

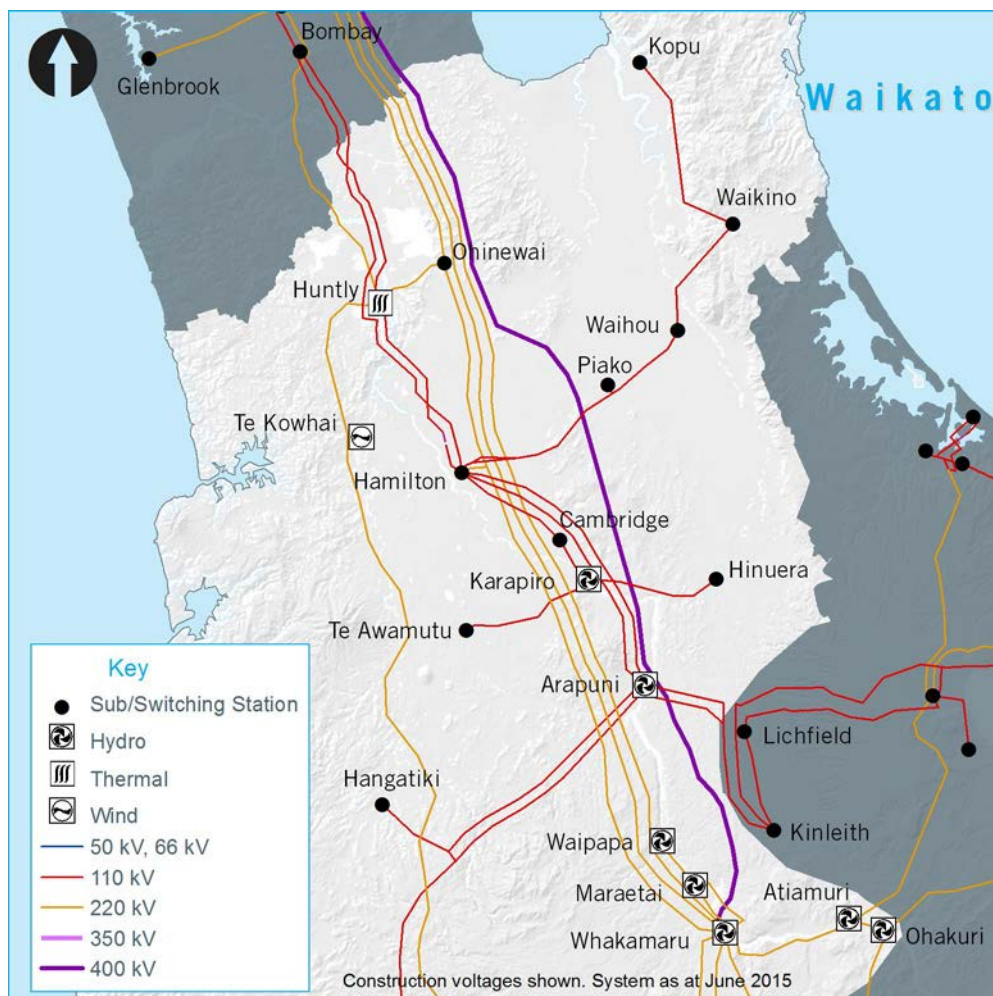
9 Waikato Regional Plan

9.1	Regional overview
9.2	Waikato transmission system
9.3	Waikato demand
9.4	Waikato generation
9.5	Waikato significant maintenance work
9.6	Future Waikato transmission configuration
9.7	Changes since the 2014 Transmission Planning Report
9.8	Waikato transmission capability
9.9	Waikato bus security
9.10	Other regional items of interest
9.11	Waikato generation proposals and opportunities

9.1 Regional overview

This chapter details the Waikato regional transmission plan. We base this regional plan on an assessment of available data, and welcome feedback to improve its value to all stakeholders.

Figure 9-1: Waikato region



The Waikato region comprises two distinct transmission networks, 110 kV and 220 kV, of which the 220 kV network forms part of the grid backbone. The 220 kV circuits enter the region from Stratford, Tokaanu, and Wairakei. The 110 kV circuits enter the region from Tarukenga to Kinleith, and from Ongarue to Hangatiki. The northern boundary is crossed by the:

- 220 kV circuits from Huntly, Ohinewai, and Whakamaru, and
- 110 kV circuits from Hamilton and Arapuni.

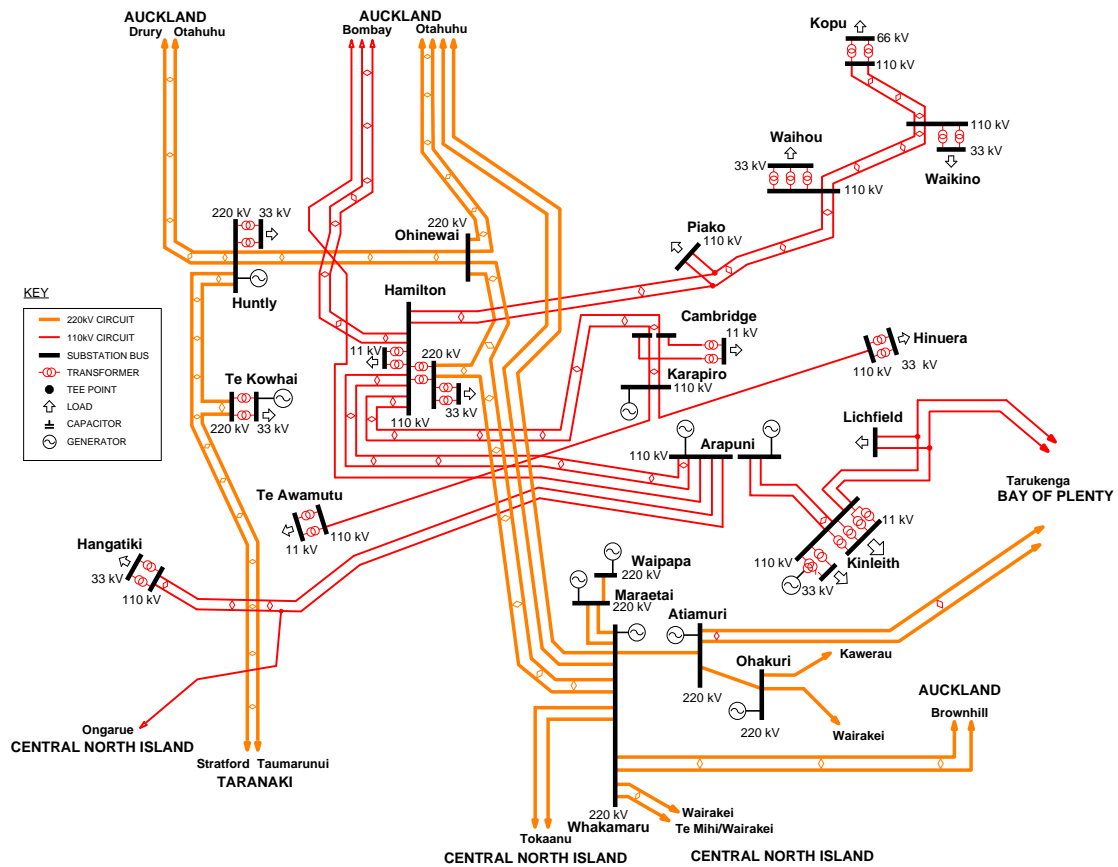
We have assessed the Waikato region’s transmission needs over the next 15 years while considering longer-term development opportunities. Specifically, the transmission network needs to be sufficiently flexible to respond to a range of future service and technology possibilities, taking into consideration:

- the existing transmission network
- forecast demand
- forecast generation
- equipment replacement based on condition assessment, and
- possible technological development.

9.2 Waikato transmission system

This section highlights the state of the Waikato regional transmission network. The existing transmission network is set out geographically in Figure 9-1 and schematically in Figure 9-2.

Figure 9-2: Waikato transmission schematic



9.2.1 Transmission into the region

This region's generation contributes a significant portion of total North Island generation and exceeds local demand. Surplus generation is exported over the 220 kV transmission network to the rest of the country. The 220 kV transmission network has enough capacity to provide n-1 security to the local load indefinitely.

9.2.2 Transmission within the region

The 110 kV transmission network within the region predominantly supplies and connects the rest of the Waikato region, including most of the regional load and some regional generation.

Transmission system issues

The 110 kV transmission network predominantly comprises low capacity circuits. Even with all circuits in service, there are still security issues at grid exit points and generation restrictions, particularly at Arapuni and Kinleith, and also within the Auckland region.

Maintenance security issues

The 220/110 kV interconnection at Hamilton supplies most of the load in the Waikato region. The outage of a 220 kV circuit to Hamilton or a 220/110 kV interconnecting transformer at Hamilton will place many grid exit points in the region on n security. We will consider options to increase the security of this interconnection to provide full or partial n-1 security.

9.2.3 Longer-term development path

We will continue to resolve the short and long-term issues in the region, including the:

- Waikato 110 kV transmission network (the 110 kV circuits that operate in parallel with the grid backbone between Tarukenga and Bombay)
- 110 kV Thames Valley spur (connecting Piako, Waihou, Waikino, and Kopu), and
- Hamilton interconnecting transformer capacity and maintenance security.

Additionally, in order to meet high load growth in the Tauranga area, one option is a transmission connection between Waihou and a new grid exit point north of Tauranga.

The following projects represent possible grid backbone developments through the Waikato region:

- installing series capacitors on the 220 kV Brownhill–Whakamaru circuits (likely within the forecast period).
- converting the 220 kV Brownhill–Whakamaru circuits to 400 kV operation by installing 400/220 kV interconnecting transformers at Brownhill and Whakamaru (likely beyond the forecast period).

9.3 Waikato demand

The after diversity maximum demand (ADMD) for the Waikato region is forecast to grow on average by 1.2% annually over the next 15 years, from 620 MW in 2015 to 740 MW by 2030. This is higher than the national average demand growth of 1.1% annually.

Figure 9-3 shows a comparison of the 2014 and 2015 TPR forecast 15-year maximum demand (after diversity⁷²) for the Waikato region. The forecasts are derived using historical data, and modified to account for customer information, where appropriate. The power factor at each grid exit point is also derived from historical data. See Chapter 4 for more information about demand forecasting.

Figure 9-3: Waikato region after diversity maximum demand forecast

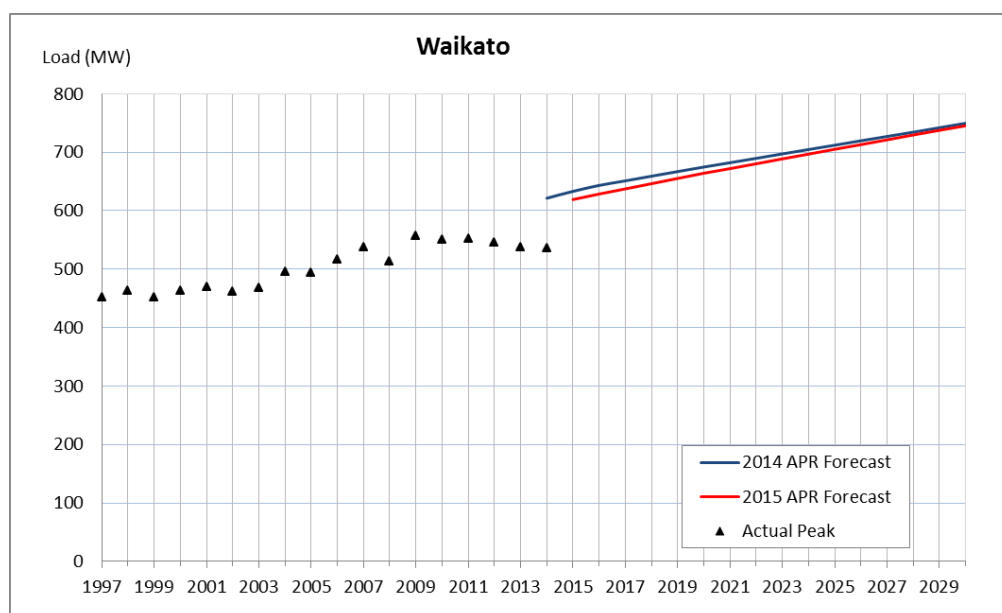


Table 9-1 lists forecasts peak demand (prudent growth) for each grid exit point for the forecast period.

Table 9-1: Forecast annual peak demand (MW) at Waikato grid exit points to 2030

Grid exit point	Power factor	Peak demand (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Cambridge	0.98	43	44	44	45	46	47	48	50	51	53	54
Hamilton 11 kV	1.00	39	39	40	40	40	41	42	42	43	44	45
Hamilton 33 kV ¹	0.99	141	143	144	146	147	148	151	155	158	161	164
Hamilton NZR	0.79	7	7	7	7	7	7	7	7	7	7	7
Hangatiki	0.91	34	35	35	36	36	37	38	39	41	42	43
Hinuera ^{2,5}	0.94	49	48	48	31	31	31	32	32	33	34	35
Huntly	1.00	27	28	28	28	28	28	28	29	29	29	30
Kinleith 11 kV	0.86	83	83	83	83	83	83	83	83	83	83	83
Kinleith 33 kV	0.98	20	20	21	21	21	21	21	21	22	22	22
Kopu	1.00	50	51	52	53	53	54	56	57	59	61	62
Lichfield ³	0.95	9	17	17	18	18	18	18	18	18	18	18
Piako ⁵	0.96	34	37	38	38	39	40	41	43	44	46	47
Putaruru ²	1.00	0	0	0	18	18	19	19	19	20	20	21
Te Awamutu	0.99	39	39	39	39	39	40	40	40	41	41	42
Te Kowhai ^{1,4}	0.98	94	95	96	97	98	99	101	103	105	107	109

⁷² The after diversity maximum demand (ADMD) for the region will be less than the sum of the individual grid exit point peak demands, as it takes into account the fact that the peak demand does not occur simultaneously at all the grid exit points in the region.

Grid exit point	Power factor	Peak demand (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Waihou	0.99	49	50	51	52	52	53	55	56	58	59	61
Waikino	0.99	38	38	39	39	40	40	42	43	44	45	47

1. There is frequent and regular load shifting between Hamilton and Te Kowhai.
2. Some load will be shifted from Hinuera to a proposed new grid exit point at Putaruru in 2018.
3. New load added from 2016 – Lichfield new drier, 8 MW.
4. New load added from 2015 – mining, 3 MW.
5. Load shift from 2016 – some Waharoa load shifted from Hinuera to Piako, 2 MW.

9.4 Waikato generation

The Waikato region's generation capacity is 2,201 MW. This generation exceeds the local demand and surplus generation is exported over the National Grid to other demand centres.

Table 9-2 lists the generation forecast for each grid injection point for the forecast period. This includes all known and committed generation stations including those embedded within the relevant local lines company's network (Waipa Networks, WEL Networks, The Lines Company or Powerco).⁷³

Table 9-2: Forecast annual generation capacity (MW) at Waikato grid injection points to 2030 (including existing and committed generation)

Grid injection point (location if embedded)	Generation capacity (MW)										
	Next 5 years						6-15 years out				
	2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Arapuni	197	197	197	197	197	197	197	197	197	197	197
Atiamuri	84	84	84	84	84	84	84	84	84	84	84
Hangatiki (Mangapehi)	2	2	2	2	2	2	2	2	2	2	2
Huntly ¹	948	948	948	948	948	948	948	948	948	948	948
Karapiro	90	90	90	90	90	90	90	90	90	90	90
Kinleith	28	28	28	28	28	28	28	28	28	28	28
Maraetai	360	360	360	360	360	360	360	360	360	360	360
Mokai	112	112	112	112	112	112	112	112	112	112	112
Ohakuri	112	112	112	112	112	112	112	112	112	112	112
Te Awamutu (Anchor Products)	4	4	4	4	4	4	4	4	4	4	4
Te Kowhai (Te Rapa)	44	44	44	44	44	44	44	44	44	44	44
Te Kowhai (Te Uku)	64	64	64	64	64	64	64	64	64	64	64
Waikino (Tirohia Landfill)	1	1	1	1	1	1	1	1	1	1	1
Waipapa	51	51	51	51	51	51	51	51	51	51	51
Whakamaru	100	100	100	100	100	100	100	100	100	100	100

1. Huntly generation capacity assumes only two 250 MW coal-fired units remains in service.

⁷³ Only generators with a capacity greater than 1 MW are listed. Generation capacity is rounded to the nearest megawatt.

9.5 Waikato significant maintenance work

Our capital projects and maintenance works are integrated to enable system issues to be resolved if possible when assets are replaced or refurbished. Table 9-3 lists the significant maintenance-related work⁷⁴ proposed for the Waikato region for the next 15 years that may significantly impact related system issues or connected parties.

Table 9-3: Proposed significant maintenance work

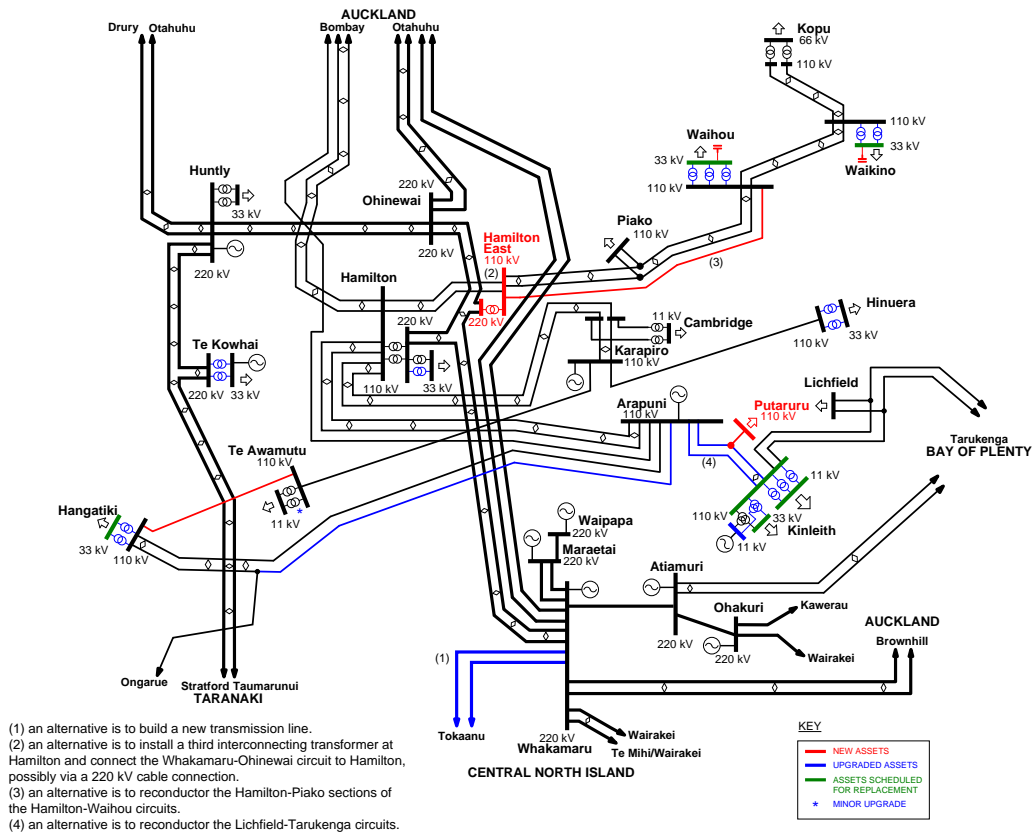
Description	Tentative year
Arapuni–Ongarue–A line reconductoring (Arapuni–Rangitoto section)	2020-2022
Hamilton–T5 supply transformer expected end-of-life	2022-2024
Hangatiki–T1 and T2 supply transformers' expected end-of-life, and Hangatiki 33 kV outdoor to indoor conversion	2021-2023 2021-2023
Hinuera–T1 and T2 supply transformers' expected end-of-life	2027-2028
Kinleith 11 kV indoor switchboard replacement	2015-2018
Kinleith 33 kV indoor switchboard replacement (possible, not proposed)	2015-2018
Kinleith 110/11 kV supply transformers (all) expected end-of-life	2016-2018
Kinleith 110/33 kV supply transformer replacement, and Kinleith 110 kV bus refurbishment / replacement	2016-2018 2016-2019
Waihou 33 kV outdoor to indoor conversion, and Waihou supply transformers' expected end-of-life	2016-2018 2022-2024
Waikino supply transformers' expected end-of-life, and Waikino 33 kV outdoor to indoor conversion	2020-2022 2020-2022

9.6 Future Waikato transmission configuration

Figure 9-4 shows the possible configuration of Waikato transmission in 2030, with new assets, upgraded assets, and assets undergoing significant maintenance within the forecast period.

⁷⁴ This may include replacement of the asset due to its condition assessment.

Figure 9-4: Possible Waikato transmission configuration in 2030



9.7 Changes since the 2014 Transmission Planning Report

Table 9-4 lists the specific issues that are either new or no longer relevant within the forecast period when compared to last year's report.

Table 9-4: Changes since 2014

Issues	Change
Piako transmission security	Removed. Second Piako connection commissioned.
Waihou transformer capacity	Added. Higher load forecast at Waihou.
Te Kowhai substation development	Removed. Lower load forecast in Hamilton.
Kinleith–Tarukenga transmission capacity	Combined with Arapuni–Kinleith 110 kV transmission capacity.

9.8 Waikato transmission capability

Table 9-5 summarises issues involving the Waikato region for the next 15 years. For more information about a particular issue, refer to the listed section number.

Table 9-5: Waikato region transmission issues

Section number	Issue
Regional	
9.8.1	Arapuni–Hamilton 110 kV transmission capacity
9.8.2	Arapuni–Kinleith–Tarukenga 110 kV transmission capacity
9.8.3	Hamilton interconnecting transformer capacity
9.8.4	Hamilton–Piako–Waihou 110 kV transmission capacity

9.8.5 Piako–Waihou–Waikino–Kopu spur low voltage

Site by grid exit point

9.8.6 Cambridge supply transformer capacity

9.8.7 Hamilton 220/33 kV and 110/11 kV supply transformer capacity

9.8.8 Hangatiki supply transformer capacity

9.8.9 Hinuera supply transformer capacity

9.8.10 Hinuera transmission security

9.8.11 Kinleith 110/33 kV supply security, supply transformer capacity and low voltage

9.8.12 Kinleith 110/11 kV supply security

9.8.13 Kopu supply transformer capacity

9.8.14 Maraetai–Whakamaru transmission capacity

9.8.15 Te Awamutu supply transformer capacity

9.8.16 Te Awamutu transmission security

9.8.17 Waihou supply transformer capacity

9.8.18 Waikino supply transformer capacity

Bus security

9.9.1 Transmission bus security

9.9.2 Kinleith 110 kV bus security

9.9.3 Hangatiki supply security

9.9.4 Bombay–Hamilton 110 kV transmission capacity

9.8.1 Arapuni–Hamilton 110 kV transmission capacity

Project status/type: This issue is for information only

Issue

The two 110 kV Arapuni–Hamilton circuits are each rated at 51/62 MVA (summer/winter).

A cost benefit analysis showed the most economic normal system configuration is to split the Arapuni 110 kV bus. The normal split for the Arapuni 110 kV bus currently comprises two bus sections:

- Arapuni G1-4 generators, Arapuni–Bombay–1, Arapuni–Hamilton–1 and 2, Arapuni–Hangatiki–1, and the Arapuni–Ongarue–1 circuits on the north bus, and
- Arapuni–Kinleith–1 and 2 circuits on the south bus
- The Arapuni G5-8 generators are selectable between the north and south bus sections.

With the Arapuni bus split:

- Arapuni north bus generation may be constrained pre-contingency to manage the loading on an Arapuni–Hamilton circuit for an outage of the other Arapuni–Hamilton circuit, and
- the Arapuni runback scheme is enabled on Arapuni G1-4 to reduce generation if an Arapuni–Hamilton circuit overloads.

When the new Putaruru grid exit point is connected in 2018 (see Section 9.8.10) the Arapuni bus may need to be normally solid (as opposed to split) to manage the loading on the 110 kV circuits between Arapuni and Tarukenga (see Section 9.8.2). With a solid Arapuni bus:

- Arapuni generation may experience greater pre-contingency constraints to manage the loading on a 110 kV Arapuni–Hamilton circuit for an outage of the other Arapuni–Hamilton circuit or the 220 kV Hamilton–Whakamaru circuit
- the Arapuni runback scheme is enabled on all Arapuni generators to reduce generation if an Arapuni–Hamilton circuit overloads
- the operation of the Arapuni runback scheme for an outage of the 220 kV Hamilton–Whakamaru circuit may overload the Lichfield–Tarukenga circuit (see Section 9.8.2)
- there are additional minimum and maximum constraints on Arapuni generation to reduce loading to within circuit capacity on the circuits between Arapuni and Tarukenga (see Section 9.8.2), and
- the worst case conditions occur during peak load periods with moderate to low thermal generation north of Whakamaru.

In addition, the Arapuni bus must be made solid for some maintenance outages, which will become increasingly difficult to arrange because of generation and load constraints. Even if the Arapuni bus split is retained, additional 110 kV disconnectors will be required to facilitate maintenance outages and reduce the restoration time following equipment faults.

With the Arapuni bus solid there is a high risk that we will need to constrain Auckland region generation with increasing frequency to the extent that it may become impractical to expect generation to be available at all times when we need it.

Solution

With the Arapuni bus split, issues with the Arapuni–Hamilton transmission capacity can be managed operationally. However, this will cause issues with the Arapuni–Kinleith–Tarukenga transmission capacity.

After connection of the new Putaruru grid exit point (see Section 9.8.10), closing the Arapuni bus split and operating the new Hangatiki–Te Awamutu circuit closed (see Section 9.8.16) will partially relieve but not resolve the issue with the Arapuni–Hamilton transmission capacity. Issues with the Arapuni–Kinleith–Tarukenga transmission capacity will remain.

A preliminary assessment of the Investment Test indicates that reconductoring the 110 kV Arapuni–Hamilton circuits (and possibly also the Arapuni–Bombay circuits) to remove the overload is unlikely to be economic. A condition assessment shows that the existing conductor will not require replacement within the forecast period.

The Arapuni–Hamilton transmission capacity issue is driven mainly by the Arapuni–Kinleith–Tarukenga transmission capacity issue and the solutions are described in more detail in Section 9.8.2 (with an overview in Section 9.10.1).

9.8.2 Arapuni–Kinleith–Tarukenga 110 kV transmission capacity

Project description:	Special Protection Schemes Variable line ratings Reconductor 110 kV circuits
Project status/type:	Possible, Base Capex / Major Capex Project
Indicative timing:	To be advised
Indicative cost band:	Special Protection Schemes – A Variable line ratings – A Reconductor 110 kV circuits – C

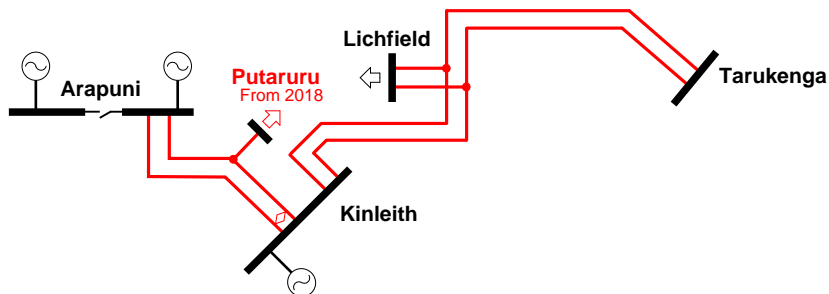
Issue

Kinleith and Lichfield are supplied through the following 110 kV circuits:

- Arapuni–Kinleith–1 rated at 57/70 MVA (summer/winter)

- Arapuni–Kinleith–2 rated at 63/77 MVA (summer/winter)
- Kinleith–Lichfield–Tarukenga–1 rated at 51/62 MVA (summer/winter), and
- Kinleith–Lichfield–Tarukenga–2 rated at 63/77 MVA (summer/winter)

Figure 9-5: Arapuni–Kinleith–Tarukenga 110 kV configuration



The loading on the Arapuni–Kinleith and Kinleith–Lichfield–Tarukenga circuits may exceed their n-1 capacity under certain operating conditions.

The connection of new load at Lichfield from 2016 and Putaruru from 2018 will progressively make the circuit capacity issues worse and more complex to manage operationally.

With the Arapuni bus split:

- generation at Kinleith and Arapuni must be managed so the:
 - minimum generation at Kinleith and Arapuni is high enough to prevent the Lichfield–Tarukenga circuits exceeding their n-1 capacity, and
 - maximum generation at Arapuni is low enough to prevent the Arapuni–Kinleith circuits exceeding their n-1 capacity.
- when the load increase at Lichfield occurs in 2016, there will be minimum generation requirements at Kinleith during high load periods
- when the new Putaruru grid exit point is connected in 2018, the minimum generation requirement at Kinleith and Arapuni becomes difficult to manage and may become unmanageable if the full capacity of either generating station is unavailable.

With the Arapuni bus solid after the connection of the Putaruru grid exit point in 2018, the:

- Lichfield–Tarukenga circuits may overload for an outage of the 220 kV Hamilton–Whakamaru circuit; this issue may be exacerbated by the Arapuni runback operating to reduce loading on the Arapuni–Hamilton circuits (see Section 9.8.1).
- Lichfield–Tarukenga circuit may overload for an outage of the other Kinleith–Lichfield–Tarukenga circuit with low generation at Arapuni and Kinleith.
- Arapuni–Kinleith or Arapuni–Putaruru circuit may overload for an outage of the other circuit with high Arapuni generation.
- worst conditions occur during summer peak load periods with moderate to low thermal generation in the Auckland region.

Solution

In the short term, the loading on these circuits will continue to be managed operationally.

While we are investigating possible alternative options, we are also investigating several interim options to manage the Arapuni–Kinleith–Lichfield–Tarukenga transmission capacity issues, which all assume there is a special protection scheme to automatically prompt Powerco to transfer load from Putaruru to Hinuera as the first

action to prevent overloading⁷⁵. These interim options include some or all of the following:

- Keep the Arapuni bus split and apply variable line ratings on the Kinleith–Tarukenga–Lichfield circuits to ease limits on generation.
- Keep the Arapuni bus split, replace the existing Arapuni–Kinleith special protection scheme with a second Arapuni generation runback scheme to allow more generation on the Arapuni South bus pre-contingency.
- Install a special protection scheme at Tarukenga to manage load at Putaruru, Lichfield, and Kinleith post-contingency.

We will investigate a range of longer-term options to resolve the capacity issues between Arapuni and Tarukenga. The options include making the Arapuni bus solid and reconductoring the:

- 110 kV Arapuni–Kinleith circuits, and normally splitting the 110 kV system between Kinleith and Lichfield, or
- 110 kV Kinleith–Lichfield–Tarukenga circuits, and installing a special protection scheme at Arapuni to manage loading on the Arapuni–Kinleith circuits.

Acquisition of property easements may be required for reconductoring work in some cases.

9.8.3 Hamilton interconnecting transformer capacity

Project description:	New interconnecting transformer
Project status/type:	Possible, Base Capex
Indicative timing:	To be advised
Indicative cost band:	B

Issue

Two three-phase interconnecting transformers at Hamilton supply much of the Waikato 110 kV transmission network load, as well as a small proportion of the Auckland 110 kV loads under certain system conditions. These transformers provide:

- a total nominal installed capacity of 420 MVA, and
- n-1 capacity of 243/243 MVA⁷⁶ (summer/winter).

During low 110 kV generation in Waikato (Arapuni and Karapiro generation) and high Waikato demand, the load on the Hamilton interconnecting transformers may exceed their n-1 capacity. This overloading issue worsens with low Upper North Island generation.

Solution

In the short term, we anticipate this issue will be managed operationally with generation rescheduling and load management.

Long-term options to address this issue include a new 220/110 kV transformer:

- in parallel with the existing transformers, or
- at a new substation, connected to the intersection of the 220 kV Otahuhu–Whakamaru C line and the 110 kV Hamilton–Waihou A line.

⁷⁵ When the new Putaruru substation is connected we intend to install a special protection scheme on the Arapuni–Kinleith circuits to reduce loading on these circuit post-contingency by automatically prompting Powerco to transfer load away from Putaruru. If the load is not reduced sufficiently within a specific time frame, the scheme will trip the load at Putaruru.

⁷⁶ The transformers' capacity is limited by protection equipment; with this limit resolved, the n-1 capacity will be 248/259 MVA (summer/winter).

The second option improves security during maintenance outages of the 220 kV circuits supplying Hamilton, and forms the connection point for a third circuit to Waihou (instead of a Hamilton connection, see Section 9.8.4 for more information).

9.8.4 Hamilton–Piako–Waihou 110 kV transmission capacity

Project description:	Increase Hamilton–Piako–Waihou transmission capacity
Project status/type:	Possible, customer-specific
Indicative timing:	2021
Indicative cost band:	C or D

Issue

Two 110 kV Hamilton–Piako–Waihou circuits supply the Thames Valley Spur, each circuit having a summer/winter capacity of 154/168 MVA. Valley Spur summer and winter peak loads are increasingly similar, with 2014 peaks of approximately 122 MW and 129 MW, respectively.

The peak load on the Valley Spur is forecast to exceed the circuits' n-1 winter capacity by approximately 6 MW in 2022, increasing to approximately 31 MW in 2030 (see Table 9-6). The circuit overloading issue will only occur between Hamilton and Piako within the forecast period.

Low voltage along the Valley Spur exacerbates the transmission loading issue (see Section 9.8.5 for more information).

Table 9-6: Valley Spur circuit overload forecast

Circuit/grid exit point	Circuit overload (MW)										
	Next 5 years						6-15 years out				
	2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Valley Spur	0	0	0	0	0	0	6	12	19	25	31

Solution

We will investigate the installation of capacitors to relieve the Valley Spur low voltage issues (see Section 9.8.5 for more information). This provides an interim solution to the Hamilton–Piako circuits' capacity issue, delaying the need for further transmission reinforcement by approximately two years.

In the short-term, the overload can be managed operationally.

Possible longer-term options include:

- constructing a third 110 kV Hamilton–Waihou circuit of a similar capacity to the existing circuits, or
- upgrading the existing 110 kV Hamilton–Piako circuits to increase their summer capacity.

The timing and choice of the capacity reinforcement option will be influenced by load growth and developments within Powerco's network, such as load transfer from the Valley Spur to the Hinuera grid exit point (see Section 9.8.9). Future investment will be customer driven.

Depending on the solution, we may need to purchase easements for either a new line or for some parts of an upgraded line.

9.8.5 Piako–Waihou–Waikino–Kopu spur low voltage

Project description:	New capacitors Replace Waihou supply transformer Replace Waikino supply transformer
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Project status/type:	New capacitors: possible, customer-specific Replace Waihou and Waikino supply transformers: possible, Base Capex
Indicative timing:	New capacitors: TBA Replace supply transformers: 2020-2024
Indicative cost band:	New capacitors: A Replace Waihou supply transformer: B Replace Waikino supply transformer : B

Issue

Supply bus voltages at the Waihou and Waikino grid exit points are forecast to fall below 0.95 pu following an outage of one 110 kV Hamilton–Waihou circuit. In addition, the step voltage change for such an outage will exceed 5%. Both grid exit points have supply transformers with off-load tap changers.

Solution

We are investigating options to maintain voltage at the Waihou and Waikino buses. Possible options include:

- installing two 20 Mvar capacitors (along the Valley Spur), which will also defer Valley Spur investment (see Section 9.8.4 for more information), or
- replacing the existing transformers at Waikino and Waihou, which are due for replacement in the next 5-10 years, with on-load tap changing transformers, and installing a lesser number of capacitors.

Property issues may arise if there is a need to expand the substation to accommodate the new capacitors. Future investment will be customer driven.

9.8.6 Cambridge supply transformer capacity

Project description:	Upgrade supply transformer capacity
Project status/type:	Possible, Base Capex and customer specific
Indicative timing:	TBA
Indicative cost band:	Resolve protection A, upgrade transformer capacity B

Issue

Two 110/11 kV transformers supply Cambridge’s load, providing:

- a total nominal installed capacity of 80 MVA, and
- n-1 capacity of 43/43⁷⁷ MVA (summer/winter).

The peak load at Cambridge is forecast to exceed the transformers’ n-1 winter capacity by approximately 2 MW in 2015, increasing to approximately 13 MW in 2030 (see Table 9-7).

In addition, the two Hamilton–Cambridge–Karapiro circuits supplying Cambridge do not have line circuit breakers at Cambridge and a fault on either circuit will disconnect one supply transformer.

⁷⁷ The transformers’ capacity is limited by the Cambridge–T3 protection limit; with this limit resolved, the n-1 capacity will be 45/47 MVA (summer/winter).

Table 9-7: Cambridge supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Cambridge	0.98	2	3	3	4	5	6	7	9	10	12	13

Solution

Resolving the protection limit will increase the transformers' n-1 capacity to 45/47 MVA (summer/winter), reducing the forecast overload by approximately 1 MW in 2018. The forecast overload increases to approximately 10 MW in 2030. We will discuss the options to increase the supply transformers' n-1 capacity with Waipa Networks. Future investment will be customer driven.

9.8.7 Hamilton 220/33 kV and 110/11 kV supply transformer capacity

Project status/type: This issue is for information only

Issue

The Hamilton grid exit point has both an 11 kV and a 33 kV supply bus.

Two 110/11 kV transformers supply Hamilton's 11 kV load, providing:

- a total nominal installed capacity of 80 MVA, and
- n-1 capacity of 40/40⁷⁸ MVA (summer/winter).

The peak load at Hamilton 11 kV is forecast to exceed the transformers' n-1 winter capacity by approximately 2 MW in 2015, increasing to 8 MW by 2030 (see Table 9-8).

Two 220/33 kV transformers supply Hamilton's 33 kV load, providing:

- a total nominal installed capacity of 220 MVA, and
- n-1 capacity of 124/132 MVA (summer/winter).

The peak load at Hamilton 33 kV is forecast to exceed the transformers' n-1 winter capacity by approximately 13 MW in 2015, increasing to 36 MW by 2030 (see Table 9-8).

Table 9-8: Hamilton supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Hamilton 11 kV	1.00	2	2	3	3	3	4	5	5	6	7	8
Hamilton 33 kV	0.99	13	15	16	18	19	20	23	27	30	33	36

WEL Networks is capable of significant load shifting between Hamilton and Te Kowhai, so the combined load is compared with the total supply transformer capacity at both grid exit points.

Four 220/33 kV transformers at Hamilton and Te Kowhai supply the total Hamilton city 33 kV load, providing:

- a total nominal installed capacity of 450 MVA, and
- n-1 capacity of 388/404 MVA (summer/winter).

⁷⁸ The transformers' capacity is limited by the 11 kV transformer branch component; with this limit resolved, the n-1 capacity will be 48/51 MVA (summer/winter).

The total load is forecast to be 217 MW in 2015, increasing to 251 MW by 2030. The total load will not exceed the combined supply transformer n-1 capacity at Hamilton and Te Kowhai within the forecast period.

Solution

The lack of n-1 security at the Hamilton grid exit point will be managed operationally by transferring load to the Te Kowhai grid exit point after a contingency has occurred. Table 9-8 shows that significant load transfers will be required towards the end of the forecast period.

In addition, the Hamilton–T5 transformer has an expected end-of-life within the next 10 years. We will discuss with WEL Networks the appropriate rating and timing for the replacement transformer. Future investment will be customer driven.

9.8.8 Hangatiki supply transformer capacity and low voltage

Project description:	Upgrade transformers' capacity
Project status/type:	Possible, customer-specific
Indicative timing:	TBA
Indicative cost band:	B

Issue

Two 110/33 kV transformers supply Hangatiki's load, providing:

- a total nominal installed capacity of 40 MVA, and
- n-1 capacity of 22/24 MVA (summer/winter).

Hangatiki winter and summer load peaks are similar. The peak load at Hangatiki is forecast to exceed the transformers' n-1 summer capacity by 16 MW in 2015, increasing to 25 MW by 2030 (see Table 9-9).

Additionally, the peak load⁷⁹ at Hangatiki is forecast to exceed the transformers' nominal installed capacity by 5 MW in 2015⁸⁰, increasing to 14 MW by 2030.

Table 9-9: Hangatiki supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)											
		Next 5 years							6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030	
Hangatiki	0.91	16	17	17	18	18	19	20	21	23	24	25	

The Hangatiki 33 kV bus has low voltages for some load conditions partially because the supply transformers have no on-load tap changer and also because of low power factor on the 33 kV bus.

Solution

The Hangatiki transformers are single-phase units, with a non-contracted spare available on site.

We are discussing longer-term options with The Lines Company, such as replacing the existing transformers with two 50-60 MVA supply transformers.

Future investment will be customer driven.

⁷⁹ The Lines Company also projects a step increase in load of about 10 MW by 2016. This step increase in load is not included in Table 9-9.

⁸⁰ There have already been instances where the load at Hangatiki exceeded the transformers' nominal rating with both supply transformers in service. In this situation both transformers are loaded up to their n-1 capacity, but this is sustainable when used only occasionally and only for the short term.

9.8.9 Hinuera supply transformer capacity

Project description:	New grid exit point Upgrade supply transformer capacity
Project status/type:	New grid exit point: possible, customer-specific Upgrade supply transformer capacity: possible, customer-specific
Indicative timing:	New grid exit point: 2018 Upgrade supply transformer capacity: to be advised
Indicative cost band:	New grid exit point: C Upgrade supply transformer capacity: A

Issue

Two 110/33 kV transformers (rated at 30 MVA and 50 MVA) supply Hinuera's load, providing:

- a total nominal installed capacity of 80 MVA, and
- n-1 capacity of 37/40 MVA (summer/winter).

The peak load at Hinuera is forecast to exceed the transformers' n-1 winter capacity by approximately 13 MW in 2015.

Table 9-10: Hinuera supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Hinuera	0.95	13	12	12	0	0	0	0	0	0	0	0
Hinuera – no Putaruru	0.95	13	12	12	13	13	14	15	16	17	18	19

Solution

In the short-term, load may be transferred within the Powerco network from Hinuera to Waihou and/or Piako to resolve this issue.

Powerco is planning to increase transmission security in the Hinuera area with a new grid exit point near Putaruru, which will be connected to the existing 110 kV Arapuni–Kinleith–2 circuit (see Section 9.8.10). This new grid exit point will reduce Hinuera load by approximately 37%, which will resolve the Hinuera supply transformer capacity issue for the forecast period.

In addition, both Hinuera supply transformers have an expected end-of-life towards the end of the forecast period. Any future investment or transformer upgrade will be customer driven.

9.8.10 Hinuera transmission security

Project description:	New grid exit point
Project status/type:	Proposed, customer-specific
Indicative timing:	2018
Indicative cost band:	C

Issue

A single 110 kV circuit from Karapiro supplies Hinuera's load, providing:

- a capacity of 63/77 MVA (summer/winter), and
- no n-1 security (given there is only one supplying circuit).

Peak load in the Hinuera area is forecast to be 49 MW in 2015, increasing to 55 MW in 2030.

Solution

Powerco is planning to increase transmission security to Hinuera’s load with a new grid exit point near Putaruru (connected to the existing 110 kV Arapuni–Kinleith–2 circuit). Land will need to be acquired for the new grid exit point.

For the outage of the Hinuera–Karapiro circuit, the load can be secured by backfeeding within the local lines distribution system from Putaruru or Piako. Future investment will be customer driven.

9.8.11 Kinleith 110/33 kV supply security, supply transformer capacity and low voltage

Project description:	Replace supply transformer
Project status/type:	Possible, customer-specific
Indicative timing:	2016
Indicative cost band:	A

Issue

Two 110/33 kV transformers (rated at 20 MVA and 30 MVA) supply Kinleith’s 33 kV load, providing:

- a total nominal installed capacity of 50 MVA, and
- switched n-1 capacity of 24/25 MVA (summer/winter).

The supply transformers cannot be connected to the 33 kV bus at the same time, due to different vector groups. The load is normally supplied by the 30 MVA transformer, and there is a loss of supply when transferring load between the two transformers.

The peak 33 kV load at Kinleith is forecast to exceed the 20 MVA transformer’s installed capacity by approximately 1 MW in 2015, increasing to approximately 3 MW in 2030 (see Table 9-11).

Table 9-11: Kinleith 33 kV supply transformer overload forecast

Circuits/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Kinleith 33 kV	0.98	1	1	2	2	2	2	2	2	3	3	3

The Kinleith 33 kV bus has low voltages for some system conditions partially because the transformer has no on-load tap changer.

Solution

We are discussing options with Powerco and Carter Holt Harvey. One possible option is to replace the 20 MVA transformer with a 40 MVA transformer. In addition, the 30 MVA transformer is approaching its expected end-of-life within the next five years. The appropriate rating and vector group for the replacement transformer will also be considered, in conjunction with the replacement work. The replacement transformer will have an on-load tap changer, which will address the low voltage issue. Any future transformer upgrade will be customer driven.

9.8.12 Kinleith 110/11 kV supply security

Project status/type:	This issue is for information only
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Issue

Four 110/11 kV supply transformers supply the Carter Holt Harvey pulp and paper mill. Each transformer normally supplies a separate 11 kV bus section to limit the fault level to the mill. Therefore, the 11 kV loads do not have no-break transformer

security for fault outages, but three of the four supply transformers have no-break security for planned outages.

Solution

The lack of n-1 security will be managed operationally.

The 11 kV switchboard and three of the four supply transformers will reach their expected end-of-life within the next five years. We are discussing replacement options, and possible options to resolve the lack of n-1 security with Powerco and Carter Holt Harvey (see Section 9.10.5 for more information).

9.8.13 Kopu supply transformer capacity

Project description:	Resolve protection limits Upgrade transformer capacity
Project status/type:	Resolve protection limits: possible, Base Capex Upgrade transformer capacity: to be advised
Indicative timing:	Resolve protection limits: 2022 Upgrade transformer capacity: 2025-2030
Indicative cost band:	Resolve protection limits: A Upgrade transformer capacity: B

Issue

Two 110/66 kV transformers supply Kopu's load, providing:

- a total nominal installed capacity of 120 MVA, and
- n-1 capacity of 59/59⁸¹ MVA (summer/winter).

The peak load at Kopu is forecast to exceed the transformers' n-1 capacity by approximately 2 MW in 2022, increasing to 8 MW by 2030 (see Table 9-12).

Table 9-12: Kopu supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Kopu	1.00	0	0	0	0	0	0	2	3	5	7	8

Solution

Resolving the protection limit will increase the transformers' n 1 capacity to 64/67 MVA (summer/winter). Following the protection upgrade, the peak load at Kopu is forecast to exceed the transformers' n 1 winter capacity by approximately 1 MW in 2030 and we will discuss options to increase the supply transformers' n-1 capacity with Powerco closer to this time. Alternatives may include:

- replacing the existing transformers with higher capacity units, or
- converting some 66 kV feeders to 110 kV operation.

Future investment will be customer driven.

9.8.14 Maraetai–Whakamaru transmission capacity

Project status/type:	This issue is for information only
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⁸¹ The transformers' n 1 capacity is limited by protection limits; with these limits resolved, the n-1 capacity will be 64/67 MVA (summer/winter).

Issue

The 220 kV Maraetai–Whakamaru–1 and 2 circuits are each rated at 202/246 MVA (summer/winter). These circuits carry the combined 411 MW output from the Waipapa and Maraetai generation stations to Whakamaru.

An outage of one of the Maraetai–Whakamaru circuits restricts generation to approximately 50% of full capacity in summer and 60% of full capacity in winter.

Solution

In case of a contingency, a generation runback scheme is in place to reduce generation to the available capacity of the remaining circuit. This situation has been considered satisfactory since the generation was first installed, and there are no plans to make transmission network changes at this stage.

9.8.15 Te Awamutu supply transformer capacity

Project description:	Resolve protection limit
Project status/type:	Possible, Base Capex
Indicative timing:	2020
Indicative cost band:	A

Issue

Two 110/11 kV transformers supply Te Awamutu’s load, providing:

- a total nominal installed capacity of 80 MVA, and
- n-1 capacity of 41/41 MVA⁸² (summer/winter).

The peak load at Te Awamutu is forecast to exceed the transformers’ n-1 capacity by approximately 1 MW in 2020, increasing to approximately 3 MW in 2030 (see Table 9-13).

Table 9-13: Te Awamutu supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Te Awamutu	0.99	0	0	0	0	0	1	1	1	2	2	2

Solution

Resolving the protection limit will increase the transformers’ n-1 capacity to 52/54 MVA (summer/winter) which will provide sufficient n-1 capacity to meet the load growth within the forecast period.

Future investment will be customer driven.

9.8.16 Te Awamutu transmission security

Project description:	New Hangatiki–Te Awamutu circuit
Project status/type:	Committed, customer-specific
Indicative timing:	2016
Indicative cost band:	D

Issue

A single 110 kV circuit from Karapiro supplies Te Awamutu’s load, providing:

⁸² The transformers’ capacity is limited by protection equipment; with this limit resolved, the n-1 capacity will be 52/54 MVA (summer/winter).

- a capacity of 63/77 MVA (summer/winter), and
- no n-1 security (given there is only one supplying circuit).

Te Awamutu's peak load is forecast to be 39 MW in 2015, increasing to 42 MW in 2030.

Solution

Waipa Networks has committed to constructing a new 110 kV circuit from Hangatiki to Te Awamutu (to be operated by Transpower) to provide n-1 security. For commercial reasons, Waipa Networks may require the new Hangatiki–Te Awamutu circuit to be operated normally open, and put into service only for an outage of the Karapiro–Te Awamutu circuit. If so, there will be no loss of supply for planned outages of the Karapiro–Te Awamutu circuit but there will be a loss of supply following a fault on the circuit.

9.8.17 Waihou supply transformer capacity

Project description:	Replace supply transformer
Project status/type:	Possible, Base Capex
Indicative timing:	2020-2024
Indicative cost band:	B

Issue

Three 110/33 kV transformers supply Waihou's load, providing:

- a total nominal installed capacity of 60 MVA, and
- n-1 capacity of 48/51 MVA (summer/winter).

The issues at Waihou involve the following:

- the peak load at Waihou is forecast to exceed the transformers' n-1 winter capacity by approximately 4 MW in 2015, increasing to approximately 16 MW in 2030 (see Table 9-15).
- an outage of a supply transformer will cause the supply bus voltage to fall below 0.95 pu from 2015⁸³.

Table 9-14: Waihou supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Waihou	0.99	4	5	6	7	7	8	10	11	13	14	16

Solution

Following a supply transformer contingency (for example, a unit failure), restoration of full capacity can be achieved by:

- shifting load to other grid exit points, and
- swapping a transformer unit with an on-site spare unit.

These supply transformers have an expected end-of-life within the next 10 years. We will discuss with Powerco the appropriate rating, timing, and number of replacement transformers. In addition, we will convert the 33 kV outdoor switchyard to an indoor switchboard within the next five years. Future investment will be customer driven.

⁸³ This is due to the Waihou supply transformers not having on-load tap changers.

9.8.18 Waikino supply transformer capacity

Project description:	Replace supply transformer
Project status/type:	Possible, Base Capex
Indicative timing:	2020-2022
Indicative cost band:	B

Issue

Two 110/33 kV transformers supply Waikino’s load, providing:

- a total nominal installed capacity of 60 MVA, and
- n-1 capacity of 37/39 MVA (summer/winter).

The peak load at Waikino is forecast to exceed the transformers’ n-1 winter capacity by approximately 1 MW in 2015, increasing to approximately 10 MW in 2030 (see Table 9-15).

Table 9-15: Waikino supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						6-15 years out				
		2015	2016	2017	2018	2019	2020	2022	2024	2026	2028	2030
Waikino	1.00	1	1	2	2	3	3	5	6	7	8	10

Solution

In the short-term, operational measures can be used to manage this issue. We will discuss with Powerco the options to increase the supply transformers’ n-1 capacity.

In addition, the existing supply transformers at Waikino will approach their expected end-of-life within the next 10 years, and conversion of the existing 33 kV outdoor switchyard to an indoor switchboard is planned for around the same time.

9.9 Waikato bus security

This section presents issues arising from the outage of a single bus section rated at 50 kV and above for the next 15 years.

Bus outages disconnect more than one power system component (for example, other circuits, transformers, reactive support or generators). Therefore, bus outages may cause greater issues than a single circuit or transformer outage (although the risk of a bus fault is low, being less common than a circuit or transformer outage).

9.9.1 Transmission bus security

Table 9-16 lists bus outages that cause voltage issues or a total loss of supply. Generators are included only if a bus outage disconnects the whole generation station or causes a widespread system impact. Supply bus outages, typically 11 kV and 33 kV, are not listed.

Table 9-16: Transmission bus outages

Transmission bus outage	Loss of supply	Generation disconnection	Transmission issue	Further information
Arapuni North 110 kV	Hangatiki	-	-	9.9.3
Atiamuri 220 kV	-	Atiamuri	-	See note 1
Bombay 110 kV	Bombay 33 kV	-	Bombay–Hamilton	See note 2 9.9.4

				overloading	
Hamilton 220 kV	Hamilton 55 kV		-	Hamilton 220/33 kV supply transformer capacity Hamilton low voltage	See note 3 See note 4
Hangatiki 110 kV	Hangatiki		-		See note 5
Hinuera 110 kV	Hinuera		-		9.8.10
Karapiro 110 kV	Hinuera Te Awamutu Cambridge	Karapiro	-		See note 6
Kinleith 110 kV	Kinleith – Carter Holt Harvey Kinleith – Powerco	Kinleith	-		9.9.2
Ohakuri 220 kV	Ohakuri		-		See note 5
Maraetai 220 kV	Maraetai Waipapa		-		See note 7
Te Awamutu 110 kV	Te Awamutu		-		9.8.16
Whakamaru 220 kV	Mokai		-	Maraetai–Whakamaru overloading	See note 8 See note 9
Waihou 110 kV	Kopu Waihou Waikino	-	-		See note 10
Waikino 110 kV	Kopu Waikino	-	-		See note 11

- All the generators at Atiamuri are connected to the 220 kV same bus section.
- Both Bombay 110/33 kV supply transformers are connected to the same 110 kV bus section.
- A bus section outage will disconnect a 220/33 kV supply transformers at Hamilton, which will cause the other supply transformer to overload (see Section 9.8.7).
- A bus section outage that disconnects the Hamilton–Ohinewai circuit will cause low voltages (see Section 9.10.3).
- There is no bus protection at Hangatiki or Ohakuri, so a bus fault removes all circuits from service causing loss of supply.
- There is no bus zone protection at Karapiro. Therefore, a bus fault at Karapiro disconnects the Cambridge spur at the Hamilton 110 kV bus. This causes a loss of connection to Karapiro generation and a loss of supply to Cambridge, Hinuera, and Te Awamutu. See Section 9.8.10 for improving transmission security to Hinuera and Section 9.8.16 for improving transmission security to Te Awamutu.
- There is a single circuit between Waipapa and Maraetai. A bus outage at Maraetai disconnects the circuit and therefore Waipapa generation station.
- Mokai generation station and Mighty River Power's G4 generator at Whakamaru are connected to the grid through a common circuit breaker. A bus section outage at Whakamaru can, therefore, disconnect Mokai generation station (as well as Whakamaru G4).
- A bus section outage will disconnect a Maraetai–Whakamaru circuit, which will cause the other circuit to overload during high generation at Maraetai and Waipapa (see Section 9.8.14).
- There is a single 110 kV bus zone protection at Waihou. Therefore, a bus fault will trip all connected circuits and transformers, causing a loss of supply at Waihou, Waikino and Kopu.
- A 110 kV bus fault at Waikino will cause both Waihou–Waikino circuits to trip. This will cause a total loss of supply to Waikino and Kopu.

We have begun preliminary investigations for Mighty River Power to improve bus security at Maraetai. The other customers (KiwiRail, The Lines Company, Powerco, Waipa Networks and WEL Networks) have not requested a higher security level. Unless otherwise noted, we do not propose to increase bus security and future investment is likely to be customer driven.

If increased bus security is required, the options typically include bus reconfiguration and/or additional bus circuit breakers.

9.9.2 Kinleith 110 kV bus security

Project status/type: This issue is for information only

Issue

There are two 110 kV bus sections at Kinleith.

An outage of one Kinleith 110 kV bus section disconnects the:

- 110 kV Arapuni–Kinleith–1 and 2 circuits
- 110/33 kV Kinleith–T4 supply transformer, and
- 110/11 kV Kinleith–T3 supply transformer.

This bus outage results in a loss of supply to Powerco and Carter Holt Harvey. If the Arapuni bus split is open there will be a loss of connection for the Mighty River Power generation connected to the Arapuni south bus. Depending on the generation at Kinleith, this outage may also result in low voltage on the remaining Kinleith 110 kV supply buses.

An outage of the remaining Kinleith 110 kV bus section disconnects the:

- 110 kV Kinleith–Lichfield–1 and 2 circuits
- 110/11 kV Kinleith–T1 supply transformer
- 110/11 kV Kinleith–T2 supply transformer, and
- 110/33/11 kV Kinleith–T5 supply transformer.

This bus outage will result in a loss of supply and generation connection at Kinleith. If the Arapuni bus split is open, the Mighty River Power generation connected to the Arapuni south bus and the remaining Kinleith load will be operating as an island, which is unlikely to be sustainable. A loss of connection for Mighty River Power and a loss of supply for Powerco and Carter Holt Harvey will be required before normal operation can resume.

Solution

We are discussing options with Powerco and Carter Holt Harvey to determine if it is economic to resolve the issue. The options will be considered in conjunction with addressing the Kinleith 110/33 kV supply transformer security and capacity issue (see Section 9.8.11) and the Kinleith 110/11 kV supply transformer supply security (see Section 9.8.12).

9.9.3 Hangatiki supply security

Project status/type: This issue is for information only

Issue

Two 110 kV circuits supply Hangatiki's load (Arapuni–Hangatiki and Arapuni–Hangatiki–Ongarue) and connect to the same north bus section at Arapuni.

A fault on the north bus will cause a voltage collapse and subsequent loss of supply at Hangatiki.

Solution

The issue can be resolved by closing the Arapuni bus split which can be reconfigured so the two circuits from Hangatiki connect to separate bus sections (see Section 9.10.1 for more information).

9.9.4 Bombay–Hamilton 110 kV transmission capacity

Project status/type: This issue is for information only

Issue

There are three 110 kV circuits connecting the Waikato and Auckland regions:

- Two Bombay–Hamilton circuits each rated at 51/62 MVA (summer/winter).
- One Arapuni–Bombay circuit rated at 51/62 MVA (summer/winter).

A Bombay 110 kV bus section outage that disconnects the Bombay–Hamilton–2, Bombay–Otahuhu–2, and Arapuni–Bombay–1 circuits may overload the Bombay–Hamilton–1 circuit from around 2022 for:

- high Auckland load
- low Huntly and Auckland area generation, and
- high Waikato generation.

Solution

We anticipate this issue will be managed operationally with generation rescheduling and load management.

Additionally, we are investigating options to supply future load growth at Bombay. Some of these options may alleviate or resolve the capacity issues (see Chapter 8, Section 8.8.2).

9.10 Other regional items of interest

9.10.1 Transmission constraints between Hamilton and Tarukenga

Issue

The 110 kV circuits between Hamilton and Tarukenga connect local Waikato load and generation. They are also in parallel with the 220 kV network to transfer power between the Waikato and Auckland, Bay of Plenty and Central North Island. The 110 kV circuits are low capacity compared with the local load, generation and parallel 220 kV network which results in constraints in the Waikato region.

Issues that are associated with this area include:

- Arapuni–Hamilton 110 kV transmission capacity, where the Arapuni–Hamilton circuits may overload during periods of high Arapuni generation resulting in pre-contingency limitations on Arapuni generation, (see Section 9.8.1 for more information)
- Arapuni 110 kV bus security, where Hangatiki and Kinleith loads are exposed to a loss of supply for an Arapuni bus fault, due to the configuration required to enable the Arapuni bus split (see Section 9.9.3 for more information)
- Arapuni–Kinleith 110 kV transmission capacity, where the Arapuni–Kinleith circuits may overload for high Arapuni generation (see Section 9.8.2 for more information)
- Kinleith–Tarukenga transmission capacity, where the Kinleith–Tarukenga circuits may overload during periods of low Arapuni or Kinleith generation (see Section 9.8.2 for more information)

- Kinleith low voltage, where there is no on-load tap changer on the Kinleith 110/33 kV supply transformer, enabling the Kinleith 33 kV bus voltage to fall below 0.95 pu for certain contingencies (see Section 9.8.11 for more information), and
- Kinleith 110 kV bus security, where a 110 kV bus outage at Kinleith results in a loss of supply to some of the load supplied from Kinleith (see Section 9.9.2 for more information)

Solution

The following projects are committed or proposed:

- Putaruru new grid exit point proposed for 2018, which will increase the load south of Arapuni, reducing constraints on Arapuni–Hamilton but increasing power flows on Arapuni–Kinleith adding to Kinleith low voltage issues (see Section 9.8.11 for more information)
- Kinleith substation redevelopment. We are in discussions with Powerco and Carter Holt Harvey. We will install on-load tap changers at Kinleith, improving Kinleith low voltage issues (see Section 9.10.5 for more information)
- Hangatiki–Te Awamutu 110 kV circuit. Waipa Networks plan to commission this circuit in 2016. When in service, the circuit will provide a parallel path to the Arapuni–Hamilton circuit which reduces but does not eliminate constraints on Arapuni generation (see Section 9.8.16 for more information)
- Brownhill–Whakamaru series compensation. We will investigate this proposal within the next few years. The series capacitors will reduce the 220 kV impedance path to Auckland reducing power flows in the 110 kV network (see Chapter 6, Section 6.4.3 for more information).

These projects will resolve or relieve some of the transmission issues but we still anticipate major transmission capacity issues between Hamilton and Tarukenga when the new Lichfield loads and Putaruru grid exit points are connected.

We are investigating a range of interim solutions to manage the transmission constraints between Arapuni and Tarukenga. The options include some or all of the following:

- Keep the Arapuni bus split and apply variable line ratings on the Kinleith–Tarukenga–Lichfield circuits to ease limits on generation.
- Keep the Arapuni bus split and modifying the existing Arapuni–Kinleith special protection scheme to a second Arapuni generation runback scheme to allow more generation on the Arapuni north bus pre-contingency.
- Install a special protection scheme at Tarukenga to manage load at Putaruru, Lichfield and/or Kinleith post-contingency.

We are also investigating possible alternative interim options.

We will investigate a range of longer-term options to resolve the capacity issues between Arapuni and Tarukenga (see Section 9.8.2).

Economic analysis indicates that it will not be economic to upgrade the 110 kV circuits until the conductor requires replacement based on a condition assessment.

9.10.2 Cambridge spur capacity

Project status/type: This issue is for information only

Issue

The Cambridge Spur connects three loads (at Cambridge, Te Awamutu, and Hinuera) and generation at Karapiro. Two 110 kV Hamilton–Cambridge circuits supply the spur, each with a capacity of 57/70 MVA (summer/winter).

The combined peak load on the spur is forecast to remain at approximately 108 MW for the next 2-3 years, decrease to 95 MW in 2018⁸⁴, and increase to 108 MW by the end of the forecast period. Generation from Karapiro is used to avoid exceeding the n-1 capacity of the Hamilton–Cambridge circuits, especially in summer. The minimum generation required for the forecast period is approximately 30-45 MW.

Solution

Generation from Karapiro will manage the loading on the Hamilton–Cambridge circuits for the forecast period. Karapiro has an installed capacity of 90 MW and typically generates 40 MW during low load periods and 80- 90 MW during peaks.

The proposed Hangatiki–Te Awamutu 110 kV circuit (see Section 9.8.16) may increase or decrease the loading on the spur, depending on the generation and load over a wide part of the power system.

We will continue to monitor the loading on the spur to determine when an issue may arise. Mitigation measures may include reconfiguring the grid or load control when there is an overload, or increasing the capacity of the Hamilton–Cambridge circuits. We will work with the parties connected to the Cambridge spur (Waipa Networks, Mighty River Power and Powerco) to determine a long-term solution.

9.10.3 Hamilton low voltage

Project status/type: This issue is for information only

Issue

During periods of high load and low Waikato 110 kV generation, the Hamilton 220 kV bus will have low voltage (below 0.90 pu) towards the end of the forecast period for the outage of the 220 kV Hamilton–Ohinewai circuit.

Solution

We will investigate options to resolve this issue closer to the time it occurs. Some include:

- reactive support in the Waikato 110 kV transmission network, and
- a third 220 kV connection to Hamilton (see Section 9.10.4).

9.10.4 Hamilton transmission security during maintenance

Project status/type: This issue is for information only

Issue

When a 220 kV Hamilton–Whakamaru circuit, a 220 kV Hamilton–Ohinewai circuit or a Hamilton 220/110 kV transformer is out for maintenance, the Waikato 110 kV system is split so it does not form a parallel connection with the 220 kV system. This places a considerable part of the Waikato region on n security⁸⁵.

⁸⁴ The reduced load forecast is due to load shifting from Hinuera to the new Putaruru grid exit point.

⁸⁵ The load on n security is the Valley Spur (Piako, Waihou, Waikino, and Kopu), the Cambridge spur (Cambridge, Karapiro, Hinuera and Te Awamutu), Bombay (depending on system conditions), and Hamilton (for 220 kV circuit outages only).

Solution

We will investigate if it is economic to provide full or partial n-1 security during maintenance. It is expected this investigation will begin in 2-5 years, after development options are addressed for other issues such as the:

- supply to Wiri (see Chapter 8, Section 8.8.3)
- Te Awamutu transmission security (see Section 9.8.16), and
- Arapuni bus security (see Section 9.10.1).

Options include a:

- third 220 kV circuit into Hamilton, and/or
- third 220/110 kV transformer at Hamilton, or
- 250 MVA 220/110 kV transformer at a new substation, connected to the intersection of the 220 kV Otahuhu–Whakamaru–C line and the 110 kV Hamilton–Waihou–A line.

9.10.5 Kinleith substation developments

Project status/type:	This issue is for information only
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Issue

Kinleith substation supplies Powerco and Carter Holt Harvey via:

- two low capacity 110 kV circuits from Bay of Plenty (Kinleith–Lichfield–Tarukenga)
- two low capacity 110 kV circuits from the Waikato region (Arapuni–Kinleith)
- three 110/11 kV supply transformers connected to individual 11 kV buses with no automatic post-contingency load shift
- one 110/33/11 kV supply transformer with the 33 kV circuit breaker normally open, connecting a single large industrial machine and a 42 MW generator, and
- one 110/33 kV supply transformer supplying the Powerco distribution network in the Tokoroa area with n security and no on-load tap changers.

The transmission system is normally split at Arapuni to reduce constraints on generation. This system split requires minimum generation at Arapuni to maintain n-1 security to the Kinleith load.

The system split is occasionally shifted to Kinleith to manage outages, either by opening the Kinleith bus section circuit breaker or the two Kinleith–Lichfield circuits at Kinleith. This configuration causes reduced security of supply for Kinleith.

The following issues exist at Kinleith:

- Kinleith–Tarukenga 110 kV transmission capacity limit (see Section 9.8.2 for more information).
- Kinleith 110/11 kV supply transformer security (see Section 9.8.12 for more information).
- Kinleith 110/33 kV supply transformer capacity (see Section 9.8.11 for more information).
- Kinleith 33 kV low voltage (see Section 9.8.11 for more information).

In addition, the supply transformers at Kinleith are reaching their expected end-of-life within the forecast period.

Solution

We are working with Powerco and Carter Holt Harvey to develop a long-term solution to supply Kinleith. This investigation is weighing security, fault level, cost, and constructability limitations.

9.11 Waikato generation proposals and opportunities

This section details relevant regional issues for selected generation proposals under investigation by developers and in the public domain, or other generation opportunities. The impact of committed generation projects on the grid backbone is dealt with separately in Chapter 6.

The maximum generation that can be connected depends on several factors and usually falls within a range. Generation developers should consult with us at an early stage of their investigations to discuss connection issues.

9.11.1 Huntly area generation

There are prospects to connect up to 540 MW to the 220 kV double-circuit transmission line between Huntly and Drury.

The existing grid will be able to cater for this level of prospective generation. We will need to reassess this if the prospective generation is significantly higher.

9.11.2 Hangatiki generation

There are prospects to connect up to approximately 40 MW of generation at Hangatiki. This generation will worsen the overloading issue on the 110 kV Arapuni–Hamilton circuits (see Section 9.8.1 for more information).

To prevent the overloading of these circuits under a wide range of load and generation scenarios, the following upgrades will be required:

- Runback schemes at Arapuni and/or Hangatiki
- Reconductoring the 110 kV Arapuni–Hamilton circuits

In addition, any new generation on the 110 kV transmission network in the Waikato region will add to the 110 kV Arapuni–Kinleith and 110 kV Bombay–Hamilton loading (see Section 9.8.2 and 9.9.4 respectively). Options to enable this level of generation include generation runback schemes, generation re-scheduling, and possibly reconductoring the Bombay–Hamilton circuit. Possible overloading of the two 110 kV Arapuni–Kinleith circuits may need to be addressed, but this may be required irrespective of additional generation at Hangatiki.