Northland

Spare Capacity and Load Characteristics Report

EECA

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Revision details

Revision	Details
A	Draft for client review/comment
B	Added opportunity Load Site connection analysis
C	Updated for Transpower and Northpower comments
D	Updated to reflect correct size of Northland Corrections Facility Load
E	Updated for WMA comments

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1. Executive Summary

Transpower maintains/manages the transmission network in New Zealand and supplies the Northland region (as described in this report) via four GXP's (one supplying Top Energy and three supplying Northpower).

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

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

As part of the ETA program, EECA has developed a set of Load Sites for the Northland region. The Load Site's 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 Northland region as Stage 1 of the project described in *Schedule 1* of the *Contract for Services*:

- The current supply demand characteristics (peak & average supply and seasonality information) at the major electrical substations.
- The (N) and (N-1) capacity available for each grid exit point and substations.

1.1 Network Spare Capacity

For the purposes of this report, a number of transmission substations owned and operated by the two EDBs will be grouped with the GXPs rather than with the zone substations. The following Figure 1 illustrates the (N) and (N-1) spare capacity at the Transpower GXPs and EDB transmission substations in the Northland region.

The spare capacity shown for Kaikohe is the 110/33 kV substation capacity and not the 110 kV GXP busbar capacity or lines capacity. The Kaitaia transmission station has no (N-1) capacity because it is supplied via a single 110 kV circuit from Kaikohe.

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

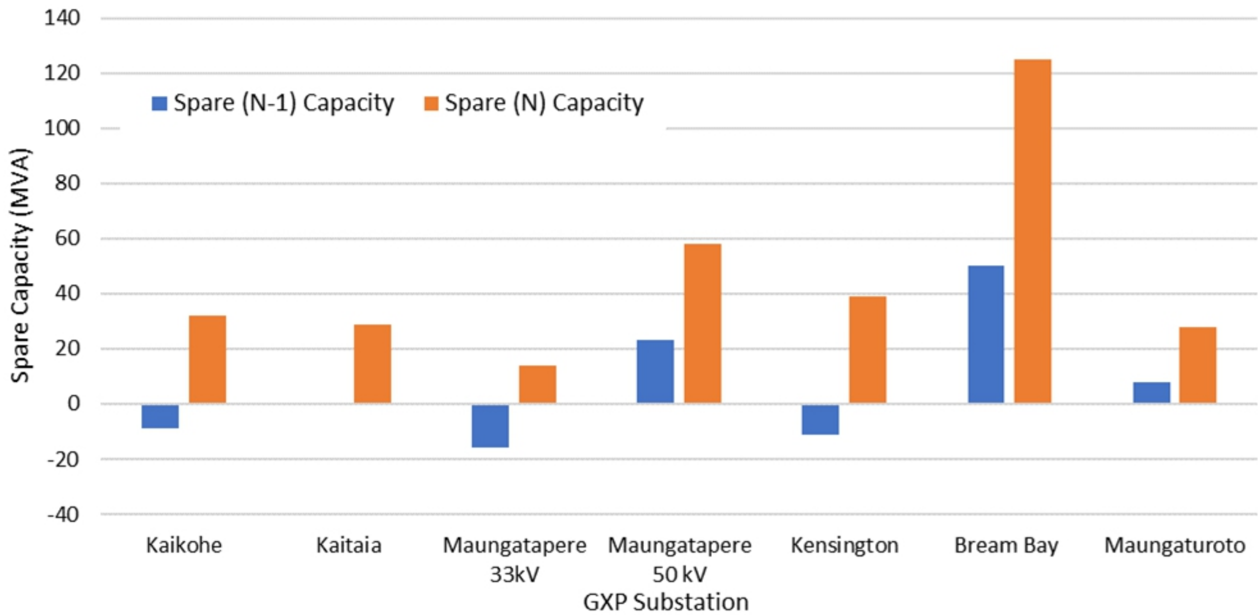


Figure 1 Summary: Approximate N and N-1 spare capacity at GXPs and transmission substations.

The following Figure 2 and Figure 3 illustrate the (N) and (N-1) spare capacity at the two EDB (Top Energy and Northpower) zone substations in the Northland region. These figures are based on the maximum loadings and the EDB 2023 disclosures. Negative numbers for (N-1) capacity indicate zone substations where the load has exceeded the (N-1) capacity in the past.

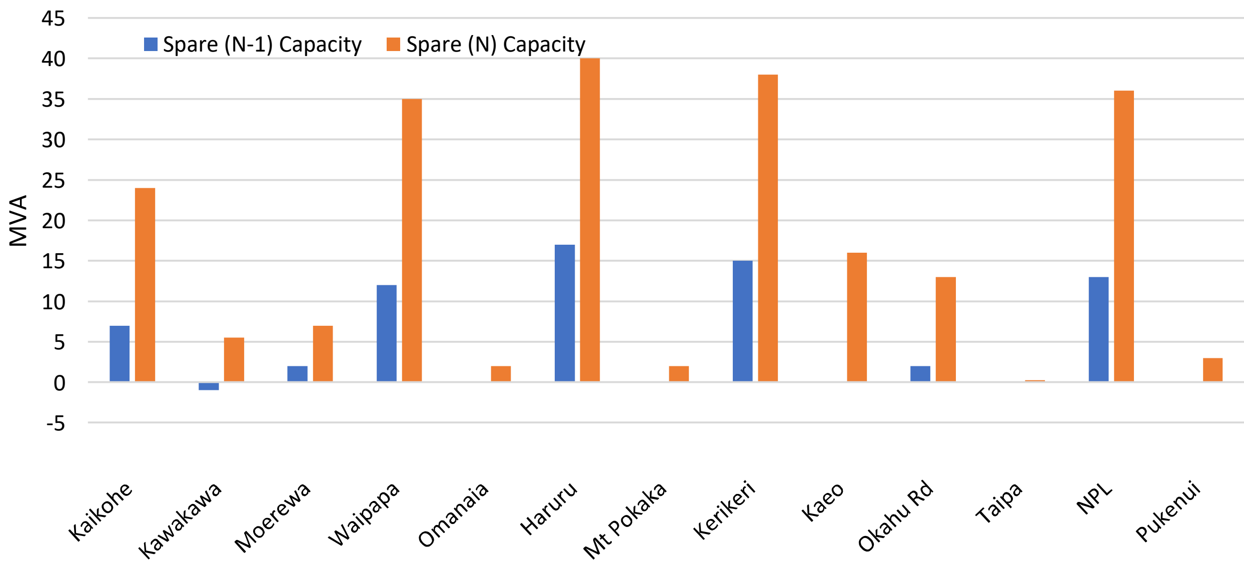


Figure 2 Summary: Approximate (N) and (N-1) spare capacity at Top Energy's zone substations

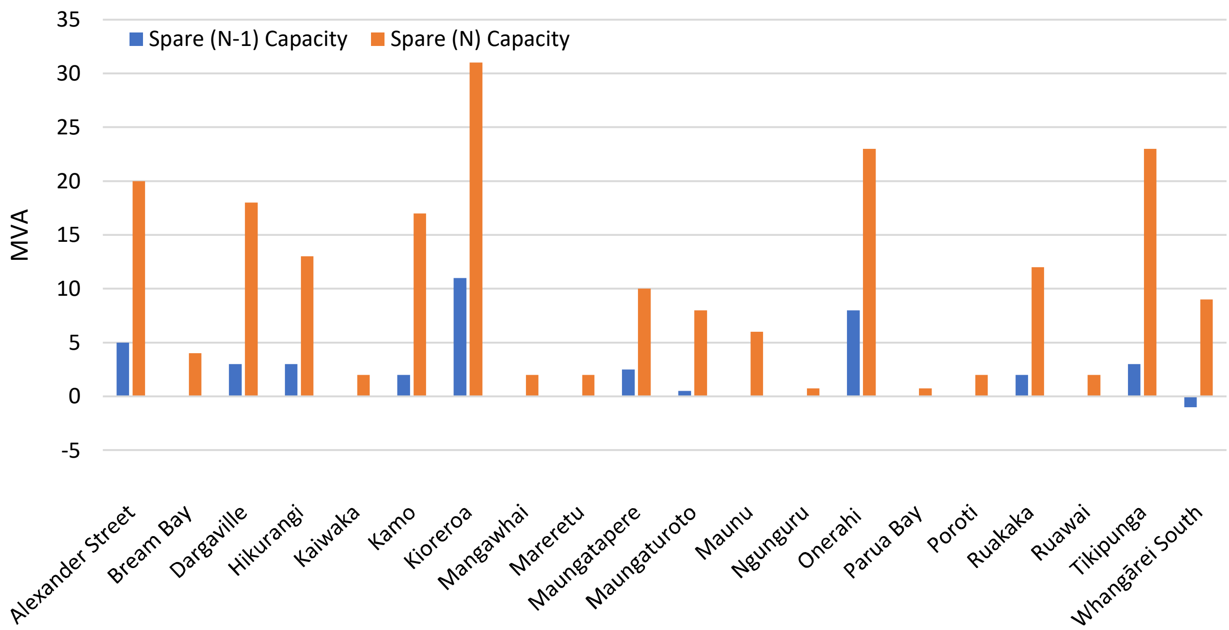


Figure 3 Summary: Approximate (N) and (N-1) spare capacity at Northpower's zone substations

1.2 Load Characteristics

The substation load characteristics are documented in detail in the main body of the report (and the supplementary document 23019-RPT-0002) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

GXP substations:

- *Kaikohe GXP* – Loading is highly influenced by generation from Ngawha into the 110 kV bus, as well as embedded distribution generation. The load is a mix of residential, commercial, and industrial loads. There is no definitive seasonal peaking, but the daily profile shows an evening/early morning peak[2] with lesser peaks around midday and towards the evening.
- *Kaitaia transmission substation* – Mix of residential, commercial and industrial loads. Winter peaking is only about 30% higher than in summer with a traditional daily morning and evening peak that is not overly accentuated.
- *Maungatapere GXP* - Supplies 73% of Northpower's consumers and just more than 55% of the total load. It is a mix of residential, commercial, and industrial loads.
  - *Maungatapere 33 kV transmission substation* – The winter peaking resembles a traditional daily morning and evening peak, while the summer daily load profile is flat.
  - *Maungatapere 50 kV transmission substation* - It is a mix of residential, commercial, and industrial loads. The winter peaking resembles a traditional daily morning and evening peak, while the summer daily load profile is flat.
- *Maungaturoto GXP* – - Supplies 18% of Northpower's consumers and just more than 10% of the total load. Mix of residential, commercial and industrial loads. Winter peaking with an approximate 50% base load and traditional daily morning and evening peak.

[2] This is the actual GXP load in apparent power which most likely represents exporting of real power and therefore gives an idea of the 110 kV busbar load.

- *Bream Bay GXP* – - Supplies 9% of Northpower's consumers and just more than 35% of the total load. Loading was significantly affected by the closure of the Marsden Point Refinery in April 2022. A full year's load profile in 2023 will indicate the new nature of the seasonal load profile for this GXP.
- *Kensington transmission substation* – Mix of residential (30,000 ICPs), and dairy industry loads. Winter peaking driven by the residential load component with a relatively flat daytime load profile in summer and traditional daily morning and evening peaks in 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[3], which is only suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details)

Summary: Load Sites vs transmission/distribution capital cost estimates

Table 1 Summary of Load Sites and estimated capital costs

No.	Load Site Name	Additional Load (MW)	Transmission Details		Distribution		TOTAL	Cost Efficiency ($M/MW)	Complexity of Connection	Refer to notes
			GXP/Transmission Substation	Upgrade Costs ($M)	Zone Substation	Upgrade Costs ($M)	Upgrade Costs ($M)			
1	Northland Regional Corrections Facility	2.90	Kaikohe	$0.00	Kaikohe	$0.00	**$0.00**	**$0.00**	Minor	2
2	Imerys Ceramics New Zealand Ltd.	1.36	Kaikohe	$0.00	Kaeo	$0.00	**$0.00**	**$0.00**	Minor	2
3	Bay of Islands College	0.30	Kaikohe	$0.00	Kawakawa	$0.00	**$0.00**	**$0.00**	Minor	1
4	Kerikeri Crematorium	0.20	Kaikohe	$0.00	Mt Pokaka	$0.00	**$0.00**	**$0.00**	Minor	1
5	Downer Whangārei Asphalt Plant	5.00	Maungatapere	$0.00	Kioreroa	$0.90	**$0.90**	**$0.18**	Minor	2
6	Whangārei Hospital	4.46	Maungatapere	$0.00	Whangārei South	$1.62	**$1.62**	**$0.36**	Minor	2
7	Grinning Gecko Cheese Company	0.67	Maungatapere	$0.00	Kioreroa	$0.00	**$0.00**	**$0.00**	Minor	1
8	Northland Polytechnic	0.36	Maungatapere	$0.00	Whangārei South	$0.00	**$0.00**	**$0.00**	Minor	1
9	Whangarei Council Maunu Cemetery	0.20	Maungatapere	$0.00	Maunu	$0.00	**$0.00**	**$0.00**	Minor	1
10	Fonterra Kauri (N-1 supply option)	26.05	Kensington	$0.00	Kauri	$10.75	**$10.75**	**$0.41**	Moderate	2
11	Whangarei District Council Aquatic Centre	0.24	Kensington	$0.00	Alexander Street	$0.00	**$0.00**	**$0.00**	Minor	1
12	Whangarei Girls High School	0.24	Kensington	$0.00	Alexander Street	$0.00	**$0.00**	**$0.00**	Minor	1
13	Whangarei Boys High School	0.20	Kensington	$0.00	Alexander Street	$0.00	**$0.00**	**$0.00**	Minor	1
14	Bream Bay College	0.17	Bream Bay	$0.00	Ruakaka	$0.00	**$0.00**	**$0.00**	Minor	1
15	Fonterra Maungaturoto (All Stages)(N-1 supply option)	28.43	Maungaturoto	$23.50	Maungaturoto	$7.63	**$31.13**	**$1.09**	Major	2
16	Otamatea High School	0.17	Maungaturoto	$0.00	Maungaturoto	$0.00	**$0.00**	**$0.00**	Minor	1
	TOTAL =>	**71.0**	**TOTAL =>**	**$23.5**	**TOTAL =>**	**$20.90**	**$44.40**			

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

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.

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

2. Introduction

The consumers in the Northland region are supplied with electricity via electrical networks that are owned by the following EDBs:

- Top Energy Ltd – 13 zone substations.
- Northpower Ltd - 20 zone substations (3 transmission 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)[4]. The program is targeted at large energy-using businesses and public sector organisations that are committed to reducing carbon emissions.

As part of the ETA program, EECA contracted Ergo to determine the existing spare supply capacity and the load characteristics at the major electrical substations within the Northland region.

Ergo previously developed similar reports for the Southland, South Canterbury, West Coast, and North Canterbury regions to name a few.

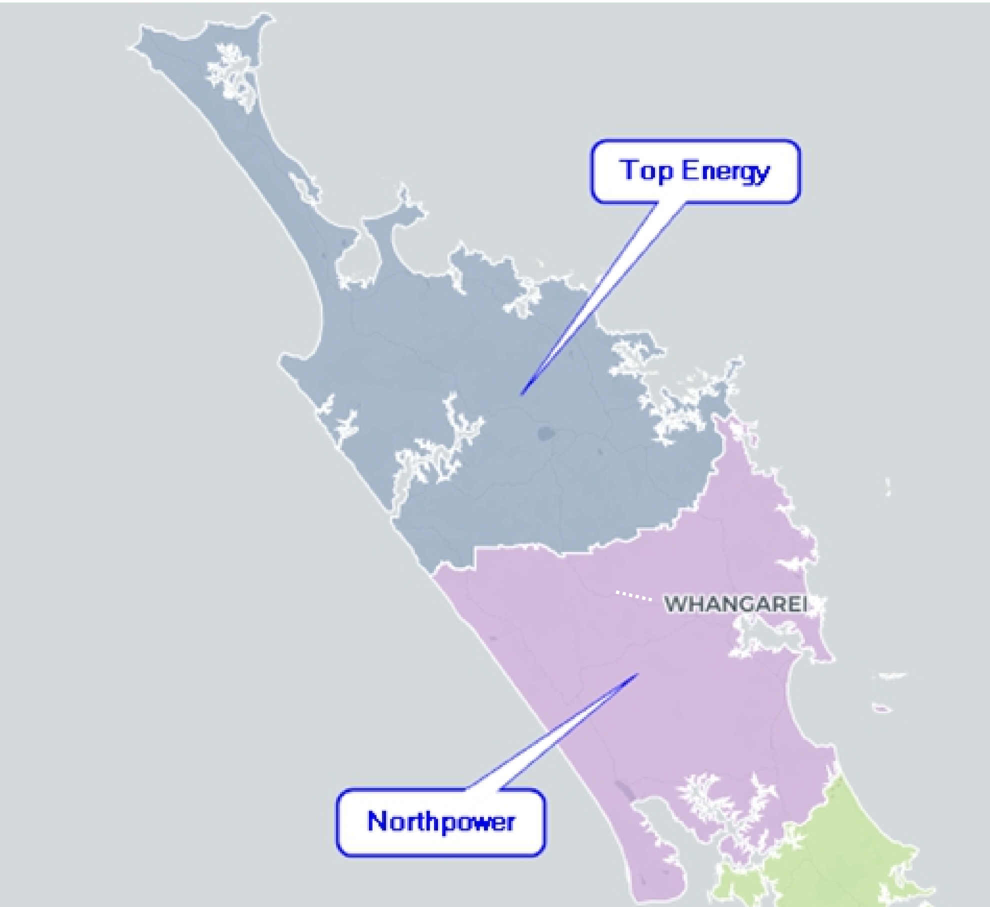


Figure 4 EDB franchise areas[5]

[4] https://www.eeca.govt.nz/co-funding/energy-transition-accelerator/
[5] 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) and (N-1) security) and supply characteristics (peak and average supply and seasonality information) for the major electrical infrastructure in the Northland region. This included reviewing both the GXP's, transmission substations, and local distribution zone substations along with their associated lines/cables within the Northland region.

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

- Transpower's *Transmission Planning Report 2022*.
- Top Energy's 2023 regulatory information disclosures[6] and Asset Management Plan.
- Northpower's 2023 regulatory information disclosures[7] and Asset Management Plan.
- SCADA substation loading data provided by Top Energy and Northpower.
- GXP metering data extracted from the Electricity Authority's website[7].
- Network diagrams provided by Top Energy and Northpower.
- Geographic Information System (GIS) asset and location data provided by Top Energy and Northpower. This was mostly supplied in the form of *.kmz files.

[6] These disclosures are the schedules included in the Asset Management Plan.

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

4. Northland Network

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

4.1 Transmission/GXP Substations

For the purposes of this report, a number of transmission substations owned and operated by the two EDBs will be grouped with the GXPs rather than with the zone substations. The following Figure 5 illustrates the relevant GXPs and transmission substations within the Northland region, which include the following:

- Kaikohe transmission substation [8].
- Kaitaia transmission substation.
- Maungatapere GXP.
    - Maungatapere 33 kV supply (transmission substation) [9]
    - Maungatapere 50 kV supply (transmission substation)[10]
    - Kensington transmission substation[10].
- Bream Bay GXP.
- Maungaturoto GXP.

The transmission network in the Northland region is also shown schematically in Figure 6. The network is comprised of 220 kV and 110 kV transmission circuits. The Northland region is supplied by a 220 kV double-circuit “main” line from Huapai and a 110 kV double-circuit “backup” line from Henderson. These circuits are effectively in parallel. The region has 74 MW local generation capacity excluding 20 MW[11] of rooftop solar generation, all of which is consumed locally. As generation capacity in Northland is well short of that needed to meet local demand, most of the region’s electricity demand is imported from the central North Island, through the Auckland region. Voltage support is provided by two static synchronous compensators (STATCOMs) at Marsden.

[8] This is the 110/33 kV part of the GXP.

[9] The substation forms part of what is known as the Maungatapere Regional substation.

[10] The substation is also known as the Kensington Regional substation.

[11] Electricity Market Information (EMI): Installed distributed solar generation trends as at 31 March 2022.

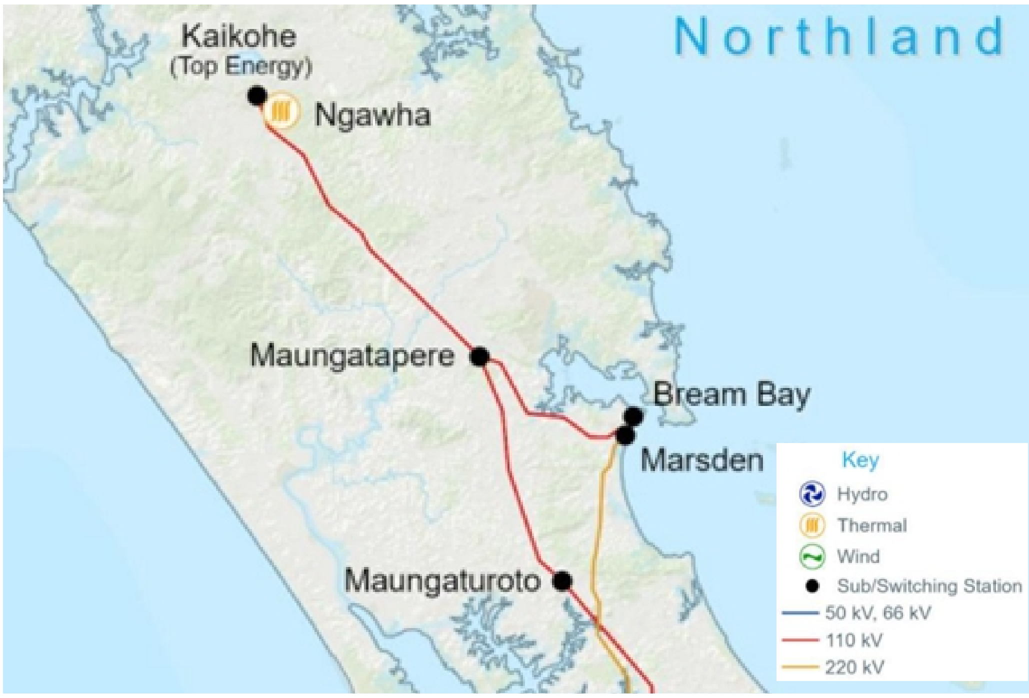


Figure 5 Transmission/GXP substations[12]

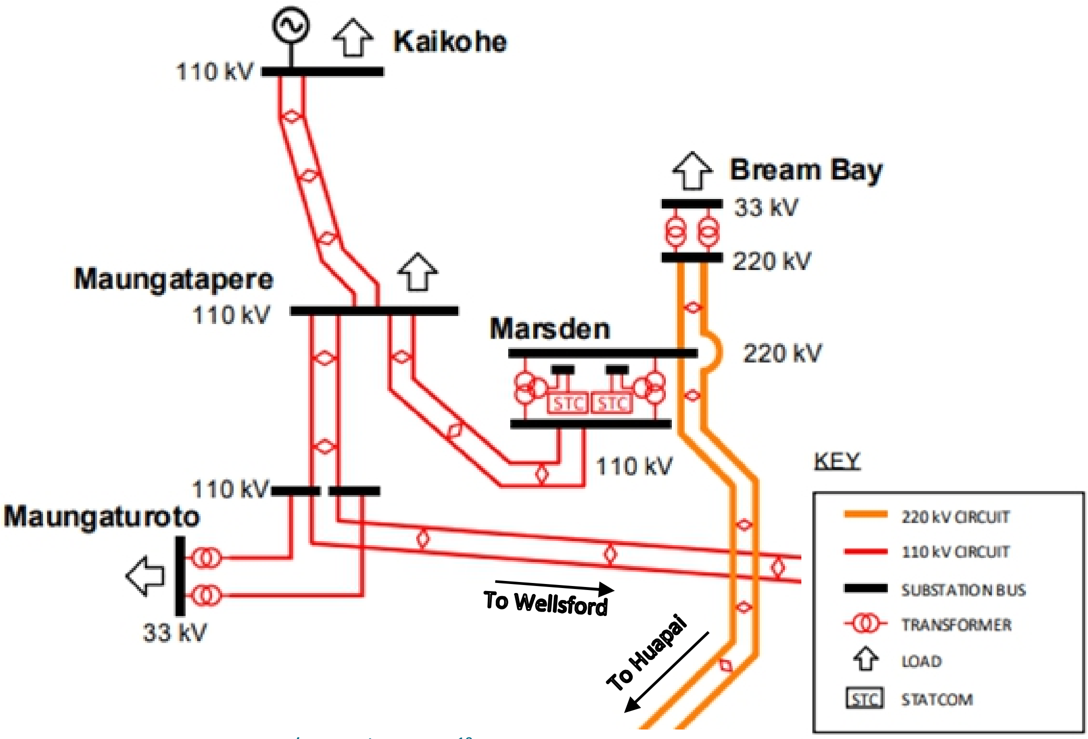


Figure 6 Existing transmission/GXP substations[10]

[12] *Transmission Planning Report 2022*.

4.2 Zone Substations

Zone substations are categorised by the EDB that owns and operates the network. As mentioned earlier, in the Northland area, there are two relevant EDB's – Top Energy and Northpower. Table 2 below gives an overview of the number of zone substations managed by each EDB, and the number of transmission substations/GXPs[13] they take power from.

Table 2 Overview of substation numbers for each EDB under review.

EDB Name	Number of zone substations	Number of transmission substations / GXPs
Top Energy	13	2
Northpower	20[14]	5

4.2.1 Top Energy

The following Figure 7 and Figure 8 shows the zone substations on Top Energy's northern and southern network areas respectively. The substations include:

- Kaikohe 33/11kV zone substation
- Kawakawa 33/11kV zone substation
- Moerewa 33/11kV zone substation
- Waipapa 33/11kV zone substation
- Omanaia 33/11kV zone substation
- Haruru 33/11kV zone substation
- Mt Pokaka 33/11kV zone substation
- Kerikeri 33/11kV zone substation
- Kaeo 33/11kV zone substation
- Okahu Rd 33/11kV zone substation
- Taipa 33/11kV zone substation
- NPL 33/11kV zone substation
- Pukenui 33/11kV zone substation

[13] Both Transpower and EDB owned.
[14] For the purposes of this report some substations operating at transmission voltages have been included in the transmission substation and GXP section of this report and not in the zone substation section.

Figure 7 Top Energy: Northern Zone Substation Geospatial Sub-transmission and Distribution Diagram[15]

[15] Top Energy's 2023 Asset Management Plan found here: https://topenergy.co.nz/tell-me-about/top-energy-group/publications-and-disclosures

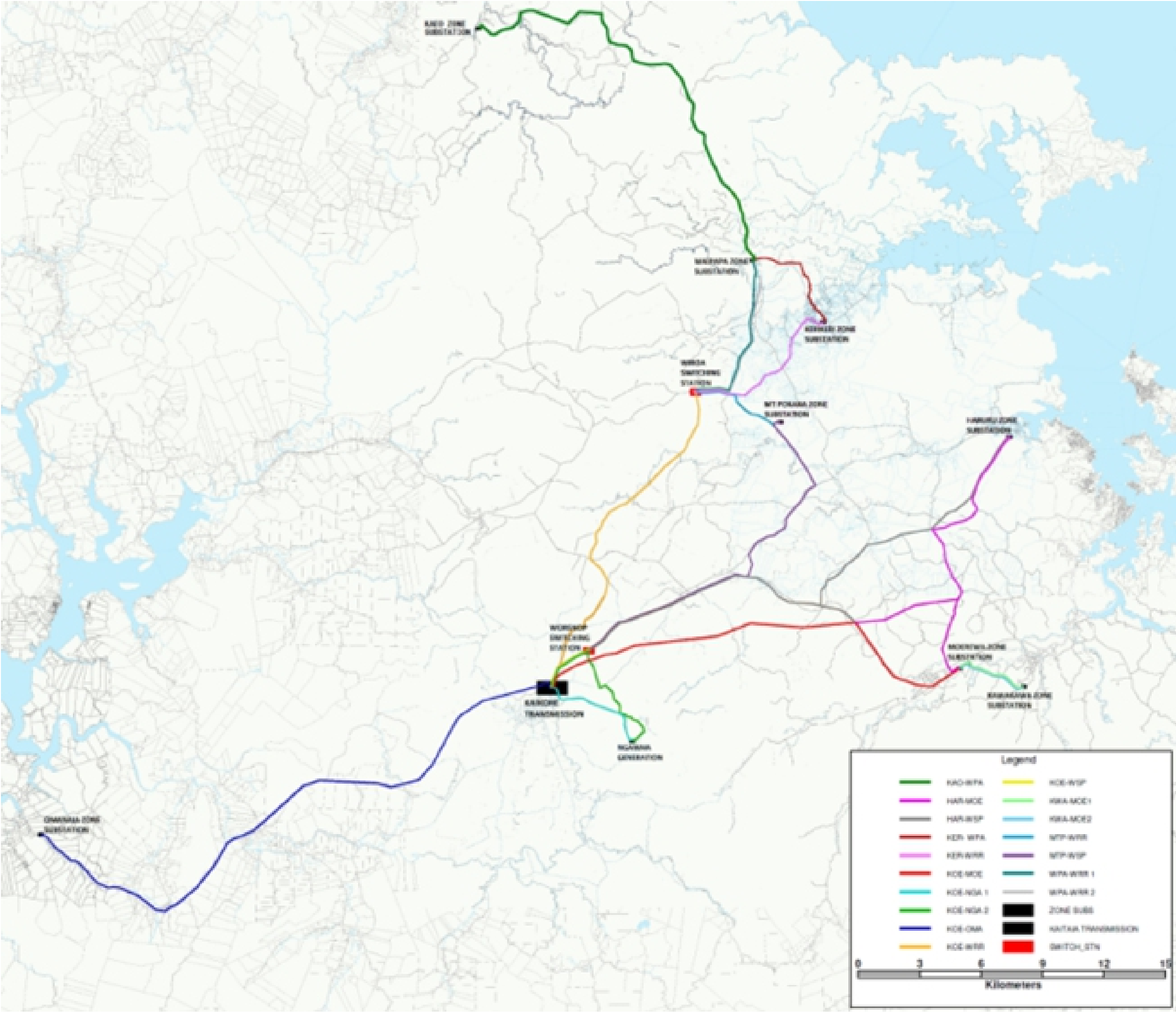


Figure 8 Top Energy: Southern Zone Substation Geospatial Sub-transmission and Distribution Diagram[15]

4.2.2 Northpower

The following Figure 9 through Figure 10 show the subtransmission network, zone substations, and schematic diagram of Northpower's network. The substations include:

- Alexander Street 33/11kV zone substation
- Bream Bay 33/11kV zone substation
- Dargaville 50/11 kV zone substation
- Hikurangi 33/11kV zone substation
- Kaiwaka 33/11kV zone substation
- Kamo 33/11kV zone substation
- Kioreroa 33/11kV zone substation
- Mangawhai 33/11kV zone substation
- Mareretu 33/11kV zone substation
- Maungatapere 33/11kV zone substation
- Maungaturoto 33/11kV zone substation
- Maunu 33/11kV zone substation
- Ngunguru 33/11kV zone substation

- Onerahi 33/11kV zone substation
- Parua Bay 33/11kV zone substation
- Poroti 33/11kV zone substation
- Ruakaka 33/11kV zone substation
- Ruawai 33/11kV zone substation
- Tikipunga 33/11kV zone substation
- Whangārei South 33/11kV zone substation

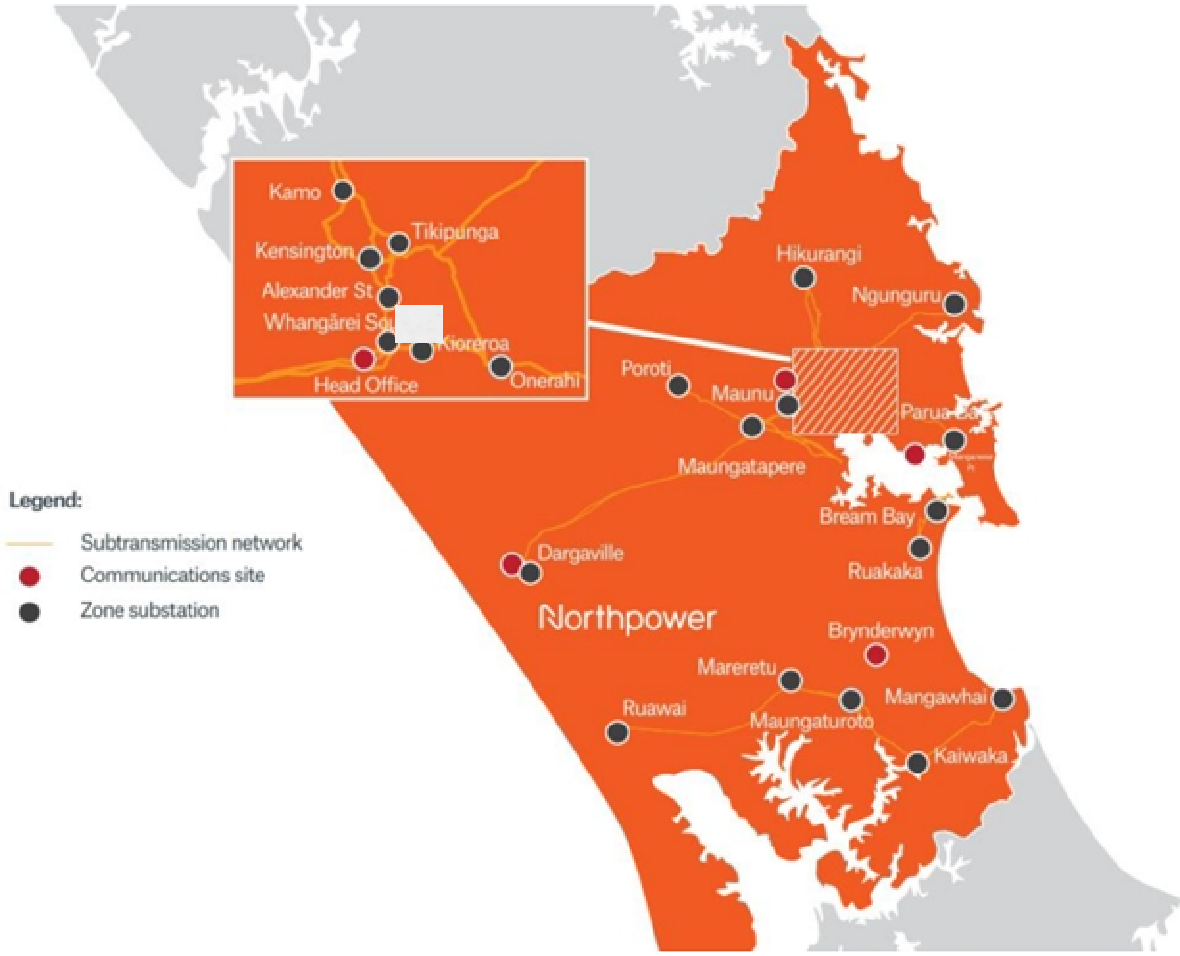


Figure 9 Northpower's zone substations and interconnecting subtransmission circuits [16]

[16] Northpower's 2023 Asset Management Plan found here: https://northpower.com/company/disclosures

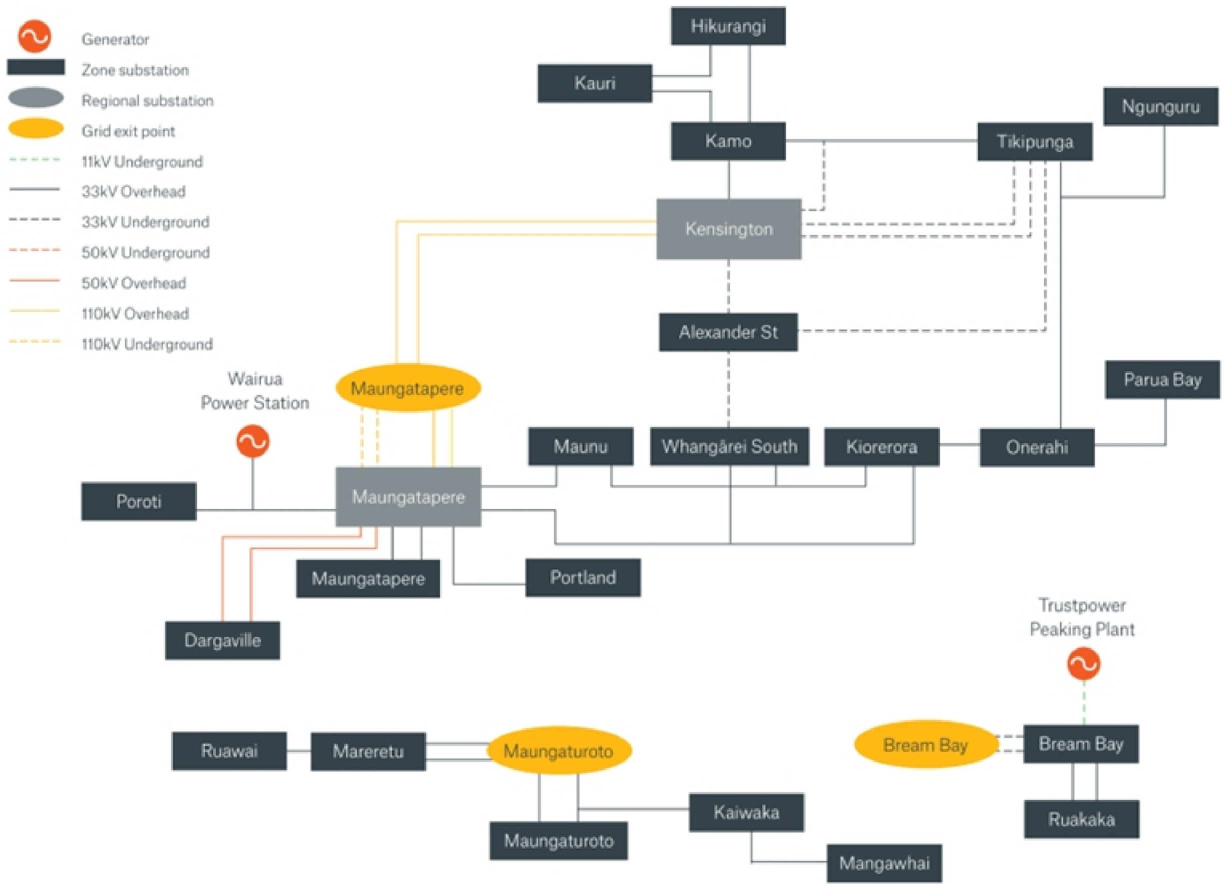


Figure 10 Northpower's network schematic diagram[16]

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 an annual AMP which often details a network specific security standard, 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 asset). 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. This scenario can be compared with to an aircraft, but in this case with two engines, which in the event of single engine failure will not crash.

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

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

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

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

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

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

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

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

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. More recently, the development of a market for interruptible load[18] has been initiated. 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 disconnect from the relevant electrical network during periods of peak loading.

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

6. Spare Capacity – Transmission Substations / GXPs

The following sections document the spare capacity that is available at the transmission substations/GXP's that supply the Northland region.

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

- As demand in the Northland regions grows, voltage stability margins will deteriorate to the point where several generator and circuit contingencies on the grid backbone can cause voltage problems within the Northland region.
- The Henderson–Wellsford–Maungaturoto–Maungatapere circuits do not have line circuit breakers at Wellsford and Maungaturoto; a fault on any section of the Henderson–Wellsford–Maungaturoto–Maungatapere circuit will disconnect the entire circuit.
- Without Ngawha generation, the peak load at Kaikohe is forecast to exceed the (N-1) capacity of the Kaikohe–Maungatapere circuits from winter 2022. With Ngawha generation, the peak load will be within the (N-1) capacity of the circuits for the forecast period to 2038.
- The peak load at Maungaturoto is forecast to exceed the (N-1) capacity of the supply transformers from winter 2030.

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

- Replacement of the 33 kV switchboard at the Maungaturoto GXP.
- Upgrade of the 110 kV busbar at the Maungaturoto GXP.

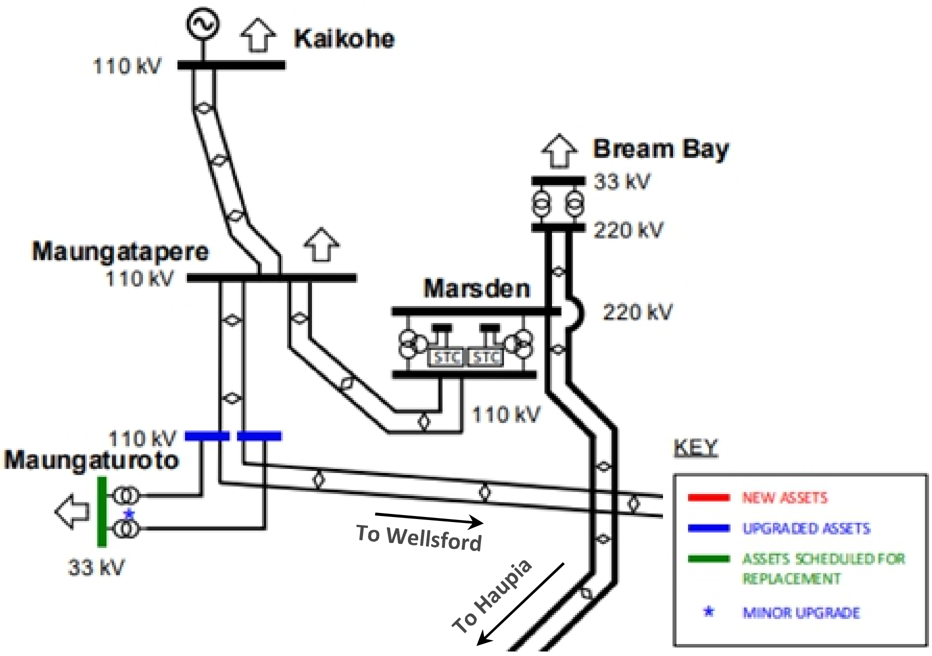


Figure 11 Existing transmission/GXP substations with future proposed upgraded/new assets[12]

6.1 Demand Forecast

The following Table 3 illustrates Transpower's forecast demand at the GXPs and the EDB's forecast for the transmission substations in the Northland region from its annual *Transmission Planning Report 2022*[12] and respective 2023 Asset Management reports. The forecast predicts the GXP demand growing at an average of 1.9% per annum over the next fifteen years which is lower than the national average of 2.1%.

Table 3 Forecast prudent annual peak demand (MW) at Northland transmission/GXP substations to 2037.

Transmission substation / GXP	Power factor	Peak demand (MW)											
		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2037
Kaikohe GXP	0.99	78	79	79	79	80	80	81	82	82	83	83	85
Kaikohe transmission substation	N/A	48	48	53	54	56	57	58	60	30[19]	30	31	32
Kaitaia transmission substation	N/A	24	26	26	26	26	27	27	27	27	28	28	28
Maungatapere GXP	1.00	120	121	124	126	128	131	133	134	136	138	139	146
Maungatapere (33 kV) transmission substation	N/A		34.2	34.7	35.1	35.5	35.8	36.2	36.6	37.0	37.3	37.7	38.0
Maungatapere (50 kV) transmission substation[20]	N/A	11.7	11.9	12.1	12.3	12.5	12.6	12.7	12.7	12.8	12.9	13.0	13.1
Kensington transmission substation	N/A	59	60.8	61.8	62.7	63.6	64.5	65.4	66.3	67.2	68.1	69	69.9
Bream Bay GXP	0.98	25	26	26	27	28	29	30	30	31	32	32	36
Maungaturoto GXP	1.00	22	24	25	25	27	28	28	29	29	30	31	32

Note: The prudent peak load forecast follows our accelerated electrification scenario in *Whakamana i Te Mauri Hiko*. This includes an estimate for each grid exit point where electrification assists in decarbonising New Zealand's economy.

6.1.1 Kaikohe GXP and Kaitaia Transmission Substation

Transpower's demand forecast indicates that the Kaikohe GXP is expected to have a 2023 peak demand of 79 MW at 0.99pf. This contrasts with the historical SCADA data that indicates that, in 2022 the Kaikohe GXP experienced a peak load of 41 MVA. However, this peak occurred for only one half-hour period at 09H30 on 7 October 2022. Prior peaks were at 35.8 MVA. It is possible that the large difference between the forecast load and the actual observed load is partially explained by the recent connection of the Ngawha generation plant (~25MW).

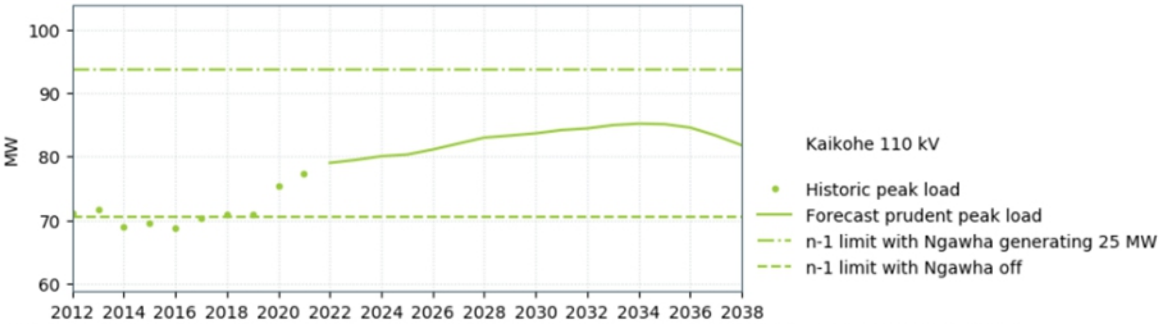
Considering the two 110 kV circuits supplying the GXP, the substation has a nominal (N security) installed capacity of 126/154 MVA (summer/winter) and an (N-1) capacity of 63/77 MVA (summer/winter).

[19] This reduction in load is because the planned Wiroa transmission substation will be commissioned by 2030 and offload approximately 50% of the Kaikohe transmission substation load.

[20] This load forecast was obtained by subtracting the Dargaville load forecast from the Maungatapere Regional substation load forecast as detailed in Table 8.5 of Northpower's 2023 AMP.

The Kaikohe transmission substation is equipped with two 110/33 kV transformers rated at 30 MVA and 50 MVA respectively are owned and operated by Top Energy. The transformers have a (N) security capacity of 80 MVA and a (N-1) capacity of 39 MVA.

The following graph[21] compares Kaikohe GXP's 110 kV circuits supply capacity with the historical loading and Transpower's demand forecast.



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.

Top Energy take supply at 110 kV from the Kaikohe GXP and supply the northern network area via a single 110 kV circuit to their Kaitaia transmission substation, and the southern network area from the Kaikohe transmission substation.

The following Figure 12 and Figure 13 illustrates Kaikohe GXP, Kaikohe transmission substation, and Kaitaia transmission substation's 2022 loading in comparison to its substation capacity. All three substations are supplied via 110 kV double circuit lines from Maungatapere GXP.

[21] Sourced from Transpower's *Transmission Planning Report 2022*.

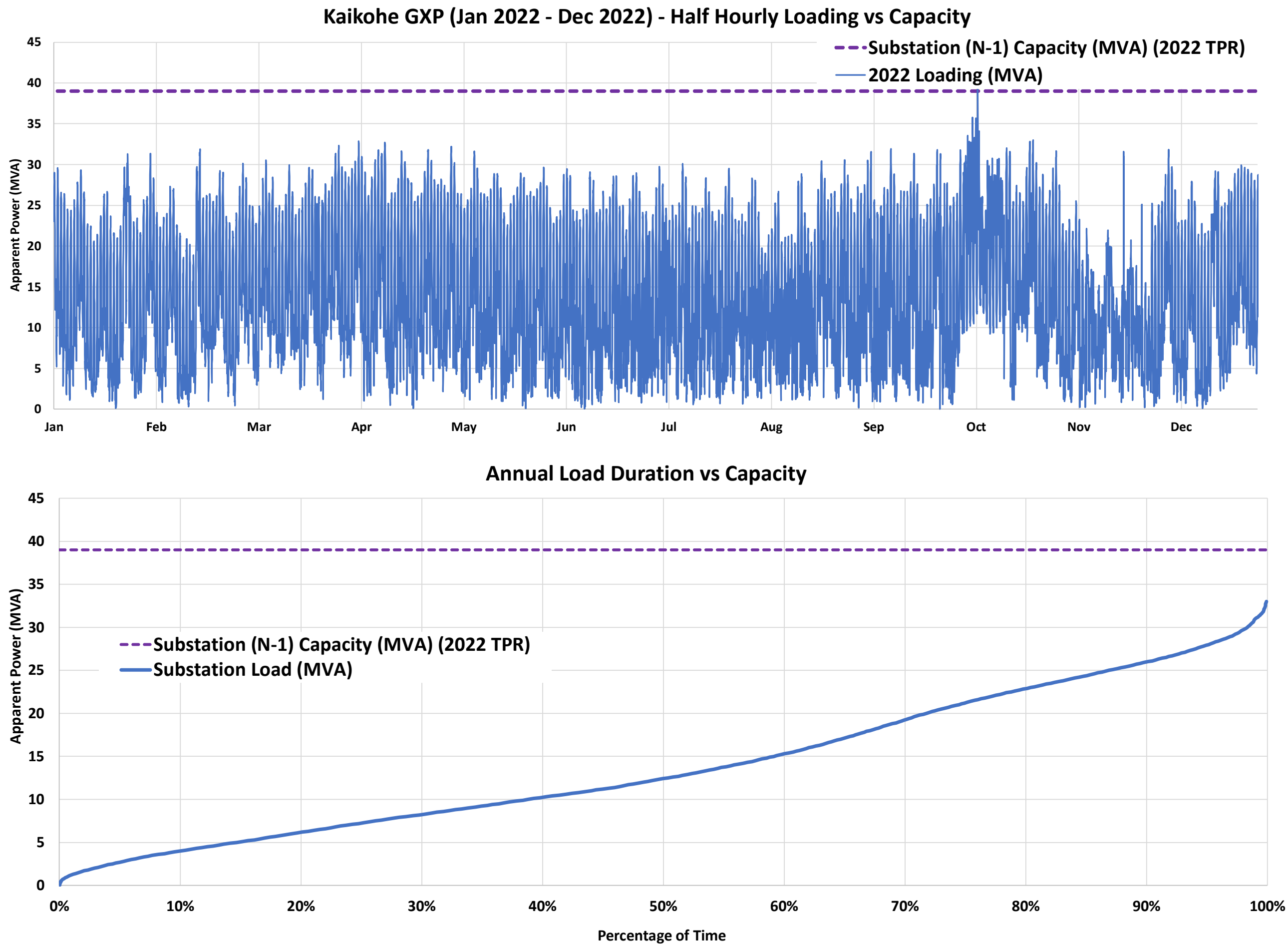
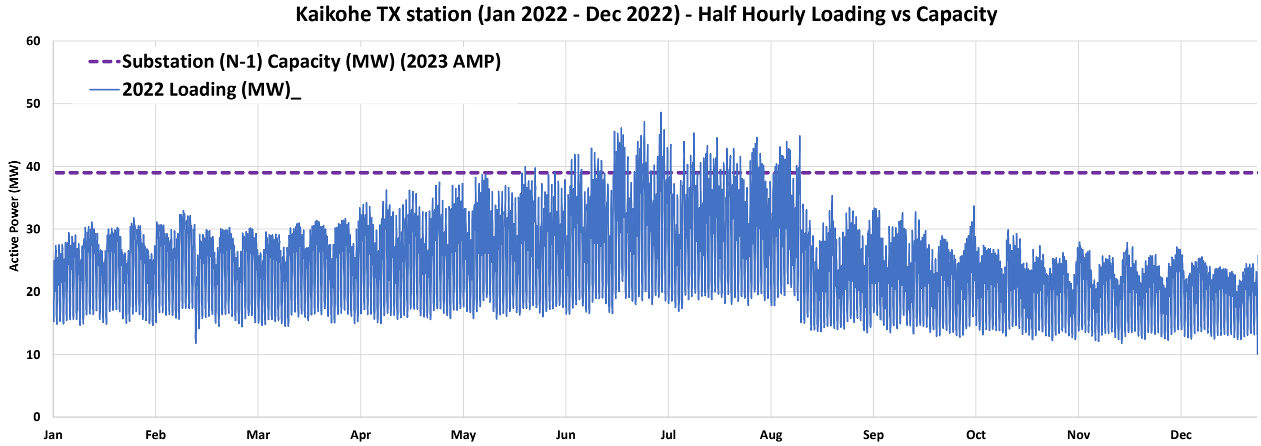


Figure 12 Kaikohe GXP: 2022 Loading: Substation capacity (note N-1 limit is based on incoming lines)



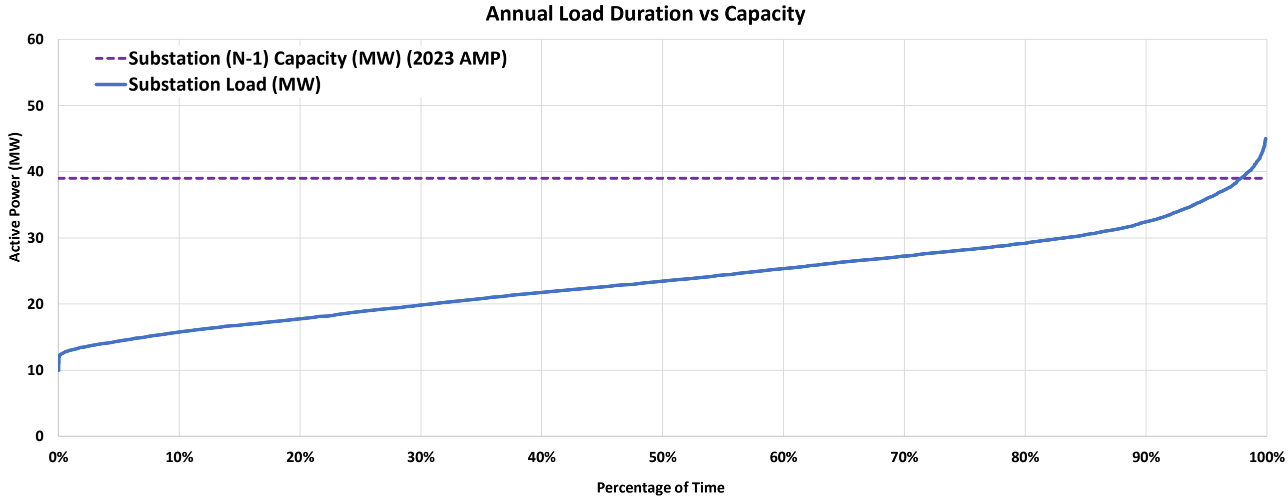


Figure 13 Kaikohe Transmission Substation: 2022 Loading: Substation capacity

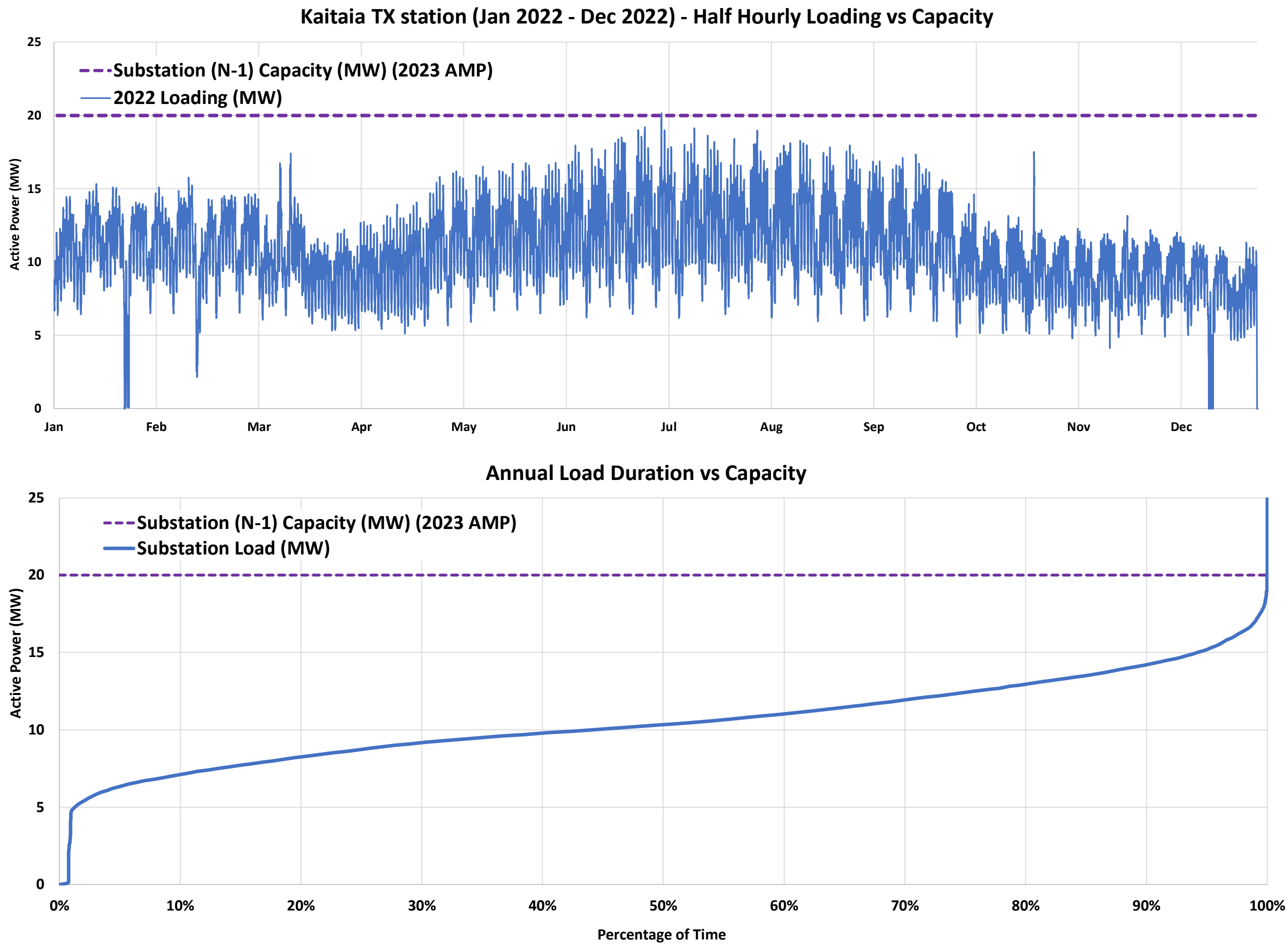
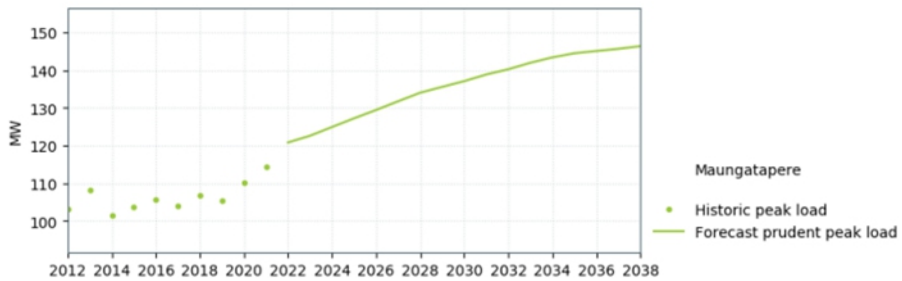


Figure 14 Kaitaia Transmission Substation: 2022 Loading: Substation capacity.

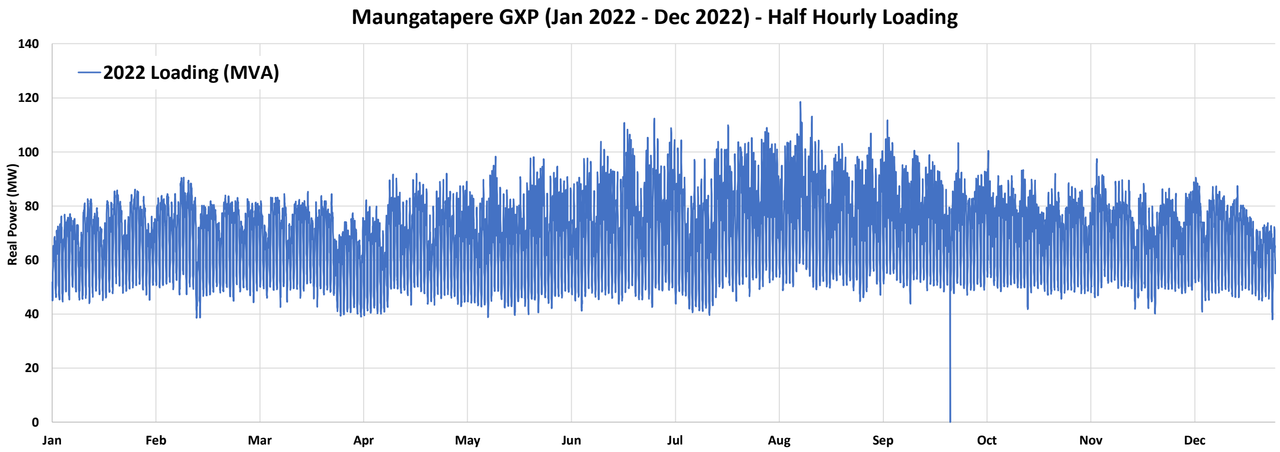
6.1.2 Maungatapere transmission substations

Northpower owns the 110 kV feeders and supply transformers at the Maungatapere GXP. The following graph shows the Maungatapere GXP's 110 kV historical loading and Transpower's demand forecast.



The Maungatapere Regional substation has two sets of transformers supplying the two 50 kV feeders to Dargaville, and supplying the 33 kV subtransmission network to Maungatapere, Whangārei and Golden Bay.

The following Figure 15, Figure 16, and Figure 17 illustrates the Maungatapere GXP, Maungatapere 33 kV, and Maungatapere 50 kV 2022 loading in comparison to its substation capacity as well as the load duration curves in relation to capacity.



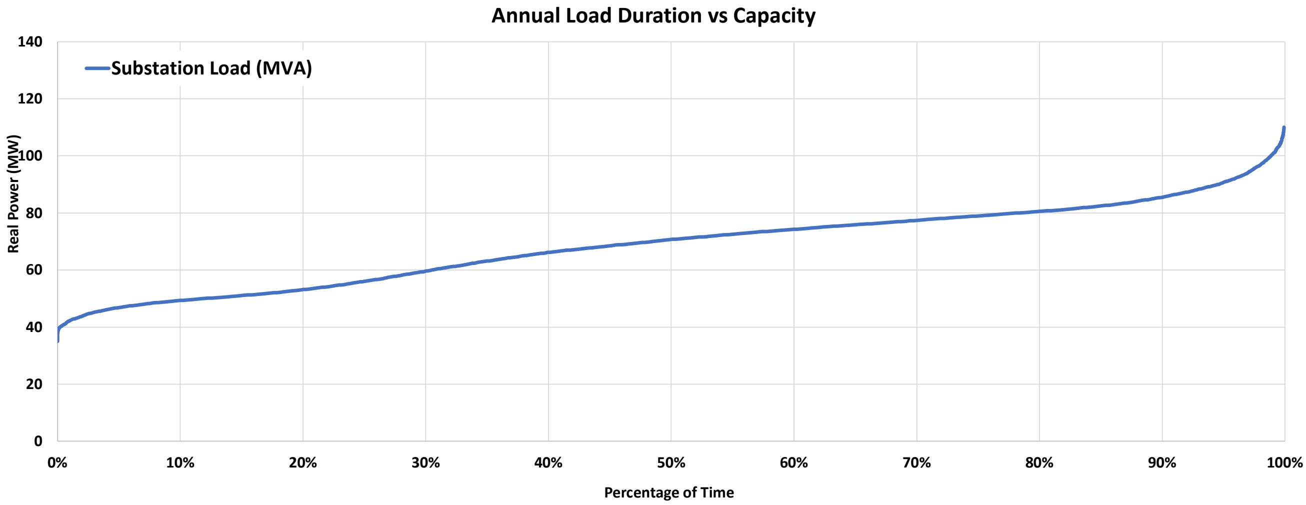


Figure 15 Maugatapere GXP: 2022 Loading and load duration.

Northpower's demand forecast indicates that the Maungatapere 33 kV transmission station is expected to have a 2023 peak demand of 46.1 MVA. This aligns well with the actual peak demand measured in 2022.

The Maungatapere 33 kV load is supplied by:

- Two 110/33 kV, 30/37/39 MVA transformers providing:
  - A total nominal installed capacity of 60 MVA.
  - A (N-1) capacity of 30 MVA.

Northpower's demand forecast indicates that the Maungatapere 50 kV transmission station is expected to have a 2023 peak demand of 11.9 MVA. This is the same as the actual peak demand measured in 2022.

The Maungatapere 50 kV load is supplied by:

- Two 110/50 kV, 25/35 MVA transformers providing:
  - A total nominal installed capacity of 70 MVA.
  - A (N-1) capacity of 35 MVA.

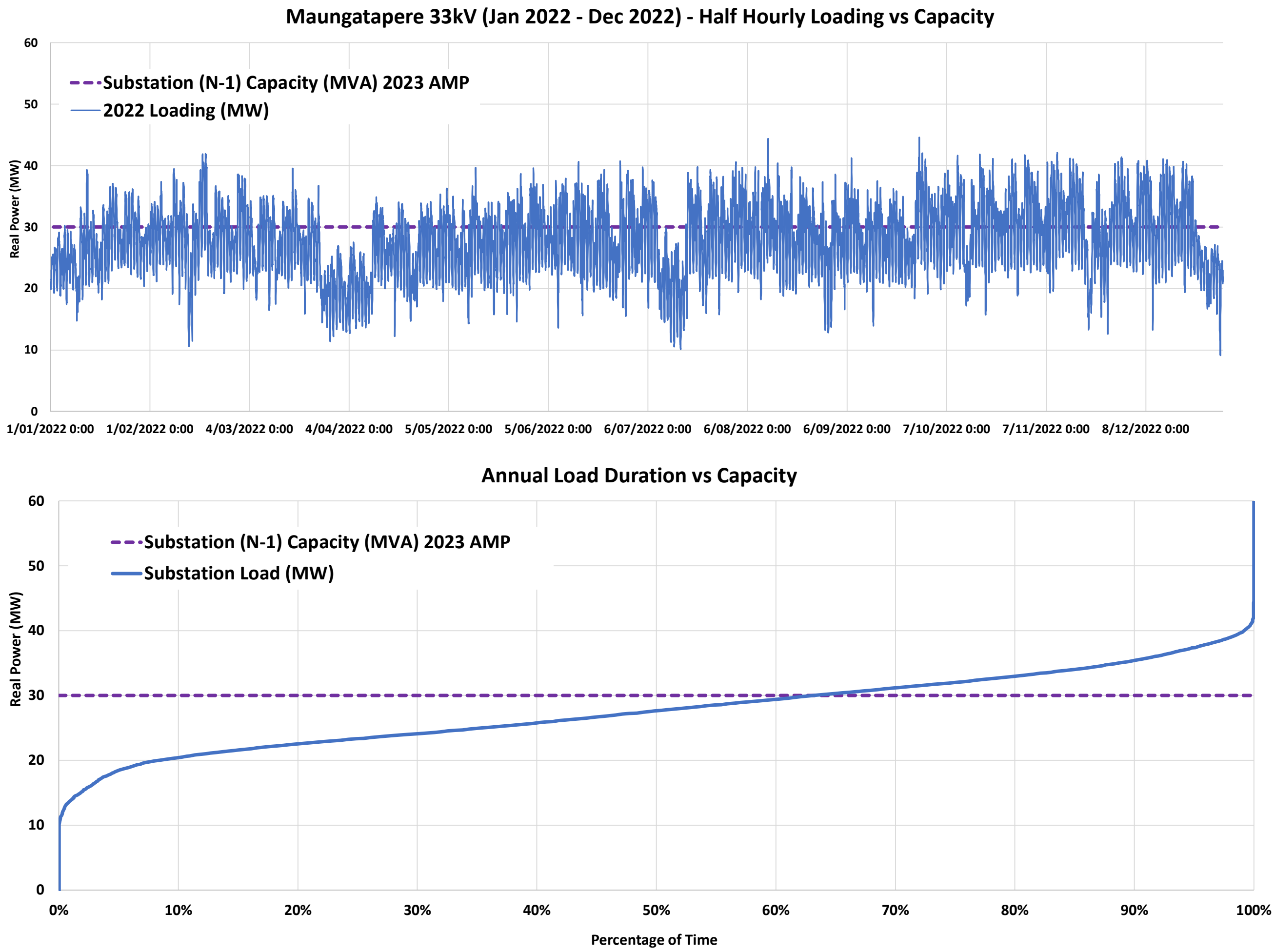


Figure 16 Maugatapere 33 kV: 2022 Loading, capacity, and load duration.

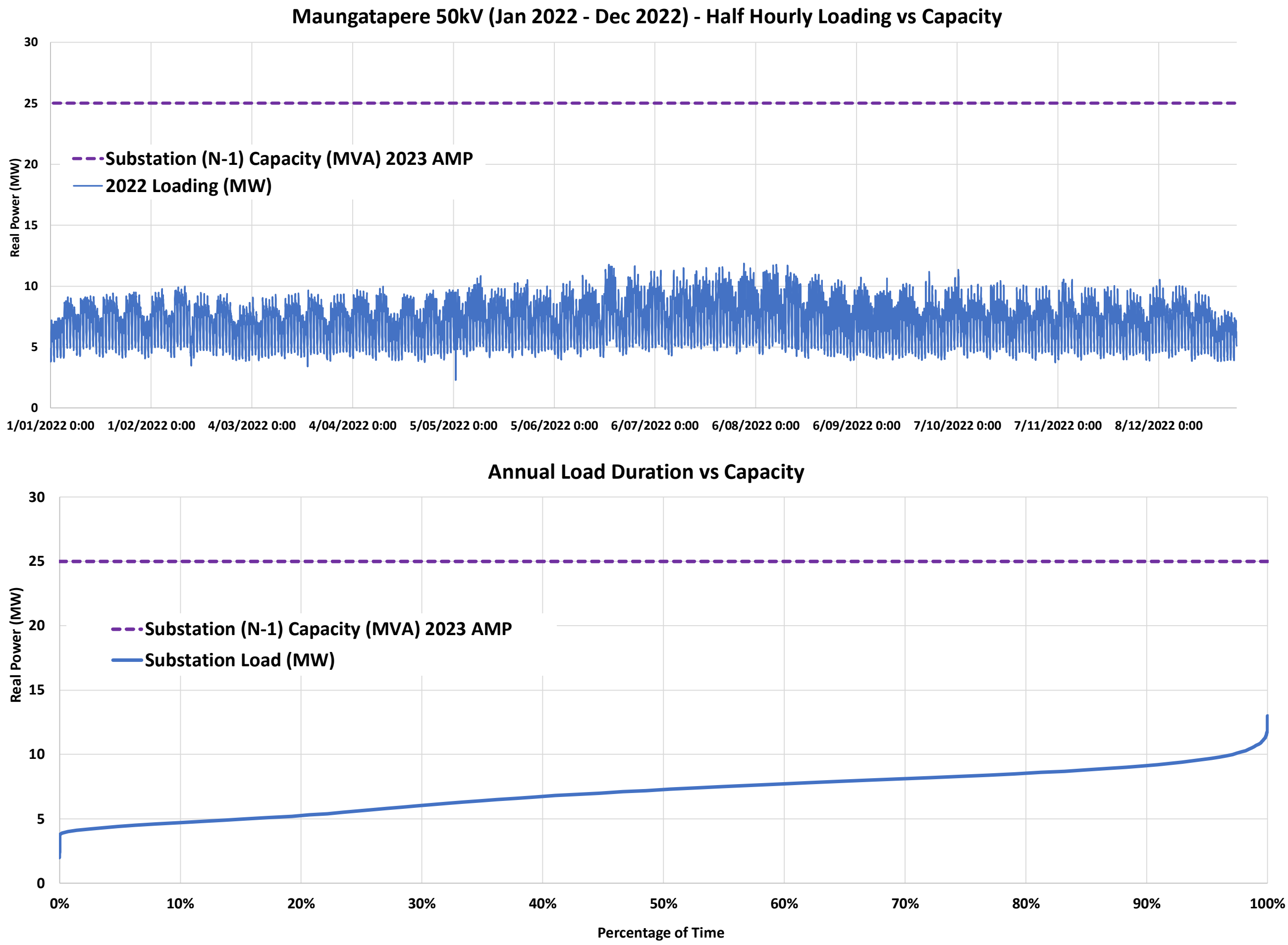


Figure 17 Maugatapere 50 kV: 2022 Loading, capacity, and load duration.

6.1.3 Kensington transmission substation

Northpower's demand forecast indicates that the Kensington transmission station is expected to have a 2023 peak demand of 61 MVA. This aligns well with the actual peak demand measured in 2022 of 59.7 MW.

The Kensington load is supplied by:

- A 110 kV double circuit overhead line from the Maungatepere GXP.
- Two 110/33 kV supply transformers rated at 50 MVA each, providing:
  - A total nominal installed capacity of 100 MVA.
  - A (N-1) capacity of 50 MVA.

The Kensington regional substation has already reached its (N-1) firm capacity limit of 50 MVA and is expected to reach 70 MVA in the next 10 years. This is a critical substation, supplying seven zone substations and a dairy-focussed substation with nearly 30,000 customers. The substation will be upgraded with two 100 MVA transformers which will be completed in 2026.

6.1.4 Bream Bay GXP

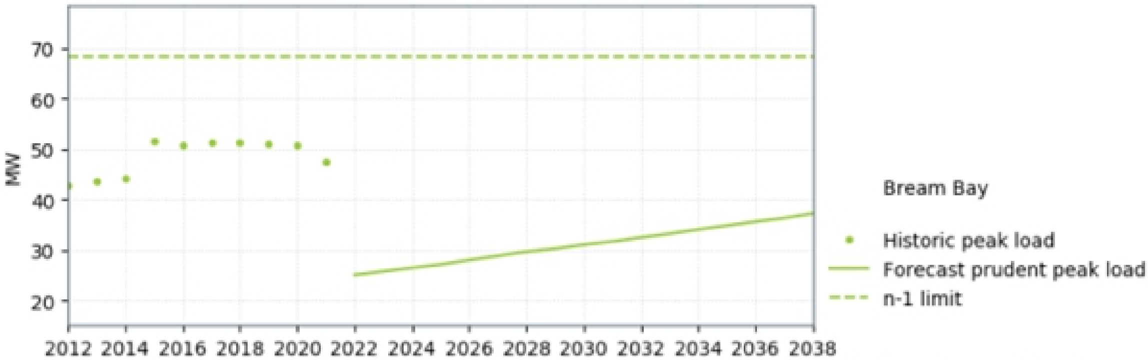
Transpower's demand forecast indicates that the Bream Bay GXP is expected to have a 2023 peak demand of 26 MW at 0.98 power factor. This contrasts with the historical SCADA data which shows a significant reduction 2022 due to the closure of the Marsden Point Refinery operations. The closure resulted in an approximate 30 MW reduction in load while the refinery still takes around 4 MW of load.

The Bream Bay load is supplied by:

- Two 220/33 kV supply transformers rated at 75 MVA each, providing:
  - A total nominal installed capacity of 150 MVA.
  - A (N-1) capacity of 75/75 MVA (summer/winter).

The peak load on the Bream Bay GXP is within the (N-1) capacity of the supply transformers for the forecast period.

The following graph[15] compares Bream Bay GXP's supply capacity with the historical loading and Transpower's demand forecast. Peak load at Bream Bay is within the (N-1) capacity of the supply transformers for the forecast period.



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

The following Figure 18 illustrates Bream Bay GXP's 2022 loading in comparison to its substation capacity.

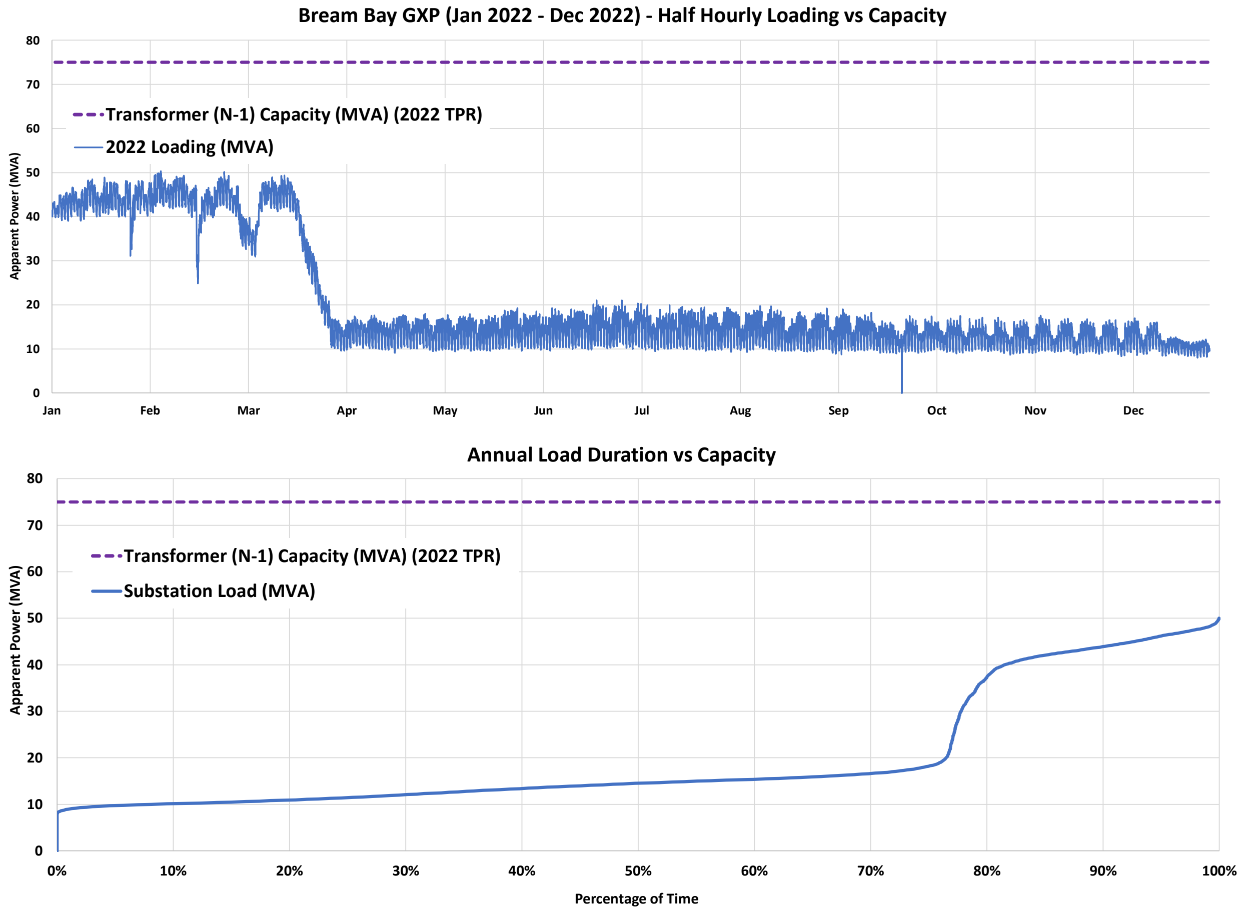


Figure 18 Bream Bay GXP: 2022 Loading: Substation capacity:

6.1.5 Maungaturoto GXP

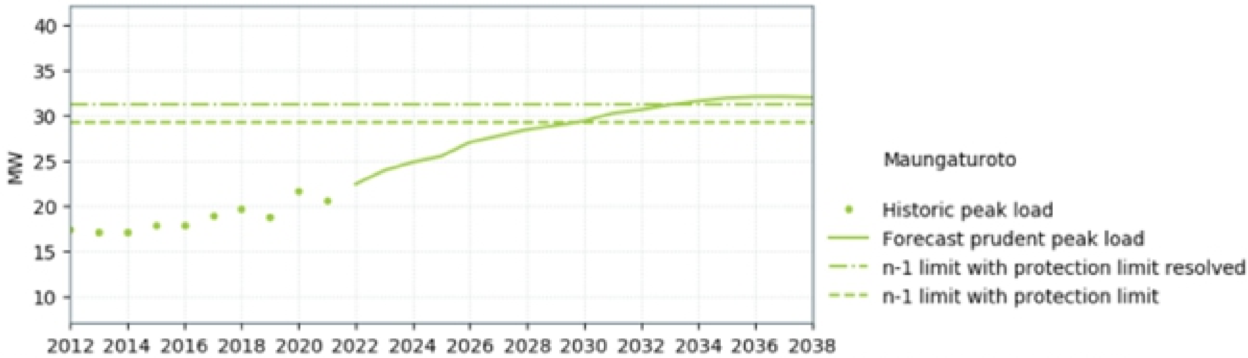
Transpower's demand forecast indicates that the Maungaturoto GXP is expected to have a 2023 peak demand of 24 MW at unity power factor. This contrasts with the historical SCADA data that indicates that, during 2022, the Maungaturoto GXP experienced a peak load of 24.2 MVA only for a single half hourly period, and only three half hourly periods were more than 21 MVA.

The Maungaturoto GXP is equipped with two 110/33 kV transformers rated at 25/30 MVA each, that provide:

- A total nominal installed capacity of 50 MVA.
- An (N-1) capacity of 25/30 MVA (summer/winter)

The 33 kV system at the Maungaturoto GXP supplies the subtransmission network of Northpower and more specifically the Kaipara District Council region except for Dargaville. This includes the zone substations of Maungaturoto, Manghawai, Kaiwaka, Mareretu, and Ruawai.

The following graph[15] compares Maungaturoto GXP's supply capacity with the historical loading and Transpower's demand forecast.



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 Maungaturoto GXP's 2022 loading in comparison to its substation capacity.

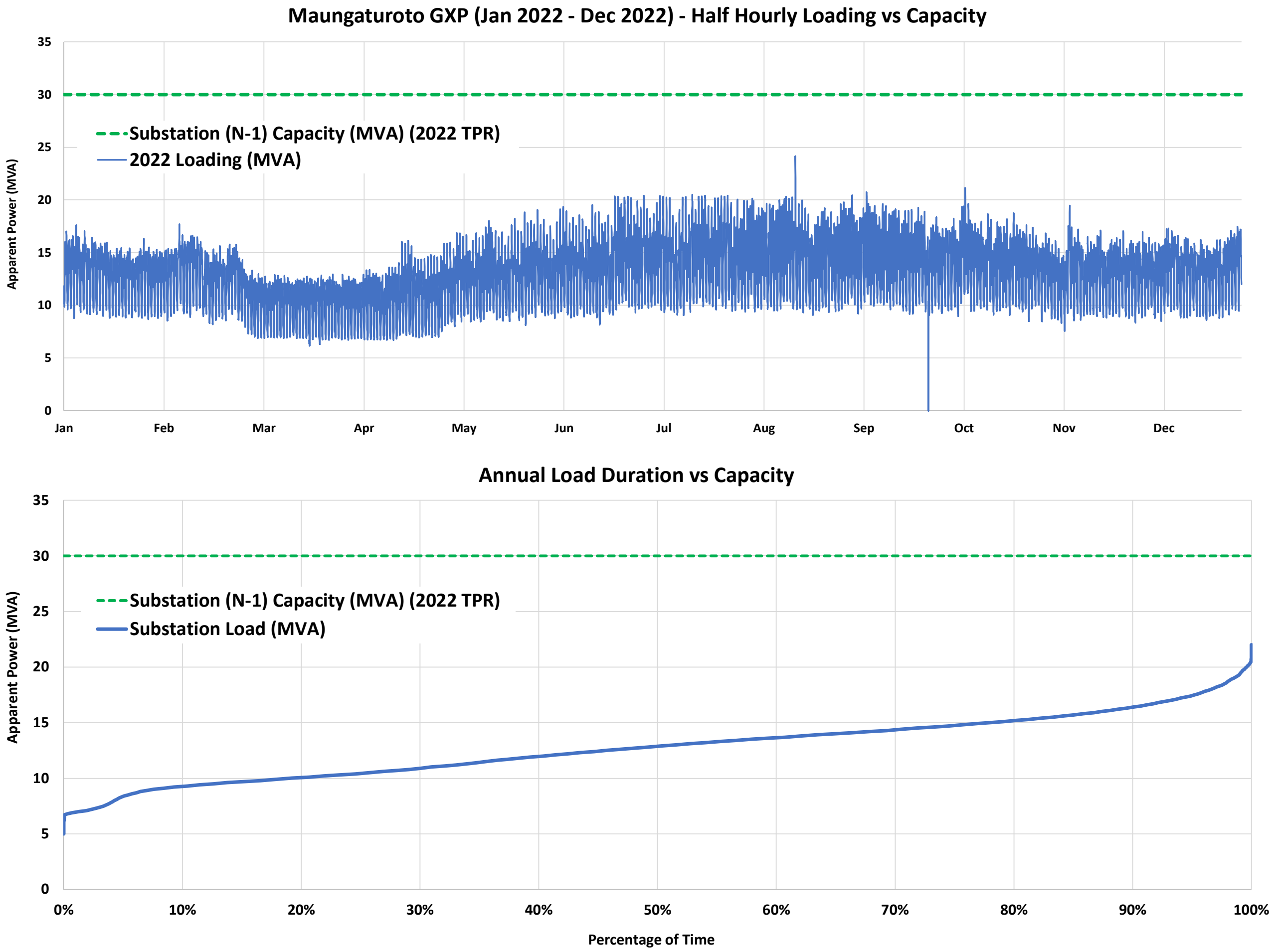


Figure 19 Maungaturoto GXP: 2021 Loading: Substation capacity

6.2 Spare Capacity based on Transpower & EDB's 2022/3 Forecast

The following Figure 20 summarises the approximate, all year, (N-1) and (N) spare capacities at each transmission substation/GXP based on:

- The substation capacity disclosed in Transpower's *Transmission Planning Report 2022*
- The 2022 forecast load provided in Transpower's *Transmission Planning Report 2022* (refer to Table 3 above).
- The Top Energy 2023 AMP and disclosure data.
- The Northpower 2023 AMP and disclosure data.

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

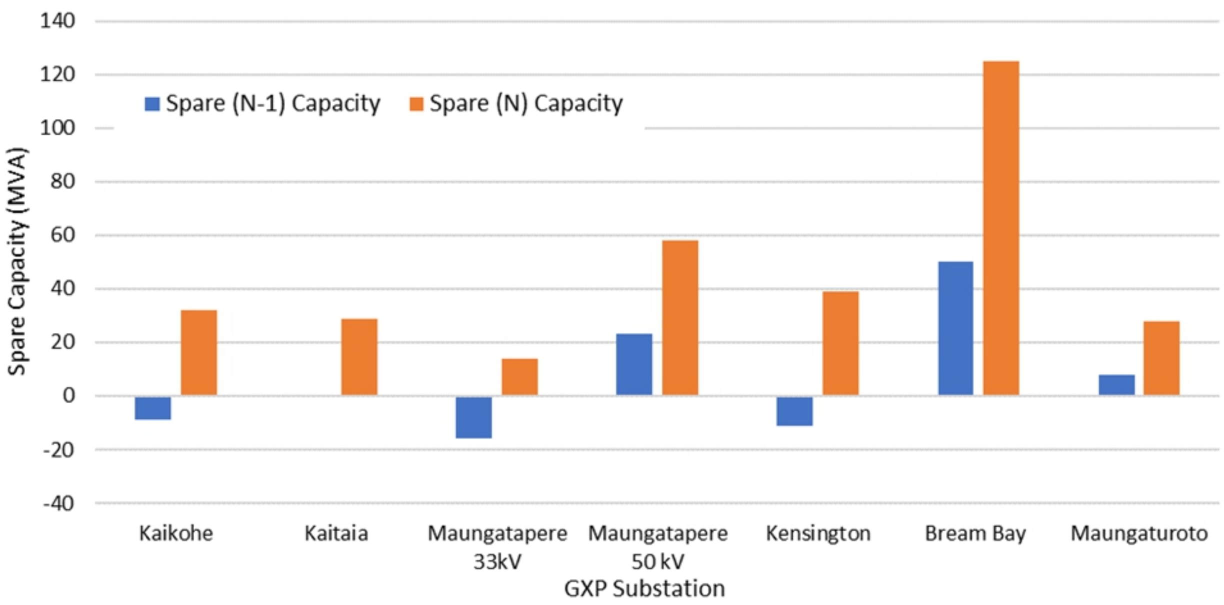


Figure 20 Summary: Approximate N and N-1 spare capacity at GXPs and transmission substations.

It should be noted that the spare capacities are based on the values disclosed by Transpower, Top Energy, and Northpower. Also, the spare (N) capacities do not include any voltage constraints or upstream transmission constraints, which would need to be confirmed by Transpower or the relevant EDB. We note the following:

- The negative values in Figure 20 indicate that there is no capacity and consumer load cannot be supplied (for (N) and (N-1) conditions).
- Figure 20 indicates that only Bream Bay has a substantial levels of spare (N-1) capacity. All other GXPs and transmission stations already exceed their (N-1) capacity or are (N) capacity substations.

7. Spare Capacity – Zone Substations

In determining the (N) and (N-1) spare capacities for the zone substation, Ergo reviewed the EDB 2023 disclosure data and the historical substation loading data for 2022. Actual historical loading data was provided by Top Energy and Northpower and all data is shown in Table 4 and Table 5 respectively.

7.1 Top Energy

Table 4 Top Energy: Spare capacity for each Zone Substation

No.	Substation Name	Spare (N) Capacity		Spare (N-1) Capacity[22]	
		Disclosure Data	Historical Data	Disclosure Data	Historical Data
1	Kaikohe	24.00	24.7	7.0	7.7
2	Kawakawa	5.50	6.4	-1.0	-0.1
3	Moerewa	7.00	4.5	2.0	-0.5
4	Waipapa	35.00	35.9	12.0	12.9
5	Omanaia	2.00	2.2	N/A	N/A
6	Haruru	40.00	39.1	17.0	16.1
7	Mt Pokaka	2.00	0.7	N/A	N/A
8	Kerikeri	38.00	34.2	15.0	11.2
9	Kaeo	16.00	15.0	N/A	N/A
10	Okahu Rd	13.00	13.5	2.0	2.5
11	Taipa	0.25	0.5	N/A	N/A
12	NPL	36.00	35.3	13.0	12.3
13	Pukenui	3.00	2.8	N/A	N/A

Note: The negative (N-1) ratings represent a zone substation where the (N-1) rating is already exceeded at times throughout the year.

[22] N/A represents zone substations with N security.

7.2 Northpower

Table 5 Northpower: Spare capacity for each Zone Substation.

No.	Substation Name	Spare (N) Capacity		Spare (N-1) Capacity	
		Disclosure Data	Historical Data	Disclosure Data	Historical Data
1	Alexander Street	20.0	20.1	5.0	5.1
2	Bream Bay	4.0	-1.3	N/A	N/A
3	Dargaville	18.0	18.1	3.0	3.1
5	Hikurangi	13.0	11.7	3.0	1.7
6	Kaiwaka	2.0	2.3	N/A	N/A
7	Kamo	17.0	17.0	2.0	2.0
9	Kioreroa	31.0	31.4	11.0	11.4
10	Mangawhai	2.0	2.5	N/A	N/A
11	Mareretu	2.0	1.4	N/A	N/A
12	Maungatapere	10.0	9.3	2.5	1.8
14	Maungaturoto	8.0	8.4	0.5	0.9
15	Maunu	6.0	5.3	N/A	N/A
16	Ngunguru	0.8	0.20	N/A	N/A
17	Onerahi	23.0	22.8	8.0	7.8
18	Parua Bay	0.8	-0.17	N/A	N/A
19	Poroti	2.0	1.9	N/A	N/A
20	Ruakaka	12.0	11.5	2.0	1.5
21	Ruawai	2.0	1.3	N/A	N/A
22	Tikipunga	23.0	22.7	3.0	2.7
23	Whangārei South	9.0	9.0	-1.0	-1.0

Note: The negative (N-1) ratings represent a zone substation where the (N-1) rating is already exceeded at times throughout the year.

7.3 Summary

7.3.1 Top Energy

7.3.1.1 (N-1) Capacity Summary

The following Figure 21 illustrates the approximate (N-1) spare capacities at Top Energy's zone substations, for the disclosed 2022 peak demand estimates[23]. It should be noted that these have been calculated based on the transformer ratings disclosed by Top Energy.

[23] Top Energy's 2023 information disclosure available here: https://topenergy.co.nz/tell-me-about/top-energy-group/publications-and-disclosures.

The spare capacities shown do not include any upstream or downstream lines, cables or other equipment thermal constraints.

The negative (N-1) ratings represent a zone substation where the (N-1) rating is already exceeded at times throughout the year. This means there is no spare (N-1) capacity left and the red graph indicates the extent that the (N-1) secure capacity has been exceeded in the past. Zone substation with (N) security have been omitted from this graph. This means that five (including Kawakawa zone substation which has already exceeded its (N-1) capacity) of the 13 zone substations do not have (N-1) security with respect to the supply transformers.

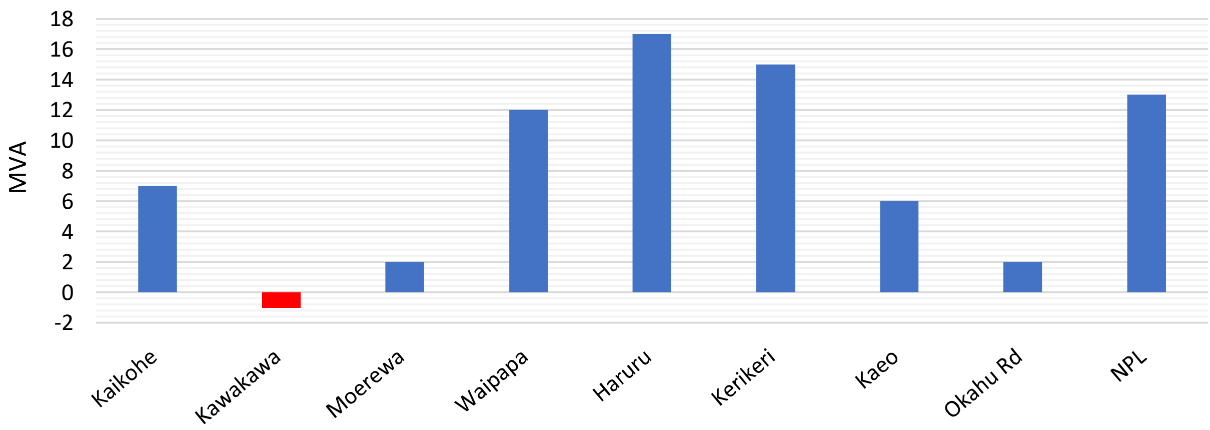


Figure 21 Summary: Approximate (N-1) spare capacity at Top Energy's zone substations.

A load transfer of 1.5 MVA (20%) from Kawakawa to Haruru planned for FY24 will restore the (N-1) capacity to approximately 8% or 0.5 MW. Forecast capital expenditure includes the upgrading of the Kawakawa zone substation and the application to connect high-capacity EV chargers will potentially require this investment to occur earlier.

7.3.1.2 (N) Capacity Summary

The following Figure 22 illustrates the approximate (N) spare capacities at Top Energy'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 Top Energy. The spare capacities shown do not include any upstream or downstream conductor or other equipment thermal constraints.

Figure 22 indicates that almost all the zone substations have significant spare (N) capacity based on actual transformer capacity (between 44% and 87% across all zone substations), except for Taipa zone substation which only has 4% spare capacity left. A replacement transformer at Taipa is provided for in the capital expenditure forecast and is scheduled for commissioning in FY29.

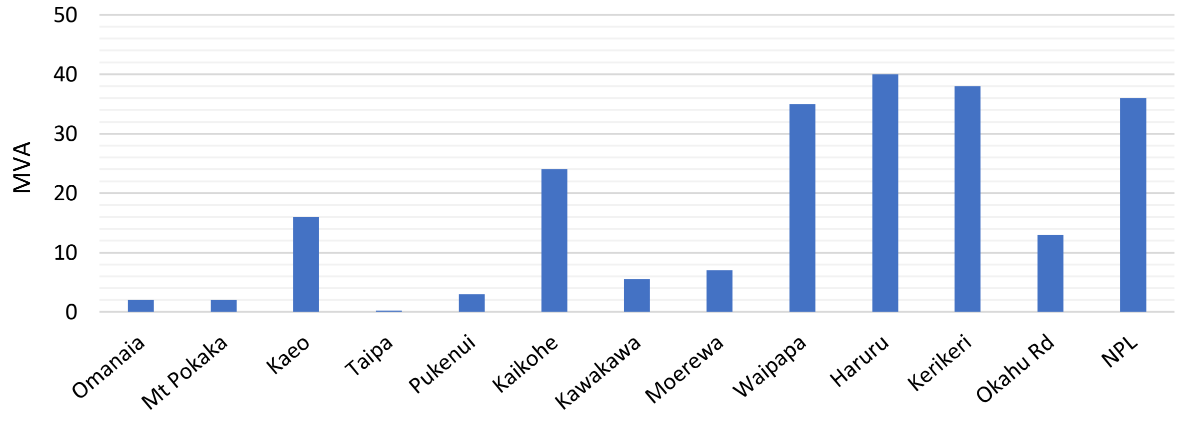


Figure 22 Summary: Approximate (N) spare capacity at Top Energy's zone substations

7.3.2 Northpower

7.3.2.1 (N-1) Capacity Summary

The following Figure 23 illustrates the approximate (N-1) spare capacities at Northpower'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 Northpower.

The spare capacities shown do not include any upstream or downstream conductor or other equipment thermal constraints.

The negative (N-1) ratings represent a zone substation where the (N-1) rating is already exceeded at times throughout the year. This means there is no spare (N-1) capacity left and the red graph indicates the extent that the (N-1) secure capacity has been exceeded in the past. Zone substation with (N) security have been omitted from this graph. This means that eight of the 20 zone substations do not have (N-1) security with respect to the supply transformers.

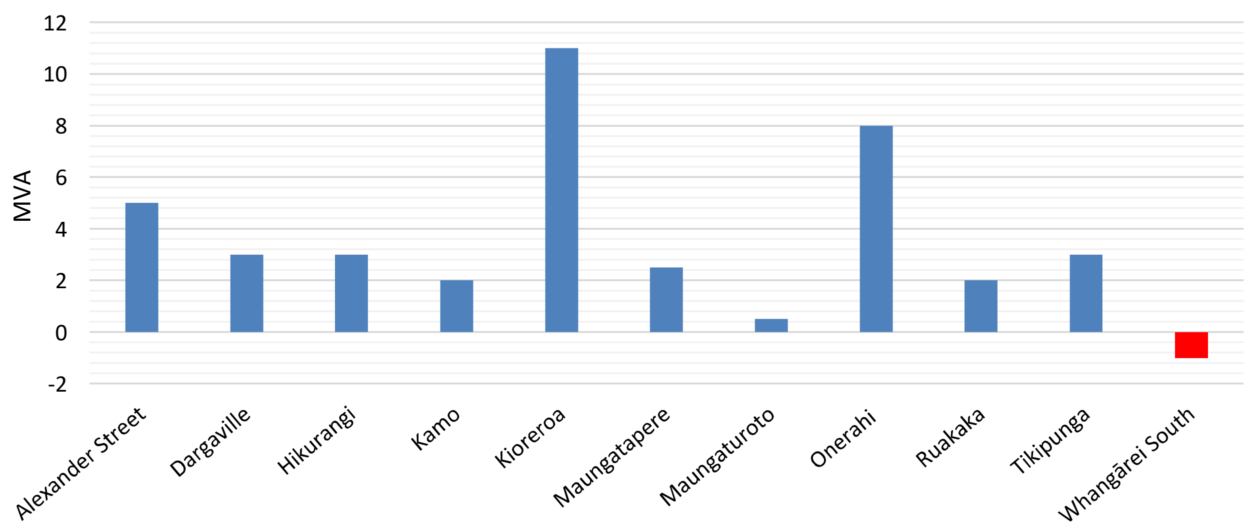


Figure 23 Summary: Approximate (N-1) spare capacity at Northpower's zone substations

7.3.2.2 (N) Capacity Summary

The following Figure 24 illustrates the approximate (N) spare capacities at Northpower's zone substations, for the disclosed peak demand estimates[24]. Again, it should be noted that these have been calculated based on the transformer ratings disclosed by Northpower.

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 another part of this report. Figure 24 indicates that there is a significant volume of spare (N) capacity at Northpower's substations, although we note that many of them are in urban/CBD locations where (N-1) security of supply would be a standard requirement.

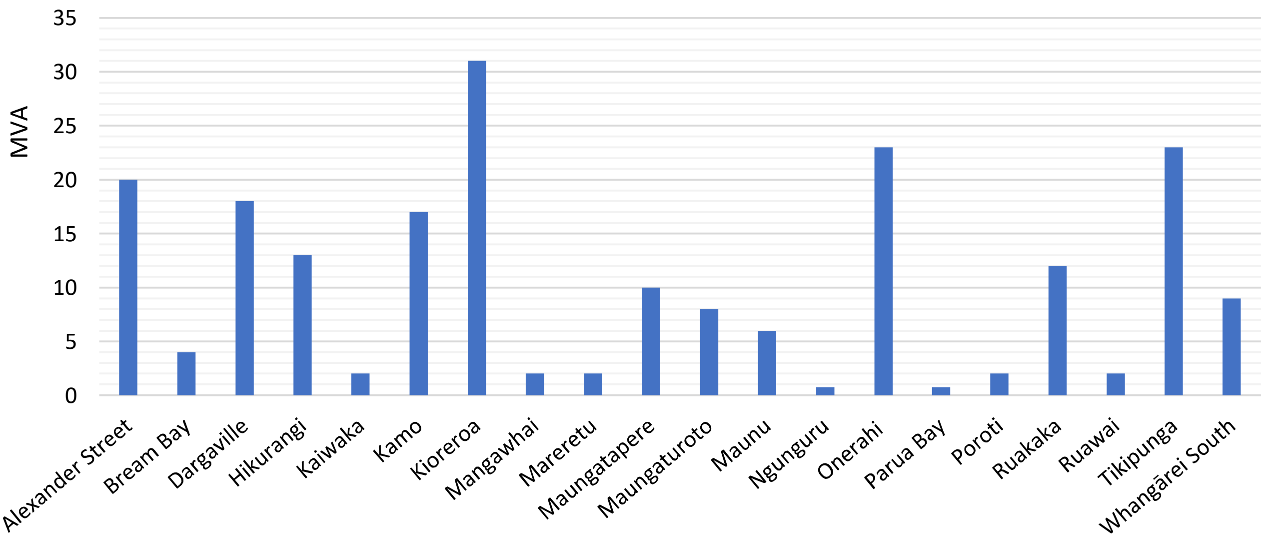


Figure 24 Summary: Approximate (N) spare capacity at Northpower's zone substations

[24] Northpower's 2023 information disclosure available here: https://northpower.com/company/disclosures.

8. Connection Options

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

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

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

The assessments made have involved a desk-based assessment using the various information provided to Ergo. Where information was not available, we have used engineering judgement. If the Load Sites are progressed further, Ergo recommends more detailed engineering assessments are undertaken in consultation with Transpower, Top Energy, and Northpower . This would likely entail power flow 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 GXPs, transmission substations and zone substations based on the publicly disclosed loading and capacity information (instead of the 2022 loading data provided by Transpower, Top Energy and Northpower). Ergo's view is that these are typically more conservative than the actual loading and are therefore appropriate for this high-level assessment.
- We have assumed the existing site security should be maintained (unless otherwise stated). For example, if the site currently presently has (N-1) security, we have recommended infrastructure upgrades to maintain this.
- The upgrades and costs of individual Load Sites are considered in isolation of the adjacent Load Sites. We have not considered the scope and costs associated with connecting multiple Load Sites at this stage.
- The Load Site loads will have unity power factor which is reasonable considering the preliminary nature of the assessment.
- Unless otherwise stated, we have assumed the existing incoming sub-transmission line/cable capacities exceed the capacity of the existing zone substation(s) they supply.
- Unless capacity information is available, we assumed existing 33 kV and 11 kV 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[25] accuracy - suitable for concept screening. Appendix 2 outlines accuracy of the cost estimates and the general assumptions.
- Cost estimates exclude land purchase, easements and consenting. These costs are difficult to estimate without undertaking a detailed review of the available land (including a site visit) and the local council rules in relation to electrical infrastructure. For example, the upgrade of existing overhead lines or new lines/cables across private land does require utilities to secure easements to protect their assets. Securing easements can be a very time consuming and costly process. For this reason, Ergo's estimates for new electrical circuits are generally based on assuming they are installed in road reserve and involve underground cables in urban locations and overhead lines in rural locations. We note that, as a general rule, 110kV and 220kV lines cannot be installed in road reserve due to wide corridor requirements. In some locations the width of the road reserve and presence of existing overhead lines is such that 66kV and 33kV or 11kV 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.

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

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. For the larger Load Sites Ergo recommend proceeding with a Concept Design Report (CDR) to improve the accuracy of the respective cost estimate.

8.3 Kaikohe GXP and Kaitaia Transmission Substation

The “Large” EECA Load Sites connecting to the Kaikohe GXP include:

- Northland Regional Corrections Facility (NRCF) (10.08 MVA)
- Imerys Ceramics New Zealand Ltd. (1.36 MVA)

Ergo notes that both Imerys (existing connection ~1 MVA) and the NRCF (existing connection ~0.6 MVA), with their existing connections to the Top Energy network, are already two out of five of Top Energy’s largest consumers.

The “Small” Load Sites connecting to the Kaikohe GXP include (refer to Sections 8.3.4 and 8.3.5):

- Bay of Islands College (0.30 MVA)
- Kerikeri Crematorium (0.20 MVA)

None of the EECA load sites are expected to connect to the Kaitaia Transmission Substation.

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

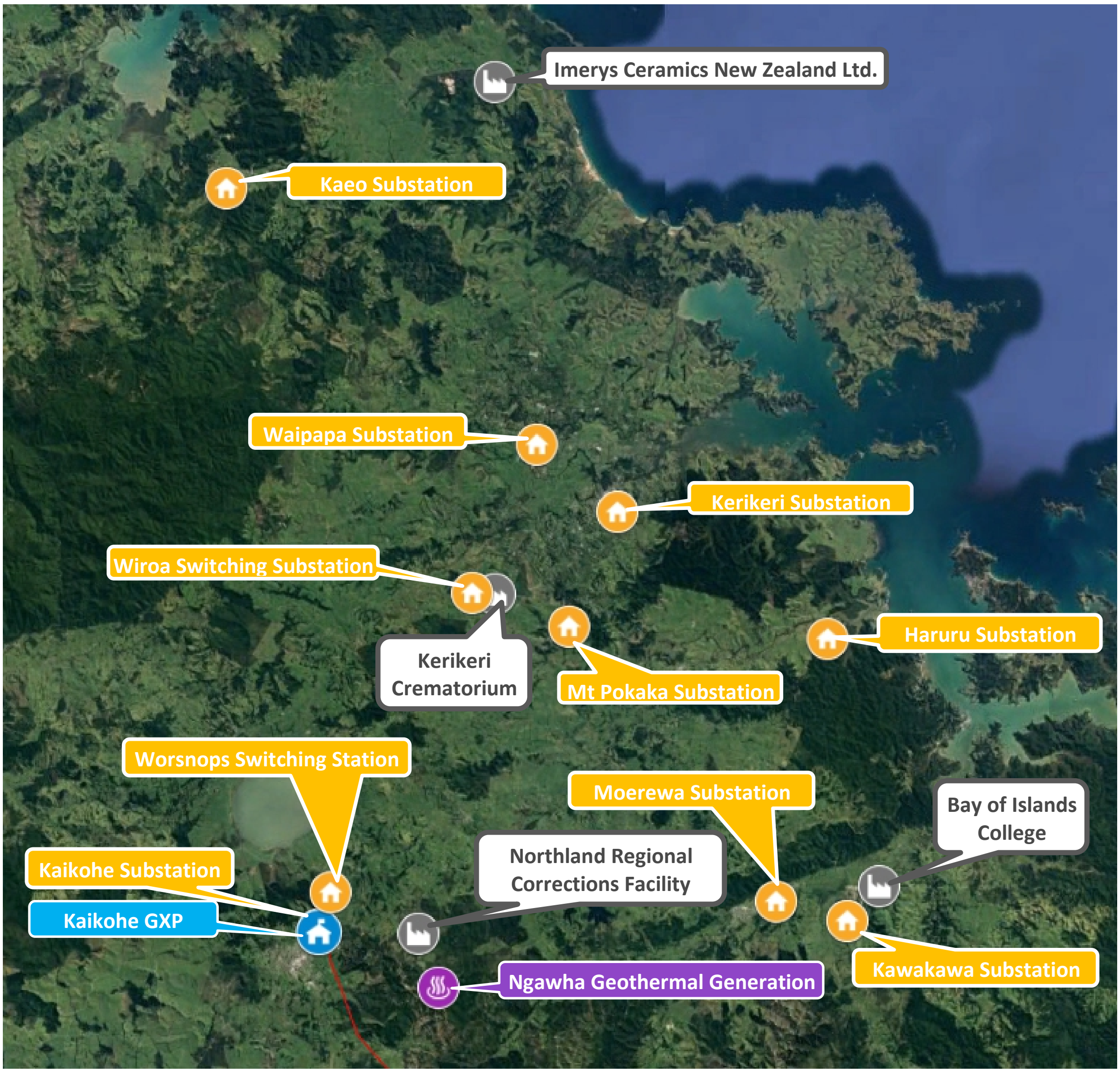


Figure 25 Kaikohe GXP: EECA Load Sites vs local substations

8.3.1 Kaikohe GXP Upgrade

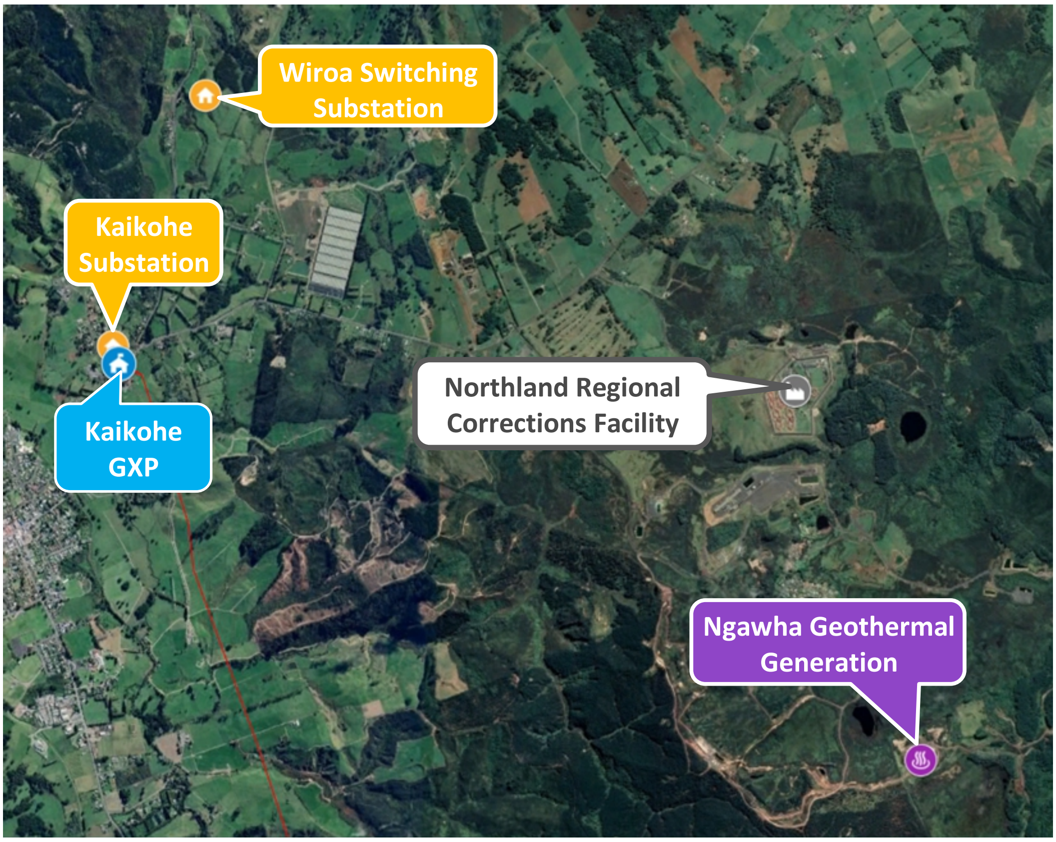
Ignoring the Ngawha generation, the Kaikohe GXP has already exceeded the (N-1) capacity of the 110 kV lines which supply it. However, considering the Ngawha generation (which connects to the network at 33 kV) supplying 25 MW, the GXP has ~16 MVA of spare capacity in the lines supplying the GXP. Since the Ngawha generation is geothermal, and therefore reliably dispatchable, it is considered in analysis that the Ngawha generation is present, and upgrades of the lines supplying Kaikohe GXP are not required. Additionally, a further 32 MW of generation is planned/in development at Ngawha, which will further support the growing load at Kaikohe.

With the two 110/33 kV transformers (Top Energy owned) at Kaikohe giving the GXP an (N-1) capacity of 39 MVA (refer to Section 6.1.1), and a present maximum loading of 48.6 MVA, the GXP transformers have no spare (N-1) capacity at present. Ergo understands that Top Energy plan to install a 110/33 kV substation at the existing Wiroa 33 kV switching substation site, which is expected to fully mitigate the risk of loss of one Kaikohe 110/33 kV transformer. The first of the two Wiroa transformers is expected to be commissioned in financial year 2029. Top Energy also notes in its 2023 AMP that the capacity issue only exists when the Ngawha generation is offline, making this an N-2 contingency (one of the Kaikohe transformers and Ngawha generation) and so consider the chances of this happening as low.

The Top Energy 2023 AMP specifies that there are several large-scale solar installations proposed to connect to their network, along with a planned installation of another OEC generating unit at Ngawha. The addition of the large solar installations is expected to load the lines supplying Kaikohe at their maximum at times (exporting power south towards Auckland) – and so Ergo considers that the addition of load to the area may be beneficial to mitigate this issue.

Due to the planned upgrades at Wiroa, and consideration of the reliable generation available at Ngawha, further upgrades of the Kaikohe GXP are not considered.

8.3.2 Northland Regional Corrections Facility

NORTHLAND REGIONAL CORRECTIONS FACILITY		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and/or high temperature heat pumps	2.00 or 2.90 MW	Kaikohe 33 kV
Existing Electrical Supply to the Plant		
NRCF is presently supplied by Top Energy's Kaikohe zone substation, which is supplied from the 33 kV bus at Kaikohe GXP. The plant is supplied by an existing dedicated feeder from the zone substation. The feeder is presently loaded at a maximum of 35 A (0.67 MVA). The plant is ≈4.4 km (straight line) from Kaikohe substation.  Figure 26 Northland Regional Corrections Facility geographic location in relation to the surrounding zone substations		
Supply Option(s) for New Load		
As discussed in section 8.3.1, it is assumed that the Kaikohe GXP has sufficient spare (N-1) capacity for the proposed load. Kaikohe zone substation has sufficient (N-1) spare capacity to accommodate the additional load of 2.90 MW. Ergo expects that the existing feeder to the site would be able to supply the proposed load. Therefore, no network upgrades are expected to connect the proposed load.		

NORTHLAND REGIONAL CORRECTIONS FACILITY
Capital Cost Estimate
There are no network related costs expected for this site. Does not include the costs of any distribution transformers/switchgear on the plant site.
Timeframe to Establish New Electrical Infrastructure
It is estimated to take 3-6 months to plan, design, procure, construct, and commission the works. Excluded is the work required to establish the Load Site. Any land acquisition and consenting, if required, is excluded.

8.3.3 Imerys Ceramics New Zealand Ltd.

IMERYS CERAMICS NEW ZEALAND LTD.		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and/or high temperature heat pumps	1.36 MW	Kaikohe 33 kV

Existing Electrical Supply to the Plant

Imerys Ceramics New Zealand Ltd. is presently supplied by Top Energy's Kaeo zone substation, which is supplied at 33 kV from the Kaikohe GXP by one overhead line. The zone substation has two transformers, but with only one line supplying the substation, it is operating on (N) subtransmission security.
The plant is presently supplied by the Kaeo zone substation Matauri Bay 11 kV feeder. The Matauri Bay 11 kV feeder is presently loaded at a maximum of 91 A (1.75 MVA).
The plant is ≈12.6 km (straight line) from Kaeo substation.

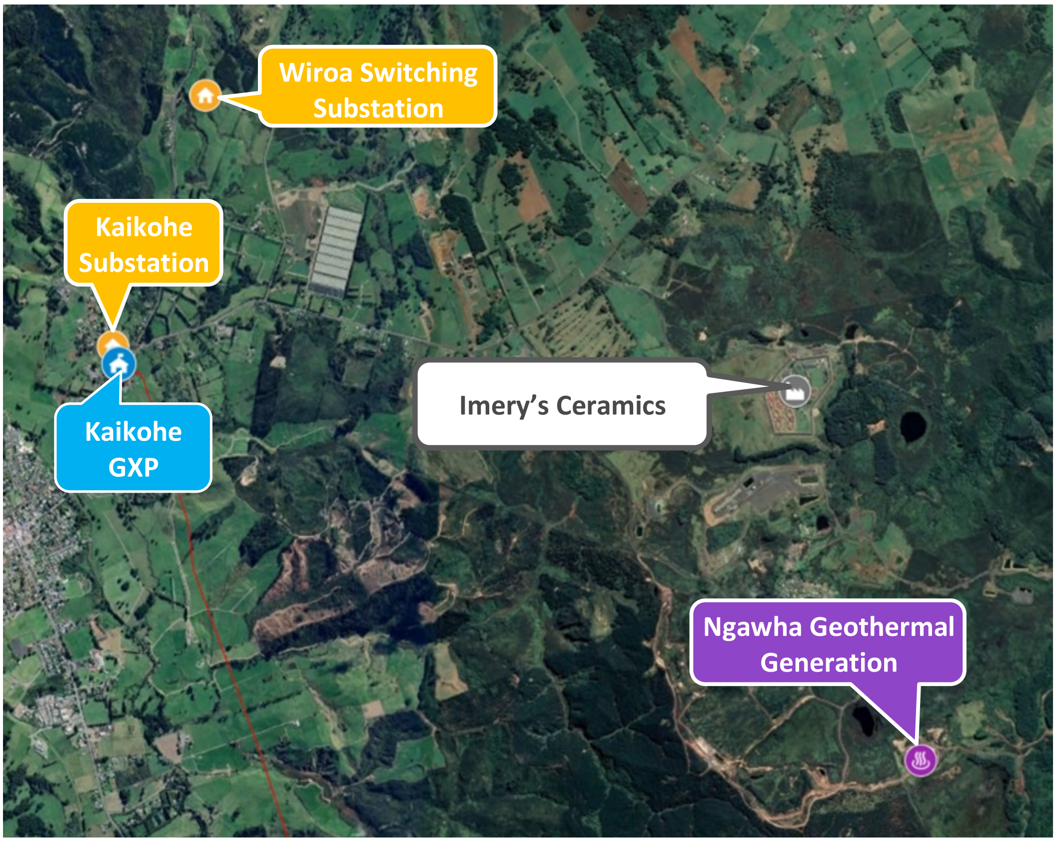


Figure 27 Imerys Ceramics New Zealand Ltd. geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

As discussed in section 8.3.1, it is assumed that the Kaikohe GXP has sufficient spare (N-1) capacity for the proposed load. Kaeo zone substation has sufficient (N) spare capacity to accommodate the additional load of 1.36 MW.

Ergo expects that the existing feeder to the site has capacity for the additional 1.36 MW of load. Therefore, no network upgrades are expected to connect the proposed load.

IMERYS CERAMICS NEW ZEALAND LTD.
Capital Cost Estimate
Ergo expects that the costs to connect the additional load at the site would be related to the costs of any distribution transformers/switchgear on the plant site, which could include ~$350 k for a distribution transformer.
Timeframe to Establish New Electrical Infrastructure
It is estimated to take 3-6 months to plan, design, procure, construct, and commission the works. Excluded is the work required to establish the Load Site. Any land acquisition and consenting, if required, is excluded.

8.3.4 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 6 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)
Bay of Islands College	Kawakawa	-1	5.5	1.71	0.30	130
Kerikeri Crematorium	Mt Pokaka	N/A	2	1.33	0.20	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.

8.3.5 Combined Load of Small Opportunities

Summing the maximum values of the “small” loads on Kaikohe GXP gives a combined load of 0.5 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 28), with a maximum load of 0.3 MVA, with a diversity factor of 0.61.

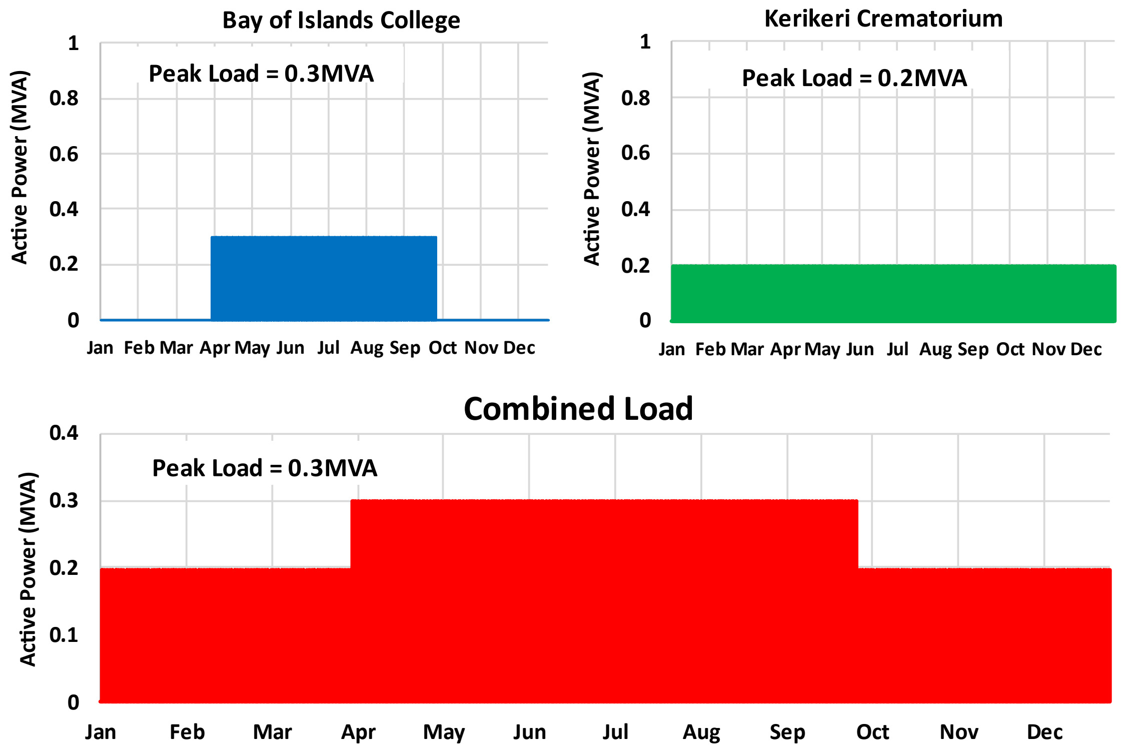


Figure 28 Loading Profiles: Kaikohe GXP “small” Load Site Profiles: Combined Load (sum of all profiles)

8.3.6 Effect of all Load Sites Connecting to Kaikohe GXP

The following Figure 29 illustrates the Kaikohe GXP 33 kV 2022 load profile together with the load profiles of all the Load Sites within the Kaikohe GXP region. Also shown in Figure 29 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Kaikohe GXP 33 kV would increase to 49.4 MVA, a difference of 0.8 MVA. Given that the sum of the individual load peaks is 53.2 MVA, there is a diversity factor of 0.93 between the loads.
- Based on Ergo's analysis, the Kaikohe GXP's 33 kV (N-1) limit is expected to be exceeded. However, as discussed in Section 8.3.1, network upgrades to mitigate the overloading issue are planned and are viewed as adequate even with the increased load due to the Load Sites.

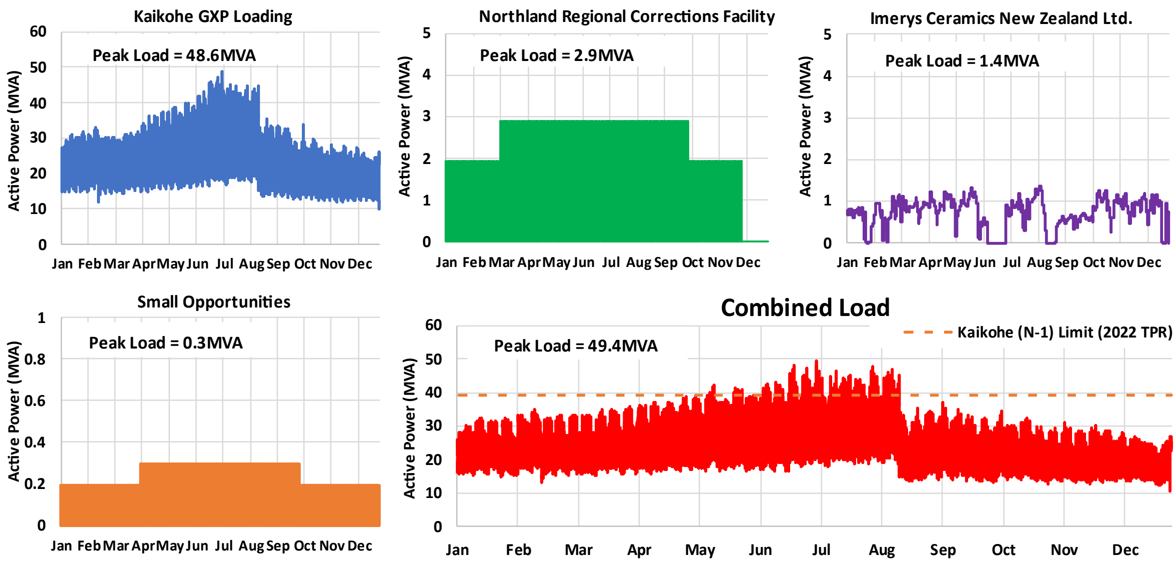


Figure 29 Loading Profiles: Kaikohe GXP 2022 33 kV historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.4 Maungatapere Transmission Substation

The “Large” EECA Load Sites connecting to the Maungatapere transmission substation at 33 kV include:

- Downers Whangārei Asphalt Plant (5.00 MVA)
- Whangārei Hospital (4.46 MVA)

The “Small” Load Sites connecting to the Maungatapere transmission substation at 33 kV include (refer to sections 8.5.3 and 8.5.5):

- Grinning Gecko Cheese Company (0.67 MVA)
- Northland Polytechnic (0.36 MVA)
- Whangārei Council Maunu Cemetery (0.20 MVA)

None of the Load Sites are expected to connect to the Maungatapere 50 kV GXP.

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

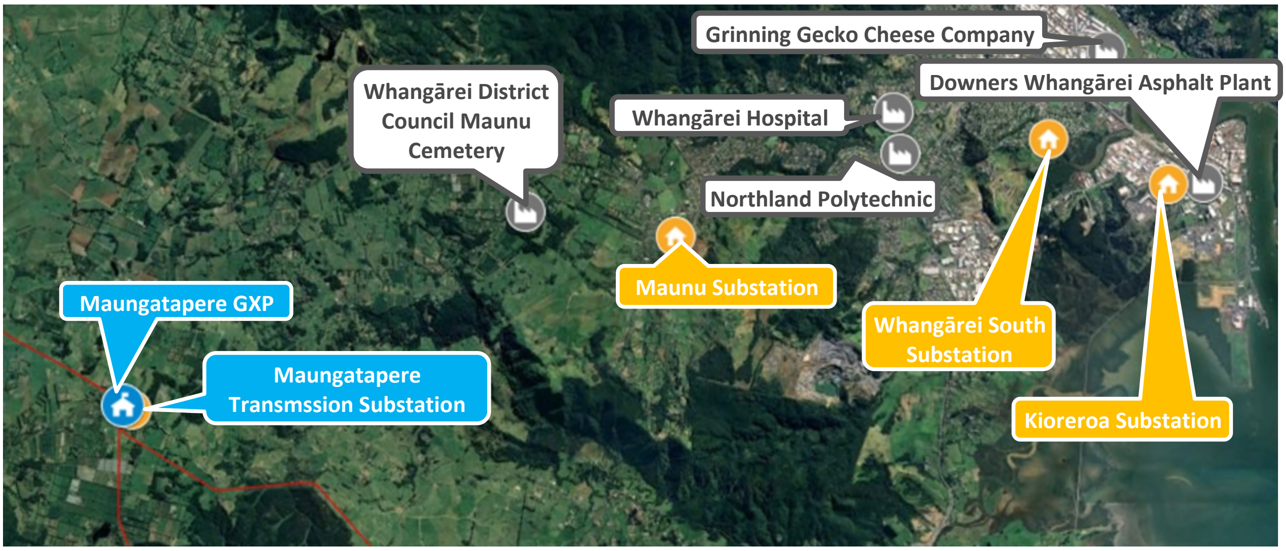


Figure 30 Maungatapere Transmission Substation: EECA Load Sites vs local substations

8.4.1 Maungatapere Transmission Substation Upgrade

The Maungatapere Transmission substation has no spare (N-1) 110/33 kV transformer capacity and little to no spare (N-1) capacity in the lines which supply Maunu, Whangārei South, and Kioreroa substations.

The Maungatapere-Whangārei South-Kioreroa lines, are expected to exceed their firm (N-1) rating with the connection of the proposed Load Sites. In the event of an outage of one of the two lines, Northpower plans to switch Kioreroa or Whangārei South to be fed via Kensington transmission substation until the faulted line is back in service, which provides the substations with a switched (N-1) supply. Additionally, Northpower has plans to upgrade the capacity of these lines by restoring an existing, disconnected subtransmission (33 kV) line. No further upgrades are expected of these lines.

Ergo understands that Northpower has plans to upgrade the transformers at Maungatapere to 100 MVA units from the existing 30 MVA units. In the meantime, Ergo expects that a transformer outage at Maungatapere may be managed similarly to a line outage (as explained above), giving the substation switched (N-1) capacity overall.

Further upgrades at Maungatapere transmission substation are not considered.

8.4.1 Downer Whangārei Asphalt Plant

DOWNER WHANGĀREI ASPHALT PLANT		
Load Site Description	**Electrical Demand (MW)**	**GXP/Transmission Substation**
New electrical boilers and/or high temperature heat pumps	5.00 MW	Maungatapere 33 kV

Existing Electrical Supply to the Plant

Downer Whangārei Asphalt Plant is presently supplied by Northpower's Kioreroa zone substation, which is supplied at 33 kV by Maungatapere transmission substation.

Kioreroa is supplied by Maungatapere Transmission substation via the two Whangārei South – Maungatapere 33 kV circuits via a tee off each line. One of the circuits is overhead lines, and the other is a combination of overhead lines and underground cables, and is connected via Maunu substation.

The plant is supplied by the Kioreroa zone substation Fert Works feeder. The Fert Works feeder is presently loaded at a maximum of 125 A (2.38 MVA).

The plant is ≈0.4 km (straight line) from Kioreroa substation.

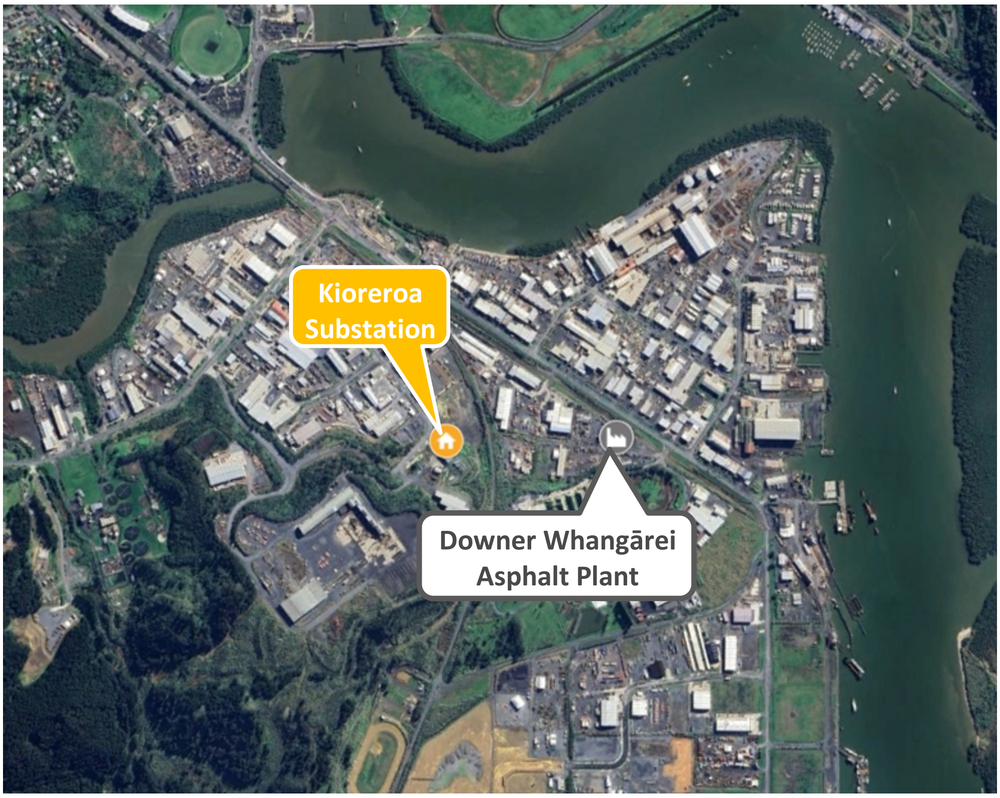


Figure 31 Downer Whangārei Asphalt Plant geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

As discussed in section 8.4.1, it is assumed that the Maungatapere transmission substation and lines supplying Kioreroa substation have sufficient (switched (N-1)) spare capacity for the proposed load. Kioreroa zone substation has sufficient (N-1) spare capacity to accommodate the additional load of 5.00 MW.

DOWNER WHANGĀREI ASPHALT PLANT
In order to connect the proposed load, Ergo expects that one new 11 kV feeder to the site from Kioreroa zone substation would be required. This feeder would likely be underground cabled, matching the existing supply/urban topography. Ergo expects the new feeder would require ~2 km of underground cabling.
Capital Cost Estimate

Table 7 Downer Whangārei Asphalt Plant: Capital cost estimate to supply the Load Site

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11 kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11 kV cable	2.00	$0.80
		TOTAL	**$0.90**

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

Timeframe to Establish New Electrical Infrastructure

It is estimated to take 6-12 months to plan, design, procure, construct, and commission the works.

Excluded are any work required to establish the Load Site.

Any land acquisition and consenting, if required, is excluded.

8.4.2 Whangārei Hospital

WHANGĀREI HOSPITAL		
Load Site Description	**Electrical Demand (MW)**	**GXP/Transmission Substation**
New electrical boilers and/or high temperature heat pumps	4.46 MW	Maungatapere 33 kV

Existing Electrical Supply to the Plant

Whangārei Hospital is presently supplied by Northpower's Whangārei South zone substation, which is supplied at 33 kV by Maungatapere transmission substation.

Whangārei South is supplied by Maungatapere Transmission substation via the two Whangārei South – Maungatapere 33 kV circuits via a tee off each line. One of the circuits is overhead lines, and the other is a combination of overhead lines and underground cables, and is connected via Maunu substation.

The plant is supplied by the Whangārei South zone substation Otaika Rd feeder. The Otaika Rd feeder is presently loaded at a maximum of 124 A (2.4 MVA).

The plant is ≈1.8 km and ≈2.9 km (straight lines) from Whangārei South and Maunu substations respectively.

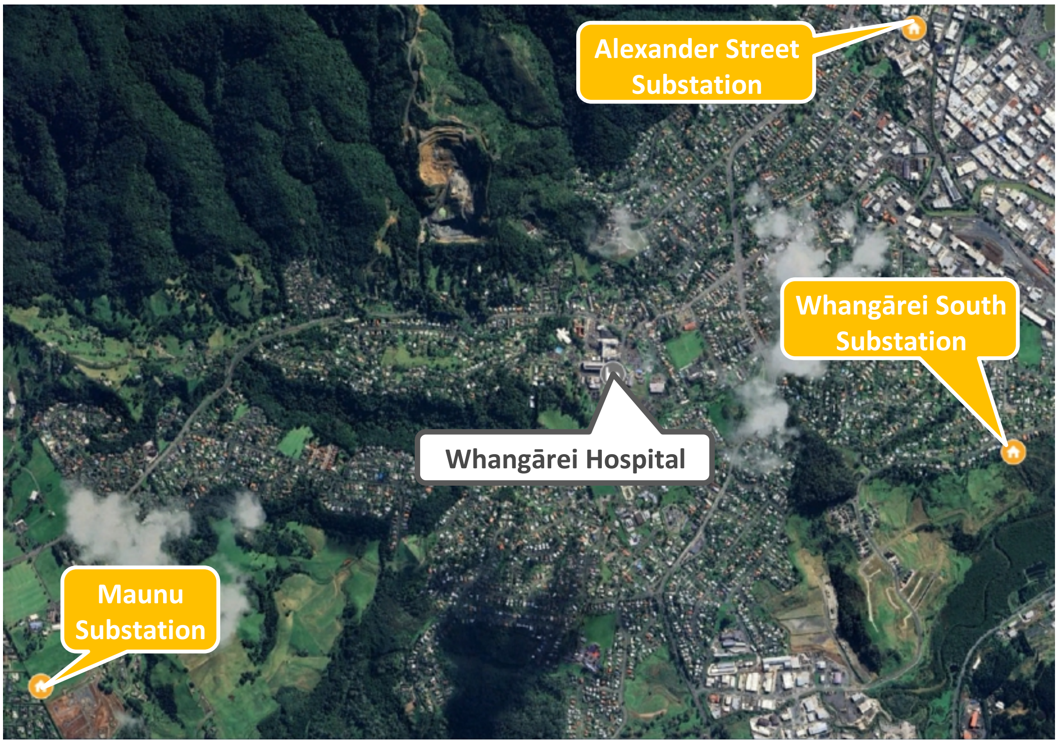


Figure 32 Whangārei Hospital geographic location in relation to the surrounding zone substations

Supply Option(s) for New Load

As discussed in section 8.4.1, it is assumed that the Maungatapere transmission substation and lines supplying Kioreroa substation have sufficient (switched (N-1)) spare capacity for the proposed load.

WHANGĀREI HOSPITAL

Whangārei South zone substation does not have sufficient (N-1) spare capacity for the proposed 4.46 MW load but has sufficient (N) spare capacity.

In order to connect the proposed load, Ergo expects that one new 11 kV feeder to the site from Maunu zone substation would be required because Maunu has spare circuit breaker capacity which Whangārei South substation does not have. In addition, the route from Whangārei South substation is largely through a built-up environment that will add to costs. This feeder would likely be a combination of underground cable and overhead line considering the existing topography.

Northpower has plans for transformer upgrades at Whangārei South, which should increase the substation capacity enough to provide (N-1) supply to the Whangārei Hospital site.

Capital Cost Estimate

Table 8 Whangārei Hospital: 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	11 kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single underground 11 kV 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

It is estimated to take 6 – 12 months to plan, design, procure, construct, and commission the works.

Excludes any new infrastructure or work required to establish the Load Site.

Any land acquisition and consenting, if required, is excluded.

8.4.3 Small Opportunities

Below is a summary of the “small” Load Sites that were provided by EECA but due to their size, are unlikely to have a material effect on the distribution or transmission network. The costs provided are estimates to provide RMUs and appropriately sized distribution transformers 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)
Grinning Gecko Cheese Company	Kioreroa	11	31	2.40	0.67	260
Northland Polytechnic	Whangārei South	-1	9	3.65	0.36	130
Whangārei Council, Maunu Cemetery	Maunu	N/A	6	0.76	0.20	80

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

Estimates exclude:

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

8.4.4 Combined Load on Zone Substations

Kioreroa

Two of the loads on Maungatapere transmission substation are expected to connect to Kioreroa zone substation. The loads are Grinning Gecko Cheese Company and Downers Whangārei Asphalt Plant. The sum of peaks of these loads is 5.67 MVA, which the zone substation does have (N-1) capacity for. Therefore, upgrades of Kioreroa zone substation are not considered.

Maunu

Two of the loads on Maungatapere transmission substation are expected to connect to Maunu zone substation. The loads are Maunu Cemetery and Whangārei Hospital. The sum of peaks of these loads is 4.66 MVA, which the zone substation does have (N) capacity for. Therefore, upgrades of Maunu zone substation are not considered.

8.4.5 Combined Load of Small Opportunities

Summing the maximum values of the "small" loads on Maungatapere Transmission Substation gives a combined load of 1.23 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 37), with a maximum load of 1.10 MVA, with a diversity factor of 0.89.

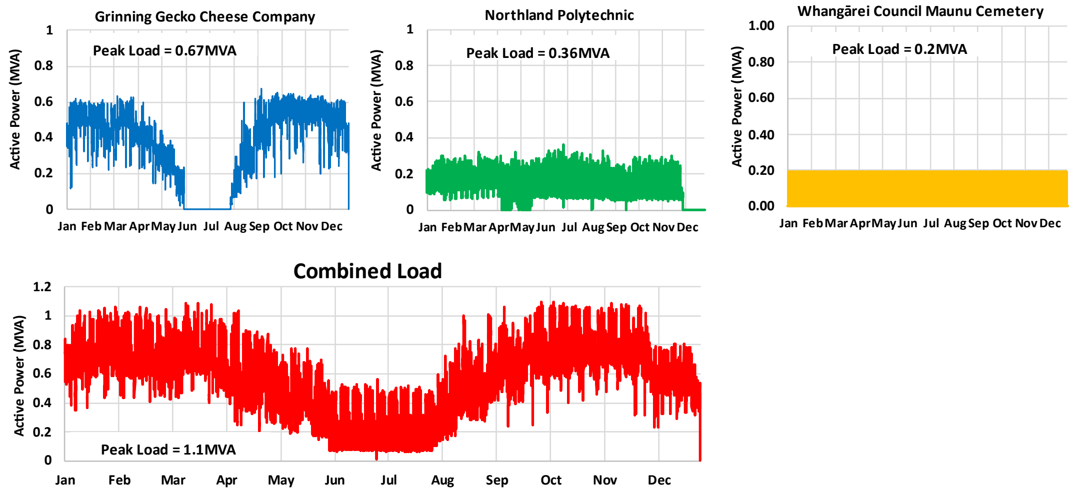


Figure 33 Loading Profiles: Maungatapere Transmission Substation "small" Load Site Profiles: Combined Load (sum of all profiles)

8.4.6 Effect of all Load Sites Connecting to Maungatapere Transmission Substation

The following Figure 38 illustrates the Maungatapere Transmission Substation 33 kV load profile together with the load profiles of all the Load Sites within the Maungatapere Transmission Substation region. Also shown in Figure 38 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Maungatapere Transmission Substation would increase to 46.9 MVA, an increase of 2.4 MVA on the 2022 maximum demand. Given that the independent sum of the individual load peaks is 55.1 MVA there is a diversity factor of 0.85 between the loads.
- Based on Ergo's analysis, the Maungatapere Transmission Substation's (N-1) limit is expected to be exceeded. However, as discussed in section 8.4.1, network upgrades to mitigate the overloading issue are planned and are viewed as adequate to supply the increased load due to the Load Sites.

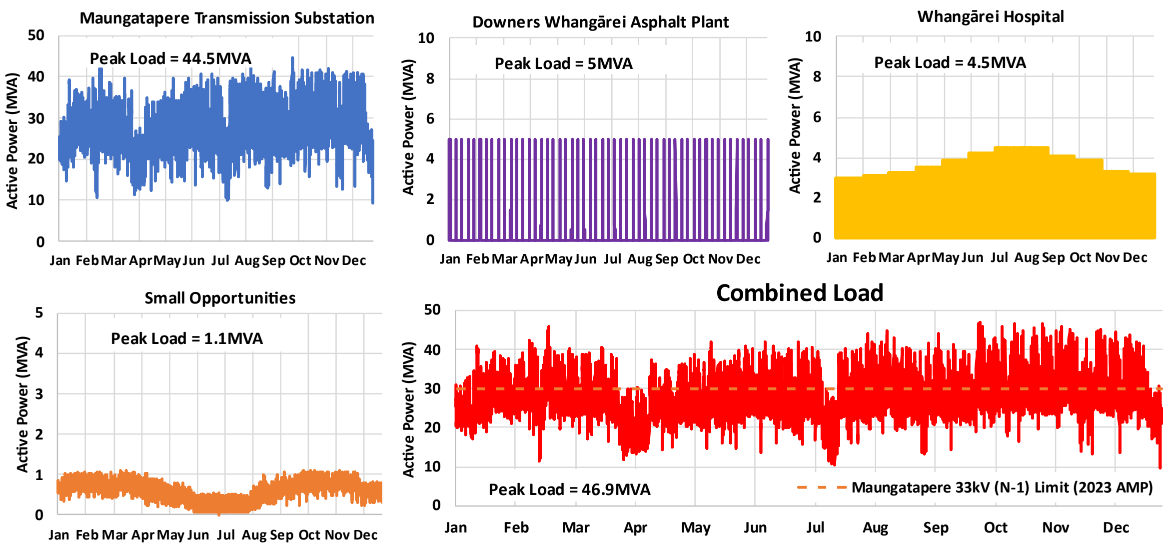


Figure 34 Loading Profiles: Maungatapere Transmission Substation 2022 33 kV historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.5 Kensington Transmission Substation

The "Large" EECA Load Sites connecting to the Kensington transmission substation at 33 kV include:

- Fonterra Kauri (26.33 MVA)

The "Small" Load Sites connecting to the Kensington transmission substation at 33 kV include (refer to sections 8.5.3 and 8.5.5):

- Whangārei District Council Aquatic Centre (0.24 MVA)
- Whangārei Girl's High School (0.24 MVA)
- Whangārei Boy's High School (0.20 MVA)

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

Figure 35 Kensington Transmission Substation: EECA Load Sites vs local substations

8.5.1 Kensington Transmission Substation Upgrade

The Kensington Transmission Substation presently has no spare (N-1) capacity. Northpower has a project underway to replace the two transformers at the substation with 100 MVA units, increasing the total (N-1) capacity of the substation to 100 MVA. This upgrade is due to be completed in 2026. At the same time, a 110 kV switchboard is being added to Kensington to improve security of supply.

The capacity of the existing lines which supply Kensington transmission substation from Maungatapere is Goat conductor which has approximately 150 MVA capacity each. Ergo notes that in the event of an outage of one or more of the towers which support these circuits, Northpower plans to restore supply to Kensington by deploying temporary towers or by backfeeding through the 33 kV network.

Further upgrades at Kensington transmission substation are not considered.

8.5.2 Fonterra Kauri

		FONTERRA KAURI
Load Site Description	**Electrical Demand (MW)**	**GXP/Transmission Substation**
New electrical boilers and/or high temperature heat pumps	Stage 1: 1 MW heat pump Stage 2: Plus 8.35 MW elect. boiler 1 Stage 3: Plus 8.35 MW elect. boiler 2 Stage 4: Plus 8.35 MW elect. boiler 3	Kensington 33 kV
Existing Electrical Supply to the Plant		
Fonterra Kauri is presently supplied by Northpower's Kensington Transmission substation, via two 33 kV overhead lines, which forms part of a ring circuit that also supplies Kamo and Hikurangi zone substations. The circuits terminate at the Kauri substation within the Fonterra site, which solely supplies the Fonterra site. The plant is ≈7.8 km (straight line) from Kensington Transmission substation.		

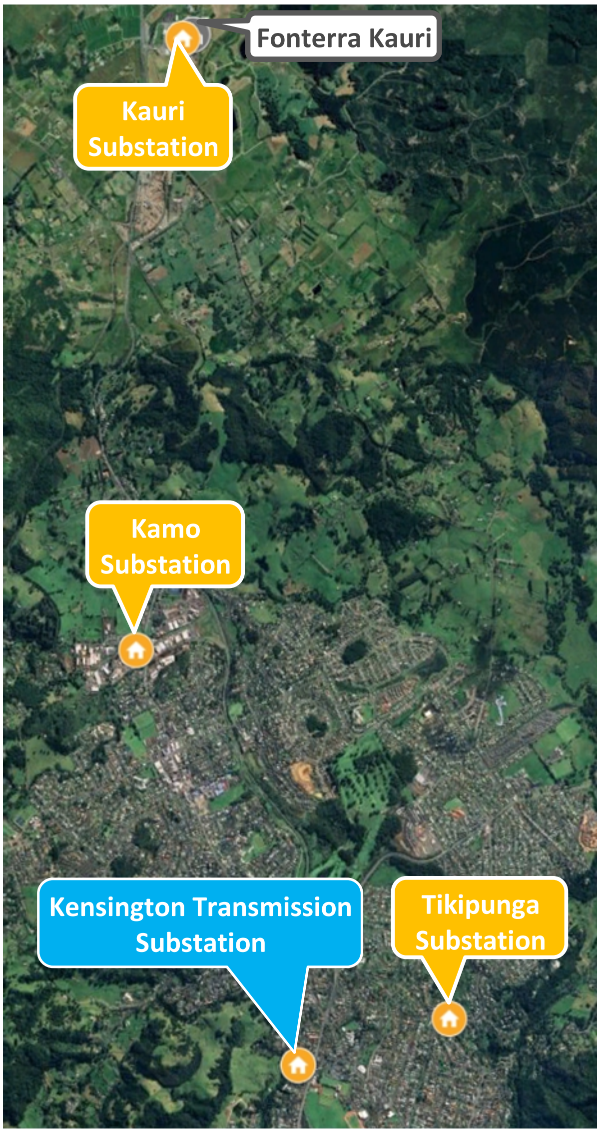


Figure 36 Fonterra Kauri geographic location in relation to the surrounding zone substations

FONTERRA KAURI
Supply Option(s) for New Load
As discussed in section 8.5.1, it is assumed that the Kensington transmission substation has sufficient spare (N-1) capacity for the proposed load post the 2026 transformer upgrade. Ergo also assume that the planned third subtransmission cable from Kensington to Kamo zone substation in financial year 2026 is installed. The current ring circuit supplying the Kauri plant consist of cables and overhead lines of various ratings from 15 MVA to 31 MVA depending on the standard to which they were originally designed and constructed. The load supplied to the Kauri substation is via the Kamo-Kauri 33 kV circuit. This circuit also supplies some of the Hikurangi load. **Stage 1:** There is sufficient capacity available with the existing infrastructure to accommodate this additional load of 1 MW for a heat pump. This total load security will be (N-1). **Stage 2:** The stage 2 load of an additional 8.35 MW can just be accommodated though the Kamo-Kauri 33 kV circuit which will run close to capacity and perhaps just over for a small percentage of the year. This supply would be at (N) security. To achieve (N-1) security, a new 33 kV substransmission circuit approximately 5 km in length, if a route similar to the existing feeder can be followed, from Kamo to Kauri would be required. This will extend the new Kensington to Kamo circuit all the way through to Kauri. The total load at Kauri will still be limited to approximately 40 MVA (N) security and 16.5 MVA (N-1) security, by the existing Kamo-Kauri overhead line constructed with Dog and Caracal conductor. Ergo assumes sufficient space/land can be acquired at Kamo zone substation to extend the 33 kV strung bus to install a new 33 kV circuit breaker for the new circuit. The Kauri substation will only have (N) security for this load (i.e. 7.5 MW existing load + 9.35 MW new load) if the two transformers can be operated at their maximum rating of 10 MVA each. For (N-1) security the Kauri substation would require upgrades. The construction will largely depend on where on the plant the load is required. For the purposes of this study Ergo has assumed a single zone substation location with upgraded transformers and switchgear. **Stage 3:** This stage will add another 8.35 MW of load to the existing load level for a total load of 25.2 MW (including the existing load). This will require the upgrading/rebuilding of the existing Kamo-Kauri overhead line circuit with all Jaguar conductor. Assuming a Jaguar conductor construction to operate at a maximum temperature of 75°C for all lines, the (N-1) capacity at Kauri will increase to approximately 34 MVA. Northpower has advised that their lines are presently rated to 55°C maximum temperature, so it is likely that the lines would require a full rebuild when Jaguar conductor is installed. The Kauri substation will have to be upgraded to accommodate this load both at (N) and (N-1) security. The construction will largely depend on where on the plant the load is required. For the

purposes of this study Ergo has assumed a single zone substation location with upgraded transformers and switchgear.

Stage 4:

This stage will add another 8.35 MW of load to the existing load level for a total load of 33.55 MW (including the existing load). Although the two circuits from Kamo to Kauri (one upgraded and one new) have a (N-1) capacity of 34 MW, the portion of the Hikurangi load supplied from Kauri must be added, unless this Kauri-Hikurangi circuit is run open. Then no additional network upgrades or new build are required to supply the load at (N) and (N-1) security.

Capital Cost Estimate

Table 10 Fonterra Kauri: 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)**	
Subtransmission	33 kV circuit breaker (ZSS)	1.00	$0.15
Subtransmission	Extend the 33 kV strung bus	1.00	$0.15
Subtransmission	Single overhead 33 kV line	5.00	$1.25
		TOTAL	**$1.55**

Table 11 Fonterra Kauri: Capital cost estimate to supply the Load Site Stage 2 ((N-1) security)

Transmission => (N-1)	Subtransmission => (N-1)	Distribution => (N-1)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	Medium size zone substation	1.00	$8.00
		TOTAL	**$8.00**

Table 12 Fonterra Kauri: 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)**	
Subtransmission	Single overhead 33 kV line	4.80	$1.20
		TOTAL	**$1.20**

Timeframe to Establish New Electrical Infrastructure

It is estimated to take 12-30 months to plan, design, procure, construct, and commission the works for both options.

Excluded is the work required to establish the Load Site within the Fonterra property boundary.

Any land acquisition and consenting, if required, is excluded.

8.5.3 Small Opportunities

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

Table 13 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)
Whangārei District Council, Aquatic Centre	Alexander Street	-2.5	5	0.15	0.24	130
Ministry of Education, Whangārei Girls High School	Alexander Street	-2.5	5	2.27	0.24	130
Ministry of Education, Whangārei Boys High School	Alexander Street	-2.5	5	1.82	0.20	80

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

Estimates exclude:

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

8.5.4 Combined Load on Zone Substations

Alexander Street

Three of the loads on Kensington transmission substation are expected to connect to Alexander Street zone substation. The loads are Whangārei District Council Aquatic Centre, Whangārei Girls High School, and Whangārei Boys High School. The sum of peaks of these loads is 0.68 MVA. The zone substation has sufficient (N-1) capacity for the three proposed loads, and so upgrades of the zone substation are not considered.

8.5.5 Combined Load of Small Opportunities

Summing the maximum values of the “small” loads on Kensington Transmission Substation gives a combined load of 0.68 MVA. However, when the load shapes are combined, they result in the following load shape (Figure 37), with a maximum load of 0.62 MVA, with a diversity factor of 0.91.

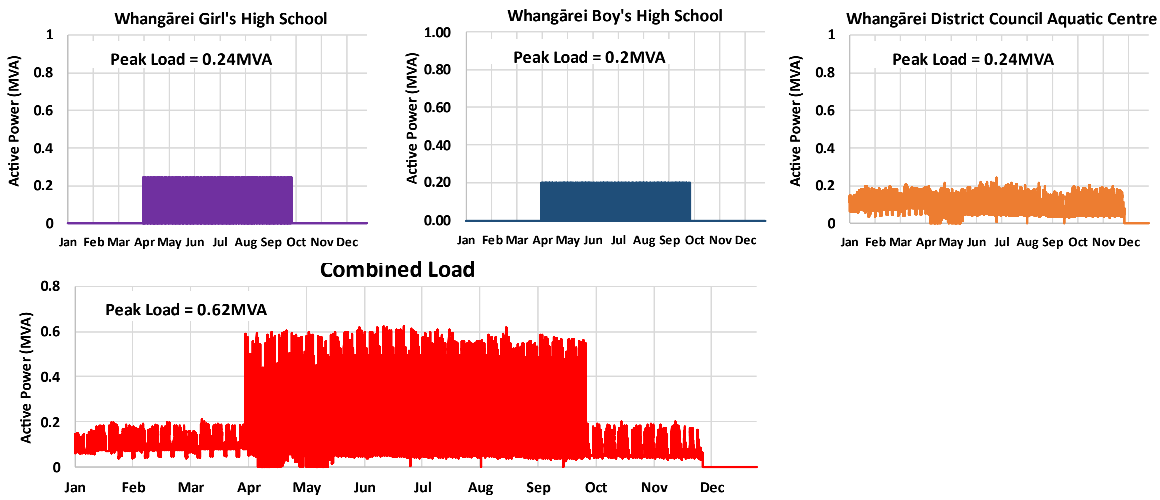


Figure 37 Loading Profiles: Kensington Transmission Substation “small” Load Site Profiles: Combined Load (sum of all profiles)

8.5.6 Effect of all Load Sites Connecting to Kensington Transmission Substation

The following Figure 38 illustrates the Kensington Transmission Substation 33 kV load profile together with the load profiles of all the Load Sites within the Kensington Transmission Substation region. Also shown in Figure 38 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Kensington Transmission Substation would increase to 78.4 MVA, an increase of 18.7 MVA on the 2022 maximum demand. Given that the independent sum of the individual load peaks is 86.7 MVA there is a diversity factor of 0.91 between the loads.
- Based on Ergo's analysis, the Kensington Transmission Substation's (N-1) limit is expected to be exceeded. However, as discussed in section 8.5.1, network upgrades to mitigate the overloading issue are planned and are viewed as adequate to supply the increased load due to the Load Sites.

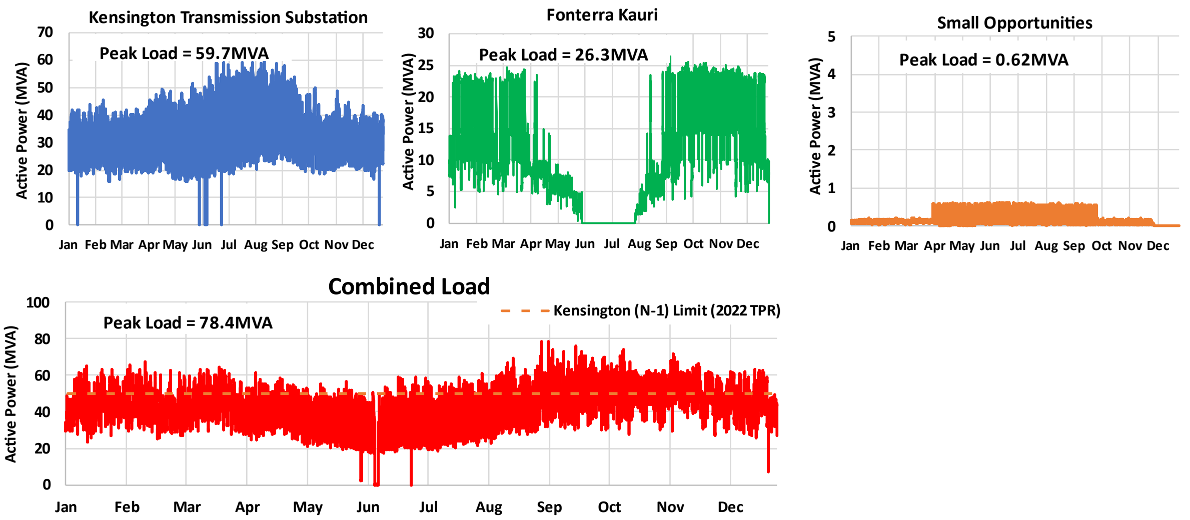


Figure 38 Loading Profiles: Kensington Transmission Substation 2022 33 kV historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.6 Bream Bay GXP

There are no "large" Load Sites expected to connect to Bream Bay GXP.

The "Small" Load Site connecting to the Bream Bay GXP is:

- Bream Bay College (0.17 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 the Marsden transmission substation does not directly supply load, but instead supplies the area via Bream Bay GXP, and only has 220 kV and 110 kV voltages on site. Refer the schematic in section 4.1.

Figure 39 Bream Bay GXP: EECA Load Sites vs local substations

8.6.1 Bream Bay GXP Upgrade

Considering the ample spare (N-1) capacity at Bream Bay GXP and the size of the Load Site expected to connect, the supply capacity at Bream Bay GXP is not expected to be exceeded. As such, upgrades of the Bream Bay GXP are not considered.

8.6.2 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 RMU and an appropriately sized distribution transformer to supply the site.

Table 14 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)
Bream Bay College	Ruakaka	2	12	2.39	0.17	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.

8.6.3 Effect of all Load Sites Connecting to Bream Bay GXP

The following Figure 40 illustrates the Bream Bay 2022 load profile together with the load profiles of all the Load Sites within the Bream Bay GXP region. Also shown in Figure 40 is:

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

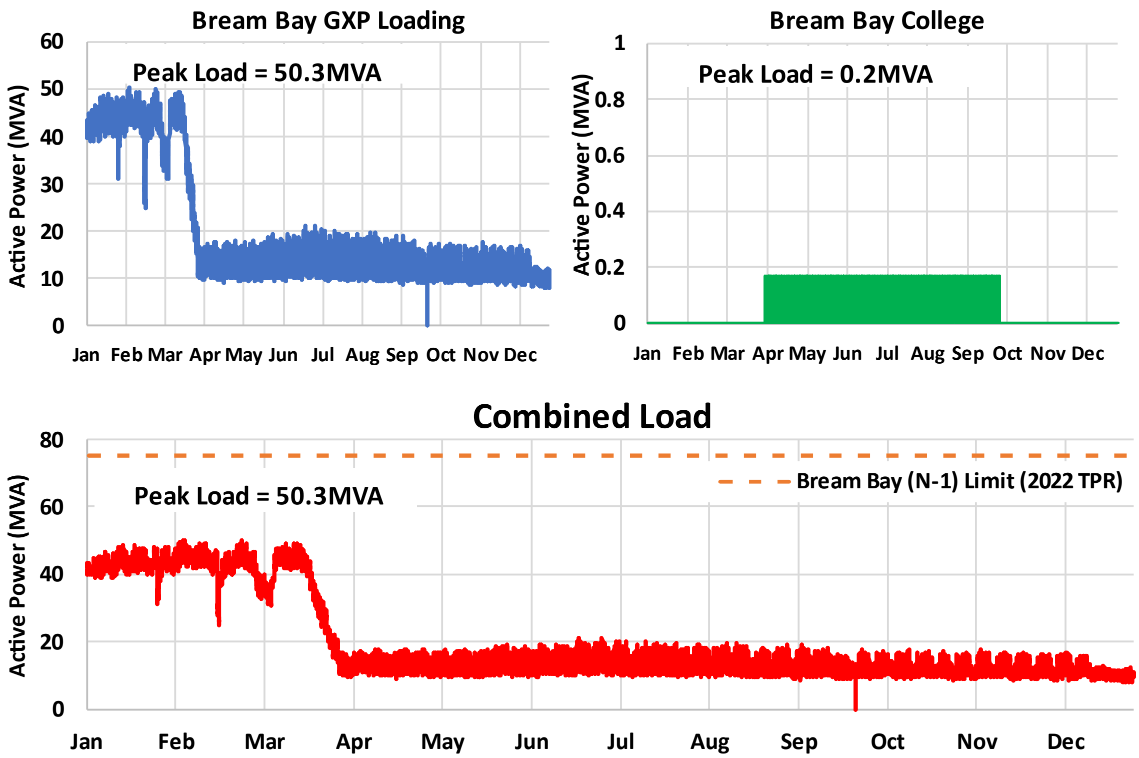


Figure 40 Loading Profiles: Bream Bay GXP 2022 33 kV historical loading: Load Site Profiles: Combined Load (sum of all profiles)

8.7 Maungaturoto GXP

The "Large" EECA Load Sites connecting to the Maungaturoto GXP include:

- Fonterra Maungaturoto (28.43 MVA)

The "Small" Load Site connecting to the Maungaturoto GXP is (refer to section 8.7.3):

- Otamatea High School (0.17 MVA)

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

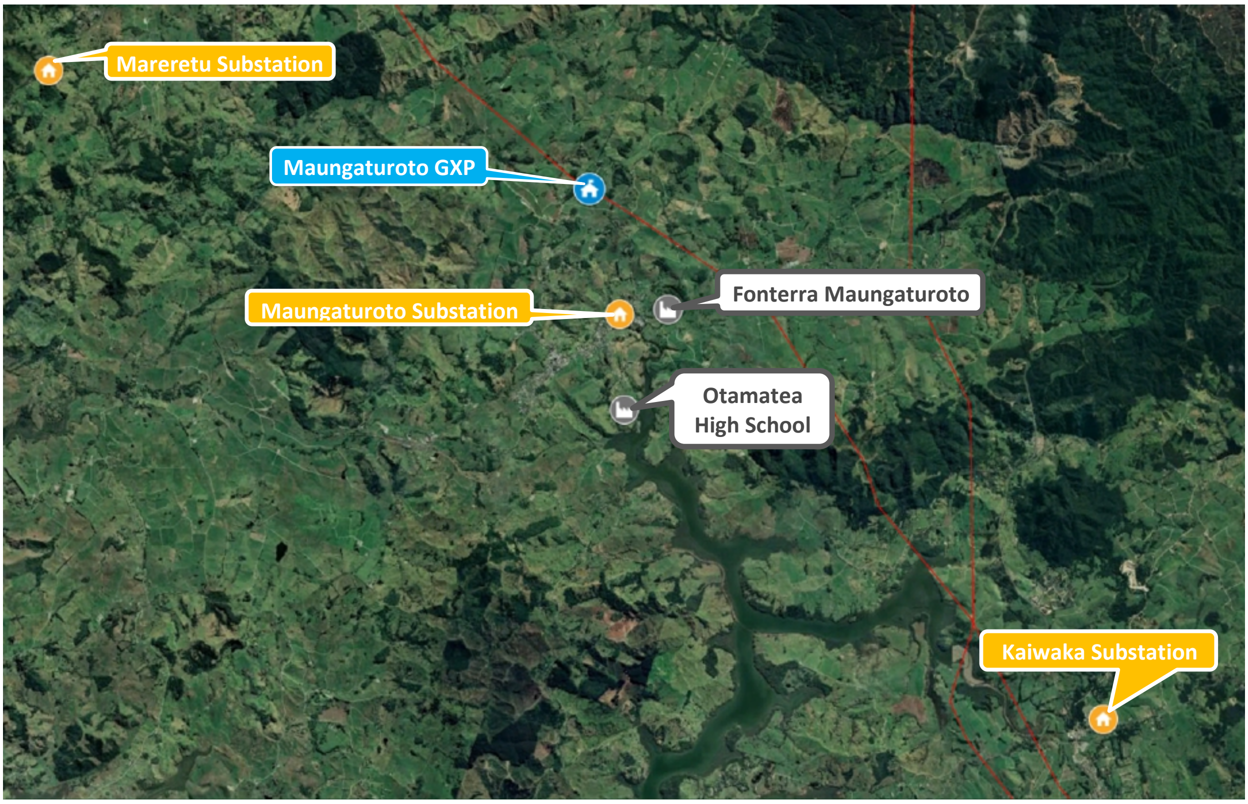


Figure 41 Maungaturoto GXP: EECA Load Sites vs local substations

8.7.1 Maungaturoto GXP Upgrade

Given the ~8 MVA existing spare (N-1) capacity of the Maungaturoto GXP, and prospective Load Site load being more than 28 MVA, the spare capacity of the GXP would be exceeded by the connection of Fonterra Maungaturoto.

The Transmission Planning Report states that there is an existing protection limit which is planned to be removed, which will slightly increase the capacity of the GXP (up to ~9 MVA of spare (N-1)) capacity, which is still insufficient for the prospective load.

Transpower is also considering the installation of a special protection scheme to reduce load automatically, post-contingency at Maungaturoto. Transpower plan to discuss longer term solutions with Northpower.

Some GXP upgrades are discussed in section 8.7.2.

8.7.2 Fonterra Maungaturoto

FONTERRA MAUNGATUROTO		
Load Site Description	**Electrical Demand (MW)**	**Transpower GXP**
New electrical boilers and/or high temperature heat pumps	Stage 1: 8 MW Stage 2: 15 MW (incl. Stage 1) Stage 3: 28.43 MW (incl. Stage 2)	Maungaturoto
Existing Electrical Supply to the Plant		
Fonterra Maungaturoto is presently supplied by Northpower's Maungaturoto zone substation, which is supplied at 33 kV from the Maungaturoto GXP via 2x overhead lines. The plant is supplied by the Maungaturoto zone substation CB4 – Dairy Factory feeder. The Dairy Factory feeder is presently loaded at a maximum of 225 A (4.29 MVA). The plant is ≈0.8 km (straight line) from Maungaturoto substation.		

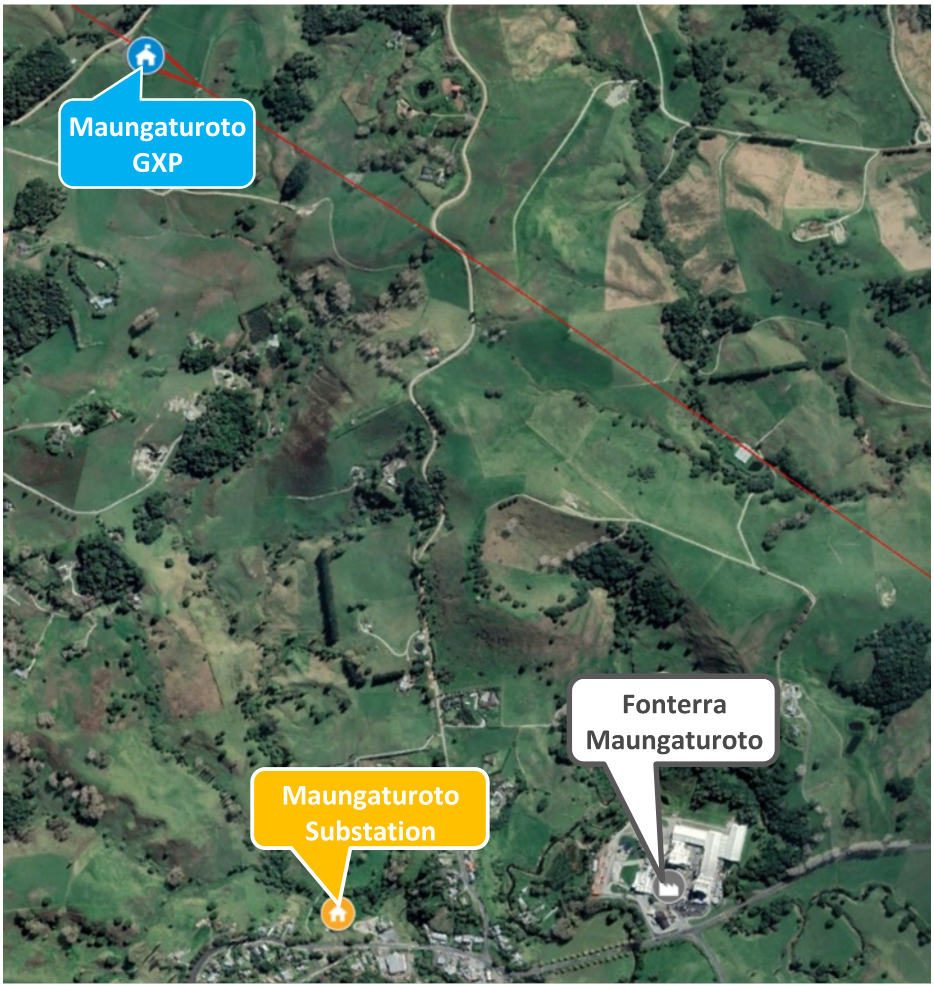


Figure 42 Fonterra Maungaturoto geographic location in relation to the surrounding zone substations

FONTERRA MAUNGATUROTO
Supply Option(s) for New Load
Maungaturoto GXP has just sufficient (N-1) spare capacity for Stage 1, sufficient (N) spare capacity for Stage 2, and insufficient capacity for Stage 3. The Maungaturoto zone substation has sufficient (N) spare capacity for Stage 1, and insufficient spare capacity for Stage 2 and Stage 3. **Stage 1:** To connect the proposed 8 MW of load, it is expected that one new dedicated 11 kV feeder (built to 33 kV ratings for Stages 2 and 3 but operated at 11 kV initially) to the site from Maungaturoto substation would be required. The new feeder would likely be overhead lines due to the rural topography. Ergo expects the new feeder would be ~1 km long. Ergo notes that with the Stage 1 load connected, the Maungaturoto zone substation will be operating near its (N) capacity limit, however, with the 11 kV switchboard and transformer upgrades/replacements planned in financial years 2024-2026, the (N) capacity limit is not considered a constraint. **Stage 2:** The additional proposed load of 7 MW (totalling 15 MW of new load) will exceed the GXP's (N-1) security rating, and so the plant would likely be required to disconnect during network events, in order to maintain network security. This would be achieved using a special protection scheme at the Maungaturoto GXP, as discussed in Section 8.7.1. The total 15 MW of new load would exceed the (N-1) limit of the lines between Maungaturoto GXP and Maungaturoto zone substation, and so another line between Maungaturoto GXP and Maungaturoto zone substation would be required for (N-1) security. Ergo expects that the size of the load, and expected increase in load due to Stage 3, would justify supplying the Fonterra site at 33 kV, establishing a new 33/11 kV zone substation to supply the site (including 2x transformers and a switchroom building), similar to the Fonterra Kauri site's existing arrangement. Ergo has taken a view that the 33 kV supply could be achieved by using the 11 kV (33 kV rated) feeder built during stage 1, with installation of and connection to a new 33 kV switchboard at the Maungaturoto zone substation. This would provide the site with (N) security at the subtransmission level, with a second 33 kV line from Maungaturoto zone substation to the site required for (N-1) security. Northpower have indicated that the Maungaturoto site is challenging to carry out expansion at and Ergo expects that a new 33 kV switchboard installation would involve installation of a new switchroom building, at an increased cost to "normal" sites. **Stage 3:** Ergo expects that the total 28.43 MW of new load would trigger upgrade of the Maungaturoto GXP, including transformer replacements, and potentially a new 33 kV indoor switchboard. Due to the size of the load, additional 33 kV voltage support would likely be required at the Maungaturoto zone substation, at the GXP (as a transmission asset), or locally at the Fonterra site. A (N) security transmission option has not been specified for Stage 3 as it is unlikely that GXP upgrades would be carried out without upgrading to (N-1) security. These upgrades assume that the Stage 2 upgrades mentioned above have been carried out.
Capital Cost Estimate

FONTERRA MAUNGATUROTO

The cost estimates given below are based on a progressive infrastructure development and does not include costs for the planned upgrade of transformers and switchrooms as detailed in Northpower's 2023 AMP. These upgrades are assumed to have been completed.

Table 15 Fonterra Maungaturoto: Capital cost estimate to supply the Load Site (Stage 1)

Transmission => (N-1)	Subtransmission => (N)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Distribution	11 kV circuit breaker (ZSS)	1.00	$0.10
Distribution	Single overhead 33 kV line	1.00	$0.25
		TOTAL	**$0.35**

Table 16 Fonterra Maungaturoto: Capital cost estimate to supply the Load Site (Stage 2 – (N) subtransmission security)

Transmission => (N)	Subtransmission => (N)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Transmission	Special protection system (GXP)	1.00	$0.50
Subtransmission	Medium switchroom (ZSS) (Maungaturoto)	1.00	$6.00
		TOTAL	**$6.50**

Table 17 Fonterra Maungaturoto: Capital cost estimate to supply the Load Site (Stage 2 – (N-1) subtransmission security)

Transmission => (N)	Subtransmission => (N-1)	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Subtransmission	Single overhead 33 kV line	2.50	$0.63
Distribution	Single overhead 33 kV line	1.00	$0.25
		TOTAL	**$0.88**

Table 18 Fonterra Maungaturoto: Capital cost estimate to supply the Load Site (Stage 3)

Transmission => (N-1)	Subtransmission => Per Stage 2	Distribution => (N)	
Network Asset	**Equipment**	**Number and Capital Cost ($M)**	
Transmission	Medium supply transformer (GXP)	2.00	$20.00
Transmission	Medium switchroom (ID)	1.00	$3.00
Distribution	33 kV Capacitor Bank	1.00	$0.40
		TOTAL	**$23.4**

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

Timeframe to Establish New Electrical Infrastructure

Stage 1 and 2 works are estimated to take 12–24 months to plan, design, procure, construct, and commission the works. Stage 3 being a GXP and therefore Transpower's involvement, is estimated to take 24-36 months depending on resource availability.

Excludes the work required to establish the Load Site.

FONTERRA MAUNGATUROTO
Excludes land acquisition and consenting, if required.

8.7.3 Small Opportunities

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

Table 19 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)
Otamatea High School	Maungaturoto	0.5	8	1.73	0.17	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.

8.7.4 Combined Load on Zone Substations

Maungaturoto

While both of the Load Sites at the Maungaturoto GXP are expected to connect to the Maungaturoto zone substation, upgrades are triggered by the Fonterra Maungaturoto connection. Upgrades are discussed in section 8.7.2, and no further upgrades are expected due to both Load Sites connecting.

8.7.5 Effect of all Load Sites Connecting to Maungaturoto GXP

The following Figure 43 illustrates the Maungaturoto 2022 load profile together with the load profiles of all the Load Sites within the Maungaturoto GXP region. Also shown in Figure 43 is:

- The cumulative sum of all the loads (Combined Load), which forecasts that the maximum load on the Maungaturoto GXP would increase to 46.0 MVA, an increase of of 21.8 MVA on the 2022 maximum demand. Given that the independent sum of the individual load peaks is 52.8 MVA there is a diversity factor of 0.87 between the loads.
- Based on Ergo's analysis, the Maungaturoto GXP's (N-1) limit is expected to be exceeded. Discussion around potential upgrades to mitigate this can be found in section 8.7.5.

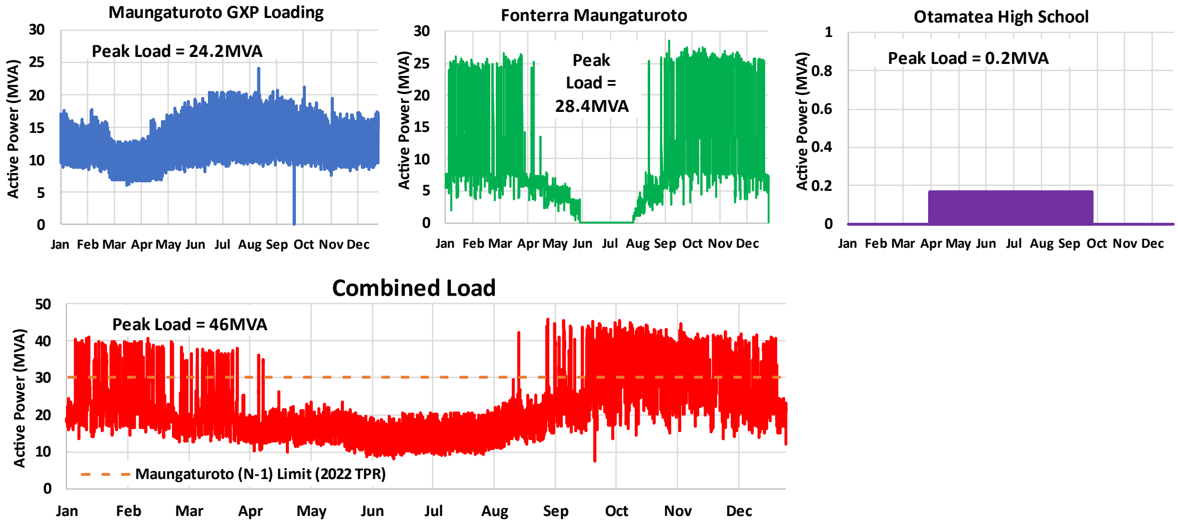


Figure 43 Loading Profiles: Kaikohe GXP 2022 33 kV historical loading: Load Site Profiles: Combined Load (sum of all profiles)

9. Conclusions

9.1 Network Spare Capacity

The following Figure 44 illustrates the (N) and (N-1) spare capacity at the Transpower GXP's and transmission substations in the Northland region.

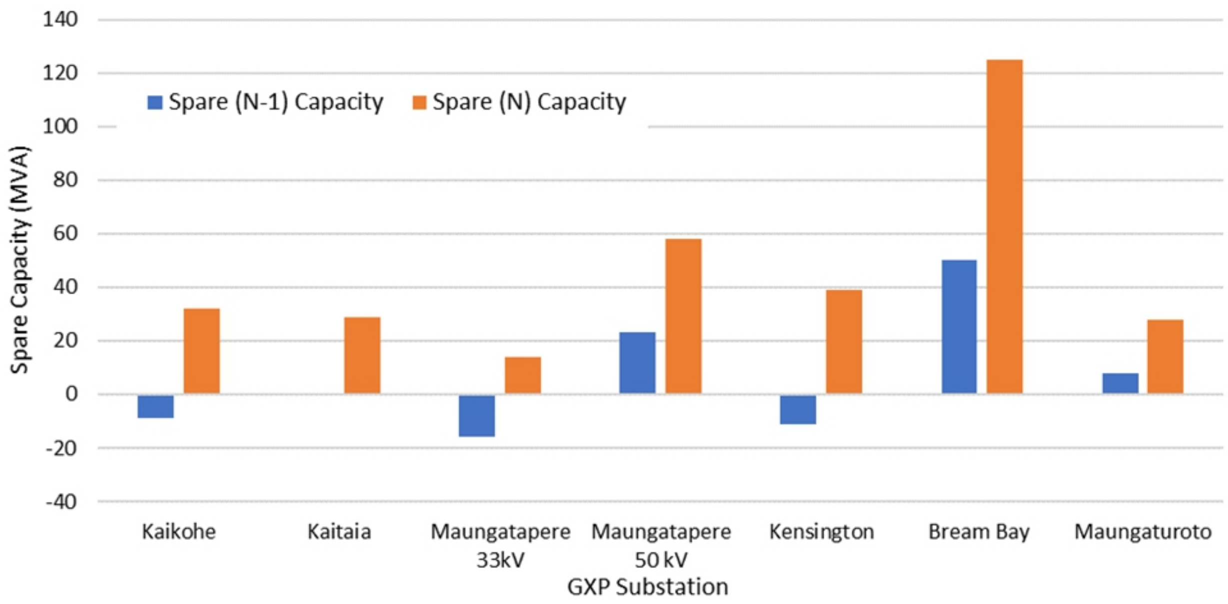


Figure 44 Summary: Approximate (N) and (N-1) spare capacity at GXP substations

The following Figure 45 and Figure 46 illustrate the (N) and (N-1) spare capacity at the EDB zone substations in the Northland region. These figures are based on the maximum loadings and the EDB 2023 disclosures.

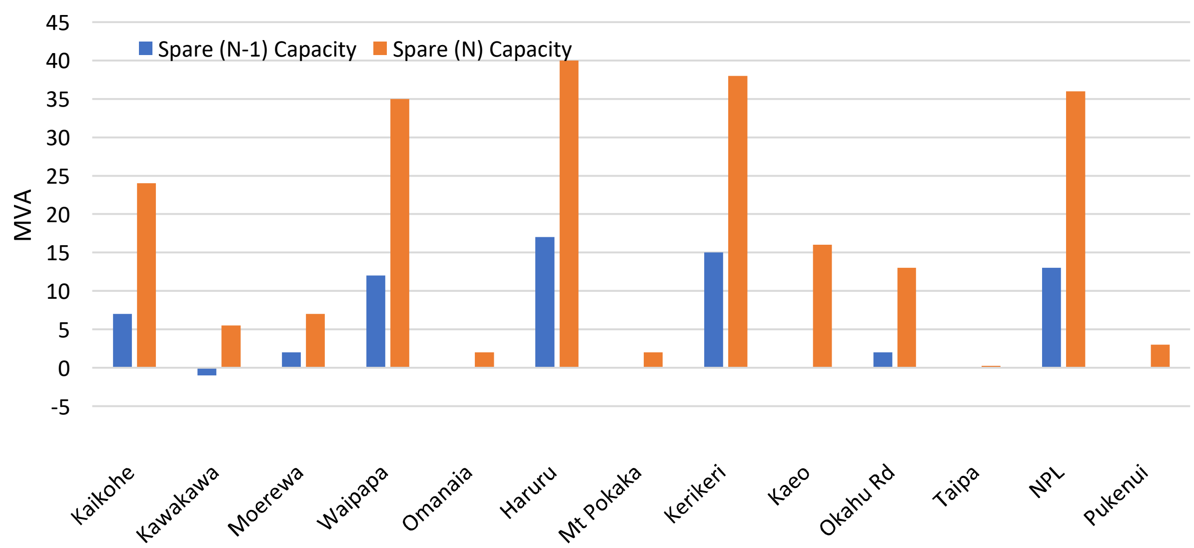


Figure 45 Summary: Approximate (N) and (N-1) spare capacity at Top Energy's zone substations

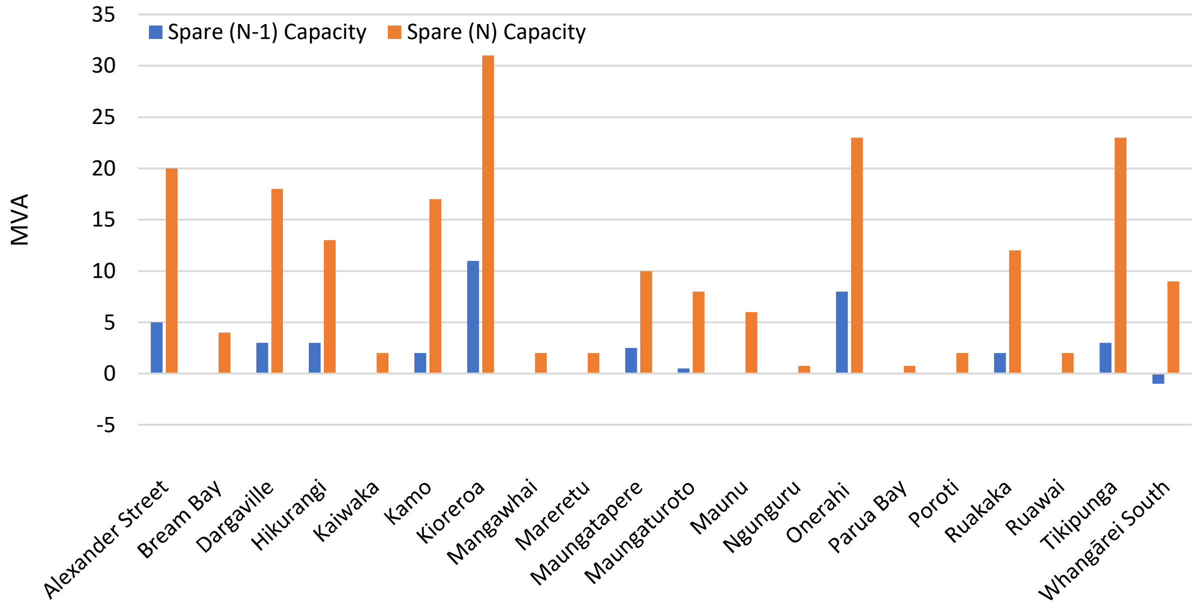


Figure 46 Summary: Approximate (N) and (N-1) spare capacity at Northpower's zone substations.

9.2 Load Characteristics

The substation load characteristics are documented in detail in the main body of the report (and the supplementary document 23019-RPT-0002) and vary widely. However, at a high level, the general characteristics of the substation loads are as follows:

GXP substations:

- *Kaikohe GXP* – Loading is highly influenced by generation from Ngawha into the 110 kV bus, as well as embedded distribution generation. The load is a mix of residential, commercial, and industrial loads. There is no definitive seasonal peaking, but the daily profile shows an evening/early morning peak[26] with lesser peaks around midday and towards the evening.
- *Kaitaia transmission substation* – Mix of residential, commercial and industrial loads. Winter peaking is only about 30% higher than in summer with a traditional daily morning and evening peak that is not overly accentuated.
- *Maungatapere GXP* - Supplies 73% of Northpower's consumers and just more than 55% of the total load. It is a mix of residential, commercial, and industrial loads.
  - *Maungatapere 33 kV transmission substation* – The winter peaking resembles a traditional daily morning and evening peak, while the summer daily load profile is flat.
  - *Maungatapere 50 kV transmission substation* - It is a mix of residential, commercial, and industrial loads. The winter peaking resembles a traditional daily morning and evening peak, while the summer daily load profile is flat.
- *Maungaturoto GXP* – - Supplies 18% of Northpower's consumers and just more than 10% of the total load. Mix of residential, commercial and industrial loads. Winter peaking with an approximate 50% base load and traditional daily morning and evening peak.
- *Bream Bay GXP* – - Supplies 9% of Northpower's consumers and just more than 35% of the total load. Loading was significantly affected by the closure of the Marsden Point Refinery in

[26] This is the actual GXP load in apparent power which most likely represents exporting of real power and therefore gives an idea of the 110 kV busbar load.

April 2022. A full year's load profile in 2023 will indicate the new nature of the seasonal load profile for this GXP.

- *Kensington transmission substation* – Mix of residential (30,000 ICPs), and dairy industry loads. Winter peaking driven by the residential load component with a relatively flat daytime load profile in summer and traditional daily morning and evening peaks in 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[27], which is only suitable for concept screening. (Refer to the assumptions outlined in Section 8.2 for more details)

Summary: Load Sites vs transmission/distribution capital cost estimates

Table 20 Summary of Load Sites and estimated capital costs

No.	Load Site Name	Additional Load (MW)	Transmission Details		Distribution		TOTAL	Cost Efficiency ($M/MW)	Complexity of Connection	Refer to notes
			GXP/Transmission Substation	Upgrade Costs ($M)	Zone Substation	Upgrade Costs ($M)	Upgrade Costs ($M)			
1	Northland Regional Corrections Facility	2.90	Kaikohe	$0.00	Kaikohe	$0.00	**$0.00**	**$0.00**	Minor	2
2	Imerys Ceramics New Zealand Ltd.	1.36	Kaikohe	$0.00	Kaeo	$0.00	**$0.00**	**$0.00**	Minor	2
3	Bay of Islands College	0.30	Kaikohe	$0.00	Kawakawa	$0.00	**$0.00**	**$0.00**	Minor	1
4	Kerikeri Crematorium	0.20	Kaikohe	$0.00	Mt Pokaka	$0.00	**$0.00**	**$0.00**	Minor	1
5	Downer Whangārei Asphalt Plant	5.00	Maungatapere	$0.00	Kioreroa	$0.90	**$0.90**	**$0.18**	Minor	2
6	Whangārei Hospital	4.46	Maungatapere	$0.00	Whangārei South	$1.62	**$1.62**	**$0.36**	Minor	2
7	Grinning Gecko Cheese Company	0.67	Maungatapere	$0.00	Kioreroa	$0.00	**$0.00**	**$0.00**	Minor	1
8	Northland Polytechnic	0.36	Maungatapere	$0.00	Whangārei South	$0.00	**$0.00**	**$0.00**	Minor	1
9	Whangarei Council Maunu Cemetery	0.20	Maungatapere	$0.00	Maunu	$0.00	**$0.00**	**$0.00**	Minor	1
10	Fonterra Kauri (N-1 supply option)	26.05	Kensington	$0.00	Kauri	$10.75	**$10.75**	**$0.41**	Moderate	2
11	Whangarei District Council Aquatic Centre	0.24	Kensington	$0.00	Alexander Street	$0.00	**$0.00**	**$0.00**	Minor	1
12	Whangarei Girls High School	0.24	Kensington	$0.00	Alexander Street	$0.00	**$0.00**	**$0.00**	Minor	1
13	Whangarei Boys High School	0.20	Kensington	$0.00	Alexander Street	$0.00	**$0.00**	**$0.00**	Minor	1
14	Bream Bay College	0.17	Bream Bay	$0.00	Ruakaka	$0.00	**$0.00**	**$0.00**	Minor	1
15	Fonterra Maungaturoto (All Stages)(N-1 supply option)	28.43	Maungaturoto	$23.50	Maungaturoto	$7.63	**$31.13**	**$1.09**	Major	2
16	Otamatea High School	0.17	Maungaturoto	$0.00	Maungaturoto	$0.00	**$0.00**	**$0.00**	Minor	1
	TOTAL =>	71.0	TOTAL =>	$23.5	TOTAL =>	$20.90	$44.40			

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

Disclaimer: The Load Site supply investigations and capital cost estimates outlined in this report are preliminary and are only suitable for screening purposes. The capital cost estimates should not be used for final budgeting purposes in order to connect the respective Load Sites. For the larger Load Sites Ergo recommend proceeding with a Concept Design Report (CDR) to improve the accuracy of the respective cost estimate.

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

Appendix 1 Glossary

BRB	Bream Bay GXP
CT	Current transformerDG Distributed generator
EDB	Electrical Distribution Business
EIPC	Electricity Industry Participation Code
ENA	Electricity Network Association
ESA	Electricity Supply Authority
FY	Financial Year
GXP	Grid exit point substation
KOE	Kaikohe GXP
KTA	Kaitaia substation
kV	Kilovolts
MPE	Maungatapere GXP
MTO	Maungaturoto GXP
MW	Megawatts
MVAr	Mega volt amps reactive
MVA	Mega volt amps
ONAN	Oil natural air natural (the methods used to cool the windings and body of the transformer)
ONAF	Oil natural air forced (the methods used to cool the windings and body of the transformer)
SCADA	Supervisory control and data acquisition

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 21 Cost estimate classification matrix[28]

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.

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