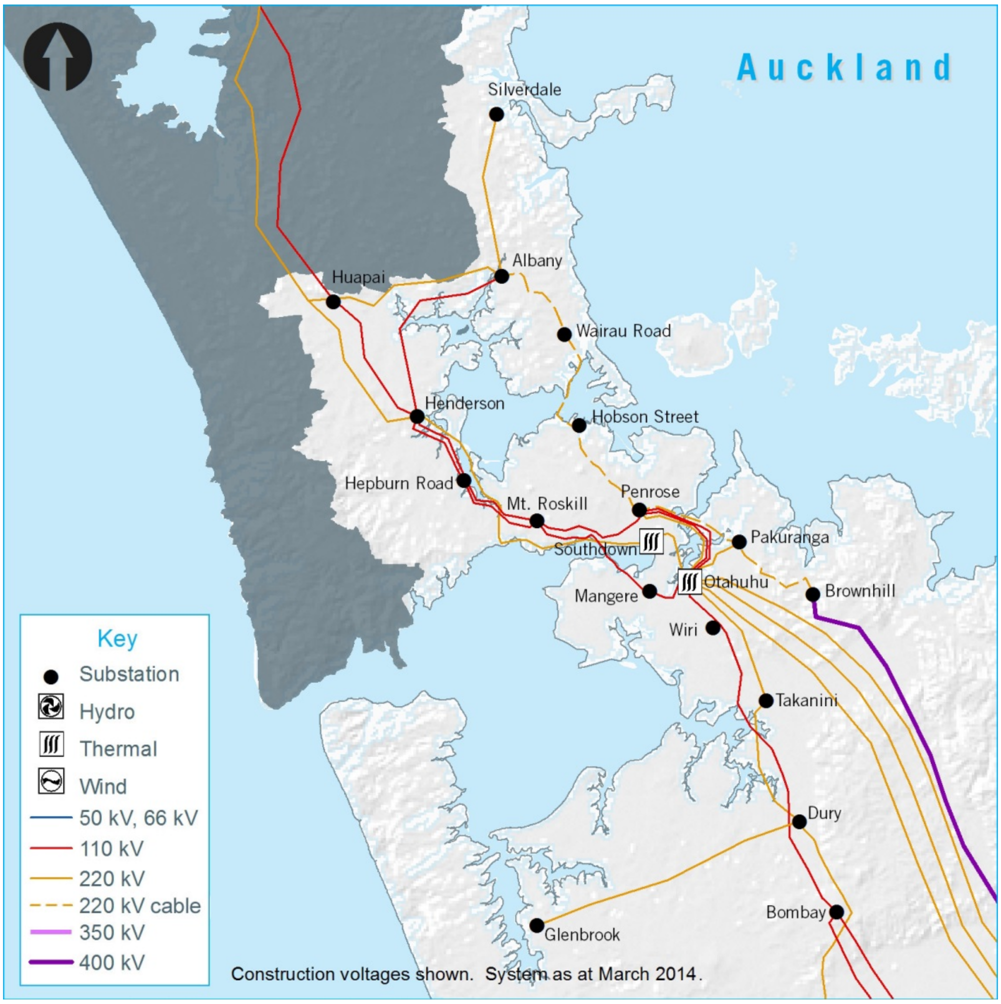
8 Auckland Regional Plan

8.1 Regional overview

This chapter details the Auckland 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 8-1: Auckland region



The Auckland region has some of the highest load densities in New Zealand, coupled with relatively low levels of local generation.

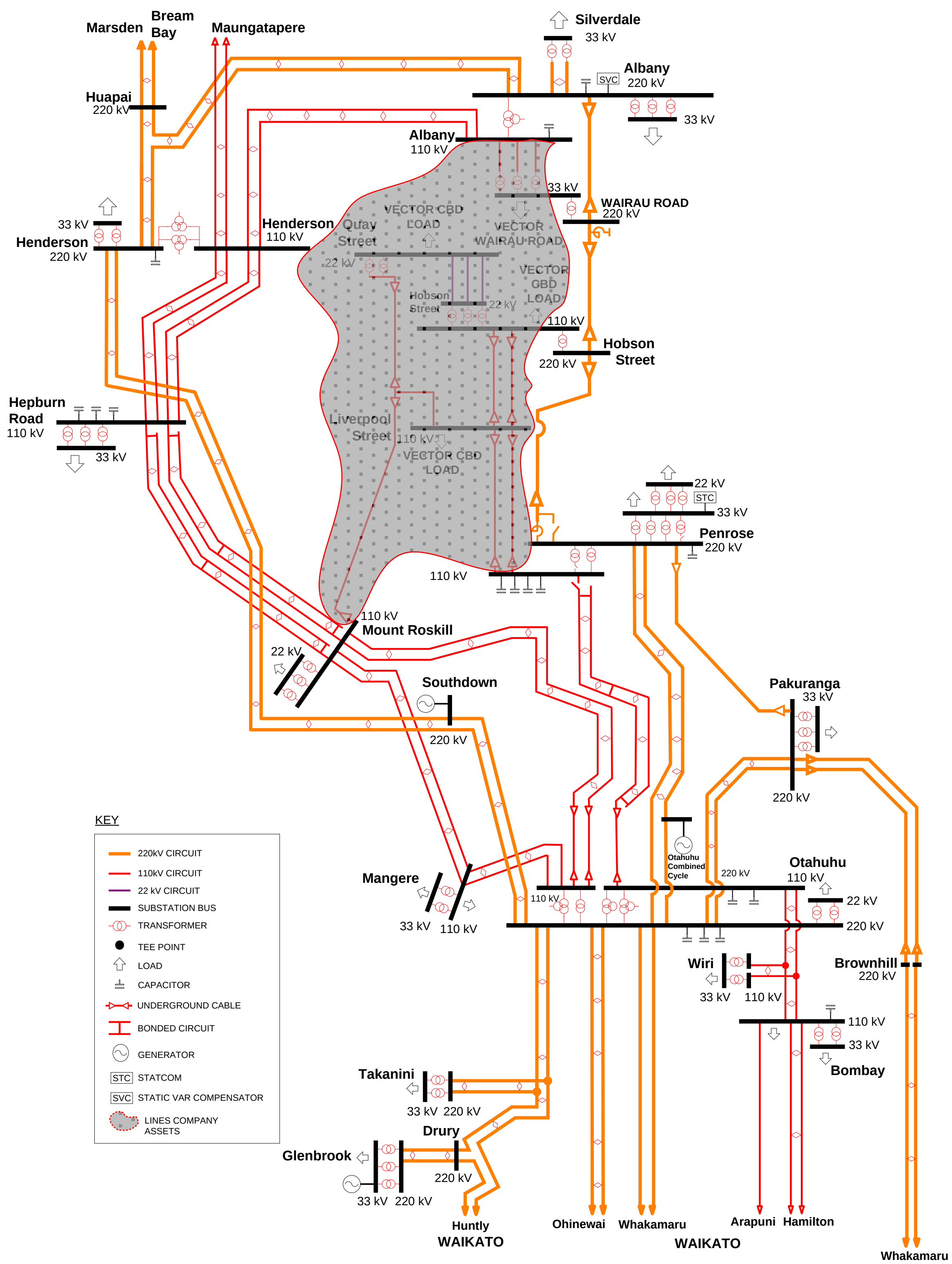
We have assessed the Auckland region's transmission needs over the next 15 years while considering longer-term development opportunities. Specifically, the transmission network needs to be sufficiently flexible to respond to a range of future service and technology possibilities, taking into consideration:

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

8.2 Auckland transmission system

This section highlights the state of the Auckland regional transmission network. The existing transmission network is set out geographically in Figure 8-1 and schematically in Figure 8-2.

Figure 8-2: Auckland transmission schematic



8.2.1 Transmission into the region

As approximately 80% of the Auckland and Northland regions' peak electricity demand is supplied by generation located south of Bombay, transmission is necessary to keep the energy flowing into Auckland and through to north Auckland and the Northland region.

Recently completed major upgrades ensure that there is secure transmission into the Auckland region as demand grows:

- North Island Grid Upgrade (NIGU), and
- Upper North Island Dynamic Reactive Support (UNIDRS).

Prior to 2012, all six 220 kV circuits into Auckland terminated at Otahuhu substation. The NIGU added two additional high capacity 220 kV circuits from the generation rich centre of the North Island from Whakamaru to Pakuranga. This provided increased:

- transmission capacity to meet increased load demand and enable new generation to displace the higher cost fossil-fuelled and base load generation in and near Auckland, and
- security by providing diverse transmission routes and terminating substations to provide two transmission feeds into the Auckland region.

Transmission into Auckland also requires voltage support to ensure stability, provided by static capacitors at Henderson, Hepburn Road, Albany, Otahuhu, Penrose, and Bombay substations. The UNIDRS project added dynamic reactive support at Albany, Penrose and Marsden to relieve voltage stability issues for outages of circuits supplying Auckland or outages of a major generation unit within or near the Auckland region.

8.2.2 Transmission and distribution networks within the region

The Auckland transmission network distributes power within the region and provides through transmission to the Northland region. It consists of three layers: the 220 kV network, the 110 kV network, and the 110 kV distribution system owned by Vector.

220 kV transmission network

The North Auckland and Northland (NAaN) major upgrade was recently completed and builds on NIGU.

There is a high capacity 220 kV ring between Otahuhu, Pakuranga and Penrose. The ring was completed as part of NAaN by installing a 220 kV Pakuranga–Penrose cable circuit to complement the existing 220 kV double-circuit Otahuhu–Pakuranga and Otahuhu–Penrose overhead lines. It provides increased capacity and security by providing a strong connection between the two “infeeds” at Otahuhu and Pakuranga.

There is a high capacity 220 kV loop from Otahuhu and Penrose through the Henderson and Albany substations in the North Isthmus. The loop was completed as part of NAaN by installing a 220 kV cable from Penrose to Albany to complement the existing 220 kV double-circuit Otahuhu–Henderson and Henderson–Albany overhead lines. It provides increased capacity and security to the North Isthmus and the Northland region by providing diverse transmission routes from diverse substations.

In addition, the 220 kV cable circuit from Penrose to Albany connects to Vector’s Hobson Street and Wairau Road substations, to provide security and capacity. The 220 kV cable also enables Vector to redistribute load from existing grid exit points, particularly the Albany 33 kV and 110 kV (Wairau Road) and Auckland CBD loads.

110 kV transmission network

The 110 kV transmission network is split into two parts at Otahuhu.

- One half of the 110 kV network has 220/110 kV interconnecting transformers at Otahuhu and Penrose. The transformers may be connected through the 110 kV Otahuhu–Penrose circuit[43], which operates in parallel with the 220 kV Otahuhu–Penrose double-circuit line. The 110 kV system also connects to the Waikato

[43] The 110 kV Otahuhu–Penrose circuit, and the Penrose 220/110 kV interconnecting transformer (T10), may be open for system reasons.

region via a Bombay–Wiri–Otahuhu double-circuit line, with power flow generally south out of Otahuhu.

- The other half of the 110 kV network has 220/110 kV interconnecting transformers at Otahuhu, Henderson and Albany. The transformers are all connected through the 110 kV network which supplies Mangere and Mount Roskill in a double-circuit ring, extending from Mount Roskill through a double-circuit 110 kV connection to Henderson and Albany. The 110 kV lines operate in parallel with the 220 kV Otahuhu–Henderson–Albany double-circuit lines. Power flow is generally into Mount Roskill on all circuits, from both Otahuhu and the North Isthmus.

110 kV distribution network

Vector's 110 kV distribution network is in parallel with the 110 kV transmission network at Penrose and Hobson Street. There is risk of overloading one of Vector's Penrose–Liverpool Street cables for an outage of the parallel cable. To prevent this, the Penrose–T10 220/110 kV interconnecting transformer and the Otahuhu–Penrose 110 kV circuit will be normally switched out (operating on hot standby).

Vector can also supply the CBD from the Mount Roskill substation via Vector's Liverpool Street substation. However, this is normally split and is used to enable maintenance outages.

Vector supplies the Auckland CBD load from their Liverpool Street, Hobson and Quay Street substations.

8.2.3 Longer-term development path

We have identified a longer-term development path to address issues involving transmission into, within and through the Auckland region, which will be re-examined when the need arises. The timing of the transmission investments depends on the net load of the Auckland and Northland regions. New generation in the region or demand-side response may defer transmission investment. Similarly, regional generation retirement or increased demand will bring forward the need for transmission investment.

Possible future upgrades include, but are not limited to the following:

- Installing series compensation on the 220 kV Pakuranga–Whakamaru circuits to improve load sharing with the other 220 kV circuits. Ultimately, the Brownhill–Whakamaru section of the Pakuranga–Whakamaru circuits will be upgraded to operate at 400 kV, by installing 400/220 kV transformers at Brownhill and Whakamaru.
- Increasing the transfer capacity into Auckland by building a switching station at Brownhill and cable circuits from Brownhill to Otahuhu.
- Possibly increasing the capacity of the 110 kV circuits between Arapuni and Otahuhu via thermal upgrades or reconductoring with higher-capacity conductors.
- Transmission reinforcement within the Auckland region via additional 220 kV cable circuits between Pakuranga, Penrose, and Mount Roskill, with a 220/110 kV connection at Mount Roskill.
- Transmission reinforcement to the North Isthmus via a second cable between Penrose and Albany.
- Additional static and dynamic reactive power support approximately every 8-10 years to ensure power system voltage stability, and sufficient reserves are maintained to cover the worst transmission contingency. The series compensation on the 220 kV Pakuranga–Whakamaru circuits may be brought forward because of its positive contribution to voltage stability and reduction in transmission losses.

Beyond the next 30 years, new transmission capacity may be required into Auckland, which can be provided by a new 400 kV line, an HVDC link or refurbishment of the existing lines.

The development of the Auckland Unitary plan (particularly in the South Auckland area) will influence future options for increasing transmission capacity into Auckland.

8.3 Auckland demand

The after diversity maximum demand (ADMD) for the Auckland region is forecast to grow on average by 1.7% annually over the next 15 years, from 2,140 MW in 2014 to 2,770 MW by 2029. This is higher than the national average demand growth of 1.2% annually.

Figure 8-3 shows the historical and forecast demand for the Auckland region. There is no comparison with earlier forecasts as we redefined the region's boundaries to better reflect the power system. The APR 2014 forecast is 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 transformers and transmission lines. See Chapter 4 for more information about demand forecasting.

Figure 8-3: Auckland region after diversity maximum demand forecast

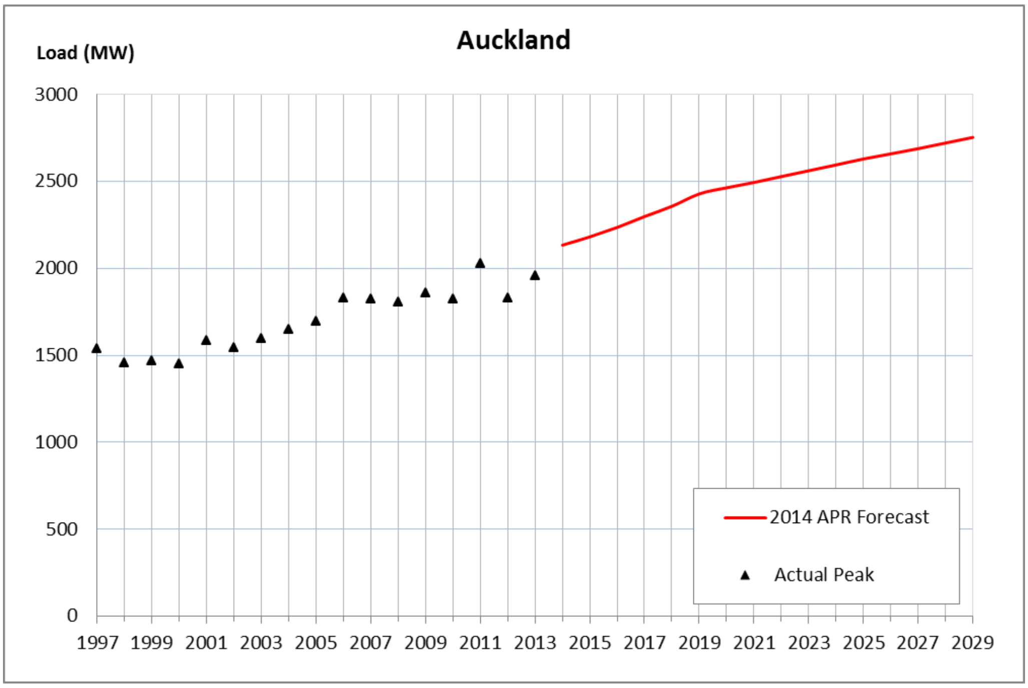


Table 8-1 lists forecast peak demand (prudent growth) for each grid exit point for the forecast period.

Table 8-1: Forecast annual peak demand (MW) at Auckland grid exit points to 2029

Grid exit point	Power factor	Peak demand (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Albany 33 kV[1]	0.99	122	124	125	127	128	130	133	136	140	143	146
Albany 110 kV - Wairau Road[1]	0.95	174	176	179	181	183	185	190	194	199	204	209
Bombay 33 kV[2]	0.98	22	11	12	12	12	12	0	0	0	0	0
Bombay 110 kV[2]	0.99	64	83	89	95	101	108	132	145	158	170	181

Grid exit point	Power factor	Peak demand (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Glenbrook 33 kV	1.00	74	74	75	75	75	76	77	78	78	79	80
Glenbrook - NZ Steel	1.00	119	119	119	119	119	119	119	119	119	119	119
Henderson	0.99	124	127	131	134	137	141	148	155	162	169	175
Hepburn Rd	1.00	151	153	155	157	158	160	164	168	172	176	181
Hobson Street[3]	1.00	115	117	120	122	125	127	132	137	142	147	152
Mangere 33 kV[4]	0.98	109	110	112	114	115	117	121	124	128	131	135
Mangere 110 kV[4]	0.87	50	50	50	50	50	50	50	50	50	50	50
Meremere[5]	0.97	4	4	4	0	0	0	0	0	0	0	0
Mt Roskill 22 kV[6]	0.98	156	158	161	163	153	156	160	165	170	175	179
Mt Roskill 110 kV	1.00	71	72	73	74	75	76	78	80	82	84	86
Otahuhu	0.99	70	70	70	70	66	66	66	66	66	66	66
Pakuranga	0.99	164	167	170	173	180	183	188	194	200	205	211
Penrose 22 kV	0.97	58	59	60	61	62	63	65	67	69	71	73
Penrose 33 kV	0.98	289	294	299	303	308	313	323	333	343	354	364
Penrose 110 kV-Liverpool Street[3]	1.00	115	117	120	122	125	127	132	137	142	147	152
Silverdale	1.00	85	87	89	90	92	94	97	101	105	108	112
Takanini[7]	0.99	133	135	137	139	145	147	151	155	159	163	167
Wiri	0.99	89	91	93	95	97	99	103	107	111	115	120

1. The customer advised that they planned to move James Street and Forrest Hill substations from Albany 33 kV to Albany 110 kV in 2013. This impact is included in the forecast demand.
2. The customer advised that approximately half of the load will shift from Bombay 33 kV to Bombay 110 kV in 2015, with the balance of the load shifting by 2020.
3. The 50/50 load split between Hobson Street and Penrose–Liverpool Street is an estimate only. Paralleling of the Vector and Transpower networks between these grid exit points is being considered.
4. The effect of the recently announced sale of Pacific Steel is not included in the load forecast for Mangere.
5. The customer advised that the load at Meremere will be shifted to Huntly (in the Waikato region) in 2016. This load is currently supplied from the Bombay grid exit point.
6. The 8 MW Tunnel Boring machine named Alice will operate behind Mount Roskill until 2018.
7. Customer advised that a new industrial load is expected at Takanini in 2018.

8.4 Auckland generation

The Auckland region's generation capacity is approximately 700 MW.

Table 8-2 lists the generation forecast for each grid injection point for the forecast period. This includes all known existing and committed generation stations including those embedded within the relevant local lines company's network (Vector or Counties Power).[44]

No new generation is known to be committed in the Auckland region for the forecast period.

[44] Only generators with capacity greater than 1 MW are listed. Generation capacity is rounded to the nearest megawatt.

Table 8-2: Forecast annual generation capacity (MW) at Auckland grid injection points to 2029 (including existing and committed generation)

Grid injection point (location if embedded)	Generation capacity (MW)										
	Next 5 years						5-15 years out				
	2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Albany (Rosedale[1])	3	3	3	3	3	3	3	3	3	3	3
Glenbrook[2]	112	112	112	112	112	112	112	112	112	112	112
Mangere (Watercare Mangere)	7	7	7	7	7	7	7	7	7	7	7
Otahuhu B CCGT	380	380	380	380	380	380	380	380	380	380	380
Otahuhu (Greenmount Landfill)	6	6	6	6	6	6	6	6	6	6	6
Penrose (Auckland Hospital)	4	4	4	4	4	4	4	4	4	4	4
Silverdale (Redvale)	10	10	10	10	10	10	10	10	10	10	10
Southdown CCGT	175	175	175	175	175	175	175	175	175	175	175
Takanini (Whitford Landfill)	3	3	3	3	3	3	3	3	3	3	3

1. Rosedale generation is limited to approximately 1 MW due to insufficient gas at the site. This amount is not expected to rise significantly within the next few years
2. This value includes an embedded generating unit with a nominal rating of 38 MW. However, its continuous output is approximately 25 MW.

8.5 Auckland 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 8-3 lists the significant maintenance-related work[45] proposed for the Auckland region for the next 15 years that may significantly impact related system issues or connected parties.

Table 8-3: Proposed significant maintenance work

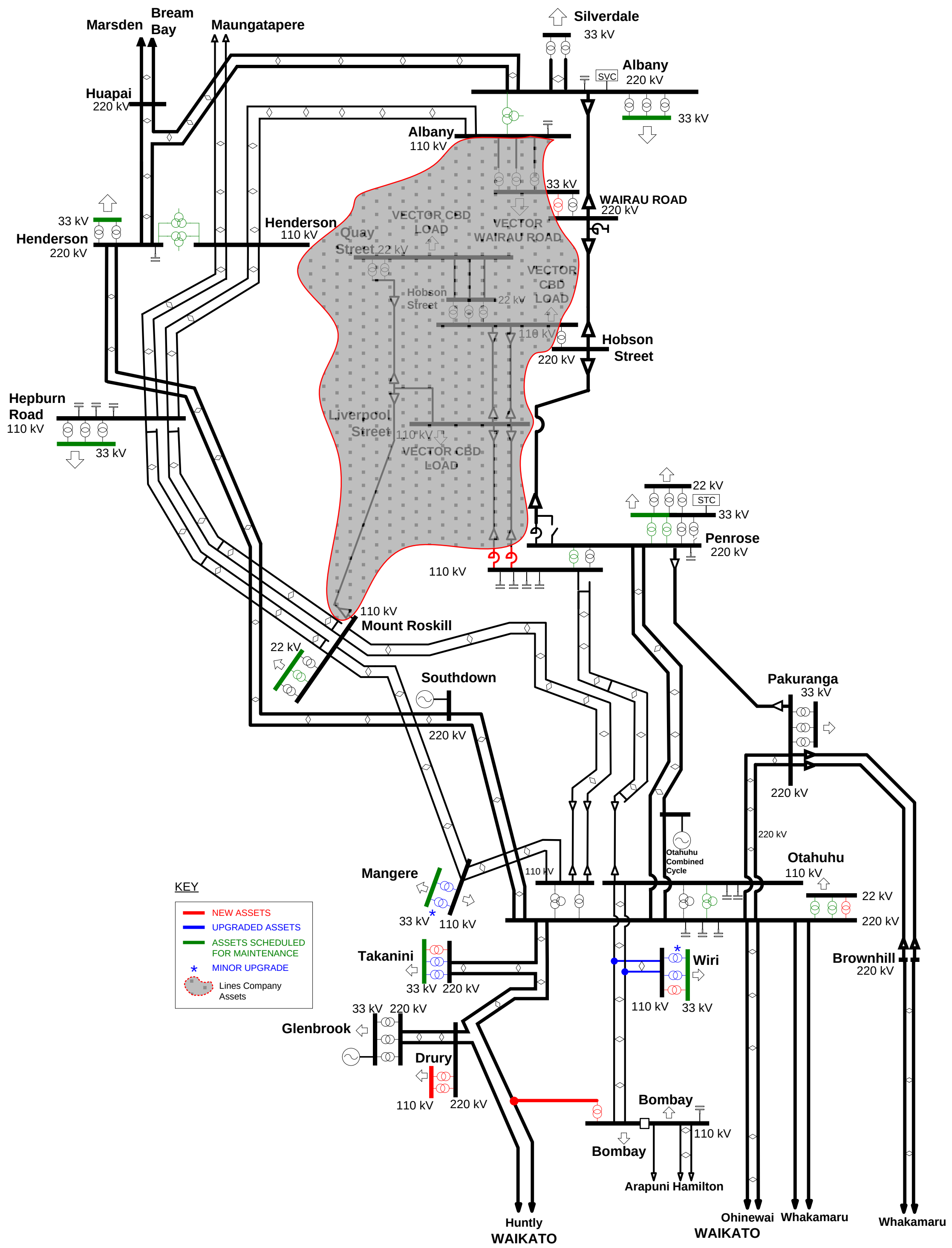
Description	Tentative year
Albany 33 kV outdoor to indoor conversion, and Albany 220/110 kV interconnecting transformer expected end-of-life	2015-2017 2022-2023
Bombay 33 kV outdoor to indoor conversion, and Bombay supply transformers expected end-of-life	2015-2017 2021-2023
Henderson 33 kV outdoor to indoor conversion, and Henderson 220/110 kV interconnecting transformers expected end-of-life	2014-2016 2023-2024
Hepburn Road 33 kV outdoor to indoor conversion	2014-2016
Mangere 33 kV outdoor to indoor conversion	2018-2020
Mount Roskill 22 kV outdoor to indoor conversion, and Mount Roskill supply transformer T3 expected end-of-life	2015-2017 2020-2022
Otahuhu–T2 220/110 kV interconnecting transformers expected end-of-life, and Otahuhu supply transformers expected end-of-life	2018-2020 2015-2020
Penrose 33 kV outdoor to indoor conversion, and Penrose–T10, 220/110 kV interconnecting transformer expected end-of-life, and Penrose supply transformers expected end-of-life	2012-2016 2017-2019 2026-2027
Takanini 33 kV outdoor to indoor conversion	2014-2016
Wiri 33 kV outdoor to indoor conversion, and Wiri supply transformer expected end-of-life	2017-2019 2021-2023

[45] This may include replacement of the asset due to its condition assessment.

8.6 Future Auckland transmission configuration

Figure 8-4 shows the possible configuration of Auckland transmission in 2029, with new assets, upgraded assets, and assets undergoing significant maintenance within the forecast period.

Figure 8-4: Possible Auckland transmission configuration in 2029



8.7 Changes since the 2013 Annual Planning Report

Table 8-4 lists the specific issues that are either new or no longer relevant within the forecast period when compared to last year's report.

Table 8-4: Changes since 2013

Issues	Change
Albany supply transformer capacity	Shifted from Northland region Removed, reduced load forecast
Bombay transmission capacity	New issue
Henderson interconnection transformer capacity Henderson supply transformer capacity	Shifted from Northland region Shifted from Northland region
Hobson Street Supply security	Removed, NAaN project commissioned
North Auckland and Northland regional transmission security	Removed, NAaN project commissioned
Silverdale supply transformer capacity	Shifted from Northland region

8.8 Auckland transmission capability

Table 8-5 summarises issues involving the Auckland region for the next 15 years. For more information about a particular issue, refer to the listed section number.

Table 8-5: Auckland region transmission issues

Section number	Issue
Regional	
8.8.1	Auckland region voltage quality
8.8.2	Bombay transmission capacity
8.8.3	Henderson interconnecting transformer capacity
8.8.4	Otahuhu interconnecting transformer capacity
Site by grid exit point	
8.8.5	Henderson supply transformer capacity
8.8.6	Mangere supply transformer capacity
8.8.7	Mount Roskill supply transformer capacity
8.8.8	Otahuhu–Penrose 110 kV transmission capacity
8.8.9	Otahuhu–Wiri Tee 110 kV transmission capacity
8.8.10	Otahuhu supply transformer capacity
8.8.11	Penrose 33 kV supply transformer capacity
8.8.12	Silverdale supply transformer capacity
8.8.13	Takanini supply transformer capacity
8.8.14	Wiri supply transformer capacity
8.8.15	Wiri Tee transmission capacity
Bus security	
8.9.1	Transmission bus security
8.9.2	Henderson–Hepburn Road
8.9.3	Bombay–Wiri Tee transmission capacity
8.9.4	Otahuhu–Mount Roskill

8.8.1 Auckland region voltage quality

Project status/type:	This issue is for information only

Issue

As demand grows in the Auckland and Northland regions, regional voltages may deteriorate to a point where the outage of a 220 kV circuit may cause voltage collapse.

Generation located in the Auckland and Northland regions is insufficient to meet reactive power demand. Reactive power from non-generation sources such as shunt capacitors, series capacitors, static synchronous compensators (STATCOM) and static var compensators (SVC) is required to ensure the maintenance of acceptable voltage levels and quality.

Solution

We completed a number of projects to improve Auckland voltage, including STATCOMs at Penrose and Marsden. Even with these projects, Auckland voltage stability is an ongoing issue requiring regular study as the Auckland and Northland regional loads grow.

See Chapter 6, Section 6.4.1, 6.4.2 and 6.5.4 for further information.

8.8.2 Bombay transmission capacity

Project status/type:	This issue is for information only

Issue

Bombay has an increased load forecast due to proposed housing and commercial developments in the area. The amount of load that can be supplied at Bombay is constrained by the capacity of the circuits supplying Bombay and the generation dispatch patterns both in the Auckland and Waikato regions.

High generation in Auckland and low generation in Waikato is the most constraining scenario with an Otahuhu–Wiri Tee circuit overloading for outage of the parallel Otahuhu–Wiri Tee circuit.

Solution

This issue of transmission capacity into Bombay is related to a number of other issues involving Wiri:

- Otahuhu–Wiri Tee transmission capacity (Section 8.8.9)
- Wiri supply transformer capacity (Section 8.8.14), and
- Bombay–Wiri Tee transmission capacity (Section 8.9.3).

The Bombay transmission capacity issue may be partially or wholly resolved by the solutions to the other issues but additional work, such as a new GXP, may be required.

8.8.3 Henderson interconnecting transformer capacity

Project description:	Resolve transformer capacity constraints
Project status/type:	Possible, Base Capex
Indicative timing:	To be advised
Indicative cost band:	A

Issue

There are two 220/110 kV interconnecting transformers at Henderson, providing:

- a total nominal installed capacity of 400 MVA, and
- n-1 capacity of 229/229 MVA[46] (summer/winter).

Loading on these transformers may exceed their n-1 capacity during peak load from 2014.

In addition, Vector is able to transfer load from Penrose to Mount Roskill. This is approximately 90 MW under normal operation, and approximately 200 MW under extreme circumstances. If this occurs during peak load periods, the load on the Henderson interconnecting transformers will exceed their n-1 capacity.

Solution

We will monitor the issue and, if required, will replace the limiting switchgear on the Henderson interconnecting transformer to enable full use of their post-contingency capacity of 254/270 MVA (summer/winter).

In addition, the interconnecting transformers at Henderson have an expected end-of-life within the forecast period. One possible option is to replace both existing interconnecting transformers at Henderson with 250 MVA units. The appropriate replacement option will be considered and carried out in conjunction with the Albany interconnecting transformer replacement (see Section 8.5).

8.8.4 Otahuhu interconnecting transformer capacity

Project status/type:	This issue is for information only

Issue

The Otahuhu 110 kV bus is normally operated split with two separate buses to give better load distribution and manage fault levels.

There are two pairs of 220/110 kV interconnecting transformers at Otahuhu.

One pair (T2 and T4, rated at 100 MVA and 200 MVA, respectively) supplies the 110 kV bus section with circuits to Bombay, Penrose and Wiri 110 kV substations, providing:

- a total nominal installed capacity of 300 MVA, and
- n-1 capacity of 135/145 MVA (summer/winter).

One pair (T3 and T5, rated at 250 MVA each) supplies the 110 kV bus section with circuits to the Mangere and Mount Roskill 110 kV substations, providing:

- a total nominal installed capacity of 500 MVA, and
- n-1 capacity of 318/332 MVA (summer/winter).

Otahuhu–T2 and T4 are effectively in parallel with the Penrose–T6 and T10 and Hobson Street T12 interconnecting transformers through the Otahuhu–Penrose–Hobson Street transmission and distribution systems.

Toward the middle of the forecast period, the T2 transformer may exceed its post-contingency capacity at peak load times for an outage of the T4 transformer.

46 The transformer's capacity is limited by switchgear; with this limit resolved, the n-1 capacity will be 254/270 MVA summer/winter.

Solution

The recent addition of an interconnecting transformer at Hobson Street, and paralleling of Vector's 110 kV distribution system between Penrose and Hobson Street, have increased capacity and security to the Auckland CBD loads.

Additionally, the Otahuhu–T2 and Penrose–T10 interconnecting transformers have an expected end-of-life within the forecast period.

We are investigating a long-term solution that will allow the most efficient use of transmission and distribution assets across the Otahuhu, Penrose and Hobson Street substations.

8.8.5 Henderson supply transformer capacity

Project description:	Supply transformer capacity increase
Project status/type:	Possible, customer-specific
Indicative timing:	To be advised
Indicative cost band:	B

Issue

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

- a total nominal installed capacity of 240 MVA, and
- n-1 capacity of 135/135 MVA[47](summer/winter).

The peak load at Henderson is forecast to exceed the transformers' n-1 winter capacity by approximately 1 MW in 2016, increasing to approximately 45 MW in 2029 (see Table 8-6).

Table 8-6: Henderson supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Henderson	1.00	0	0	1	4	7	11	18	25	32	39	45

Solution

We will convert the Henderson 33 kV outdoor switchgear to an indoor switchboard within the next five years. This will raise the n-1 limit but will not resolve the issue.

In addition, Vector has the ability to shift load between Henderson and Hepburn Road, providing an operational solution when the issue arises. A longer-term option is to install a third supply transformer. This will be considered in the new indoor switchboard design.

8.8.6 Mangere supply transformer capacity

Project description:	Supply transformer capacity increase
Project status/type:	Possible, Base Capex
Indicative timing:	2014
Indicative cost band:	A

Issue

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

47 The transformers' capacity is limited by a bus section, circuit breaker and disconnector; with these limits resolved, the n-1 capacity will be 144/150 MVA (summer/winter).

- a total nominal installed capacity of 240 MVA, and
- n-1 capacity of 118/118 MVA[48] (summer/winter).

The peak load at Mangere is forecast to exceed the transformers' n-1 winter capacity by 1 MW in 2014, increasing to approximately 27 MW in 2029[49] (see Table 8-7).

Table 8-7: Mangere supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Mangere	0.98	1	2	4	6	7	9	13	16	20	23	27

Solution

We are investigating the option of increasing the protection limits on these transformers.

In addition, we also plan to convert the Mangere 33 kV outdoor switchgear to an indoor switchboard within the next five years.

Future development options to increase transformer capacity for this grid exit point will be customer driven.

8.8.7 Mount Roskill supply transformer capacity

Project status/type:	This issue is for information only

Issue

Three 110/22 kV transformers (one rated at 50 MVA and two at 70 MVA each) supply Mount Roskill's load, providing:

- a total nominal installed capacity of 190 MVA, and
- n-1 capacity of 140/141 MVA[50] (summer/winter).

The peak load at Mount Roskill is forecast to exceed the transformers' n-1 winter capacity by 8 MW in 2014, increasing to 32 MW in 2029 (see Table 8-8).

Table 8-8: Mount Roskill supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2018	2021	2023	2025	2027	2029
Mount Roskill	0.98	8	11	13	15	6	8	13	17	22	27	32

Solution

The issue can be managed operationally in the short-term. The load is temporarily increased until 2017 due to major road tunnelling works in the area.

The Mount Roskill–T3 supply transformer has an expected end-of-life within the forecast period. In addition, we also plan to convert the 22 kV outdoor switchyard to an indoor switchboard within the forecast period.

48 The transformers' capacity is limited by a protection equipment limit; with this limit resolved, the n-1 capacity will be 138/144 MVA (summer/winter).

49 The effect of the recently announced sale of Pacific Steel is not included in the load forecast for Mangere.

50 The transformer's capacity is limited by a circuit breaker limit on the 50 MVA transformer and relay limits on the 70 MVA transformers; with auxiliary equipment limits resolved, the n-1 capacity will be 145/152 MVA (summer/winter).

Vector has indicated a preference for a 33 kV supply at this grid exit point in the longer term.

We will discuss the ratings and timing for the replacement transformer with Vector. Further development options to increase transformer capacity for this grid exit point will be customer driven.

8.8.8 Otahuhu–Penrose 110 kV transmission capacity

Project description:	Resolve terminal spans constraint at Otahuhu Replace transformers
Project status/type:	Resolve terminal spans constraint at Otahuhu: possible, Base Capex Replace transformers: possible, Base Capex
Indicative timing:	Resolve terminal spans constraint: 2021 Upgrade transmission circuit: to be advised
Indicative cost band:	Resolve terminal spans constraint: A Replace transformers: C

Issue

The 110 kV Otahuhu–Penrose circuit is rated at 177/195 MVA (summer/winter). After commissioning of the NIGU project, an outage of the Penrose–T10, 220/110 kV transformer will cause the circuit to overload from 2026.

Solution

The Otahuhu–Penrose 110 kV circuit is limited by the terminal spans at Penrose substation. With this limit removed, the circuit rating is 191/210 MVA, which will delay the issue in the short term.

Longer-term solutions include:

- replacing the old Otahuhu–T2 and T4 interconnecting transformers with higher impedance transformers (see Section 8.8.4) and/or
- reconfiguring the Auckland interconnectors and 110 kV transmission system (see Section 8.2.2).

Thermally upgrading and/or reconductoring is unlikely as there is a 2.6 km cable section in this circuit that limits capacity to 200/211 MVA.

8.8.9 Otahuhu–Wiri Tee 110 kV transmission capacity

Project description:	Transmission capacity increase
Project status/type:	Possible, Base Capex
Indicative timing:	To be advised
Indicative cost band:	C

Issue

Two 110 kV Bombay–Wiri–Otahuhu circuits supply Wiri's load, with the:

- Bombay–Wiri section of each circuit rated at 62/76 MVA (summer/winter), and
- Otahuhu–Wiri section of each circuit rated at 92/101 MVA (summer/winter).

Wiri is a double hard tee connection, and an outage of one of the 110 kV Bombay–Wiri–Otahuhu circuits is forecast to overload the Otahuhu–Wiri section of the remaining circuit during peak load periods from 2015. This will occur during periods of high Auckland generation and low Waikato generation.

Solution

In the short term, Vector can limit Wiri load with future load growth transferred to other grid exit points. Possible longer-term options are:

- a new 110 kV cable from Otahuhu to a new 110/33 kV supply transformer at Wiri
- a new 110/33 kV transformer at Otahuhu and a new 33 kV cable to Wiri
- reconductoring the 110 kV Otahuhu–Wiri circuits with higher capacity conductor, or
- a new 220/110 kV connection at Bombay substation on the Huntly–Otahuhu circuit (to reinforce the supply to Wiri from Bombay) and a 110 kV bus at Wiri.

See also the Wiri supply transformer capacity issue (Section 8.8.15) and the Bombay–Wiri Tee transmission capacity issue (Section 8.9.3).

8.8.10 Otahuhu supply transformer capacity

Project description:	Replace supply transformer, capacity increase.
Project status/type:	Possible, customer-specific
Indicative timing:	To be advised
Indicative cost band:	B

Issue

Two 220/22 kV transformers supply Otahuhu's load, providing:

- a total nominal installed capacity of 100 MVA, and
- n-1 capacity of 59/59 MVA[51] (summer/winter).

The peak load at Otahuhu is forecast to exceed the n-1 winter capacity by 11 MW in 2014, decreasing to approximately 7 MW in 2029 (see Table 8-9).

Table 8-9: Otahuhu supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Otahuhu	1.00	11	11	11	11	7	7	7	7	7	7	7

Solution

Upgrading the LV cable and removing the bushing constraints on the supply transformers will not resolve the issue.

We will discuss other options with Vector, which include:

- limiting peak load to the firm transformer capacity, with future load growth transferred to other grid exit points
- adding a third supply transformer, or
- replacing the two existing supply transformers with higher-rated units.

Both supply transformers have an expected end-of-life within the forecast period. We will discuss the ratings and timing for the replacement transformers with Vector. Further development options to increase transformer capacity for this grid exit point will be customer driven.

8.8.11 Penrose 33 kV supply transformer capacity

Project status/type:	This issue is for information only

51 The transformers' capacity is limited by LV cable ratings, followed by a transformer bushings limit (64 MVA); with these limits resolved, the n-1 capacity will be 67/71 MVA (summer/winter).

Issue

Three 220/33 kV transformers (two rated at 200 MVA and one at 160 MVA) supply Penrose's load, providing:

- a total nominal installed capacity of 560 MVA, and
- n-1 capacity of 429/450 MVA (summer/winter).

The peak load at Penrose is forecast to exceed the transformers' n-1 winter capacity by approximately 7 MW in 2021, increasing to approximately 53 MW in 2029 (see Table 8-10).

Table 8-10: Penrose supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Penrose	0.98	0	0	0	0	0	0	7	18	30	41	53

Solution

We are discussing future development options for this connection point with Vector. It is expected that the peak load will be limited to the firm transformer capacity, with future load growth transferred to other grid exit points. Vector has announced plans to build a new zone substation at Newmarket that will eventually take load off the Penrose 33 kV bus.

A 220/33 kV system spare supply transformer is located at Penrose. This allows us to manage outages of the existing three supply transformers for the next 15 years. The firm capacity is not increased, because only three of the four transformers are permanently connected.

Additionally, we also plan to convert the Penrose 33 kV outdoor switchyard to an indoor switchboard within the forecast period.

8.8.12 Silverdale supply transformer capacity

Project description:	Resolve supply transformer metering constraints
Project status/type:	Possible, Base Capex
Indicative timing:	2029
Indicative cost band:	A

Issue

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

- a total nominal installed capacity of 220 MVA, and
- n-1 capacity of 109/109 MVA[52] (summer/winter).

The peak load at Silverdale is forecast to exceed the transformers' n-1 winter capacity by approximately 4 MW in 2029 (see Table 8-11).

Table 8-11: Silverdale supply transformer overload forecast

Circuit/grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Silverdale	1.00	0	0	0	0	0	0	0	0	0	0	4

52 The transformers' capacity is limited by a metering limit, followed by a cable limit (120 MVA); with these limits resolved, the n-1 capacity will be 126/132 MVA (summer/winter).

Solution

Recalibrating the metering parameters resolves the issue for the forecast period and beyond.

8.8.13 Takanini supply transformer capacity

Project description:	Upgrade transformer branch limiting components
Project status/type:	Possible, Base Capex
Indicative timing:	2014-2016
Indicative cost band:	Upgrade transformer branch limiting components: A

Issue

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

- a total nominal installed capacity of 300 MVA, and
- n-1 capacity limit of 126/126 MVA[53] (summer/winter).

The peak load at Takanini is forecast to exceed the transformers' n-1 winter capacity by 13 MW in 2014, increasing to approximately 47 MW in 2029 (see Table 8-12).

Table 8-12: Takanini supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Takanini	0.99	13	15	17	19	25	27	31	35	39	43	47

Solution

Vector has advised that they expect to keep peak load within the transformers' n-1 capacity for several years.

The Takanini 33 kV outdoor switchyard will be converted into an indoor switchboard within the next five years. Upgrading the protection in conjunction with the 33 kV conversion provides sufficient capacity beyond the forecast period; however, the 33 kV equipment will have an unusually high rating.

The equipment configuration is also unusual for the high level of load forecast for Takanini. The transformers are connected in a double tee configuration to the 220 kV circuits, which is typically used for loads less than half that at Takanini. Also, typically two transformers are used to supply a maximum of 120 to 150 MW of load[54], after which a third transformer is installed. It is expected that a third supply transformer and a 220 kV bus upgrade will be required within the forecast period to improve the level of security at Takanini.

Further development options to increase the transformer capacity for this grid exit point will be customer driven.

8.8.14 Wiri supply transformer capacity

Project description:	Upgrade protection Upgrade transformer capacity
Project status/type:	Upgrade protection: possible, Base Capex Upgrade transformer capacity: possible, customer-specific
Indicative timing:	Upgrade protection: 2021 Upgrade transformer capacity: 2027

53 The transformers' capacity is limited by protection equipment limit, followed by the circuit breaker (137 MVA) and 33 kV bus (137 MVA) limits; with these limits resolved, the n-1 capacity will be 188/198 MVA (summer/winter).

54 The Takanini load is forecast to reach 130 MW in 2014 and 150 MW in 2021.

Indicative cost band:	Upgrade protection: A Upgrade transformer capacity: B

Issue

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

- a total nominal installed capacity of 200 MVA, and
- n-1 capacity limit of 106/106 MVA[55] (summer/winter).

The peak load at Wiri will exceed the transformers' summer n-1 capacity by approximately 4 MW in 2021, increasing to approximately 20 MW in 2029 (see Table 8-13).

Table 8-13: Wiri supply transformer overload forecast

Grid exit point	Power factor	Transformer overload (MW)										
		Next 5 years						5-15 years out				
		2014	2015	2016	2017	2018	2019	2021	2023	2025	2027	2029
Wiri	0.99	0	0	0	0	0	0	4	8	12	16	20

Solution

Resolving the protection equipment limits will delay the overload until approximately 2027. We will discuss future supply options with Vector, including:

- limiting peak load to the firm transformer capacity (i.e. 106/106 MVA), with future load growth transferred to other grid exit points, and/or
- replacing the existing transformers with two 120 MVA units, or
- installing a third supply transformer.

The solution to the Otahuhu–Wiri transmission capacity issue may also address the Wiri supply transformer capacity issue (see Section 8.8.9).

The Wiri single phase supply transformers have an expected end-of-life within the next five years. In addition, we also plan to convert the Wiri 33 kV outdoor switchyard to an indoor switchboard within the same timeframe.

We will discuss with Vector the rating, timing and number of transformer replacements in conjunction with the transformer upgrade and 33 kV outdoor to indoor switchyard conversion work.

Any future transformer upgrade will be customer driven.

8.8.15 Wiri Tee transmission capacity

Project status/type:	This issue is for information only

Issue

Wiri is connected to the Bombay–Wiri–Otahuhu circuits through the Wiri Tee circuit sections, each rated at 92/101 MVA (summer/winter).

The peak load at Wiri already exceeds the circuits' n-1 summer capacity.

Solution

This issue arises along with the Otahuhu–Wiri circuit issue (see Section 8.8.9) and is expected to be resolved with that issue's solution. Although the Wiri Tee section is

55 The transformers' capacity is limited by protection equipment limit; with this limit resolved, the n-1 capacity will be 109/115 MVA (summer/winter).

only approximately 90 metres in length, it crosses over a motorway, which is expected to complicate an otherwise relatively minor project to increase this circuit section's capacity.

8.9 Auckland 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).

8.9.1 Transmission bus security

Table 8-14 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 8-14: Transmission bus outages

Transmission bus outage	Loss of supply	Generation disconnection	Transmission issue	Further information
Bombay 110 kV	Bombay 33 kV			See note 1
	Meremere			See note 2
Hepburn Road 110 kV			Henderson–Hepburn Road overloading	
Mount Roskill 110 kV	Mount Roskill 110 kV			See note 3
	Mount Roskill 22 kV			See note 3
Southdown 220 kV		Southdown		
Otahuhu 110 kV			Bombay–Wiri Tee overloading	8.9.3
			Otahuhu–Mangere–Mount Roskill overloading	8.9.4

1. Bombay has two 110 kV bus sections. However, both Bombay supply transformers are connected to the same 110 kV bus section.
2. Meremere is supplied from the Bombay 33 kV, so issues affecting Bombay also affects Meremere.
3. Vector has confirmed their support for the installation of a 110 kV bus section circuit breaker at Mount Roskill 110 kV bus to alleviate the risk of total loss of supply in the event of a bus fault.

The customers (Counties Power, Vector, or Mighty River Power) have not requested a higher security level (excluding the Mount Roskill 110 kV bus). 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.

8.9.2 Henderson–Hepburn Road transmission capacity

Project status/type:	This issue is for information only

Issue

An outage of a 110 kV bus section at Hepburn Road will cause the Henderson–Hepburn Road–3 and 4 circuits to exceed their thermal capacity from 2027.

Solution

A number of other network developments, particularly in the Auckland region, are likely to influence the severity and timing of this issue. We will monitor this issue as these developments take place.

8.9.3 Bombay–Wiri Tee transmission capacity

Project status/type:	This issue is for information only

Issue

The Bombay–Wiri Tee section of the Bombay–Otahuhu circuits are rated at 62/76 MVA (summer/winter). The Bombay–Wiri Tee–2 will overload from 2014 for a 110 kV bus section outage at Otahuhu that disconnects:

- Otahuhu–T4, and
- Otahuhu–Wiri Tee–1 and 2.

Solution

The overload occurs due to unequal load sharing of the Wiri supply transformers because the transformers have different characteristics and the Wiri 110 kV bus is split.

Most of the options to address the Otahuhu–Wiri 110 kV transmission capacity (see Section 8.8.9) or the Wiri supply transformer capacity (see Section 8.8.14) will also address this issue.

Another option is to upgrade Wiri 110 kV to a full bus and close the split. This addresses the issue until near the end of the forecast period, when additional reactive support at Bombay is required to remove the overload until after the forecast period.

8.9.4 Otahuhu–Mount Roskill transmission capacity

Project description:	Increase transmission capacity
Project status/type:	Possible, Base Capex
Indicative timing:	2025
Indicative cost band:	A

Issue

The Otahuhu–Mount Roskill 110 kV circuits are rated at 95/102 MVA[56] (summer/winter). These circuits will overload from 2025 for an outage of a 110 kV bus section at Otahuhu that disconnects:

- Otahuhu–T5
- Mangere–Otahuhu–1 and 2, and
- Otahuhu Capacitors C11 and C12.

Solution

One option is to swap the Mangere–Otahuhu–1 and Otahuhu–Mount Roskill–2 circuits at Otahuhu. This resolves the issue until the end of the forecast period.

[56] The circuits' capacity is limited by a cable limit. With this limit resolved; the circuits' capacity will be 95/105 MVA (summer/winter).

8.10 Other regional items of interest

8.10.1 Otahuhu–Wiri–Bombay transmission capacity

The Bombay transmission capacity issue (Section 8.8.2), the Otahuhu–Wiri Tee transmission capacity issue (Section 8.8.9) and the Wiri supply transformer capacity issue (Section 8.8.14) will all be investigated together as part of a Bombay regional plan. This integrated work plan will begin in 2014.

8.11 Auckland 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.

8.11.1 Maximum regional generation

The Auckland region has some of the highest load densities in New Zealand, coupled with relatively low levels of local generation, and so there is no practical limit to the maximum generation that can be connected within the region. However, there will be limits on the maximum generation that can be connected at a substation or along an existing line due to the rating of the existing circuits.

8.11.2 Auckland generation issues

There are numerous inter-related issues with supplying the load within the Auckland region, as discussed earlier in this chapter. In addition, the increase in fault level due to generators will be an issue for some parts of the transmission and/or distribution systems.

Therefore, depending on its connection point, new generation within the Auckland region may assist in addressing an issue, make it worse, have no effect, or may require specific additional transmission investment to enable connection. Fault-level issues may also preclude new generation connection in some locations.

