (1.24 MVA)
- Kisco Foods Christchurch (1.15 MVA)
- Expol Christchurch (1.15 MVA)

The "Small" Load Sites include (refer to Sections 8.10.16 and 8.10.18):

- Farmlands Rolleston (0.96 MVA)
- Expol Rolleston (0.58 MVA)
- Apparelmaster Christchurch (0.82 MVA)
- Air New Zealand Christchurch (LPG portion) (0.81 MVA)
- Christchurch Women's Prison (0.81 MVA)
- Hamilton Jet Christchurch (0.67 MVA)
- Ag Research Lincoln (0.61 MVA)
- Tegal Foods Ltd. Christchurch (0.60 MVA)
- Ara Institute of Canterbury Christchurch (0.57 MVA)
- Christchurch Men's Prison (0.56 MVA)
- Nova Trust Templeton (0.55 MVA)
- Southern Cross Healthcare (0.45 MVA)
- Hillmorton Hospital (0.45 MVA)
- Burnside High School (0.45 MVA)
- Christchurch City Council Civic Offices (0.39 MVA)
- Zealandia Horticulture Belfast (0.35 MVA)
- Oderings Nurseries Spreydon (0.29 MVA)
- Rochester & Rutherford Hall (0.28 MVA)
- Hornby High School (0.23 MVA)
- Lincoln High School (0.23 MVA)
- Riccarton High School (0.22 MVA)
- Christchurch City Council Botanic Gardens (0.22 MVA)
- Moffatt's Flower Company Limited (0.22 MVA)
- Barry's Bay Cheese (0.18 MVA)
- Kirkwood School (0.18 MVA)
- Holly Lea Christchurch (0.16 MVA)
- Kipp's Patch Microgreens Christchurch (0.15 MVA)

- Halswell Residential College (0.15 MVA)
- Commodore Hotel Christchurch (0.14 MVA)
- Breens Intermediate School (0.14 MVA) (refer to Sections 8.10.16 and 8.10.18)
- Clearwater Gardens (0.13 MVA)
- St Margaret's College (0.12 MVA)
- Bupa Ilam (0.12 MVA)
- Cobham Intermediate (0.12 MVA)
- Merrin School (0.12 MVA)
- Rolleston School (0.12 MVA)
- Feedco Canterbury Ltd. Rolleston (0.10 MVA)

The geographic locations of the Load Sites are shown on the following Figure 53 (wider region), Figure 54 (central/east Christchurch enlargement), and Figure 55 (west Christchurch enlargement) in relation to the local transmission and distribution substations.

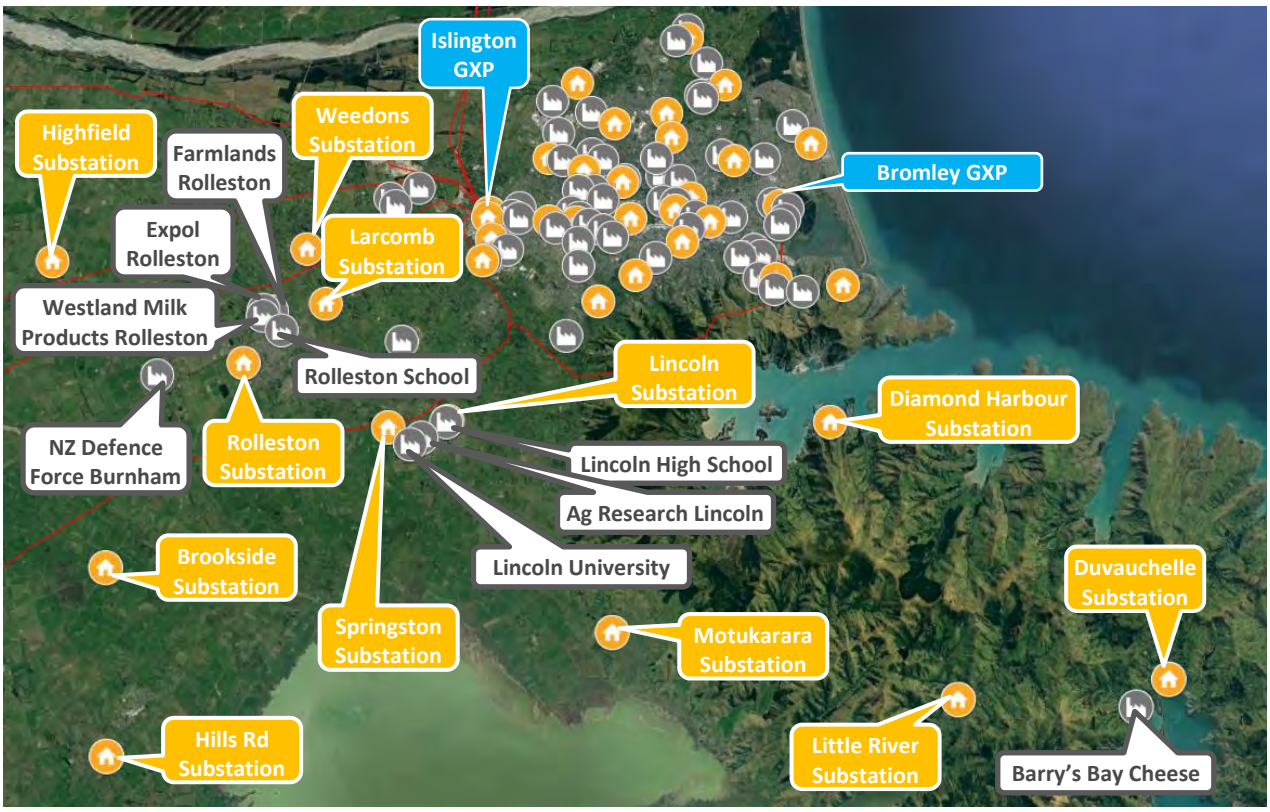


Figure 53 Islington GXP: Local zone substations and Load Sites

Figure 54 Islington GXP: EECA Load Sites vs local substations: Christchurch Central/East enlarged (loads are shared between Islington and Bromley GXPs)

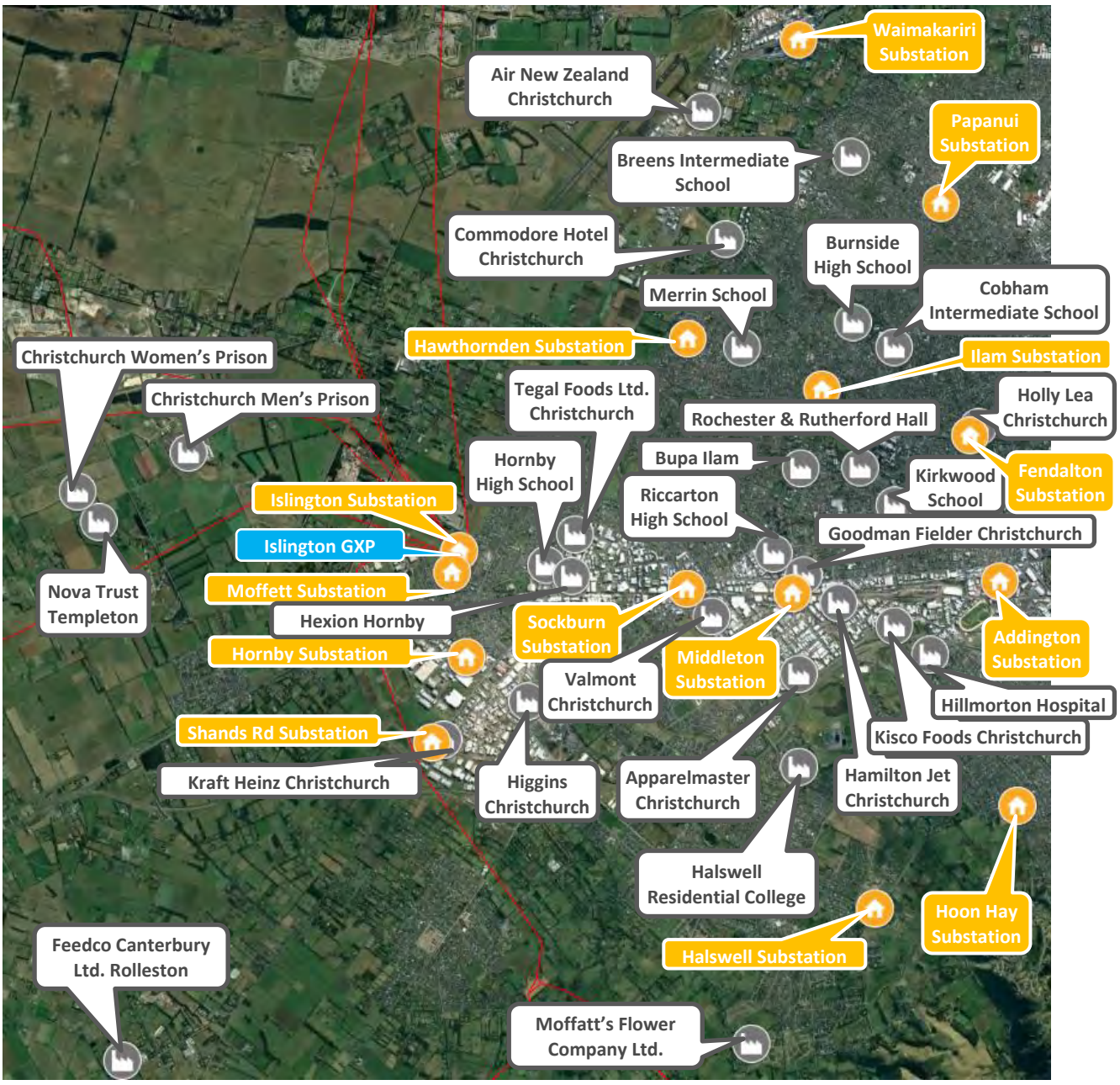


Figure 55 Islington GXP: EECA Load Sites vs local substations: Christchurch West enlarged

8.10.1 Islington GXP Upgrade

Transpower's demand forecast indicates that the Islington GXP has ≈16 MVA of (N-1) spare capacity and ≈116 MVA of (N) spare capacity at 33 kV. As discussed in Section 6.1.9, because the interconnecting transformers at Islington (200/66 kV) supply other areas of the network in a meshed configuration, the available capacity at Islington 66 kV GXP cannot exclusively be assigned to the load local to Islington GXP itself, and the available capacity of the transformers is unknown without a detailed powerflow study.

As shown by Section 8.10.19, the spare capacity at Islington GXP is not expected to be exceeded by the connecting loads and as such, upgrades at Islington GXP have not been considered.

8.10.2 Synlait Milk Rakaia

		SYNLAIT MILK RAKAIA
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	Stage 1 16.55 MW Stage 2 29.41 MW (45.96 MW total)	Islington (66kV)

Existing Electrical Supply to the Plant

Synlait Milk Rakaia is presently supplied by Orion's Dunsandel zone substation, which is supplied at 66 kV by Islington GXP via Springston zone substation.
The Dunsandel zone substation was built to supply the Synlait Milk plant when it was commissioned in 2008. As such, the zone substation is directly adjacent to the plant. Synlait has previously worked with Orion to install a large-scale electrode boiler on the site, in 2018.

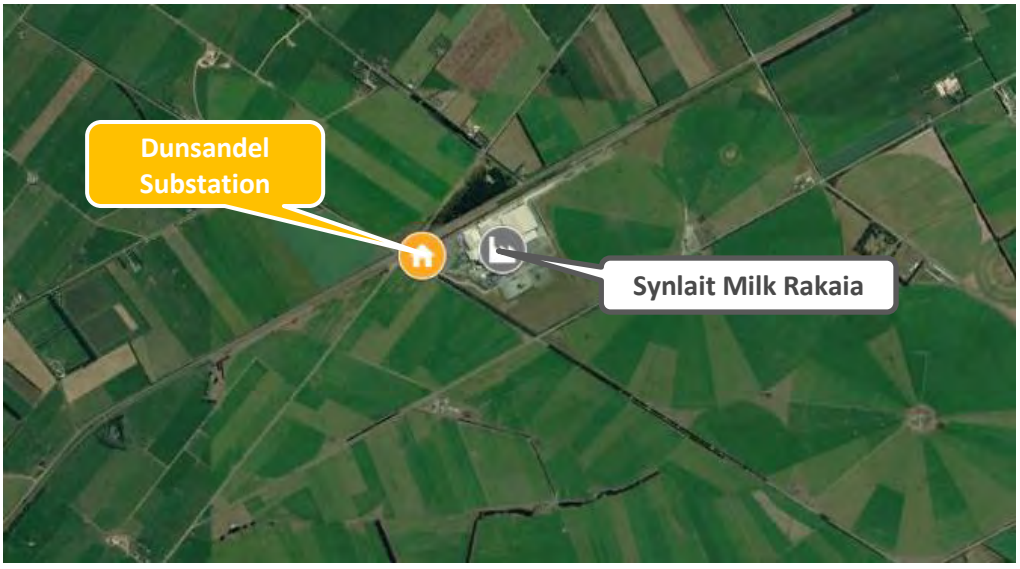


Figure 56 Synlait Milk Rakaia geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for this additional load, while Dunsandel zone substation has spare (N) capacity for the Stage 1 load, but not the Stage 2 load.

If an (N) security supply for Stage 1 only was acceptable, this could be supplied via three new dedicated 11kV circuit breakers and cabling from Dunandel zone substation.

Orion is constructing the new Norwood GXP near Dunsandel zone substation, with the GXP and related connections to zone substations being constructed in 2022-2026. To relieve the 66kV line constraint between Hororata and Dunsandel, Orion plans to connect Dunsandel zone substation to this new GXP; connection of Dunsandel substation to Norwood GXP will be complete at the end of financial year 2024. Orion have advised that the GXP will have capacity for the proposed load (Stage 1 and 2).

If Stage 1 and 2 were to proceed requiring an (N-1) connection, Orion have advised that the project would trigger a redevelopment of Dunsandel zone substation, whether the load connects at 66 kV or 11 kV. Ergo has assumed two new 66/11 kV transformers (with associated 66 kV switchgear) would be

required to supply the proposed load. Accompanying this would be a new 11 kV switchboard to supply the Synlait plant directly. Also included is the price for a second line between Norwood GXP and Dunsandel zone substation.

Ergo has assumed that the substation and line upgrades would take place during Stage 1, with only extra cabling involved for Stage 2.

Capital Cost Estimate

Table 19 Synlait Milk Rakaia: Capital cost estimate to supply the Load Site (Stage 1 (N) supply)

Transmission => (N-1)	Subtransmission => (N)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	3.00	$0.30
Distribution	Single underground 11kV cable	1.70	$1.02
		TOTAL	**$1.32**

Table 20 Synlait Milk Rakaia: Capital cost estimate to supply the Load Site (Stage 1 (N-1) supply)

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	Single overhead 66kV line	18.00	$6.30
Subtransmission	66kV circuit breaker bay	3.00	$1.95
Distribution	Large supply transformer (ZSS)	2.00	$4.60
Distribution	Large switchroom (ZSS)	1.00	$4.00
Distribution	Single underground 11kV cable	1.70	$1.02
		TOTAL	**$17.87**

Table 21 Synlait Milk Rakaia: Capital cost estimate to supply the Load Site (Stage 2 (N-1) supply,), assuming Stage 1 is completed first

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Single underground 11kV cable	3.40	$2.04
		TOTAL	**$2.04**

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

Timeframe to Establish New Electrical Infrastructure

Stage 1 (N) estimated to take 12 – 18 months.

Stage 1 and 2 (N-1) estimated to take 36 – 48 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.

8.10.3 Kraft Heinz Christchurch

KRAFT HEINZ CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	7.29 MW	Islington (33 kV)

Existing Electrical Supply to the Plant

The Kraft Heinz plant is presently supplied by Orion's Shands Rd zone substation, which is supplied at 33 kV by Islington GXP (underground cabled circuit), directly and via Hornby Zone substation (a mixture of underground cable and overhead conductors).
The plant is supplied directly by the Shands Rd zone substation 121 and 112 feeders. The Shands Rd 121 feeder is presently loaded at a maximum of 191 A (3.65 MVA); the Shands Rd 112 feeder is presently loaded at a maximum of 133 A (2.54 MVA). Both feeders are underground cabling, in different conductor sizes, of PILC cables.
The plant is ≈0.2 km (straight line) from Shands Rd substation.

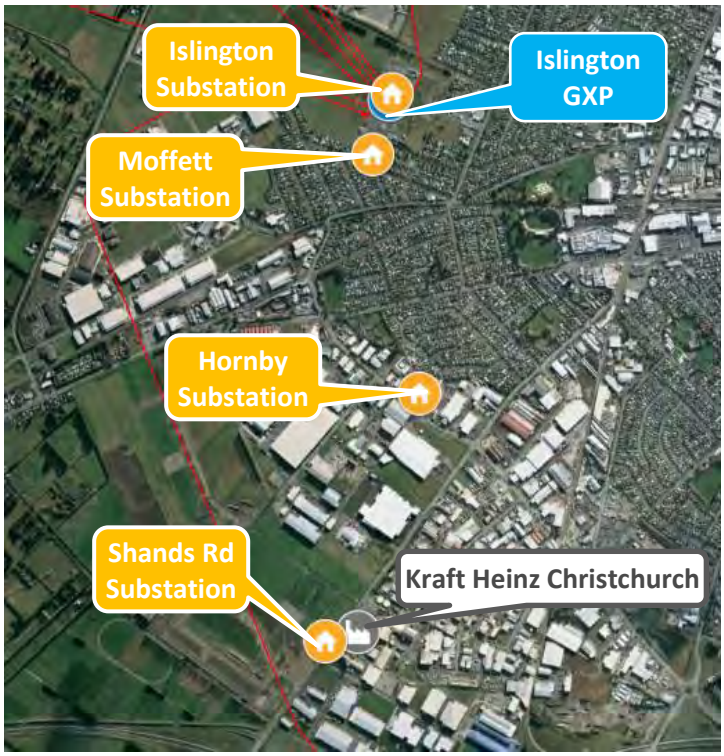


Figure 57 Kraft Heinz Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Islington GXP has sufficient (N-1) spare capacity, and Shands Rd zone substation has sufficient (N) spare capacity, to accommodate the additional load of 7.29 MW. The lines feeding Shands Rd substation have sufficient capacity to accommodate the additional load with (N-1) security, however, a transformer replacement and 11 kV bus upgrade would be required for the substation to accommodate the load with (N-1) security.

In order to connect the proposed load, Ergo expects that one new 11 kV feeder to the site from Shands Rd substation would be required. This feeder would likely be underground cabled, matching

the existing supply. Orion has advised that typically dual transformer substations such as Shands Rd are not to exceed their (N-1) capacity, however, a special protection system could be installed at Shands Rd to manage the risk of cascade failure in the interim (until the aforementioned transformer and switchboard upgrades).

Capital Cost Estimate

Table 22 Kraft Heinz Christchurch: Capital cost estimate to supply the Load Site with (N) security at the site

Transmission => (N-1)	Subtransmission => (N)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Special protection system (ZSS)	1.00	$0.25
Distribution	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	0.70	$0.42
		TOTAL	**$0.52**

Table 23 Kraft Heinz Christchurch: Capital cost estimate to supply the Load Site with (N-1) security at the site

Transmission => (N-1)	Subtransmission => (N-1)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	Large supply transformer (ZSS)	2.00	$4.60
Distribution	11kV circuit breaker (ZSS)	13.00	$1.30
Distribution	Single underground 11kV cable	0.70	$0.42
		TOTAL	**$6.32**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12 – 18 months for (N) and 18-24 months for (N-1)

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.

8.10.4 Goodman Fielder Christchurch

GOODMAN FIELDER CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	4.71 MW	Islington (66 kV)

Existing Electrical Supply to the Plant

The Goodman Fielder Christchurch plant is presently supplied by Orion's Middleton zone substation, which is supplied at 66 kV by Islington GXP (2x overhead conductor double circuits).
The plant is supplied by the Middleton zone substation feeders 4 and 19 primary ring, which includes feeder 9. The Middleton 4 feeder is presently loaded at a maximum of 129 A (2.45 MVA); the Middleton 19 feeder is presently loaded at a maximum of 127 A (2.41 MVA); the Middleton 9 feeder is presently loaded at a maximum of 100 A (1.91 MVA). All three feeders are underground cabling, with a mixture of conductor sizes as well as a mix of XLPE and PILC.
The plant is ≈0.3 km (straight line) from Middleton substation.

Figure 58 Goodman Fielder Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for this additional load, and Middleton zone substation has sufficient (N-1) spare capacity to accommodate the additional load of 4.71 MW. In order to connect the proposed load, Orion has advised that a new dedicated 11 kV feeder from the zone substation would likely be required, which will avoid overloading the existing primary ring supplying the site. Due to the urban topography, the new feeder would likely be underground cabling.

GOODMAN FIELDER CHRISTCHURCH

Capital Cost Estimate

Table 24 Goodman Fielder Christchurch: 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)	0.40 $0.32
	TOTAL	**$0.42**

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.

8.10.5 Air New Zealand Christchurch (biomass portion)

AIR NEW ZEALAND CHRISTCHURCH (BIOMASS PORTION)		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	4.13 MW	Islington (66 kV)

Existing Electrical Supply to the Plant

Air New Zealand Christchurch is presently supplied by Orion's Waimakariri zone substation, which is supplied at 66 kV by Islington GXP (2x overhead conductor double circuits).
The plant is supplied by the Waimakariri zone substation 19 feeder. The Waimakariri 19 feeder is presently loaded at a maximum of 170 A (3.24 MVA). The feeder is a mixture of sizes of underground XLPE cables.
The plant is ≈1.7 km (straight line) from Waimakariri substation.

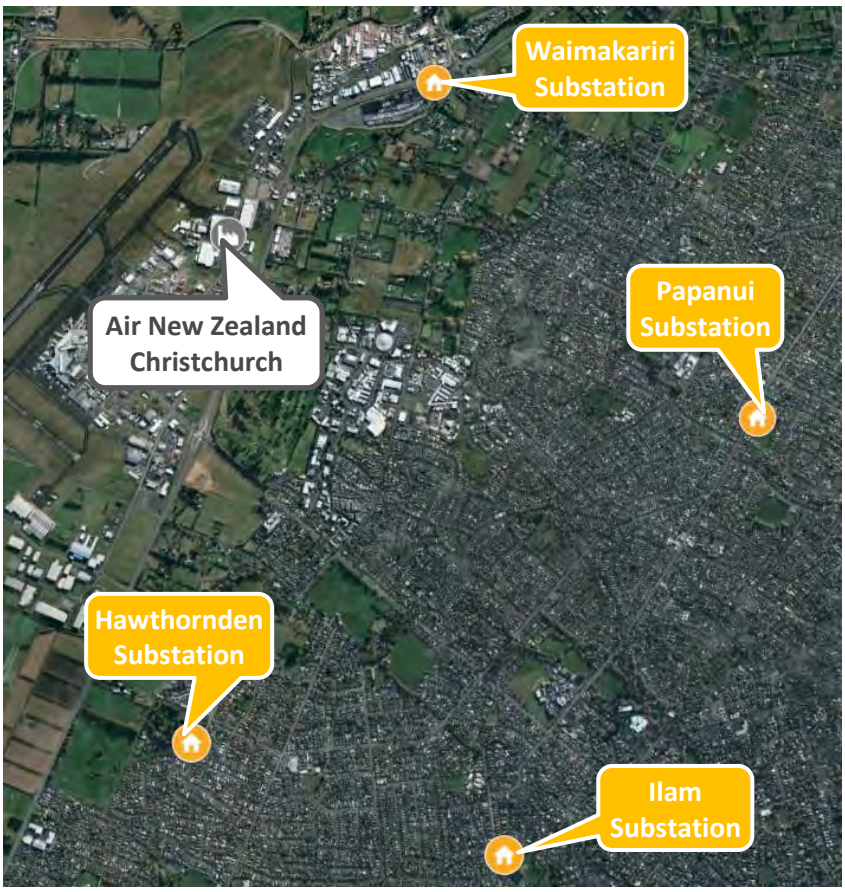


Figure 59 Air New Zealand Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for this additional load, and Waimakariri zone substation has sufficient (N-1) spare capacity to accommodate the additional load of 4.13 MW. In order to connect the proposed load, Ergo expects that a new dedicated 11 kV feeder from the zone substation would be required. Due to the urban topography, the new feeder would likely be underground cabling.

AIR NEW ZEALAND CHRISTCHURCH (BIOMASS PORTION)
Capital Cost Estimate

Table 25 Air New Zealand Christchurch (biomass portion): 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 of any distribution transformers/switchgear on the plant site.

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.

8.10.6 Valmont Christchurch

VALMONT CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	3.36 MW	Islington (33 kV)

Existing Electrical Supply to the Plant

Valmont Christchurch is presently supplied by Orion's Sockburn zone substation, which is supplied at 33 kV by Islington GXP (3x underground cable circuits).
The plant is supplied by the Sockburn zone substation 114 feeder. The Sockburn 114 feeder is presently loaded at a maximum of 109 A (2.08 MVA). The feeder is a mixture of sizes of underground XLPE and PILC cables.
The plant is ≈0.5 km (straight line) from Sockburn substation.

Figure 60 Valmont Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Islington GXP and Sockburn zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 3.36 MW. In order to connect the proposed load, Ergo expects that a new dedicated 11 kV feeder from the zone substation would be required. Due to the urban topography, the new feeder would likely be underground cabling.

Capital Cost Estimate

Table 26 Valmont Christchurch: 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**

VALMONT CHRISTCHURCH
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.

8.10.7 Westland Milk Products Rolleston

WESTLAND MILK PRODUCTS ROLLESTON		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	2.65 MW	Islington (66 kV)

Existing Electrical Supply to the Plant

Westland Milk Products Rolleston is presently supplied by Orion's Weedons zone substation, which is supplied at 66 kV by Islington GXP via a single circuit comprised of a mix of overhead conductors and underground cables.
The plant is supplied by the Weedons zone substation 121 feeder. The Weedons 121 feeder is presently loaded at a maximum of 252 A (4.79 MVA). The feeder is a mixture of sizes of underground XLPE cables. The other two feeders from Weedons zone substation which feed the same area (123 and 111) are similarly loaded, as is the Rolleston zone substation feeder (112) which runs in the road nearby.
The plant is ≈4.2 km (straight line) from Weedons substation.

Figure 61 Westland Milk Products Rolleston geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for this additional load, and Weedons zone substation has sufficient (N-1) spare capacity to accommodate the additional load of 2.65 MW. Orion has advised that it would be most likely that this additional load would be fed from the planned Railway Rd 11 kV switching station, fed by the new Burnham zone substation. The Railway Rd switching station is expected to be built/commissioned during financial years 26-27. The switching

station is being planned to supply the load at the Rolleston industrial park, so Ergo expects that the new switching station will be nearer to the load than the three nearby zone substations.

In order to connect the proposed load, Ergo expects that a new dedicated 11 kV feeder from the switching station would be required. Matching the existing supply, the new feeder would likely be underground cabling. Ergo has conservatively assumed a length of 4 km for the new feeder, while the location of the new switching station is unknown.

Capital Cost Estimate

Table 27 Westland Milk Products Rolleston: 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	4.00	$2.40
		TOTAL	**$2.50**

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

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.

8.10.8 Hexion Hornby

		HEXION HORNBY
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	2.30 MW	Islington (33 kV)

Existing Electrical Supply to the Plant

Hexion Hornby is presently supplied by Orion's Moffett zone substation, which is supplied at 33 kV by Islington GXP via two circuits comprised of underground cables.
The plant is supplied by the Moffett zone substation 113 feeder. The Moffett 113 feeder is presently loaded at a maximum of 233 A (4.43 MVA). The feeder is a mixture of sizes of underground XLPE and PILC cables. There are two other feeders which could supply the site, Hornby 121, and Sockburn 131. The Hornby 121 feeder is loaded similarly to Moffett 113, while Sockburn 131 is more lightly loaded, at 176 A (3.36 MVA).
The plant is ≈1.6 km (straight line) from Moffett substation, ≈1.8 km (straight line) from Hornby substation; and ≈1.6 km (straight line) from Sockburn substation.

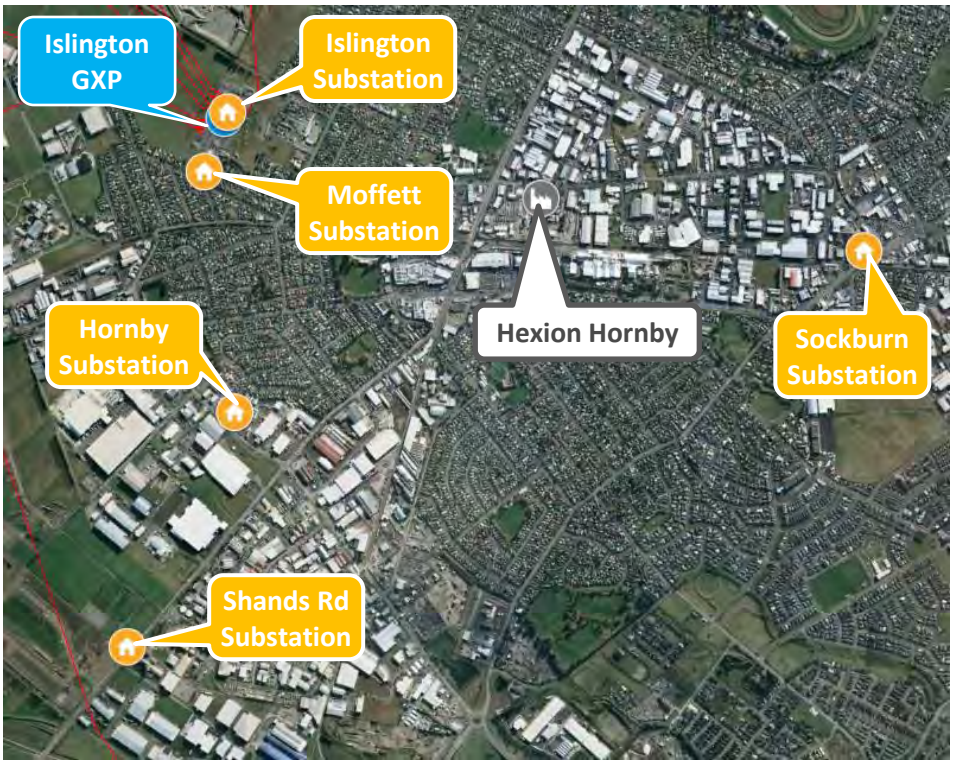


Figure 62 Hexion Hornby geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Islington GXP and Moffett zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 2.30 MW. In order to connect the proposed load, Ergo expects that a new dedicated 11 kV feeder from the zone substation would be required. Due to the urban topography, the new feeder would likely be underground cabling.

HEXION HORNBY

Capital Cost Estimate

Table 28 Hexion Hornby: 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)	1.90	$1.52
		TOTAL	**$1.62**

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.

8.10.9 Higgins Christchurch

		HIGGINS CHRISTCHURCH
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	1.95 MW	Islington (33 kV)

Existing Electrical Supply to the Plant

The Higgins Christchurch plant is presently supplied by Orion's Branston Rd No. 76 building substation, which is supplied by Hornby zone substation. Horny zone substation is supplied at 33 kV by Islington (two underground cable circuits).
The building substation which supplies the site is supplied directly from Hornby zone substation feeder 111. The Hornby 111 feeder is presently loaded at a maximum of 171 A (3.26 MVA). The feeder is underground cabling, in different conductor sizes, of PILC and XLPE cables.
The plant is ≈1 km (straight line) from Hornby substation.

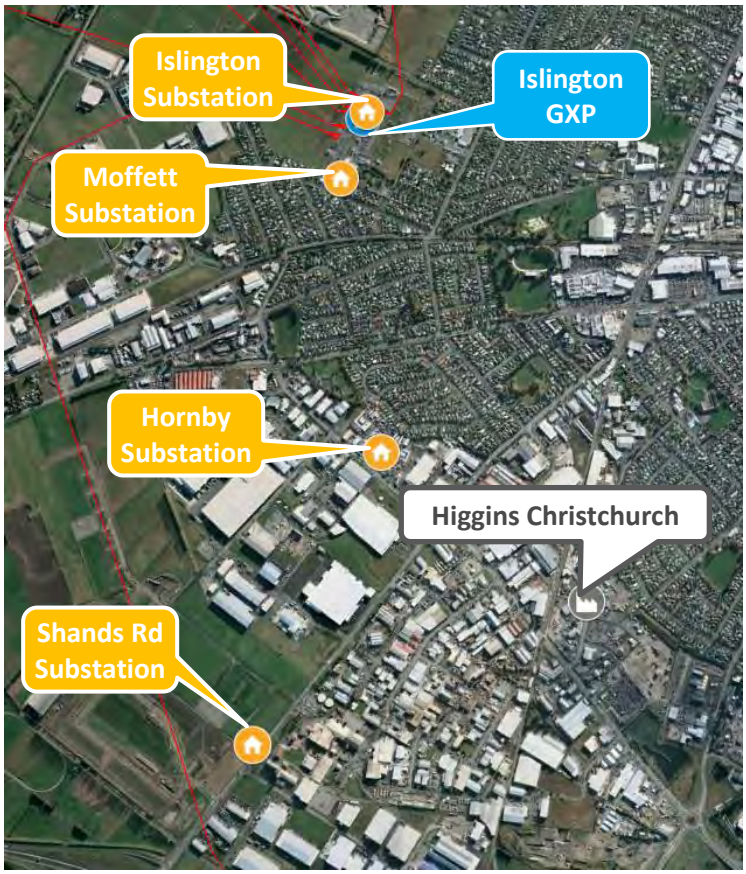


Figure 63 Higgins Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Islington GXP and Hornby zone substation have sufficient (N-1) spare capacity to accommodate the additional load of 1.95 MW. It is expected that addition of the proposed load would overload the existing feeder supplying Branston Rd No.76 building substation.

HIGGINS CHRISTCHURCH

In order to connect the proposed load, Ergo expects that one new 11 kV feeder to the site from Hornby substation would be required. This feeder would likely be underground cabled, matching the existing supply.

Capital Cost Estimate

Table 29 Higgins Christchurch: Capital cost estimate to supply the Load Site with (N-1) security at the 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)	1.50	$1.20
		TOTAL	**$1.30**

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

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.

8.10.10 Lincoln University

		LINCOLN UNIVERSITY
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	1.64 MW	Islington (33kV)

Existing Electrical Supply to the Plant

Lincoln University is presently supplied by Orion's Springston zone substation, which is supplied at 33 kV by Islington GXP via two circuits, one of which is from Islington via Shands Rd zone substation, the other is from Islington via Hornby, Prebbleton, and Lincoln zone substations.
The plant is supplied by the Springston zone substation 115 feeder. The Springston feeder is presently loaded at a maximum of 102 A (1.95 MVA). The feeder is a mixture of sizes of underground XLPE cables. Four other feeders are nearby, Springston 114, 133 and 134, and Lincoln 113, which are similarly loaded.
The university is ≈1.4 km (straight line) from Springston substation, and ≈2.2 km (straight line) from Lincoln substation.

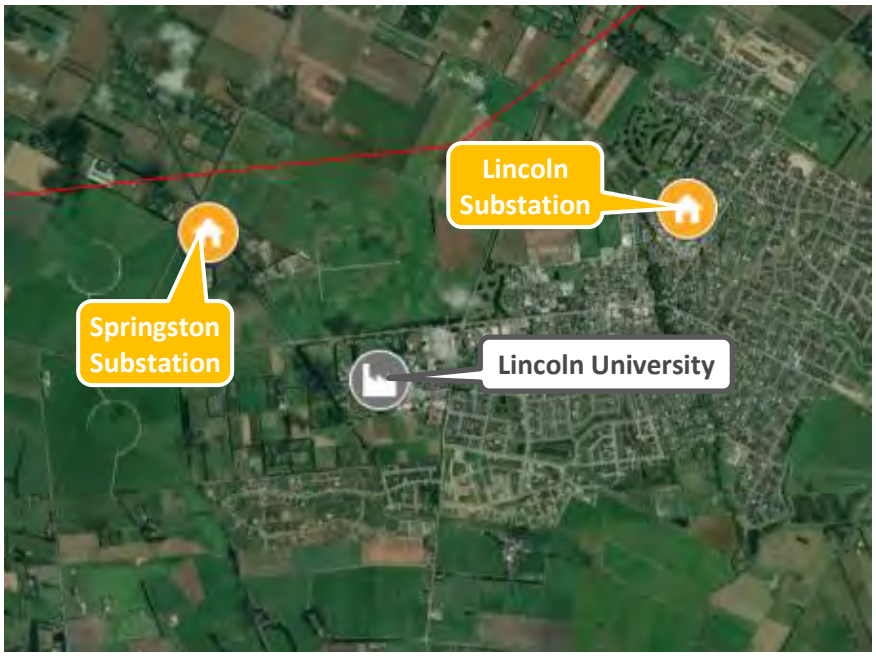


Figure 64 Lincoln University geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Islington GXP has sufficient (N-1) spare capacity for the additional 1.64 MW of load. Orion has advised that Springston zone substation will have an (N-1) capacity of 23 MVA by the end of financial year 25, at which point Springston will have capacity for the additional load.

Lincoln University has a private network which is supplied by 2x 300 mm^2 Al cable feeders from Springston zone substation, and no further upgrades to the Orion network should be required to connect the additional load.

Capital Cost Estimate

There is no expected cost to Orion's network associated with this proposed load.

LINCOLN UNIVERSITY
Does not include the costs of any switchgear/equipment on the plant site.
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.

8.10.11 Silver Fern Farms Belfast

SILVER FERN FARMS BELFAST		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	1.29 MW	Islington (66 kV)

Existing Electrical Supply to the Plant

Silver Fern Farms Belfast is presently supplied by Orion's Belfast zone substation, which is supplied by Islington GXP at 66 kV.
The site is supplied via the Factory Rd No.85 substation building, which has two direct supplies from Belfast zone substation.
The plant is ≈0.5 km (straight line) from Belfast substation.

Figure 65 Silver Fern Farms Belfast geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for the additional 1.29 MW of load.

Due to the Belfast substation's recent completion, as well as the proximity to the plant site and the size of the existing 11 kV feeder cables in the area, it is expected that Belfast zone substation has sufficient (N) capacity to supply the additional load. This will be upgraded to (N-1) security at the completion of the Belfast second transformer project (projected for financial years 26-27) and the cable links projects (projected for financial years 23-24).

Ergo expects that the costs associated with this connection would be related to any required distribution transformers or site equipment.

Capital Cost Estimate
Ergo estimates that the cost for an RMU and 2x 750 kVA distribution transformers for this load would be ≈$0.40M. Does not include the costs of any switchgear/equipment on the plant site.
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.

8.10.12 NZ Defence Force Burnham

NZ DEFENCE FORCE BURNHAM		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	1.28 MW	Islington (33 kV)

Existing Electrical Supply to the Plant

NZ Defence Force Burnham is presently supplied by Orion's Rolleston zone substation, which is supplied at 33 kV by Islington GXP via Shands Road zone substation.
The plant is supplied by the Rolleston zone substation 111 feeder. The Rolleston 111 feeder is presently loaded at a maximum of 182 A (3.48 MVA). The feeder is a mixture of sizes of underground XLPE and PILC cables as well as overhead conductors.
The plant is ≈4.4 km (straight line) from Rolleston substation.

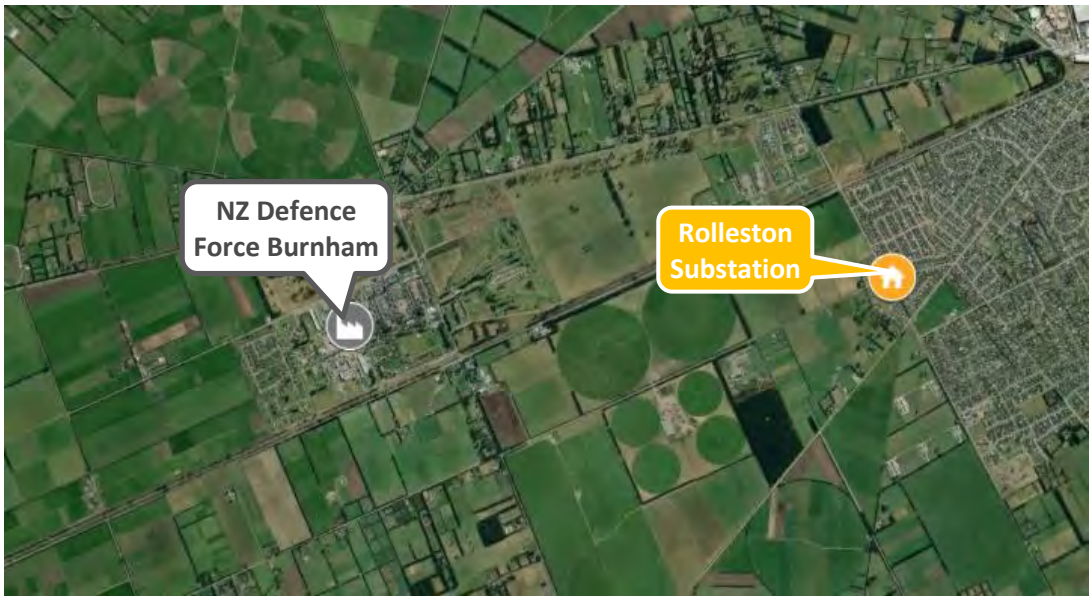


Figure 66 NZ Defence Force Burnham geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Islington GXP has sufficient (N-1) capacity for this additional load, while Rolleston substation has sufficient (N) capacity. Orion has a project planned (Runners Rd 11 kV feeder project) to install a dedicated underground cabled circuit from Rolleston zone substation to Burnham Camp. This project is scheduled for financial year 24, with the upgrade agreed with NZDF already. Ergo has estimated the cost of this project, including 6.6 km of underground cable and a new circuit breaker at Rolleston zone substation.

Ergo notes that, with the increasing load at Rolleston town, increased network capacity is required, and Orion has several projects planned to remedy these capacity issues. These include a new GXP at Norwood (projected for financial year 24), along with a 66 kV switching station (projected for financial years 22-23), and a new zone substation at Burnham (projected for financial years 25-26).

NZ DEFENCE FORCE BURNHAM

Capital Cost Estimate

Table 30 NZ Defence Force Burnham: 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	6.60	$3.96
			$3.96

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

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.

8.10.13 St George's Hospital Inc.

ST GEORGE'S HOSPITAL INC.		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and high temperature heat pump	1.24 MW	Islington (33kV)
Existing Electrical Supply to the Plant		

St George's Hospital Inc. is presently supplied by Orion's McFaddens zone substation, which is supplied at 33 kV by Islington GXP via Papanui zone substation.
The plant is supplied by the McFaddens zone substation 24 feeder. The McFaddens 24 feeder is presently loaded at a maximum of 203 A (3.86 MVA). The feeder is a mixture of sizes of underground XLPE and PILC cables.
The plant is ≈1.4 km (straight line) from McFaddens substation.

Figure 67 St George's Hospital Inc. geographic location in relation to the surrounding zone substations

ST GEORGE'S HOSPITAL INC.

Supply Option(s) for New Load

Islington GXP and McFaddens zone substation have sufficient (N-1) capacity for the additional 1.24 MW of load. Ergo expects that, to connect the additional load, replacement of the existing underground 0.04in^2 (25mm^2) to 0.06in^2 Copper PILC and 95mm^2 Aluminium PILC cables would be required (a total length of 3.6 km).

Capital Cost Estimate

Table 31 St George's Hospital Inc.: 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)	3.60	$2.88
			$2.88

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.

8.10.14 Kisco Foods Christchurch

KISCO FOODS CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	1.15 MW	Islington (66 kV)

Existing Electrical Supply to the Plant

Kisco Foods Christchurch is presently supplied by Orion's Middleton zone substation, which is supplied at 66 kV by Islington GXP.
The plant is supplied by the Middleton zone substation 2 feeder. The Middleton 2 feeder is presently loaded at a maximum of 179 A (3.41 MVA). The feeder is a mixture of sizes of underground XLPE and PILC cables.
The plant is ≈1.5 km (straight line) from Middleton substation, and ≈1.6 km (straight line) from Addington substation.

Figure 68 Kisco Foods Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for this additional load , and Middleton zone substation has sufficient (N-1) capacity for the additional 1.15 MW of load. Ergo expects that, to connect the additional load, replacements of the existing underground 95mm^2 Aluminium PILC and XLPE cables between the site and Middleton zone substation may be required (a total length of 0.2 km).

KISCO FOODS CHRISTCHURCH

Capital Cost Estimate

Table 32 Kisco Foods Christchurch: 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)	0.20 $0.16
		$0.16

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.

8.10.15 Expol Christchurch

EXPOL CHRISTCHURCH		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers	1.15 MW	Islington (66 kV)

Existing Electrical Supply to the Plant

Silver Fern Farms Belfast is presently supplied by Orion's Belfast zone substation, which is supplied by Islington GXP at 66 kV.
The site is supplied via the Station Rd No.20 substation building.
The plant is ≈0.6 km (straight line) from Belfast substation.

Figure 69 Expol Christchurch geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

It is assumed that Islington 66 kV GXP has spare (N-1) capacity for the additional 1.15 MW of load.

Due to the Belfast substation's recent completion, as well as the proximity to the plant site, it is expected that Belfast zone substation has sufficient (N) capacity to supply the additional load. This will be upgraded to (N-1) security at the completion of the Belfast second transformer project (projected for financial years 26-27) and the cable links projects (projected for financial years 23-24).

Ergo expects that to connect the proposed load, replacements of the ~0.6km of 95mm^2 Aluminium cables which presently supply the site would be required.

EXPOL CHRISTCHURCH

Capital Cost Estimate

Table 33 Expol Christchurch: 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)	0.60	$0.48
		TOTAL	**$0.48**

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

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.

8.10.16 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 an RMU and distribution transformer to supply the site.

Table 34 Summary of the "small" Load Sites that are unlikely to have a material effect on the MV/HV network

Opportunity name	Zone sub	Zone sub (N-1) spare capacity (MVA)	Zone sub (N) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Farmlands Rolleston	Weedons	9	32	4.90	0.96	260
Expol Rolleston	Weedons	9	32	4.79	0.58	200
Apparelmaster Christchurch	Middleton	14	54	2.96	0.82	260
Air New Zealand Christchurch	Waimakariri	21	61	3.24	0.81	260
Christchurch Womens Prison	Moffett	9	32	3.82	0.81	260
Hamilton Jet Christchurch	Middleton	14	54	3.55	0.67	200
Ag Research Lincoln	Lincoln	0	10	6.57	0.61	200
Tegal Foods Ltd Christchurch	Sockburn	16	46	3.36	0.60	200
Ara Institute of Canterbury Christchurch	Oxford Tuam	25	65	1.06	0.57	200
Christchurch Mens Prison	Moffett	9	32	3.82	0.56	200
Nova Trust Templeton	Moffett	9	32	3.82	0.55	200
Southern Cross Healthcare Christchurch	Armagh	22	62	4.49	0.45	130
Hillmorton Hospital	Middleton	14	54	2.96	0.45	130
Burnside High School	Hawthornden	7	47	3.07	0.45	130
Christchurch City Council Civic Offices	Oxford Tuam	25	65	1.73	0.39	130
Zealandia Horticulture Belfast*	Belfast	#N/A	#N/A	4.34	0.35	130
Oderings Nurseries Spreydon	Milton	5	45	4.08	0.29	130
Rochester & Rutherford Hall	Ilam	4	15	1.90	0.28	130
Hornby High School	Hornby	7	27	4.50	0.23	130
Lincoln High School	Lincoln	0	10	4.32	0.23	130
Riccarton High School	Sockburn	16	46	1.22	0.22	130

Opportunity name	Zone sub	Zone sub (N-1) spare capacity (MVA)	Zone sub (N) spare capacity (MVA)	Current Feeder loading (MW)	Opportunity Load (MW)	Estimate cost ($k)
Christchurch City Council Botanic Gardens	Oxford Tuam	25	65	1.12	0.22	130
Moffatt's Flower Company Limited	Halswell	4	27	3.90	0.22	130
Barry's Bay Cheese	Duvauchelle	3	11	0.63	0.18	80
Kirkwood School	Middleton	14	54	2.92	0.18	80
Holly Lea Christchurch	Fendalton	5	45	2.72	0.16	80
Kipp's Patch Microgreens Christchurch	Dallington	12	52	5.82	0.15	80
Halswell Residential College	Halswell	4	27	2.21	0.15	80
Commodore Hotel Christchurch	Hawthornden	7	47	4.82	0.14	80
Breens Intermediate School	Papanui	6	38	1.44	0.14	80
Clearwater Gardens	Dallington	12	52	5.82	0.13	80
St Margaret's College	Fendalton	5	45	3.42	0.12	80
Bupa Ilam	Middleton	14	54	2.45	0.12	80
Cobham Intermediate	Ilam	4	15	1.90	0.12	80
Merrin School	Hawthornden	7	47	2.41	0.12	80
Rolleston School	Larcomb	9	32	5.87	0.12	80
Feedco Canterbury Ltd Rolleston	Larcomb	9	32	2.44	0.10	50

*Note these sites will be fed by the new Belfast zone substation, but are presently fed by Grimseys-Winters 11 kV switching station feeders 12, 17, and 18. The loads supplied are for the most heavily loaded of the relevant Grimseys-Winters feeders. Ergo expects there will be no issue connecting the proposed loads to the Belfast Substation.

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.

8.10.17 Combined Load on Zone Substations

8.10.17.1 Zone substations with 2 or 3 connecting opportunities

A number of zone substations supplied by Islington GXP are expected to have 2 or 3 opportunities connect. These zone substations are:

- Belfast (3 loads)
- Fendalton (2 loads)
- Halswell (2 loads)
- Hawthornden (3 loads)
- Hornby (2 loads)
- Ilam (2 loads)
- Larcomb (2 loads)
- Lincoln (2 loads)
- Milton (2 loads)
- Oxford-Tuam (3 loads)
- Sockburn (3 loads)
- Waimakariri (2 loads)
- Weedons (3 loads)

All of these substations are expected to have capacity for the proposed loads (considering the sum of the peaks of the loads), at their existing substation security level. Therefore upgrades to the above substations are not considered.

8.10.17.2 Dallington

Four of the loads on Islington GXP are expected to connect to Dallington zone substation. The loads are all “small” loads and are: Kipp’s Patch Microgreens Christchurch, Clearwater Gardens, Shirley Intermediate School, and Chisnallwood Intermediate School. The sum of peaks of these loads is 0.53 MVA, which the zone substation has (N-1) capacity for. Therefore, upgrades of Dallington zone substation are not considered.

8.10.17.3 Middleton

Seven of the loads on Islington GXP are expected to connect to Middleton zone substation. The loads are: Goodman Fielder Christchurch, Kisco Foods Christchurch; and “small” loads Apparelmaster Christchurch, Hamilton Jet Christchurch, Hillmorton Hospital, Kirkwood School, and Bupa Ilam. The sum of peaks of these loads is 0.53 MVA, which the zone substation has (N-1) capacity for. Therefore, upgrades of Middleton zone substation are not considered.

8.10.17.4 Moffett

Four of the loads on Islington GXP are expected to connect to Moffett zone substation. The loads are: Hexion Hornby, and “small” loads Christchurch Womens Prison, Christchurch Mens Prison, and Nova Trust Templeton. The sum of peaks of these loads is 4.71 MVA, which the zone substation has (N-1) capacity for. Therefore, upgrades of Moffett zone substation are not considered.

8.10.18 Combined Load of Small Opportunities

Summing the maximum values of the "small" loads on Islington 33 kV GXP gives a combined load of 4.00 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 70), with a maximum load of 3.32 MVA, with a diversity factor of 0.83.

Summing the maximum values of the "small" loads on Islington 66 kV GXP gives a combined load of 9.26 MVA. However, when the load shapes are combined, they result in the load shape shown in Figure 72, with a maximum load of 7.04 MVA, with a diversity factor of 0.76.

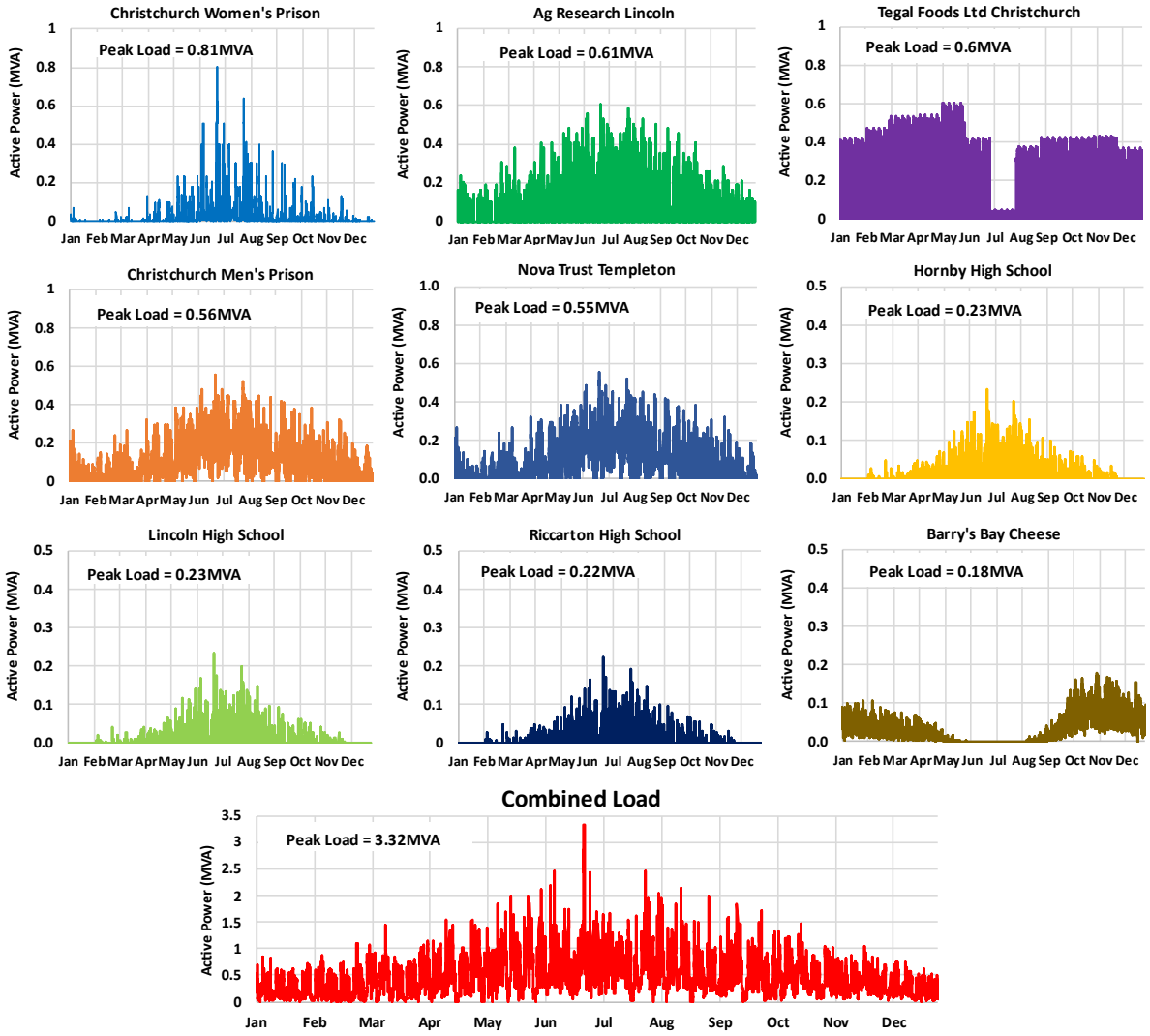


Figure 70 Loading Profiles: Islington 33 kV GXP "small" Load Site Profiles: Combined Load (sum of all profiles)

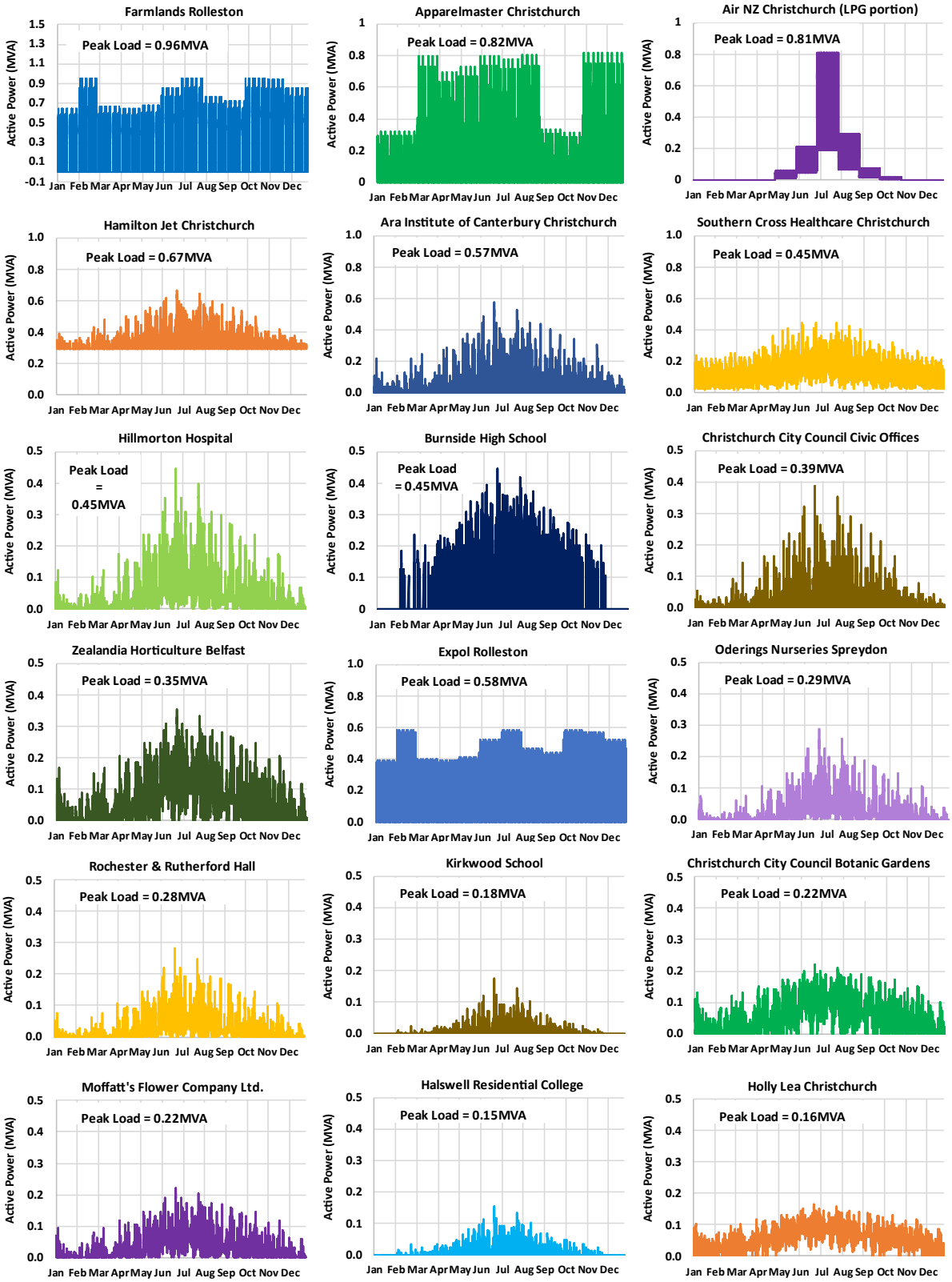


Figure 71 Loading Profiles (#1): Islington 66 kV GXP "small" Load Site Profiles

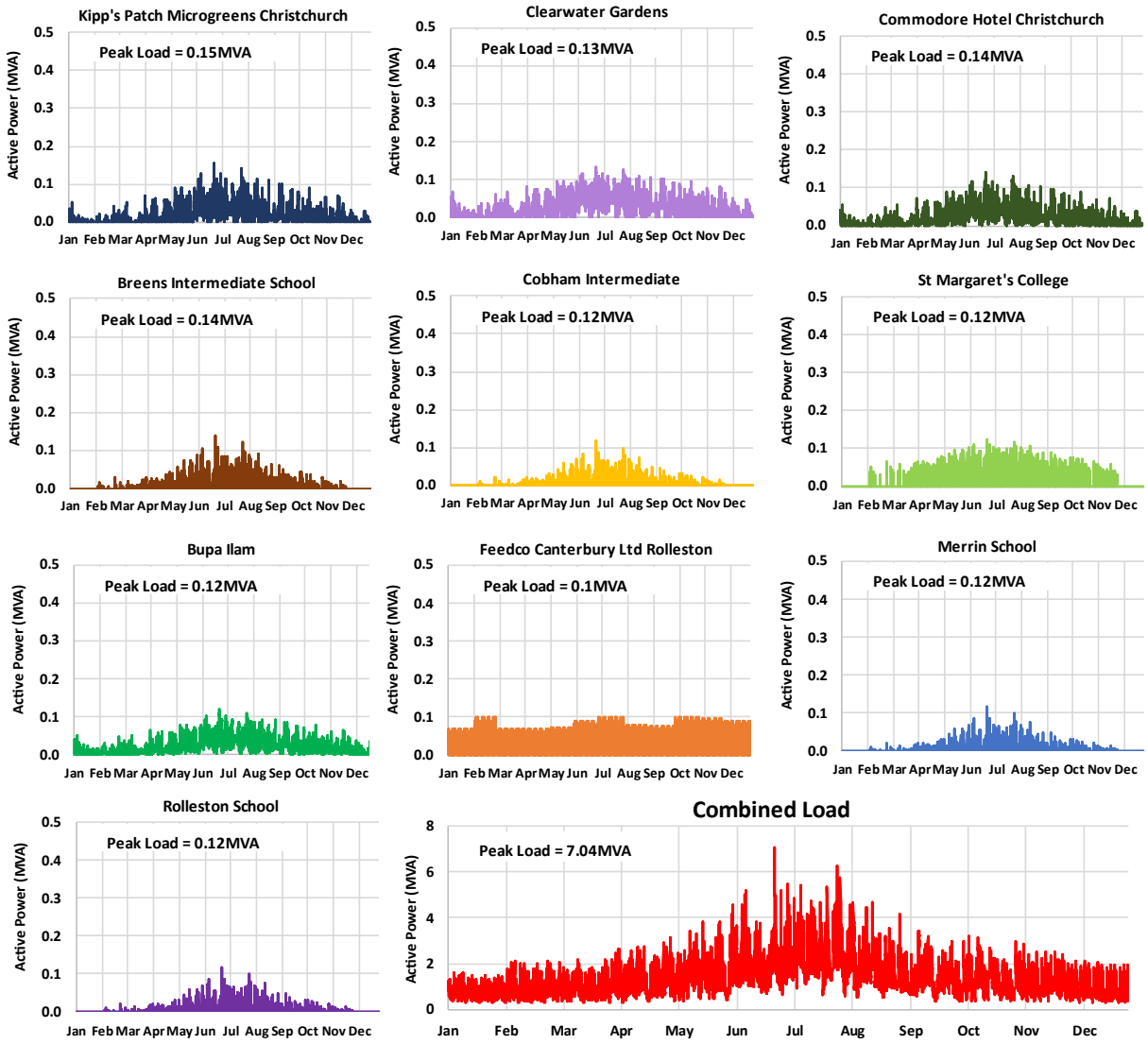


Figure 72 Loading Profiles (#2): Islington 66 kV GXP "small" Load Site profiles and Combined Load (sum of all profiles)

8.10.19 Effect of all Load Sites Connecting to Islington GXP

The following Figure 73 and Figure 74 illustrate the Islington 2022 load profile together with the load profiles of all the Load Sites within the Islington GXP region. Also shown in Figure 73 and Figure 74 is:

- For Islington 33 kV GXP:
  - The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Islington 33 kV GXP would increase to 89.2 MVA, a difference of 12.6 MVA. Given that the independent sum of the individual load peaks is 96.8 MVA there is a diversity factor of 0.92 between the loads.
  - Based on Ergo's analysis, the Islington 33 kV GXP's (N-1) limit is not expected to be exceeded.
- For Islington 66 kV GXP:
  - The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Islington 66 kV GXP would increase to 459.1 MVA, a difference of 17.6 MVA. Given that the independent sum of the individual load peaks is 510.8 MVA there is a diversity factor of 0.90 between the loads.

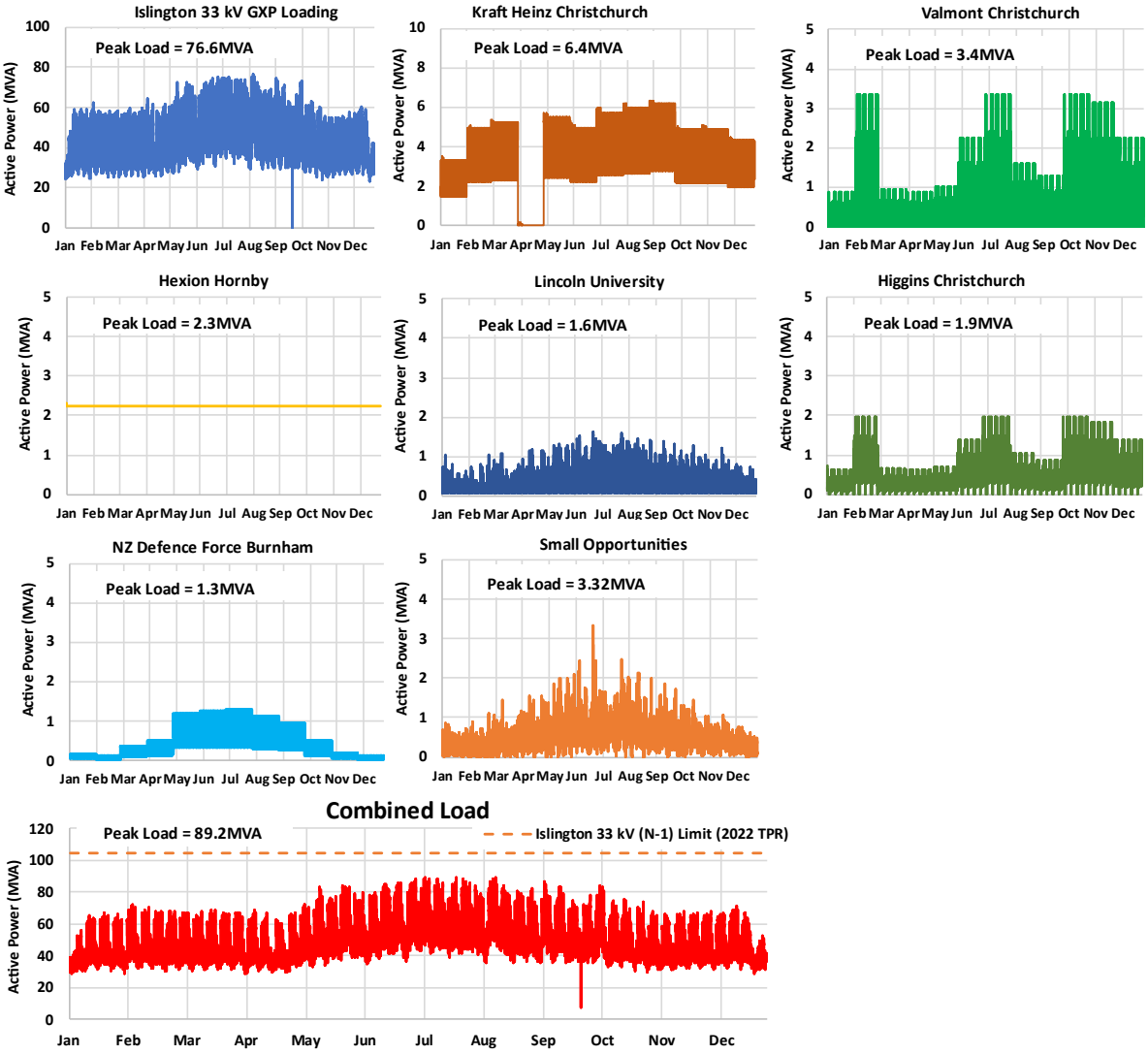


Figure 73 Loading Profiles: Islington 33 kV GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

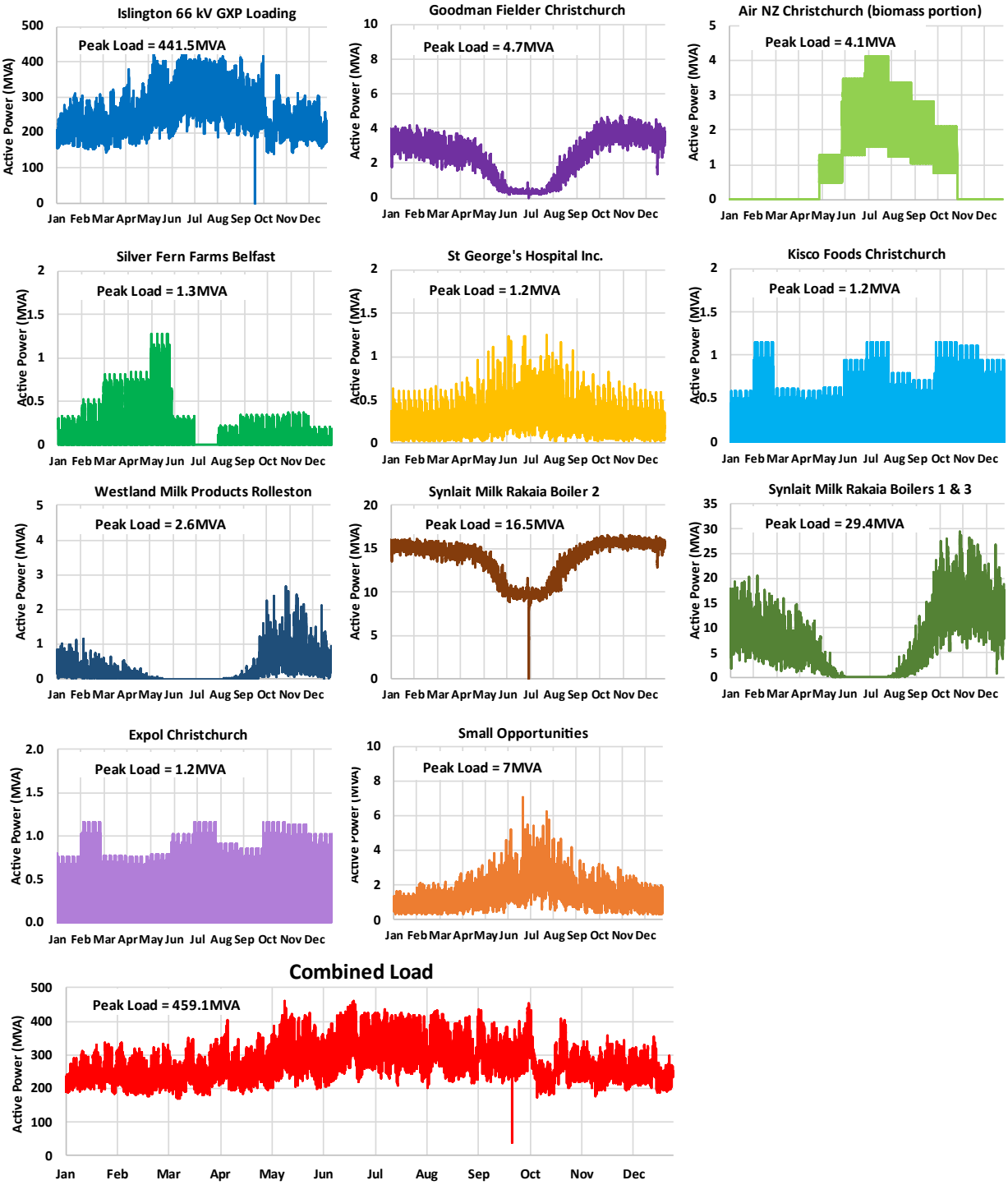


Figure 74 Loading Profiles: Islington 66 kV GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.11 Kaiapoi GXP

The EECA Load Sites include:

- Hellers Kaiapoi (2.15 MVA)
- Kaiapoi EV Charging Station (2.1 to 6.1 MVA)
- Island Horticulture (0.84 or 3.80 MVA)

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

It is noted that Ergo presently does not have access to Mainpower's map or loading data outside of public disclosures at this time and therefore analysis for this GXP is at a high level only.

From the Mainpower 2022 AMP[28], it is known that the Kaiapoi GXP has 4x 11 kV feeders, which are well interconnected and capable of supplying 4 MW each. There is capacity at the GXP for a further four 11 kV feeders.

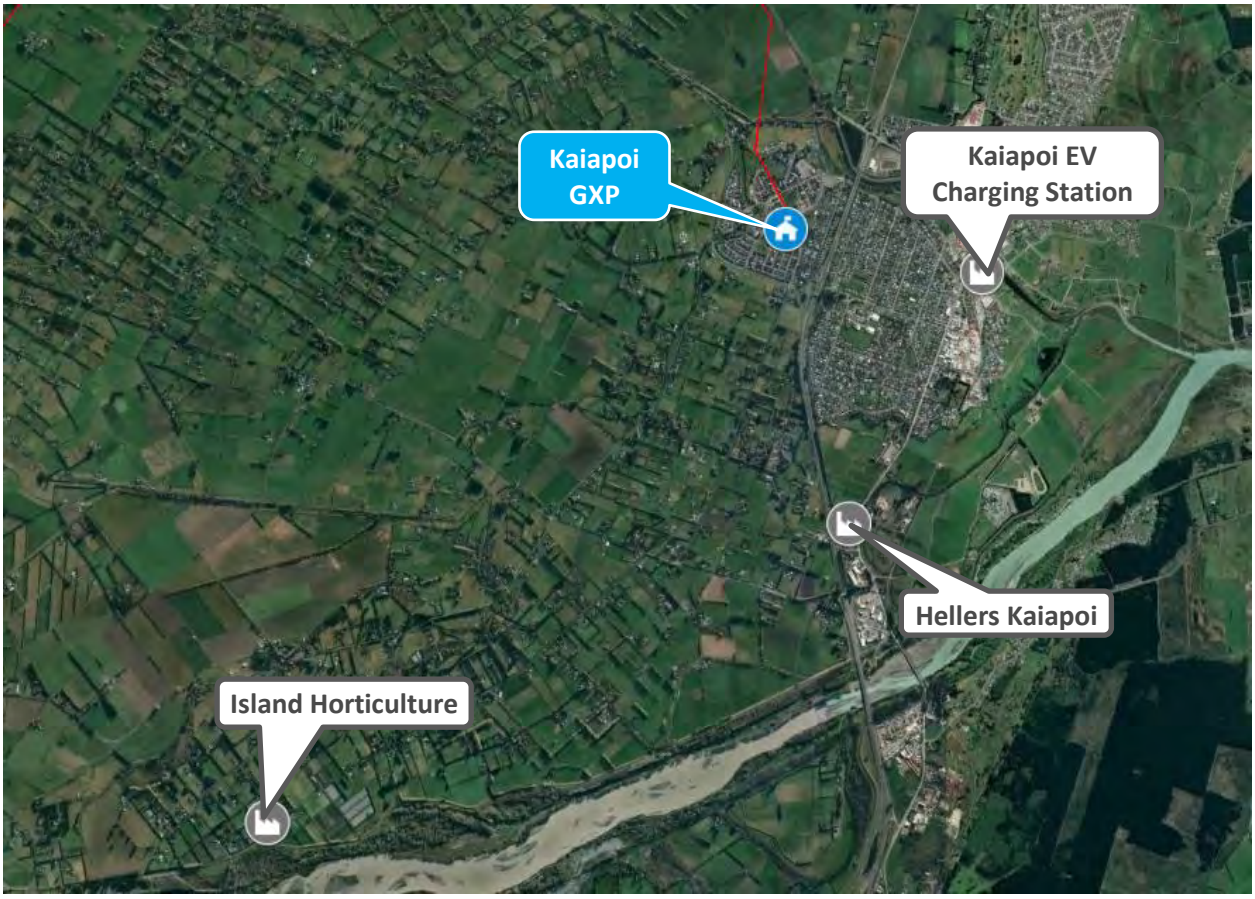


Figure 75 Kaiapoi GXP: Local zone substations and Load Sites

8.11.1 Kaiapoi GXP Upgrade

Section 8.11.5 shows that the branch (N-1) capacity of the Kaiapoi GXP is expected to be exceed for short periods of time if all of the proposed loads at Kaiapoi GXP connect. Regarding this, Ergo notes that according to Transpower's Transmission Planning Report 2022, it is expected that some load will shift from Kaiapoi GXP to the newly upgraded Southbrook GXP upon the completion of upgrades at

[28] https://mainpower.co.nz/assets/documents/mainpower-amp2022-web-1648689478.pdf

Southbrook GXP and zone substation, which may provide the additional capacity required to retain (N-1) branch security.

Additionally, Ergo understands from the Transmission Planning Report 2022 that there is an 11 kV switchboard replacement planned for Kaiapoi GXP, with commissioning in 2023-2024, which is the limiting factor of the branch capacity. With this constraint removed, the GXP (N-1) security is not expected to be exceeded. While a cost for this upgrade is not stated, Ergo assumes that the cost has been agreed/budgeted, with the project already underway at this stage.

For these reasons, upgrade costs are not investigated for this GXP.

8.11.2 Hellers Kaiapoi

		HELLERS KAIAPOI
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boilers and high temperature heat pump	2.15 MW	Kaiapoi

Existing Electrical Supply to the Plant

Hellers Kaiapoi is presently fed by Kaiapoi GXP, via two of the 11 kV feeders from the site (the supply can be switched between the two feeders). The site is one of the five "large" consumers fed from the Mainpower network.
The site is ≈2.5 km (straight line) from Kaiapoi GXP.

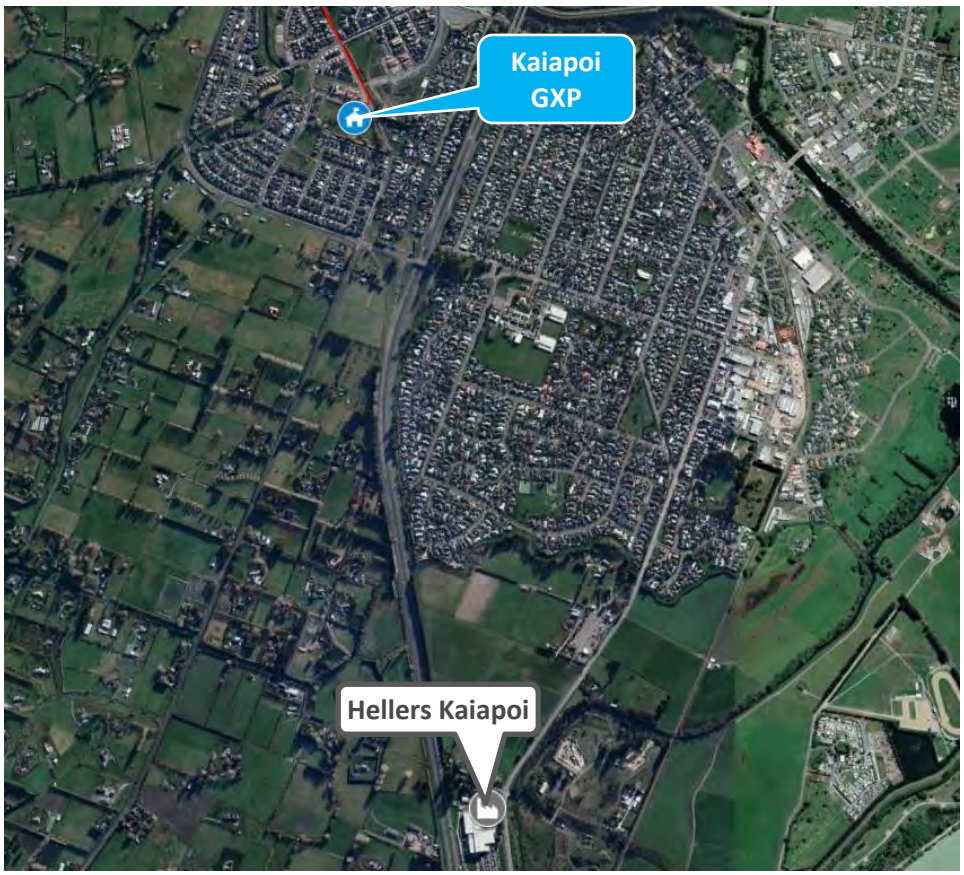


Figure 76 Hellers Kaiapoi geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Kaiapoi GXP has sufficient (N-1) capacity for the additional 2.15 MW of load. Ergo expects that connecting the additional load would require installation of a new dedicated 11 kV feeder at Kaiapoi GXP. Due to the urban topography, the feeder would likely involve underground cabling within the town, and Ergo has conservatively assumed the route would be cabled entirely to the site.

HELLERS KAIAPOI

Capital Cost Estimate

Table 35 Hellers Kaiapoi: 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	3.80	$1.52
		TOTAL	**$1.62**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12-24 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.

8.11.3 Kaiapoi EV Charging Station

KAIAPOI EV CHARGING STATION		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
Charging station for electric vehicles	2.1 to 6.1 MW	Kaiapoi

Existing Electrical Supply to the Plant

Shown below is a potential location for the Kaiapoi EV charging station, nearby a number of local shops and eateries, including the main street of Kaiapoi.
Kaiapoi EV charging station would be fed by Kaiapoi GXP, which it is ≈2.5 km (straight line) away from.

Figure 77 Kaiapoi EV Charging Station geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Kaiapoi GXP has sufficient (N-1) capacity for the additional 6.1 MW of load. Ergo expects that connecting the additional load would require installation a new dedicated 11 kV feeder at Kaiapoi GXP. Due to the urban topography, the feeder would likely involve underground cabling within the town.

Capital Cost Estimate

Table 36 Kaiapoi EV Charging Station: 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	2.70	$1.08
		TOTAL	**$1.18**

KAIAPOI EV CHARGING STATION
Does not include the costs of any distribution transformers/switchgear on the plant site.
Timeframe to Establish New Electrical Infrastructure
Estimated to take 12-24 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.

8.11.4 Island Horticulture

		ISLAND HORTICULTURE
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boilers and/or high temperature heat pump	0.84 or 3.80 MW	Kaiapoi

Existing Electrical Supply to the Plant

Island Horticulture is presently fed by Kaiapoi GXP. The site is one of the five "large" consumers fed from the Mainpower network.
The site is ≈6.5 km (straight line) from Kaiapoi GXP.

Figure 78 Island Horticulture geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Kaiapoi GXP has sufficient (N-1) capacity for the additional 0.84 or 3.80 MW of load.

To connect the 0.84 MW option, Ergo expects a minimal effect on the network, including costs associated with a new distribution transformer/kiosk to supply the site.

Ergo expects that connecting the additional 3.80 MW load would require installation of a new dedicated 11 kV feeder at Kaiapoi GXP. The feeder would likely be underground cabling within Kaiapoi, and overhead line through the rural portion of the route.

ISLAND HORTICULTURE
Capital Cost Estimate
For the 0.84 MW option, Ergo expects that the cost of an RMU/distribution transformer (1 MVA capacity) to supply the site would be ~$0.26M. For the 3.8 MW option, Ergo expects the following costs:

Table 37 Island Horticulture: 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	2.10	$0.84
Distribution	Single overhead 11kV line	5.10	$1.02
		TOTAL	**$1.96**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12-24 months, for both options.

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.

8.11.5 Effect of all Load Sites Connecting to Kaiapoi GXP

The following Figure 79 illustrates the Kaiapoi 2022 load profile together with the load profiles of all the Load Sites within the Kaiapoi GXP region. Also shown in Figure 79 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Kaiapoi GXP would increase to 38.0 MVA, a difference of 7.8 MVA. Given that the independent sum of the individual load peaks is 42.3 MVA there is a diversity factor of 0.90 between the loads.
- Based on Ergo's analysis, the Kaiapoi GXP's branch (N-1) limit is expected to be (marginally) exceeded for short periods of time throughout the year. The GXP's transformer (N-1) limit is not expected to be exceeded.

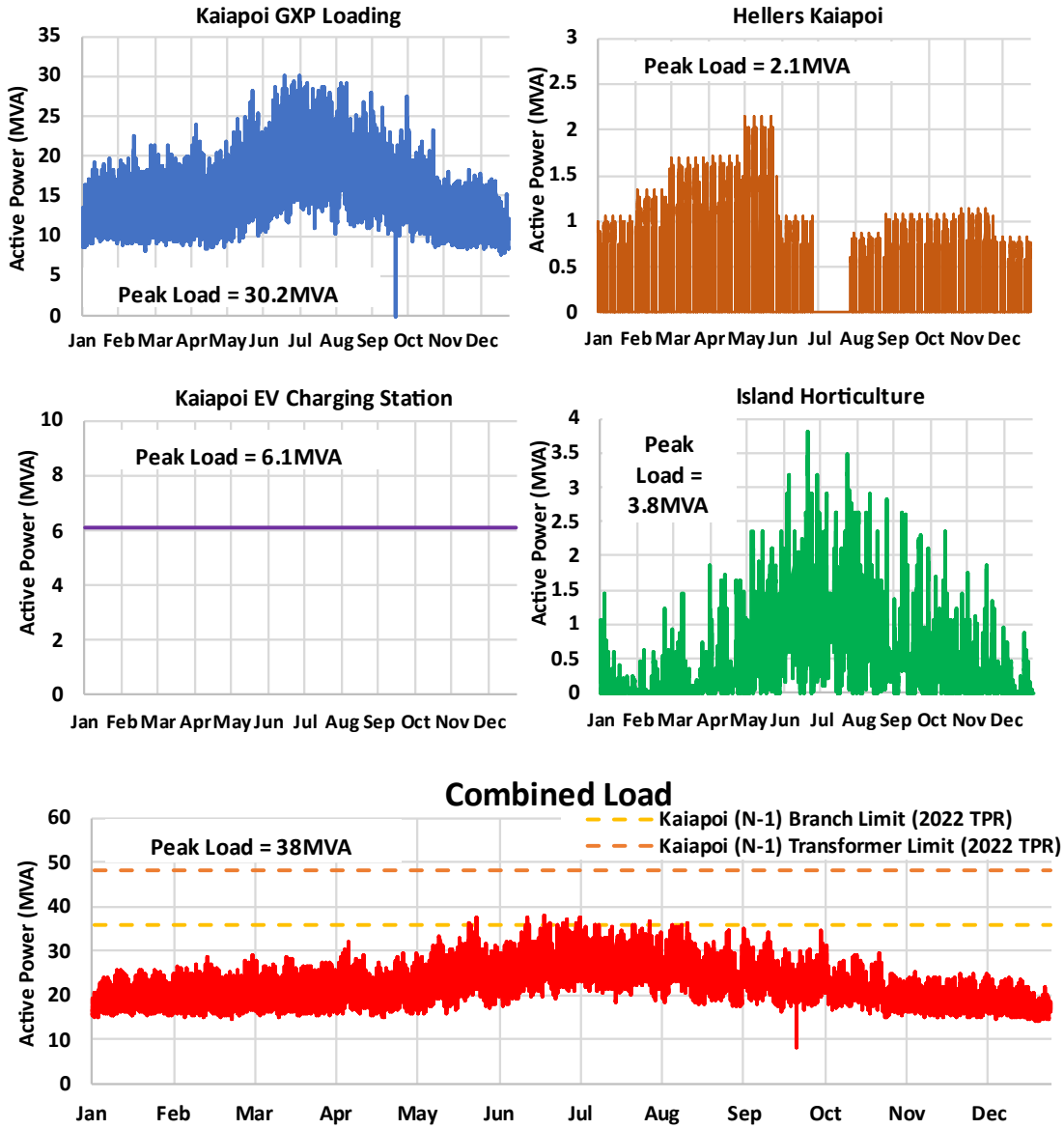


Figure 79 Loading Profiles: Kaiapoi GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.12 Kimberley GXP

The EECA Load Sites include:

- Fonterra Darfield (58.82 MVA)

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

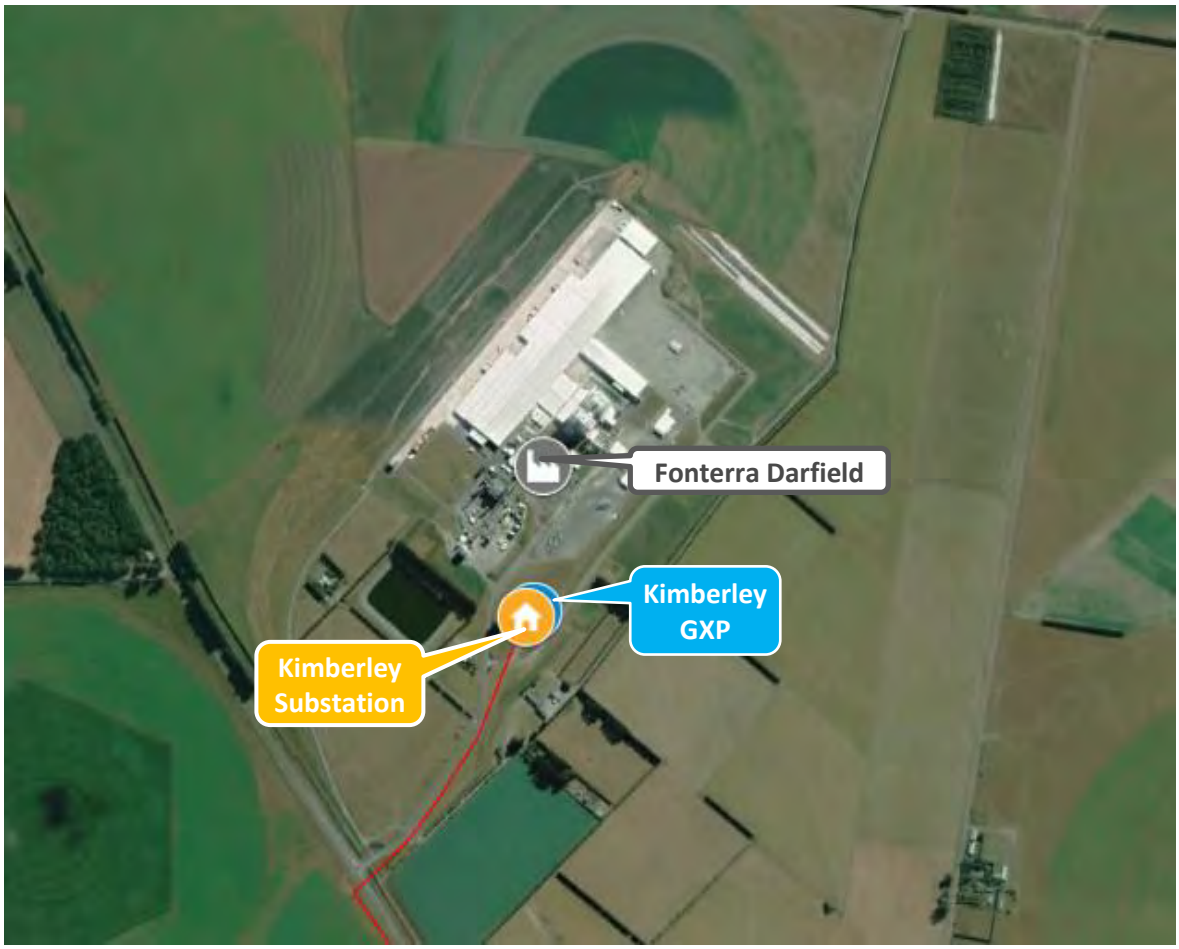
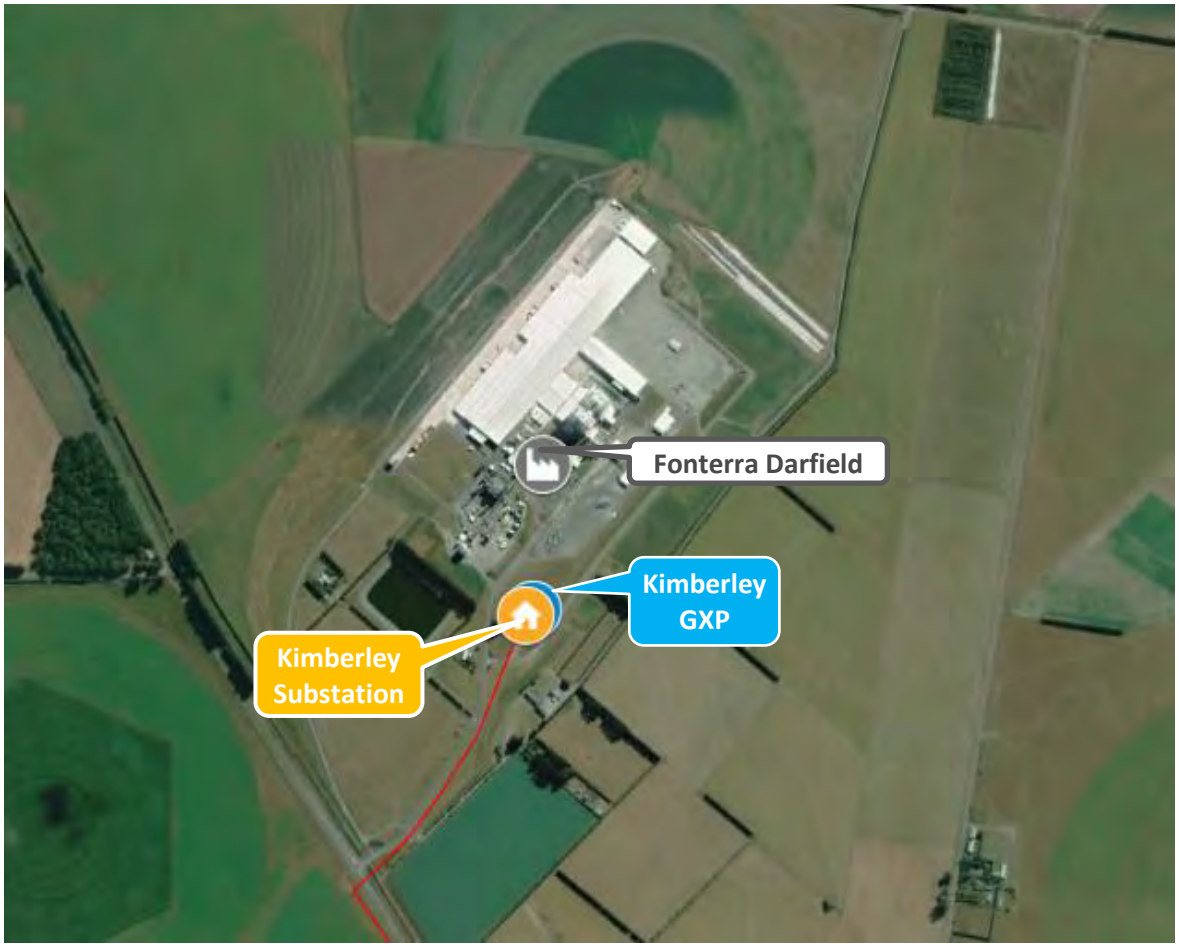


Figure 80 Kimberley GXP: Local zone substations and Load Sites

8.12.1 Kimberley GXP Upgrade

Due to there being one large Load Site proposed to connect at Kimberley GXP, Ergo has outlined the likely (transmission and distribution) infrastructure upgrades and costs against the Load Site in Section 8.12.2.

8.12.2 Fonterra Darfield

		FONTERRA DARFIELD
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boilers and high temperature heat pump	58.82 MW including: Stage 1: 6 MW; Stage 2: 15 MW (Stage 1 + 9MW); Stage 3: 58.82 MW (Stage 2 + 43.82 MW)	Kimberley
Existing Electrical Supply to the Plant		
Fonterra Darfield is presently supplied at 11kV from the Kimberley GXP, which was built to supply the plant, in 2012. Due to this, Fonterra Darfield is immediately adjacent to the GXP substation, being ≈300 m from the site.  Figure 81 Fonterra Darfield geographic location in relation to the surrounding zone substations		
Supply Option(s) for New Load		
Stage 1: The Kimberley GXP has sufficient (N-1) spare capacity for the initial 6 MW of load (Stage 1). In order to connect the proposed load, Ergo expects that a new dedicated 11 kV feeder from the GXP would		

likely be required. Ergo expects that the new feeder would be underground cabling, matching the existing supplies to the site.

Stage 2:

The equipment at the Kimberley GXP has sufficient (N) spare capacity for the total Stage 2 load of 15 MW (6 + 9MW). In order to manage the increase in loading, additional voltage support would need to be installed Kimberley. Additionally, with the 15 MW of load connected, when coincident with high network loads and low generation from Coleridge occur, the Islington-Kimberley 66 kV lines exceed their (N-1) limit. Ergo expects that Transpower will require the Kimberley load to be swiftly disconnected/decreased, to manage system security. This could be implemented via the installation of a special protection scheme.

Additionally, to connect the proposed load, Ergo expects that a new dedicated 11 kV feeder from the zone substation would likely be required. Ergo expects that the new feeder would be underground cabling, matching the existing supplies to the site.

Stage 3:

The Kimberley GXP/ substation does not have enough (N-1) or (N) spare capacity to supply the additional Stage 3 load (43.82MW). In order to connect the additional load, Ergo expects that significant upgrades would be required at the GXP, including transformer replacements and extension of the existing 11 kV switchboard (≈11 additional feeders) – essentially involving a new GXP substation building.

With the additional load, the lines between Islington and Kimberley would exceed their (N-1) capacity, which Ergo suspects would remain the case after the possible Islington-Kimberley 66 kV line upgrades. Ergo has assumed that the site would require (N-1) security to the site. Therefore, Ergo has taken the view that Kimberley GXP/substation would have to be supplied at 66 kV via the new Norwood GXP, which is seen as the preferable solution, compared to the other possibility of upgrading the Islington-Kimberley 66 kV lines to 110 kV, as the proposed Norwood-Kimberley 66 kV line would be approximately half the length, and decrease the complexity of the upgrades by retaining the existing voltages. The proposed Kimberley-Norwood 66 kV lines would be ≈20 km long, and would likely be overhead lines for the entire run, due to the rural topography of the route.

Orion has advised that they could look to coordinate this work with the 66 kV sub transmission connection between Norwood GXP and Hororata GXP – which Ergo understands may present some cost-saving efficiencies/alter the solution.

Capital Cost Estimate

Table 38 Fonterra Darfield: Capital cost estimate to supply the Load Site (Stage 1, (N-1) security)

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11kV circuit breaker (ZSS)	1	$0.10
Distribution	Single underground 11kV cable	0.7	$0.42
		TOTAL	**$0.52**

FONTERRA DARFIELD

Table 39 Fonterra Darfield: Capital cost estimate to supply the Load Site (Stage 2, (N) security)

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Transmission	Special protection system (GXP)	1	$0.50
Distribution	11kV Capacitor Bank	1	$1.00
Distribution	11kV circuit breaker (ZSS)	1	$0.10
Distribution	Single underground 11kV cable	0.7	$0.42
		TOTAL	**$2.02**

Table 40 Fonterra Darfield: Capital cost estimate to supply the Load Site (Stage 3, (N-1) Security)

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Transmission	Double overhead 66kV line	20	$10.00
Transmission	Medium supply transformer (GXP)	2	$7.00
Transmission	66kV circuit breaker bay	3	$1.95
Distribution	Large switchroom (ZSS)	1	$4.00
Distribution	11kV circuit breaker (ZSS)	11	$1.10
		TOTAL	**$24.05**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12-18 months for stage 1, 24-36 months for stage 2, and 36-48 months for stage 3.

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.

8.12.3 Effect of all Load Sites Connecting to Kimberley GXP

The following Figure 82 illustrates the Kimberley 2022 load profile together with the load profiles of all the Load Sites within the Kimberley GXP region. Also shown in Figure 82 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Kimberley GXP would increase to 73.4 MVA, a difference of 57.9 MVA. Given that the independent sum of the individual load peaks is 74.3 MVA there is a diversity factor of 0.99 between the loads.

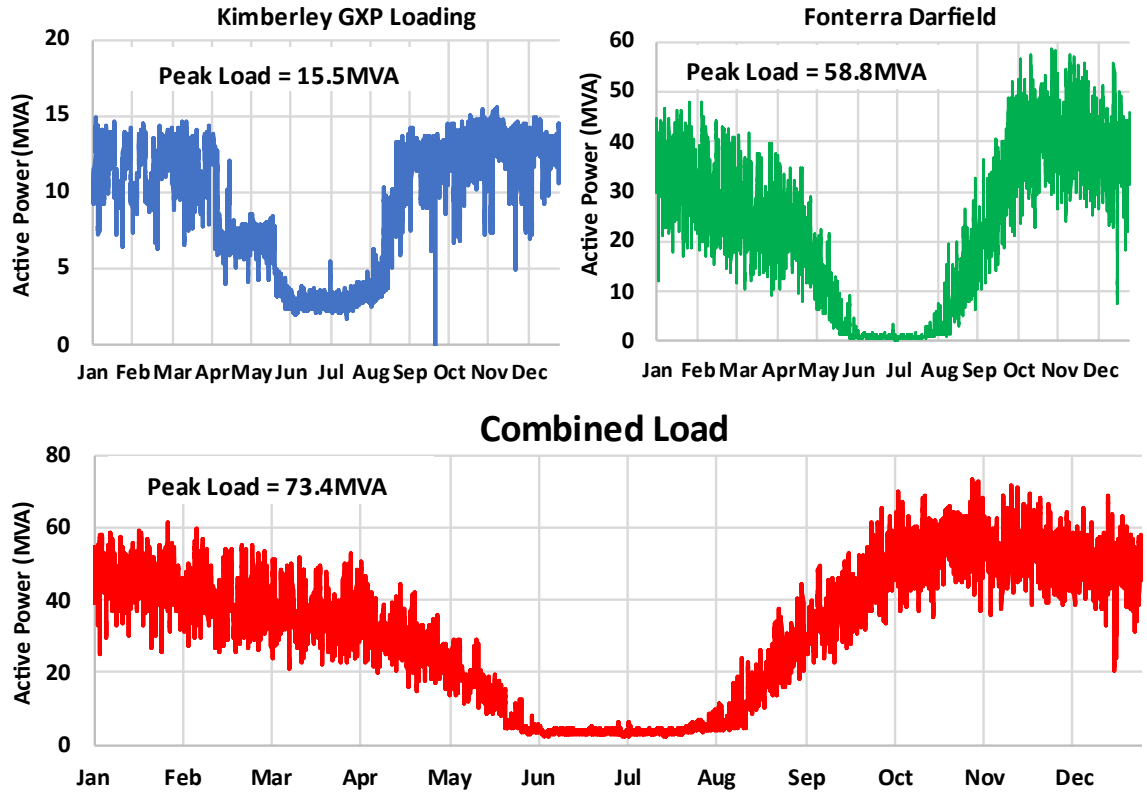


Figure 82 Loading Profiles: Kimberley GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.13 Southbrook GXP

The EECA Load Sites include:

- McAlpines Ltd. Rangiora (1.21 MVA)

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

It is noted that Ergo presently does not have access to Mainpower's map or loading data outside of public disclosures at this time and therefore analysis for this GXP is at a high level only.

Figure 83 Southbrook GXP: Local zone substations and Load Sites

8.13.1 Southbrook GXP Upgrade

The spare capacity at Southbrook GXP is not expected to be exceeded by the connecting loads and as such, Ergo has not considered the cost of any upgrades at Southbrook GXP.

8.13.2 McAlpines Ltd. Rangiora

MCALPINES LTD. RANGIORA		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New high temperature heat pump	1.21 MW	Southbrook

Existing Electrical Supply to the Plant

The supply to McAlpines Ltd. Rangiora was recently upgraded to a connection to the new high-security 11 kV switchboard at Southbrook zone substation. The site is one of the five "large" consumers fed from the Mainpower network.

The site is ≈0.3 km (straight line) from Southbrook zone substation.

Figure 84 McAlpines Ltd. Rangiora geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Southbrook GXP has sufficient (N-1) spare capacity to accommodate the additional load of 1.21 MW. Mainpower has indicated that while the Southbrook substation appears to have capacity at present, there is substantial load growth in the area, with Mainpower already having a number of large confirmed loads connecting to the substation in the near future, and the substation is therefore constrained. Cables extending West of the switchyard are also constrained due to their installation conditions. Mainpower expects that further investigation would be required to determine the actual capacity available to the proposed load.

MCALPINES LTD. RANGIORA

Mainpower is planning to construct a new zone substation east of Rangiora which will be able to supply some of the load which is presently fed by the Southbrook and Kaiapoi substations. It is therefore expected that the construction of this substation will increase the capacity at Southbrook and Kaiapoi, however the exact amount of load transfer will depend on the presently unknown load growth.

Ergo has taken a view that enough load would be able to be transferred to the proposed new substation to allow Southbrook substation to supply the proposed load. It has been assumed that a new feeder to the west of Southbrook substation supplying the site would be required due to the capacity constraints on the existing west feeders. Ergo does however note that this is dependent on there being sufficient capacity at Southbrook.

Capital Cost Estimate

Table 41 McAlpines Ltd. Rangiora: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	11kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11kV cable	0.50	$0.20
		TOTAL	**$0.30**

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

Timeframe to Establish New Electrical Infrastructure

Estimated to take 12-24 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.

8.13.3 Effect of all Load Sites Connecting to Southbrook GXP

The following Figure 85 illustrates the Southbrook 2022 load profile together with the load profiles of all the Load Sites within the Southbrook GXP region. Also shown in Figure 85 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Southbrook GXP would increase to 50.4 MVA, a difference of 0.7 MVA. Given that the independent sum of the individual load peaks is 50.9 MVA there is a diversity factor of 0.99 between the loads.

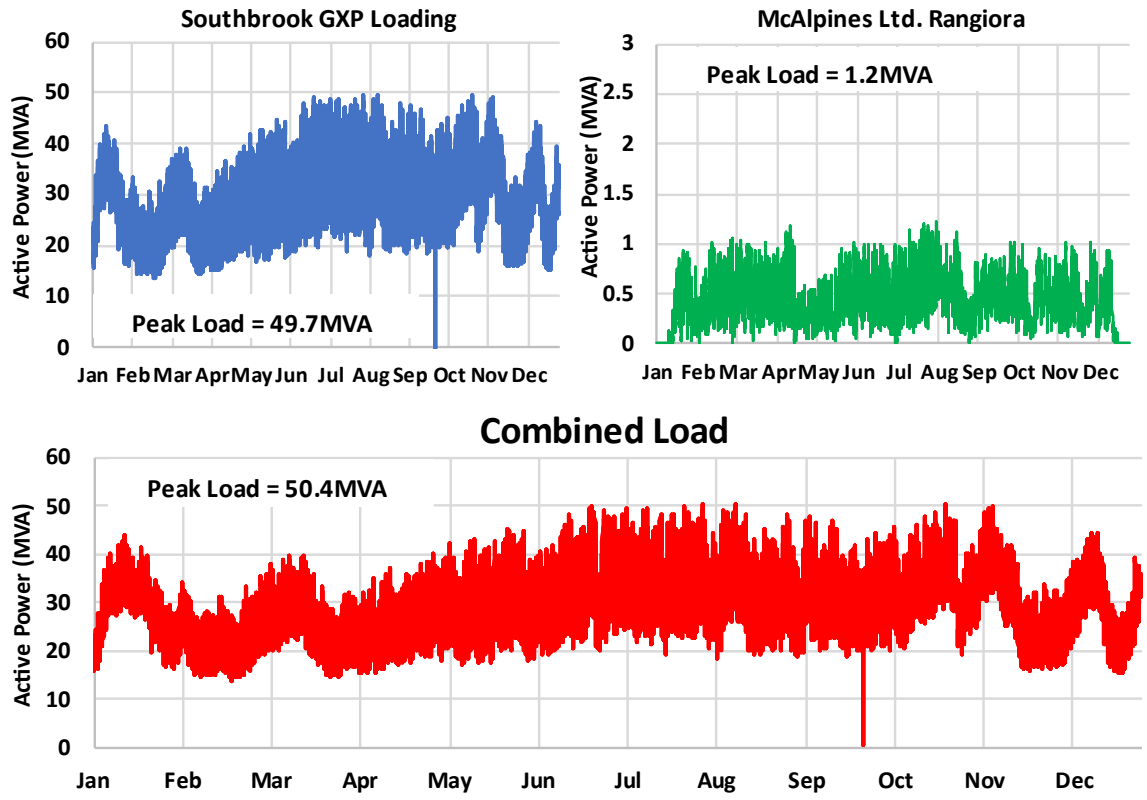


Figure 85 Loading Profiles: Southbrook GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.14 Waipara GXP

The EECA Load Sites include:

- Harris Meats (0.59 MVA)

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

It is noted that Ergo presently does not have access to Mainpower's network maps or loading data outside of public disclosures at this time and therefore analysis for this GXP is at a high level only.

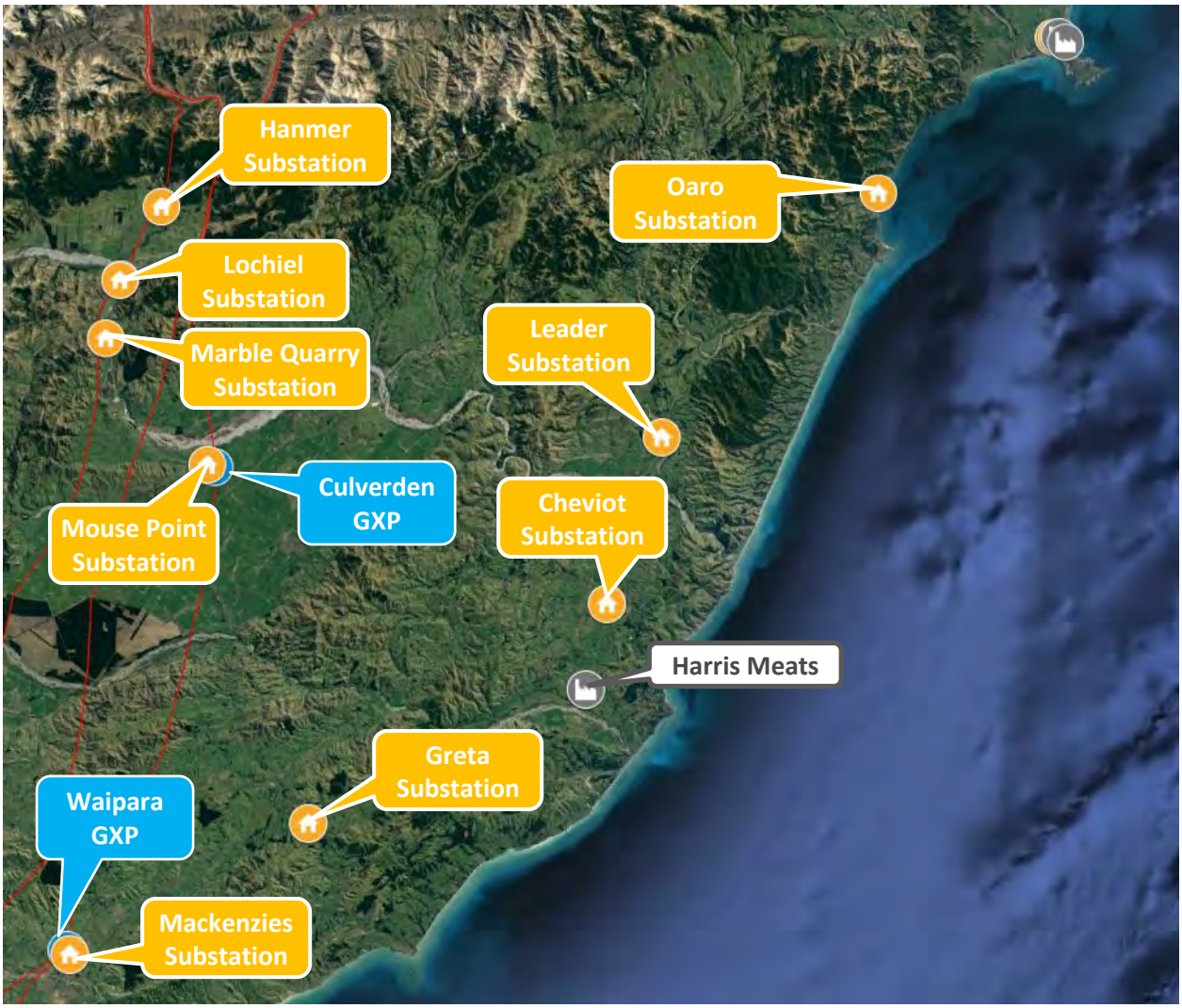


Figure 86 Waipara GXP: Local zone substations and Load Sites

8.14.1 Waipara GXP Upgrade

Based on the loading data presented in sections 6.1.14 and 0, Ergo expects that the capacity of the Waipara 220/66 kV transformers will not be exceeded by the addition of the proposed load.

For this reason, upgrades at Waipara 66 kV are not considered.

8.14.2 Harris Meats

		HARRIS MEATS
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electric boilers and high temperature heat pump	0.59 MW	Waipara (66 kV)

Existing Electrical Supply to the Plant

Harris Meats is presently fed by Waipara GXP, via Cheviot zone substation.
The site is ≈7 km (straight line) from Cheviot zone substation and ≈23 km (straight line) from Greta zone substation.

Figure 87 Harris Meats geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

Cheviot zone substation has 1 MW of spare (N) capacity, and there is a project planned to better interconnect one of the Cheviot zone substation feeders with one Greta zone substation feeder,

which will allow for some load transfer between the two substations. Because of this, Ergo expects that the local zone substation/s will have enough spare capacity to feed the load at Harris Meats.

Mainpower has indicated that the size of the load may mean that connection would require conductor replacements on the feeder supplying the site, to support the voltage. Ergo does not expect that any other network upgrades are required to supply the proposed load.

Capital Cost Estimate

Table 42 Harris Meats: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N)		Distribution => (N)
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	Reconductor 11kV line (larger)	8.00	$1.20
		TOTAL	**$1.20**

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

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.

8.14.3 Effect of all Load Sites Connecting to Waipara 66 kV GXP

The following Figure 39 illustrates the Waipara 66 kV 2022 load profile together with the load profiles of all the Load Sites within the Waipara GXP region. Also shown in Figure 39 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Waipara 66 kV GXP would increase to 7.3 MVA, a difference of 4.5 MVA. Given that the independent sum of the individual load peaks is 7.9 MVA there is a diversity factor of 0.93 between the loads.

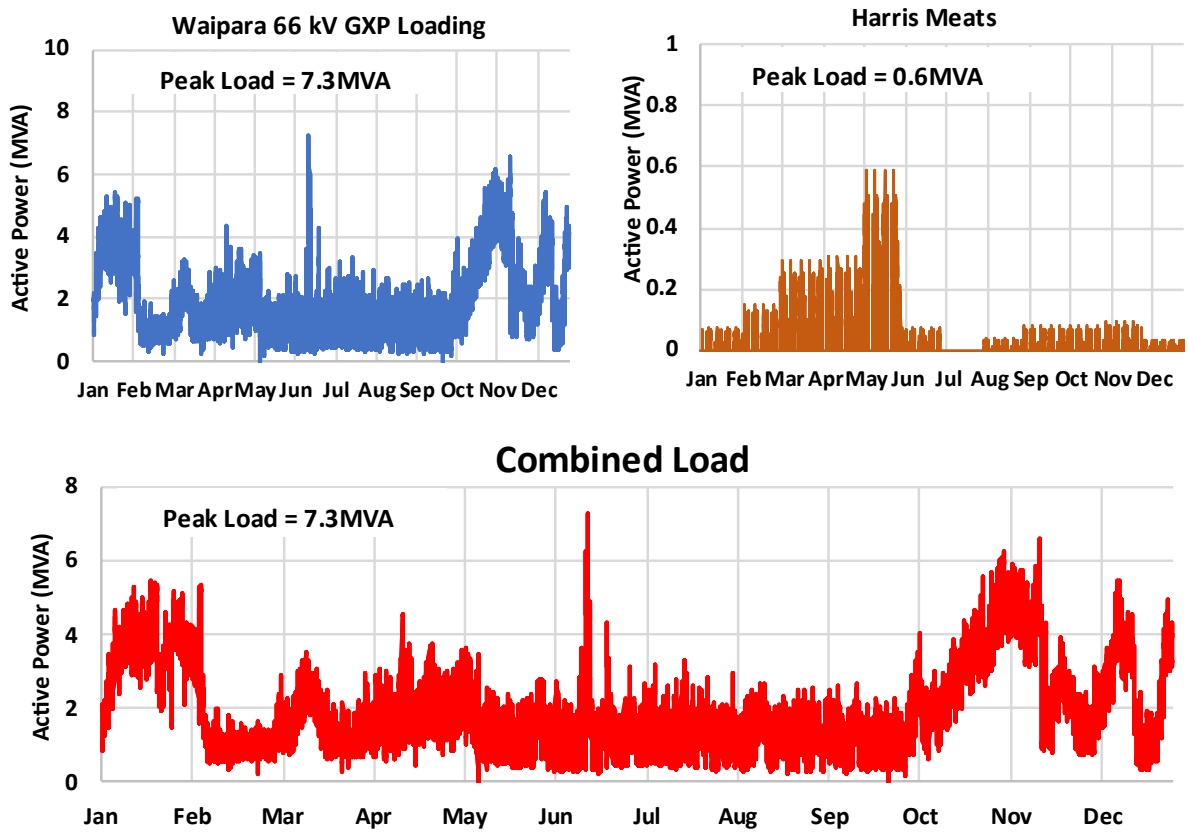


Figure 88 Loading Profiles: Waipara 66 kV GXP 2022 historical loading: Load Site Profiles: Combined Load (sum of all profiles)

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 North Canterbury Region.

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

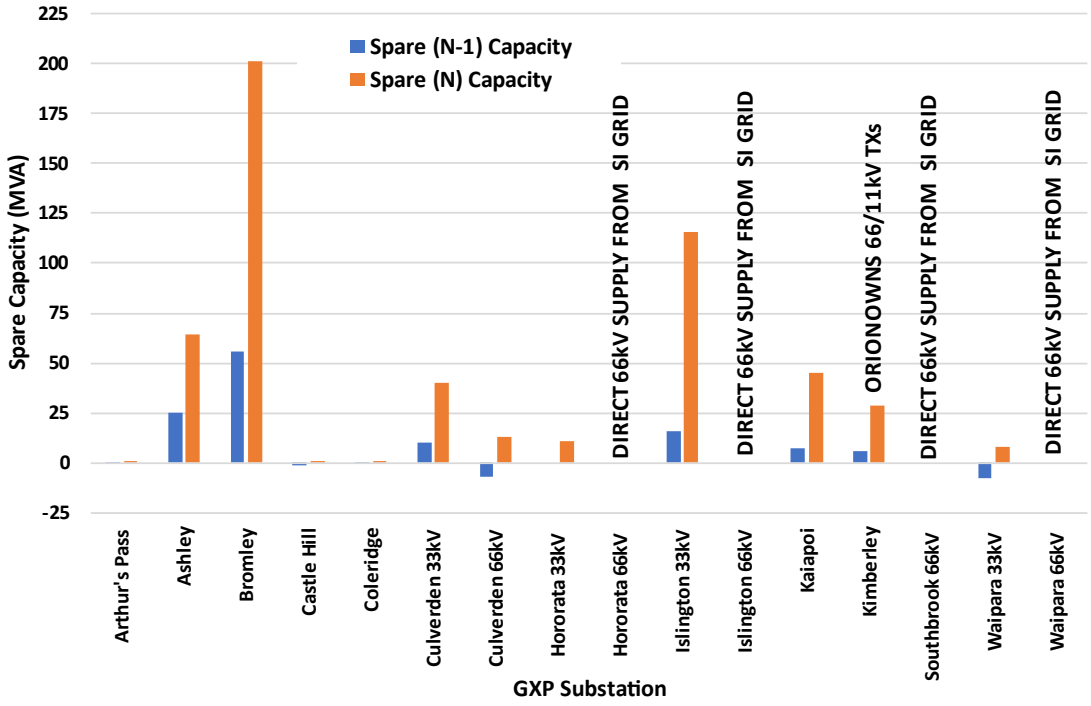


Figure 89 Summary: Approximate (N) and (N-1) spare capacity at GXP substations

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

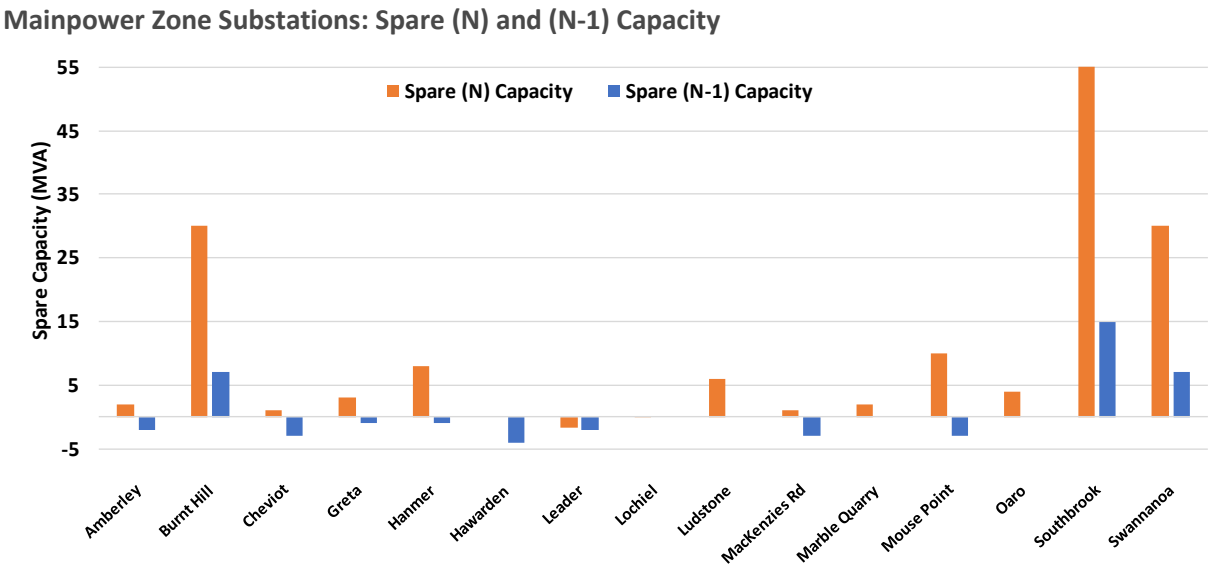


Figure 90 Summary: Approximate (N) and (N-1) spare capacity at Mainpower's zone substations

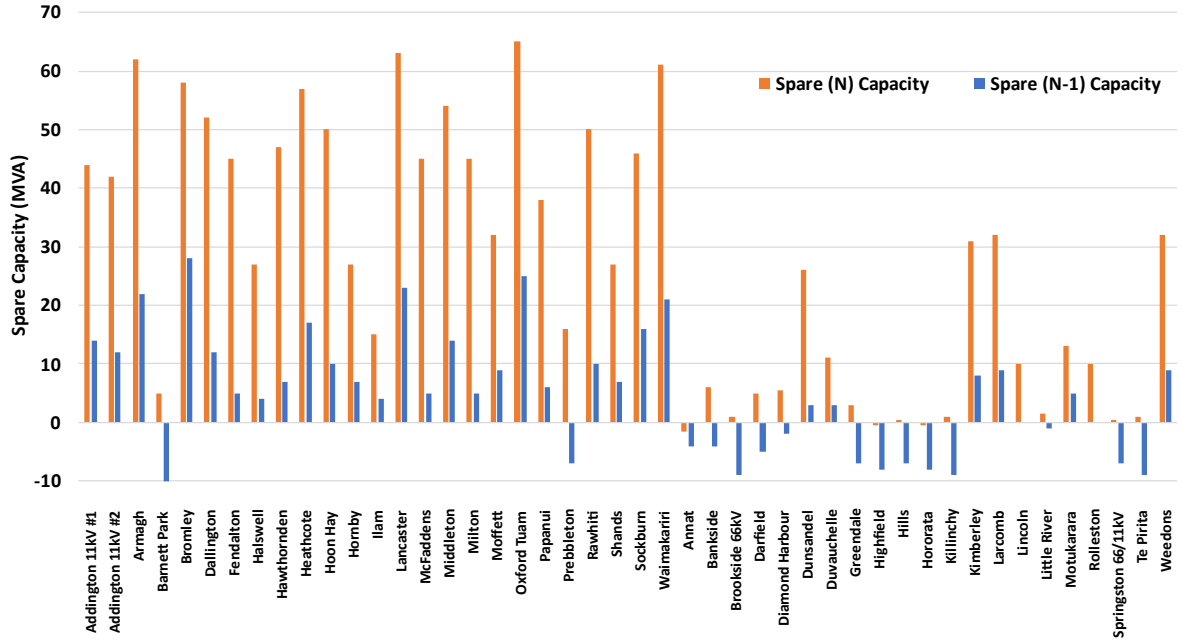


Figure 91 Summary: Approximate (N) and (N-1) spare capacity at Orion's zone substations

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-0002) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

GXP substations:

- *Arthur's Pass GXP* – Very small GXP with a winter peak. GXP supplies the Arthurs Pass township with relatively flat daily load curves.
- *Ashley GXP* – Similar peak loading through both summer and winter due to continuous operation of the connected Daiken plant which is the majority of loading.
- *Bromley GXP* – GXP supplies large parts of Eastern Christchurch and therefore has a relatively conventional urban winter peak load profile with a morning and evening peak. Historical data indicates load was transferred from an adjacent GXP to Bromley for a period in October which is likely an anomaly.
- *Castle Hill GXP* – Very small GXP with a winter peak. GXP supplies the Castle Hill township.
- *Coleridge GXP* - Very small GXP with a winter peak. GXP supplies the Coleridge region.
- *Culverden GXP* – GXP supplies the Culverden, Hanmer and Kaikoura regions which is dominated by irrigation, dairy and holiday accommodation. The 33kV supply is summer peaking with the 66kV supply winter peaking (although relatively flat).
- *Hororata GXP* – GXP supplies area to the West of Christchurch with supply provided at both 33kV and 66kV. Summer peaking due to significant irrigation loading in the area.
- *Islington GXP* - GXP supplies Orion at both 33kV and 66kV which in turn supplies Christchurch City and the area's west of the city. Both are largely winter loading with a typical residential, commercial daily load profile with a morning and evening peak.
- *Kaiapoi GXP* – A mix of residential, commercial and industrial loading with winter peak.
- *Kimberley GXP* – Majority of load is Fonterra's Darfield dairy factory with some supply provided to the Darfield area. As a result, loading is relatively consistent from August – April with a flat daily load profile.
- *Southbrook GXP* – Load profile is a mix of irrigation (causing high summer peaks) and residential, commercial, industrial resulting in a typical winter loading profile with daily peaks in the mornings and evenings.
- *Waipara GXP* – Mix of rural and residential loading. Both summer (likely due to irrigation) and winter peaks are similar. Daily load profiles are dominated by morning and evening peaks for both summer and winter.

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[29], which is only suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details)

Ergo notes that generally, load sites would be sharing the cost of upgrades with the relevant EDBs and/or Transpower. For example, a customer contribution ratio of 60% can be assumed for customers connecting to Orion's network. Ergo notes however that this is an average only and specific contributions would be determined during development of the detailed customer solution.

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.

[29] 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 43 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	G L Bowron Company Christchurch	6.36	Bromley	$0.00	Heathcote	$2.50	**$2.50**	**$0.39**	Moderate	2
2	Winstone Wallboards Christchurch	6.05	Bromley	$0.00	Heathcote	$2.50	**$2.50**	**$0.41**	Moderate	2
3	Alsco New Zealand Christchurch	2.04	Bromley	$0.00	Lancaster	$0.64	**$0.64**	**$0.31**	Moderate	2
4	Paua Co. Bromley	1.44	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
5	Ardex Christchurch	0.82	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
6	Woolston Foundry Christchurch	0.48	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
7	Castle Rock Orchards	0.46	Bromley	$0.00	Heathcote	$0.00	**$0.00**	**$0.00**	Minor	1
8	Aromaunga Baxter Flowers	0.33	Bromley	$0.00	Heathcote	$0.00	**$0.00**	**$0.00**	Minor	1
9	Te Aratai College	0.33	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
10	Taylors Manufacturing Christchurch	0.25	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
11	Shirley Boys High School	0.22	Bromley	$0.00	Rawhiti	$0.00	**$0.00**	**$0.00**	Minor	1
12	Scott Technology Christchurch	0.17	Bromley	$0.00	Bromley	$0.00	**$0.00**	**$0.00**	Minor	1
13	Shirley Intermediate School	0.12	Bromley	$0.00	Dallington	$0.00	**$0.00**	**$0.00**	Minor	1
14	Chisnallwood Intermediate School	0.12	Bromley	$0.00	Dallington	$0.00	**$0.00**	**$0.00**	Minor	1
15	Tekoa Range/Hanmer EV Charging Station (1.6MW option)	1.60	Culverden	$0.00	Hanmer	$1.60	**$1.60**	**$1.00**	Moderate	1
16	Kaikoura EV Charging Station (4.5MW option)	4.50	Culverden	$0.00	Ludstone	$4.48	**$4.48**	**$1.00**	Moderate	2
17	Kaikoura High School	0.12	Culverden	$0.00	Ludstone	$0.00	**$0.00**	**$0.00**	Minor	1
18	Canterbury Clay Bricks Darfield	2.30	Hororata	$0.00	Darfield	$2.30	**$2.30**	**$1.00**	Moderate	2,4
19	Gladfield Malt Dunsandel	1.98	Hororata	$0.00	Greendale	$1.38	**$1.38**	**$0.69**	Minor	1
20	Mitchell Bros Sawmillers Darfield	1.16	Hororata	$0.00	Darfield	$0.73	**$0.73**	**$0.63**	Moderate	2,4
21	Darfield EV Charging Station (2.3MW option)	2.30	Hororata	$0.00	Darfield	$0.78	**$0.78**	**$0.34**	Moderate	2,4
22	ANZCO Foods Rakaia	0.95	Hororata	$0.00	Killinchy	$0.66	**$0.66**	**$0.69**	Minor	
23	Meadow Mushrooms Giggs Farm	0.55	Hororata	$0.00	Greendale	$0.00	**$0.00**	**$0.00**	Minor	1
24	Synlait Milk Rakaia	45.96	Islington	$0.00	Dunsandel	$19.91	**$19.91**	**$0.43**	Moderate	2,3
25	Kraft Heinz Christchurch((N-1) security option)	7.29	Islington	$0.00	Shands Road	$6.32	**$6.32**	**$0.87**	Moderate	2
26	Goodman Fielder Christchurch	4.71	Islington	$0.00	Middleton	$0.42	**$0.42**	**$0.09**	Moderate	2
27	Air New Zealand Christchurch (biomass portion)	4.13	Islington	$0.00	Waimakariri	$1.70	**$1.70**	**$0.41**	Moderate	2
28	Valmont Christchurch	3.36	Islington	$0.00	Sockburn	$0.90	**$0.90**	**$0.27**	Moderate	2
29	Westland Milk Products Rolleston	2.65	Islington	$0.00	Weedons	$2.50	**$2.50**	**$0.94**	Moderate	2
30	Hexion Hornby	2.30	Islington	$0.00	Moffett	$1.62	**$1.62**	**$0.70**	Moderate	2
31	Lincoln University	1.64	Islington	$0.00	Springston	$0.00	**$0.00**	**$0.00**	Minor	1
32	Higgins Christchurch	1.95	Islington	$0.00	Hornby	$1.30	**$1.30**	**$0.67**	Minor	1
33	Silver Fern Farms Belfast	1.29	Islington	$0.00	Belfast	$0.00	**$0.00**	**$0.00**	Minor	1
34	NZ Defence Force Burnham	1.28	Islington	$0.00	Rolleston	$3.96	**$3.96**	**$3.09**	Moderate	2
35	St George's Hospital Inc.	1.24	Islington	$0.00	McFaddens	$2.88	**$2.88**	**$2.32**	Moderate	2
36	Kisco Foods Christchurch	1.15	Islington	$0.00	Middleton	$0.16	**$0.16**	**$0.14**	Moderate	2
37	Expol Christchurch	1.15	Islington	$0.00	Belfast	$0.48	**$0.48**	**$0.42**	Minor	2
38	Farmlands Rolleston	0.96	Islington	$0.00	Weedons	$0.00	**$0.00**	**$0.00**	Minor	1
39	Apparelmaster Christchurch	0.82	Islington	$0.00	Middleton	$0.00	**$0.00**	**$0.00**	Minor	1
40	Air New Zealand Christchurch	0.81	Islington	$0.00	Waimakariri	$0.00	**$0.00**	**$0.00**	Minor	1
41	Christchurch Womens Prison	0.81	Islington	$0.00	Moffett	$0.00	**$0.00**	**$0.00**	Minor	1
42	Hamilton Jet Christchurch	0.67	Islington	$0.00	Middleton	$0.00	**$0.00**	**$0.00**	Minor	1
43	Ag Research Lincoln	0.61	Islington	$0.00	Lincoln	$0.00	**$0.00**	**$0.00**	Minor	1
44	Tegal Foods Ltd Christchurch	0.60	Islington	$0.00	Sockburn	$0.00	**$0.00**	**$0.00**	Minor	1
45	Expol Rolleston	0.58	Islington	$0.00	Weedons	$0.00	**$0.00**	**$0.00**	Minor	1
46	Ara Institute of Canterbury Christchurch	0.57	Islington	$0.00	Oxford Tuam	$0.00	**$0.00**	**$0.00**	Minor	1
47	Christchurch Mens Prison	0.56	Islington	$0.00	Moffett	$0.00	**$0.00**	**$0.00**	Minor	1
48	Nova Trust Templeton	0.55	Islington	$0.00	Moffett	$0.00	**$0.00**	**$0.00**	Minor	1
49	Southern Cross Healthcare Christchurch	0.45	Islington	$0.00	Armagh	$0.00	**$0.00**	**$0.00**	Minor	1
50	Hillmorton Hospital	0.45	Islington	$0.00	Middleton	$0.00	**$0.00**	**$0.00**	Minor	1
51	Burnside High School	0.45	Islington	$0.00	Hawthornden	$0.00	**$0.00**	**$0.00**	Minor	1
52	Christchurch City Council Civic Offices	0.39	Islington	$0.00	Oxford Tuam	$0.00	**$0.00**	**$0.00**	Minor	1
53	Zealandia Horticulture Belfast*	0.35	Islington	$0.00	Belfast	$0.00	**$0.00**	**$0.00**	Minor	1
54	Coca Cola Europacific Partners Christchurch	0.35	Islington	$0.00	Heathcote	$0.00	**$0.00**	**$0.00**	Minor	1
55	Oderings Nurseries Spreydon	0.29	Islington	$0.00	Milton	$0.00	**$0.00**	**$0.00**	Minor	1
56	Rochester & Rutherford Hall	0.28	Islington	$0.00	Ilam	$0.00	**$0.00**	**$0.00**	Minor	1
57	Hornby High School	0.23	Islington	$0.00	Hornby	$0.00	**$0.00**	**$0.00**	Minor	1
58	Lincoln High School	0.23	Islington	$0.00	Lincoln	$0.00	**$0.00**	**$0.00**	Minor	1
59	Hellers Kaiapoi	2.15	Kaiapoi	$0.00	Kaiapoi	$1.62	**$1.62**	**$0.75**	Moderate	2
60	Kaiapoi EV Charging (6.1MW option)	6.10	Kaiapoi	$0.00	Kaiapoi	$1.18	**$1.18**	**$0.19**	Moderate	2
61	Island Horticulture	3.80	Kaiapoi	$0.00	Kaiapoi	$1.96	**$1.96**	**$0.52**	Moderate	2
62	Fonterra Darfield	58.82	Kimberley	$19.45	Kimberley	$7.14	**$26.59**	**$0.45**	Major	2,3
63	McAlpines Rangiora	1.21	Southbrook	$0.00	Southbrook	$0.30	**$0.30**	**$0.25**	Minor	5
64	Harris Meats	0.59	Waipara	$0.00	Cheviot	$1.20	**$1.20**	**$2.03**	Minor	1
	TOTAL =>	**198.4**	**TOTAL =>**	**$19.5**	**TOTAL =>**	**$73.11**	**$92.56**			

Notes

1 Doesn't include distribution transformer or switchgear costs for Load Sites (details provided in body of report). Estimated between $50k - $350k depending on size.
2 Assumes supply is taken from the EDB at either 33kV or 11kV. Costs will vary depending on size, security and site requirements
3 Proposed to take supply from the new Norwood GXP. Costs include stage 1, stage 1A, and stage 2.
4 Ergo have proposed to connect load to Kimberley instead of Hororata due to the Hororata 33kV constraint
5 Connection of this load to Southbrook is dependent on confirmation of capacity at Southbrook zone substation.

Appendix 1 Glossary

APS	Arthur's Pass GXP/substation
ASY	Ashley GXP/substation
BRY	Bromley GXP/substation
CLH	Castle Hill GXP/substation
COL	Coleridge GXP/substation
CT	Current transformer
CUL	Culverden GXP/substation
DG	Distributed generator
EDB	Electrical Distribution Business
EIPC	Electricity Industry Participation Code
ENA	Electricity Network Association
ESA	Electricity Supply Authority
GXP	Grid exit point substation
HOR	Hororata GXP/substation
ISL	Islington GXP/substation
KBY	Kimberley GXP/substation
kV	Kilovolts
MW	Megawatts
MVArs	Mega volt amps reactive
MVA	Mega volt amps
NWO	Norwood GXP/substation (future)
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)
SCADA	Supervisory control and data acquisition
SBK	Southbrook GXP/substation
WPR	Waipara GXP/substation

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 44 Cost estimate classification matrix[30]

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.

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