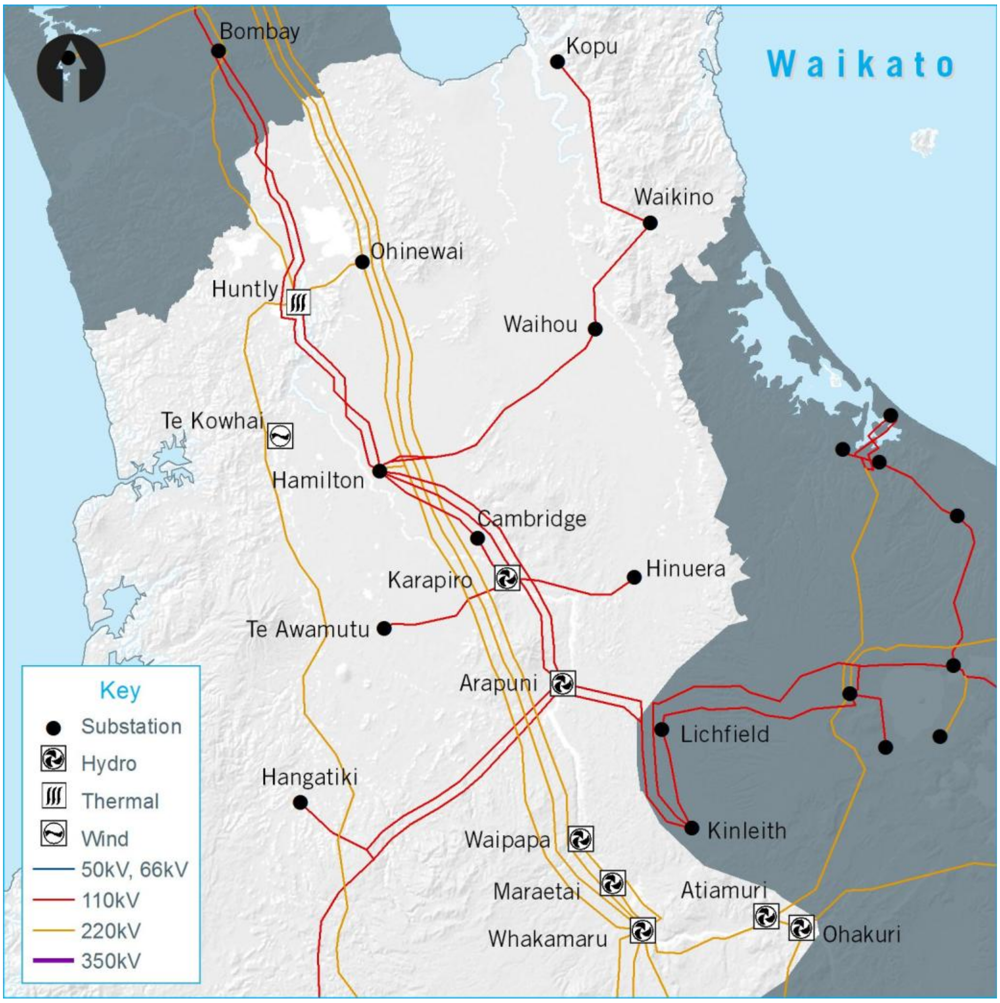
9 Waikato Regional Plan

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 Kinleith to Arapuni, 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.

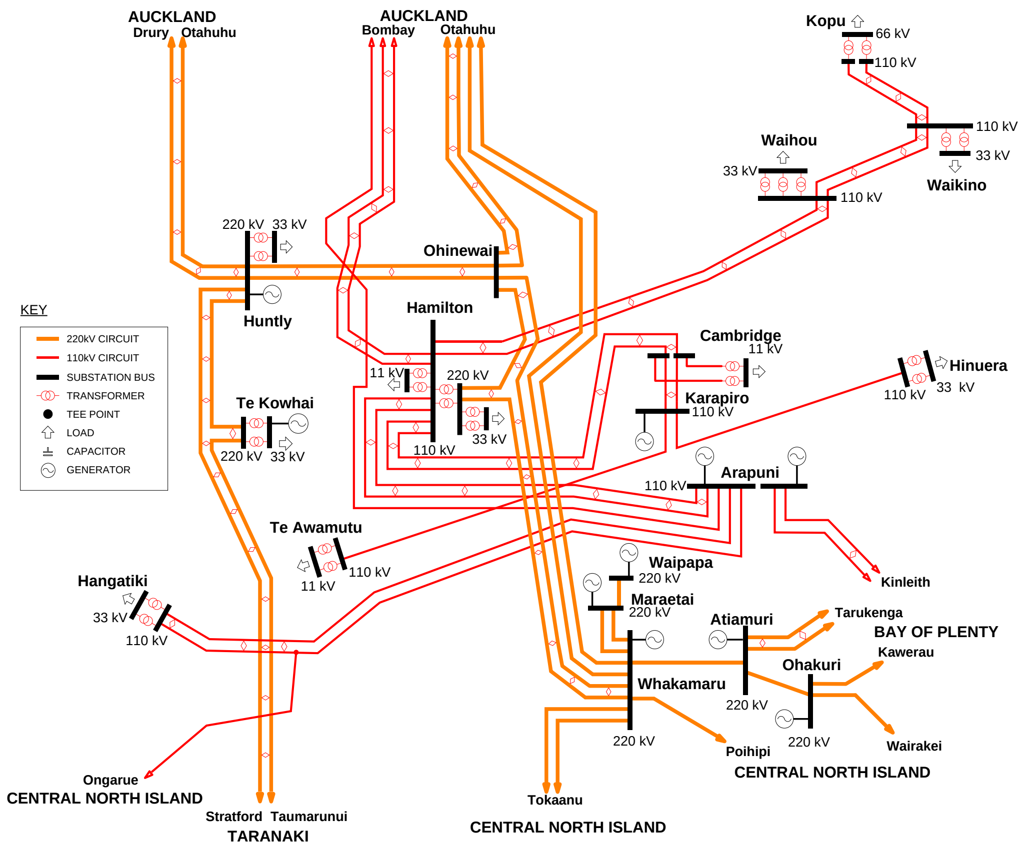
We have assessed the Waikato region's transmission needs over the next 15 years while considering longer-term development opportunities. Specifically, the transmission network needs to be flexible to respond to a range of future service and technology possibilities, taking into consideration:

- 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 contributes a significant portion of the 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.

The committed 400 kV-capable transmission line[58] between Whakamaru and Pakuranga (Auckland) will reduce loading on the 220 kV and 110 kV circuits within the Waikato region.

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. This results in capacity and supply security issues for some outages. It also results in generation restrictions, particularly at Arapuni, even with all circuits in service. We have a number of investigations planned or underway to address these issues.

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 are presently working on a Waikato regional development strategy. This project focuses on resolving 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, 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. This may involve converting parts of the Thames Valley spur to 220 kV.

The following are possible developments in the grid backbone 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 1.8% annually over the next 15 years, from 511 MW in 2012 to

58 Part of the North Island Grid Upgrade (NIGU) project, see Chapter 6 for more information.

668 MW by 2027. This is higher than the national average demand growth of 1.7% annually.

Figure 9-3 shows a comparison of the 2011 and 2012 forecast 15-year maximum demand (after diversity[59]) 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, and is used to calculate the real power capacity for power transformer and transmission line. See Chapter 4 for more information about demand forecasting.

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

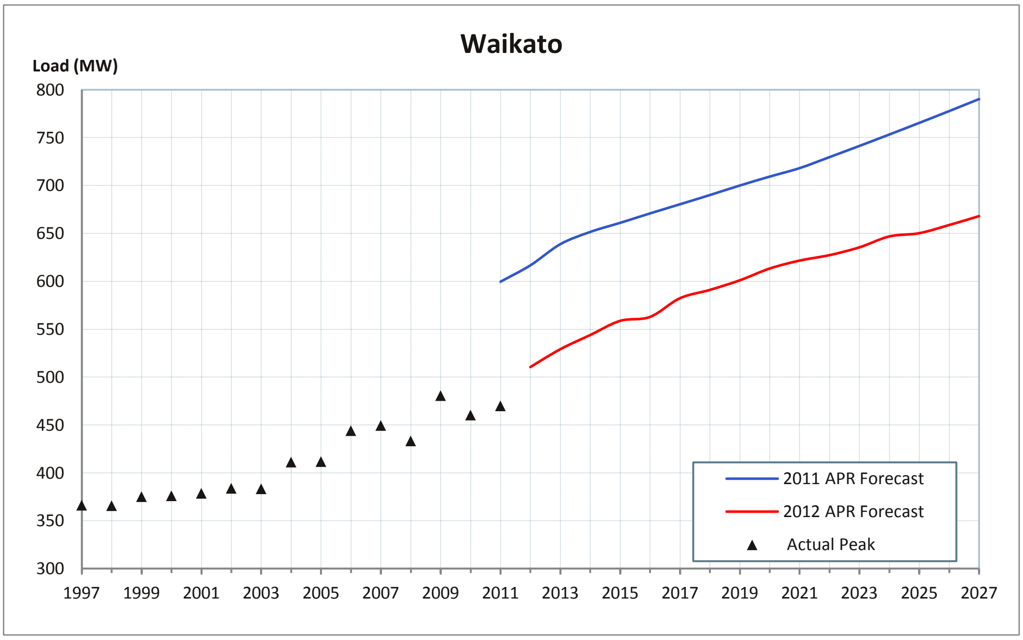


Table 9-1 lists forecasts peak demand (prudent growth) for each grid exit point for the forecast period, as required for the Grid Reliability Report.

Table 9-1: Forecast annual peak demand (MW) at Waikato grid exit points to 2027

Grid exit point	Power factor	Peak demand (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Cambridge[1]	0.98	38	39	39	40	40	41	42	43	45	46	47
Hamilton 11 kV	1.00	47	48	49	25	0	0	0	0	0	0	0
Hamilton 33 kV[2]	0.99	148	151	154	182	212	216	225	234	241	249	256
Hamilton NZR	0.80	8	8	8	8	8	8	8	8	8	8	8
Hangatiki	0.88	30	31	31	32	33	33	35	36	37	38	39
Hinuera[3]	0.95	47	48	42	43	44	45	47	49	51	52	54
Huntly[4]	0.99	25	25	26	26	42	43	44	45	47	48	49
Kopu	-0.99	50	52	53	55	56	58	62	65	67	70	72
Piako[5]	0.98	0	28	28	29	30	31	33	35	36	38	39
Putaruru[3]	0.95	0	0	7	8	8	8	8	9	9	9	10
Te Kowhai[2]	0.97	105	110	112	117	120	122	127	131	135	139	141
Te Awamutu[1]	0.98	37	37	38	39	39	40	41	43	44	46	48

59 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						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Waihou[5]	0.96	67	41	43	44	45	47	49	52	54	56	58
Waikino	1.00	41	42	44	45	46	48	50	53	55	57	59
Whakamaru	1.00	11	11	11	11	12	12	12	13	13	14	14

1. The customer provided this forecast.
2. The forecast is distorted by frequent and regular load shifting between Hamilton and Te Kowhai.
3. Some load will be shifted from Hinuera to a proposed new grid exit point at Putaruru in 2014.
4. An industrial load increase of 5 MW is expected at Huntly in 2012.
5. Some load will be shifted from Waihou to a new grid exit point at Piako.

9.4 Waikato generation

The Waikato region's generation capacity is 2,662 MW.

Table 9-2 lists the generation forecast for each grid injection point for the forecast period, as required for the Grid Reliability Report. 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).[60]

Table 9-2: Forecast annual generation capacity (MW) at Waikato grid injection points to 2027 (including existing and committed generation)

Grid injection point (location if embedded)	Generation capacity (MW)										
	Next 5 years						5-15 years out				
	2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Arapuni	197	197	197	197	197	197	197	197	197	197	197
Atiamuri	84	84	84	84	84	84	84	84	84	84	84
Huntly	1448	1448	1448	1448	1448	1448	1448	1448	1448	1448	1448
Karapiro	90	90	90	90	90	90	90	90	90	90	90
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 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
Waipapa	51	51	51	51	51	51	51	51	51	51	51
Whakamaru	100	100	100	100	100	100	100	100	100	100	100

9.5 Waikato significant maintenance work

Our capital project 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 work[61] proposed for the Waikato region for the next 15 years that may significantly impact related system issues or connected parties.

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

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

Table 9-3: Proposed significant maintenance work

Description	Tentative year	Related system issues
Cambridge 11 kV switchgear replacement	2013	Upgrading the 11 kV switchgear will improve the Cambridge supply transformer n-1 capacity issue. See Section 9.8.6 for more information.
Hamilton T5 supply transformer expected end-of-life	2022-2024	A significant increase in supply transformer capacity is required within the forecast period. Increasing the capacity of T5 will reduce the transformer overload. See Section 9.8.7 for more information.
Hangatiki T1 and T2 supply transformers' expected end-of-life	2013-2015	Upgrading the transformers' capacity is one of the possible options to resolve the transformer overload issue. See Section 9.8.8 for more information.
Hinuera T1 and T2 supply transformers' expected end-of-life	2022-2029	Upgrading the capacity of T1 is one of the possible options (following construction of Putaruru) to resolve the transformer loading issue. See Section 9.8.9 for more information.
Waihou supply transformers' expected end-of-life, 33 kV outdoor to indoor conversion, and 110 kV substation rebuild	2022-2027 2013-2015	Upgrading the transformers' capacity is one of the possible options (following construction of Piako) to resolve the transformer overloading issue. See Section 9.8.15 for more information. The replacement transformer with on-load tap changing capability will improve the voltage profile at Waihou. See Section 9.8.5 for more information.
Waikino supply transformers' expected end-of-life, and 33 kV outdoor to indoor conversion	2018-2022	Upgrading the transformers' capacity is one of the possible options to resolve transformer overloading issue. See Section 9.8.16 for more information. The replacement transformer with on-load tap changing capability will improve the voltage profile at Waikino. See Section 9.8.5 for more information.

9.6 Future Waikato projects summary and transmission configuration

Table 9-4 lists projects to be carried out in the Waikato region within the next 15 years.

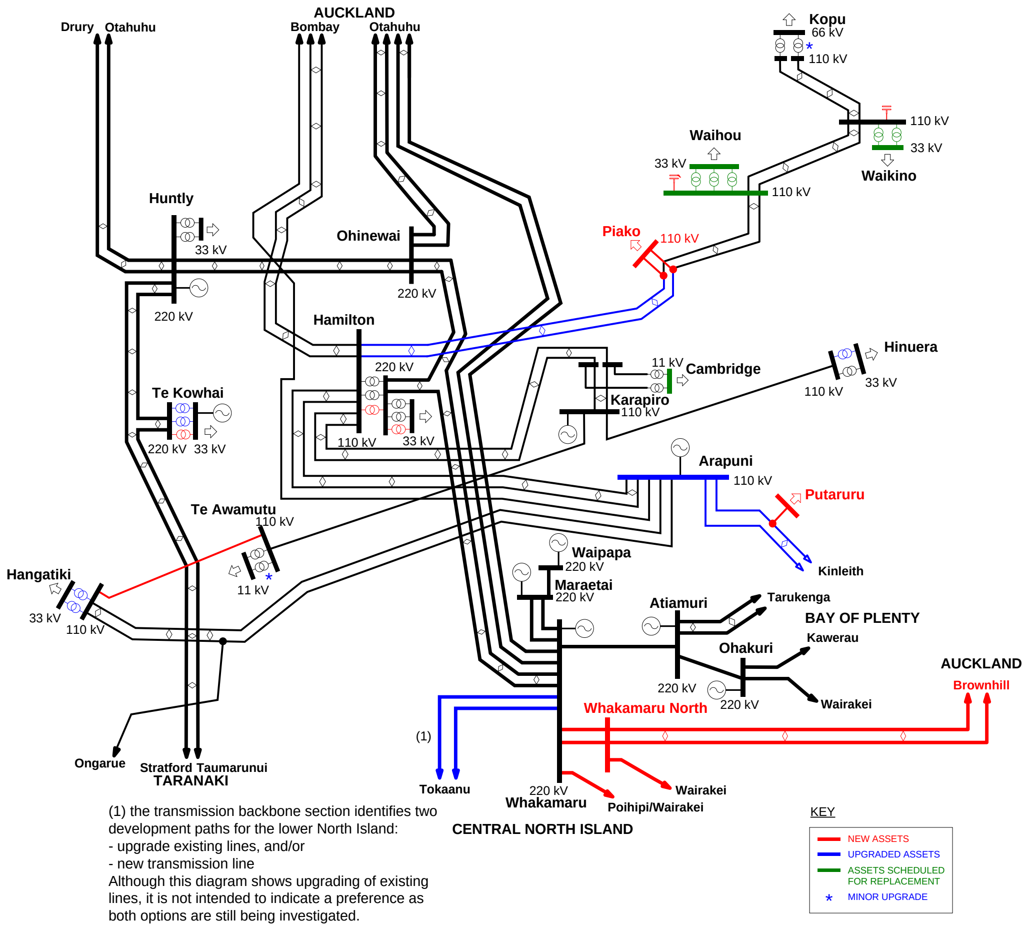
Figure 9-4 shows the possible configuration of Waikato transmission in 2027, with new assets, upgraded assets, and assets undergoing significant maintenance within the forecast period.

Table 9-4: Projects in the Waikato region up to 2027

Site	Projects	Status
Arapuni	Reconfigure 110 kV bus.	Committed
Arapuni–Kinleith	Increase the line capacity by reconductoring/thermal upgrading.	Possible
Cambridge	Replace 11 kV switchgear.	Committed
Hamilton	Install a new 220/110 kV interconnecting transformer. Install a new 220/33 kV supply transformer.	Possible Possible
Hamilton–Waihou	Increase the line capacity by building a new 110 kV Hamilton–Waihou circuit or upgrade 110 kV Hamilton–Waihou circuits.	Possible
Hangatiki	Replace 110/33 kV supply transformers	Base Capex
Hinuera	Upgrade the 110/33 kV 30 MVA supply transformer capacity.	Possible
Karapiro	Upgrade 110 kV switchyard.	Base Capex
Kopu	Resolve supply transformer protection limits.	Base Capex
Piako	New grid exit point.	Committed
Putaruru	New grid exit point.	Possible
Te Awamutu	New transmission circuit either from Hangatiki or Karapiro. Resolve supply transformer protection limits.	Possible Base Capex
Te Kowhai	Install radiators and fans on the existing supply transformers.	Committed

Site	Projects	Status
	Install a new 220/33 kV supply transformer.	Possible
Waihou	Rebuild 110 kV structure. Replace 110/33 kV supply transformers. Convert 33 kV outdoor switchgear to an indoor switchboard. Install new capacitors.	Base Capex Base Capex Base Capex Possible
Waikino	Install new capacitors. Replace supply transformers. Convert 33 kV outdoor switchgear to an indoor switchboard.	Possible Base Capex Base Capex

Figure 9-4: Possible Waikato transmission configuration in 2027



9.7 Changes since the 2011 Annual Planning Report

Table 9-5 lists the specific issues that are either new or no longer relevant within the forecast period when compared to last year's report.

Table 9-5: Changes since 2011

Issues	Change
Bombay–Hamilton and Arapuni–Bombay 110 kV transmission capacity	Issue removed. Loading on these circuits is managed with Arapuni constraints or a bus split.
Te Awamutu supply transformer capacity	New issue.

9.8 Waikato transmission capability

Table 9-6 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 9-6: Waikato regional transmission issues

Section number	Issue
Regional	
9.8.1	Arapuni–Hamilton 110 kV transmission capacity
9.8.2	Arapuni–Kinleith 110 kV transmission capacity
9.8.3	Hamilton interconnecting transformer capacity
9.8.4	Hamilton–Waihou 110 kV transmission capacity
9.8.5	Waihou–Waikino–Kopu spur low voltage
Site by grid exit point	
9.8.6	Cambridge supply transformer capacity
9.8.7	Hamilton 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	Kopu supply transformer capacity
9.8.12	Maraetai–Whakamaru transmission capacity
9.8.13	Te Awamutu supply transformer capacity
9.8.14	Te Awamutu transmission security
9.8.15	Waihou supply transformer capacity
9.8.16	Waikino supply transformer capacity

9.8.1 Arapuni–Hamilton 110 kV transmission capacity

Project status/purpose:	This issue is for information only

Issue

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

The 110 kV bus is currently permanently split with two bus sections:

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

Cost benefit analysis showed that it is economic to permanently split the bus until the new Pakuranga–Whakamaru line[62] is commissioned. This analysis will be revisited prior to the commissioning of the new line to decide the operational strategy in the future.

With the Arapuni bus split open:

[62] This is a new 220/400 kV double-circuit transmission line, and forms part of the North Island Grid Upgrade (NIGU) project.

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

With the Arapuni bus split closed, and following the commissioning of the Pakuranga–Whakamaru line:

- Arapuni generation may be constrained pre-contingency to manage the loading on the Arapuni–Hamilton circuits for an outage of the Arapuni–Hamilton or Hamilton–Whakamaru circuit.
- the Arapuni runback is enabled on Arapuni G1-4 to reduce generation if an Arapuni–Hamilton circuit overloads.

The worst case conditions are during:

- summer, when Huntly generation is sometimes restricted due to high river temperatures, and
- high hydro inflow periods, when renewable generation south of Whakamaru is dispatched ahead of thermal generation in the upper North Island.

Solution

The Arapuni bus split is currently implemented by connecting three 110 kV circuits directly to the 110 kV bus. This is not a long-term solution, as it restricts maintenance access to those circuits. An investigation is underway to determine a longer-term strategy for the Arapuni bus split.

A number of projects that are presently being implemented or considered as solutions to other issues will also relieve the loading on the 110 kV Arapuni–Hamilton circuits. These other projects include the NIGU project, the Tarukenga interconnecting transformer replacement and the new Putaruru grid exit point (see Section 9.8.10 for more information).

An investigation into longer-term options to resolve this issue is ongoing. However, a preliminary assessment of the Investment Test indicates that reconductoring the 110 kV circuits to remove the overload may not be economic. A condition assessment shows that the existing conductor will not require replacement within the forecast period.

9.8.2 Arapuni–Kinleith 110 kV transmission capacity

Project reference:	ARI_KIN-TRAN-EHMT-01
Project status/purpose:	Possible, to meet the Grid Reliability Standard (not core grid)
Indicative timing:	2020-2027
Indicative cost band:	A

Issue

There are two 110 kV Arapuni–Kinleith circuits (1 and 2), rated at 57/70 MVA and 63/77 MVA (summer/winter), respectively. There is a possibility of a new grid exit point (Putaruru) being single tee-connected part way along Arapuni–Kinleith circuit 2 in 2013[63] (see Section 9.8.10 for more information).

Loading on the 110 kV Arapuni–Kinleith circuits may exceed their n-1 capacity under certain operating conditions.

With the Arapuni bus split open, factors contributing to this overload include:

- the summer ratings period, and

[63] Putaruru load is expected to be approximately 7 MW from 2014.

- full generation from three Arapuni generation units connected to the south bus.

With the Arapuni bus split closed, factors contributing to this overload include:

- high net load at Kinleith (for example when Kinleith generation is off during high pulp and paper plant production periods)
- high generation at Arapuni
- high Huntly and Auckland-area generation, and
- high south power flow (for example, HVDC south power flow).

Additionally, the 110 kV circuits between Kinleith and Lichfield are often opened to prevent overloading during some outages in the Bay of Plenty region. The Kinleith load is then supplied by the two 110 kV Arapuni–Kinleith circuits and generation at Kinleith. For some system conditions the load at Kinleith may be on n security when the system is split.

Peak load at Kinleith is approximately 95 MW (offset by up to 40 MW of on-site generation) and is forecast to remain steady. The net Kinleith load rarely exceeds 75 MW. The typical daily peaks are between 55 MW and 65 MW.

Solution

In the short term, loading on Arapuni–Kinleith circuits is managed by:

- opening Arapuni bus split, and
- restricting Arapuni south bus generation during summer ratings.

Following the commissioning of the Pakuranga–Whakamaru double-circuit line and the new Putaruru grid exit point, the Arapuni bus split will be opened less frequently. In the medium term, possible options to relieve the loading on Arapuni–Kinleith during south power flow include:

- special protection schemes, or
- reconfiguration of the Kinleith 110 kV bus.

In the longer term, possible options to increase the capacity of the Arapuni–Kinleith circuits include:

- reconductoring Arapuni–Kinleith 1
- reconductoring the Arapuni–Putaruru line section, and
- thermally upgrading the Kinleith–Putaruru line section.

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

9.8.3 Hamilton interconnecting transformer capacity

Project reference:	HAM-POW_TFR-DEV-01
Project status/purpose:	Possible, to meet the Grid Reliability Standard (core grid)
Indicative timing:	2025
Indicative cost band:	New interconnecting transformer: B New substation: C

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 and Bay of Plenty 110 kV loads under certain load flow conditions. These transformers provide:

- a total nominal installed capacity of 420 MVA, and

- n-1 capacity of 243/243 MVA[64] (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, and
- after completion of the Tarukenga interconnecting transformer replacement project (see Chapter 10, Section 10.9.4).

Solution

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

However, with low upper North Island generation and/or higher load growth there may not be enough Waikato 110 kV generation to manage this issue towards the end of the forecast period.

Developments being considered or underway, such as the NIGU project, will reduce loading on the Hamilton interconnecting transformers. We are also discussing options for the long-term supply of Hamilton City with WEL Networks (see Section 9.8.7). If the existing 110/11 kV load at Hamilton is moved to the 33 kV bus, the loading on the Hamilton transformers will decrease.

Two of the options that Transpower is considering for upgrading the 220/110 kV Hamilton interconnecting transformers (when required) include a new 200 MVA transformer:

- in parallel with the existing transformers, or
- at a new substation, connected to the intersection of the 220 kV Otahuhu–Whakamaru 3 circuit and the 110 kV Hamilton–Waihou circuits.

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–Waihou 110 kV transmission capacity

Project reference:	HAM_WHU-TRAN-DEV-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	2017
Indicative cost band:	Third Hamilton–Waihou circuit: D Reconductoring Hamilton–Waihou circuit: C

Issue

Two 110 kV Hamilton–Waihou circuits supply the ‘Valley Spur’ (Waihou, Waikino, and Kopu), each circuit having a summer/winter capacity of 154/168 MVA. Valley Spur summer and winter peak loads are increasingly similar, with 2011 peaks of approximately 114 MW and 127 MW, respectively.

The peak load in the Valley Spur is forecast to exceed the circuits’ n-1 summer capacity by approximately 1 MW in 2016, increasing to approximately 40 MW in 2027 (See Table 9-7).

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

Table 9-7: Valley Spur circuit overload forecast

Grid exit point	Circuit overload (MW)										
	Next 5 years						5-15 years out				
	2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Valley Spur	0	0	0	0	1	5	14	22	28	35	40

The transmission loading is further exacerbated by the low voltage along the spur (see Section 9.8.5 for more information).

Solution

Together with Powerco, we have investigated connecting a new grid exit point to these circuits at Piako, part-way between Hamilton and Waihou (see Section 9.8.15 for more information). Approximately 40% of the Waihou load will be shifted to Piako, and consequently the circuit overloading issue will only occur between Hamilton and Piako.

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–Waihou circuits' capacity issue, delaying the need for further transmission reinforcement by approximately one year.

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

We will also investigate longer-term additional investment, other than installing capacitors along the Valley Spur. Possible 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–Waihou 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 Hinuera grid exit point.

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 Waihou–Waikino–Kopu spur low voltage

Project reference:	VLYS-REA_PWS-DEV-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	New capacitors: 2014-2017 Supply transformer replacement: 2013-2015
Indicative cost band:	New capacitors: A Waihou supply transformer replacement: B Waikino supply transformer replacement: A

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 or within Powerco's network), 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 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.

9.8.6 Cambridge supply transformer capacity

Project reference:	CBG-SUBEST-EHMT-01
Project status/purpose:	Committed, minor enhancement and customer-specific
Indicative timing:	2013
Indicative cost band:	A

Issue

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

- a total nominal installed capacity of 80 MVA, and
- n-1 capacity of 38/38[65] MVA (summer/winter).

The peak load at Cambridge is forecast to exceed the transformers' n-1 winter capacity by approximately 3 MW in 2012, increasing to approximately 12 MW in 2027 (see Table 9-8).

Table 9-8: Cambridge supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Cambridge	0.98	3	4	5	5	5	6	8	8	10	11	12

Solution

The Cambridge 11 kV switchgear is currently being replaced. This will resolve the bus and protection limits, providing sufficient capacity until 2023 when the transformers' n-1 winter capacity will be exceeded by approximately 1 MW. This overload will increase to approximately 2 MW in 2027. We will discuss the options to increase the supply transformers' n-1 capacity with Waipa Networks closer to this time.

9.8.7 Hamilton supply transformer capacity

Project reference:	HAM-SUBEST-DEV-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	New supply transformer at Hamilton: 2015 New supply transformer at Te Kowhai: 2018
Indicative cost band:	Cost for one new supply transformer: A (at Hamilton), C (at Te Kowhai)

Issue

Hamilton has both an 11 kV and a 33 kV supply bus. In 2015, the 11 kV supply will be decommissioned and the load transferred to the 33 kV.

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

65 The transformers' capacity is limited by the 11 kV bus and protection limits; with these limits resolved, the n-1 capacity will be 45/47 MVA (summer/winter).

- a total nominal installed capacity of 80 MVA, and
- n-1 capacity of 40/40[66] MVA (summer/winter).

The peak load at Hamilton 11 kV is forecast to exceed the transformers' n-1 winter capacity by approximately 10 MW in 2012, increasing to approximately 13 MW in 2014 (see Table 9-9).

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 34 MW in 2012, increasing to approximately 68 MW in 2015. When the 11 kV supply bus is decommissioned and the load is transferred to the 33 kV bus, the 220/33 kV transformer overload forecast increases to approximately 141 MW in 2027 (see Table 9-9). This large overload is partly due to load shifting from Te Kowhai to Hamilton to manage distribution company loads.

Table 9-9: Hamilton supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Hamilton 11 kV	1.00	10	12	13	0	0	0	0	0	0	0	0
Hamilton 33 kV	0.99	34	37	40	68	97	102	111	119	127	135	141

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 420 MVA, and
- n-1 capacity of 342/350 MVA (summer/winter).

The total load is forecast to be 220 MW in 2012, increasing to 354 MW by 2027. The total supply transformer capacity will not be exceeded until approximately 2026.

Solution

An interim solution is to transfer load to the Te Kowhai grid exit point. Table 9-9 shows that significant load transfers will be required by 2027. As a longer-term solution, we are investigating a range of options with WEL networks that include:

- increasing the rating of the two existing supply transformers at Te Kowhai (a committed project, see Section 9.9.4)
- installing a third 220/33 kV supply transformer at Hamilton, and
- installing a third 220/33 kV supply transformer at Te Kowhai (see Section 9.9.4).

In addition, Hamilton T5 transformer has an expected end-of-life in the next 10-15 years. We will discuss with WEL Networks the appropriate rating and timing for the replacement transformer.

9.8.8 Hangatiki supply transformer capacity

Project reference:	HTI-POW_TFR-REPL-01
Project status/purpose:	Base Capex, replacement

[66] 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).

Indicative timing:	2015
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 approximately 13 MW in 2012, increasing to approximately 20 MW in 2027 (see Table 9-10).

Table 9-10: Hangatiki supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Hangatiki	0.88	13	14	14	15	15	16	17	18	19	20	20

Solution

The Hangatiki transformers are made up of single-phase units, with a non-contracted spare available on site. There is a possibility of new embedded generation in this area that may reduce peak transformer loading.

We are discussing longer-term options with The Lines Company, such as replacing the existing transformers with two 40 MVA supply transformers.

In addition, all the Hangatiki supply transformers have an expected end-of-life within the next five years. Future investment will be customer driven.

9.8.9 Hinuera supply transformer capacity

Project reference:	New grid exit point: PTR-SUBEST-DEV-01 Transformer replacement: HIN-POW_TFR-EHMT-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	New grid exit point: 2014 Transformer replacement: to be advised
Indicative cost band:	New grid exit point: C Transformer replacement: 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 2012. The overload will decrease in 2014 if Putaruru is completed. The transformers' n-1 winter capacity will be exceeded by approximately 8 MW in 2014, increasing to approximately 20 MW in 2027 (see Table 9-11).

Table 9-11: Hinuera supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Hinuera	0.95	13	14	8	8	9	10	12	14	16	18	20
Hinuera (no Putaruru)	0.95	13	14	15	16	17	18	21	23	25	28	30

Solution

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 circuit 2 (see also Section 9.8.10). This new grid exit point will reduce Hinuera load by approximately 15% by 2027, but will not resolve the Hinuera supply transformer overload issue.

We will discuss with Powerco the options to relieve this issue, one of which is to replace the 30 MVA transformer with a 60 MVA unit. This will provide n-1 security of supply beyond the forecast period[67]. In the short term, load may be transferred within the Powerco network from Hinuera to Waihou to resolve this issue. Any future investment or transformer upgrade will be customer driven.

9.8.10 Hinuera transmission security

Project reference:	PTR-SUBEST-DEV-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	2014
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 47 MW in 2012, increasing to 54 MW in 2027.

Solution

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

Some of Hinuera's load will be transferred to Putaruru, with most of the remainder secured by backfeeding within the local lines distribution system from Putaruru or Waihou.

9.8.11 Kopu supply transformer capacity

Project reference:	KPU-POW_TFR_PTN-EHMT-01
Project status/purpose:	Base Capex, minor enhancement
Indicative timing:	Q4 2012
Indicative cost band:	A

67 The 50 MVA transformer's capacity is limited by 33 kV metering; this limit will bind from 2021 if it is not resolved.

Issue

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

- a total nominal installed capacity of 120 MVA, and
- n-1 capacity of 45/45 MVA[68] (summer/winter).

The peak load at Kopu is forecast to exceed the transformers' n-1 capacity by approximately 9 MW in 2012, increasing to approximately 31 MW in 2027 (see Table 9-12).

Table 9-12: Kopu supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Kopu	-0.99	9	11	12	14	15	17	21	24	26	29	31

Solution

Resolving the protection limit will increase the transformers' n-1 capacity to 64/67 MVA (summer/winter), providing sufficient capacity until 2018. Following the protection upgrade, the peak load at Kopu is forecast to exceed the transformers' n-1 winter capacity by approximately 1 MW in 2018. This overload will increase to approximately 13 MW in 2027. 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.

9.8.12 Maraetai–Whakamaru transmission capacity

Project status/purpose: This issue is for information only

Issue

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

The generation stations' combined capacity is 411 MW. If there is an outage of one of the Maraetai–Whakamaru circuits, generation is restricted 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.

9.8.13 Te Awamutu supply transformer capacity

Project reference: TMU-POW_TFR_PTN-EHMT-01
Project status/purpose: Base Capex, minor enhancement
Indicative timing: 2013
Indicative cost band: A

[68] The transformers' capacity is limited by protection equipment; with this limit resolved, the n-1 capacity will be 64/67 MVA (summer/winter).

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 MVA[69] (summer/winter).

The peak load at Te Awamutu is forecast to exceed the transformers' n-1 capacity by approximately 1 MW in 2015, increasing to approximately 10 MW in 2027 (see Table 9-13).

Table 9-13: Te Awamutu supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Te Awamutu	0.98	0	0	0	1	1	2	3	5	6	8	10

Solution

Resolving the protection limit will increase the transformers' n-1 capacity to 52/54 MVA (summer/winter), providing sufficient capacity for the forecast period and beyond.

9.8.14 Te Awamutu transmission security

Project reference:	HTI_TMU-TRAN-DEV-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	Q1 2015
Indicative cost band:	D

Issue

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

- 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 38 MW in 2012, increasing to 46 MW in 2027.

Solution

We have investigated and discussed several options with Waipa Networks for providing n-1 security to Te Awamutu, which include:

- a new 110 kV circuit from Hangatiki to Te Awamutu, or
- a second 110 kV circuit from Karapiro to Te Awamutu.

Waipa Networks may construct a new 110 kV circuit from Hangatiki to Te Awamutu, to be operated by Transpower.

9.8.15 Waihou supply transformer capacity

Project reference:	New grid exit point: PAO-SUBEST-DEV-01 Transformer replacement: WHU-POW_TFR-REPL-01
Project status/purpose:	New grid exit point: committed, customer-specific Transformer replacement: Base Capex, replacement
Indicative timing:	New grid exit point: 2012-2013 Transformer replacement: 2022-2027

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

Indicative cost band:	New grid exit point: C Transformer replacement: 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).

Waihou winter and summer peak loads are similar. The peak load at Waihou is forecast to exceed the transformers' n-1 summer capacity by approximately 26 MW in 2012. The overload will decrease when Piako is completed, increasing to approximately 17 MW in 2027 (see Table 9-14).

Table 9-14: Waihou supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Waihou	0.96	26	1	2	3	5	6	9	11	13	15	17

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, taking up to 14 hours to complete.

Solution

Powerco is planning to increase transmission security to Waihou with a new grid exit point at Piako. Piako will connect to the existing 110 kV Hamilton–Waihou circuits and reduce Waihou peak load by approximately 40% by 2027.

This will not resolve the Waihou supply transformer overload issue. A likely long-term solution is to replace the existing transformers with higher-rated transformers. These transformers have an expected end-of-life within the next 10-15 years. We will discuss with Powerco the appropriate number, rating, and timing for the replacement transformers.

In addition, we will convert the 33 kV outdoor switchyard to an indoor switchboard within the next five years.

9.8.16 Waikino supply transformer capacity

Project reference:	WKO-POW_TFR-EHMT-01
Project status/purpose:	Base Capex, replacement
Indicative timing:	2021
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 summer capacity by approximately 5 MW in 2012, increasing to approximately 23 MW in 2027 (see Table 9-15).

Table 9-15: Waikino supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Waikino	1.00	5	6	7	8	10	11	14	17	19	21	23

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 5-10 years, and conversion of the existing 33 kV switchgear from outdoor to an indoor switchboard is planned for around the same time.

9.9 Other regional items of interest

9.9.1 Cambridge spur capacity

Project statuspurpose:	This issue is for information only

Issue

The Cambridge Spur comprises three loads (at Cambridge, Te Awamutu, and Hinuera), which are offset by Karapiro generation. There are two 110 kV circuits supplying this spur, each with a capacity of 57/70 MVA (summer/winter).

The summer peak load on this spur is approaching the winter peak load, and the combined load on the Cambridge Spur in summer 2011 was approximately 100 MW. This is forecast to increase to approximately 128 MW by 2027. To avoid exceeding the n-1 capacity of the Hamilton–Cambridge–Karapiro circuits during peak summer load periods, Karapiro's minimum generation will need to be approximately 47 MW in 2012. However, the minimum Karapiro generation will decrease to 42 MW following the commissioning of Putaruru in 2014, increasing to 62 MW in 2027.

Solution

Karapiro generation is generally reliable and has a capacity of 90 MW. It typically operates at 40 MW during low load periods and 80-90 MW during daytime peaks. Hinuera load will decrease when the new Putaruru grid exit point is commissioned in 2014. However, with continued load growth and periods of low water inflows, there will eventually be insufficient available generation to avoid exceeding the Hamilton–Cambridge–Karapiro circuits' n-1 capacity (requiring a circuit upgrade).

The proposed Hangatiki–Te Awamutu 110 kV circuit will also impact the loading on these circuits (see Section 9.8.14). Depending on the generation and load pattern in the region, the flows on the Cambridge spur may increase or decrease.

We will investigate options to alleviate the overload.

9.9.2 Hamilton low voltage

Project status/purpose:	This issue is for information only

Issue

The Hamilton 220 kV bus will have low voltage (below 0.9 pu) from 2019 for the following system conditions:

- high load periods

- loss of the 220 kV Hamilton–Ohinewai circuit, and
- low Waikato 110 kV generation.

Solution

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

- reactive support in the Waikato 110 kV transmission network, and
- a third 220 kV connection to Hamilton (see Section 9.9.3).

9.9.3 Hamilton transmission security during maintenance

Project status/purpose:	This issue is for information only

Issue

When either a 220 kV Hamilton–Whakamaru circuit or a 220 kV Hamilton–Ohinewai circuit or Hamilton 220/110 kV interconnection is out for maintenance, the 110 kV system is split from the 220 kV system, placing a considerable part of the Waikato region on n security.

Solution

It may be economic to provide full or partial n-1 security during maintenance. We are considering options that include a:

- new 200 MVA 220/110 kV transformer at a new substation, connected to the intersection of the 220 kV Otahuhu–Whakamaru 3 circuit and the 110 kV Hamilton–Waihou circuits, or
- third 220 kV circuit into Hamilton, and/or
- third interconnecting transformer in parallel with the existing transformers.

9.9.4 Te Kowhai substation developments

Project reference:	TWH-POW_TFR-EHMT-01
Project status/purpose:	Supply transformer upgrade: committed, customer-specific New supply transformer: possible, customer-specific
Indicative timing:	Supply transformer upgrade: 2012 New supply transformer 2018
Indicative cost band:	Supply transformer upgrade: A New supply transformer: C

Issue

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

- a total nominal installed capacity of 200 MVA, and
- n-1 capacity of 109/109 MVA (summer/winter).

There are also two embedded generators (Te Uku and Te Rapa) at Te Kowhai. The net load in 2011 ranged from an injection of approximately 70 MW to an off take of approximately 85 MW.

Solution

The distribution network is capable of substantial load shifting between Te Kowhai and Hamilton. The supply capacity at Hamilton is highly constrained (see Section 9.8.7). Following discussions with WEL Networks, to enable additional load transfer to Te Kowhai from Hamilton, we are:

- increasing the rating of the two existing supply transformers by installing radiators and fans in 2012, increasing the n-1 capacity to 132 MVA, and

- proposing to install a third 120 MVA 220/33 kV supply transformer at Te Kowhai by around 2018.

9.10 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 maximum generation that can be connected at any substation 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. See our website for more information about connecting generation.[70]

9.10.1 Hauauru Ma Raki wind station

The proposed Hauauru Ma Raki wind generation station (also referred to as the Waikato wind station) may generate up to 540 MW, and will connect to the 220 kV double-circuit transmission line between Huntly and Drury.

If it is necessary to cater for a generation scenario with maximum wind generation and maximum Huntly generation (assuming sustained low hydro generation), then it may be necessary to reconductor the two 220 kV Huntly–Ohinewai circuits, and thermally upgrade the two 220 kV circuits between the wind station connection and Drury.

9.10.2 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.

For example, during 2012 winter peak loads, with combined Huntly, Otahuhu, and Southdown generation of 1,525 MW and Arapuni generation of 180 MW, any generation at Hangatiki will cause the Arapuni–Hamilton circuits to overload.

In addition, any new generation on the 110 kV transmission network in the Waikato region will add to the 110 kV Bombay–Hamilton and 110 kV Arapuni–Kinleith loading (see Section 9.8.2). 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.

70 http://www.transpower.co.nz/connecting-new-generation.