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.

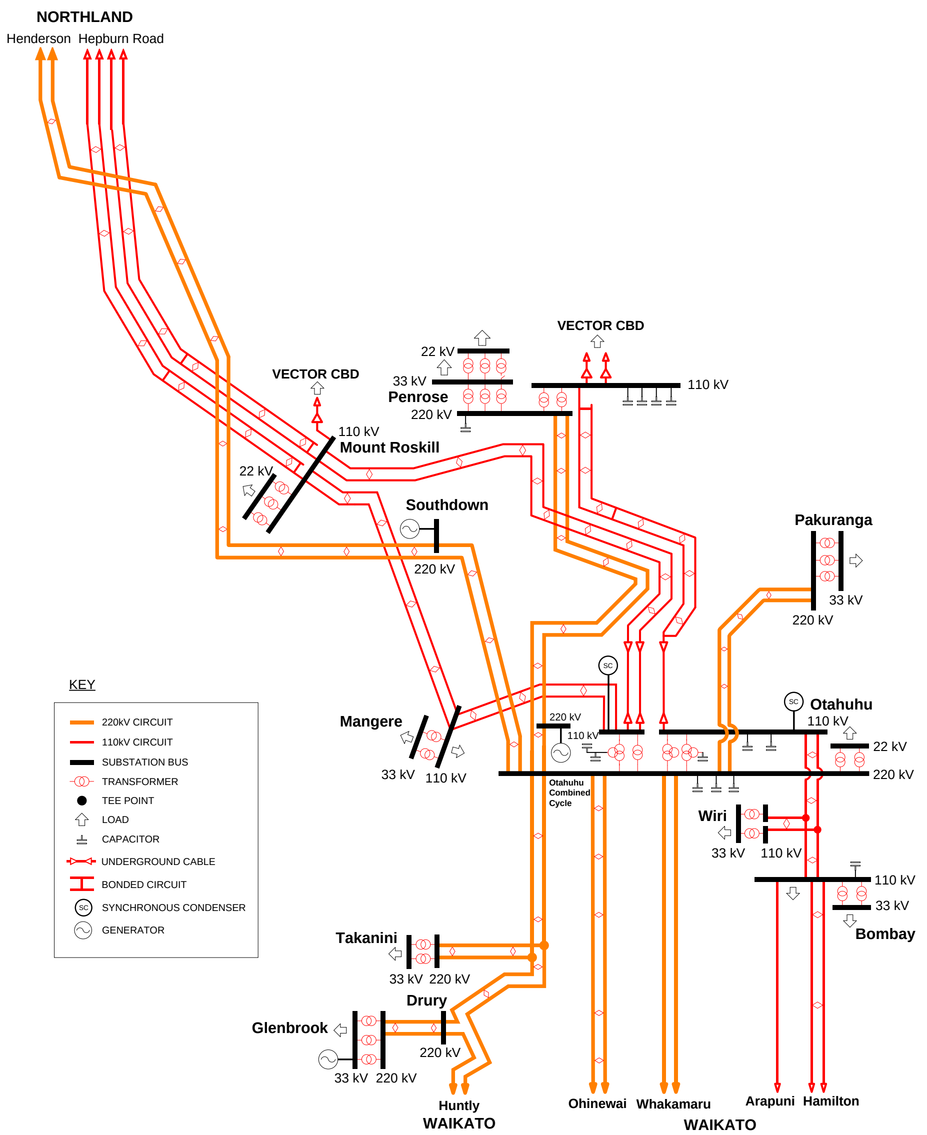
We have assessed the Auckland region's transmission needs over the next 15 years while considering longer-term development opportunities. Specifically, the transmission network needs to be flexible to respond to a range of future service and technology possibilities, taking into consideration:

- 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/through the region

As approximately 70% 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.

There are three major projects and a series of small projects that we are progressing to ensure that the Auckland region has secure transmission as demand continues to grow.

Broader project descriptions that provide a context for the issues identified in later sections include the:

- North Island Grid Upgrade (NIGU) project
- North Auckland and Northland (NAaN) grid upgrade project, and
- Upper North Island Reactive Support (UNIRS) project.

North Island Grid Upgrade (NIGU) project

This committed project includes building a new transmission link into the Pakuranga substation from the south, operating the existing Otahuhu–Pakuranga line at its design voltage of 220 kV (previously operating at 110 kV), and providing additional reactive support for the area to maintain voltages in the Auckland and Northland regions (see Chapter 6, Sections 6.3.2 and 6.4.2).

This project:

- provides additional transmission capacity into the Auckland region (see Section 6.4.2)
- provides diversity for transmission from the south into the Auckland region (all existing 220 kV transmission circuits terminate into Otahuhu), and
- converts Pakuranga from 110 kV to 220 kV, which reduces the load on the 110 kV system supplying the eastern side of the Auckland region, including Penrose.

North Auckland and Northland (NAaN) grid upgrade project

This committed project adds new transmission capacity between the Pakuranga, Penrose, and Albany substations. It also enables the building of new grid exit points at Hobson Street (Auckland CBD) and Wairau Road (North Shore). The NAaN project reinforces transmission in the Auckland region and across into the Northland region. The 220 kV circuit from Pakuranga to Penrose will:

- increase capacity to the Penrose 220 kV bus by adding a third 220 kV circuit alongside the existing 220 kV Otahuhu–Penrose double-circuit line, and
- build on the NIGU project by increasing the diversity for transmission from the south into the Auckland region, as there will be 220 kV transmission from Pakuranga to Otahuhu and Penrose.

The 220 kV circuit from Penrose to Albany will:

- increase capacity to the Northland region (including the North Isthmus) by adding a third 220 kV circuit from Otahuhu to Henderson
- build on the NIGU project by increasing the diversity for transmission from the south into the Northland region (including the North Isthmus), as there will be 220 kV transmission from Pakuranga, through Penrose, to Albany
- provide capacity and security to Vector's Hobson Street and Wairau Road substations through a 220 kV connection to the Albany–Penrose circuit, and
- enable Vector to redistribute load from existing grid exit points, particularly the Albany 33 kV and 110 kV (Wairau Road) loads and Auckland CBD loads.

Upper North Island Reactive Support (UNIRS) project

The purpose of this project is to relieve voltage stability issues associated with an outage of major generators and/or circuits supplying the Upper North Island area (see Chapter 6). It includes installing dynamic reactive support at Penrose and Marsden.

8.2.2 Transmission and distribution network within the region

The Auckland transmission network consists of three layers: the 220 kV network, the 110 kV network, and the 110 kV distribution system belonging to the local lines company, Vector.

220 kV transmission network

The 220 kV network supplies Otahuhu from the south, via a double-circuit line from Huntly, a double-circuit line from Whakamaru via Ohinewai, and two single-circuit lines from Whakamaru.

At Otahuhu the 220 kV network splits into two with one network supplying Penrose via a double-circuit line, and the other network supplying the Northland region (including the North Isthmus) via a second double-circuit line to Henderson.

The commissioning of a new 220 kV substation at Otahuhu (physically separated from the existing switchyard) provides physical diversity, making the power supply more resilient for rare but high-impact disturbances.

110 kV transmission network

The 110 kV transmission network is split into two parts.

- One half of the 110 kV network is a backup supply to Penrose, in parallel with the 220 kV Otahuhu–Penrose double circuit line, with 220/110 kV interconnectors at Otahuhu and Penrose. The 110 kV system also connects to the Waikato region by a Bombay–Wiri–Otahuhu double-circuit line, with power flow generally south out of Otahuhu.
- The other half of the 110 kV network supplies Mangere and Mount Roskill in a double-circuit ring, extending from Mount Roskill through a double-circuit 110 kV connection to substations in the Northland region (at Henderson and Albany). There are 220/110 kV interconnections at Otahuhu, Henderson, and Albany, making the 110 kV network parallel with the 220 kV Otahuhu–Henderson double-circuit line. Power flow is generally into Mount Roskill on all circuits, from both Otahuhu and the Northland region.

110 kV distribution system

Vector's 110 kV distribution system connects from Penrose to Mount Roskill via Vector's Liverpool Street substation, and is normally split between Mount Roskill and Liverpool Street. However, it is often used to transfer the Liverpool Street load (up to 90 MW) between the Penrose and Mount Roskill substations.

8.2.3 Reactive power

To improve the network voltage and voltage stability, static capacitors are installed at the Otahuhu, Penrose, and Bombay substations. Condensers at Otahuhu provide dynamic reactive power under contract.

8.2.4 Longer-term development path

We have identified a longer-term development path to address issues involving transmission into, within and through the Auckland region, the details of which will be revisited 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:

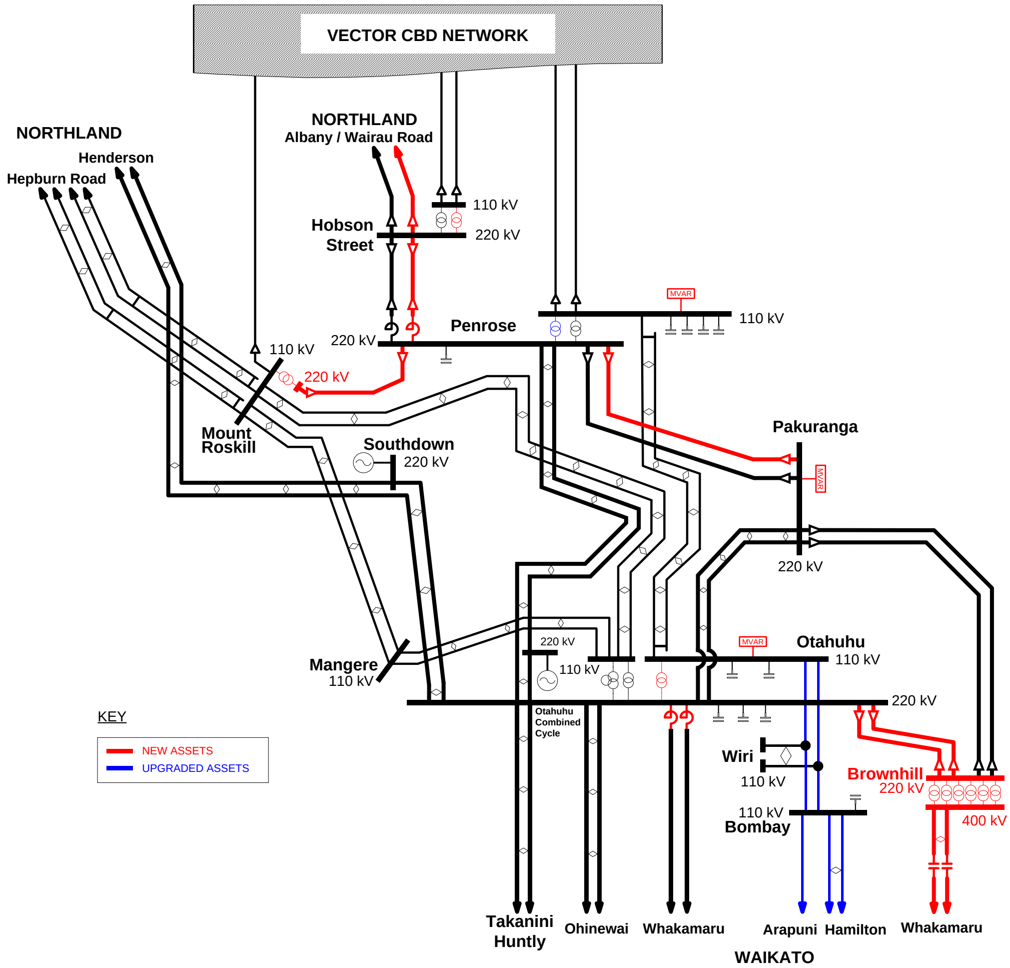
- Installation of series compensation on the 220 kV Pakuranga–Whakamaru circuits to improve load sharing with the other 220 kV circuits. Ultimately, the Brownhill–Whakamaru section of the Pakuranga–Whakamaru circuits will be upgraded to operate at 400 kV, by installing 400/220 kV transformers at Brownhill 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 re-conductoring with higher-capacity conductors.
- Transmission reinforcement within the Auckland region via additional cables between Pakuranga, Penrose, and Mount Roskill.
- Transmission reinforcement into the Northland region via a second cable between Penrose and Albany.
- Additional static and dynamic reactive power support approximately every 2 to 3 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 spatial plan (particularly in the South Auckland area) will have a large influence on future options for increasing transmission capacity into Auckland.

Figure 8-3 provides an indication of the possible transmission development within and through Auckland in the longer term (beyond 2027).

Figure 8-3: Indicative Auckland and Northland region schematic beyond 2027



8.3 Auckland demand

The after diversity maximum demand (ADMD) for the Auckland region is forecast to grow on average by 2.1% annually over the next 15 years, from 1,530 MW in 2012 to 2,078 MW by 2027. This is higher than the national average demand growth of 1.7% annually.

Figure 8-4 shows a comparison of the 2011 and 2012 forecast 15-year maximum demand (after diversity[48]) for the Auckland 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.

[48] 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.

Figure 8-4: Auckland region after diversity maximum demand forecast

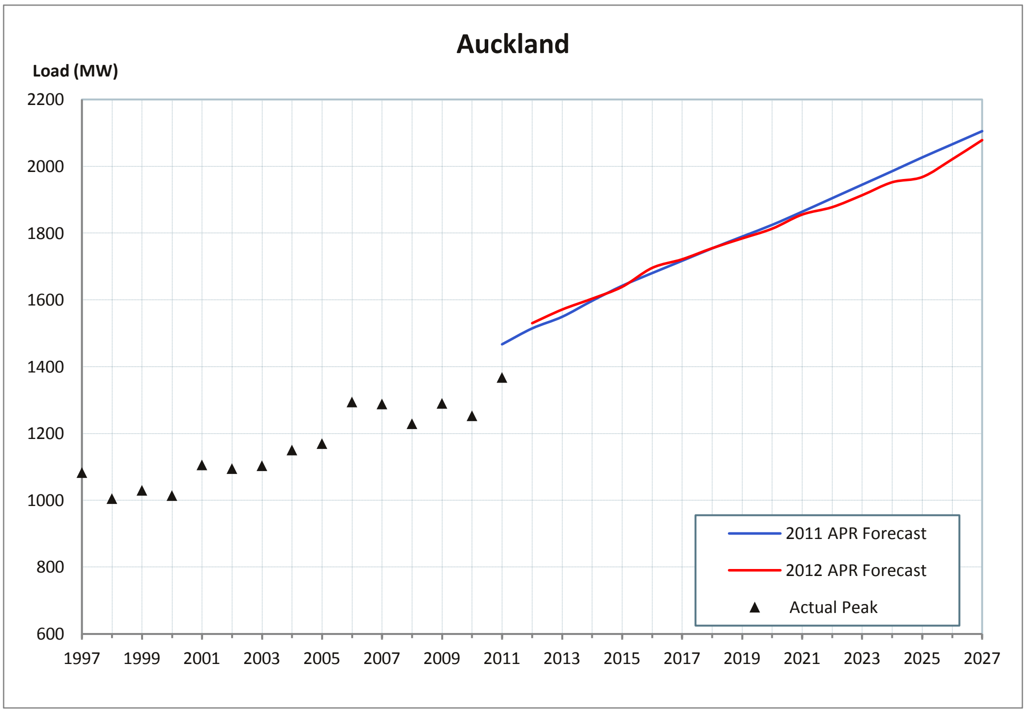


Table 8-1 lists forecast peak demand (prudent growth) for each grid exit point for the forecast period, as required for the Grid Reliability Report.

Table 8-1: Forecast annual peak demand (MW) at Auckland 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
Bombay 33 kV[1]	0.98	25	26	26	27	14	14	14	0	0	0	0
Bombay 110 kV[1]	1.00	51	52	53	54	69	70	73	90	93	96	98
Glenbrook 33 kV	1.00	32	33	33	34	35	35	37	38	39	40	41
Glenbrook NZ Steel	0.99	116	116	120	120	120	120	120	120	120	120	120
Hobson Street[2, 3]	0.97	0	0	126	130	134	137	144	150	155	161	164
Mangere 33 kV	0.94	115	119	122	126	129	133	141	149	155	161	166
Mangere 110 kV	0.87	55	55	55	55	55	55	55	55	55	55	55
Meremere[4]	0.95	14	14	15	15	0	0	0	0	0	0	0
Mt Roskill 22 kV	0.98	130	134	138	142	146	151	160	168	175	182	187
Mt Roskill 110 kV – Kingsland	0.97	66	68	70	72	74	76	80	83	86	89	91
Otahuhu	0.99	66	69	71	73	75	77	82	86	91	95	100
Pakuranga	0.98	163	167	171	174	178	182	189	196	203	210	218
Penrose 22 kV	0.96	50	52	53	55	56	58	62	65	67	70	72
Penrose 33 kV	0.98	300	309	318	328	338	348	369	388	403	420	432
Penrose 110 kV - Liverpool Street[3]	0.97	238	246	126	130	134	137	144	150	155	161	164
Penrose 110 kV - Quay Street[5]	NA	0	0	0	0	0	0	0	0	0	0	0
Takanini[6]	0.99	125	129	133	137	141	145	154	162	168	175	180
Wiri	0.99	82	85	87	90	92	95	101	106	110	115	118

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

1. The customer advised that approximately half of the load will shift from Bombay 33 kV to Bombay 110 kV in 2016, with the balance of the load shifting in 2020.
2. A new grid exit point at Hobson Street is planned to be commissioned in 2013/2014. Some of the Penrose–Liverpool Street load will be transferred to Hobson Street.
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 customer advised that the load at Meremere will be shifted to Huntly (in the Waikato region) in 2016.
5. The Penrose 110 kV–Quay Street load has been transferred to Penrose–Liverpool Street and the Penrose–Quay Street circuits decommissioned.
6. The customer advised that their forecast is lower than Transpower's forecast.

8.4 Auckland generation

The Auckland region's generation capacity is approximately 681 MW.

Table 8-2 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 (Vector or Counties Power).[49]

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

Table 8-2: Forecast annual generation capacity (MW) at Auckland 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
Glenbrook[1]	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)	5	5	5	5	5	5	5	5	5	5	5
Penrose (Auckland Hospital)	4	4	4	4	4	4	4	4	4	4	4
Southdown CCGT	170	170	170	170	170	170	170	170	170	170	170
Takanini (Whitford Landfill)	3	3	3	3	3	3	3	3	3	3	3

1. This is a 38 MW embedded generating unit with a continuous output rating of 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[50] proposed for the Auckland region for the next 15 years that may significantly impact related system issues or connected parties.

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

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

Table 8-3: Proposed significant maintenance work

Description	Tentative year	Related system issues
Bombay supply transformers expected end-of-life, and 33 kV outdoor to indoor conversion	2018-2020 2016-2018	Bombay supply transformer capacities are sufficient for the forecast period. The customer may relinquish 33 kV supply from Bombay within 10-20 years.
Mangere 33 kV outdoor to indoor conversion	2014-2016	The forecast load will exceed the transformer n-1 capacity from 2012. The n-1 capacity is limited by protection limit. If appropriate, the work to resolve this limit will be coordinated with the 33 kV outdoor to indoor conversion work. See Section 8.8.5 for more information.
Mount Roskill supply transformer T3 expected end-of-life, and 22 kV outdoor to indoor conversion	2015-2019	The Mount Roskill load is forecast to exceed the transformer n-1 capacity from 2012. The n-1 capacity is limited by a few branch components initially, and then the transformers need a capacity upgrade by 2020 to meet n-1 capacity. See Section 8.8.6 for more information.
Otahuhu interconnecting transformer expected end-of-life	2019-2021	The options to replace the transformers must be coordinated with the: Penrose T10 interconnecting transformer replacement – see Section 8.8.3 for more information Otahuhu–Wiri transmission capacity issue – see Section 8.8.8 for more information, and Otahuhu–Penrose 110 kV transmission capacity issue – see Section 8.8.10
Otahuhu supply transformers expected end-of-life	2021-2023	The Otahuhu load already exceeds the transformers' n-1 capacity. See Section 8.8.7 for more information.
Penrose T10 interconnecting transformer expected end-of-life	2017-2019	This work will be coordinated with the Otahuhu interconnecting transformer replacement. See Section 8.8.3 for more information.
Penrose supply transformers expected end-of-life, and 33 kV outdoor to indoor conversion	2026-2028 2012-2014	A spare transformer enables us to manage the existing three supply transformers for the next 15 years. See 8.8.11 for more information
Takanini 33 kV outdoor to indoor conversion	2014-2016	Takanini supply transformer n-1 capacity is limited by a few transformer branch component limits. If appropriate, the work to resolve these limits will be coordinated with the 33 kV outdoor to indoor conversion work. See Section 8.8.12 for more information.
Wiri supply transformer expected end-of-life and 33 kV outdoor to indoor conversion	2014-2017	The Wiri load is forecast to exceed the transformer n-1 capacity by 2019. See Section 0 for more information.

8.6 Future Auckland projects summary and transmission configuration

Table 8-4 lists projects to be carried out in the Auckland region within the next 15 years.

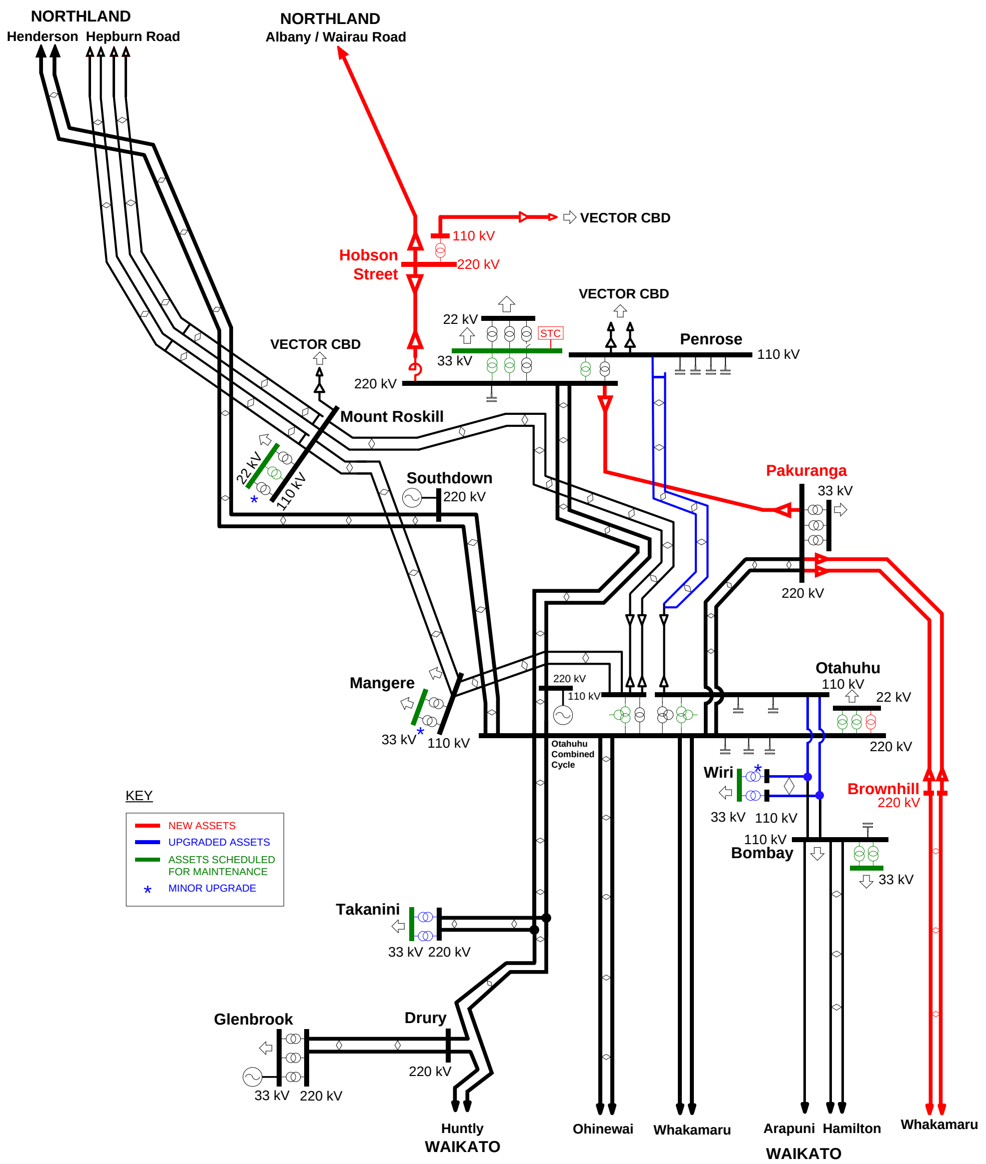
Figure 8-5 shows the possible configuration of Auckland transmission in 2027, with new assets, upgraded assets, and assets undergoing significant maintenance within the forecast period.

Table 8-4: Projects in the Auckland region up to 2027

Site	Projects	Status
Albany–Penrose	220 kV cables between Albany and Penrose.	Committed
Brownhill – Whakamaru	400 kV capable double-circuit transmission line.	Committed
Brownhill–Pakuranga	220 kV cables between Brownhill and Pakuranga.	Committed
Bombay	Replace 110/33 kV supply transformers.	Base Capex

Site	Projects	Status
	Convert 33 kV outdoor switchgear to an indoor switchboard.	Base Capex
Hobson Street	New substation at Hobson Street.	Committed
Mangere	Resolve supply transformer protection limits. Convert 33 kV outdoor switchgear to an indoor switchboard.	Base Capex Base Capex
Mount Roskill	Upgrade supply transformer branch limiting components. Replace Mount Roskill T3 supply transformer. Convert 22 kV outdoor switchgear to an indoor switchboard.	Possible Base Capex Base Capex
Otahuhu	Replace Otahuhu T2/T4 interconnecting transformers. Replace 220/22 kV supply transformers. Install a new 220/22 kV supply transformer.	Base Capex Base Capex Possible
Otahuhu–Wiri	Increase transmission capacity to Wiri.	Possible
Otahuhu–Penrose	Increase the circuit's capacity.	Possible
Pakuranga–Penrose	Install 220 kV cable between Pakuranga and Penrose.	Committed
Penrose	Install a new +/- 40 Mvar STATCOM at 33 kV bus. Replace Penrose T10 interconnecting transformer. Replace 220/33 kV supply transformer. Convert 33 kV outdoor switchgear to an indoor switchboard.	Committed Base Capex Base Capex Base Capex
Takanini	Upgrade supply transformer branch limiting components. Convert 33 kV outdoor switchgear to an indoor switchboard.	Possible Base Capex
Wiri	Resolve supply transformer's protection limits. New or upgrade the existing supply transformers' capacity. Convert 33 kV outdoor switchgear to an indoor switchboard.	Base Capex Possible Base Capex

Figure 8-5: Possible Auckland transmission configuration in 2027



8.7 Changes since the 2011 Annual Planning Report

Table 8-5 lists the specific issues that are either new or no longer relevant within the forecast period when compared to last year's report.

Table 8-5: Changes since 2011

Issues	Change
Pakuranga supply transformer capacity	Removed. Project to install a third transformer completed.
Otahuhu–Penrose 110 kV transmission capacity	New issue.
Bombay transmission security	Removed. Project to install a 110 kV bus coupler completed.

8.8 Auckland transmission capability

Table 6-2 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 8-6: Auckland region transmission issues

Section number	Issue
Regional	
8.8.1	Auckland region voltage quality
8.8.2	North Auckland and Northland regional transmission security
8.8.3	Otahuhu interconnecting transformer capacity
Site by grid exit point	
8.8.4	Hobson Street supply security
8.8.5	Mangere supply transformer capacity
8.8.6	Mount Roskill supply transformer capacity
8.8.7	Otahuhu supply transformer capacity
8.8.8	Otahuhu–Wiri 110 kV transmission capacity
8.8.9	Penrose 220 kV transmission security
8.8.10	Otahuhu–Penrose 110 kV transmission
8.8.11	Penrose 33 kV supply transformer capacity
8.8.12	Takanini supply transformer capacity
8.8.13	Wiri supply transformer capacity
8.8.14	Wiri Tee transmission capacity

8.8.1 Auckland region voltage quality

Project context:	UNIRS – Chapter 6, See Section 6.4.1 (UNIRS)

Issue

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

Solution

We have a number of projects underway to improve Auckland voltage, including a STATCOM at Penrose and a STATCOM at Marsden. Despite these projects, Auckland voltage stability is an ongoing issue requiring continual study as the Auckland and Northland regional loads grow.

8.8.2 North Auckland and Northland regional transmission security

Project context:	NAaN
Project reference:	ALB_PAK-TRAN-DEV-01
Project status/purpose:	Committed, to meet Grid Reliability Standard (core grid)
Indicative timing:	Q4 2013
Indicative cost band:	G

Issue

There are three issues with respect to Auckland transmission security.

- North Auckland and Northland supply can be maintained with n-1 security until winter 2016. From that date, further transmission reinforcement or a transmission alternative will be required.
- North Auckland and Northland load is supplied by a single 220 kV double-circuit overhead line, leaving this significant load at risk from a double-circuit outage.
- Vector requires transmission reinforcement in the Auckland CBD (Hobson Street) and on the North Shore (Wairau Road, in the Northland region) in 2014 and 2013, respectively.

Solution

We have committed to install a 220 kV underground cable link between the Pakuranga, Penrose and Albany substations, which:

- provides security of supply for the North Auckland and Northland beyond 2016
- improves transmission diversity into the North Auckland and Northland, and
- connects to new grid exit points at Hobson Street and Wairau Road.

The link will provide a capacity of approximately 790 MVA (winter). As the cable link will have significantly lower impedance than the parallel 220 kV overhead transmission circuits between Otahuhu, Henderson, and Albany, more power will flow through the cable than in the parallel circuits. A series reactor in the cable circuit is included to balance the power flow between the parallel routes.

8.8.3 Otahuhu interconnecting transformer capacity

Project status/purpose:	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 interconnecting transformers through the Otahuhu–Penrose transmission system.

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

Solution

The recent conversion of Pakuranga from 110 kV to 220 kV reduced the load on Otahuhu T2 and T4, and Penrose T6 and T10 transformers. These transformers now have sufficient capacity until the Auckland CBD load reaches approximately 300 MW. This is likely to occur in the second half of the forecast period or beyond. Any load permanently transferred to Hobson Street will also reduce the loading on the interconnecting transformers at Otahuhu and Penrose.

Additionally, the Otahuhu T2, T4 and Penrose T10 interconnecting transformers have an expected end-of-life within the forecast period. We will investigate the number and ratings for the replacement interconnecting transformers.

8.8.4 Hobson Street supply security

Project context:	NAaN
Project reference:	HOB-SUBEST-DEV-01
Project status/purpose:	Committed, customer-specific
Indicative timing:	2014
Indicative cost band:	D (including an initial 250 MVA 220/110 kV transformer)

Issue

Vector has indicated that to ensure security of supply, it requires reinforcement of its Hobson Street substation by 2014.

Solution

A new 220/110 kV grid exit point will be built at Hobson Street connecting to the new Albany–Penrose cable (see Section 8.8.2). This will also allow Vector to transfer some load from the Penrose 110 kV grid exit point.

8.8.5 Mangere supply transformer capacity

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

Issue

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

- a total nominal installed capacity of 240 MVA, and
- n-1 capacity of 118/118 MVA[51] (summer/winter).

The peak load at Mangere is forecast to exceed the transformers' n-1 winter capacity by 5 MW in 2012, increasing to approximately 56 MW in 2027 (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				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Mangere	0.94	5	9	12	16	20	24	32	39	45	51	56

Solution

We will discuss options with Vector. Possible solutions include:

- resolving the protection limit of the transformers which will solve the overload issue until 2018, or
- limiting the peak load to the transformer capacity, with future load growth transferred to other grid exit points.

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

51 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).

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

8.8.6 Mount Roskill supply transformer capacity

Project reference:	ROS-POW_TFR-EHMT-01
Project status/purpose:	Possible, customer-specific
Indicative timing:	2015
Indicative cost band:	A

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[52] (summer/winter).

The peak load at Mount Roskill is forecast to exceed the transformers' n-1 winter capacity by 1 MW in 2012, increasing to 58 MW in 2027 (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				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Mount Roskill	0.98	1	5	9	13	17	21	31	39	46	53	58

Solution

We will investigate removing the transformers' circuit breaker and protection relay constraints. This will increase the n-1 capacity to 145/152 MVA (summer/winter), which is sufficient to delay the issue for several years.

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.

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.

8.8.7 Otahuhu supply transformer capacity

Project reference:	OTA-POW_TFR-EHMT-01
Project status/purpose:	New transformer: 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[53] (summer/winter).

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52 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).

53 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).

The peak load at Otahuhu is forecast to exceed the n-1 winter capacity by 9 MW in 2012, increasing to approximately 42 MW in 2027 (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				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Otahuhu	0.99	9	11	13	16	18	20	24	29	33	38	42

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, and
- 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.

8.8.8 Otahuhu–Wiri 110 kV transmission capacity

Project reference:	OTA_WIR-TRAN-DEV-01
Project status/purpose:	Possible, to meet the Grid Reliability Standard (core grid) and/or customer-specific
Indicative timing:	To be advised
Indicative cost band:	D

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 summer peak load periods from approximately 2012. This will occur during periods of high Auckland generation and low Waikato generation.

Solution

We are investigating several options. 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 connecting to a new 110/33 kV supply transformer at Wiri
- a new 110/33kV transformer at Otahuhu and a new 33 kV cable connected into 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 8.8.14).

8.8.9 Penrose 220 kV transmission security

Project context:	NIGU and UNIRS See Section 6.4.2 (NIGU project) and Section 8.8.2 (NAaN)

Issue

The two 220 kV Otahuhu–Penrose circuits are rated at 469/492 MVA (summer/winter). During peak demand periods, an outage of one Otahuhu–Penrose circuit may cause the other circuit to exceed the conductor rating from 2013.

Solution

In the short term, the loading on the 220 kV Otahuhu–Penrose circuits may be reduced following an outage by taking the low impedance Penrose 220/110 kV transformer (T10) out of service.[54] This transfers some of the load to the 110 kV Otahuhu–Penrose 2 circuit. This solution is sufficient until 2014.

We are committed to installing a 220 kV Pakuranga–Penrose cable circuit as part of the NAaN project, scheduled for completion in 2013 (see Section 8.8.2). This will address the issue until approximately 2027 or beyond, when a second 220 kV Pakuranga–Penrose circuit will be required.

8.8.10 Otahuhu–Penrose 110 kV transmission capacity

Project reference:	OTA_PEN-TRAN-DEV-01
Project status/purpose:	Possible, to meet Grid Relilability Standard (not core grid)
Indicative timing:	To be advised
Indicative cost band:	To be advised

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 220/110 kV transformer (T10) will cause the 110 kV Otahuhu–Penrose circuit to overload from 2020.

Solution

The Otahuhu–Penrose 110 kV circuit is limited by the terminal spans at Otahuhu and Penrose substations. 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
- thermally upgrading the circuit to a higher temperature, or
- replacing the circuit with a higher capacity conductor.

8.8.11 Penrose 33 kV supply transformer capacity

Project status/purpose:	This issue is for information only

54 The two existing Penrose 220/110 kV interconnecting transformers are 200 MVA 5% impedance and 250 MVA 15% impedance units. By switching the 5% impedance transformer out of service, the higher impedance unit will balance the power flow between the remaining 220 kV and the existing 110 kV circuits.

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 28 MW in 2012, increasing to approximately 183 MW in 2027 (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				
		2012	2013	2014	2015	2016	2017	2019	2021	2023	2025	2027
Penrose	0.98	28	39	50	61	72	84	109	131	149	168	183

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.

We have installed a fourth 220/33 kV supply transformer. This is a system spare transformer to enable us to manage outages on the existing three supply transformers for the next 15 years (in particular, allowing the existing T9 transformer to undergo extensive preventative maintenance). The firm capacity will not increase, because only three of the four transformers can be in service to maintain fault levels within the equipment ratings.

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

8.8.12 Takanini supply transformer capacity

Project reference:	Upgrade protection: TAK-POW_TFR-EHMT-01 Upgrade circuit breaker and busbar: TAK-SUBEST-EHMT-01
Project status/purpose:	Upgrade protection: Base Capex, minor enhancement Upgrade circuit breaker and busbar: possible, customer-specific
Indicative timing:	2014-2016
Indicative cost band:	Upgrade protection: A Upgrade circuit breaker and busbar: 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[55] (summer/winter).

The peak load at Takanini is forecast to exceed the transformers' n-1 winter capacity by 6 MW in 2012, increasing to approximately 61 MW in 2027 (see Table 8-11).

[55] 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).

Table 8-11: Takanini 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
Takanini	0.99	6	10	14	18	22	26	35	43	49	56	61

Solution

If the protection equipment, circuit breaker, and busbar limits are resolved, the transformers' thermal capacity will be sufficient until the second half of the forecast period.

In addition, the Takanini 33 kV outdoor switchyard will be converted into an indoor switchboard within the next five years. If appropriate, we will upgrade the transformer branch limiting components in conjunction with the conversion work.

Vector has advised that they expect to keep peak load within the transformers' n-1 capacity for several years. Further development options to increase the transformer capacity for this grid exit point will be customer driven.

8.8.13 Wiri supply transformer capacity

Project reference:	Upgrade protection: WIR-POW_TFR_PTN-EHMT-01 Upgrade transformer capacity: WIR-POW_TFR-EHMT-01
Project status/purpose:	Upgrade protection: Base Capex, minor enhancement Upgrade transformer capacity: possible, customer-specific
Indicative timing:	Upgrade protection: 2019 Upgrade transformer capacity: 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[56] (summer/winter).

The peak load at Wiri will exceed the transformers' summer n-1 capacity by approximately 2 MW in 2019, increasing to approximately 20 MW in 2027 (see Table 8-12).

Table 8-12: Wiri 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
Wiri	0.99	0	0	0	0	0	0	2	7	12	16	20

Solution

Resolving the protection equipment limits will delay the overload until 2020. 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.

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

The solution to the Otahuhu–Wiri transmission capacity issue may also address the Wiri supply transformer capacity issue (see Section 8.8.8).

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

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

Any future transformer upgrade will be customer driven.

8.8.14 Wiri Tee transmission capacity

Project status/purpose:	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 8.8.8). It is expected to be resolved with that issue. Although the Wiri Tee section is only approximately 90 m in length, it crosses over a motorway, which is expected to complicate an otherwise a relatively minor project to increase this circuit section's capacity.

8.9 Other regional items of interest

There are no other items of interest identified to date beyond those set out in Section 8.8. See Section 8.10 for more information about specific generation proposals relevant to this region.

8.10 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 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.[57]

8.10.1 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.

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

8.10.2 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.