Electricity
Asset Management Plan
2016 – 2026

Executive Summary

Summary of the Asset Management Plan

Vector's strategic vision is to:

"Create a new energy future"

with a focus on five strategic pillars:

- **SUSTAINABLE GROWTH**
- **CUSTOMER FOCUS**
- **OPERATIONAL EXCELLENCE**
- **PARTNERSHIPS**
- **SAFETY, PEOPLE AND CULTURE**

This Asset Management Plan supports achieving Vector's vision.

Purpose of the Plan

The purpose of this Asset Management Plan (AMP) is to comply with the requirements set out in the Commerce Commission's Electricity Distribution Information Disclosure Determination. It covers a ten year planning period starting from 1st April 2016.

The AMP accurately represents asset management practices at Vector as well as the forecasted ten year capital and maintenance expenditure on the Vector electricity network[1]. The objectives of the AMP are to:

- Inform stakeholders about how Vector intends to manage its electricity distribution network based on information available at preparation;
- Demonstrate alignment between electricity network asset management and Vector's vision and goals;
- Provide visibility of effective life cycle asset management at Vector;
- Provide visibility of the level of performance of the network;
- Provide guidance of asset management activities to its staff and field service providers;
- Provide visibility of forecast electricity network investment programmes2 and forecast medium-term construction activities to external users of the AMP;
- Demonstrate innovation and efficiency improvements;
- Discuss the impact of regulatory settings on future investment decisions;
- Discuss expected technology and consumer developments and the asset investment strategies to deal with a changing environment;
- Demonstrate that safe asset management processes are in place; and
- Meet Vector's regulatory obligations under the aforementioned Determination.

From an asset manager perspective the AMP:

[1] After allowing for the difference between Vector's financial year (Jul-Jun) and the regulatory financial year (Apr – Mar).

- Supports continued efficient improvement in Vector's performance;
- Is essential to Vector's goal to continually improve its asset management practices; and
- Will help the Vector Group achieve its overarching vision.

Business Operating Environment

Qualification

This AMP represents Vector's current and best view of the ongoing investment, maintenance and operational requirements of its electricity network, in the current operating environment. However, as discussed below, the business faces significant ongoing uncertainty, especially in relation to the current investment landscape and the still-evolving regulatory environment. This has a direct impact on Vector's ability to make investment decisions and attract investment capital.

To meet the regulatory disclosure deadlines, the investment modelling and capital project forecast for this AMP was locked in December 2015. Vector follows an annual budget process which does not coincide with the regulatory timelines, so changes in the 2016/17 projects may occur from this AMP as revisions from external parties (eg: Auckland City), business risk models and capital project reviews are continually updated. The rate of deployment of new technology is also difficult to predict and may occur very rapidly.

Works programmes may also be modified to reflect any changing operational and economic conditions as they exist or are foreseen at the time of finalising the budget, or to accommodate changes in regulatory or customer requirements that may occur from time to time. Any expenditure must be approved through normal internal governance procedures. This AMP does therefore not commit Vector to any of the individual projects or initiatives or the defined timelines described in the plan.

Regulatory Factors

As a supplier of electricity distribution services, Vector's electricity distribution business is subject to price and quality regulation. This regulation is undertaken by the Commerce Commission under Part 4 of the Commerce Act 1986.

Vector does not believe that current regulation provides an adequate level of certainty or provides the right investment incentives. Vector needs regulation that recognises customer demands for choice, Auckland's significance to the broader economy and the unique challenges Vector faces as we provision for growth in the region.

In particular the rationale for asset indexation which pushes cash flows to the end of asset lives needs serious consideration as the ability to recover those cash flows over the medium to longer term will become more and more unlikely.

Shorter economic asset lives needs are required to bring cost recovery forward to enable full recovery and to share costs with current consumers.

Cost of capital needs to incorporate a broader range of market risks and investment options. The risk faced by distributors is increasing, and this needs to be reflected in the way the cost of capital is set. Cost of capital also needs to incentivise the right investment. That is, the investment that will benefit consumers in the long term and not the investment that is merely representative of an allowed low risk return.

Distributors also currently bear growth and CPI forecast risk when the Commission set prices. Mechanisms for ensuring distributors do not wear the consequences of forecast error need to be implemented.

Factors Specific to the Auckland Region

Vector notes that the significant and sustained growth expected in the Auckland region is not reflected in the rest of New Zealand. The pressures this places on the existing network infrastructure and the activities Vector must undertake to support this growth must be considered in the Regulatory treatment of Vector's network.

Vector anticipates that Auckland will experience continued population increase and associated growth in business activities and electricity demand for the foreseeable future. However, the extent to which this population growth translates into new electricity connections varies considerably over years, and network reinforcements are therefore deferred until sufficient certainty of new developments and network demand is obtained.

Future network reinforcement will inevitably involve conventional asset investment, but will also employ emerging technology and alternative energy sources to enhance utilisation of existing network assets and defer investments where feasible to do so. Underlying all of this, Vector will continue to ensure a safe and reliable electricity supply, meeting Vector's customers' electricity demand requirements.

Improvements in the AMP and Asset Management at Vector

This (2016) AMP builds on the previous Plans and incorporates further developments in Vector's approach to and thinking on asset management. Vector has, over an extended period, engaged external expert technical advisers on an annual basis to review its asset management practices. While these reviews have been very positive in their feedback – confirming asset management at Vector conforms to industry best-practice – Vector has taken note of the feedback and recommendations received, and where practical and beneficial, reflected this in its asset management practices.

Important further changes recorded in this AMP include:

- Network augmentation plans have been thoroughly reviewed and updated, reflecting new load forecasts, changing technology, customer connection and relocation activity,
- Findings from the Penrose investigation and improvements to risk management practices that have been implemented,
- We have further expanded our information-base on asset performance and condition, allowing us to enhance our network renewal and maintenance plans. The asset renewal programme was reviewed in light of the latest asset performance information,
- The 10 year capex and maintenance forecasts were updated, and
- Vector's updated asset management maturity assessment results are included.

Vector's Network

Vector's supply area covers most of the area administered by the Auckland Council as shown in the map below. Vector operates an electrically contiguous network[3] from Papakura in the south to Rodney in the north. While Vector operates this as a single network, for legacy reasons, it is convenient to describe a Southern region and a Northern region to reflect the different characteristics of the networks.

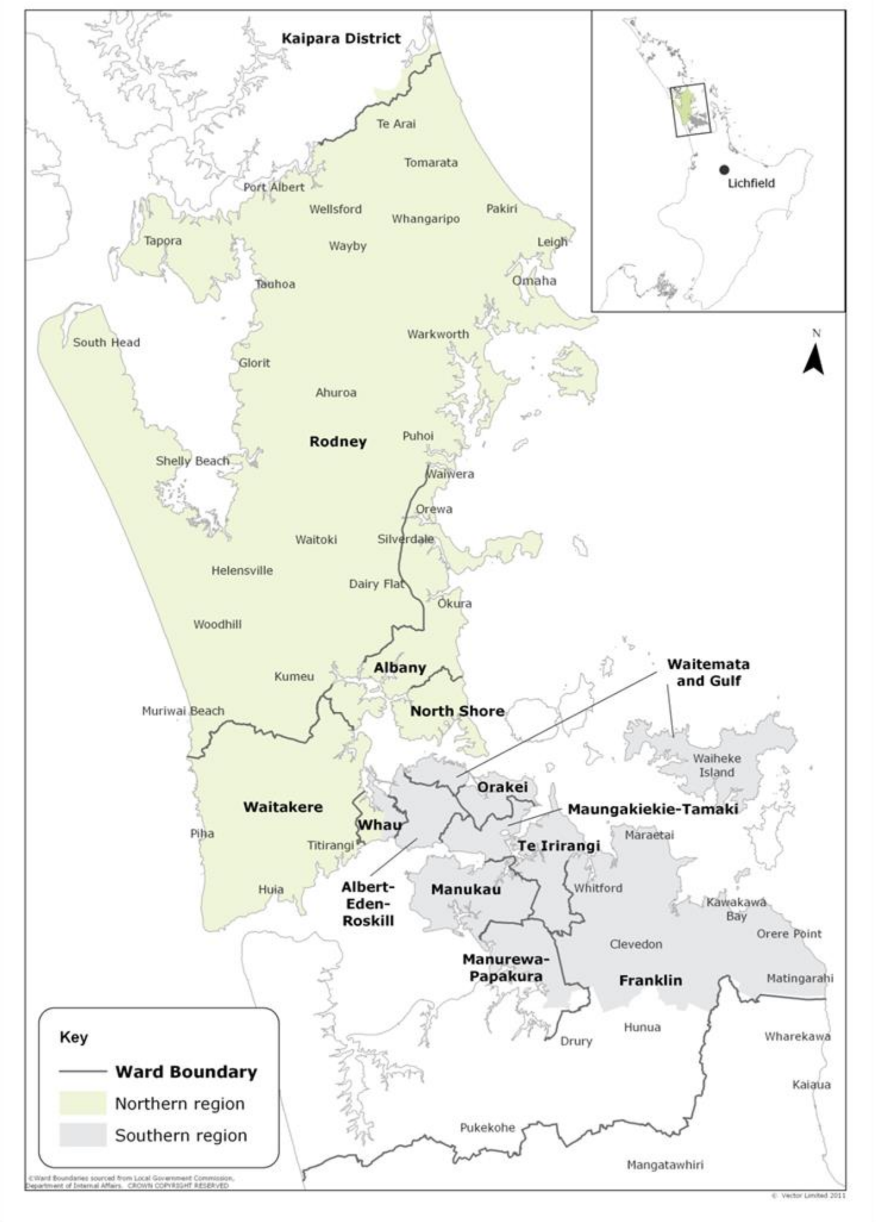
The Northern region covers those areas administered by the previous North Shore City Council, the Waitakere City Council and the Rodney District Council, and consists of residential and commercial areas in the southern urban areas, light industrial and

[3] In addition to the electricity network in Auckland, Vector also owns an 11kV network to supply the Fonterra cheese factory at Lichfield.

commercial developments around the Albany Basin, and residential and farming communities in the northern rural areas.

The Southern region covers areas administered by the previous Auckland City Council, the Manukau City Council and the Papakura District Council, and consists of residential and commercial developments around the urban areas on the isthmus, concentrated commercial developments in the Auckland central business district (CBD), industrial developments around Rosebank, Penrose and Wiri areas, and rural residential and farming communities in the eastern rural areas.

In addition, Vector supplies a large customer at Lichfield which is a stand-alone supply.



Network Summary (Year ending 31st March 2015)

Description	Quantity
Consumer connections	542,826
Network maximum demand (MW)*	1,732
Energy injected (GWh)*	8,685
Lines and cables (km)**	18,116

Zone substations***	105
Distribution transformers	21,328

* Includes embedded generation exports

** Energised circuit length

*** Figure includes Lichfield but excludes Auckland Hospital and Highbrook

Demand Forecasts

Demand growth remains a key investment driver for the electricity distribution network. Vector is observing short-term fluctuations in annual peak demand, but is predicting a 25% demand reduction per residential customer over a ten year period. However, it is anticipated with the forecast ongoing population growth and building activity in Auckland, maximum electricity demand will continue to grow, unless a breakthrough in emerging technologies occur that would allow significant improvements in energy efficiency and/or peak demand reduction.

Vector has been monitoring developments of various technologies that could impact on the demand and demand characteristics on the network and this has been incorporated in Vector's demand forecasts (with various scenarios analysed).

As in previous years, the demand forecast takes into account any existing and known new distributed generation, reactive compensation development and demand management policies.

The demand forecasts are detailed at zone substation level in Appendix 4. The maximum network demand and energy consumption for the 2014/15 (regulatory year) is given below.

	Peak Demand* (MW)	Total Energy Injected (GWh)
From grid exit points	1,722	8,585
From embedded generation**	10	100
Total	1,732	8,685

* Coincident demand

** Embedded generation excludes Southdown

Network Development

Planning Criteria

Vector's approach to network development planning is driven by:

- Ensuring the safety of the public, staff and service providers;
- Meeting network capacity and security requirements in an economically efficient manner;
- Customer needs, which vary by customer segment and are reflected by service level standards and associated pricing;
- Striving for least life-cycle cost solutions (optimum asset utilisation) and optimum timing for capex;
- Maximising capex efficiency in a sustainable manner;
- Outcomes that improve asset utilisation take into account the increased risk trade-off;

- Incorporating enhanced risk management strategies and processes into Vector's planning philosophy;
- Continuously striving for innovation and optimisation in network design, and trialling new technology such as remote switching technology, smart meters at distribution substations, LV/MV monitoring and control technologies to improve network performance;
- Developing non network and demand-side solutions where economic and practicable;
- Reference to targets set by industry best practice where economic and practical;
- Ensuring assets are operated within their design rating;
- Meeting statutory requirements such as voltage, power quality (PQ); and
- Providing different levels of service to different customer segments, reflecting as far as practicable their desired price/quality trade-off.

Vector's planning criteria are detailed in Section 5 of this AMP.

Network Development Plan

Vector's ten-year network development plan is described in Section 5 of the AMP.

Based on these demand forecasts and Vector's network planning criteria, various projects are planned (and alternatives considered) to ensure that supply capacity and security will be maintained at economic levels. Planning is detailed for the first five years of the plan, but only indicative for the following five years as the nature and timing of disruptive technology and consumer behaviours is difficult to predict.

Service Commitment

Vector contracts with energy retailers for line services, while end users contract with energy retailers for both energy and line services (interposed arrangement).

Vector's published service standards include a payment to customers that lodge a claim where an outage has occurred and Vector is unable to restore power supply within the target restoration times. This payment is $50 for residential customers and $200 for business customers (<69kVA).

Large events and events outside of Vectors' control are excluded from the scheme.

Vector's supply quality and service standards are explained in detail in Section 4 of this AMP.

Asset Management Planning

Maintenance Planning Policies and Criteria

Vector's overall philosophy on maintaining network assets is based on four key factors:

- Ensuring the safety of consumers, the public and the network field staff;
- Ensuring reliable and sustainable network operation, in a cost-efficient manner;
- Achieving the optimal trade-off between maintenance and replacement costs. That is, replacing assets only when it becomes more expensive to keep them in service. Vector has adopted, where practicable, condition-based assessments rather than age based replacement programmes; and
- Integration (alignment) of asset management practices given Vector is a multi-utility asset manager.

Of note is a significant change in Vector's use of live-line maintenance techniques from previous years. During 2015 Vector reviewed its work practices to ensure that at all times the safest method of work is always selected when performing work on its network. This has reduced the use of live-line techniques and increased the future level of planned network outages. Vector is currently monitoring the overall impact on customer service and operating costs as a result of this change.

Vector has maintenance standards for each major class of asset it owns. These detail the required inspection, condition monitoring and maintenance tasks, and the frequency at which these are required. The goal of these standards is to ensure that assets can operate safely and efficiently to their rated capacity for at least their full normal lives. Data and information needs for maintenance purposes are also specified.

Based on these maintenance standards, to ensure that all assets are appropriately inspected and maintained, Vector's maintenance contractors develop an annual maintenance schedule for each class of asset they are responsible for. The asset maintenance schedules are aggregated to form the overall annual maintenance plan which is implemented once it has been signed off by Vector. Progress against the plan is monitored monthly.

Defects identified during the inspections are recorded in the contractor's defect database with an electronic copy being kept by Vector. Contractors prioritise the defects for remedial work based on risk and safety criteria (which are reviewed by Vector's asset specialists). Work necessary in less than three months is undertaken immediately as corrective maintenance. Work that can be carried out over a three to twelve month period is included in the corrective maintenance or asset replacement programme. Work not required within 12 months is generally held over for the future.

Root cause analysis is normally undertaken as a result of faulted equipment. This is also supplemented by fault trend analysis. If performance issues with a particular type of asset are identified, and if the risk exposure warrants it, a project will be developed to carry out the appropriate remedial actions. The asset and maintenance standards are also adapted based on learning from such root cause analysis.

The following summarises the different types of maintenance programmes for the electricity network assets:

- Preventative maintenance:

  Asset inspections as per asset management standards;

  Condition testing as specified in asset management standards; and

  Inspection and test intervals based on industry best practice and Vector experience.

- Corrective maintenance:

  Correction of defects identified through preventative maintenance.

  - Reactive maintenance:

  Correction of asset defects caused by external influences, or asset failure.

- Value added maintenance:

  Asset protection (eg. cable location and marking, stand-overs).

- Vegetation maintenance:

  Preventing interference or damage to assets (eg. tree-trimming).

- Non-core maintenance:

  Non-standard assets (eg. tunnels) and maintaining spares.

Asset Renewal Planning

Vector's asset renewal plans are discussed in Section 6. The overall asset-condition of various asset categories is discussed in detail, highlighting areas where upgrades or renewal is required (as well as the process and factors to support these decisions). This forms the basis of the ten-year asset renewal programme.

In general Vector replaces assets on a condition-assessment rather than age-basis. Vector strives to achieve the optimal replacement point where the risk associated with asset failure and the likelihood of this occurring becomes unacceptably high, and it is more economically efficient to replace an asset than to continue to maintain it.

Vector participates in several forums as a way to monitor local and international developments in asset maintenance. As part of its ongoing improvement programme, Vector is focusing on improved risk identification and management practices to direct future renewal and maintenance activities.

Risk Management

Risk Management Policies

Managing risk is one of Vector's highest priorities. Risk management is practiced at all levels of the organisation and is overseen by the Board Risk and Assurance Committee, the Executive Risk and Assurance Committee and Vector's Chief Risk Officer.

Vector's risk management policy is designed to ensure that material risks to the business are identified, understood, and reported and that controls to avoid or mitigate the effects of these risks are in place where possible. Detailed contingency plans are also in place to assist Vector in managing high impact events.

The consequences and likelihood of failure or non-performance, current controls to manage these, and required actions to reduce risks, are all documented, understood and evaluated as part of the asset management function. Risks associated with the assets or operations of the network are evaluated, prioritised and dealt with as part of the network development, asset maintenance, refurbishment and replacement programmes, and work practices.

Asset-related risks are managed by a combination of:

- Reducing the probability of failure through the capital and maintenance work programme and enhanced work practices, including design standards, equipment specification and selection, quality monitoring, heightened contractor and public awareness of the proximity of or potential impact of interfering with assets;
- Collaborating with key risk stakeholders to understand and agree risk interdependencies; and
- Reducing the impact of failure through the application of appropriate network security standards and network architecture, selected use of automation, robust contingency planning and performance management of field responses.

The capital and maintenance asset risk management strategies are outlined in the Asset Maintenance and Network Development sections (Section 6 and Section 5 respectively). Vector's contingency and emergency planning is based around procedures for restoring power in the event of a fault on the network, and is detailed in Section 5 of this AMP.

Vector also recognises that information technology (IT) systems are a very important part of its business and asset management framework. Vector operates advanced real-time network control and protection systems, deeply integrated with the IT systems of the rest of the business. Potential compromise of the (cyber) security of Vector's IT systems, including real-time control systems, is recognised as a major (and increasing) business and network risk. During 2016 we have engaged a global cyber security expert to review the governance and technical aspects of cyber risk for our business. Given the dynamic nature of this risk Vector has implemented several enhancements to its cyber-security systems to manage this risk and create a more robust operating environment. Further security enhancements will be implemented on an ongoing basis.

Health and Safety

At Vector, safety is a fundamental value, not merely a priority. Vector is committed to a goal of zero harm to people, assets and the environment. Vector's Health and Safety Policies can be found in Section 8 of this AMP. In summary, the policies are developed to ensure safety and wellbeing of its staff, contractors and the public at its work sites and around its assets.

To achieve this Vector aims to comply with all relevant health and safety legislation, standards and codes of practices; establish procedures to ensure its safety policies are followed; encourage its staff and service providers to participate in activities that will improve their health, safety and wellbeing; and take all practical steps to ensure its field services providers (FSPs) adhere to Vector's health and safety policies and procedures.

Sustainability

Vector's environmental policy has been developed to monitor and improve Vector's environmental performance and to take preventive action to avoid adverse environmental effects of Vector's operation.

To achieve this Vector will:

- Plan to avoid, remedy or mitigate adverse environment effects of Vector's operations; and
- Focus on responsible energy management and energy efficiency for all Vector's premises, plant and equipment where it is cost effective to do so.

Vector's long term operational objectives with regard to environmental factors are to:

- Utilise energy as efficiently as practicable;
- Plan for the future reduction of emissions and in particular the management of greenhouse gas emissions;
- Wherever practical, use ambient and renewable energy; and
- Influence and work with and within our supply chains to maximise energy efficiency.

Approval of the AMP and Reporting on Progress

The AMP is the responsibility of the Chief Network Officer. In turn this is presented to the CEO and board for discussion and approval.

Approval of the disclosure AMP is sought once a year, at the March board meeting. This timing is aligned with the regulatory requirement to publish a disclosure AMP before the end of March each year.

Progress in implementing Vector's asset management plan is regularly monitored, and progress against its investment plans and asset performance measured through several metrics, including:

- Monthly reporting on progress and expenditure on major projects/programmes;

- Reliability performance – SAIDI, SAIFI, CAIDI (network wide, as well as on a per feeder or zone substation basis);
- Performance and utilisation of key assets such as sub-transmission cables, distribution feeders, power transformers, etc;
- Progress with risk register actions;
- Health, safety and environmental issues; and
- Security of supply.

Financial Forecasts

The following tables summarise the capital and operations and maintenance expenditure forecast covering the AMP planning period.

Capital Expenditure Forecast:

FY16 AMP	Financial Year ($000)									
	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26
Consumer connection	54,274	47,408	42,021	40,815	40,482	38,292	38,423	37,805	38,160	33,350
System growth	50,153	42,156	35,006	42,156	36,211	39,822	36,027	39,209	35,537	32,943
Asset replacement and renewal	88,884	77,193	69,434	78,794	75,241	75,096	78,778	66,056	70,929	63,386
Asset relocations	17,139	15,747	9,761	10,141	10,141	10,141	10,141	10,141	10,141	10,141
Reliability, safety and environment:	0	0	0	0	0	0	0	0	0	0
Quality of supply	0	0	0	0	0	0	0	0	0	0
Legislative and regulatory	12	0	0	0	0	0	0	0	0	0
Other reliability, safety and environment	2,025	1,856	1,687	1,687	1,687	1,687	1,687	1,922	1,687	1,687
Non network assets	12,674	12,281	9,215	14,680	11,295	10,531	12,387	11,241	12,005	0
Total Capital Expenditure	**225,162**	**196,641**	**167,123**	**188,274**	**175,058**	**175,570**	**177,444**	**166,373**	**168,459**	**141,507**

* Figures are in 2017 real New Zealand dollars (million)
** The year reference indicates the end date of the Vector financial year
*** The forecasts are inclusive of cost of finance and in line with Vector's business practice

Direct Operational Expenditure Forecast:

FY16 AMP	Financial Year ($000)									
	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26
Asset Replacement & Renewal	13,291	14,791	17,791	17,791	17,791	17,791	15,791	15,791	15,791	15,791
Routine & Corrective Maintenance & Inspection	11,628	11,890	12,107	12,329	12,558	12,787	13,017	13,247	13,477	13,708
Service Interruptions & Emergencies	9,247	9,318	9,390	9,462	9,285	9,108	8,929	8,750	8,820	8,890
System Operations and Network Support	9,440	9,527	9,615	9,646	9,678	9,710	9,742	9,774	9,807	9,840
Vegetation Management	4,232	4,264	4,296	4,328	4,361	4,394	4,427	4,461	4,495	4,529
Total Capital Expenditure	**47,837**	**49,790**	**53,199**	**53,557**	**53,673**	**53,790**	**51,906**	**52,023**	**52,390**	**52,759**

* Figures are in 2017 real New Zealand dollars (million);
** The year reference indicates the end date of the Vector financial year

Electricity
Asset Management Plan
2016 – 2026

Background and Objectives – Section 2

[Disclosure AMP]

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2. Background and Objectives

2.1 Introduction

This AMP covers a ten year planning period, from 1st April 2016 through to 30th June 2026[1] and was approved by the board of directors on 22nd March 2016.

The first five years of the Plan is based on detailed analysis of customer, network and asset information and hence provides a relatively high degree of accuracy (to the extent reasonably possible) in the descriptions and forecasts. The capital and maintenance budgets set out in the Plan, particularly for the first year, are important inputs into Vector's annual budgeting cycle.

The latter period of the Plan is based on progressively less certain information and an accordingly less accurate and detailed level of analysis. From year five on, the AMP is only suitable for provisional planning purposes. In addition to the normal variability around asset performance and customer growth patterns, the accelerating rate of development in technologies such as photovoltaic panels, electric vehicles, batteries, smart network and home appliances is introducing even more uncertainty. When this materially impacts the network development plan is difficult to predict, but Vector believes changes could occur with very limited pre-warning.

2.2 Asset Management Strategy

Asset management is critical for ensuring Vector's electricity distribution business provides safe and reliable services which meet the needs and expectations of consumers, help to achieve the business's commercial and strategic objectives and satisfies its regulatory obligations. Effective planning helps ensure Vector maintains and invests appropriately in its network. Vector's ongoing goal is to ensure good industry practice asset management, given its critical nature to the business and consumers, while reflecting the regulatory and economic environment within which it finds itself.

Vector also recognises that providing a network that is safe to customers, the public and operators alike is a top priority. This is reflected in Vector's work processes and standards.

Asset management is strongly influenced by safety and customer needs as well as commercial, financial and regulatory requirements:

- Safety is one of Vector's key priorities. The health and safety policy sets out the directives of Vector's health and safety framework to ensure health and safety considerations are part of all business decisions;
- Customer needs and expectations, along with safety and technical regulations, are the key determinants of network design. Network layout and capacity is designed to ensure contracted or reasonably anticipated customer demand can be met during all normal operating circumstances. Quality of supply levels, which relate to the level of redundancy built into a network to avoid or minimise outages under abnormal operating conditions, have been translated into the Vector electricity network security standards[2]. These standards balance customer requirements and the value they place

[1] Vector operates to a June financial year. All asset management and financial reporting is carried out based on its financial calendar. Works programmes and the corresponding expenditures presented in this document align with its financial reporting timeframes. To comply with the Commerce Act (Electricity Distribution Services Information Disclosure Determination 2012) (amended 2105), the budgets and expenditure forecasts presented in Section 9 are converted into disclosure years (ending on 31st March). This plan therefore covers the ten financial years from 1st July 2016 to 30th June 2026 as well as the three months prior to the start of the 2017 financial year.

[2] These are discussed in Section 5 of the AMP (asset management plan).

on reliability of supply with the level of service Vector can economically and safely provide;[3]

Most direct interaction with customers occurs through the Customer Excellence group. Asset management involves close interaction with the Customer Excellence to assist with understanding and addressing customer technical requirements, consumption forecasts and upcoming developments;

- There are technical and commercial regulations around how networks are allowed to be built and operated, how network services are provided and sold, and the limits on commercial returns on investments. These regulations directly influence investment decisions. There are also a number of regulatory compliance rules that have an impact on network configuration and operations;

  Regulatory certainty and a suitable rate of return on investments are critical to the investment framework, given the long-term nature of the assets and the need for electricity distribution businesses to have confidence that they can expect to recover their cost of capital (ie. earn a sustainable commercial return) from efficient and prudent investment. Importantly, Vector also has to attract capital both locally and from offshore;[4]

  Direct contact with the regulators is generally maintained through the Regulatory group, which in turn works with the Asset Manager to provide guidance on regulatory issues and requirements. Setting and executing regulatory strategy is also closely intertwined with asset investment activities;

- Vector operates in a commercial environment where shareholders expect a commercially appropriate return on their investments reflecting the risk of the investment. To maintain commercially sustainable returns, Vector has to ensure it is able to make optimal investment in the network, including maintenance, replacement, upgrades and new assets, while always keeping safety as a priority. This requires demonstration that investment decisions are not only economically efficient, but that realistic alternative options have been investigated to ensure the most beneficial solution – technically and commercially – is applied. This may involve taking a view on likely future technical changes in the energy sector.

  In addition, financial governance has a direct and significant bearing on asset management. Capital allocation and expenditure approvals are carefully managed in accordance with Vector's governance policies. Short and long-term budgeting processes take into account the balance between network needs, construction resources and available funding – requiring careful project prioritisation.

  Asset management, in particular where expenditure is involved, therefore requires close interaction with the Finance and Network Services groups.

In the context described above, a Vector Asset Management Plan (AMP) was developed to define and record Vector's asset management policies, responsibilities, targets, investment plans and strategies to deal with the future of the electricity network. It describes Vector's asset management policies, responsibilities, targets, investment plans and strategies to provide confidence to its board and regulators that it has considered all options to ensure the electricity distribution network is maintained and enhanced to deliver a commercially sustainable return to shareholders and meets the needs of consumers, while ensuring safe and efficient electricity network operations. It also reflects feedback obtained from customers on their requirements for the quality and cost of their electricity supplies, and the manner in which they interact with Vector. The Plan sets out the forward

[3] Customers who require a higher standard of supply than that provided under the normal Vector security standards, can contract for that.

[4] In Vector's experience, the New Zealand regulatory regime is often cited by capital markets and rating agencies as being uncertain.

path for Vector's electricity network capital investment and maintenance needs and how we intend to address these.

As such, the Asset Management Plan, along with associated processes and documents form a key input into the budgeting process. These documents are intended to assist the executive with the budget process, clarifying the electricity network priorities and also prioritising these along with other business investment needs.[5] The regulatory regime and economic conditions directly impact on the return Vector is able to make on its assets, which in turn determines the revenue which Vector is able to earn and the extent it is able to invest in its networks.

2.2.1 Purpose of the AMP

The purposes of this AMP are to:

- Inform stakeholders how Vector intends to manage and expand its electricity distribution network based on information available at preparation;
- Demonstrate the impact of regulatory settings on future investment decisions;
- Demonstrate alignment between electricity network asset management and Vector's goals and values;
- Demonstrate innovation and efficiency improvements;
- Provide visibility of effective life cycle asset management at Vector;
- Provide visibility of the level of performance of the network;
- Provide guidance of asset management activities to its staff and field service providers;
- Provide visibility of forecasted electricity network investment programmes and upcoming medium-term construction programmes to external users of the AMP;
- Discuss Vector's views on expected technology and consumer developments and the asset investment strategies to deal with a changing environment;
- Meet Vector's regulatory obligation under the aforementioned Determination; and
- Demonstrate that safe management processes are in place.

This AMP does not commit Vector to any of the individual projects or initiatives or the defined timelines described in the Plan. Vector follows an annual budget process and the implementation of the works programmes may be modified to reflect any changing operational and economic conditions as they exist or are foreseen at the time of finalising the budget, or to accommodate changes in regulatory or customer requirements that may occur from time to time. Any expenditure must be approved through normal internal governance procedures.

Vector is also continually monitoring industry bodies to identify emerging risks and learnings and continually revises its internal procedures and practices as refinements are identified.

2.2.2 Alignment with Corporate Vision and Goals

Vector's strategic vision is to:

"**Create a new energy future**" with a focus on five strategic pillars:

[5] As with all companies, Vector does not have unlimited cash resources, and competing investment needs and commercial opportunities have to be balanced.

SUSTAINABLE GROWTH

Enhancing our financial performance and growth while innovating to deliver shareholder value

CUSTOMER FOCUS

Engaging with our customers to deliver value and exceed expectations

OPERATIONAL EXCELLENCE

Excelling at what we do while managing our impact on the environment and the communities in which we operate

PARTNERSHIPS

Engaging and collaborating with key partners to develop a range of innovative options for creating a new energy future

SAFETY, PEOPLE AND CULTURE

Providing a safe and great place to work that values diversity, inclusion and develops skilled people who can lead our company in to the future

The group vision is supported by the strategies of the various Vector business units. Asset management, as captured in this AMP, is a key part of the regulated networks business plan and consequently plays an important part in achieving the overall Vector vision.

The manner in which the AMP supports Vector's vision is demonstrated in

Table 2-1 below demonstrates how asset management supports Vector to achieve its strategic objectives.

Group Goal	← **Asset Management in support of**
Sustainable Growth	• Investigate new technologies and associated opportunities • Optimise capital contributions • Support commercially attractive investments • Innovation and optimal investment efficiency • Economies of scale from long-term view • Strategic scenario planning
Customer Focus	• Providing safe and reliable services • Fit-for-purpose network designs • Understanding and managing customer needs in designs • Security and reliability levels adapted to customer needs • Meeting regulatory requirements • Maintaining appropriate price/quality trade-off
Operational Excellence	• Full compliance with health, safety and environmental regulations • Needs clearly defined • Understanding risks • Technical excellence • Reliable asset information source • High quality network planning • Effective maintenance planning • Fit-for-purpose network designs • Providing reliable service • Security and reliability levels adapted to customer needs • Easy-to-maintain and operate networks • Investigate new technologies and opportunities offered • Clear prioritisation standards • Clear roles and responsibilities for asset management • Strong, well-documented asset management processes • Clear communication of network standards and designs
Partnerships	• Engaging appropriate business partners to achieve business outcomes efficiently and safely
Safety, People and Culture	• Safety is fundamental to our operations • Health and safety, environmental and risk management principles embedded in asset investment decisions and work practices • Asset management and performance expectations clearly set • Clear roles and responsibilities

Table 2-1 : How asset management supports Vector's group goals

The Asset Owner determines the operating context for the Asset Manager, focusing on corporate governance, strategies and goals, and the relationship between regulatory issues and other stakeholder requirements. The Asset Manager interprets these strategies and goals and translates the strategic intentions into an asset investment strategy which is supported by a series of asset management policies. These are documented in the Asset Management Plan. Technical standards, work practices and equipment specifications support the asset management policies, guiding the capital and operational works programmes.

Performance of the network is monitored against a set of performance indicators that are based on realising customer expectations, meeting regulatory requirements, meeting safety obligations and achieving best-practice network operation. Performance monitoring ensures resources are optimally allocated to the appropriate areas.

The diagram in Figure 2-1 illustrates the relationship between Vector's corporate strategies and goals with its asset management policy framework.

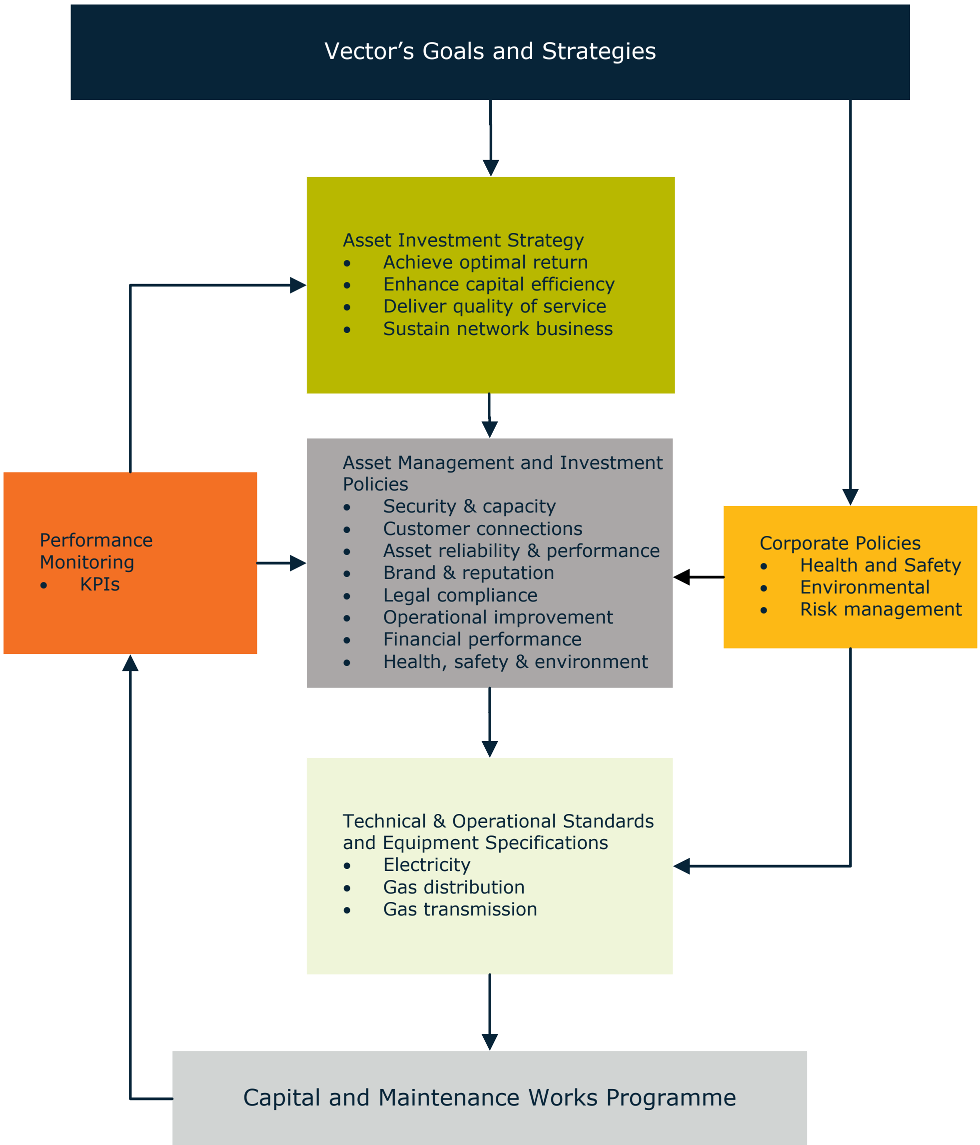


Figure 2-1 : How Vector's asset management strategies relate to the strategic goals

Vector's electricity network asset management objective is to efficiently and effectively deliver safe and reliable electricity network services to customers at a quality commensurate with their technical and economic preferences.

2.2.3 Aligning Network Investment with Strategy

The diagram in Figure 2-2 shows the high level asset investment process within Vector. This highlights the relationship between the different asset creation and evaluation processes within Vector and how they align with Vector's business objectives and service level targets.

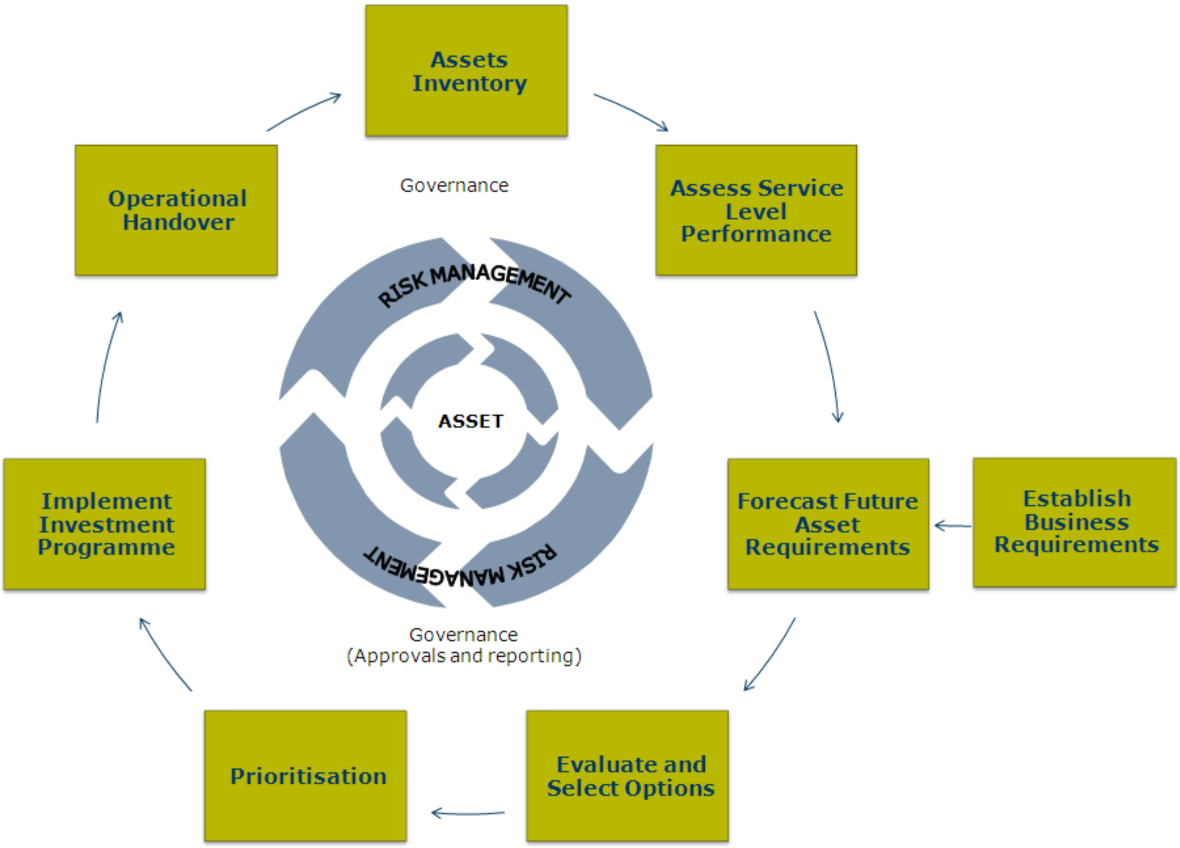


Figure 2-2 : High-level overview of the Vector asset investment process

Information on the performance, utilisation and condition of existing assets and the different parts of the network is needed to forecast future investment, renewal or upgrading requirements and improve service level. This requires ongoing monitoring of asset condition and network performance, the consumption of resources associated with maintaining the assets, and the efficiency and effectiveness with which assets are utilised (including network configuration).

The levels of service required from the electricity network are guided by the wider business requirements including the overall asset management strategy. These requirements in turn are determined by Vector's operating environment and reflect corporate, community, environmental, financial, legislative, institutional and regulatory factors together with stakeholder expectations.

The combination of asset condition and performance drivers, load demand and the business requirement drivers form the basis for assessing future asset needs and the resulting network development plans. As Vector operates an electricity network in a changing environment, future requirements are likely to differ materially from the situation faced today. Section 5 discusses the anticipated impact of some of these variables, and Vector's development strategies to position for this.

Once the future network or asset requirements are established, options for addressing these needs have to be evaluated and potential solutions have to be identified. Decision tools and systems used to support the evaluation of options include load-flow analysis, effective capital budgeting techniques, optimised renewal modelling, life-cycle costing, risk assessments and geographic information. At the same time, the feasibility of non-network or unconventional solutions to address network requirements is also considered.

Vector broadly categorises asset investment planning in two main streams:

- Network development planning is undertaken to ensure service target levels are met in an environment of increasing load (demand) growth, or increased customer quality expectations. It is based on systematic analysis of maximum demand trends, consumer requests and demographic estimates. Vector's approach to network development planning is set out in Section 5; and
- Asset maintenance and replacement planning is undertaken to ensure assets remain fully functional for their reasonably expected lifespan when operating within expected design ratings. It also includes activities to prolong asset lives or to enhance asset performance. Maintenance planning addresses both capital investments on renewal or refurbishment, or long, medium and short-term asset maintenance. Vector's approach to maintenance planning is set out in Section 6.

Prioritisation is a process that ranks all projects identified during the network development and maintenance planning processes. This process ensures only projects that meet Vector's investment thresholds and strongly align overall strategic requirements are included in the project programme.

Projects also undergo a second prioritisation process, to compare investment needs across the company. This is to ensure the best use of available resources on a company-wide basis.

Budgets are prepared on a cash-flow basis mirroring expected expenditure based on works programmes. The board approves the overall expenditure on an annual cycle and project expenditure on the larger projects in accordance with DFA governance rules.

2.3 Org Structure and Responsibilities

2.3.1 Senior Level Organisation Structure

The Vector senior level organisation structure related to the electricity network is provided below.

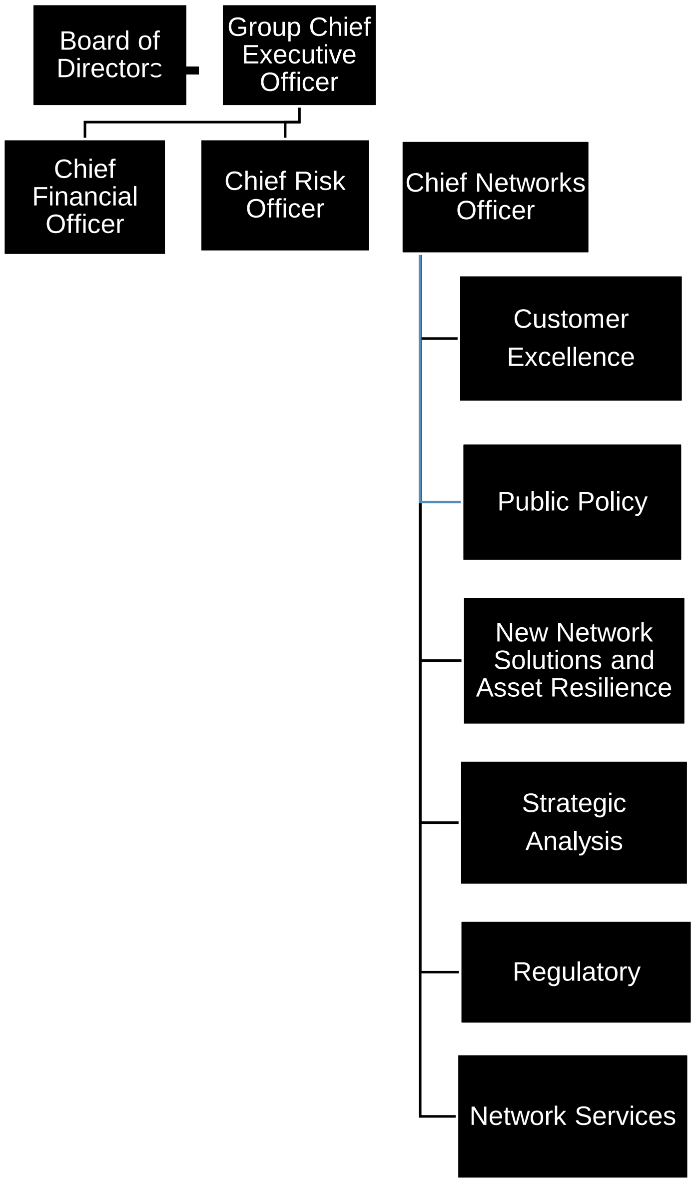


Figure 2-3 : The Vector senior management structure

The primary responsibility for the management of the electricity distribution network lies with the Chief Networks Officer. Determining what activities are needed on the network is the responsibility of the New Network Solutions and Asset Resilience Groups, and determining how to efficiently and safely perform these activities is the responsibility of Network Services.

In summary, the responsibilities of the groups supporting the electricity network are as follows[6]:

- **Office of the CEO**

  Public affairs; company secretary;

- **Chief Risk Officer**

[6] Vector functions not directly involved in the operation of the electrical network removed for clarity

Human resource management support, training and development, recruitment, health, safety and environmental policies, corporate risk management and payroll services.

- **Finance**

  Financial accounting and reporting, budgeting, treasury, management accounting, investor relations, procurement support, business analytics and insurance.

- **Chief Networks Officer**

  Overall management and operation of the electricity and gas networks, managed through the following functional teams:

  - **Customer Excellence**

    Key customer relationships, mass market customer relationships, customer connections, commercial strategies.

  - **Public Policy**

    General council for regulated activities, policy and strategy guidance

  - **New Network Solutions and Asset Resilience**

    Engineering decision making on the maintenance and renewal of existing network assets and planning for future upgrades on the network.

  - **Strategic Analysis**

    Information management, strategic analysis, business scenario modelling and data analytics

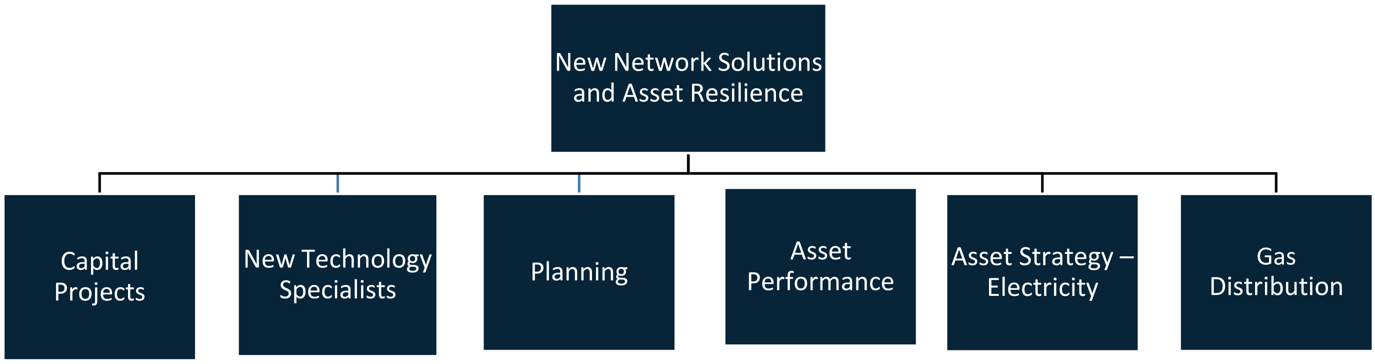
  - **Regulatory**

    Responsible for interaction with the industry regulators, monitoring regulatory compliance, developing regulatory strategies, making regulatory submissions, setting electricity pricing, developing pricing strategy.

  - **Network Services**

    Project and contract management services to deliver all activities on the network, including operation of a 24/7 Control Room function for both networks.

2.3.2 New Network Solutions and Asset Resilience



Capital Projects

This team is responsible for the detailed design of complex projects and confirming any outsourced designs comply with Vector's engineering standards. The team also maintain and own all design standards for the electricity network.

New Technology Specialists

Vector has dedicated engineers responsible for monitoring and assessing new technologies against traditional solutions to ensure optimal investment decisions are made for all capital investments.

Planning

This team continually monitor present and future customer energy needs, identify capacity/security constraints on the network and facilitate investments to augment where shortfalls are identified, and provide technical assistance to support new large customers connecting to the network.

Asset Performance

This team monitors the overall performance of the network from a risk and customer service perspective to identify areas for improvement and co-ordinate such projects.

Asset Strategy – Electricity

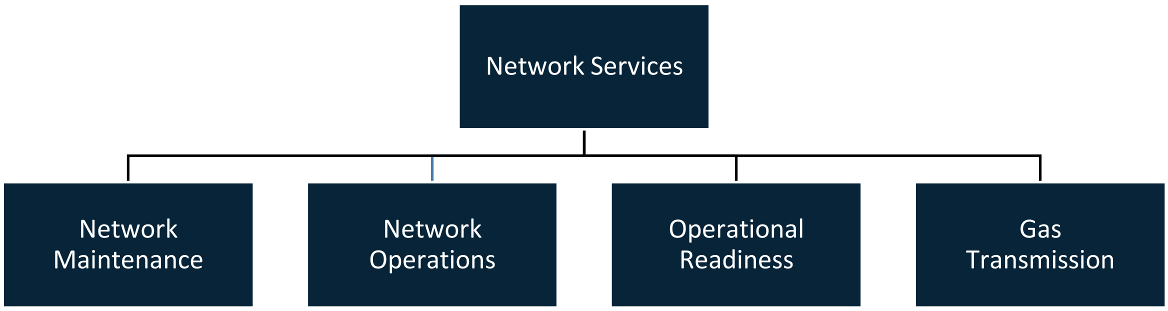
This team is responsible for asset selection, maintenance and renewal strategies and associated standards for the electrical network.

Gas Distribution

This team manages all asset management and planning functions for the gas distribution network.

2.3.3 Network Services

In Vector's asset management model, the service provider function is predominantly fulfilled by the Network Services group.



Network Maintenance

The Service Operations section is responsible for the maintenance of the electricity network. This is done in conjunction with Vector's service provider partners (Northpower and Electrix), who carry out all physical work in the field.

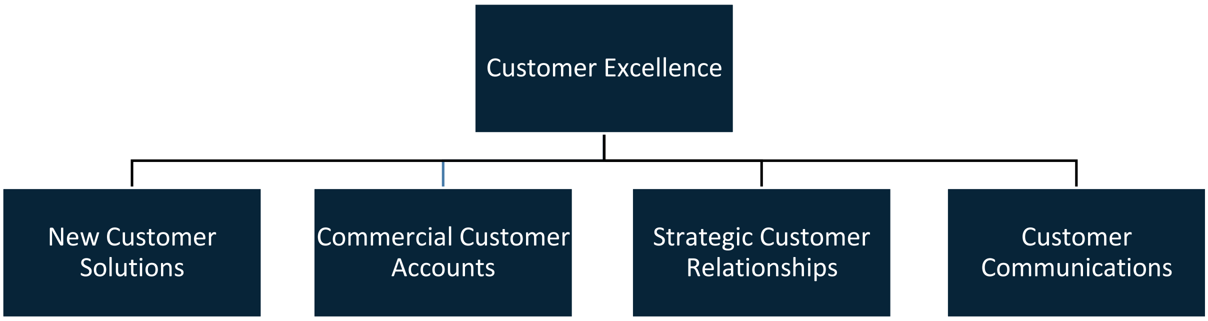
Network Operations

Network Operations is responsible for the day-to-day operational management of the network. It includes the control room, from where network operations are monitored and operational instructions are issued. Other functions include managing HV outages; switching on the network to ensure optimal configuration or to maintain supply during asset outages.

Operational Readiness

The Operational Readiness team provides programme and project management expertise to deliver the capital works program.

2.3.4 Customer Excellence



New Customer Solutions

Design and deliver new customer experience (e.g. online journey, outage app, call centre optimisation) to reduce time to serve customers and enable customer self service

Commercial Customer Accounts

Manage commercial arrangements with Gas and Electricity customers and associated projects. Manage retailer and Transpower relationships and contracts.

Manage retailer and shipper relationships and associated contracts.

Strategic Customer Relationships

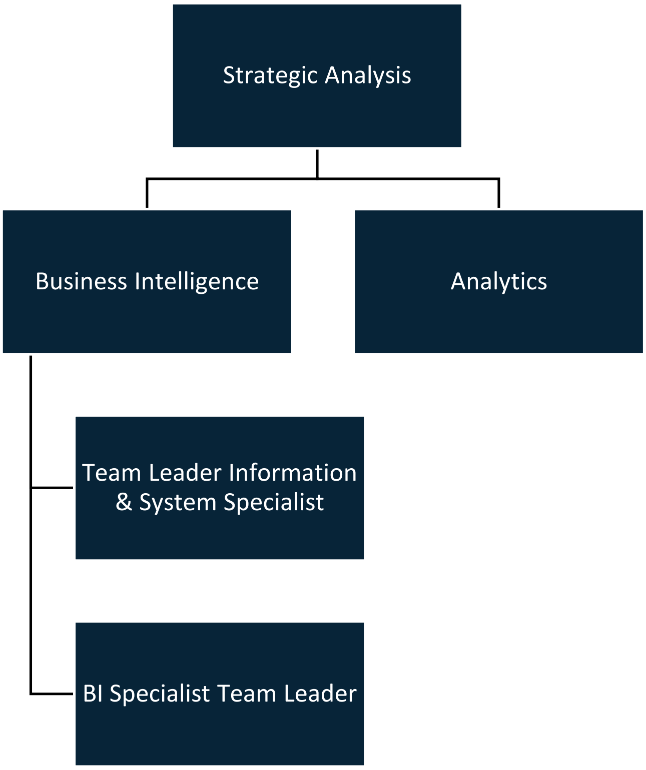
Complaints resolution. Manage strategic customer relationships including Council, Auckland Transport, NZTA. Executing undergrounding project with partners (Water Care, Spark etc).

Customer Communications

Develop, design and execute customer communication strategy, including all touch points (direct and via FSPs)

Standardise pricing for new electricity connections. Provide pricing solutions to commercial customer accounts

2.3.5 Strategic Analysis



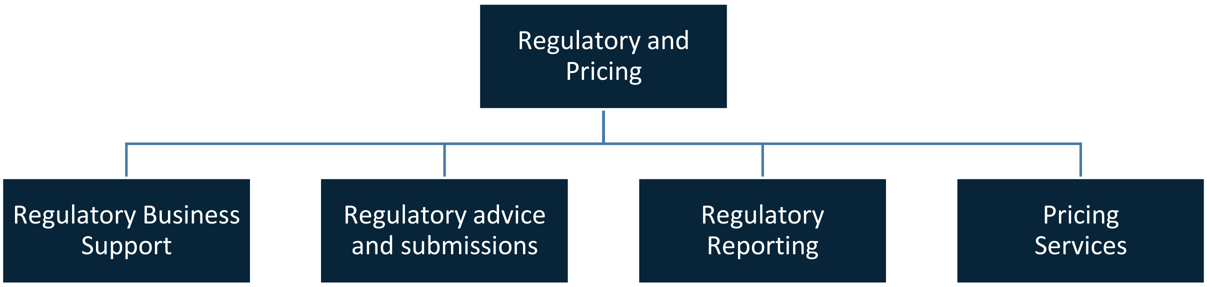
Business Intelligence

The purpose of the Business Intelligence team is to support the Networks business to make more informed decisions through the provision of quality data and business intelligence tools.

Analytics

The purpose of this function is to provide superior analytics to support business objectives and enable data driven decisions.

2.3.6 Regulatory



Regulatory Business Support

The regulatory business support team provides support to the regulated networks business to deliver disclosures to the Commerce Commission and support compliance with the Electricity Industry Participation Code.

Pricing Services

The pricing team sets distribution pricing and ensures compliance with the Default Price Quality Determination as set by the Commerce Commission. The pricing team also ensure compliance with pricing disclosures required by the Information Disclosure Determination 2012 (amended 2015) as set by the Commerce Commission.

Regulatory Reporting

The regulatory reporting function ensures financial disclosures are delivered efficiently, to appropriate quality.

Regulatory advice and submissions

The regulatory team delivers regulatory advice to the business with respect to operating in a regulated environment. Submissions are made to the Commission, the Electricity Authority, and other bodies as may affect Vector’s interests.

2.3.7 Asset Management Activities by Other Groups

While the bulk of electricity network asset management activities are performed by the Asset Resilience group, supported by the Network Services group, some electricity-related assets are directly sourced and incorporated by others.

2.3.7.1 Information Technology

There is increasing overlap in the real-time operation of electricity network assets and corporate-wide information technology services. Not only does Asset Management require increasingly sophisticated information systems, but the traditional SCADA networks are, over time, becoming less of a stand-alone electricity network application with unique requirements and protocols, and more of an integrated IT network application. Procurement and implementation of Asset Management and IT support systems, and core SCADA equipment, is managed by the Information Technology group.

2.3.7.2 Communications

Vector Comms are engaged to provide asset management and maintenance services on the fibre communications network and associated infrastructure that support the operation of the electricity network.

2.3.8 Field Service Model

Vector has, through a competitive process, has partnered with field service providers to maintain its electricity and gas networks.

- Electrix Ltd is Vector's maintenance contractor for the northern network area; and
- Northpower Ltd is Vector's maintenance contractor for the southern network area; and
- Treescape Ltd to maintain trees encroaching on the electricity and gas networks.

The maintenance contracts deliver the reactive, preventative, corrective and reactive maintenance works programmes, based on the requirements set by the Vector maintenance standards.

Service providers are performance managed by Vector's Network Services group. The maintenance contract defines the responsibilities, obligations and Key Performance Indicators (KPIs) to complete scheduled works. Vector maintains a library of technical standards which contractors must comply with when performing their duties. Figure 2-4 below describes the flow of work when maintaining Vector's assets.

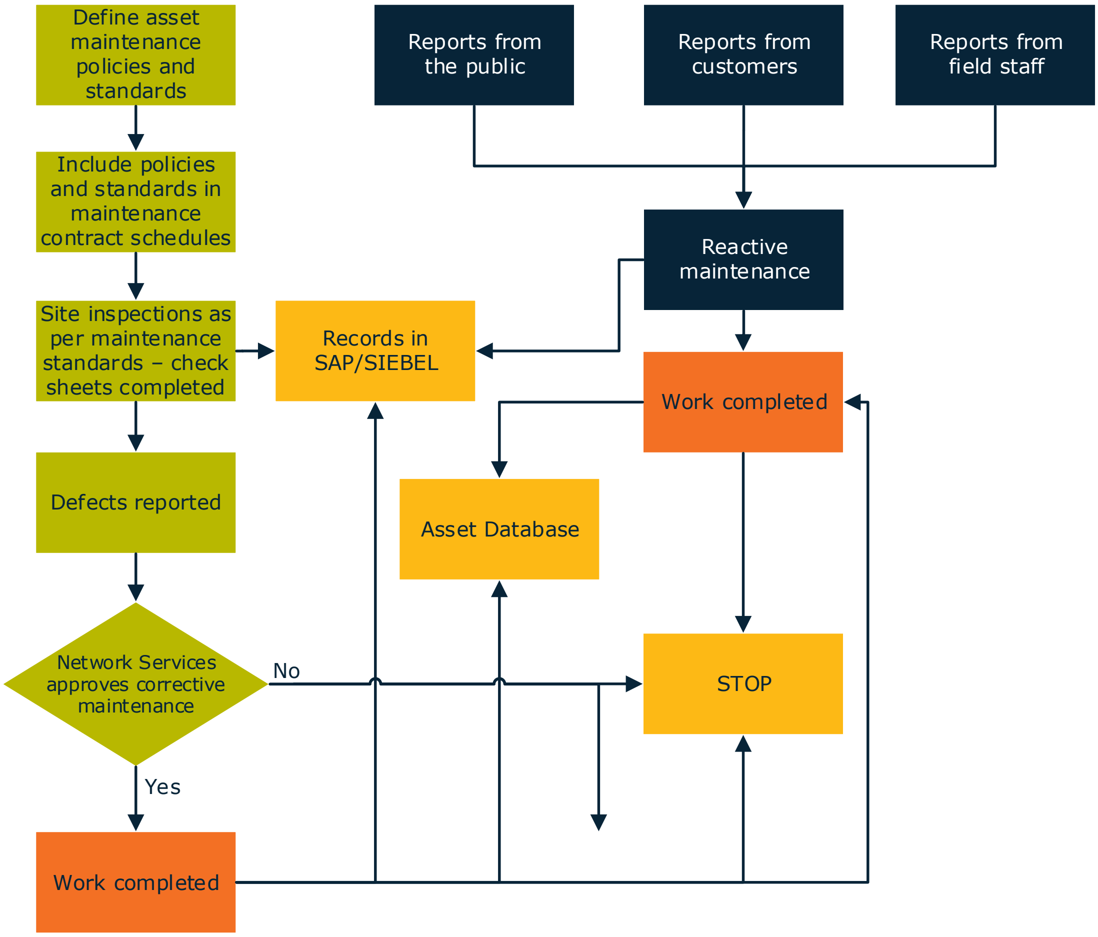


Figure 2-4 : Asset maintenance processes

As described in previous AMP sections, Vector has a comprehensive approach to the maintenance and renewal of its network assets.

The delivery of all of these maintenance activities in accordance with prescribed maintenance standards are closely monitored and adjusted by Network Services, on a monthly basis, to ensure the agreed annual target volumes are complied with. Extensive monthly feedback is obtained on actual versus planned progress, KPI performance, causality and issues impacting progress or performance, new risks, action plans and focal points for the coming months.

The overall effectiveness of the programme is evaluated by contract KPI performance and the roll up to Vector's corporate performance metrics, of which environmental compliance, public, employee and contractor safety and network SAIDI are the core measures.

2.3.9 Governance – Reporting and Approvals

Performance against the annual budgets is closely monitored, with formalised change management procedures in place. Regular reports monitor:

- Health, safety and environmental issues;
- Monthly overall expenditure against budget;
- Progress of key capital projects against project programme and budget;
- Reliability performance – SAIDI, SAIFI, CAIDI; and

- Progress with risk register actions (the board has a risk committee with a specific focus on risks to the business).

Implementation of the AMP requires decisions to be made by both the board and management at all levels, reflecting their functional responsibilities and level of delegated financial authorities (DFAs), as set in accordance with the Vector governance rules. Functional responsibilities define the role of each staff member in the organisation. The DFAs specify the level of financial commitment that individuals can make on behalf of the company.

2.4 Stakeholder Interests

Vector has a large number of internal and external stakeholders that have an active interest in how the assets of the company are managed. The essential service nature of the service Vector provides, and its importance to the Auckland well-being and economy, creates a keen interest in how Vector conducts its business.

In Figure 2-5, the important external stakeholders to Vector are highlighted. Understanding of how these stakeholders interact with Vector and the requirements or expectations they have of the company has a major bearing on the manner in which Vector constructs and operates the electricity networks.

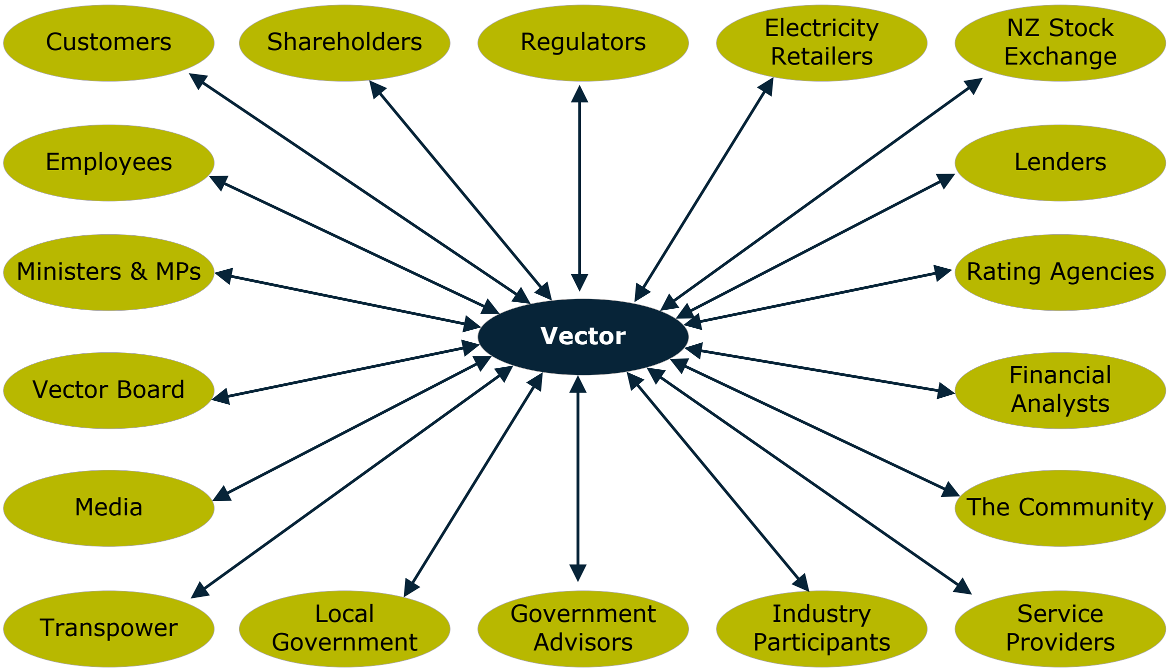


Figure 2-5 : Vector's key external stakeholders

2.4.1 Stakeholder Expectations

Important stakeholder expectations[7] are listed in Table 2-2 below.

Customers (and End-Use Consumers)	
Health and safety	Reliable supply of electricity
Quality of supply	Planned outages

[7] The stakeholders and their expectations are not listed in any order of priority.

Security of supply Efficiency of operations Reasonable price Timely response to outages Innovation, solution-focus	Timely response to complaints and queries Information in fault situations Environment Timely connections
Shareholders	
Health and safety and environment Sustainable growth Sustainable dividend growth Reliability Confidence in board and management Accurate forecasts	Regulatory and legal compliance Prudent risk management Good reputation Good governance Clear strategic direction Return on investment
Retailers	
Reliability of supply Quality of supply Managing any customer issue Health and safety and environment	Information in fault situations Ease of doing business Good systems and processes
Regulators	
Statutory requirements Accurate and timely information Health and safety and environment	Inputs on specific regulatory issues Input into policy proposals and initiatives Fair and efficient behaviour
Vector Board	
Health, safety and the environment Regulatory and legal compliance Good governance Accurate and timely provision of information Expenditure efficiency	Prudent risk management Security and reliability of supply Return on investment Accurate budgeting
New Zealand Stock Exchange	
Compliance with market rules	Good governance
Financial Analysts/Rating Agencies/Lenders	
Transparency of operations Accurate performance information Clear strategic direction Adhering to New Zealand Stock Exchange rules	Prudent risk management Good governance Accurate forecasts Confidence in board and management
Service Providers	
Safety of the work place Stable work volumes Quality work standards Maintenance standards Clear forward view on workload	Construction standards Innovation Consistent contracts Clearly defined processes Good working relationships
Government Advisors	
Accurate and timely provision of information Vector’s views on specific policy issues Efficient and equitable markets	Innovation Infrastructure investment

Ministers and MPs	
Security of supply Reliable supply of electricity Efficient and equitable markets Industry leadership	Investment in infrastructure and technologies Environment Good regulatory outcomes Energy and supply outage management
Local Government	
Public safety and health Environment Coordination between utilities Sustainable business	Support for economic growth in the area Visual and environmental impact Compliance
Community	
Public safety Good corporate citizenship Electricity safety programme	Engagement on community-related issues Improvement in neighbourhood environment Visual and environmental impact
Energy Industry	
Health and safety and environment Leadership Innovation Participation in industry forums	Policy inputs Influencing regulators and government Sharing experience and learning
Transpower	
Effective relationships Ease of doing business Secured source of supply Health and safety and environment	Well maintained assets at the networks interface Co-ordinated approach to system planning and operational interfaces Sharing experience and learning
Media	
Effective relationship Access to expertise	Information on company operations

Table 2-2 : Stakeholder expectations

Vector ascertains its stakeholders' expectations by, amongst other things:

- Meetings and discussion forums;
- Consumer engagement surveys;
- Engagement with legislative consultation processes;
- Annual planning sessions;
- Direct liaison with customers;
- Membership on industry working groups;
- Feedback received via complaints and compliments;
- Investor roadshows and annual general meetings;
- Analyst enquiries and presentations;
- Monitor analyst reports;
- Media enquiries and meetings with media representatives; and
- Monitoring publications and media releases.

Vector accommodates stakeholders' expectations in its asset management practices by, amongst other things:

- Due consideration of the health, safety and environmental impact of Vector's operations;
- Providing a safe and reliable distribution network;
- Quality of supply performance meeting consumers' needs and expectations, subject to price / quality trade off;
- Optimisation of capital and operational expenditures (capex and opex);
- Maintaining a sustainable business that caters for consumer growth requirements;
- Comprehensive risk management strategies and contingency planning;
- Compliance with regulatory and legal obligations;
- Security standards reflecting consumers' needs and expectations, subject to price/ quality trade off;
- Network growth and development plans;
- Provision of accurate and timely information;
- Development of innovative solutions; and
- Comprehensive asset replacement strategies.

2.4.2 Addressing Conflicts with Stakeholder Interests

In the operation of any large organisation with numerous stakeholders with diverse interests, situations will inevitably arise where not all stakeholder interests can be accommodated, or where conflicting interests exist. From a Vector asset management perspective, these are managed as follows:

- Clearly identifying and analysing stakeholder conflicts (existing or potential);
- Having a clear set of fundamental principles drawing on Vector's vision and goals, on which compromises will normally not be considered (see Section 2.2.2);
- Effective communication with affected stakeholders to assist them to understand Vector's position, as well as that of other stakeholders that may have different requirements; and
- Where Vector fundamentals are not compromised, seeking an acceptable alternative or commercial solution.

Other aspects considered when assessing aspects impacting on stakeholder interests or resolving conflicts include:

- Health and safety;
- Cost/benefit analysis;
- Central and local government interface and policies;
- Commercial and technical regulation;
- Long-term planning strategy and framework;
- Environmental impacts;
- Societal and community impacts;
- Legal implications;
- Sustainability of solutions (technically and economically);

- Works/projects prioritisation process;
- Security and reliability standards;
- Quality of supply;
- Risks; and
- Work and materials standards and specifications.

At a practical level in relation to asset management, Vector has developed an extensive set of asset management and investment policies, guidelines and standards which implicitly embrace practical solutions to the requirements of stakeholders. These policies and standards provide guidance to the safe operation and maintenance of the electricity network assets.

2.5 Asset Management Maturity

The AMMAT set out in Schedule 13 of the Commerce Commission's Information Disclosure Determination is a series of questions against which a business has to assess its asset management maturity level.

The full assessment criteria for the individual questions and how Vector has self-scored against each criteria are included in the Appendices of this AMP. At an overall level, Vector's asset management maturity compares well with generally accepted New Zealand electricity asset management standards, and is considered adequate for ensuring ongoing safe and efficient operation of our network, but with scope for further improvement.

Vector's progress against the AMMAT will be measured in future AMPs – with the goal to progressively achieve a minimum of "3" rating on each criteria.

2.6 Significant Assumptions

On a practical level, incorporating the Vector values and goals in the asset management strategy determines the fundamental assumptions or premise on which the AMP is based. These assumptions[8], listed in Table 2-3 below, reflect the manner in which Vector understands and implements its strategic direction.

Key Premise for the AMP	
Safety will not be compromised	• Safety of the public, staff and contractors is paramount. Safety is a focus across the business. • Current safety regulations place the accountability for public safety on Vector as the owner of the assets. This is not expected to change.[9] • Vector fully complies with New Zealand safety codes, prescribed network operating practices and regulations.
The present industry structure remains	• The Vector electricity network will continue to operate as a stand-alone, regulated electricity distribution business (not vertically-integrated). Open access of the network will be maintained. • The transmission grid will continue to be owned and operated by a separate entity. Grid development will continue broadly in its current direction and the existing grid will be maintained in accordance with good industry practice, ensuring that sufficient electricity capacity, at appropriate reliability levels, will be retained to meet the needs of Vector's customers.

[8] The assumptions are not listed in any priority order.

[9] This does not absolve Vector's service providers from meeting Vector's health & safety obligations, particularly in respect of public safety – Vector requires full compliance with its health and safety policies from all its service providers. Their performance in this regard is audited on a regular basis and managed under performance-based contracts.

Key Premise for the AMP	
Existing Vector electricity business operation model remains	• Field services will continue to be outsourced. Adequate resources with the relevant skills will be available to implement the works programme to deliver the service to the required level.
Current supply reliability levels remain unchanged	• Under the current regulatory arrangement in New Zealand, there is no significant incentive to improve network reliability from historical levels. However, it is imperative that reliability does not materially deteriorate. Under current price quality regulation Vector will therefore ensure reliability levels are maintained, but not at the expense of safety. Vector is still assessing the impact on customers from increased outages arising from a move away from live-line techniques to drive improved work practice safety • Customer survey results indicate Vector's customers in general are satisfied with the quality of service they receive, at the level of price they pay for the service. There is no material evidence to support increased service levels with the associated price increases.
A deteriorating asset base will be avoided	• In general, assets will be replaced when economic to do so, which is likely to be before they become obsolete, reach an unacceptable condition, can no longer be maintained or operated, or suffer from poor reliability. In a number of instances (where it is technically and economically optimal and safety is maintained), some assets will be run to failure before being replaced.
Regulatory requirements will be met	• Regulatory requirements with regards to information disclosure or required operating standards will be met accurately and efficiently.
A sustainable, long-term focused network will be maintained	• Asset investment levels will be appropriate to support the effective, safe and reliable operation of the network. • Expenditure will be incurred at the economically optimum investment stage without unduly compromising supply security, safety and reliability. • Vector's ability to forecast future customers energy demands remains sufficiently reliable (with the impact of disruptive technologies) to determine the optimal timing for such investments • New assets will be good quality and full life-cycle costing will be considered rather than short-term factors only. • Networks will be effectively maintained, adhering to international good industry practice asset management principles. • Avoid over design or building excess assets. • Investments must provide an appropriate commercially sustainable return reflecting their risks.
Existing efficiency, reliability and supply quality levels will generally be maintained	• At present there is no regulatory incentive to improve efficiency, reliability and quality of supply. • Vector is currently assessing the overall impact on customer service arising from reducing the use of live-line techniques to improve safety in the workplace.
Under normal operating conditions the full required demand will be met	• Assets will not be unduly stressed or used beyond appropriate short or long-term ratings to avoid damage. This is part of maintaining a long term sustainable electricity distribution network.
Network security standards (for delivery) will be met where it is economic to do so	• Where full compliance to target security standards may create uneconomic investment, Vector may accept variations to standards, as long as this is consciously accepted, explicitly acknowledged and contingency plans prepared to cater for asset failure.
Asset-related risks will be managed to appropriate levels	• Network risks will be clearly understood and will be removed or appropriately controlled – and documented as such. Risks may arise from our own assets or those of key stakeholders. Interdependency of risk will be understood and agreed.
An excessive future "bow-wave" of asset replacement will be avoided	• Although asset replacement is not age-predicated, there is a strong correlation between age and condition. To avoid future replacement capacity constraints or rapid performance deterioration, age-profiles will be monitored and appropriate advance actions taken.

Key Premise for the AMP	
Quality of asset data and information will continue to improve	• Vector's asset management is highly dependent on the quality of asset information. Its information system and data quality improvement programme will continue for the foreseeable future.
More non-network solutions will be adopted	• Vector will continue to investigate non-network solutions as practical alternatives to network reinforcements. This includes demand side options, pricing incentives, embedded generation, reactive compensation, alternative fuel, energy storage, etc. Such alternatives will be implemented where it is economical and practical.
New consumer and network technology will progressively influence how the network is operated and utilised	• The rate at which new consumer technologies are developing is accelerating. Demand and consumption patterns are changing and will increasingly impact on how the network is managed. Vector to continue to explore the opportunities that new technologies offer. Subject to economic justification and sufficient regulatory incentives, Vector will continue to invest in its evolution of the intelligent electricity network.

Table 2-3 : Key premises for the AMP

These key premises have a direct and major impact on the quality of service provided by the network, the condition of the assets, the levels of risk accepted and the asset expenditure programmes. Similarly the impact of new technologies have the potential to significantly change the security standards expected by customers in the future.

Electricity
Asset Management Plan
2016 – 2026

Network Service Areas & Configuration–Section 3

[Disclosure AMP]

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3. Network Service Areas & Configuration

3.1 Regions Covered

The Vector network is centred on the Auckland isthmus and supplies north to Mangawhai Heads (Northern region) and south to Franklin (Southern region). The map in Figure 3-1 shows the network boundaries, with Northpower in the north and Counties Power in the south. It also shows the boundary of the new wards administered by the Auckland Council. In addition, Vector supplies a large customer at Lichfield which is a stand-alone supply.

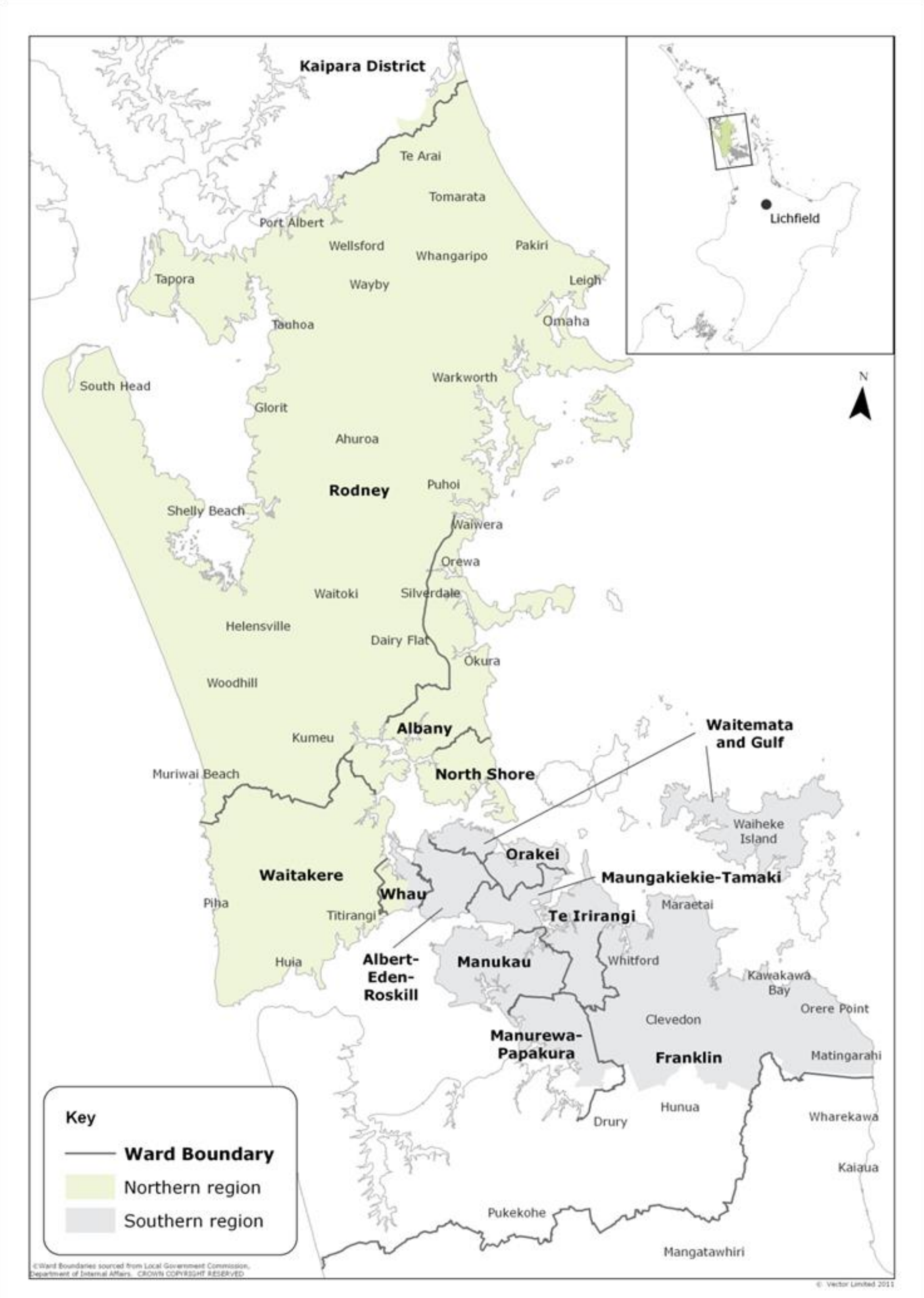

Figure 3-1 : Vector electricity supply area

While Vector operates its network in Auckland as a single unit, there are some legacy differences in network architecture and distribution practices associated with previous ownership structures and it is convenient to separately describe the Southern and Northern regions.

3.1.1 Northern Region

The Northern region covers those areas administered by the previous North Shore City Council, Waitakere City Council and Rodney District Council. The Northern region consists of residential, commercial and industrial developments in the urban areas, and residential and farming communities in the rural areas.

Most commercial and industrial developments are in Takapuna, the Albany basin, Glenfield, Henderson and Te Atatu. New regional commercial centres are being developed as part of the development in growth areas such as Westgate, Orewa/Silverdale and Whenuapai. There are few high density, high rise developments typical of major central business districts (CBDs) but the trend is evolving.

Areas north of the Whangaparaoa Peninsula and west of Henderson and Te Atatu are predominantly rural apart from scattered small townships. Zoning in these areas is largely for farming or conservation use.

The eastern and south-eastern parts of Waitakere and the southern parts of North Shore consist of medium density urban dwellings that are part of metropolitan Auckland.

The historical development of the electrical network has centred around coastal townships that have in time expanded with population growth. With New Zealand Transport Agency's expansion of the motorway network north of the Albany basin, it is expected that urban development will continue to move northwards.

3.1.2 Southern Region

The Southern region covers areas administered by the previous Auckland City Council, Manukau City Council, Papakura District Council and Franklin District Council (in part). The Southern region consists of residential, commercial and industrial developments in the urban areas, and residential and farming communities in the rural areas.

Most commercial and industrial developments are in Penrose, Newmarket, St Lukes, Mt Wellington, East Tamaki, Mangere, Takanini and Onehunga. Auckland also has the largest CBD area in New Zealand which accommodates the main commercial centre of the country.

There is also a significant number of in-fill commercial and residential developments scattered throughout the region. Development density in Auckland tends to be higher than in other parts of the country. This includes high rise residential apartments in the CBD, high density town house developments in suburban areas, industrial parks etc.

3.2 Large Consumers

Vector has a number of large customer sites at various locations in its network. The following are those customer sites with individual demand[1] above 5MVA, which are considered to have a significant impact on network operations and asset management:

- Fonterra cheese factory at Lichfield;
- Auckland International Airport;
- Mangere Waste Water Treatment Plant;
- Owens Illinois at Penrose;

[1] Some sites have installed capacities higher than 5MVA but demand less than 5MVA. These sites have not been included.

- Fisher & Paykel appliance factory at East Tamaki;
- Pacific Steel at Mangere;
- Ports of Auckland in the Auckland CBD;
- Sylvia Park at Mt Wellington;
- Sky City in the Auckland CBD;
- Devonport Naval Base at Devonport;
- Auckland Hospital at Newmarket;
- Carter Holt Harvey at Penrose; and
- Masport Limited at Mt Wellington.

3.3 Load Characteristics

Traditionally, residential load has a winter evening peaking characteristic. This is ideal from an asset rating perspective, as the cool temperature and (usually) moist ground condition increase conductor ratings. However, Vector anticipate a strong trend towards installing new residential appliances such as heat pumps, with indications that some winter peaking residential feeders and substations will move towards summer daytime peaking. The Auckland CBD and other air conditioned office blocks already exhibit summer peaking characteristics. Presently the winter residential peak load is about one and a half times the summer peak load but it is expected this gap will continue to close. The typical daily load profiles for residential and commercial loads for summer and winter are illustrated in Figure 3-2 to Figure 3-5 below. The demands are expressed as a percentage of the peak demand. It can be seen that the residential load has peaks in the mornings and evenings whereas the commercial load is consistent throughout the day. During weekends, the commercial load, due to office blocks not being occupied, is much lower, apart from large shopping centres that operate seven days a week.

Figure 3-2 : Typical summer load profile for residential customers

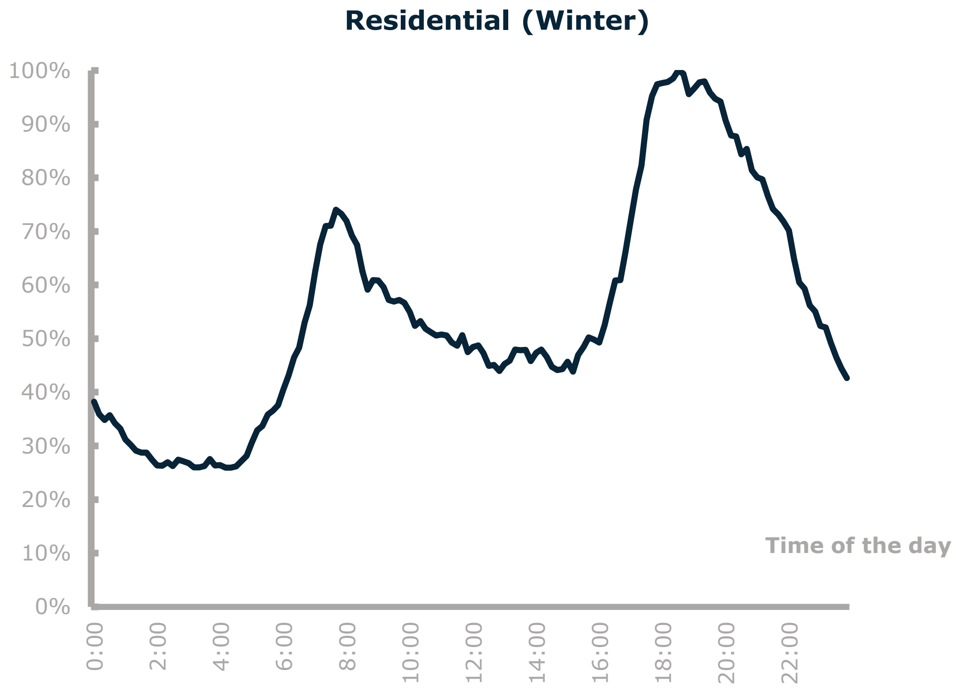

Figure 3-3 : Typical winter load profile for residential customers

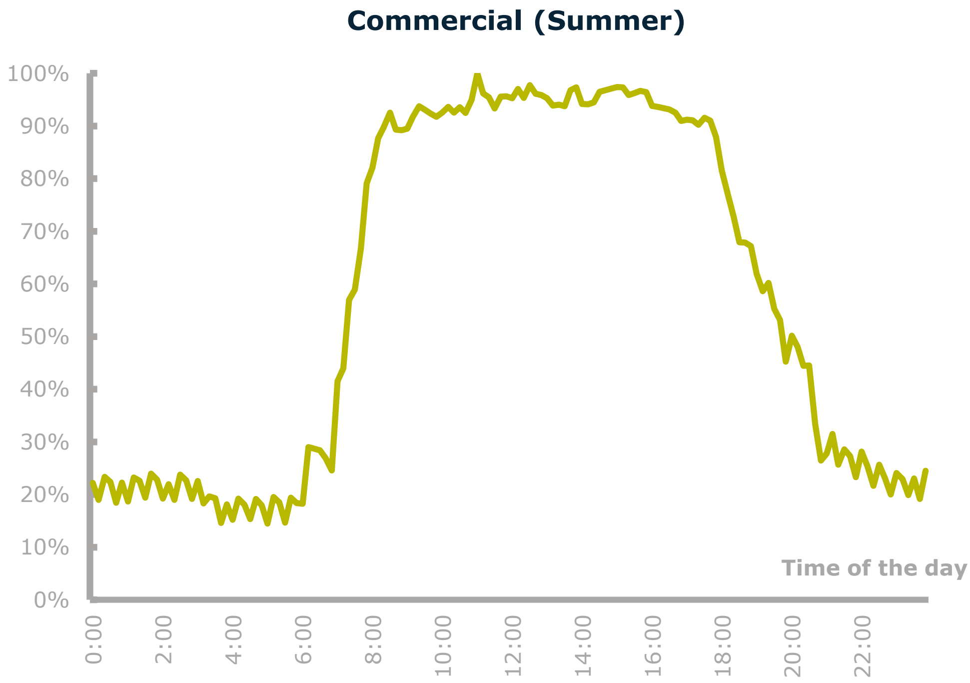

Figure 3-4 : Typical summer load profile for commercial customers

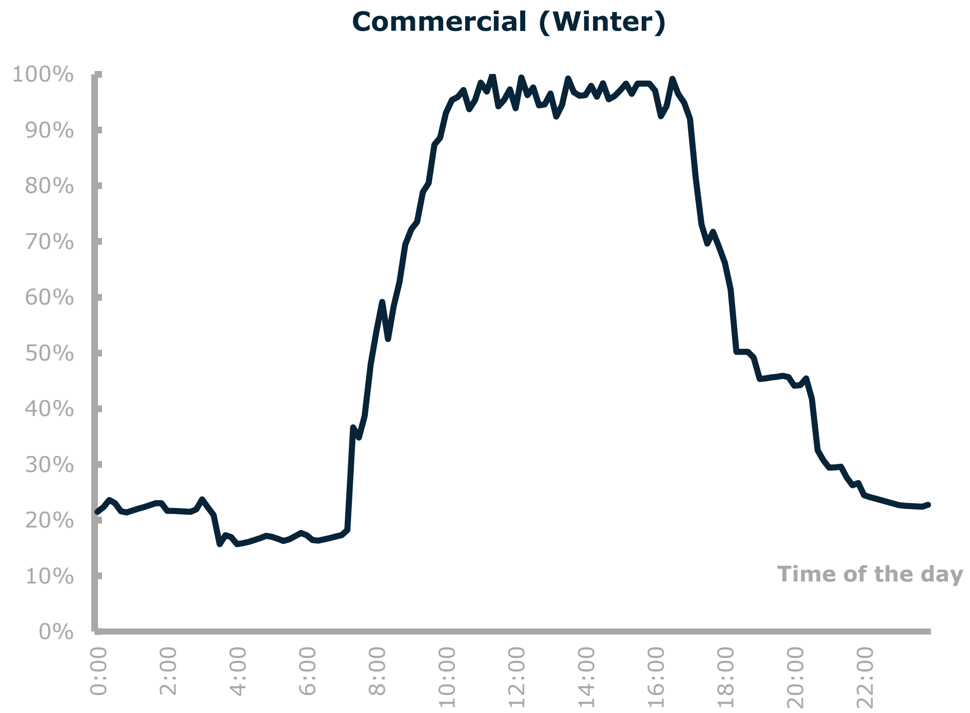

Figure 3-5 : Typical winter load profile for commercial customers

Demand curves for industrial customers are far more variable, depending on the nature of the customer's business.

The half-hour peak demand on the regional networks and the energy delivered for the past regulatory year are listed in Table 3-1.

Regulatory Year	Northern Regional Peak Demand (MW)	Southern Regional Peak Demand (MW)	Vector Peak Demand (MW)	Northern Energy Delivered (GWh)	Southern Energy Delivered (GWh)
2014/15	637	1121	1753	2572	5795

Table 3-1 : Half-hour peak demand and energy delivered on the regional networks

The peak demands reported above are the coincidental peak demands of all Grid Exit Points (GXPs) delivering supply to Vector, as well as major distributed generation with net export into the Vector distribution network.

Lichfield is included in the Northern region in the above table.

3.4 Network Configuration

The architecture of the Vector network is shown in Figure 3-6.

Vector receives electricity supply from the national grid at fifteen Grid Exit Points (GXPs). The Vector network is made up of three component networks: sub-transmission (110kV, 33kV and 22kV), medium voltage distribution (22kV and 11kV) and low voltage distribution (400/230V).

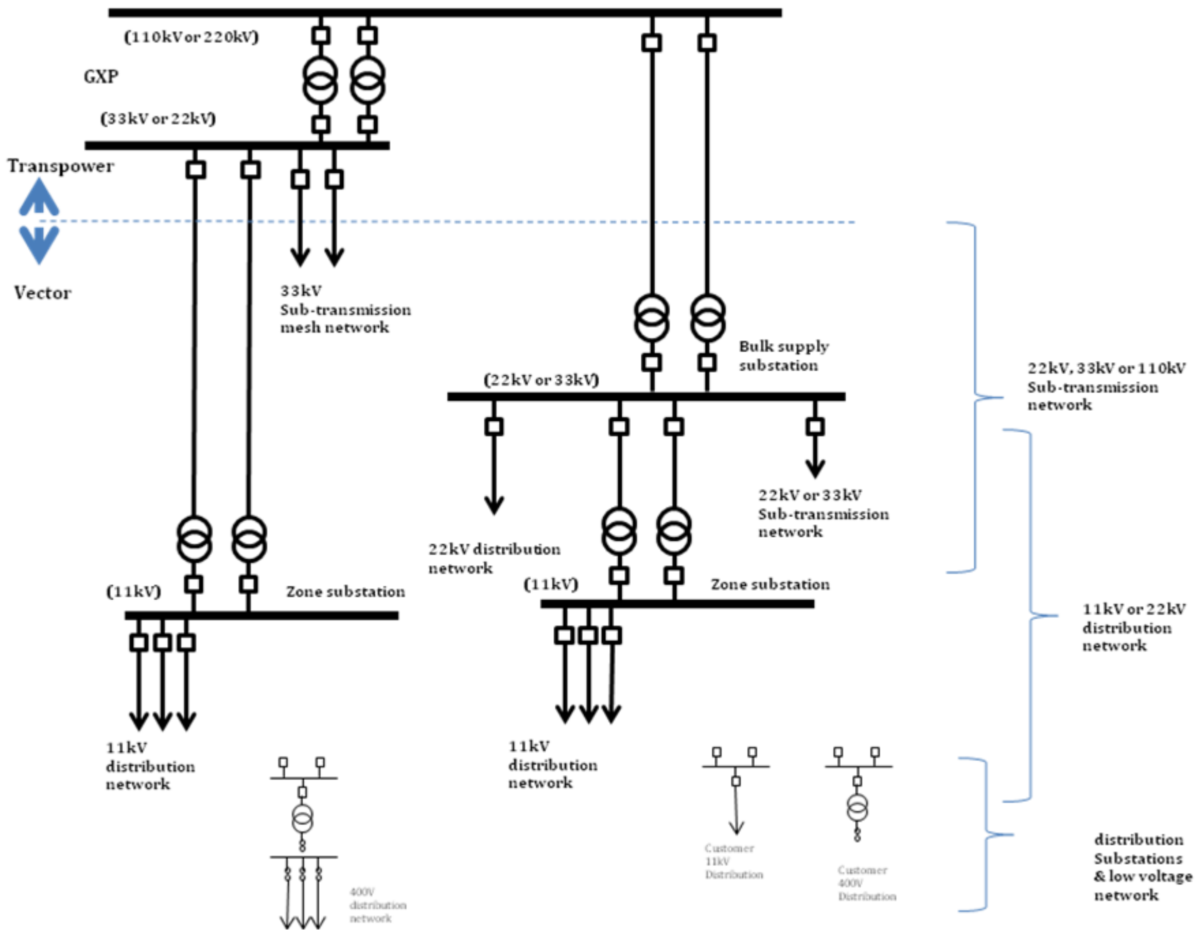

Figure 3-6 : Schematic of Vector's network

3.4.1 Bulk Supply Points

The electricity supply into Auckland from generation in the central North Island and the South Island is provided by six 220kV circuits and two 110kV circuits. All eight circuits terminate onto the 220kV busbars and 110kV busbar at Otahuhu GXP. From Otahuhu GXP, two 220kV circuits and four 110kV circuits have been installed to supply the demand north of the Auckland isthmus. Another four 220kV circuits and two 110kV circuits have been installed to supply the Auckland isthmus.

Vector takes supply from the national transmission grid at fourteen GXPs to supply its sub-transmission network in Auckland. Another (Lichfield GXP) is dedicated to the supply of the Fonterra cheese factory at Lichfield in Tokoroa. Sub-transmission supply is taken at 110kV, 33kV and 22kV. Vector has also established seven internal bulk supply substations to supply its sub-transmission networks in Auckland, to supply load centres that are at a distance from the grid.

Table 3-2 to **Error! Reference source not found.** show the winter and summer peak demands at GXPs.

Grid Exit Point	Supply Voltage	Firm Capacity[2] (MVA)	2015 Winter Peak Demand (MW)
Auckland CBD[3]	110kV		186

[2] Firm capacities supplied by Transpower

[3] Penrose 110 and Hobson 110 are supplying CBD in parallel

Albany	33kV	234	149
Henderson	33kV	135	112
Hepburn	33kV	245	129
Lichfield	110kV	10	8
Mangere	110kV		47
Mangere	33kV	118	102
Otahuhu	22KV	59	62
Pakuranga	33kV	261	136
Penrose	22kV	89	42
Penrose	33kV	383	274[4]
Roskill	110kV		62
Roskill	22kV	141	102
Silverdale	33kV	109	69
Takanini	33kV	126	100
Wairau[5]	110/33kV		116
Wellsford	33kV	39	31
Wiri	33kV	101	85

Table 3-2 : Grid Exit points for Auckland and Lichfield winter loads

Grid Exit Point	Supply Voltage	Firm Capacity (MVA)	2015 Summer Peak Demand (MW)
Auckland CBD[6]	110kV		224
Albany	33kV	234	107
Henderson	33kV	135	75
Hepburn	33kV	239	91
Lichfield	110kV	10	8
Mangere	110kV		46
Mangere	33kV	118	87
Otahuhu	22KV	59	51
Pakuranga	33kV	261	87
Penrose	33kV	372	200[7]
Penrose	22kV	89	36
Roskill	110kV		37
Roskill	22kV	140	67
Silverdale	33kV	109	51
Takanini	33kV	126	71
Wairau[8]	110/33kV		87

[4] The 33kV load at Penrose includes the 22kV load supplied through 33/22kV transformers

[5] Wairau 33kV and Albany 110kV are supplying Wairau in parallel

[6] Penrose 110 and Hobson 110 are supplying CBD in parallel

[7] The 33kV load at Penrose includes the 22kV load supplied through 33/22kV transformers

[8] Wairau 33kV and Albany 110kV are supplying Wairau in parallel

Grid Exit Point	Supply Voltage	Firm Capacity (MVA)	2015 Summer Peak Demand (MW)
Wellsford	33kV	37	25
Wiri	33kV	92	72

Table 3-3 : Grid Exit points for Auckland and Lichfield summer loads

The following map in Figure 3-7 shows the locations of the GXPs and the main 110kV and 220kV lines supplying into and across Auckland.

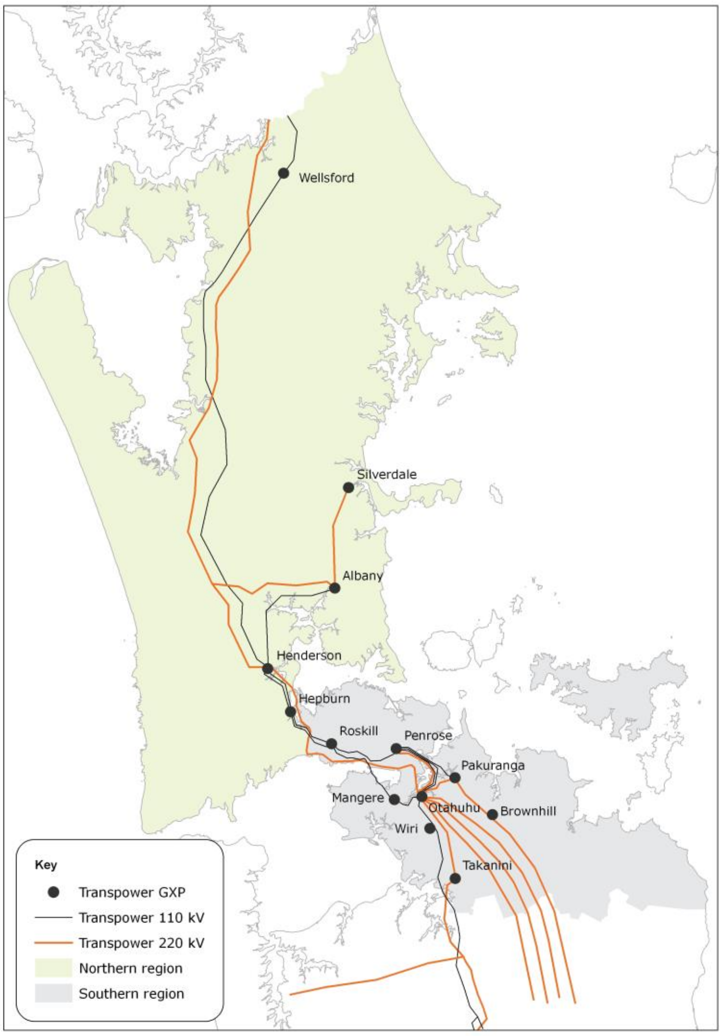

Figure 3-7 : Locations of GXPs and major transmission lines supplying Vector

3.4.1.1 Lichfield

Lichfield substation was established with two 20MVA 110/11kV transformers, from a tee off the Transpower 110kV lines. Vector owns the transformers and the 11kV cabling and switchgear on the Lichfield site. The map in Figure 3-8 shows the location of Lichfield GXP.

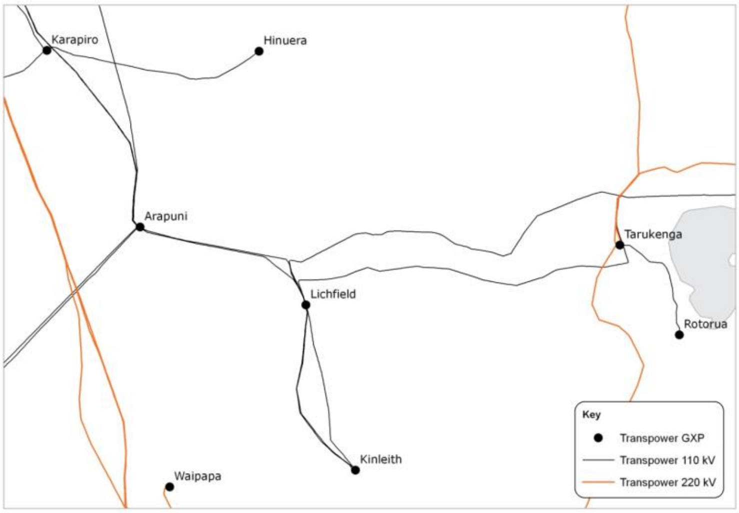

Figure 3-8 : Location of Lichfield GXP

3.4.1.2 Distributed Generation

The major distributed generators on the network (capacity > 1MW) are at Greenmount, Whitford, Redvale and Rosedale landfill sites, Mangere Waste Treatment Plant, and at Auckland Hospital.

3.4.2 Sub-Transmission Network

The sub-transmission networks for the Northern and Southern regions have been developed differently. Overall, 58% of Vector's subtransmission is underground.

The list of Vector's zone substations as at the end of the 2015 disclosure year, together with their existing and forecast installed firm capacities, security of supply classification, the 2015 winter peak demands, transfer capacities, existing and forecast utilisation is given in schedule 12b (report on forecast capacity) contained in the Appendices of this AMP.

3.4.2.1 Northern network

The Northern upper network has a mixture of interconnected 33kV ring and radial circuits connected to the Transpower GXPs. Many zone substations have 33kV switchgear to allow meshed subtransmission. This allows some interconnection between GXPs.[9] 34% of the Northern subtransmission is underground.

Transformer sizes are in the range 5 – 20 MVA, with around half the zone substations having a single transformer.

3.4.2.2 Southern network

The Southern upper network has mostly underground radial circuits supplying zone substations with two or three transformers. Sub-transmission voltages are 110, 33 and 22 kV. 85% of the Southern subtransmission is underground.

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[9] A detailed map of Vector's sub-transmission network and associated single-line-diagram can be made available for reference upon request to Vector's main offices in Auckland.

Substations in the Southern region typically do not have 33kV or 22kV switchboards except for those that are established as part of a bulk supply station or switching station. Most transformers are 20 MVA nameplate.

3.4.3 Distribution and LV Networks

The function of the distribution network is to deliver electricity from zone substations to customers. It includes a system of cables and overhead lines, operating at 11 or 22kV, which distribute electricity from the zone substations to smaller distribution substations. Typically up to 2,000 customers are supplied by a medium voltage (MV) distribution feeder, the number being determined by the load density and level of security.

The 11kV distribution network was originally constructed as an overhead network with interconnected radial feeders. However in recent decades all new subdivisions have been reticulated underground (distribution and LV networks). This is required by the District Plan.

The 22kV distribution network (around Highbrook industrial development and the Auckland CBD) is more recently established and is underground.

At the end of March 2015, 70% of the distribution (11kV and 22kV) network was underground in the Southern region and 31% in the Northern region. Overall, 47% of Vector's distribution network is underground.

At distribution substations the electricity is stepped down to 400/230V and delivered to customers either directly or through a reticulation network of low voltage (LV) overhead lines and cables. Up to 150 customers are supplied from each distribution substation. A typical distribution substation contains an MV (22kV or 11kV) / LV transformer, LV board and MV switchgear. The LV cables are configured in a radial formation with limited interconnection capacity to other distribution transformers (LV cables are not sized to supply adjacent substations).

At the end of March 2015, 62% of the LV network is underground in the Southern region and 48% in the Northern region. Overall, 56% of Vector's LV distribution network is underground.

There are a number of large customers in the Southern region connected to the network at higher voltage levels. The ownership of the substations serving these customers varies from site to site but generally Vector owns the incoming switchgear and any protection equipment associated with it. The customer typically owns the transformer(s), any outgoing switchgear and associated protection, and the building.

A more detailed description of the distribution network assets is given in Section 6 of this AMP, with overall asset quantities provided in Vector's Annual Information Disclosure (Schedule 9a)[10].

3.4.4 Protection, Automation and Control Systems (PAC)

3.4.4.1 Zone substations

All new and refurbished zone substations are equipped with multifunctional intelligent electronic devices (IEDs). Each IED combines protection, control, metering monitoring, and automation functions within a single hardware platform. It also communicates with the substation computer or directly to Supervisory Control and Data Acquisition (SCADA)

[10] http://vector.co.nz/electricity-disclosures/financial-and-network-information

central computers over the IP based communication network using industry standard communication protocols.

The substation’s DC auxiliary system provides power supply to the substation protection, automation, communication, control and metering systems, including the primary equipment motor drive mechanisms. The DC systems consist of a dual string of batteries, battery charger, a number of DC/DC converters and a battery monitoring system.

Vector’s feeder automation enables SCADA functionalities, auto-reclosing, auto-sectionalising, feeder reconfiguration, fault detection and voltage control.

3.4.4.2 Communication System

Vector’s communications network consists of differing architectures and technologies, some of which are based on proprietary solutions. The physical network infrastructure consists of a mix of optical fibre, copper (Cu) wire telephone-type pilot cables and third party radio communication systems.

The communications network is used for protection signalling, SCADA communications, operational telephony, access security, metering, remote equipment monitoring and automation.

Vector is committed to an open communications architecture based on industry standards. This has resulted in the adoption and deployment of ethernet and internet protocol (IP) based communication technology.

3.4.4.3 Energy and Power Quality Metering

Vector’s energy and power quality (PQ) metering system comprises a number of intelligent web-enabled revenue class energy and PQ meters installed at GXPs and zone substations. The meters communicate to the metering central software over an ethernet-based IP routed communication network.

3.4.4.4 Load Control Systems

Vector’s load control system consists mainly of audio frequency ripple injection. The load control systems offer the ability to:

- Control residential hot water cylinders;
- Control street lighting;
- Meter switch for tariff control;
- Time shift load to improve network asset utilisation;
- Time shift load to defer reinforcement of network assets; and
- Manage GXP demand charges from Transpower.

The load control equipment utilises older technology, much of which is approaching the end of its life. As newer customer metering (“smart meters” or associated intelligent home hubs) and communications technologies are rolled out, alternative means of load control will become possible. It is therefore anticipated that the existing load control systems will be phased out. Strategies for the transition are being developed.

3.4.4.5 Distribution substations

Most distribution transformers are fuse protected on the MV side. LV protection depends on the customer connection arrangements.

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Service Levels – Section 4

[Disclosure AMP]

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4. Network Performance

This section describes the electricity distribution business' performance indicators and targets set under Vector's asset management strategy. Performance against these targets is also discussed.

4.1 Customer Experience

Vector is committed to delivering customer excellence as we create the new energy future. We will do this by consulting with and listening to our customers, speaking in plain English and developing new tools to reduce their time and effort to be served. Vector recognises customer communication as essential in order to understand, add value and deliver services and products our customers like, want and need.

Keeping engaged, aligned and ahead of changing customer expectations is fundamental to delivering optimal asset investment and asset management practices.

Our intention is to develop easy and fast options for our customers.

Customer interaction, consultation and the outcome experience is part of everyday business encompassed by;

- Call centre representatives;
- Customer service team representatives;
- Operations and project representatives;
- Service contracting representatives;
- Service feedback surveys;
- Lifestyle surveys;
- Digital platforms (website, social media, apps etc); and
- Dedicated account management for nominated customers.
- Vector Customer Advisory Board

Vector has established a Customer Advisory Board consisting of diverse representation of our customers and key stakeholders to help define and test evolution of our customer relationships, strategies, services and standards. Vector is using this Board, along with results of the surveys conducted, to drive services to meet customer expectation.

Significant individual needs, preferences and expectations are derived through lifestyle surveys. Lifestyle insight providing a sound basis for changing business objectives in alignment with changing customer expectations.

The most recent lifestyle survey, conducted in November 2015, continues to reinforce the strong themes from previous engagement surveys. This survey was designed to draw out customer preferences around network performance, pricing, preferred manner of communication, appliance usage, and energy usage.

Key findings in summary;

- Respondents tend to be more positive than negative in terms of network pricing. However a sizeable number of respondents don't really know if it is good value for money or not. The level of indecision might be driven by the lack of transparency from Retailers regarding what Vector's charges are, and the lack of awareness regarding the energy industry.
- Although current outage duration and frequency performance meets our service levels, this is largely not in sync with customers' expectations.

- With communications, respondents prefer text messages and email when planned and unplanned outages occur. A very small proportion of respondents (8%) are outage app users with user experience rated to be useful by **60%** of them.
- Traditional resistance heaters are still the main method for space and water heating. However, regardless of cost, heat pumps are the first choice for space heating, with solar related appliances being the top preferred method for water heating.
- A significant number of respondents identified they had no or limited insulation or ventilation in their homes.
- A good proportion of respondents (44%) would consider changing usage habits to save money, but expected significant monthly savings in the order of 20% or more. A higher proportion of respondents (56%) have less or no motivation to change.
- 1 in 2 respondents do not know whether they are currently on the "controlled" tariff or not. This is an area that respondents care little about trying to understand.
- EV penetration and intention to purchase are very low at the moment. Of further interest is to understand what the most significant factor to affect uptake is.
- Although solar PV penetration is low, there is a high interest in using solar PV. Respondents who are interested in solar PV are more peak time and energy conscious. Insulation and ventilation are more significantly used in those respondents' homes.
- Intent to purchase a domestic battery is high as long as savings are more than cost. A quite sizeable proportion of respondents would allow external control over how batteries are used if there are financial benefits.
- Intention to install gas is minimal. A sizeable proportion of respondents do not know if gas is available in their streets or not. The initial cost of connection and switching are the major concerns for respondents when deciding to install gas, when gas is available in their streets.

In Q2 FY16, Vector launched a program to track Customer Effort Scores. A representative sample of customers were asked to score how easy they felt it was dealing with Vector. The intention is to set targets for each business unit for Q4 FY16 in order to lift performance.

4.2 Service Standards

Service	Response time target
Contact centre	**Telephone Service Level**: answer 80% of calls within 20 seconds **Service Quality:** call quality and complaint management. Contact centre must achieve >91% **Customer Satisfaction:** customer satisfaction with call >81%
Field response	75 minutes maximum, from time of logging fault until first response unit is on site Resolution times - from time of fault reported: • CBD 2 hours

	• Urban 2.5 hours • Rural 4.5 hours
Customer complaints	Acknowledge all complaints within two working days Resolve 90% of complaints within 10 working days

Table 4.2-1: Vector Target Response Times RY15 – RY16

We follow through on what's important to our customers and have an affirmed commitment in the form of service standards. The following service standards are published online, and apply to all customers connected to our electricity network;

Time to Restore Power - Once we learn of an outage on our network we endeavour to restore the power supply as quickly as possible. Restoration standards are;

- 2 hours per interruption in the CBD,
- 2.5 hours per interruption in urban areas, and
- 4.5 hours per interruption in rural areas.

Number of Interruptions - Although we strive to minimise interruptions to all customers, location specific outage causes and distance related network exposure will result in a varying number of interruptions experienced by each customer. Interruption standards are;

- 4 interruptions per annum in the CBD,
- 4 interruptions per annum in urban areas, and
- 10 interruptions per annum in rural areas.

Three Free Call Outs - We provide three free call outs per annum, meaning if an interruption is specific to the customer's lines or equipment we will attend, make safe and provide remediation advice, the first three call outs are on us.

Historical adherence to the service standards is summarised in Table 4.2-1

Regulatory Year	**RY11**	**RY12**	**RY13**	**RY14**	**RY15**
Time To Restore **% of Customers Exceeding Restoration Standards**	10.2%	9.1%	10.1%	9.5%	10.1%
Number of Interruptions **% of Customers Exceeding Interruption Standards**	8.4%	19.8%	6.0%	9.9%	7.1%

Table 4.2-1: Service Standards Performance RY11–RY15

4.2.1 Complaints Resolution

Although Vector seeks to provide a high standard of service and a reliable electricity supply, there may be times when customers have concerns with their service.

If the cause for concern or complaint is not immediately resolved, it is logged as a formal complaint with our customer services team. The customer services team is responsible for complaint resolution, identifying trends and raising issues with the appropriate business units in order to implement permanent solutions and prevent recurrence, where appropriate.

Vector adheres to a formal complaint resolution process. Vector's preference is for proactive, consultative and direct engagement with customers via the customer services team. Engagement takes the form of meetings with customers or customer representatives to present and discuss areas of concern. A significant number of these discussions are related to supply quality issues. This provides Vector the opportunity to explain historical and current supply quality performance, listen to and understand customer concerns and consult on appropriate actions and future recommendations.

Vector's formal complaint process is as follows:

- Acknowledgement of receipt of the complaint by Vector (see timeframe below);
- Keeping the customer informed with progress in addressing the complaint;
- Attempting to resolve the complaint within the timeframes specified by the EGCC (see below); and
- If the complaint is not resolved within the specified timeframes, informing the customer of the reason for the delay and working towards resolution.

If we have not resolved the complaint within the specified timeframes then the customer is advised of the option of contacting the EGCC.

Response Times

Vector attempts to resolve customer complaints to everyone's satisfaction as quickly as possible. Vector's response time target is to resolve >90% of complaints within the timeframes as detailed below. We have two internal targets for complaints:

- Acknowledgement within two working days; and
- Resolved in ten working days.

Vector's customer services team is responsible for achievement of these targets and is incentivised via Vector's KPI programme.

In deciding the target level of service, Vector takes into account typical industry practice, level of service over recent years and compliance with targets set by the EGCC.

During RY15 1,640 *customer complaints were received, of which* 1,148 (70%) *were resolved within the prescribed timeframe.*

These targets are tighter than the industry targets under the EGCC, which stipulates that complaints must be resolved within 20 working days, or 40 working days for complex cases.

EGCC Complaints

The EGCC (Electricity and Gas Complaints Commission) is an independent body that facilitates resolution between the electricity company and the consumer if the other means of resolution have failed. All customers have the option of contacting the EGCC directly if their complaint has not been resolved to their satisfaction.

In RY15, 14 (0.85%) complaints went to the EGCC, of which 7 were resolved under Vector's standard resolution process.

4.2.2 Justification of Consumer Oriented Performance Targets

Supply reliability and response targets are normally established by taking into account customer needs on a qualitative basis, due to the complexity and informational requirements of quantifying customer requirements, and relating them to network performance.

As indicated by customer surveys, at present there is no evidence from the Vector customer base to support heightened (or reduced) levels of supply reliability, especially where these would involve increased line charges. In the absence of other drivers or incentives, Vector's quality targets therefore coincide with the regulatory quality targets, which are also based on historical performance levels.

Vector Service Level Payments

Vector contracts with energy retailers for line services, while end users contract with energy retailers for both energy and line services (interposed arrangement).

Vector's published service standards include a payment to customers that lodge a claim where an outage has occurred and Vector is unable to restore power supply within the target restoration times. This payment is $50 for residential customers and $200 for business customers (<69kVA).

Large events and events outside of Vectors' control are excluded from the scheme.

4.2.3 Maintaining our Performance

Fundamental to maintaining supply reliability is the need for high volumes of coordinated and planned works to be safely delivered through our field service providers. The absolute need to deliver worker safely is first and foremost. For example, Vector's policy that all works on Vector's network must be carried out in a de-energised state and that live line work is only justifiable under certain conditions, for example: sensitive customers, complex switching, worker and public safety.

Supply reliability performance maintenance programmes continue to address the following:

- Reducing the number of interruptions experienced by customers, through improvements in the coordination between inspection, defect remediation and vegetation management;
- Reducing the time customers are without electricity through further usage of intelligent monitoring and strategic remote control;
- Large scale asset renewal and vegetation removal on the most critical network sections of the top 40 worst performing feeders;
- Targeting major cause contributors to reduce the frequency of customer interruptions;
- Where safe and cost effective to do so, increased use of generators to minimise the impact of required shutdown outages; and
- Improvements in network and asset management information and related IT systems.

4.3 Supply Reliability Performance

Vector's strategic goal is to ensure supply reliability performance targets are achieved in accordance with regulatory thresholds and customer expectations.

Targets and measures for overall network reliability are defined by the regulatory requirements; whereas Vector's standard service levels consider individual supply reliability expectations.

In the context of average network supply reliability, both the frequency and duration of interruptions are recorded and reported through the following internationally recognised measures:

- SAIDI (system average interruption duration index): the length of time in minutes that the average customer spends without supply over a year; and
- SAIFI (system average interruption frequency index): the number of sustained supply interruptions which the average customer experiences over a year.

Both SAIDI and SAIFI are required measures under the default price-quality path applying to Vector under Part 4 of the Commerce Act and have prescribed thresholds.

New Zealand practice requires that both of these measures consider only the impact of sustained interruptions related to high voltage (HV) distribution and sub-transmission network. Low voltage (LV) interruptions are excluded, on the basis that these are highly localised and generally affect only an individual or small cluster of customers. SAIDI and SAIFI include planned and unplanned events, but exclude Transpower or generator related events.

Vector's reliability targets are based on the Commerce Commissions prescribed quality standards methodology, which combines extreme event treatment with ten year historic performance, to define target values and cap and collar values for each measure. The Commerce Commission also introduced a 50% weighting factor against planned SAIDI and SAIFI values.

Vector's target SAIDI and SAIFI values are indicated in Table 4.3-1, referred to as Normalised Planned and Unplanned. Note however that Vector is currently monitoring the impact on these targets as they do not reflect the consequences of reducing live-line techniques to improve workplace safety.

Regulatory Year	RY16	RY17	RY18	RY19	RY20
SAIDI Normalised Planned and Unplanned	96	96	96	96	96
SAIFI Normalised Planned and Unplanned	1.29	1.29	1.29	1.29	1.29

Table 4.3-1: Supply Reliability Targets RY16-RY20

4.3.1 Trends in Supply Reliability

This section considers longer-term trends in Vector's supply reliability performance and provides a relative impression of how the network has historically performed.

The following Figure 4-1 shows Vector's SAIDI from RY05 through to the last complete return. In order to illustrate Vector's underlying performance, "excluded events" have been identified, using the Commerce Commission's beta methodology, and "extreme threshold" SAIDI re-introduced.

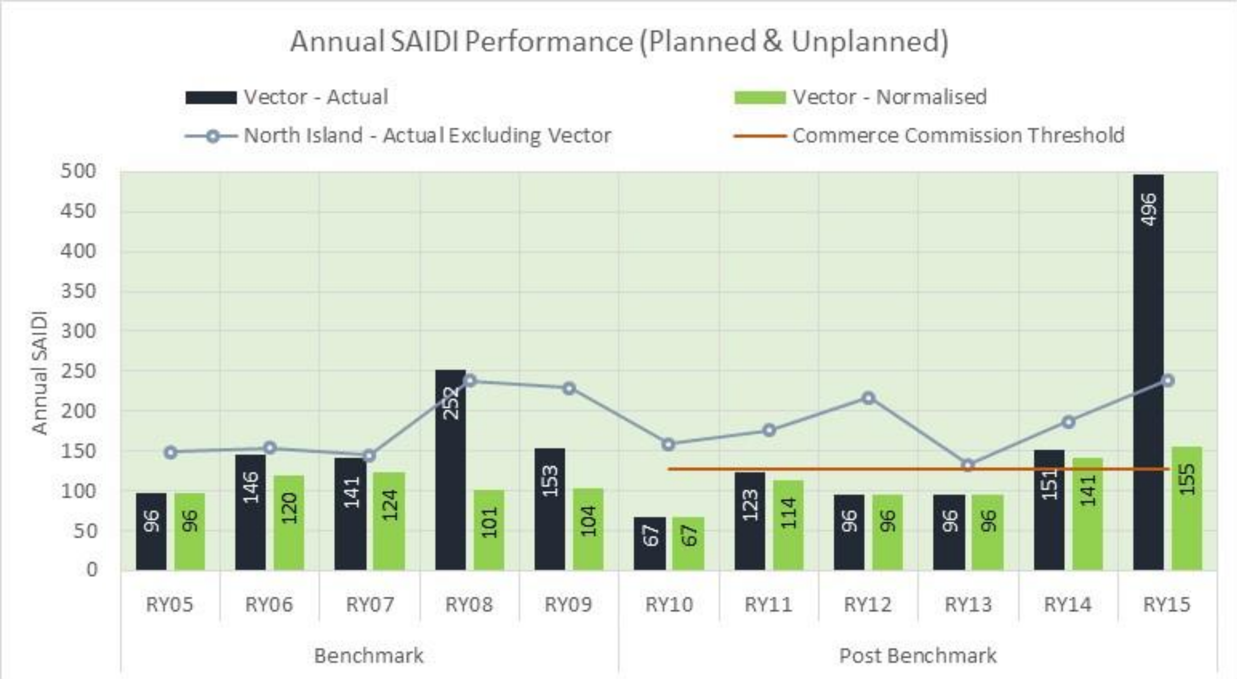

Figure 4-1 : Vector SAIDI

Annual SAIDI Performance Summary;

- Vector's SAIDI compares well against other New Zealand North Island electricity distribution businesses (EDBs). Performance highs and lows are closely mirrored by the rest of the North Island, indicating correlation with wider area weather events.
- Vector generally performed very well against the Commerce Commission threshold from the start of the regulatory period RY10 to the first threshold breach in RY14.
- During RY15, the singular event cable trench outage which occurred at the Transpower Penrose substation contributed 215 minutes.
- In addition, both RY14 and RY15 experienced turbulent weather events identified as the primary cause driving the breaches in threshold.

Vector's historic SAIFI performance is presented in Figure 4-2.

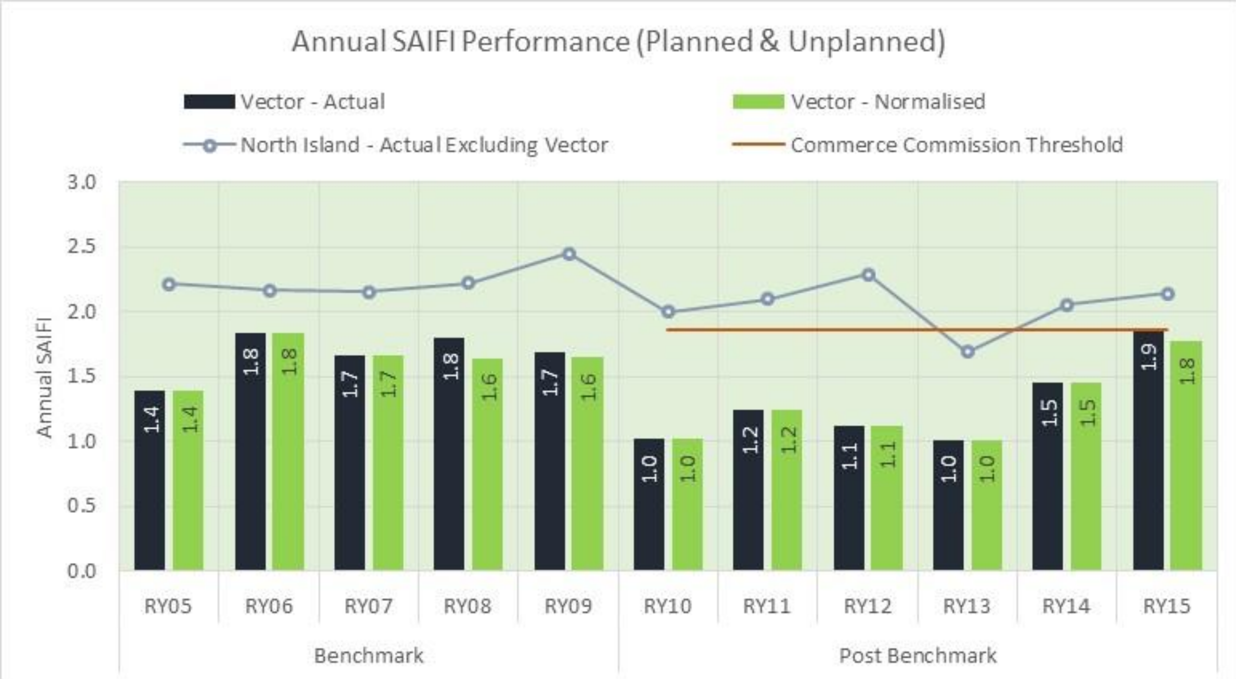

Figure 4-2 : Vector SAIFI

Annual SAIFI Performance Summary;

- Vector's SAIFI also compares well against other New Zealand North Island electricity distribution businesses (EDBs).
- Vector has performed exceptionally well against the Commerce Commission threshold since the start of the regulatory period RY10.
- During RY15, the singular event in a cable trench which occurred at the Transpower Penrose substation contributed 0.16 to the SAIFI total.

4.3.2 Causes of Interruptions to Supply

There are a host of reasons why interruptions to supply occur. Typically, on the Vector network, around 95% are unplanned and result from a range of causes including vegetation, animals, third parties, asset condition and adverse weather. Planned interruptions are generally undertaken for maintenance or network upgrade purposes.

Figure 4-3 shows the proportional SAIDI performance by outage cause compared over the last two regulatory periods as against last year.

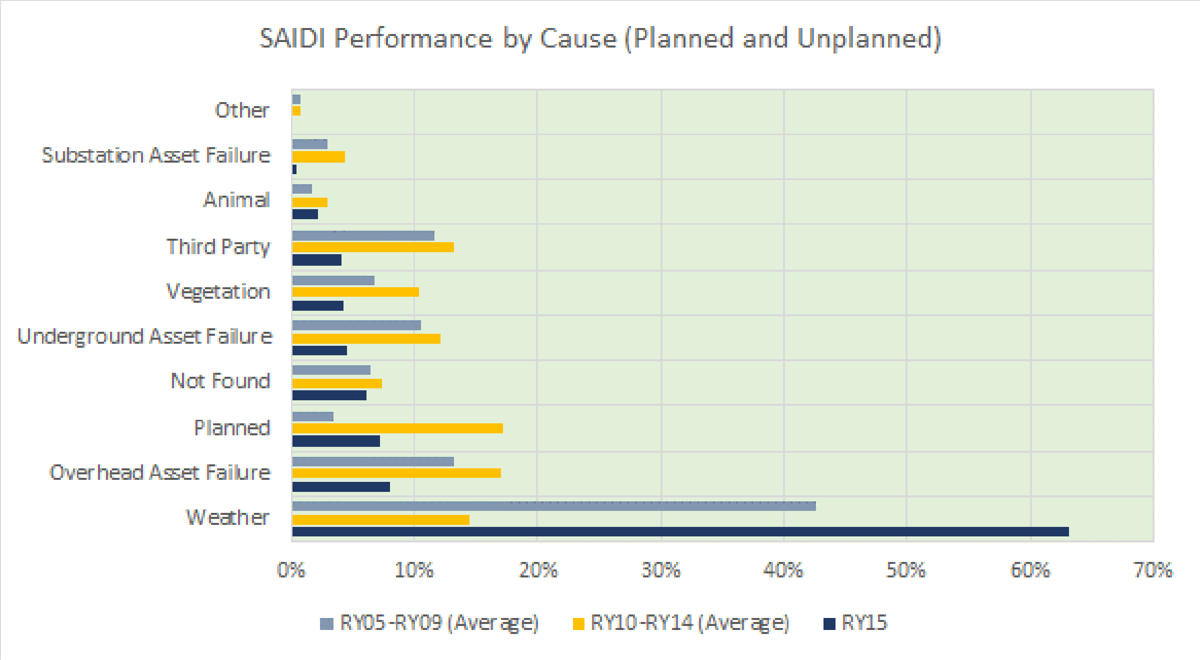

Figure 4-3 : Percentage SAIDI performance by cause

The outage causes are classified in accordance with the following definitions:

- **Weather** – Encapsulates all unplanned customer interruptions related to direct lightning damage or protection operation, other adverse environmental causes such as flooding or land subsidence and overhead asset events relating to high wind pressure exposure greater than 60 kilometres per hour.
- **Overhead Asset Failure** – Considers all unplanned customer interruptions resulting from overhead equipment failure, both mechanical and or electrical. Includes binders, capacitor banks, cross-arms, conductors, connectors, poles, foundation and stay wires, fuses, links, insulators, lightning arrestors, reclosers, switchgear and transformers.
- **Planned** – All scheduled maintenance and replacement works resulting in a pre-notified customer interruption.
- **Not Found** – Classification used when circuit protection devices operate to interrupt customers, however after circuit patrolling and sectionalisation, the circuit is re-energised and no cause of fault or location can be found.
- **Underground Asset Failure** - captures all unplanned customer interruptions resulting from underground equipment failure. Includes cable, cable joint, cable riser, cable termination, ground mounted transformers, cross bonding / link boxes etc.
- **Vegetation** - Unplanned customer interruption resulting from vegetation contact, including debris, tree fall, and grass sub-causes.
- **Third Party** - Unplanned customer interruption resulting from external contractors or members of the public, includes dig-in, overhead contact, vandalism, and vehicle damage sub-causes.
- **Animal** - Captures all unplanned customer interruptions resulting from fauna including: birds, possums, vermin, cats and other similar fauna.
- **Substation Asset Failure** - Captures all unplanned customer interruptions resulting from equipment failure within a substation be it a zone substation or a distribution substation. Includes buswork, cabling, cable terminations, capacitor banks, circuit breakers, communications failures, protection mal-operation, load control equipment, switches, voltage transformers, switch-units and transformers.

- **Other -** Captures all unplanned customer interruptions related to interruptions resulting from Vector's Contractors or Staff incidents eg, commissioning errors, incorrect protection settings, SCADA problems, switching errors, dig-in's or overhead contacts.

4.3.3 Processes for Measuring Network Performance

Operational responsibility of Vector's sub-transmission and distribution networks rests with the network control team. Resolution of planned and unplanned events is under direction of the duty control room engineer.

All planned and unplanned records are captured by the network control engineer both in hard copy (electricity fault switching log) and electronically (the HVEvents database).

The HVEvents database records such fault details as outage type, system level, location, and cause, customers without supply and restoration times. To ensure accuracy, each outage record is peer-reviewed by the network control team and/or the network performance analyst. In addition, Vector's external auditors (KPMG), review this process annually and conduct sample checks for accuracy.

At year-end the period's average network customer base is calculated using the billing and revenue system (averaging customers at the start and end of the year). The following reliability metrics are extracted from the HVEvents database for disclosure reporting:

- Interruption frequency by class;
- Interruption frequency by voltage level;
- Interruption duration by class; and
- SAIDI/SAIFI/CAIDI (calculated using average customer count).

Figure 4-4 shows the process for recording outage information and the process for auditing the quality of the recorded data.

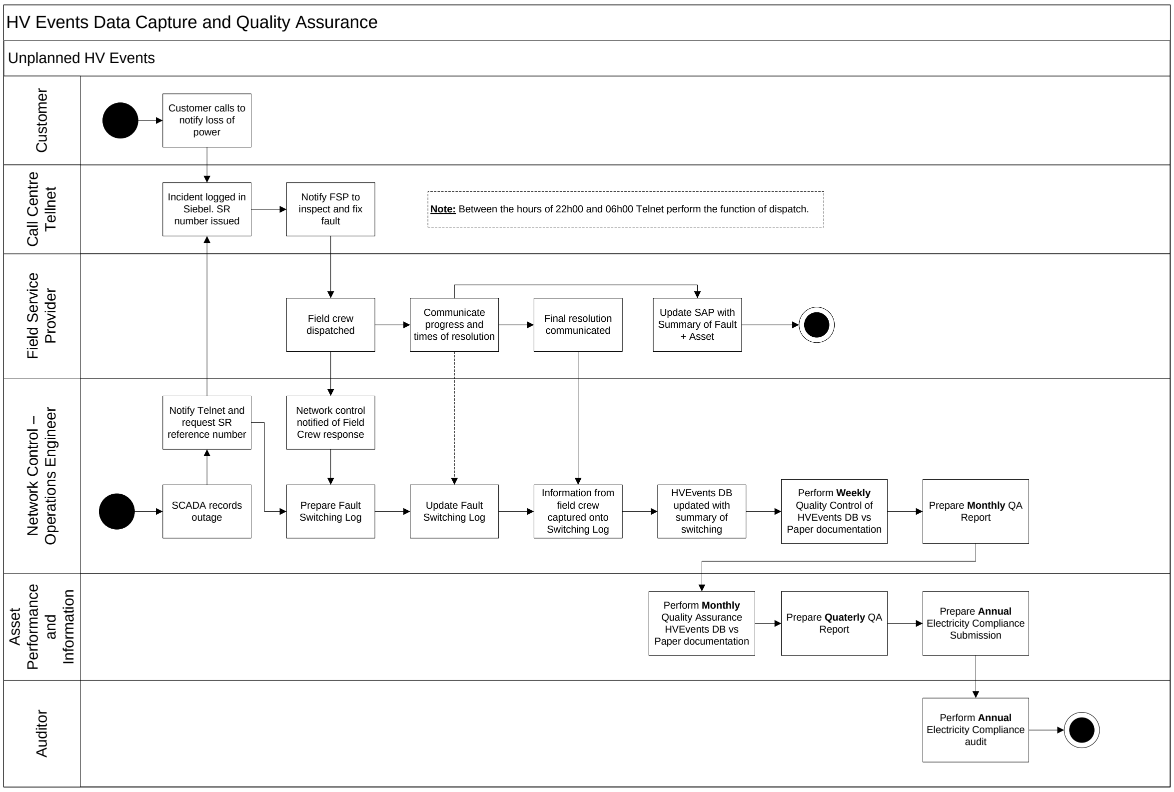

Figure 4-4 : Process for capture and QA of outage information

4.4 Asset Performance

4.4.1 Failure Rate

Asset failure rate is a direct measure of the number of recordable events per system length, and provides an indication for understanding the underlying network performance. Vector has recently adopted a wider definition of Failure Rate, which now considers both high and low voltage unplanned events as a single measure relative to the total network length.

Although asset failures are indicative of underlying asset health, the relationship between asset failure and delivering exceptional customer experience is complex and changing with adoption of customer technologies.

The following Table 4.4-1 presents Vector’s combined failure rate through RY12 to RY15. In order to understand Vector’s underlying performance, “excluded events” have been identified, by removing outlier days in which the total daily event count is greater than 2.5 times the daily average, and re-introducing the average daily event count.

Regulatory Year	RY12	RY13	RY14	RY15
Failure Rate Normalised Faults per 100 Kilometres	62.6	60.0	56.8	59.3

Table 4.4-1: Failure Rate Performance RY12-RY15

Vector's Network failure rate target is given in Table 4.4-2.

Regulatory Year	RY16	RY17	RY18	RY19	RY20
Failure Rate Normalised Faults per 100 Kilometres	60	60	60	60	60

Table 4.4-2: Failure Rate Target RY16-RY20

It should be noted that not all asset failures lead to supply interruptions. Asset failure rate provides a measurement of how the network performs.

4.5 Works Performance Measures

4.5.1 Capital Works Delivery

Capital work is scheduled physically and financially from the time a project is in proposal stage. Each project is split into a number of stages that state delivery expectations from defining the solution, through to final commissioning and close out. Project delivery through the stages with an emphasis on cost control is monitored monthly and reported to general manager level, any cost variations from budget being communicated to board level. Project initiators, engineers and contract managers meet on a monthly basis to discuss project progress and issues and roadblocks are quickly escalated.

To ensure focus remains on delivery of the works programme, our FSPs have profit at risk KPIs associated with delivery against forecast.

Monthly forecasts are compiled for the whole programme of work and circulated to executive level. Actual against forecast is also tracked as part of the executive dashboard metrics.

Each month an exceptions report is submitted to the board, which details the number of active projects with a value greater than $500,000 and their status. This report is designed to provide a no surprises environment, where projects with time or budget issues are highlighted at an early stage.

4.5.2 Field Operations Performance Assessment

A performance incentive scheme has been agreed with Vector's FSPs that is intended to:

- Measure the performance of Vector and the FSPs through the establishment of KPIs for both Safety and SAIDI outcomes, and provide appropriate incentives to deliver the required performance by both parties;
- Recognise that the FSPs entitlement to any incentive payment is dependent upon its performance as measured against KPIs, and drive continuous improvement and efficiencies through the annual review of the KPIs and the criteria for those KPIs; and
- Recognise that Vector's performance within key processes is critical to the FSPs' ability to deliver overall results.

Systems have been developed and implemented to provide visibility to both Vector and FSPs on their respective performances against KPIs that employ end-to-end measures.

For each KPI there is a "meet" and "outstanding" performance incentive level; in some cases there is an additional "not meet" disincentive criterion. KPIs have been established for Vector's FSPs in the following areas, which are described in more detail below:

- Network performance;
- Delivery and quality of works;
- Health, safety, environmental and people;
- Cost management and efficiency; and
- Information quality.

4.5.3 Health and Safety

Vector is committed to continual and progressive improvement in its health and safety performance. The building of sustainable Health and Safety capability at all levels, the delivery of services, and exceptional engagement with all stakeholders remain focussed on the following fundamental objectives;

- Providing a safe and healthy workplace for all Vector people (including contractors), the public and visitors;
- Ensuring health and safety considerations are part of all business decisions;
- Monitoring and continuously improving our health and safety performance;
- Communicating with Vector people, customers, and stakeholders on health and safety matters;
- Operating in a manner that manages health and safety hazards and mitigation of the risks;
- Fostering personal commitment to health, safety and wellbeing and encouraging safe and healthy lifestyles, both at work and at home; and
- Supporting the safe and early return to work of injured or ill Vector people.

In addition to the specific performance measures relating to Health and Safety that have been put in place with the FSPs, Vector monitors electricity-related public safety incidents and incidents arising from its employees. These incidents are revised monthly to ensure lessons are captured and where appropriate, corrective actions are implemented.

The primary Health and Safety performance measure considered by Vector is the total recordable injury frequency rate (TRIFR). TRIFR encompasses all incidents resulting in a medical treatment, restricted work injury, lost time injury or fatality, which impacts Vector People including all contractors and service providers. The incident count is divided by the number of hours worked for the same measurement timeframe, Vector reports TRIFR as a moving 12 month value which is then normalised to report TRIFR in per million hours worked.

Table 4.5-1 below shows the trend in total recordable injury frequency rate injuries at Vector (including Vector staff, contractors and FSPs).

Regulatory Year	RY13	RY14	RY15
TRIFR Total Recordable Injury Frequency Rate	12.29	11.26	9.13

Table 4.5-1: Health and Safety Performance RY13–RY15

Vector's stated objective for RY16 is a 10% reduction in TRIFR from the previous year, with subsequent annual reductions of 5% out to RY20. The Health and Safety TRIFR targets are presented in Table 4.5-2.

Regulatory Year	RY16	RY17	RY18	RY19	RY20
TRIFR Total Recordable Injury Frequency Rate	8.22	7.76	7.30	6.85	6.39

Table 4.5-2: Health and Safety Targets RY16-RY20

Vector is continuing to place a strong focus on: designing out hazards, where ever possible, through our safety in design process, Vector's policies and procedures assist the workforce to deliver the right action at the right time, and to focus on personal behaviours and safety leadership to encourage an individual and team safety culture.

The Health and Safety at Work Act 2015 has been passed by Parliament, and will come into effect on 4 April 2016. The new law will be supported by regulations, Approved codes of practice (ACOPs) and guidelines that are being developed in time for April 2016. Vector has reviewed and updated our Health, Safety and Environment (HSE) management system in line with the new legislation. Vector's commitment to ensuring the intent of the new legislation to proactively undertake risk management to prevent harm has driven our policy for all works on Vector's network to be carried out in a de-energised state unless justifiable under certain conditions, as well as our storm response work will only be undertaken when it is safe for the workers to do so.

4.5.4 Environment

Vector strives to be recognised as a leading environmentally responsible company, with exceptional emphasis on operating in such a way as to respect and protect the natural environment.

Vector's environmental target is full compliance with all requirements from local and regional councils to have no prosecutions based on breaches, environmental regulations or requirements.

Environmental incidents are also reported, recorded and investigated with any learnings and improvements shared with the FSPs at the HSE leadership forum.

Electricity
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Network Development Planning – Section 5

[Disclosure AMP]

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5.1 Network Development Planning

Network development relates to growth initiatives which:

- Extend Vector's electricity network to developing areas;
- Increase the network capacity or supply levels of the existing network to cater for demand growth or changing consumer demand;
- Provide new customer connections; and
- Address the relocation of existing services when requested by customers, utilities or requiring authorities.[1]

5.2 Network Planning Process

The processes used for planning and implementing network development projects commences post-winter with an update of the demand forecast. Network constraints arising from the forecast are identified, options to correct the security shortfall identified, costed and evaluated to select the optimal outcome. The selection criteria is based on the lowest cost that best fits Vector's strategic goals.

The resultant list of projects is compared to the list of asset replacement and relocation projects to identify potential synergies and cost savings through the merger of co-located projects. A consolidated list of projects is assembled and prioritised based with a weighting determined by alignment with Vector's strategic goals.

Project resourcing capability is reviewed, both internal and with external service providers, to advise how much of the proposed programme can be delivered. Likewise a financial review ensures that the proposed expenditure programme remains within the Regulators Default Price Path profile.

Based on delivery capability and available budget, a prioritised project list (works programme) is selected by removing the lower priority projects. Those projects not selected are either moved into next year's project list or are substituted for another project following a manual "sensibility" check of the selected projects.

The works programme is included in the Asset Management Plan along with a high-level project delivery schedule and expenditure forecast.

Implementation follows the internal capex budget approval timetable, aligning with the commencement of the financial year. A business case is prepared for each significant project for separate internal financial approval, reconfirming the validity of the option selected and ensuring deliver the required outcomes. The overall works programme is scheduled taking into account internal and contractor resource availability, operational factors such as network loading during commissioning and lead-time for the delivery of overseas sourced materials. As projects are approved, project managers are assigned to coordinate internal resource and work with Vector's contractors to deliver the project.

Once commissioned, project close-out reviews ensure the outcomes proposed in the business case are delivered.

5.3 Network Planning Criteria

The objective of the security criteria is to provide customers with the level of network reliability they consider acceptable for the price they are prepared to pay. This level is

[1] The main requiring authorities are Auckland Council (Auckland Transport), KiwiRail and NZTA.

reflected in Vectors Service Level Standards[2]. Reliability is achieved by building redundancy into critical parts of the electricity network to enable supply to be restored quickly following a network outage. This is achieved by ensuring primary circuits are operating at loading levels such that when an outage occurs, customers may be switched to an adjacent healthy circuit while repairs are carried out. To hasten the speed of field switching and restore supply to affected customers as quickly as possible, telemetered switching of remote but critical network switches may be carried out centrally by operations staff.

To achieve full 100% redundancy would normally require network distribution equipment to be operating at a maximum loading level of 50% of the circuit capacity. However, investment for a network demand peak which may only be present for one half-hour interval in the year is very financially costly and inefficient in terms of asset utilisation.

Fault analysis has failed to show correlated evidence suggesting failure rates are higher at times of peak loading compared to other times of the year. On this basis Vector has chosen to accept a marginally lower network security level than the deterministic N-1 standard (100% backup available at all times) typical of the industry.

Vector's security of supply standard is based on having network capacity available to the 11kV distribution level (with the exception of network faults) for 100% of the year and for residential customers, full back-up capacity available for 95% of the year. For commercial and industrial customers the standard is the same except the back-up availability is 98% of the year.

In practice, this lower level of security has had minimal impact on fault outage times experienced by customers, but contributes to improved asset utilisation and more efficient investment. Network investments are made by the addition of "blocks" of capacity ensuring that if the investment threshold is marginally below N-1, the addition of capacity increases network security well above N-1 (100% primary supply, 100% back-up supply). This ensures ongoing N-1 security until this capacity is eroded by the increase of existing load or the connection of new customers.

Exceptions to the general application of this standard are the remote parts of the network where the cost of reinforcement and load do not warrant the need for a back-up supply. These parts of the network are generally supplied by an overhead network allowing relatively quick repair times, albeit their remoteness can cause delays getting repair crews to the location of the fault.

Expanding parts of the network such as within subdivisions, may be supplied without the benefit of distribution network back-up supply until sufficient load (>400kVA) warrants the support of a permanent back-up supply. Low voltage supplies are also on N security.

The Auckland CBD has an N-2 security level down to 22kV sub-transmission level to ensure security to this compact but critical load. Below sub-transmission level, N-1 security is offered to customers.

Network Element	**Load Type**	**Primary Voltage**	**Load Magnitude**	**Security Limits[3,4]**	**Ability to Meet Demand after Outage (% of year)**	**Customer Interruption Duration for Outage**
Bulk supply substation	CBD (Quay, Hobson, Liverpool)	110kV	Any	N-1	100% (1st outage)	Nil (1st outage)
				N-2	100% (2nd outage)	< 5min (2nd outage)

[2]http://vector.co.nz/documents/101943/203930/Vector+Service+Standard+-+Residential.pdf/7f338bd7-7412-4c19-b54b-16f2a1b23eef

[3] Circuit rating is set by the post contingency, healthy circuit, cyclic rating.

[4] Applies to "credible contingencies" only

Network Element	Load Type	Primary Voltage	Load Magnitude	Security Limits[3,4]	Ability to Meet Demand after Outage (% of year)	Customer Interruption Duration for Outage
	Urban (Wairau, Kingsland)	110kV	Any	N-1	100%	Nil
Sub-transmission circuits	CBD (Quay, Hobson, Liverpool)	110kV	Any	N-2	100% (1st outage) 100% (2nd outage)	Nil (1st outage) < 5min (2nd outage)
	Urban (Wairau, Kingsland)	110kV	Any	N-1	100%	Nil
	Urban & Rural	33kV, 22kV	Any	N-1	95% (residential), 98% (commercial/ industrial)	< 3 hrs Northern < 2.5 hrs Southern
Zone substation	CBD (Quay, Hobson, Liverpool)	22kV	Any	N-1 N-2	100% (1st outage) 100% (2nd outage)	Nil (1st outage) < 2.5 hrs Southern
	Urban & Rural	33kV, 22kV	Any	N-1	95% (residential), 98% (commercial/ industrial)	< 3 hrs Northern < 2.5 hrs Southern
		Backstop capacity is provided through the 11 kV distribution network and supply will be restored by manual field switching in accordance with times set out in the Service Level Standards, subject to the 95% (residential) and 98% (commercial/industrial) capacity availability figures.				
Distribution feeder	CBD	22kV, 11kV	Any	N-1	100%	< 2 hrs
	Urban	11kV	> 2.5MVA overhead > 1MVA underground	N-1	95% (residential), 98% (commercial/ industrial)	< 3 hrs Northern < 2.5 hrs Southern
	Urban	11kV	< 2.5MVA overhead < 1MVA underground	N	Nil	Repair time
	Rural	11kV	> 2.5MVA overhead	N	95%	< 6 hrs Northern < 3 hrs Southern
	Rural	11kV	< 2.5MVA overhead	N	Nil	Repair time
Distribution substation	CBD	11kV	Any	N	Nil	< 2 hrs
	Urban	11kV	Any	N	Nil	< 3 hrs Northern < 2.5 hrs Southern
	Rural	11kV	Any	N	Nil	< 6 hrs Northern < 3 hrs Southern
LV Distribution	Rural/Urban	400V	Any	N	Nil	Repair time

The standard is not based on a probabilistic approach but relies on a marginal lowering of deterministic security standards (eg N, N-1) to a level slightly below N-1.

5.4 Sub-transmission and Zone Substation Security

The capacity of Vector's zone substations is documented in Schedule 12b, which is provided as an Appendix to this AMP.

5.5 Equipment Capacity Assessment

Asset capacities are specified at the equipment specification stage prior to the procurement of network equipment, and verified through type-testing (e.g. switchgear) or individual test results (e.g. transformers). Existing equipment relies on equipment procurement records or name-plate parameters. Standard distribution cable sizes are nominated to ensure a relatively small range of cables are held in stock and to minimise spares.

Cable ratings are calculated using CymeCap cable-rating software based on field-tested ground thermal conductivity results and standardised cable installation practices. All new sub-transmission cables are modelled including the provision of trench profiles to ensure the required network rating can be achieved prior to procurement of the assets.

Circuit ratings are the lowest of the individual asset ratings in the circuit. As the forecast demand is compared against circuit ratings to identify potential security breaches, solutions clearly include the replacement or uprating of inadequately rated equipment to increase the overall circuit capacity.

5.6 Planning Risks

The key risks associated with planning are forecasting, circuit rating uncertainty, security of supply and construction/project delivery risk.

In reviewing the demand forecast Vector looks to subject matter experts for the provision of inputs to the model. Population and employment forecasts are provided by the Auckland Council and Statistics New Zealand, developers and consultant provide information about near-term developments, while local and international literature provides guidance on future energy usage trends. The demand forecast is a "bottom-up" model, which is cross-checked against historical trends and the energy forecast to ensure alignment.

The summer and winter demand forecast are reviewed and updated annually, building on historical growth recorded from the previous five years. This approach allows medium term demand trends to be captured without the influence of short-term fluctuations (e.g. weather) or the loss of sensitivity around changing usage patterns (e.g. reduced residential energy usage per ICP) as may be evident through the use of longer term trends.

The accuracy of timing of reinforcement projects is dependent on the accuracy of both the demand forecast and the circuit rating. The demand forecast has been discussed earlier while the circuit rating is determined by the lowest rated asset in the circuit. Equipment specification, type-testing and test sheets provides ratings for switchgear and transformers, while CymeCap software is used to model cable ratings. Field tests provide soil thermal resistivity inputs to the model and while thermistors on selected cables provide confirmation that the calculated desktop ratings align with field measurements.

It is important that where our security of supply standards indicate N-1 or N-2 security, that the levels of security are truly independent[5]. To achieve this our designs need to ensure that common-mode failure possibilities are identified and where the risk exceeds levels[6] acceptable to Vector, remedial steps are taken to reduce the risk level.

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[5] The outage at Transpower Penrose in October 2014 showed that although we electrically have dual cables to each substation providing N-1 electrical security, the use of a common air-filled cable trench can compromise security by increasing the risk through common-mode failure (e.g. fire)

[6] See Section 8 of the AMP for more details

Accepted Breaches of the Security Standards

High Impact, Low Probability Events

Vector has a comprehensive risk process in place (see Section 8). However there are rare events on the transmission, sub-transmission or distribution network where concurrent outages affect both the primary and the back-up supply resulting in prolonged outages to customers while repairs are made. Fully mitigating these events can be costly and beyond the requirements of both Vectors security of supply standards and good industry practice.

However historic design or construction practices may lead to elevated risk levels through the possibility of common-mode or cascade failures. The former relates to a single event causing multiple failures such as damage to both the primary and back-up cables that are physically separated but share the same trench. Cascade failures arise where a fault on the primary circuit results in a fault the back-up circuit.

Situations where multiple concurrent equipment failures may arise are:

- Loss of multiple transmission/sub-transmission cables in a common trench. Vector has a number of double circuits feeding zone substations which share a common trench where a single event might damage more than one circuit[7];
- Complete failure of a 110kV, 33kV, 22kV, or 11kV multiple busbars at a substation, which would affect multiple circuits[8]; and
- Total loss of a zone substation (single or multiple transformers) through events that are not preventable by good industry practice

In most cases the likelihood of these events may be reduced through regular inspection, maintenance and testing programmes, through the application of network security and design standards, but in some cases imminent failures cannot be reliably detected.

Over the course of the year closer consideration will be given to the individual risks posed by events that fall into the categories above, rank them in terms of their criticality, and evaluate mitigation measures that may reduce the likelihood or consequences of these events. Following the Penrose outage closer attention will also be paid to incremental changes to asset risk profiles over time, where gradual changes to the network topology can progressively accumulate to alter the risk profile of network elements.

Where the cost of mitigation is excessive for the benefits derived, Vector may choose to accept the risk.

Demand Forecast

The network development programme is based on forecast demand estimates and investments are made as far as realistically possible on a just-in-time principle. This approach seeks to avoid security breaches arising from growing demand, while at the same time avoiding too-early investment and hence under-utilised assets. In some instances, unforeseen at the time of planning, may lead to the timing of investments not exactly coinciding with the moment at which a security standard is exceeded. Security standards may, therefore, be breached until commissioning of the required new assets takes place;

[7] In practice, these circuits are well separated and instances of more than one underground circuit being damaged through one incident are extremely rare. The cost of providing redundant trenching is prohibitive.

[8] The busbar is the point in a substation to which all circuits are connected and while a degree of redundancy and busbar protection can be provided, this is not practical or economically feasible in the great majority of cases.

Security Standards

The security standards are based on an optimal trade-off between network reliability and the cost of providing electricity distribution services.[9] This, in turn, requires an evaluation of outage risk and the expenditure needed to reduce the risk. There are parts of Vector's distribution area where the provision of our standard security standards would be highly uneconomic. These are generally areas with very low customer and/or consumption density, often remote from our main distribution network. To upgrade supplies to these areas to Vector's normal security standards would be costly and require the recovery of costs from the customers affected. For these areas, the security standards may, therefore, be relaxed.[10,11]

Project Delivery

Project delivery risk arises where a project has been identified but delays in the delivery of the project either through consenting, procurement or construction delays, are such that seasonal demand increases can threaten the security of supply or the delays attract additional financing costs potentially pushing the project over-budget. Projects are scheduled to be delivered on a just-in-time basis meaning that any unforeseen events that delay the delivery of the reinforcement works may compromise the security of adjoining feeders or substations. Delays that push the project into winter will increase the time that the adjacent substation/feeder operates at N security without adequate backup in the event of a fault. This risk is managed by ensuring realistic project delivery timeframes are used and scheduling critical works to occur (e.g. commissioning) outside periods of peak loading. Ensuring robust Safety in Design principles and strong Health and safety practices also assist to reduce the risks from delays in project delivery.

5.7 Network Constraints Identified By Demand Forecast

Auckland's housing stock deficit and increasing population are driving the growth of new residential housing. Developers are establishing new subdivisions or expanding existing developments to accommodate the growing residential housing demand. To accelerate the construction of new housing, Auckland Council has enabled developers to apply for special housing area status[12] where the consenting process can be fast-tracked.

Population forecasts are used as a proxy for new residential connections. Our demand forecasts are derived at an 11kV feeder level, then aggregated to zone substation and grid-exit point level. To establish the resolution necessary to forecast feeder loads, Auckland Council derived population forecasts at a census-area unit (CAU) level are assigned to the nearest feeder as a proxy for demand. This approach works well for small population/load increases. For the larger greenfield developments, demand is estimated based on existing demand supplying similar housing stock elsewhere on the Auckland network and applied to the forecast as an adjustment to the organic demand forecast, spread over the years the development is expected to take to construct.

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[9] In several surveys, carried out over an extended period, Vector's customers indicated they are satisfied with existing reliability levels and do not want Vector to improve on this if it means increasing the price of distribution services.

[10] The difference in supply reliability for different parts of the network are also reflected in the security standards themselves, but there may be instances where even these standards have to be further relaxed to provide an economic supply to consumers.

[11] Customers who do require a higher level of supply reliability have the option to negotiate a special contract with Vector, that would reflect the extra cost involved to provide this through their line charges or through an upfront investment requirement.

12http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/unitaryplan/Documents/Key%20topics%20in%20detail/upkeytopicsruralurbanboundary.pdf

Unfortunately greenfields areas are reticulated to meet rural demand and have limited electrical capacity to supply the intensive residential load arising from new subdivisions. To address the demand shortfall, invariably a substantial investment in new infrastructure is required.

Brownfields residential sites are included in the demand forecast either as incremental organic growth based on gradual population increases (e.g. infilling) or as specific "block" demand increases due to the addition of a new apartment block or redevelopment of an area not included in the population forecast. In this latter situation the proposed demand increase is included in the forecast as an adjustment to the organic growth trend.

As with the brownfields residential sites, organic commercial demand growth is included in the forecast by using employment growth forecasts as a proxy. Larger commercial and industrial demand increases (or decreases) are included in the demand forecast as an adjustment to the organic growth based on direct consultant or developer advice.

5.8 Load Forecasting Methodology

The demand forecast is derived by applying a linear regression over five years of historical demand modified by forecast new connections and identified demand. Two demand forecasts are prepared, one summer and the other winter, for each of the 750 11kV and 22kV distribution feeders on the network. Feeder demand forecasts are aggregated to zone substation and GXP levels, by applying a diversity factor at each level.

Historical demand information is filtered to remove load transfers or data errors that may distort the forecast, bearing in mind that the objective of the forecast is to identify long-term network constraints that may lead to network investment, rather than temporary breaches of security standards due to operational switching.

Population forecasts provided by the Auckland Council act as a proxy for new connections. Unitary Plans, developer information and Special Housing Areas (SHA's) identify the location and approximate timing of the growth. The forecast also incorporates and supports the latest revision of the City Rail Link (CRL) project plan.

This forecasting approach does not rely on forecasting individual ADMD figures for each of the customer segments but relies on forecasts of the aggregated feeder demand. The advantage of this approach is that gradual changes in individual ADMD over time are automatically included in the linear regression used in the forecast. Further it minimises the number of "estimates" needed on inputs to the forecast (e.g. ADMD trends, etc.) and theoretically improves the accuracy of the forecast. In practice, the annual review of the forecast ensures the regression mirrors underlying growth trends.

Weather influences are not included in the forecast as these are seen as short term events and are normally accommodated within the capacity buffer provided by the network security standards. Longer term trends such as those arising from global warming will be automatically reflected in the longer term linear regression. Otherwise weather should not be factored into investment decisions.

Employment growth forecasts developed by the Auckland Council are used as a proxy for commercial and industrial growth. Near-term growth figures are amended where actual growth information is provided by developers or consultants based on forthcoming projects.

Where the linear regression fails is its inability to include trends that have not yet influenced historical data. Batteries, electric vehicles, customer-driven demand-side management and solar-PV are examples where their current influence is minimal but will have an impact at the latter part of the 10 year demand forecast. These disruptive technologies are expected to result in a long-term net reduction in the average residential ADMD and has been conservatively reflected in the latter years of the ten-year forecast.

5.9 Network Demand Forecast

The output of the network demand forecast model for the next 10 years is shown in Schedule 12C which is included as an Appendix to this AMP.

5.10 Forecasting Under Uncertainty

Auckland is undergoing a substantial expansion of green-fields residential developments whose timing is determined by developers. At any one time there are a number of developers at different stages of development, ensuring timing and size diversity while spreading the reticulation risk.

A close watch is kept on new-connection and subdivision reticulation request trends as an increase in reticulation requests signals a corresponding increase in new-connection requests six to twelve months later. The delay between reticulation and new connections (ie new load) requests is sufficient to allow substantial localised new load to be identified ahead of time and adjustments made to the scheduling of short-term reinforcement projects as required.

Where new investments are required smaller incremental investments are preferred, especially if they defer larger investments (eg reinforce distribution feeders rather than build zone substations). However the smaller investments must fit with the longer-term reinforcement plan and not lead to future asset stranding. To achieve this the network plans consider multiple planning timeframes, namely short term covering the next three years, medium-term out to ten years and long-term, beyond ten years. The short term planning relies on historical growth trends and forecast new load already in the planning stages (eg new subdivisions, commercial buildings and industrial load changes). This visibility allows for greater forecasting accuracy while allowing sufficient time for planning, approval and network construction to be implemented ahead of the new network demand.

The medium-term plans look out ten years, capturing regional development trends such as land rezoning, new transport routes and larger infra-structure projects. The medium-term planning captures societal energy-usage changes such as the adoption of disruptive technologies (eg batteries, solar-PV, electric vehicles, etc) and global trends (eg climate change, carbon dioxide issues, micro-grids, etc) at a level sufficient to impact investment.

The long-term plan looks at growth patterns within the region to the end of the current asset lifecycle, say 40 years. A top-down approach forecasts probable network demands within the region and superimposes zone substations and GXPs to meet these demands. The objective is less to develop accurate demand forecasts and more to provide a long-term development plan identifying the optimal location of significant network assets to meet these requirements. The impact of rapidly evolving disruptive technologies in the energy distribution sector will have a significant effect on long term plans

Large network assets are not automatically replaced like-for-like at their end of serviceable life. A review is conducted to ensure the replacement assets are appropriate to meet future network needs including considering alternatives to replacement.

5.11 Disruptive Influences

Historically the rate of load growth on Vector's distribution network has been closely correlated to population growth with short term second order effects influenced by economic outlook.

All the reasons are unclear but contributing factors are that on-average, newer housing stock has a lower energy demand footprint than older houses. The mix of housing stock is changing with increased numbers of apartments and town houses being constructed, progressive adoption of newer energy-efficient appliances (eg refrigerators) and newer technology (eg LED lighting, heat-pumps) and wider albeit low acceptance of new technologies such as electric vehicles and solar-PV generation are all impacting consumer energy needs.

In the commercial area, there is expected to be increased use of electricity for transport with the recent electrification for the local train network[13] and the planned extension as part of the City Rail Loop (CRL). An extension of the Light Rail Network (LRN) has been mooted, again powered by electricity and displacing energy use that are currently dominated by other fuels. The increasingly stringent regulations on the energy performance of buildings, will also impose new and different demand on the network.

Vector has been monitoring the uptake of disruptive consumer technologies, and their potential effects on the network's ability to deliver quality service to its customers. The main technologies that are currently expected to have the greatest impact on the low voltage network are heat pumps (particularly in summer), photovoltaic panels, batteries and electric vehicles.

Vector is becoming increasingly concerned with the commercial risks it is required to absorb when investing in long term assets to support the future needs of its customers and does not believe the regulatory environment is providing a commensurate rate of return on these investments.

5.12 Location of Network Growth

The location of residential network growth used in the demand forecast model has been based on the location of SHA's, known greenfield developments and zoning changes. Figure 5-1 and Figure 5-2 show location and scale of land allocated for greenfield developments. These are taken from Auckland Council website[14].

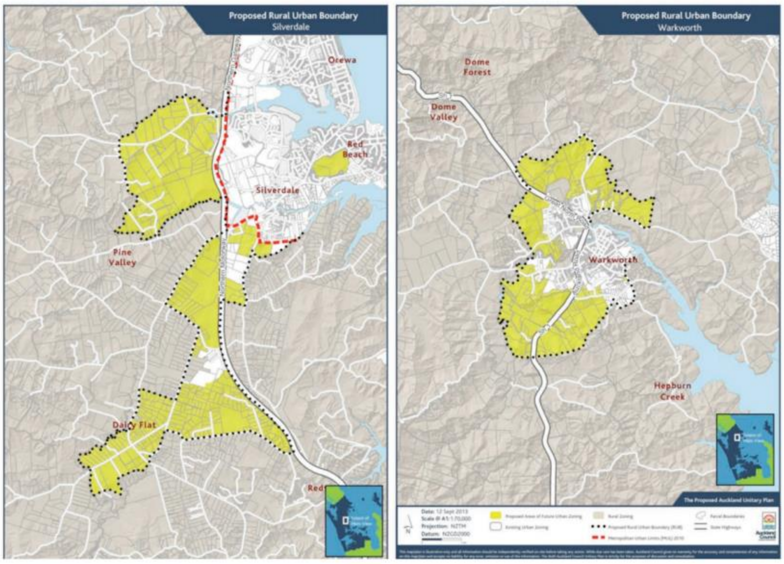

Figure 5-1: Warkworth and Silverdale re-zoned land

[13] KiwiRail is supplied by Transpower, not via Vectors network

[14]http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/unitaryplan/Documents/Key%20topics%20in%20detail/upkeytopicsruralurbanboundary.pdf

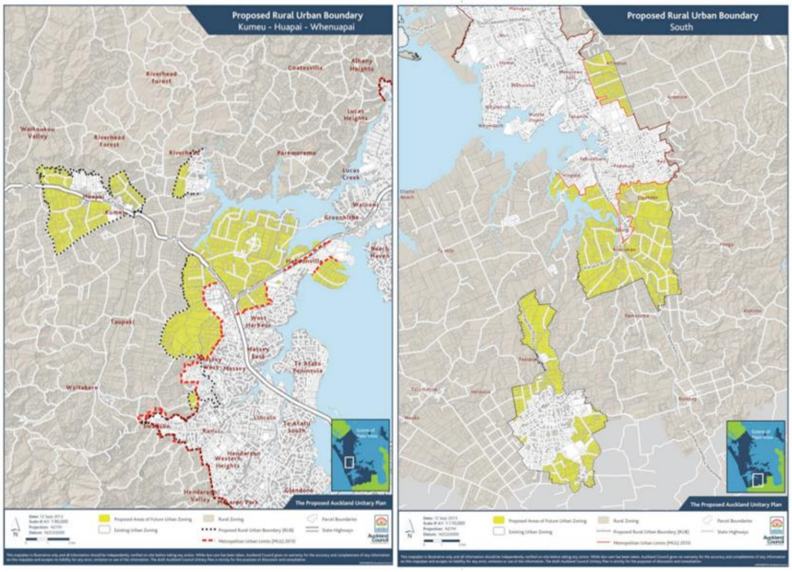

Figure 5-2 : Northwest and South re-zoned land

Similarly land that has been allocated as Special Housing Areas (SHA's) is shown in Figure 5.3 on location of the existing SHAs, tranches 1-8 are shown in Figure 5-3.

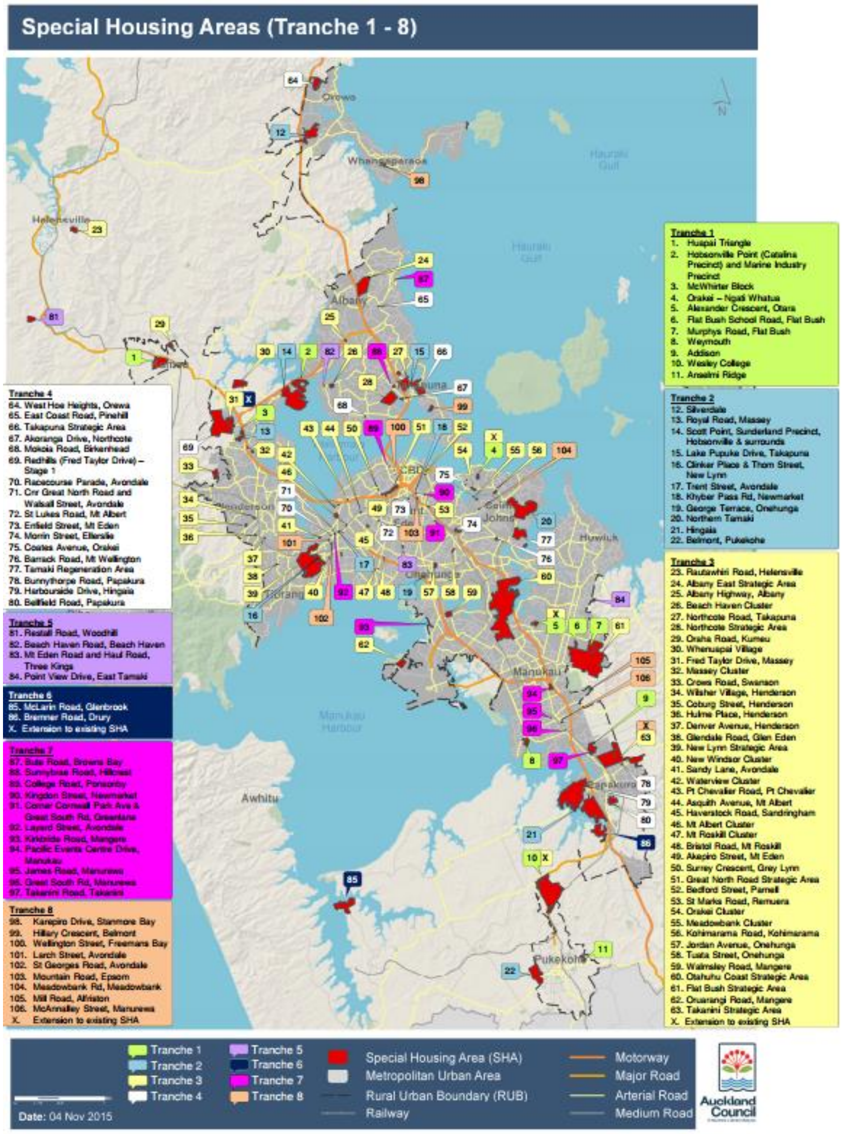

Figure 5-3: SHA Areas, (Tranche 1-8)[15].

Further, individual developers are bringing smaller tranches of land to the market for predominantly residential use

5.13 Distributed Generation's Impact on Demand Forecasts

Distributed generation refers to generation connected to the Vector network either directly or via a customer's installation which has the capacity to export electricity.

At this time, the main focus of distributed generation is PV solar with most applications from the residential sector. The last three years has seen 450 applications in 2013, 695 in 2014 and 514 for the 11 months to the end of November 2015. Figure 5-4 shows the historical number of applications for connection of PV to Vector network.

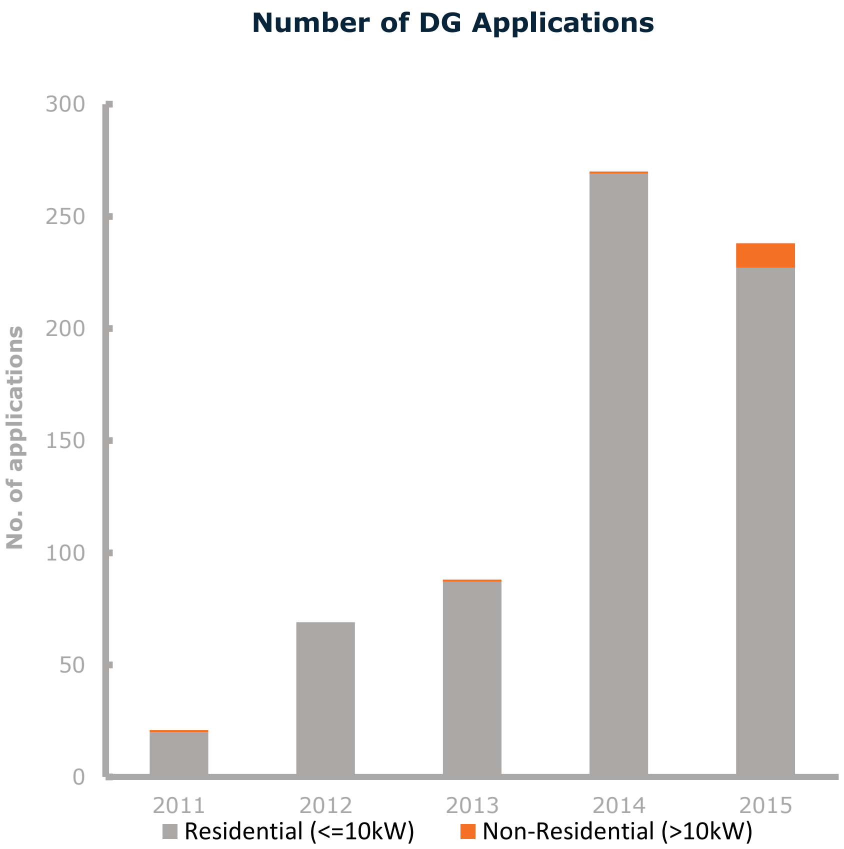

Figure 5-4: Number of PV applications in the past 5 years

Analysis of the location of PV installations shows a relatively low penetration density across the population of distribution substations. Figure 5-5 and Figure 5-6 show the capacity of the PV installed in residential and commercial distribution substations respectively. Typically these substations would range in size from 100kVA to 500kVA.

15 http://www.aucklandcouncil.govt.nz/EN/ratesbuildingproperty/housingsupply/Documents/overviewofalltranches.pdf

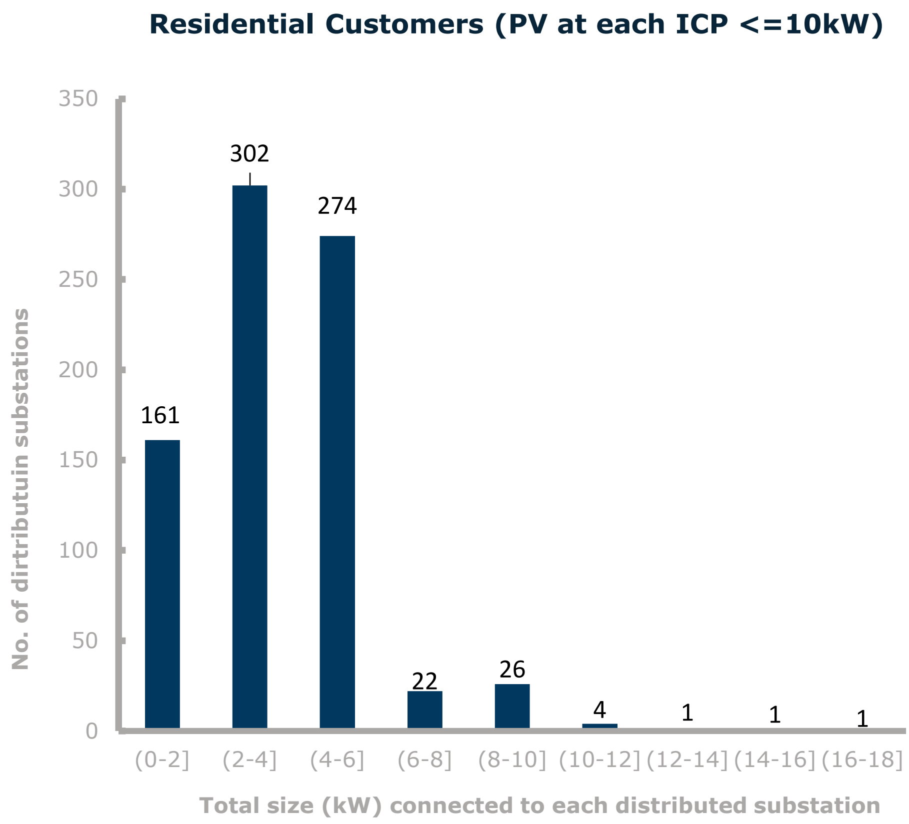

Figure 5-5: Number of distribution substations supplying residential customers with PV (<=10kW)

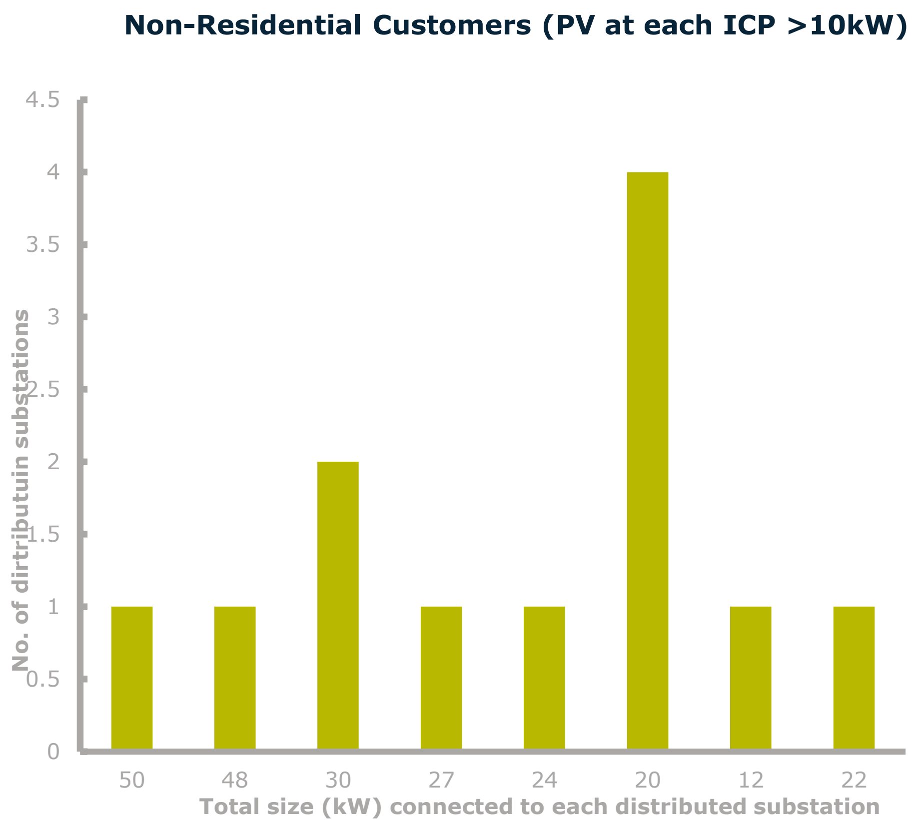

Figure 5-6: Number of distribution substations supplying commercial customers with PV (>10kW)

This level of PV penetration into the low voltage network is still low and has had negligible effect on network investment at this time. Solar PV's maximum power output is in the middle of the day when residential load is relatively low. Vector has approximately 300 solar PV/battery installations on the network, presenting an opportunity to experiment with differing charging/discharging profiles to optimise the use of PV-generated energy for the customer.

At this time residential solar-PV is not impacting the demand forecast, but overseas uptake is a reflection of the potential for New Zealand particularly when matched to battery or thermal storage[16]. Auckland's electricity demand profile is winter-peaking and this load is driving network investment rather than summer load. Individual residential winter solar-PV output is insufficient to offset evening peak demands, causing power offtake from the network equivalent to an installation without a solar contribution. Unfortunately solar-PV does not offset winter-peak demand induced network investment on Auckland's network at this time.

The most significant offset to investment caused by residential demand is expected to be through the use of energy storage elements such as batteries. The ability to store energy at off-peak times, either from solar-PV or from the network, and discharge at peak times has the potential to reduce peak residential demand. This, when combined with increased penetration of energy efficient LED lighting, ongoing efficiency improvements in appliances and increased adoption of heat-pumps is expected to reduce individual residential demand by 25% over the next ten years. This is reflected in our demand forecast.

The use of large-scale solar-PV within commercial premises has been increasing slowly and is seen as an area of growing future interest. However from a network perspective these installations are viewed as providing an energy offset for the customer rather than a permanent demand offset. Loss of sunshine causes the customer to revert to the network to meet demand and the network must retain sufficient capacity to meet these situations.

Vector is keen to understand how batteries may be used to improve the operation of the network, particularly reducing peak demand to defer investment. The long-term objective is to flatten the demand profile using off-peak charging and on-peak discharging to deliver this outcome. At this time we are experimenting with Tesla's batteries to explore the opportunities available at both the network and customer levels.

Our forward plans include the installation of a Tesla Powerpack (1MW, 2MWhr) battery in one of our existing zone substations to offset imminent security constraints and learn how to optimise the operation of the battery to the benefit of both our customers and the network. A pilot project is underway to install 30 Tesla Powerwall (3kW, 7kWh) batteries in a new, residential development allowing experimentation with operating parameters to maximise the benefit to both the network and the customers. Following this project, a larger scale rollout of 130 Powerwall batteries (100 to residential customers, 30 to schools) is proposed.

Our current hot water load management system is designed to manage network demand to meet grid-exit point demand targets. Operationally this configuration is too coarse for the targeted control needed to manage demand on distribution assets down to 11kV feeder level.

Vector is investigating the feasibility of using smart meters to control hot water as a potential replacement for the current load management system. If successful, this approach will increase the level of load that may be controlled, targeting those network assets in imminent need of reinforcement and providing demand reductions at peak loads. This will delay investment network reinforcement as well as increasing the utilisation of existing primary assets while increasing the useful functionality of the smart

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[16] Using surplus energy to heat hot water for later use or pre-cooling homes using solar PV and heat-pumps in summer to avoid taking demand from the network later in the day

meters already installed within residential premises. However until the feasibility of this application is confirmed, the benefits have not been included in the demand forecast.

5.14 Distributed Generation Connection Policies

Vector's policies on distributed generation may be found on its website[17]. The website separately outlines the connection procedure for generation less than 10kW, and that above 10kW. Also included is the methodology for determining eligibility for Avoided Cost of Distribution rebates. Vector follows the requirements laid down in the Electricity Industry Participation Code which stipulates the requirements for the connection of distributed generation. Connection applications in the "less than 10kW" category are predominantly for residential solar-PV. DG applications at the larger capacity end of the range (greater than 1MW) have been either for standby applications or for internal energy consumption (e.g. biogas, diesel or combined heat and power (CHP)). Only two applications in the last five years has been for exporting electricity into the network.

With this in mind it is expected that the volume and capacity of solar-PV installations to increase over the next ten years. Standby generation will increase as customer's tolerance for outages or power-dips decreases. Standby generation has no effect on the performance of the network nor is it used to offset future reinforcement at this time. It is unlikely Vector will see major generation (e.g. windfarms, gas-fired generation) injecting into its network. Commercial-scale solar is expected to increase although, unless coupled with batteries, is unlikely to permanently offset network capacity. It is expected that off-grid installations will become more attractive in semi-remote locations as price points make these solutions more attractive.

5.15 Strategies Promoting Energy Efficient Network Operation

Network strategies are generally directed towards increasing utilisation of installed assets and therefore improving the financial efficiency of the investment. A proportion of the losses are related to network loading - double the loading and the losses increase by a factor of four. The best way to reduce the losses whilst increasing utilisation is to "flatten" the demand profile by moving energy consumption from peak demand times to off-peak periods.

Vector's battery trials will achieve this outcome, subject to sufficiently large penetration into the network. Vector is currently installing batteries on the network with the 30 houses in the contained community and the new substation battery acting as a test-bed for this work.

Disruptive technologies are impacting most on the LV network but this is the network we know least about. The challenge has been lack of monitoring equipment on this network but the widespread introduction of smart meters has provided an opportunity to rectify this. During the year we have been experimenting with a limited set of residential smart meter data to identify how this information may be used to provide insight into the operation of the LV network. Initial results have been encouraging, particularly confirming the customer/distribution transformer linkage. Work continues, and will include distribution transformer demand profiles to identify both underutilised and overloaded assets, and identification of power quality issues (high and low voltage) particularly associated with new technologies (eg electric vehicles, solar-PV).

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[17] http://vector.co.nz/electricity/distributed-generation?redirect=http%3A%2F%2Fvector.co.nz%2Fhome%3Fp_p_id%3D3%26p_p_lifecycle%3D0%26p_p_state%3Dmaximized%26p_p_mode%3Dview%26_3_groupId%3D101943%26_3_keywords%3Ddistributed%2BGeneration%2Bpolicy%26_3_struts_action%3D%252Fsearch%252Fsearch%26_3_redirect%3D%252F

Vector has the capability of shedding load via its centralised load control systems (ripple control) by switching residential water heating systems. This plant is used successfully to reduce peak demand across the network. However, the coarseness and magnitude of the load shed, particularly where the ripple plant injection point is at GXP (in the Southern region) level, means that current load control is not a suitable tool for managing localised forecast network security breaches.

We are investigating how smart meters may be used to provide the granular control needed to be of benefit for investment deferral and improved asset utilisation. The effective use of load management can flatten demand profiles and reduce losses. Work in this area was mentioned earlier in this section and offers the potential to lower losses over battery installations by avoiding charging/discharging losses. The results of the trials will confirm this.

Energy substitution is the transference of consumption from one energy type to another such as using reticulated gas or LPG instead of electricity for cooking, home-heating and water-heating. While the commercial and industrial sectors are receptive to multi-fuel options, particularly as the financial benefits are more obvious, the residential sector is less inclined to change, largely due to the initial investment required and in some cases, the limited availability of gas reticulation close to their premises.

Substantial penetration of gas can be achieved if it is promoted and installed during the initial reticulation of green-fields subdivisions, and will result in an LV network demand reduction particularly at critical peak loads. Vector encourages developers to include gas reticulation as part of the subdivision design but without incentives, gas is seen as an avoidable reticulation cost.

5.16 Standardised Assets and Designs

Vector uses standardised design and equipment on its network. This has the advantage of lowering project costs through competitive bulk materials supply agreements, standardised installation drawings and practices, lower stock-holding and emergency spares, standardised maintenance practices, and engaging in a rigorous equipment selection process to ensure fit-for-purpose whilst ensuring appropriate equipment performance over the life of the equipment.

Standardisation has been applied to distribution and zone transformers, switchgear, protection and accommodation (buildings), cables, poles, and installation practices. Vector may apply differing architectural treatments to its zone substations to better align with local architecture but construction techniques, materials and fit-outs align with well-established standards.

Standard designs are introduced to avoid producing customised solutions for identical network installations. The standard designs ensure rigour and consistency in evaluation, design and application, cost savings over bespoke designs, simplified procurement and reduced stockholding, less rework during construction, safer outcomes and improved mechanism for capturing incremental improvements.

The approach that has been adopted within Vector is that when designs are repeated used on the network, standard designs are developed. As design improvements are identified either by Vector’s own staff or as feedback from our Field Services Providers, standard designs are amended and updated.

5.17 Project Prioritisation

Once the need for a network development project has been identified, the initial prioritisation is determined by the timing of the security breach. That is, when the demand is expected to exceed remaining circuit capacity. Security standards are approved by the Board, balancing reliability risk against premature investment whilst aligning with good industry practice. Where possible projects are initiated on a just-in-time basis, ensuring sufficient lead time for long-lead time procurement and construction timeframes. Where possible, budgets are levelled by adjusting starting dates to allow resource levelling and work continuity.

When levelling budgets, a risk assessment is carried out to determine the impact of the deferral or advancement. This assessment considers growth rates, strength and condition of adjacent networks and potential mitigation measures if the assessment is incorrect. As the projects near approval stage there may be opportunities to exchange projects depending on urgency. This latter option is disruptive to the works programme and is only used as a last resort.

Once the development list is compiled it is combined with projects from other areas (eg asset replacement) and all projects are ranked[18]. The projects are assessed against their ability to deliver the corporate goals[19], which is determined by evaluating each project against value-weighted questions. A secondary weighting is based on project urgency.

The projects list is selected based on priority ranking to an "affordable" budget based on DPP targets. A review of the deferred lower-ranked projects is carried out to ensure critical projects have not inadvertently been excluded.

The priority ranking process captures network security projects on a bottom-up basis while evaluating all projects against company goals on a top-down basis

The comparison between the demand forecast and the threshold set by equipment rating and security standards determines the needs for future network reinforcement. Where the solution is relatively straight forward such as moving network open-points these will be completed without the generation of a project. Where the solution involves investment, a project will be initiated. On this basis those projects identified are to address forecast network constraints.

The selection process follows a process based on considering operational solutions first (eg moving open points), 11kV feeder solutions and then sub-transmission solutions, namely eliminating lower cost investments before considering more expensive investments. Non-network solutions are included but invariably found these solutions will not deliver sufficient capacity, cannot be delivered in the required timeframe or are more expensive to implement than the network solution. The capabilities of batteries are being investigated and targeted load management using smart meters as network solutions for the future. These two options will increase our range of non-network options available for future projects.

A list of reinforcement projects that are required to address a specific security constraint are included in this AMP. High-level options are presented but are examined with greater scrutiny closer to the target project commencement date. In assessing options to solve network constraints, a project cost based on traditional solutions is selected. Non-traditional solutions such as solar-PV and batteries are in their infancy in Vector in terms of large-scale roll-out of network-wide solutions. However when detailed option analysis is carried out for each project, the non-traditional solutions are given close scrutiny and the least cost option based on the lowest present-value cost without increasing Vectors risk profile, will be the one selected.

5.18 Material Projects over next 5 years

[18] We use Microsoft Project Server for the ranking process

[19] Disciplined growth and cost efficiency, Operational excellence, Customer and Regulatory outcomes

FY17 Projects

Airport Zone Substation Expansion

Description
Auckland International Airport have indicated their future energy needs to increase significantly, exceeding the existing installed firm capacity. This is a customer-driven project.
Options
Option 1: Install an additional transformer and 33kV switchroom
Option 2: Upgrade existing transformers and switchroom to increase firm capacity
Option 3: Non-Network options
The size and rapidity of the load growth, and its primarily commercial nature, mean that non-network options are not feasible.
Proposed Solution
Option 1 - a transformer and 33kV switchroom will be installed.

CBD 22kV Cables Rollout

Description
In 2004 a strategic review and supporting business case recommended that new distribution reticulation in the Auckland CBD would be at 22kV. Existing 11kV substations would be progressively transferred to the 22kV network as the 11kV assets reach the end of their economic lives, or when additional distribution capacity is required to cater for demand growth. The analysis supporting the original business case remains valid and Vector will continue to follow this strategy during this AMP period.

Precinct Tower Power Supply

Description
A 40-story 8 MVA commercial building (Precinct Tower) will be constructed adjacent to Britomart in the Auckland CBD. The capacity required is beyond that available in the 11kV network. Two new 22kV cables to be installed to supply this expansion coordinating with the City Rail Loop excavation works in Lower Queen St, and Albert St.
Options
Option 1: Supply Precinct Tower from the existing 11kV network
This option cannot meet the capacity requirements of Precinct Towers.
Option 2: Install 22kV cables to supply Precinct Tower
This option is to install 22kV cables in Lower Queen St, Lower Albert St, Customs St and Albert St, to supply Precinct Towers.
Option 3: Non-Network options
Non-network solutions are not a realistic option for this power supply
Proposed Solution
Option 2 - 22kV cables will be installed to supply the Precinct Tower.

Flatbush 11kV Feeder Cables

Description
Residential development in the Flatbush area is proceeding rapidly. While most of the 11kV reticulation is being installed as part of subdivision, some feeders from the new Flatbush zone substation need to be extended to maintain security of supply.
Options
Option 1: Reinforce the 11kV network
Cables will be laid to provide backstop between feeders and enable load transfer from overloaded feeders to lightly loaded feeders.
Option 2: Non-Network options

Since there is rapid green-fields development there is no practical alternative to 11kV investment.

Proposed Solution
Option 1 – 11kV cables will be installed (often in existing ducts).

Construction of Glenvar Zone Substation

Description
Torbay substation is a single 33/11kV transformer substation loaded to more than 80% of its capacity. The load on this substation is forecast to nearly double in the next 10 years predominantly as a result of Long Bay development, exceeding the capacity of the existing substation
Options
Option 1: Install a second transformer at Torbay This option will provide the necessary capacity the forecast load but is expensive, and Torbay's geographical location is distant from the growth centre ensuring substantial ongoing reticulation costs.
Option 2: Establish a new zone substation at Glenvar Construction of Glenvar substation ensures the electrical capacity is located adjacent to the new developments proposed to the north and west of East Coast Road, and can provide electrical support for Torbay substation and the Long Bay development.
Proposed Solution
Option 2 - The installation of the Stapleford feeder from Browns Bay substation provided a short term solution by deferring the new zone substation at Glenvar. As anticipated, the uptake of the residential housing at the Long Bay subdivision development has now exceeded the capacity of this feeder and a more substantial investment in capacity is required. Glenvar substation has the advantage of being able to electrically support the single transformer, Torbay substation, supply part of the new subdivisions at Long Bay and reinforce to the west and north where further load growth is expected.

Land Purchase for Greenwood Zone Substation

Description
A new zone substation is planned for the corner of Ascot and Greenwood Roads in Mangere as the ability to extend supply from existing Mangere West zone substation is impractical and uneconomic. This project is for the purchase of the site. See below for a description of the substation construction project and the alternatives considered.

Construction of Greenwood Zone Substation

Description
A series of large load increases is forecast for central and western Mangere. These include major expansion of the Mangere Watercare treatment plant, the new Sistema and Coca-Cola Amatil factories, growth at Auckland International Airport, and other significant industrial and residential developments. The transformer capacity of the existing zone substations will be exceeded in the near future.
Options
Option 1: Install a new zone substation A new zone substation will provide the new capacity required and maintain security margins. It will be supplied initially by the Mangere West subtransmission cables which have spare capacity. The Greenwood-Airport cable project (see below) will create a 33kV ring, release spare subtransmission capacity and increase security of supply.
Option 2: Install a third transformer at Mangere West zone substation and new cable from Mangere GXP Increasing capacity at Mangere West will address shortfall in the medium term, but backstopping will become increasingly difficult. A new feeder from the GXP makes this the most expensive option.
Option 3: Install a third transformer at Mangere West zone substation with 33kV ring A cable from Mangere West to the Airport substation is cheaper than one from the GXP, but while the Greenwood substation provides more capacity and better security at a similar cost
Option 4: Non-Network options The size and rapidity of the load growth, and its primarily industrial nature, mean that non-network and demand side options are not feasible.

Proposed Solution
Option 1 - a new zone substation will be installed on Greenwood Road, with a 33kV switchroom to connect to the Mangere GXP – Mangere West cables.

Hillcrest Tonar 11kV Feeder Reinforcement

Description
The Tonar 11kV feeder supplied from Hillcrest substation is currently backstopped by a single feeder. The load forecast indicates this feeder cannot be fully supported beyond winter 2017. A project to increase the backstopping capacity at Tonar feeder is required.
Options
Option 1: Increase the backstopping capacity by connecting to an adjacent feeder Installing a short section of cable to connect an adjacent feeder will increases the backstopping capacity of them Tonar feeder.
Option 2: Non-Network options The cost of non-network options exceeds the cost of the solution proposed in Option 1
Proposed Solution
Option 1 increase the backstopping capacity from the adjacent feeder is the recommended solution

City Rail Link Supply - Aotea Station

Description
Auckland Transport are constructing an underground rail line (City Rail Link) linking Britomart and the city centre with the existing western line near Mt Eden. A power supply is required for the proposed Aotea Station
Options
Option 1: Connect Aotea Station to the existing 22kV network Connect Aotea Station into the existing 22kV network in within the CBD.
Option 2: Connect Aotea Station to the existing 11kV network Existing 11kV cables have insufficient capacity to supply the Aotea Station without reinforcement. Investment in higher capacity 22kV cables is preferred over 11kV investment.
Option 4: Non-Network options The use of non-network solutions is impractical for the supply to Aotea Station
Proposed Solution
Option 1 – connect Aotea station into the existing 22kV network.

Construction of Hobsonville Point Zone Substation

Description
Auckland's Northwest transformation is the largest urbanisation project in New Zealand. Developments in this area started in 2013, accelerated by the Governments (Special Housing Areas (SHA)) to address the Auckland housing shortage. Developments to date include large subdivisions at Hobsonville Point, Scott Point and Whenuapai. Hobsonville substation, currently supplying this area, does not have sufficient capacity to supply the forecast load. Based on this forecast, a staged plan has been developed to progressively reinforce the network in a manner that minimises the overall cost and risk of stranded assets in the event of development slow-down.
Options
Option 1: Establish Hobsonville Point substation. This option proposes establishing a substation at Hobsonville Point as the first stage. Vector owns a site on 132 Hobsonville Road, very close to the existing subtransmission circuit and optimally sited to supply Hobsonville Point and Scott Point developments. This substation will initially supply Whenuapai area until the load on the substation reaches its capacity. A second substation is then required at Whenuapai to provide additional capacity in the area (see below). This option has the lowest overall NPV cost.
Option 2: Upgrade Hobsonville substation This option recommends upgrading Hobsonville substation with larger capacity transformers, new 11kV switchboard to handle the additional capacity, and a new building to accommodate the larger switchboard. Five

new, 4km long feeders need to be installed to Hobsonville Point. The size of the load forecast at Hobsonville Point and Scott Point will force the construction of Hobsonville Point substation. This outcome will have committed Vector to the additional reinforcement costs at Hobsonville substation without avoiding the need for Hobsonville Point substation. In terms of capital efficiency Option 1 is the better solution.

Option 3: Non-Network options

The rapid growth and sheer size of load forecast for this area ensures that a network battery cannot provide a total solution to the load growth. Similarly analysis shows that the installation of PV and in-house batteries will not significantly delay the need for new zone substation(s). The opportunity will be taken to work closely with developers and customers to deploy alternative solutions and ensure that the design of the network is optimised to take advantage of these solutions.

Proposed Solution

Option 1, construction of Hobsonville Point substation. This option has the lowest overall NPV while lending itself to an integrated development plan for the wider Whenuapai area.

Hospital Capacity Reinforcement

Description

Auckland Hospital is supplied by a dedicated transformer at Liverpool substation via two dedicated 11kV feeders. The load is forecast to grow to 12MVA, beyond the capacity of the existing 11kV feeders.

Options

Option 1: Install two new 11kV feeders from Liverpool substation

This option is to install two new 11kV feeders from Liverpool substation to the Hospital substation to reinforce the existing supply. However due to the difficulty in establishing an economic route across the Grafton Motorway, this option has been discounted in favour of lower cost options.

Option 2: Install a new 33kV feeder from Newmarket substation.

Due to the size of the load, the option of establishing a small zone substation at the Hospital to meet the customers forecast demand was investigated. This option allows capacity for future growth but future load increases, as advised by the Hospital, are expected to be modest, so the investment was not considered warranted when compared to Option 3.

Option 3: Install two new 11kV feeder from Newmarket substation

This option proposes two new 11kV feeders from Newmarket substation to the Hospital site. This option will deliver the 12MVA capacity requested by the Hospital.

Option 4: Non-Network options

Generators are used by the Hospital to provide backup supply and it is believed this will continue. As a network solution this option could not be implemented without the support of permanent network infrastructure. The existing supply arrangements from Liverpool do not meet the Hospitals future security needs and therefore a permanent solution is sought that will meet these requirements. Batteries may be an option that the Hospital may wish to consider in the future but cannot be considered as a solution to the proposed security upgrade as part of this project as the customer requires a continuous supply solution rather than short term peak cover

Proposed Solution

Option 4, two feeders from Newmarket is the preferred option. This is the most cost effective solution meeting the long-term security requirements of the Hospital.

Land Purchase - Kumeu Zone Substation

Description

The proposed Special Housing Area at Huapai-Kumeu will accommodate 3500 new houses, with longer term plans forecasting up to 10,000 dwellings. The network does not have sufficient capacity supply this load. This project is to secure land in anticipation of the need for a new zone substation at Kumeu.

11kV Supply - 309 Broadway, Newmarket

Description

The Westfield Group have advised of a 6.5MVA commercial redevelopment at 309 Broadway, Newmarket. The existing network has insufficient capacity to meet this demand

Options

Option 1: Install a single 11kV feeder from Newmarket substation

This option proposes a new 11kV feeder from Newmarket substation to supply the development at 309 Broadway. However due to the size the load a single feeder only offers N security and therefore fails to meet Vectors security standards.

Option 2: Install two new 11kV feeders from Newmarket substation

This option is to install two new 11kV feeders from Newmarket substation to supply the development at 309 Broadway.

Option 3: Non-Network options

Non-network solutions are unsuitable as the primary supply to this commercial installation.

Proposed Solution

Option 2, installing two 11kV feeders, is the preferred solution.

Land Purchase - Newmarket South

Description

Growth projects in Newmarket area are rapidly consuming available capacity in Newmarket substation. It is planned to establish a new substation in the Newmarket South area (refer to Newmarket South zone substation construction project). Land needs to be secured for this substation.

Land Purchase - Redhills Zone Substation

Description

The existing Special Housing Area at Redhills is at the design stage and will comprise 5000 new dwellings. The wider area is forecast to include nearly double as many households. The existing network does not have sufficient capacity to meet these long term load requirements. A new zone substation will be required and this project is to secure a substation site in anticipation of this expansion.

Watercare Rosedale - 11kV Feeder

Description

Watercare are expanding their treatment plant at Rosedale and require a larger power supply. Due to the size of their load a dedicated 11kV feeder is required.

Options

Option 1: Install a dedicated feeder from Rosedale substation

This option requires the 11kV switchboard needs to be extended and 2km of feeder cable installed to the Watercare’s plant.

Option 2: Install a dedicated feeder from Bush Road substation

Bush Road substation is the same distance away from the plant, however there is insufficient space in the switchroom for additional circuit-breakers. A new switchroom was built and the 33kV switchboard but capabile of accommodating the 11kV switchboard in due course. The installation of an 11kV switchboard in the new switchroom will result in the premature retirement of the old switchboard and its associated write-off costs. The additional works associated with establishing a new switchboard (including other works) adds a premium of over $1m over Option 1.

Proposed Solution

Option 1, a new Rosedale feeder, is recommended as it is the most cost effective solution.

Spur Road Weiti - 11kV Feeder

Description

A developer is planning on subdividing the eastern side of the proposed Penlink road. Two 11kV feeder cables are required to supply and backstop the initial 150 lots. The same circuits will be used to supply and backstop the remaining lots in the subdivision and eventually connect up to the future circuits installed as part of the proposed 1000 lot development.

Proposed Solution

This project, being customer initiated is dependent on the developer’s time-frame.

Te Atatu Henderson Westgate Future-Proofing Ducts

Description
It is proposed to install future-proofing ducts under the SH16 cycleway currently being constructed by NZTA. The first section of the duct will be used when the existing overhead supply from Transpower Henderson to Te Atatu needs to be replaced. The second section of the duct will provide a supply from Transpower Henderson to Westgate substation. The ducts along the motorway offer the shortest possible route for both sections.

Wairau Hospital 11kV Feeder Reinforcement

Description
The circuit supplying North Shore Hospital from Hillcrest substation faulted under the motorway in August 2015. This is one of a number of faults that have occurred on this and adjacent cables of the same vintage and type. Analysis suggests that the cable is end of life and due for replacement. Rather than replace the cable to Hillcrest the preference is to supply the hospital from Wairau Rd substation to free up capacity at Hillcrest for forecast residential development. The fault under the motorway will be costly to repair and the need to replace the existing cable ensures other impending constraints may be addressed with this solution
Options
Option 1: Repair the motorway section of the hospital feeder This option recommends repairing the faulty section of the cable under the motorway. The solution requires drilling under the motorway and inserting a new section of cable while abandoning the faulty cable section. Given the recent history of faults on adjacent circuits of the same vintage and cable type, this solution is considered a temporary fix at best. The North Shore Hospital is a significant customer and a costly solution that will not fix the reliability issue is not recommended.
Option 2: Replace the entire section of the old cable This solution proposes the cable from Hillcrest substation to North Shore Hospital be overlaid with a new cable and the old cable be abandoned. This solution will improve the reliability of supply to the North Shore Hospital but is more expensive than Option 3 and offers fewer benefits.
Option 3: Supply the hospital from Wairau substation Wairau substation is closer to the hospital than Hillcrest. As part of a previous road widening project future-proofing ducts were installed along 90% of the route minimising further trenching costs and reducing the overall project cost. Further this option transfers the hospital load to Wairau Rd substation, freeing up capacity at Hillcrest for forthcoming residential development. This option is lower cost than Option 2.
Proposed Solution
Option 3, a new 11kV feeder from Wairau Rd substation, is the lowest cost option that addresses the circuit reliability while increasing available capacity at Hillcrest substation.

Warkworth Matakana 11kV Feeder Reinforcement

Description
The Matakana 11kV feeder from Warkworth substation is a very long semi-rural feeder with limited backstopping. The load on this feeder is high and growing. This feeder is 10 times longer than the average feeder on Vector's network and supplies 2234 customers, well above the norm for northern network feeders. Network reinforcement is required to reduce the load and decrease the SAIDI impact of this feeder.
Options
Option 1: Establish Matakana substation This option proposes a new substation within Matakana township to remove exposure of the bulk of the customers to outages arising from the long rural line. This is a costly option and will be needed in the future as the area develops. However lower cost options presented below offer better outcomes at this time
Option 2: New 11kV feeder to Matakana This option is to construct a new 11kV feeder from Warkworth to Matakana using existing poles. The new feeder can be used to supply Matakana township reducing the number of customers affected by outages on the long rural circuit. As the existing 11kV circuit supplying Matakana is built to 33kV insulation levels this option allows a future upgrade path to supply the substation proposed in Option 1 at 33kV as load grows.
Option 3: Non-Network solution; battery banks This option proposes the installation of network batteries for peak shaving purposes and reliability improvements.
Proposed Solution
The non-network solution proposed in Option 3 is to be explored further as a means of deferring the more expensive options. Detailed network and cost analysis is required to ensure this solution will deliver the expected

results. One of the benefits of this option is that when the load growth outgrows the battery solution, the battery may be relocated to another part of the network to fulfil a similar role.

Construction of Warkworth South Zone Substation

Description
The load on Warkworth substation is approaching its firm capacity and back-up 11kV security to this substation is insufficient. The Warkworth area has been identified as a “future urban” zone in the draft Auckland Unitary Plan. NZTA have been granted final consent to construct the Puhoi to Warkworth SH1 motorway extension, improving roading access and encouraging growth. The rate of greenfield development is forecast to accelerate requiring network reinforcement to maintain security of supply.
Options
Option 1: Establish Warkworth South substation This option proposes a new 33/11kV zone substation in Glenmore Road, Warkworth, on a site owned by Vector. In 2012 a new 33kV feeder was constructed to Woodcocks Road (currently operating at 11kV) in anticipation of supplying a future Warkworth South substation. Construction of Warkworth South substation will move the load centre from Warkworth substation (4km out of town) to the centre of the “future urban” zone. A staged reinforcement programme is proposed with the first stage based on a single subtransmission circuit from Warkworth (already in place) and a single transformer. Network security is initially provided by the 11kV backstopping from Warkworth substation. Stage two comprises the installation of a 33kV switchboard and a second 33kV subtransmission circuit and transformer, with timing determined by the demand uptake and network security.
Option 2: Upgrade Warkworth substation This option proposes installing larger transformers at Warkworth to increase the firm capacity of the substation. To accommodate the increased capacity the 11kV switchboard has to be replaced, resulting in a substation re-build due to space limitation. Warkworth substation is located 4km away from the township and load centre, resulting in considerable and unnecessary expenditure on 11kV feeders to deliver the distant capacity to the township. When compared to Option 1 this solution is not only costlier but does not provide the security that two substations can offer (Warkworth and Warkworth South substations).
Option 3: Non-Network: Network battery The load growth in the Warkworth area is a combination of greenfield business and residential. According to the load forecast, a typical 1MW/2MWh battery will defer security issues for Warkworth by less than one year before further network reinforcement is needed.
Proposed Solution
Option 1, construction of Warkworth South substation, is the recommended solution. The proposed staged construction has the smallest overall NPV and is in the optimal location to supply the upcoming developments, whilst adding diversity to the existing supply.

Wynyard South - 22kV Reinforcement

Description
The Auckland Waterfront Development Agency (AWDA) plans to progressively develop the Wynyard Quarter into a commercial hub over the next 15 years. The existing 22kV distribution feeders from Hobson substation do not have the capacity to supply the forecast load increase. An Auckland Transport road-improvement project being carried out in the Wynyard South area, providing Vector with options to ensure the network has sufficient capacity to meet demand.
Options
Option 1: Relocate existing 11kV cables. This option proposes relocating existing 11kV cables as part of Auckland Transport upgrade. The existing cables have already been identified as having insufficient capacity to meet forecast demand and it would be short-sighted to relocate existing cables to return to overlay with 22kV cables in the nearer future.
Option 2: Install 22kV cables and ducts in coordinate with AT’s Wynyard South road improvement project This option proposes installing 22kV cables as the improvement project progresses, progressively retiring the aged 11kV cables. This approach provides the forecast capacity needed for the redevelopment, avoids re-opening newly laid roads to install new cables and is consistent with the implementation of a 22kV distribution network within the CBD.
Option 3: Non-Network options Non-network solutions are not an option for this project
Proposed Solution

Option 2 22kV reinforcement is the recommended option.

FY18 Projects

Land Purchase - Ellerslie Zone Substation

Description
Commercial development is proposed along the southern strip of the Ellerslie Racecourse. The existing substations supplying this area are Drive, McNab and Remuera. All are heavily loaded. The plan is to inject additional zone substation capacity into the Ellerslie area to relieve capacity constraints on the adjacent substations. This will be achieved by establishing a new substation in Ellerslie. This project is to purchase land for the new zone substation.

Greenwood 11kV Feeder Installation

Description
New industrial and residential developments in the Ihumatao (Airport) area are supplied by a single 11kV cable from Mangere West substation. Security of supply needs to be provided.
Options
Option 1: Reinforce the 11kV network A new 11kV cable will be laid from the Greenwood zone substation. Most of the cable route has ducts in place already.
Option 2: Non-Network options Since there is rapid greenfields development there is no practical alternative to 11kV investment.
Proposed Solution
Option 1 – a new 11kV cable will be laid.

Construction of Millwater Zone Substation

Description
The Silverdale-Wainui area has been rezoned from rural to urban. Residential developments of Millwater and Orewa have resulted in a steady load increase on Orewa substation. The Highgate business development currently under construction, is expected to increase load on both Red Beach and Orewa substations. Additional zone substation capacity is required to maintain security of supply
Options
Option 1: Establish Millwater substation This option proposes commissioning Millwater substation in 2022. In the interim 11kV feeder circuits will be extended as part of the reticulation of the forthcoming developments. Land has still to be secured for this substation.
Option 2: Non-network solution – Network battery solution This option considers utilising network batteries for demand management to defer construction of the Millwater substation.
Proposed Solution
Option 1 - establish Millwater substation is the recommended solution. This predominantly residential load offers opportunities for non-network solutions such as PV and in-house battery storage which will have the effect of deferring Millwater substation. Our practice is to build substations on a just-in-time basis ensuring that demand reductions arising from any non-network solutions implemented by the individual customers will incrementally delay the timing of the substation

Newmarket South Zone Substation Construction

Description
The proposed Westfield redevelopment in Broadway, Newmarket and the transfer of the Auckland Hospital load is forecast to push Newmarket substation's load above its security limit post-2018. Adjacent Newton, Remuera and Drive substations are heavily loaded with minimal spare capacity for possible load transfers. The

construction of Newmarket South substation will ensure network security and release capacity at Newmarket, Remuera and Drive substations.

Options
Option 1: Establish Newmarket South substation
This option proposes establishing a second substation (Newmarket South) in Newmarket. The new substation will release capacity at Newmarket, Remuera and Drive substations to allow the connection of additional load as well as supply the proposed Westfield expansion in Newmarket.
Option 2: Reinforce Newmarket substation
This option proposes reinforcing Newmarket substation with an extended 11kV switchboard and the addition of a fourth transformer. Building alterations will be required to accommodate the switchboard. The disadvantage of this option is that network fault levels are increased beyond acceptable limits for downstream distribution switchgear, the load increase is beyond levels than can be supported by adjacent zone substations while the close proximity of primary equipment on a confined site will compromise network security[20]. Reinforcing Newmarket substation only briefly defers the need for Newmarket South substation while the NPV calculations show this option is more costly than Option 1.
Option 3: Establish a new substation at Ellerslie to supply the southern precincts of Newmarket
This option proposes a new substation at Ellerslie with cascade load transfer from Newmarket to Remuera and Drive and then onto Ellerslie substations. Ellerslie is approximately 5km from the Newmarket commercial centre requiring 11kV cabling to be installed to enable the load transfer. Furthermore, this cabling only defers the need for Newmarket South substation. NPV analysis concluded this solution it is more expensive than that proposed in Option 1
Option 4: Non-Network options
The size of the load involved means that any non-network solutions offer minimal relief deferring the construction of the Newmarket South zone substation. An NPV assessment based on the implementation of a combination non-network and the Newmarket South substation make this an expensive option compared to Option 1.
Proposed Solution
Option 1, construction of Newmarket South substation is the recommended solution.

Rosedale Second 33/11kV Transformer Installation

Description
Rosedale substation was commissioned in 2014. The substation is designed and constructed in anticipation of two transformers, although initially equipped with a single transformer. Load increases arising from the Corinthian and Watercare Rosedale plant upgrade will add a further 10MVA. The load is forecast to exceed the transformer rating in 2019. This project is to restore network security.
Options
Option 1: Install a second transformer
Rosedale substation was designed to accommodate a second transformer. The second transformer will address the forecast security issues at this substation.
Option 2: Non-network solution – Network battery
This option proposed using network batteries for peak-shaving to postpone the installation of the second transformer.
Option 3: Load transfer to adjacent substations
Rosedale substation was constructed to supply local demand and release capacity for new connections and load increases on adjacent substations. Transferring load back to the neighbouring substations reverses the benefits gained through the construction of Rosedale
Proposed Solution
Option 1 – install the second transformer at Rosedale is the preferred solution.

Swanson - Bethells 11kV Feeder Reinforcement

Description

[20] While N-1 security is built into the site, the confined site ensures that the failure of one primary asset (eg transformer fire, bus fault) may damage the adjacent assets that form part of the back-up supply. As the site becomes further congested with the addition of another transformer, extended switchboard, etc the risk of collateral damage increases.

Bethells 11kV feeder from Swanson substation is a long semi-rural feeder with limited backstopping. This feeder is 10 times longer than average feeder length on Vector network. Network reinforcement is required to reduce the length of the feeder and its SAIDI contribution to Vectors reliability statistics.

Options

Option 1: Establish Waitakere substation

This option proposes construction of a new substation at Waitakere.

Option 2: Reinforce Bethells feeder with a second 11kV feeder

This option proposes adding a second 11kV line to the existing Bethells line as far as Waitakere. This will allow the re-distribution of load across two feeders with the opportunity to upgrade the initial line to 33kV when the new Waitakere substation is required. By removing part of Bethells feeder load onto the new feeder, capacity is freed up and the customer count on the Bethells feeder reduced.

Option 3: Non-Network solution; Network batteries

This option focuses on installation of network batteries for peak reduction and increased reliability. The network battery can stay on this circuit until the Waitakere substation is warranted.

Proposed Solution

Option 2, construction of the second 11kv line is the preferred option

Land Purchase - Whenuapai Zone Substation

Description

Rezoning Whenuapai from rural to predominantly urban-residential in the draft Auckland Unitary Plan will result in substantial load being connected to what is currently a rural network. The first stage of the development (SHAs for Whenuapai village) will be supplied from the proposed Hobsonville Point substation, later stages will necessitate an additional zone substation. This project is to secure land for the proposed Whenuapai zone substation.

Whenuapai Zone Substation Construction

Description

The Whenuapai area is flagged as a future urban zone, with Special Housing Areas (SHA) areas currently being developed. Surrounding substations at Westgate, Hobsonville and the proposed Hobsonville Point have their capacity committed leaving a capacity shortfall at Whenuapai by 2020.

Options

Option 1: Establish Whenuapai substation

This option proposes constructing Whenuapai substation in 2020. 11kV distribution feeder circuits will be installed as part of the various developments. Cost estimates will be finalised once substation land is secured

Option 2: Non-network solution

This option proposes using non-network solutions (eg PV, network batteries) to defer the establishment of the Whenuapai zone substation.

Proposed Solution

Option 1 - establish Whenuapai substation is the recommended solution. This predominantly residential load offers opportunities for non-network solutions such as PV and in-house battery storage which will have the effect of deferring Whenuapai substation. Our practice is to build substations on a just-in-time basis ensuring that demand reductions arising from any non-network solutions implemented by the individual customers will incrementally delay the timing of the substation

FY19 Projects

Brickworks Second 33/11kV Transformer

Description

Brickworks substation is adjacent to a designated Special Housing Area which, when completed, is expected to add a further 10MVA load. The Brickworks single transformer substation has insufficient capacity to supply this load.

Options

Option 1: Install a second transformer at Brickworks
Brickworks substation was constructed on a staged basis anticipating the need for a second transformer when the adjacent development proceeded. Installation of a second transformer and second supply from New Lynn substation will provide the security needed for this increased demand. The installation of distribution feeders will be managed with the developer
Option 2: Non-network solution
This option proposes using non-network solutions (eg PV, network batteries) to defer the installation of the second transformer at Brickworks zone substation.
Proposed Solution
Option 1 – install a second transformer in Brickworks substation is the recommended solution. This predominantly residential load offers opportunities for non-network solutions such as PV and in-house battery storage which will have the effect of deferring the Brickworks upgrade. Our practice is commit reinforcements on a just-in-time basis ensuring that demand reductions arising from any non-network solutions implemented by the individual customers will incrementally delay the timing of the project

Coatesville Second 33/11kV Transformer Installation

Description
Load growth forecast at Dairy Flat will result in network security breach at Coatesville zone substation. This is a single transformer substation with limited backstopping from adjacent network. A solution is needed to resolve the forecast security breach.
Options
Option 1: Install a second transformer
This option proposes a second transformer at Coatesville. The solution increases the capacity and improves the security at this substation, enabling the early stages of the Dairy Flat development to be supplied from Coatesville. The substation was recently upgraded and installation of a second transformer will be relatively straight forward.
Option 2: Non-network solution
This option proposes using non-network solutions (eg PV, network batteries) to defer the installation of the second transformer at Coatesville zone substation.
Proposed Solution
Option 1 – install a second transformer in Coatesville substation is the recommended solution. This predominantly residential load offers opportunities for non-network solutions such as PV and in-house battery storage which will have the effect of deferring the Coateville upgrade. Our practice is commit reinforcements on a just-in-time basis ensuring that demand reductions arising from any non-network solutions implemented by the individual customers will incrementally delay the timing of the project

Drive - Alexandra Park 11kV Feeder Installation

Description
The Alexandra Park development, comprising a mix of both commercial and residential customers, is estimated to deliver 6MVA of network load. There is insufficient capacity in the existing 11kV network to meet this additional demand
Options
Option 1: Install a new 11kV feeder from Drive substation
This option proposes connection of the Alexandra Park development to the existing 11kV network until feeder capacity is reached. Following this a new 11kV feeder will be installed from Drive substation.
Option 2: Non-Network options
The development comprises commercial and residential medium-rise buildings offering few opportunities for non-network solutions
Proposed Solution
Option 1, a new feeder from Drive substation, is the recommended solution.

East West Link Reinforcement

Description
East West Connections is a joint NZ Transport Agency (NZTA) and Auckland Transport (AT) initiative to improve freight efficiency, commuter travel, public transport, walking and cycling options within Auckland. The current project is to improve the east-west connection between SH1 at Sylvia Park through to SH20 at Onehunga. This project proposes installation of future-proofing ducts along part of the east-west route, in conjunction with the East West Connections project, to facilitate the replacement and/or reinforcement of future sub-transmission network. This project is at the early concept stage but is expected to develop over the forthcoming year.

Kingsland – City Rail Link supply Mt Eden Station

Description
Auckland Transport is constructing an underground railway line (City Rail Link) linking Britomart and the Auckland CBD with the existing western railway line near Mt Eden. The tunnel construction methodology will use a Tunnel Boring Machine (TBM) between Aotea and Mt Eden stations, with boring commencing at the Mt Eden portal. The TBM power supply is required at Mt Eden. Once the TBM project is completed the power supply will be used to provide a permanent supply to Mt Eden station and a back-up supply to Aotea Station
Options
Option 1: Connect Mt Eden Station to the existing 11kV network The existing 11kV network has insufficient capacity to meet the expected demand of the TBM.
Option 2: Install two new 11kV feeders from Kingsland substation This option will recommends installing two new 11kV feeders from Kingsland substation to Mt Eden Station. An 11/22kV step-up transformer is needed to match the 22kV back-up supply from Aotea Station. This solution is more expensive than the 22kV option from Kingsland.
Option 3: Install two new 11kV feeders from Newton substation This option will recommends installing two new 11kV feeders from Kingsland substation to Mt Eden Station. As with Option 2 an 11/22kV step-up transformer is needed to match the 22kV back-up supply from Aotea Station. This option will also initiate a capacity upgrade at Newton substation
Option 4: Install a new 22kV feeder from Kingsland substation This option recommends installing a new 22kV feeder from Kingsland substation to Mt Eden station. The new feeder will be connected to Kingsland 22kV bus. This proposal meets the customer's capacity requirements, avoids the need for step-up transformers, while providing through the tunnel via the back-up supply at Aotea Station.
Option 5: Non-Network options This project does not lend itself to non-network solutions
Proposed Solution
Option 4, a 22kV feeder from Kingsland is the recommended solution.

Light Rail Transit supply reinforcement

Description
Auckland Transport is investigating a Light Rail Transit (LRT) network as a solution to traffic congestion on arterial roads out of the CBD. The project is at the option-investigation stage. Due to the significant road-works involved in this project, Vector will take the opportunity to install future-proofing ducts where appropriate.

Westgate 33kV Supply Reinforcement

Description
Westgate zone substation will be commissioned using the Henderson-Riverhead 33kV overhead circuit. A secondary supply is available from Hobsonville. As the load grows in the Hobsonville-Redhills area, the subtransmission supply capacity from Henderson will be exceeded.
Options
Option 1: Install a second 33kV circuit from Henderson to Westgate As part of NZTA cycleway construction along SH18, Vector has installed two sets of future-proofing ducts from Henderson to Westgate substation in anticipation of the constraints on the Henderson-Riverhead circuit. This project is to install the cable and terminate at either end. Provision has been made for an extra circuit-breaker at Transpower

Henderson as part of the 33kV outdoor/indoor switchgear conversion programme. A 33kV circuit-breaker has been installed at Westgate substation as part of the substation construction scope.

Proposed Solution
Option 1 - installation of the cables along the Northwestern cycleway is the proposed solution.

FY20 Projects

Land Purchase - Brigham Creek Substation

Description
This project is secure land for a future substation at Brigham Creek. Based on growth forecasts the proposed substations at Hobsonville Point and Whenuapai will run out of capacity by 2023. Securing land early allows the optimal site to be selected to minimise distribution reticulation costs and to mitigate adverse reaction from local residents when construction commences.

Greenwood-Airport Cable Installation

Description
A new transformer will be required at the Airport zone substation to meet forecast load and Greenwood zone substation is scheduled for construction constructed (see above). The capacity of the existing subtransmission cable circuits to the Airport and Greenwood/Mangere West will be exceeded in the near future.
Options
Option 1: Install new cables from the Mangere GXP to Greenwood (and to the Airport when required) The length of the cable routes, and the need for new cable bays at the GXP, makes this a very expensive solution.
Option 2: Install a cable between the Greenwood and Airport substations, creating a 33kV ring. The short cable route means this solution is more cost-effective. It utilises the capacity of all four radial cables while increasing the security to all three substations
Option 3: Non-Network options The size and rapidity of the load growth, and its primarily industrial nature, mean that non-network options are not feasible.
Proposed Solution
Option 2 - a cable between the Greenwood and Airport substations recommended solution.

Kumeu Zone Substation Construction

Description
The Huapai-Kumeu area is zoned as future urban. The existing substations at Riverhead and Waimauku can sustain the forecast load increase until 2020. At this time network reinforcement will be required to allow for connection of the new customers.
Options
Option 1: Establish Kumeu zone substation This option proposes constructing Kumeu substation in 2020. 11kV feeder circuits will be laid as part of the subdivision reticulation.
Option 2: Load transfer to adjacent substations As mentioned in the description load transfer opportunities are exhausted by 2020 when Riverhead and Waimauku substations reach capacity
Option 3: Non-network solution This option proposes installing network/home batteries. Implementation of this solution will delay the timing of Kumeu substation but not remove the need. Vectors zone substation construction practice has always been to build substations on a just-in-time basis ensuring that the deferral benefits of any non-network solutions implemented in the interim are maximised.
Proposed Solution
Option 1 – establishing Kumeu substation is the preferred option.

Redhills Zone Substation Construction

Description
Redhills is a rural greenfields area with a reticulation network sized for the current rural load. This area has been designated as future urban, with existing SHA areas already at the design stage. The existing network is not capable of supplying the forecast load beyond 2022.
Options
Option 1: Establish Redhills substation This option proposes construction of Redhills substation in 2022 to provide the capacity to meet the demand.
Option 2: Non-network solutions This option proposes installing network/home batteries and PV solutions. Implementation of these solutions will delay the timing of Redhills substation but not remove the need. Vectors zone substation construction practice has always been to build substations on a just-in-time basis ensuring that the deferral benefits of any non-network solutions implemented in the interim, are maximised.
Proposed Solution
Option 1 – establishing Redhills substation is the preferred option.

Spur Road Second 33/11kV Transformer Installation

Description
Spur Road's single transformer substation is forecast to exceed capacity in 2020. This is primarily due to forecast residential growth in the Silverdale-Wainui area. Installation of a second transformer at Spur Road has been deferred many years by reinforcing the supply at adjacent substations. Opportunities for further deferral will be exhausted by 2020.
Options
Option 1: Install a second transformer There is sufficient room within Spur Road substation's yard to install a second transformer. Subtransmission upgrade is not required. The new transformer will allow the load to be redistributed across both transformers, while increasing the network security at both Spur Rd and adjacent Red Beach substations.
Option 2: Non-network solutions This option proposes installing network/home batteries and PV solutions. Vectors practice has always been to implement reinforcement projects on a just-in-time basis ensuring that the deferral benefits of any non-network solutions implemented in the interim, are maximised.
Proposed Solution
Option 1 – installation of the second transformer in Spur Rd is the recommended solution.

Takapuna Second 33/11kV Transformer Installation

Description
The load within Takapuna city centre is forecast to grow. Takapuna is a single transformer substation with limited load transfer capability to adjacent substations. Network security is forecast to be breached by 2021.
Options
Option 1: Install a second transformer in Takapuna substation A new transformer supported by a new back-up subtransmission supply is the proposed solution. This solution will restore network security to accepted levels
Option 2: Load transfer from Takapuna substation Opportunities for load transfer whilst still maintaining security levels will be exhausted by 2021
Option 3: Non-network solutions Takapuna substations load is predominantly commercial leaving few opportunities to realistically reduce load using non-network solutions at this time.
Proposed Solution
Option 1 – installing a second transformer and subtransmission circuit is the recommended solution

Wiri West Zone Substation Construction

Description

A large area west of McLaughlins Road is due to be rezoned for industrial development. There is limited opportunity to supply load from adjacent zone substations.
Options
Option 1: Install a zone substation A site has already been acquired, close to existing subtransmission cables. A zone substation will provide capacity and maintain security of supply.
Option 2: Reinforce the 11kV network If load development proves to be lower than expected, feeders from Mangere East and Wiri may be laid to supply the area.
Option 3: Non-Network options The load forecast for this area will be closely monitored. If innovative or non-network solutions are economic in deferring the investment, they will be implemented. There may be fewer non-network options for industrial load.

Proposed Solution
Developments will be closely monitored to confirm the best solution.

FY21 Projects

Dairy Flat Substation Land Purchase

Description
This project is secure land for a future substation at Dairy Flat. The existing substations, Spur Road and Coatesville, will not have sufficient capacity to supply the load beyond 2025.

5.18.1 Progress against Existing Development Projects

Westgate Substation Construction

Progress against planned
This project is currently under construction, civil work is nearly complete with expected commissioning in June 2016. There has been no significant change to the original scope of this substation; however the load increase at Westgate development is not as significant as what was initially expected. Westgate was initially planned to supply only Westgate development however with the less-than-expected actual load increase we will take the opportunity to supply the initial stages of Red-Hills SHA from Westgate, ultimately postponing the Red-Hills substation construction. The postponement is pending the completion of Westgate development to ensure there will be additional spare capacity at Westgate.

CBD 22kV Cables Rollout

Progress against planned
This is an on-going project following Vector's long term plan for distribution network in CBD. The plan is to progressively convert the existing 11kV network to 22kV and eventually phase out 11kV in CBD. The project has been progressing as planned.

City Rail Link 22kV Upgrade

Progress against planned
This projects is to extend the CBD 22kV distribution network in coordinate with Auckland Transport's City Rail Link excavation works in Lower Queen St and Albert St. The project is also required to supply the new Precinct Tower to be built at the existing Downtown Shopping Centre site. The project started December 2015 and has been in progress coordinating with Auckland Transport's project program. The project targets to complete in 2019.

Precinct Tower Power Supply

Progress against planned
This project is to extend the CBD 22kV distribution network to supply the new Precinct Tower to be built at the existing Downtown Shopping Centre site. The project is also in coordinate with the City Rail Link excavation works in Lower Queen St and Albert St. The project started December 2015 and has been in progress coordinating with Auckland Transport's project program. The project targets to complete in 2018.

Wynyard South - 22kV Reinforcement

Progress against planned
This project is to extend the CBD 22kV distribution network to Wynyard Quarter to meet the capacity demand required for the development in the area. The project has been progressing in coordinate with the road improvement project being carried out by Auckland Transport. The project targets to complete in 2018.

5.18.2 Significant Variances from Previous AMPs

Schedule Date	Substation	Project and Programme Description	2015 AMP Schedule Date	Reason for Change (in AMP15)
-	Albany	Substation construction	FY25	Postponed due to revised load forecast
FY25	Balmoral	11kV reinforcement to off-load Drive	FY25	No change
-	Birkdale	Zone substation upgrade	FY15	Complete
FY20	Brickworks	Second 33/11kV transformer	-	New project as a result of forecast growth
FY20	Brighams Creek	Land purchase	FY20	No change
FY24	Brighams Creek	Substation construction	-	New project as a result of growth
On-going	CBD	22kV cables rollout	On-going	No change
FY25	CBD	22kV distribution Beach Rd cable link		New project
	Chevalier	Cycleway ducts	FY17	Project replaced with SH16 to St Lukes - future-proofing ducts
FY19	Coatesville	Second 33/11kV transformer	FY18	Postponed one year as a result of new load forecast
FY21	Dairy Flat	Land purchase	-	New project to due to zoning change
FY26	Dairy Flat	Substation construction	-	New project to due to zoning change
FY19	Drive	11kV feeder to supply Alexandra Park development	FY19	No change
FY18	Ellerslie	Land purchase	FY18	No change
-	Ellerslie	Substation construction	FY25	Postponed due to revised load forecast
FY17	Flatbush	11kV feeder cables	FY16	Project timing dependent on the land development
-	Flatbush	Land purchase	FY15	Complete
-	Flatbush	Substation construction	FY15	Complete
FY19	Glenvar	Substation construction	FY19	No change
-	Greenhithe	Second 33/11kV transformer	FY23	Postponed due to revised load forecast
-	Greenhithe	Watercare 11kV feeder	FY21	Customer driven
FY18	Greenwood	11kV feeder		New project
FY20	Greenwood	Greenwood - airport cable		New project
FY17	Greenwood	Land purchase		New project (replaces Ihumatao)

Schedule Date	Substation	Project and Programme Description	2015 AMP Schedule Date	Reason for Change (in AMP15)
FY19	Greenwood	Substation construction		New project (replaces Ihumatao)
-	Hans	11kV cable	FY16	Postponed due to revised load forecast
FY26	Hans	Third 33/11kV transformer	-	Bought forward as a result of new load forecast
-	Highbury	Second 33/11kV transformer	FY17	Cancelled due to revised load forecast
FY17	Hillcrest	Tonar 11kV feeder reinforcement	FY17	No change
-	Hobson	110kV GXP	FY15	Complete
FY22	Hobson	3rd 22kV feeder to supply the Waterfront	FY22	No change
FY17	Hobson	City Rail Link supply - Aotea Station	FY16	Deferred driven by Auckland Transport project program
-	Hobson	Queens Wharf 22kV cable	FY23	Postponed due to revised load forecast
FY23	Hobsonville	33/11kV transformer upgrade	-	New project due to high population forecast
FY18	Hobsonville Point	Substation construction	FY18	No change
-	Hobsonville Point	Land purchase	FY15	Complete
	Hospital	11kV feeder	FY16	Complete
FY17	Hospital	Hospital capacity reinforcement		New project
	Ihumatao	Land purchase	FY21	Replaced by Greenwood zone substation
	Ihumatao	New zone substation	FY25	Replaced by Greenwood zone substation
FY26	Kaukapakapa	Substation construction	FY25	Postponed due to revised load forecast
FY24	Keeling Rd	Second 33kV supply	FY18	Postponed due to subtransmission budget adjustment
-	Keeling Rd	Second 33/11kV TX	FY15	Complete
FY20	Kingsland	City Rail Loop supply to Mt Eden Station	FY20	No change
FY16	Kumeu	Land purchase	FY16	No change
FY22	Kumeu	Substation construction	FY19	New project as a result of forecast growth increase
FY17	Lichfield	Fonterra Lichfield 11kV network changes	-	New project due to customer expansion
-	Liverpool	110/22kV transformer upgrade	FY19	Postponed due to revised load forecast
-	Liverpool	22kV subtransmission cable upgrade to Victoria St	FY20	Postponed due to revised load forecast
-	Liverpool	Telecom Mayoral Dr - 22kV feeder	FY23	Deferred, customer driven

Schedule Date	Substation	Project and Programme Description	2015 AMP Schedule Date	Reason for Change (in AMP15)
-	Liverpool	University Medical School - 11kV feeder	FY24	Deferred, customer driven
-	Mangere Central	11kV feeder	FY18	Postponed due to revised load forecast
FY26	Mangere Central	Third transformer	FY21	Deferred by Greenwood zone substation
-	Mangere West	11kV feeder reinforcement - Sistema	FY16	Complete
FY17	Maraetai	11kV feeder		New project
-	Matakana	Land purchase	FY25	Postponed due to revised load forecast
FY20	Millwater	Substation construction	FY20	Name changed from Wainui to Millwater
	Mt Albert	Future ducts	FY17	Postponed due to revised load forecast
FY17	Newmarket	Newmarket - 11kV supply to 309 Broadway	FY16	Deferred, customer driven
FY17	Newmarket South	Land purchase	FY16	Deferred for further investigation
FY21	Newmarket South	Substation construction	FY19	Deferred for further investigation
FY23	Onehunga	11kV feeder reinforcement	FY23	No change
-	Orewa	Third 33kV subtransmission supply	FY20	Combined with Millwater construction
FY25	Parnell	11kV reinforcement to off load feeder 13	FY25	No change
-	Penrose	33kV switchboard replacement	FY17	Moved to Asset Replacement budget program
FY21	Quay	110kV feeder	FY21	No change
FY17	Red Hills	Land purchase	FY17	No change
FY22	Red Hills	Substation construction	FY22	No change
-	Red Beach	Second 33/11kV transformer	FY15	Complete
FY25	Riverhead	33/11kV transformer upgrade	FY25	No change
	Rosebank	11kV future-proofing duct	FY15	Expected to complete FY16
FY17	Rosedale	Project Corinthian	-	New project - Customer driven
FY19	Rosedale	Second 33/11kV transformer	-	New project as a result of high growth at Rosedale
-	Rosedale	Substation construction	FY15	Complete
FY17	Rosedale	Watercare 11kV feeder	FY16	Customer driven
-	Roskill	33kV switchboard replacement	FY19	Moved to Asset Replacement budget program
-	Sandspit	Substation construction	FY25	Deferred beyond planning period
-	Southdown	New 33kV feeders	FY21	Postponed due to revised load forecast

Schedule Date	Substation	Project and Programme Description	2015 AMP Schedule Date	Reason for Change (in AMP15)
FY19	Southdown	Land purchase for zone substation	FY19	No change
FY23	Southdown	Zone substation construction	FY23	No change
FY20	Spur Road	Second 33/11kV transformer	FY20	No change
FY17	Spur Road	Weiti Development – new 11kV feeder	FY15	Customer driven
FY21	St Johns	33kV reinforcement	FY17	Deferred due to change of other project at Glen Innes
FY18	Swanson	Bethells feeder reinforcement	-	New project to address high SAIDI at Bethells
-	Takanini	Brookby supply upgrade	FY15	Customer project not proceeding
FY23	Takanini	Mill Road 11kV Cable	FY23	Brought forward as a result of new load forecast
FY23	Takanini South	Land purchase	FY23	Brought forward as a result of new load forecast
FY22	Takapuna	Second 33/11kV transformer	-	Brought forward as a result of new load forecast
-	Various	Distributed electrical energy storage integration and management	FY19	Postponed due to revised load forecast
-	Various	Distributed generation integration and management	FY18	Postponed due to revised load forecast
FY20	Various	East West Link reinforcement	-	New project
-	Various	Electrical Vehicle Integration and management	FY18	Scope included in other development projects
-	Various	Electricity distribution network power flow and state estimation	FY16	Scope included in other development projects
-	Various	Electricity distribution network dynamic network reconfiguration - fault location, isolation and system restoration systems	FY25	Scope included in other development projects
-	Various	Electricity distribution network dynamic network reconfiguration - load transferring schemes	FY18	Scope included in other development projects
-	Various	Electricity distribution network optimisation (operation, maintenance and loss reduction)	FY20	Scope included in other development projects
-	Various	Electricity distribution network real-time thermal rating	On-going	Scope included in other development projects
-	Various	Electricity distribution network voltage / var / Watt control	FY19	Scope included in other development projects

Schedule Date	Substation	Project and Programme Description	2015 AMP Schedule Date	Reason for Change (in AMP15)
-	Various	Electricity distribution network voltage cyber security - intrusion detection	FY17	Scope included in other development projects
-	Various	Electricity distribution network voltage cyber security - Independent Health Monitor	FY16	Scope included in other development projects
-	Various	Electricity distribution network voltage cyber security - Security event logging and management	FY17	Scope included in other development projects
-	Various	Electricity distribution network voltage cyber security - Vulnerability management	FY16	Scope included in other development projects
-	Various	Electricity network information modelling	FY17	Scope included in other development projects
-	Various	Fault level management	On-going	Scope included in other development projects
-	Various	Fault level monitoring	On-going	Scope included in other development projects
-	Various	Integration of Microgrids	FY20	Scope included in other development projects
-	Various	LV network - operation	FY16	Scope included in other development projects
-	Various	Network automation - LV network	On-going	Scope included in other development projects
-	Various	Network automation - MV network	On-going	Scope included in other development projects
-	Various	Network automation - primary substation next generation	On-going	Scope included in other development projects
-	Various	Network automation - secondary MV/LV distribution substation	On-going	Scope included in other development projects
FY25	Waimauku	Second 33kV Supply	FY19	Postponed as a result of subtransmission budget reduction
-	Wairau	110kV mast relocation	FY16	Complete
FY17	Wairau	North Shore Hospital 11kV feeder	FY17	No change
-	Waiwera	Land purchase	FY20	Postponed due to revised load forecast
-	Waiwera	Substation construction	FY24	Postponed due to revised load forecast
FY17	Warkworth	Matakana 11kV feeder	FY17	No change
FY18	Warkworth South	Substation construction	FY17	Postponed to allow for just-in-time investment
FY25	Warkworth South	Subtransmission reinforcement	FY25	No change
-	Waterview	North portal - permanent supply	FY16	Completion expected 2016

Schedule Date	Substation	Project and Programme Description	2015 AMP Schedule Date	Reason for Change (in AMP15)
FY17	Waterview	South portal - permanent supply	FY15	Deferred, customer driven
FY20	Westgate	33kV Supply Reinforcement 1	FY19	Postponed 1 year as a result of new load forecast
FY26	Westgate	33kV Supply Reinforcement 2	FY25	Postponed 1 year as a result of new load forecast
FY17	Westgate	Substation construction	FY16	Under construction
FY17	Westgate	Westgate future-proofing ducts	FY17	No change
FY18	Whenuapai	Land purchase	FY18	No change
FY20	Whenuapai	Substation construction	FY25	New project as a result of northwest growth
FY23	Wiri West	Substation construction	FY23	Brought forward due to zone change. Timing dependent on development
-	Woodford	Second 33/11kV transformer	FY25	Postponed due to revised load forecast
FY19	CBD	Wynyard South reinforcement	-	Project combining all the various projects in CBD Wynyard Quarter
FY19	Airport	Airport zone substation expansion	-	New project
-	Mangere Central	Coca Cola supply- Timberley Rd, Mangere	-	Complete
FY19	CBD	City Rail Loop - 22kV upgrade	-	New project
FY18	CBD	Downtown shopping centre supply	-	New project
FY22	Various	Light Rail Transit supply - reinforcement	-	New project
FY17	Chevalier	Sh16 to St Lukes – future-proofing ducts	-	New project

Electricity
Asset Management Plan
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Lifecycle Asset Management (Maintenance and Renewal) – Section 6

[Disclosure AMP]

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6. Lifecycle Asset Management (Maintenance and Renewal)

This section covers Vector's life cycle asset maintenance, renewal and refurbishment plans, and the policies, criteria, assumptions, data and processes used to prepare these.

Vector's asset management strategy is to establish efficient controls to manage financial, health and safety, reliability and environmental risks. Optimal life cycle investment considers the balance between asset renewal requiring capital expenditure and the combination of reactive, preventive and corrective operational expenditure.

An important input assumption to the Asset Management Plan is an expected 25% reduction in residential load over the 2016-2026 period with only slight growth in Auckland CBD. This assumption is taken into consideration when considering maintenance or renewal activities or selecting new technologies to meet future customer needs. The developing alternative technologies will become increasingly important in the future planning of the network.

Overall it is assumed that the climate change in New Zealand will not cause a significant impact on asset performance and aging trends and global temperature or wind speeds will not change significantly over the next decade.

Development of asset replacement programs relies heavily on projections developed form asset condition data in Vector's business systems. This data is subject to continual improvement and as data quality is improved, revisions on future investment requirements are updated accordingly.

6.1 Key drivers for maintenance planning

Asset risks are analysed and documented in FMEA registers for each asset class. Further analysis of the network reliability trends documented in asset risk reports identifies those risks that can be economically mitigated via maintenance.

The strategic drivers are as follows:

Operational Excellence

- Ensure electrical assets are in compliant, safe and serviceable order;
- Ensure reliable network performance is sustained;
- Ensure network investments and operating activities are efficient; and
- Drive continual innovation and efficiency improvements in the area of maintenance and operations.

Customer and Regulatory Outcomes

- Ensure high levels of public, staff and service provider safety;
- Ensure assets are designed, operated and maintained to the required standard in order to provide the agreed level of service; and
- Ensure an appropriate level of response to customer concerns, requests and enquiries.

Cost Efficiency and Productivity

- Strive to achieve the optimal life cycle investment considering the balance between capital and operational expenditure;
- Coordinate works and extract efficiency from asset replacement and asset development projects and programmes; and
- Apply innovative approaches to decision making, solutions, and works execution.

6.2 Vector's Asset Maintenance and Inspection Approach

Asset Resilience teams have analysed likelihood and consequence of various failures for each asset class in order to develop an economical response to each asset risk.

Asset maintenance is an asset management activity which is ensures a tolerable level of asset risks without an effect on the longevity of asset service life. Asset maintenance is stipulated by the asset maintenance policy EPA007 and conducted in accordance with a comprehensive suite of in-house developed maintenance standards that define asset inspections, condition testing and associated maintenance tasks.

Each maintenance standard addresses the purpose, content, record requirements and associated treatment criteria. The frequency of asset maintenance for all assets is defined in Maintenance Schedule ESM001. The treatment criteria and resulting actions generally direct field staff, to repair or replace components of the asset. This activity is funded with Vector OPEX budget.

Asset refurbishment or replacement is applied when the asset reaches the end of its economical service life. In practice it means that when the cost of further repair or maintenance exceeds the cost of refurbishment or replacement, as described by Asset Renewal Policy EPA008.

Assets that have low impact on network performance, such as pole fuses supplying individual dwellings, are allowed to run to failure where no adverse safety outcomes arise.

Maintenance services at Vector are categorised as follows:

Reactive Maintenance

- Action undertaken directly following customers' complaints, accidents or any other work that is required to rectify asset failure or damage to assets caused by unforeseen circumstances;
- Safety response and repair or replacement of any part of the network components damaged due to environmental factors or third parties interference; and
- Remediation or isolation of unsafe network situations, including immediate vegetation threats, low clearance lines and non-compliant installations.

Preventive Maintenance

- Provision of asset patrols, inspections and condition detection tasks, condition testing, maintenance service work; and
- The coordination of shutdowns and associated network switching and restoration, along with the capture and management of all defined data.

Corrective Maintenance

- Assets identified from planned inspections or service work to be in poor condition, requiring repair;
- Poor condition or unserviceable assets identified via one-off coordinated network inspections or identified through coincident capital works;
- Removal of graffiti, painting and repair of buildings and asset enclosures, removal of decommissioned assets, remediation of television interference complaints, one-off type inspection and condition detection tasks outside of planned maintenance standards; and
- Coordination of shutdowns and associated network switching and restoration, along with the capture and management of all defined data.

Value Added Maintenance

- Issuing maps and site plans to indicate the location of network assets;
- Asset location services, including the marking out of assets, safe work practice site briefings, worksite observer, urgent safety checks, safety disconnections;
- Issuing close approach permits, high load permits, high load escorts; and
- Disconnection and reconnection associated with the property movement of customers and any concerns relating to non-compliance of electricity regulations.

Vegetation Management

- Includes regular inspections of the overhead sub-transmission and distribution networks, issuing of cut and trim notices to tree owners, liaison with tree-owners or affected parties, on-going maintenance or removal of no-interest trees, enforcement of Vector's obligations under the regulations, resource consent applications, and all first cut tree works required to maintain the prescribed clearances around Vector's network assets; and
- The inspection of the grounds and buildings at Vector's zone substation properties, removal of foreign objects including vegetation debris at those sites, ongoing maintenance of lawns, trees, and planted areas at those sites and regular reporting of building defects found and needing repair via corrective maintenance activities.

6.2.1 Asset Maintenance Standards and Schedules

Vector's asset maintenance standards are an integral building block to support asset management decision making and provides the foundation for both asset maintenance and asset renewal approaches.

The asset maintenance standards are developed by Vector's Asset Strategy team. The execution and delivery of the standards and the resulting corrective maintenance and asset replacement works are managed by Vector's Network Services (NS) group. All field work including inspections, testing, maintenance, replacement work, system updates and data capture are carried out by Vector's field service providers.

Asset Maintenance Standards prescribe preventive maintenance requirements and how to treat defects identified either through corrective maintenance or asset renewal processes. The purpose of these standards, is to establish effective controls for the asset risks during assets normal service life.

Progress against the maintenance schedules and the associated maintenance costs are monitored on a monthly basis. Defects identified during asset inspections are recorded within SAP-PM. FSPs recommend the priorities for defects remedial work in accordance with the maintenance standards. Maintenance priorities are based on costs, risks and safety criteria.

In making decisions on repairing or replacing the assets, Vector consider recommendations submitted by the FSPs in conjunction with other asset and network risk factors.

6.2.2 Spares Policy and Procurement Strategy

Vector's strategic spares guideline EEA-0034 outlines the methodology for the handling and purchase of asset spares for the purposes of maintaining the electricity supply in the event of a major equipment failure or contingency event.

Vector's Asset Strategy team are responsible for determining what items should be held as strategic stock and for re-ordering apparatus when stock levels are less than optimal. When new equipment is purchased for the first time (eg: a new type of switchboard) an initial stock of manufacturer recommended spare parts is also purchased as part of Vector's strategy.

Lack of spares for key equipment could present a risk to the business, which is especially the case on older, discontinued equipment. Unavailability of spares is one of the asset risk factors considered when prioritising asset replacement programmes.

6.3 Vector's Asset Replacement and Renewal Approach

The approach to asset renewal is risk-based as stipulated in EPA008 Asset Renewal Policy. Risk factors considered in decision making include environmental impact, safety, customer impact, fault duty, feasibility of maintenance or repair and availability of spares. Age is not a direct driver of Vector's asset renewal.

Where Vector has large populations of lower cost distribution assets and associated components, the optimal investment options to repair, replace or refurbish are readily evaluated.

For the more critical distribution and sub-transmission assets where replacement costs are typically very high, the optimal investment options require more complex multi-criteria evaluation and business case justification. In summary, the process of identifying an asset for renewal replacement relies on the following:

- Vector's Field Service Providers (FSPs) schedule and execute Vector's maintenance standards with respect to asset inspections, condition testing and associated maintenance tasks by primary asset category;
- Vector's evaluation and trend analysis of condition test data, such as transformer oil analysis, step and touch voltage test, cable serving test results, partial discharge (PD) and thermographic inspection output, etc. as defined in the maintenance standards; and
- An evaluation of asset risks based on the historical fault records and reactive maintenance notifications, FMEA analysis applicable to the asset class and type and consequence of the failure of the specific asset.

Portfolio prioritisation covers the following aspects: health and safety risk, network security and capacity risk, brand and reputation risk, potential financial impacts and potential effects on the environment.

The final project prioritisation list along with the respective estimates forms the asset replacement and renewal capital expenditure forecast.

To improve consistency of data capture, enhance ability to analyse performance and condition trends and linkage to other asset management drivers such as risks, Vector initiated the development of the SAP – plant maintenance (PM) module as its key tool for asset management.

Key information recorded in SAP-PM includes:

- Preventive inspections, testing and routine maintenance transactions;
- Status tracking of defect notifications discovered during preventive activities which are being remedied through reactive, corrective or asset renewal actions; and
- A select set of test measurement points.

All field transaction data is directly recorded by Vector's FSPs. The activities associated with inspections, tests, and preventive and routine maintenance are captured in a consistent electronic format and provided to Vector.

6.4 Asset Inspection, Maintenance, Refurbishment and Renewal Programmes

In this section, the details of Vector's asset inspection, maintenance, testing, refurbishment and renewal programmes are discussed and presented by major asset category. Detailed asset quantities and age profiles for each asset category can be found in Vector's Annual Information Disclosure (Schedules 9a and 9b)[1], with a detailed grading of asset condition per asset category also provided in the Appendices of this AMP (Schedule 12a).

Specific Renewal and Replacement Programmes over the next 1, 5 and 10 year planning period are documented in detail in the Appendices of this document.

6.4.1 Sub-transmission Cables

The sub-transmission network provides the connection from Transpower's grid exit points to Vector's zone substations where electricity is converted to distribution voltages to supply the distribution network. Vector's sub-transmission cables operate at 110kV, 33kV and 22kV.

Vector's Southern network area operates 110kV, 33kV and 22kV as sub-transmission voltages. Cables are a mixture of three core and single core construction with aluminium being the main choice of conductor material (69%).

Vector's Northern network area operates 33kV sub-transmission cables. The majority of these cables are single phase aluminium core construction.

Vector Assets Installed at Transpower GXPs

Vector owns all 22kV, 33kV and 110kV sub-transmission cables and overhead lines terminating onto Transpower's switchboards at all GXPs feeding its network, irrespective of whether the circuit breakers are owned by Vector or Transpower.

Asset Condition and Systemic Issues

PILC Cables

There is approximately 78km of 22kV and 33kV PILC type cables installed on the Vector network between the early 1920's and late 1980's.

The cables are generally in good to very good condition and any failures are usually due to old joints or third party damage.

A number of older cables were laid on private property and when faults develop these are proving difficult to access due to concerns raised by the private land owners. In some cases structures have been erected over cables. Cables will be replaced as their failure rate increases or as part of a network redevelopment programme.

Oil Filled PILC Cables

There is approximately 162km of 110kV, 33kV and 22kV fluid filled cable installed on the Vector network with all but 3km on the Southern network. These cables were installed between 1964 and 1990 and are generally in very good condition.

All fluid filled cables have their fluid pressure closely monitored via the SCADA system to promptly identify and minimise any fluid leaks. Cables subject to excessive fluid loss are investigated in order to locate the source and repair. In Vector's experience, the majority of leaks are traced back to joint locations and are due to thermo-mechanical movement within the cable or ground movement.

[1] http://vector.co.nz/electricity-disclosures/financial-and-network-information

A systemic issue has been found with thermo-mechanical movements in three core aluminium conductor joints. These core movements can potentially develop into short circuit faults.

Further cable operating (including joints, faults, leaks) information is being compiled for these cables. If for any reason a joint location is being exposed (eg. road realignment, oil leak repair), the joint will be opened to identify any thermo-mechanical movement that may have occurred. If significant core movement has been identified, the joint will be remade.

Minimising fluid loss from these cables thus maintaining their integrity is very important. However, very often due to network security constraints it is difficult to arrange an outage to disconnect the cables from the network for the necessary repairs. In such cases fluid loss is closely monitored/managed so that the cables can remain in service for as long as possible without compromising their integrity and risking electrical failure. Figure 6-1 below shows the sub-transmission cable fluid consumption over the past ten years.

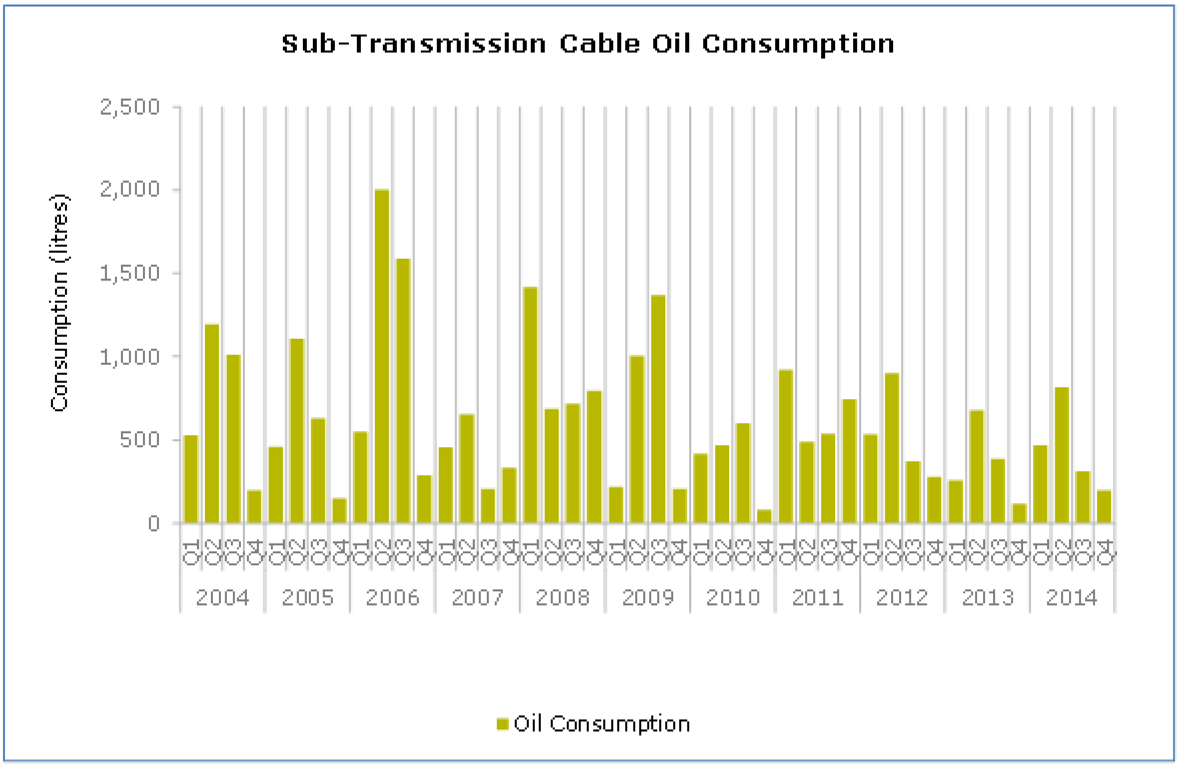

Figure 6-1 : Sub-transmission cable fluid consumption

<u>XLPE Cables</u>

There is approximately 343km of 110kV, 33kV and 22kV XLPE sub-transmission cable installed across Vector's network.

In the Southern network area, XLPE at sub-transmission voltages was introduced in the late 1990's. As an outcome those problems experienced world-wide with treeing in the earlier 1960's and 1970's technology cables have been avoided. Given the very low unassisted fault rates this type of cable is generally believed to be in good condition.

A systemic issue affecting five of the 33kV circuits was incorrectly installed joints. This has caused some joint failures on these cables. All joints on two of these circuits have already been replaced. Due to their locations and the back fill material used the joints in the other circuits have not been replaced. The strategy is to closely monitor and test (when the opportunity arises) these joints and replace them should they fail or their condition deteriorate.

In the Northern network area XLPE construction was implemented from the 1970s onwards. Given the very low unassisted asset failure rate these cables are also believed to be in good condition. The Northern network is predominantly overhead construction. There are many short sections of cable inserted between long runs of overhead lines as requests were made to underground short sections of overhead lines by local residents or developers. These short sections of cable (often no more than 100 metres) are not desirable from a preventive maintenance testing perspective and as such only tested after fault repairs.

The Routine Inspection, Maintenance and Testing Standard ENS-0196 requires serving tests on sub-transmission cable every two years. This requirement however applies only to long continuous cable sections typically those from GXP to zone substations or zone to zone substations.

Gas Filled Cables

There are now only two 22kV circuits of gas-filled cables remaining within the Southern network area, the parallel circuit between Quay and Liverpool zone substations and a Ponsonby to Kingsland circuit. Both of these circuits have now reached the end of their economic life and will be run to failure, as with ample interconnection and use of new technologies, supply to the areas that these cables feed will not be adversely compromised.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's sub-transmission cables and associated cable termination assets are prescribed in Vector's Network Standard ENS-0196 Maintenance of Sub-transmission Cables and Terminations.

In summary ENS-0196 defines the following routine actions:

Weekly

- Patrol of cable routes to detect any works or activities that could affect the integrity or rating of the cables; and
- Gas/oil pressure gauge inspections at sites without remote alarm or remote transducer indication.

Monthly

- Gas pressure gauge inspections at sites with remote alarm but without remote transducer indication.

Six-Monthly

- Gas/oil pressure gauge and transducer functional end to end testing;
- Oil pressure gauge and reservoir pit inspections and servicing; and
- Gas pressure gauge and cylinder kiosk inspections and servicing.

Yearly

- Cable termination, cable sealing end and above ground reservoir inspections, including thermographic survey.

Two-Yearly

- Gas pressure gauge, pressure regulator and safety valve testing;

- Oil pressure gauge and transducer calibration;
- Cross-bonding link box inspections and servicing; and
- Cable serving integrity tests.

Three-Yearly

- 110kV cable termination oil level inspections.

Five-Yearly

- Cable Covering Protection Unit (CCPU or SVL) tests.

In addition, selected circuits are subject to regular partial discharge testing to gain an early indication of any problems.

Refurbishment and Replacement Criteria

The decision and final timing around the replacement of sub-transmission cables is based on test results and/or condition assessments, an evaluation of historical performance and associated repair costs, rating constraints, future capacity requirements and consideration of industry related failure information, more generally a risk and condition based decision.

Cables are sometimes replaced when requested by roading authorities or customers to relocate existing assets.

Replacing these circuits represents a significant investment, however keeping those in operation would pose an unacceptable level of risk to the network.[2] The increasing cost of maintenance and operation of keeping these cables is also another factor for replacing them.

6.4.2 Zone Substation Buildings

Due to historical reasons, Vector's zone substations until circa 2005 were built to two different design philosophies. Based on its predominantly urban environment, substations in the Southern region were generally built to contain primary equipment within enclosed buildings. The Northern region, initially developed largely in a rural environment, applied a more traditional rural approach using outdoor switchyards for sub-transmission equipment and enclosed buildings for distribution switchboards.

Due to these different philosophies, Northern region substations generally occupy twice the land area compared to a similarly configured urban substation. This is more costly and in turn requires more maintenance (activities such as weed control, security fences, tree trimming and lawn mowing are more intensive). Construction in both regions ranges from timber framed, brick, in-situ reinforced concrete, or masonry block construction, now in varied condition and maintenance needs primarily due to age, materials and construction methodology.

For new constructions, although enclosed substation buildings versus outdoor switchyards are typically more costly to build, these costs need to be evaluated against acceptable aesthetics for the surrounding community (the 'built environment'), the significantly increased cost of land in Auckland, reduced maintenance and longer life of equipment, and enhanced site safety and security.

Consequently Vector's current philosophy for new and replacement substations is to enclose all substation equipment regardless of network region.

[2] The requirement for replacing the old 22 kV sub-transmission cables was also identified by Siemens GmbH in an assessment carried out in 2009.

Currently substations are of pre-cast concrete tilt slab, monolithic roofing construction, or monolithic prefabricated buildings. The former typically include power transformer, 33kV and 11kV equipment while the latter are typically for outdoor switchyard replacements, in particular within industrial/commercial zones. Off-site prefabrication is preferred so as to minimise quality and hence timeframe risks. Masonry block is not preferred due to increased site construction timeframes, cost and site risk management.

Both construction types are designed for ease and quickness of construction, low maintenance, safety of personnel, adjoining properties and the public, and achievement of environmental, acoustic, fire, seismic and building requirements. For procurement consistency the civil and structural components use a common design template. Architectural treatment is guided by the local built environment inclusive of appropriate input from Council, Iwi, developers and the local community, and cost considerations.

Vector regularly evaluates the performance and long-term requirements of its more rural aged substations with a view to converting their outdoor switchyards to indoor facilities where it is economically viable to do so.

Asset Condition and Systemic Issues

Substation buildings and switchyard facilities vary in condition from very good to poor. The poorest, while structurally sound, require ongoing refurbishments due to deteriorating doors, window frames, roofs and cladding, or outdoor support structures.

Inspection and Maintenance Approach

The substation building maintenance regime covers safe access/egress and working conditions, substation building structures, fire detection and protection, ventilation systems, environmental control fixtures, grounds, lighting and power, fences, security systems, emergency lighting, and emergency services access.

Maintenance intervals are specified in Vector Standard ENS-0188 and maintenance activities are defined in ENS-0189.

A summary of the standardised frequency for maintenance is given below:

<u>Three-Weekly</u>

- Grounds inspection: ensure perimeter security fencing and gates are free from damage; all locks and chains are sound and site signage is correct. Structural integrity and cleanliness of external walls, doors and windows, all drains and plumbing; and
- Vegetation service: site vegetation has adequate building, switchyard, and security fence clearance; tree pruning where necessary; edges and lawns mown and trimmed were required; rubbish and vegetation trimmings are removed; unintended plants, and weeds or mould removed from driveways, equipment yards and buildings.

<u>Monthly</u>

- Building compliance assessment.

<u>Two-Monthly</u>

- Electrical assets visual inspection, and
- Building services visual inspection and condition assessment: telephone and radio are operational; spill kits and first-aid kits fully stocked; extinguishers compliant; rubbish removed; structural integrity and cleanliness of internal walls, doors and windows; drains, plumbing, sump pumps and alarms functioning as required. Test

operation of substation lighting and emergency lighting, smoke detectors, intrusion alarms, electric fences and fire alarms. Test operation of radiant heaters, air conditioning and building air pressurisation systems where fitted, and replace filters where required. Ensure trench covers are secure, and buildings, trenches, cable ducts are sealed from water, bird and vermin ingress. Restock consumables.

Yearly

- Alarm testing and compliance; ensure correct operation of fire alarms, intrusion alarms and crisis alarms where fitted, clean and test smoke detectors; and
- Building warrant of fitness compliance and certification.

Refurbishment and Replacement Criteria

Vector's ongoing risk based cost-benefit assessments for substation facilities replacement also consider any co-incident need for primary plant replacement, and vice versa.

Seismic Upgrades

Local authorities are empowered to enforce the seismic compliance rules of the Building Act 2004. Under the Act, Auckland Council policy requires assessments be made and reported to Council by building owners to verify certain structures seismic performance. The Council policy requires compliance with the provisions of the Building Act ten years from when Council have made their own determinations.

The Building Act defines a "Seismically Prone Building" as one that does not meet the requirements of 1/3 of the current Earthquake provisions in NZS1170. The New Zealand Society of Earthquake Engineering (NZSEE) has published a document "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes dated June 2006." This document provides a means of determining the likely level of seismic compliance that a building may have. It includes factors such as the importance of the building and likely impact of failure of the structure on the public.

Vector has adopted a minimum criterion of 2/3 of the earthquake provisions in NZS1170. For sites unable to meet a 2/3 criterion it becomes cost effective to rebuild and gain 100% rating.

In 2010 Vector engaged a structural engineer to produce an initial evaluation of performance on all pre-1976 constructed buildings, plus a number of buildings whose age was uncertain or the construction type or asset criticality warranted investigation. Overall, 71 sites were assessed and it was recommended that 48 required remediation or detailed assessment by a suitably experienced structural design consultant.

Detailed assessments have shown 15 sites required remediation. Of these, several buildings have been rebuilt due to Vector's switchgear replacement programme. For FY17 three remaining sites will be completed: Northcote, Mangere Central and The Drive.

- In particular, The Drive has a Heritage listing disallowing a like-for-like replacement, is of brick construction needing major reinforcement, and its indoor switchgear is due for replacement. Since the overall cost is similar, rather than a 2/3 strengthening of the building, the likely option will be a new switch room at the same site co-incident with the switchgear replacement programme, and a 1/3 NZS1170 compliant reinforcement of the existing building.

Vector continues to advise Council of its zone substation building seismic reinforcement compliance progress. Reinforcement works have cost in the order of $600k and $200k per annum respectively for the Northern and Southern network regions, from a predicted annual expenditure of $1M per region. Reinforcements will be completed well within the required 10 years.

6.4.3 Zone Substation Switchboards and Circuit Breakers

The Vector network comprises sub-transmission operating at voltage levels of 110kV, 33kV, and 22kV and distribution operations at 22kV and 11kV.

Substation class primary circuit breakers (CBs) and switchboards deployed to operate at these voltage levels are installed inside purpose built buildings or in outdoor switchyards enclosed by security fencing, or both (This class of equipment does not include distribution switchgear). All zone substation CBs and switchgear have protection relays to control their operation and are monitored by the Network Operations group (control centre) via the SCADA system.

Vector's zone substation switchboards and circuit breaker asset comprises oil, compound, SF_6 and resin insulated equipment of varying age and manufacturer. The arc-quenching media used in this equipment include oil, SF_6 and vacuum. The majority of the switchgear is 11kV rated followed by 33kV, 22kV and 110kV. This generally corresponds to the network topology in that the higher the system voltage the fewer the number of devices there are on the network.

The CBs on the Vector electricity network range from new to over 50 years of age. Further, the CBs consist of a mix of technologies corresponding to the relative age of the equipment. The oil type circuit breakers (OCB) are the oldest on the network followed by SF6 and vacuum type. Note that CB type as mentioned here refers to the arc quenching technology incorporated and not the insulation medium.

Vector Assets Installed at Transpower GXPs

Vector owns the 33kV feeder circuit breakers at Wellsford GXP, Albany GXP, Hepburn Road GXP (except for the two Rosebank feeders) and Henderson GXP. These circuit breakers were purchased from Transpower in 1992 by the then Waitemata Electric Power Board (WEPB). Vector has responsibility for their maintenance and operations.

Asset Condition and Systemic Issues

The SF_6 and Vacuum CBs are the newest in the network (SF_6 breakers are older than the vacuum breakers in the MV class as they were developed ahead of reliable vacuum interrupters). The Switchboards with vacuum interrupters are in good condition and pose a manageable risk to the network due to modern manufacturing technologies, higher design specifications and compliance with the latest international equipment standards. A catastrophic failure in this class of equipment is often restricted to the immediate panel, minimising collateral damage in the affected area.

The SF_6 CBs pose some environmental risk due to the gas they contain. However, the equipment is designed to be sealed for life and there are gas recovery techniques in the event the equipment requires service. Under normal operating conditions, experience shows only a catastrophic failure of the tank or seals would result in the expelling of gas – a very low probability event.

The oil type CBs are approaching the end of their design life which vary anywhere from 25 to 55 years of age. Underrating, failures, mal-operation and lack of spare parts continue to be of concern for this aged equipment. This class of equipment often poses a risk in the event of a catastrophic failure. When OCB's fail it can result in fire, explosion and irreparable collateral damage to adjoining or nearby apparatus.

To address these risks, Vector has embarked on a programme to replace the old oil-filled switchgear with modern SF6 insulated fixed pattern equipment compliant to IEC 62271-1.

The oldest technology CBs and switchboards are showing signs of rust, leaking compound and oil, metal fatigue and age related operational concerns. Other apparatus have been shown to have high maintenance requirements or latent defects resulting in earlier than expected replacement and repair programmes.

More modern switchboards with air insulated bus bars and vacuum circuit breakers have proven to be less problematic, as expected with more modern manufacturing techniques and higher equipment specifications. The metal clad portions, comprising powder coated galvanised steel and stainless steel, are not expected to show the same signs of metal fatigue as apparatus that was produced even up to the late 1980's.

New indoor switchboards and outdoor CBs installed by Vector since 2005 are of maintenance free design where end of life is determined by lifetime fault interruption and switching operations and not traditional time-based estimations. IEC Specification 62271-1 has both electrical and mechanical endurance classifications as part of the standard. Vector equipment complying with this standard is classed E2 and M2 which equates to extended electrical and mechanical endurance respectively. For a majority of manufacturer products the mechanism is rated for 10,000+ operations and interrupter life of 100 full fault rated operations.

Vector's numerical protection relays deployed on its switchboards complying with IEC-61850 protocol can be used to determine contact wear to indicate when the switchgear is nearing the end of its operational design life. This information will be used in future asset replacement programmes for switchgear of this type.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's sub-transmission switchboard assets are prescribed in Vector's Network Standards:

- ENS-0049 Maintenance of Substation Circuit Breakers and Switchboards
- ENS-0199 Maintenance of Fixed Pattern Switchboards and Circuit breakers 11kV to 33kV
- ENS-0223 Maintenance of indoor 110kV GIS switchboards

In the next year, these standards will be re mapped to new standards as below;

- ESM101-Primary Switchgear – Fixed Pattern
- ESM102-Primary Switchgear -110kV GIS
- ESM103-Primary Switchgear Indoor Conventional
- ESM104-Primary Switchgear Outdoor

New equipment purchased under Vector specifications complying with IEC 62271-1 are virtually maintenance free, fit for life designs. Such equipment requires little maintenance activity outside of thermographic survey, PD monitoring and the occasional cleaning of the cabinetry. Existing stations, largely equipped with conventional withdrawable OCB and vacuum circuit breakers (VCBs), will continue to be monitored and maintained on a time, fault and condition basis.

- In summary ENS-0049 defines the following routine actions:

<u>Two-Monthly</u>

- Visual inspection of both switchboard and breakers; of particular interest signs of excessive heating, unusual discoloration, compound leaks, correct operation of indication lamps, relay flags reset, all appropriate breakers set remote, secondary cabinet heaters, thermostats and lights working, SF_6 gauge pressures within acceptable limits, oil sight levels and gauges within acceptable limits, all earthing connections intact.

Yearly

- Thermographic inspection.

Two-Yearly

- Acoustic partial discharge inspection; and
- Trip and close timing tests; perform as found/as serviced trip/close operation test, taking accurate time measurement of trip coil current and supply voltage or time measurement of trip coil voltage.

Four-Yearly

- Outdoor OCB maintenance service, general visual and mechanical inspection, clean external tank, clean bushings, perform as found/as left insulation resistance measurement, check heater operation, clean internal tank, perform as found/as left contact resistance measurements, clean contacts, contact travel and sync assessment, arc-control devices clean, isolating contacts clean and lubricate, trip/close mechanisms clean and lubricate, interlocks and indicators functional, control relays or contactors clean, insulating oil replacement, operational cycle checks.

Eight-Yearly

- Indoor OCB maintenance service, general visual and mechanical inspection, bushing clean, insulation resistance as found/as left testing, check heater function, internal tank clean, contact resistance as found/as left, clean contacts, arc-control devices clean, isolating contacts clean and lubricate, trip/close mechanisms clean and lubricate, interlocks and indicators functional, control relays or contactors clean, insulating oil replacement, operational cycle checks; and
- Outdoor vacuum/SF_6 CB maintenance service, general visual inspection, external tank clean, bushing clean, insulation resistance as found/as left testing, check heater function, internal tank clean, contact resistance as found/as left, clean contacts, arc-control devices clean, isolating contacts clean and lubricate, trip/close mechanisms clean and lubricate, interlocks and indicators functional, control relays or contactors clean, operational cycle checks.
-

Twelve-Yearly

- Indoor vacuum/SF_6 CB maintenance service.

Sixteen-Yearly

- Switchboard maintenance service, general visual inspection, clean all cubicles, panels and cabinets, clean de-energised spouts and bushings, perform as found/as serviced insulation resistance measurements.

Refurbishment and Replacement Criteria

- Repair of identified defects are programmed for remediation at a convenient time based on operational importance;
- Trip times measured must be within ten percent of previous test results, or satisfactory operation will occur at 70% of rated trip coil voltage. Trip times and spread must be within manufacturer’s specified tolerance; and

- Any pole contact resistance value must be within 25 percent of remaining pole contact resistance measurements.

Further diagnostic or corrective maintenance service work is triggered on:

- Identified thermal hotspots greater than ten degrees above surroundings;
- Levels of acoustic discharge, significantly above background noise;
- Levels of PD, significantly above background noise; and
- The prescribed maintenance service can be bought forward at any stage based on fault operations and fault magnitude.

Through this process of maintenance activities and testing, various CB types have been included in Vector's asset replacement programme. Assets such as indoor 11kV English Electric, Brush and Southwales switchboards and outdoor 33kV Reyrolle, English Electric, Takaoka and Nissin Bulk oil circuit breakers (BOCB) have been identified as the next priority replacements.

Despite new switchboards being either SF6 or vacuum, the risk due to the aging of the existing population of OCBs on the Vector network is increasing. Some manufacturers (Reyrolle for example) have vacuum retrofit CBs available that can be installed to replace the OCBs. Such retrofits may not lower the incidence of sudden failure due to associated apparatus age and lifetime fatigue, but removing the oil will significantly reduce the collateral damage that can potentially be caused by catastrophic failure.

Vector has adopted a program of identifying Reyrolle switchboards suitable for retrofit vacuum circuit breaker replacement and have extended this program to include the fitment arc proof explosion doors with behind closed door racking capability.

All Reyrolle Switchboards so identified will be fitted with type tested arc and explosion proof doors with closed door racking mechanism followed by a program of staged OCB to VCB replacement. This will provide a significant increase in the safety and operation of this type of equipment. Retrofitting of arc proof door to identified switchboards will be completed in FY16.

Some switchboards are, however, of an age and design that makes retrofitting a non-viable option and need to be replaced in their entirety. These switchboards and CBs have been identified and prioritised for replacement.

6.4.4 Zone Substation Transformers

Sub-transmission transformers are also known as power transformers. These transformers are used to transform significant amounts of electrical power from the sub-transmission network voltages to the distribution network voltages.

In Vector's case power transformers step sub-transmission voltage levels from 110kV down to either 33kV or 22kV. These voltage levels are then stepped down further from 33kV to medium voltage distribution 22kV or 11kV. The two Lichfield power transformers step grid voltage at 110kV down to 11kV medium voltage for distribution.

Vector owns 214 sub-transmission transformers, including two at Lichfield which is outside of Vector's main supply network in Auckland. Transformer sizes range in rating from 5MVA to 75MVA. The majority are fitted with on-load tap-changers.

The engineering design life of a power transformer is about 30 to 40 years. However, provided a unit is not subject to excessive loading or high winding temperatures and is well maintained, this life can often be economically extended beyond 60 years.

The majority of Vector's power transformers are operating at the lower end of the permissible winding temperature range. Therefore, an extended operating life for most units can be expected. Transformer specifications have varied over the years from the very early versions of BS 171 (British Standard) to the latest AS 2374 (Australian Standard) which means different thermal and loading guides have been used. Vector's standard for operating temperatures has established three operating temperatures that should never be exceeded:

Top oil temperature	105°C
Conductor hot-spot temperature	125°C
Metallic part temperature	135°C

To take into account the different transformer designs and operating conditions, oil and winding temperature trips are assigned based on the year of manufacture, and knowledge of and comfort with, the cooling systems.

Asset Condition and Systemic Issues

Vector's transformers are in good condition overall but there are a small number where the degree of polymerisation (DP) tests would indicate these transformers are approaching the end of their useful life.

The DP test results for the proposed units indicate a weakness in the winding insulation strength resulting in a risk that a close in fault may cause a complete loss of the transformer.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's sub-transmission transformer assets are prescribed in Vector's Network Standard ENS-0193 Maintenance of Zone Substation Transformers.

In summary ENS-0193 defines the following routine actions:

<u>Two-Monthly</u>

- Visual inspections encompassing tap change mechanism tank, main tank, conservator tank, bushings and insulators, buchholz and pressure relief devices, radiators, heat exchangers, ancillary coolant pumps and motors, instrument and marshalling cubicles, oil and winding temperature gauges, earthing installation, seismic and foundation mounts.

<u>Yearly</u>

- Transformer oil condition sample, transformer condition assessment (TCA) provided by TJ|H2b Analytical Services[3], covering dissolved gas analysis (DGA), water content, breakdown voltage, acidity;
- Tap changer oil condition sample for oil insulated contacts, tap changer activity signature analysis (TASA) provided by TJ|H2b covering dissolved gas analysis (DGA), particle counts, water content and breakdown voltage; and
- Thermographic inspection.

<u>Two-Yearly</u>

- Acoustic partial discharge inspection.

<u>Three-Yearly</u>

- Transformer oil condition sample, transformer condition assessment (TCA) provided by TJ|H2b covering dissolved gas analysis (DGA), particle counts, water

[3] TJ|H2b Analytical Services is an independent laboratory service that specializes in the diagnostic testing of oil, gas and other insulating materials used in transformers, tap-changers and circuit breakers.

content, breakdown voltage, acidity, interfacial tension, oil colour, dielectric dissipation factor, oxidation inhibitor, furan analysis and estimated degree of polymerisation (DP).

Four-Yearly

- Tap changer oil condition sample for vacuum insulated contacts, tap changer activity signature analysis (TASA) provided by TJ|H2b covering dissolved gas analysis (DGA), particle counts, water content and breakdown voltage.

Refurbishment and Replacement Criteria

In development of the 10 year sub-transmission transformer replacement programme, analysis of circuit parameters, including the historical maintenance history, historical fault performance, associated costs, historical network reliability impact and risk profiles, have led to the identification of several transformers due for replacement.

All intrusive maintenance activity on transformers, including that on the on-load tap changer, is purely condition driven.

Further diagnostic or corrective maintenance activities are triggered as a result of inspection or testing, based on:

- The oil analysis condition code together with TJ|H2b Analytical Services' recommendations;
- Identified thermal hotspots greater than ten degrees above surroundings;
- Levels of acoustic discharge, significantly above background noise; and
- Levels of partial discharge, significantly above background noise.

Diagnostic testing may require:

- Transformer winding resistance/impedance/insulation resistance/ratio testing, core insulation resistance testing, auxiliary wiring and CT insulation resistance testing, magnetising inrush current testing, bushing and winding insulation power factor and dielectric loss testing.

Maintenance servicing may require:

- Internal tap changer inspection and service;
- Desiccant replacement;
- Bushing clean and re-grease; and
- Bearing and lubricant service of fans, motors and coolant pumps.
- Modern transformer management systems are self-monitoring and visual inspection is carried out in accordance with Vector Standards with a frequency of four-yearly inspections.
  Systemic issues with our programmable logic controller (PLC) based systems is on the increase. In addition a large percentage of the installed base is still electromechanical type devices and falls into the age category of > 32 years.
- These devices are not supported by the supplier or in most cases the supplier does not exist anymore. Spares availability is non-existent and we are reliant on recovered equipment from decommissioned systems to be used as spares.
- A replacement program is underway to replace PLC based systems and where possible replacements will be aligned with transformer related projects

If off-site refurbishment is deemed necessary this is performed in accordance with Vector's Network Transformer Refurbishment Standard ENS-0164.

While the requirement for replacing sub-transmission transformers is based primarily on analysis of the condition and fault data that is currently available, the decisions are supported by the experience and observations of Vector's asset specialists. The priority order of replacement is based on indicative condition and failure rates, coordination with network growth and reinforcement projects, expenditure requirements and project delivery capability. The proposed replacement order may change as more test information comes to hand.

6.4.5 Zone Substation DC Supply and Auxiliaries

Substation direct current (DC) auxiliary power systems provide supply to the substation protection, automation, communication, control and metering systems, including power supply to the primary equipment motor driven mechanisms. Vector's standard DC auxiliary systems consist of a dual string of 'mono-block' lead-acid batteries, battery charger, dc/dc converters and a battery monitoring system. The major substations are equipped with a redundant dc auxiliary system.

Battery monitoring is an essential process for security of supply, ensuring battery systems continue to have the capacity to operate equipment during a supply outage and to enable restoration of supply once any contingency has been rectified. Vector is continuing to implement online battery monitoring in its substations. The intention is to in future reduce the requirement for onsite maintenance and inspections.

Asset Condition and Systemic Issues

The DC systems are in a good state. All zone substations have current industry standard valve regulated lead acid (VRLA) battery types.

Batteries have a supplier specified design life of 10 years. A programme is in place to ensure zone substations do not exceed this age cap, with battery replacements prioritised by performance criterion of impedance results monitored on-line and industry standard two-yearly on-site discharge tests.

Inspection and Maintenance Approach

Maintenance for batteries is based on Vector ENS-4005 - Maintenance of DC Systems and the recommendations of IEEE–1188 (IEEE Recommended Practice for Maintenance, Testing and Replacement of VRLA Batteries for Stationary Applications).

Battery condition is assessed using monthly on-line monitoring of battery temperature, voltage and impedance, and two-yearly discharge testing.

Refurbishment and Replacement Criteria

Due to the criticality of the DC auxiliary systems, refurbishment is not applicable for batteries or dc-dc convertors: they are replaced. Similarly battery chargers that are no longer supported by the vendor are replaced using a run-to-failure approach.

Replacement of batteries is based on Vector ENS-4005 Maintenance of DC Systems and the recommendations of IEEE–1188 (IEEE Recommended Practice for Maintenance, Testing and Replacement of VRLA Batteries for Stationary Applications). Tesla battery packs will be considered for future zone substation dc system deployment.

6.4.6 Load Control Systems

Vector's uses audio control frequency ripple control plants, pilot wire system and cycle control plant to control:

- Residential hot water cylinders for peak load shedding;
- Street lighting on behalf of Auckland Transport;

Emerging technologies, notably smart meters and/or intelligent home energy control devices, are likely to supersede existing load control systems in the near-term. Vector's intention is to maintain existing systems during any transitional phase.

Investment decisions will be co-ordinated with Auckland Transport's street lighting luminaire upgrade programme and deployment of their own control systems within the next five years.

The current load control system operates by an on-off control signal generated at each zone substation that then operates the street lights or hot water loads along the feeders radiating from that substation.

In particular, a fault within the overhead pilot wire system peculiar to the Northern region will also lose power to connected street lighting or hot water load after that fault, which can affect large customer areas for long periods.

Vector Assets Installed at Transpower GXPs

Vector's ripple injection plants in the Southern region are connected to its sub-transmission network. For zone substations connected to a Transpower GXP the ripple injection plants are located at the respective GXP. For zone substations supplied from a Vector bulk supply substation, the ripple injection plants are located at the respective bulk supply substation. Ripple injection plants in the Northern region are 11kV rated and are located within the zone substations.

Asset Condition and Systemic Issues

The Northern network pilot wire system is in very poor condition and beyond its economic service life. To minimise customer disruption, interim measures have been implemented to protect customers from loss of service due to failures arising from the system. These interim measures have however rendered large parts of the system unable to control the connected load. Similarly other the ripple and cyclo plant in the Northern network is not currently in operation. Vector is currently preparing an exit strategy from the current technologies and will consult with affected parties (retailers and meter providers) as part of this process.

The Southern network ripple injection plant remains operational for load control, being offered into the NZ Energy Market for transmission peak management. The equipment is reaching the end of its economic life.

Inspection and Maintenance Approach

For pilot wire this is prescribed in ENI-0090 Hot Water Pilot Network - Bridging the Pilot Service Fuse, and Vector's Network Standard ENS-0187 Overhead Network Condition Assessment.

For ripple injection plant maintenance is undertaken at OEM recommended intervals.

Refurbishment and Replacement Criteria

For pilot wire this is prescribed in Vector's Network Standard ENS-0187 Overhead Network Condition Assessment.

- HW pilot wire is not replaced where it is proven that all customers are connected to mains power.
- Streetlight pilot wire is not replaced where it is proven that Auckland Transport has taken over control of their street lighting connected to mains supply.

For ripple injection plant maintenance is undertaken at OEM recommended intervals.

6.4.7 Overhead Lines

Vector's Southern network area consists of overhead conductors operating at sub-transmission voltage levels of 33kV, distribution medium voltage levels of 22kV and 11kV and distribution low voltage levels at 400V and 230V.

Vector's Northern network area operates overhead conductors at sub-transmission voltage levels of 110kV and 33KV, distribution medium voltage at 11kV and distribution low voltage levels at 400V and 230V.

The overhead conductor types and sizes vary across the overhead network and comprise copper (Cu), all aluminium conductors (AAC), aluminium conductor steel reinforced (ACSR) conductors and all aluminium alloy conductors (AAAC).

Low voltage aerial bundle conductors (LVABC) and covered conductor thick (CCT) for 11kV lines are used in areas susceptible to tree damage. There is a small section of high voltage aerial bundle conductor (HVABC) which was installed about 15 years ago.

Asset Condition and Systemic Issues

The condition of most conductors is good. However, there are areas reticulated with small sized copper and ACSR conductors which have reached the end of their life. These are replaced when identified.

Early preformed conductor ties used a rubber cushioning packer that has a tendency to perish. In the past this has been a cause of TV interference though as yet the impact of the switch from VHF to UHF broadcast is not known. These are being replaced as they fail.

Kidney type insulators are prone to failure and have been a common source of TV interference, though as above the impact of the transition from VHF to UHF broadcast is unknown. The use of kidney insulators has been superseded by ceramic and glass disc and polymer strain insulators.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's overhead conductor are prescribed in Vector's Network Standard ENS-0187 Overhead Network Condition Assessment. A summary of ENS-0187 is given as follows, and applies to all overhead conductors regardless of type, size and operating voltage:

<u>Yearly</u>

- Visual inspection of ground clearances measured for adequate clearance, conductor separation and proximity to structures visually assessed for adequate clearance, adequate clearance from vegetation, spans checked for balanced sags, conductors free from broken strands, corrosion and clash burn marks, CCT high voltage conductors free from insulation damage and joints in conductors are visually secure and not showing signs of overheating.

Refurbishment and Replacement Criteria

The remaining serviceable life of conductors is difficult to predict because it is dependent upon several factors. These are the conductor material, natural environment, public exposure, access, mechanical loads, electrical loads and number and magnitude of downstream electrical faults.

Conductors are not refurbished but recovered conductors in good condition may be reused. Conductors are repaired or replaced when they fail, in line with industry practice.

6.4.8 Overhead Structures

Vector's Southern network area consists of overhead structures supporting sub-transmission voltage levels of 33kV, a minor amount of 22kV distribution medium voltage, predominantly distribution medium voltage of 11kV and distribution low voltage levels at 400V and 230V.

Vector's Northern network area operates an overhead sub-transmission network with voltage levels of 110kV and 33KV, distribution medium voltage at 11kV and distribution low voltage levels at 400V and 230V.

New Vector poles are concrete, with the exception of a very small number where specific conditions (such as requirements for resource consent, or to access difficult locations) dictate otherwise. For these exceptions, Fibreglass sand polymer, Copper Chromium Arsenic (CCA) treated softwood or steel poles are used. Older wood poles are either hardwood or creosote treated softwoods.

Historical asset information obtained from the Vector GIS for the Southern region, in particular age information is deficient due to historical legacy issues.

Asset Condition and Systemic Issues

Due to legacy/historical issues related to data collection and recording, pole age and condition information is not sufficiently accurate for reliable detailed replacement profiles to be prepared at this stage. Following Vector's current programme to update historical asset performance information this situation is expected to improve.

Some number 1 vierendeel poles have failed through corrosion of the steel reinforcing at the steel strand spacer block interface near the base of the pole. This is not easily detected through visual inspection and as a consequence whenever a number 1 pole is likely to experience a loading change caused by work on that pole, it is to be replaced. Work is underway on an external bracing system that will reinstate the lost strength at the spacer block interface. If successful this will remove the need to replace many of these poles.

Ground inspections of the 110 kV circuits have identified 3 hardwood poles as requiring replacement because of strength considerations.

There are 102 steel towers in the Northern region. These were originally installed by the State Hydro Electricity Department and although most are more than 80 years old, they are mainly in good condition and a detailed inspection is to be carried out in the near future.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's overhead structures are prescribed in Vector's Network Standard ENS-0057 Pole Inspection and Replacement and Standard ENS-0187 Overhead Network Condition Assessment.

In summary ENS-0187 and ENS-0057 define the following routine actions:

<u>Yearly</u>

- Ground based visual inspection of each pole and tower, conductors, insulators, binders and associated steel work, conductor and stay wire, preforms, crossarms, crossarm straps and braces, transformer platforms, bolts, connectors, fault passage indicators, stays and anchors, surge arrestors, pole mounted transformers, pole mounted capacitors, gas and ABSs, reclosers, sectionalisers, low voltage (LV) fuses, high voltage (HV) fuses, cable risers and other steel works.

Five-Yearly

- Wooden pole strength versus load assessment, ground based visual inspection, ultrasonic strength assessment, calculation of remaining pole strength, including site reinstatement. Any pole not meeting serviceability requirements in accordance with AS/NZS 7000 and HB 331-212 is tagged and programmed for repair or replacement.

Ten-Yearly

- Concrete pole strength versus load assessment. Any pole not meeting serviceability requirements in accordance with AS/NZS 7000 and HB 331-212 is tagged and programmed for repair or replacement.

Refurbishment and Replacement Criteria

The remaining life of a pole is difficult to predict accurately because it is dependent upon several factors. These include the pole material and construction procedures at the time, natural environment, public exposure, access and the load that is being supported.

Predicted pole replacement expenditure is based on a combination of the available asset records and an assumption that the performance of poles will be largely similar to that observed over the last five years. Following an improvement in Vector's Pole Inspection Standard (ENS-0057) implemented in 2010, a moderate reduction in future replacement needs is predicted.

Poles identified as problematic during the inspection and test programme may be repaired on site or replaced depending upon their condition. Poles inspected that require attention are tagged according to their as-found condition, in accordance with Vector Inspection and Replacement Standard ENS-0057:

Blue Tag

- Overhead line structures found to be at risk of failing to support normal or design loads, and where engineering cannot be performed on site at the time of finding the suspect structure, shall be fitted with a blue tag. A full inspection and engineering shall be completed within ten working days of the structure being believed to be in a suspect condition.

Yellow Tag

- Overhead line structures found to be incapable of supporting design loads must be marked with a yellow tag and repaired or replaced within 12 months of identification.

Red Tag

- Overhead line structures found to be at risk of failure under normal loads, or with the risk of injury to any person or damage to any property, must be marked with a red tag and repaired or replaced not later than three months after the discovery of the risk of failure.

6.4.9 Overhead Switchgear

Overhead switches include MV air break switches (ABS), isolating links, SF_6 switches, reclosers and sectionalisers. These devices are installed to enhance network operation, allow remote switching (in some instances), reduce the impact of faults and the extent of outages and enhance reliability performance.

Asset Condition and Systemic Issues

Age profiles for 11 kV and 33 kV ABS and enclosed overhead switches installed in the Northern and Southern networks suffer from insufficient data. For legacy reasons, historical records are not completely accurate. This has meant the age profiles are artificially skewed and do not necessarily represent assets at the end of their useful lives. The average age of removed ABSs has been between 20 and 25 years but, as noted, this cannot be used as a reasonable proxy for the expected end of life age for an ABS or of average age of the assets.

Most ABSs are more than 20 years old and are in good to fair condition, while a small number are only a few years old and are in excellent condition. The vast majority of the SF_6 switches are less than ten years old and are in good condition.

The reclosers are a mixture of vacuum or SF_6 insulated equipment with a small number of older oil-filled units. The older oil-filled reclosers are in good condition and the SF_6 and vacuum reclosers and sectionalisers are in excellent condition.

Vector is not experiencing any systemic operational problems with its overhead switches.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's overhead switchgear are prescribed in Vector's Network Standard ENS-0055 Maintenance of Overhead Switches and ENS-0187 Overhead Network Condition Assessment.

In summary ENS-0055 and ENS-00187 define the following routine actions:

<u>Yearly</u>

- Visual inspection of the operating handle and mechanism alignment, support framework securely attached, extent of corrosion, secure electrical connections (including earthing), control boxes functional, SF_6 gauges operational and pressure within acceptable levels;
- Sectionaliser, functional operation testing, local and remote operation; and
- Recloser, functional operation testing, local and remote operation.

<u>Three-Yearly</u>

- Air break switch maintenance service, functional operation testing, bucket based visual inspection, contacts cleaned, dressed and lubricated, operating mechanisms bearings and pivots lubricated, contacts adjusted for correct alignment and operation; and
- Thermographic inspection.

<u>Five-Yearly</u>

- Earth system visual inspection and remote earth testing of overall earthing system resistance, each earth bank resistance, and step and touch voltage measurement. Marginally non-compliant sites require step and touch voltage retesting using off-frequency injection current.

<u>Nine-Yearly</u>

- Gas break switch/sectionaliser maintenance service, functional operation testing, bucket based visual inspection, extent of corrosion, secure electrical connections, SF_6 gauges operational and pressure within acceptable levels, sound earth connections, correct site signage, and attachment bracket condition; and

- Recloser maintenance service, functional operation testing, bucket based visual inspection, extent of corrosion, secure electrical connections, SF_6 gauges operational and pressure within acceptable levels, sound earth connections, correct site signage, arrestor function and attachment bracket condition.

Refurbishment and Replacement Criteria

ABSs are maintained when tested. There is no proactive replacement programme for ABSs and they are replaced when they are no longer serviceable.

The gas switches are fully enclosed and have lower maintenance requirements than ABSs. They are expected to have a life of about 40 years though a number have had issues with loss of gas. Faulty gas switches are returned to the supplier. Gas switches are also installed when system reliability issues call for a remotely operable switch.

The remaining life of an ABS is difficult to predict because it is dependent upon several factors. Typically these are the natural environment, public access, electrical loads and number and magnitude of downstream electrical faults experienced over the life of the asset.

Predicted replacement expenditure is based on the assumption the current base replacement rates will increase over the next ten years, to allow for additional switches installed to improve reliability.

6.4.10 Overhead Hardware - Crossarms

Vector's Southern network area consists of crossarms supporting sub-transmission voltage levels of 33kV, a small amount of 22kV distribution medium voltage, predominantly distribution medium voltage of 11kV, and distribution low voltage levels at 400V and 230V.

Vector's Northern network area consists of crossarms supporting sub-transmission voltage levels of 110kV and 33KV, distribution medium voltage at 11kV and distribution low voltage levels at 400V and 230V.

Asset Condition and Systemic Issues

The crossarms in operation across the network are almost entirely hardwood (99%) and their condition ranges from poor to good. Vector also has a small number of steel crossarms that are in good condition and fibreglass crossarms that are in excellent condition.

Crossarms installed in the 1990s were durability class 3 and are regarded as having a life of about 20 years. This is unlike the older crossarms which were more durable and were regarded as being capable of up to 40 years of service. Only durability class 1 crossarms (longer life) are now installed on the network.

Vector has extremely limited information on the age profiles of crossarms on the network. This is partly as a result of the manner in which assets were categorised under the previous ODV valuations, where pole-top structures were not separately identified.

Inspection and Maintenance Approach

The routine inspection and maintenance requirements for Vector's crossarms are prescribed in Vector's Network Standard ENS-0187 Overhead Network Condition Assessment. There are no routine testing requirements for crossarms.

A summary of ENS-0187 specific to crossarms is as follows:

Yearly

- Visual inspection of hardwood crossarms and transformer platforms free from rot, significant cracks or splits, deformation and signs of burning. Steel crossarms are free from obvious rust and general deformation. Laminated pine crossarms are free from signs of de-lamination, fibre glass arms are free from signs of de-lamination or failure of the outer epoxy coating and double arms are constructed with spacer pipes, internally nutted bolts or eyebolts, or spacer blocks.

Refurbishment and Replacement Criteria

The remaining life of a crossarm is difficult to predict because it is dependent upon several factors other than age. These are typically the timber species used, pre-installation seasoning, natural environment and the load being supported. Forecast replacement expenditure is based on the assumption crossarms will continue to be replaced at the present run rate, as discovered during the annual overhead network inspection.

6.4.11 Distribution Transformers

In Vector's distribution network, there are 2 different operating voltages – 11kV and 22kV. The 22kV distribution network covers the Auckland CBD and Highbrook Business Park, while the remainder of the distribution network operates at 11kV.

Distribution transformers convert distribution voltage levels (22kV and 11kV) to customer voltage levels (typically 400V three phase or 230V single phase). The units are generally constructed with an off-load tap changer which enables the LV output to be raised or lowered depending on system requirements.

For the majority of distribution transformers currently in service, the windings, insulated with paper insulation, are contained in a tank of mineral insulating oil. For a very small number of transformers the windings are contained in a tank of synthetic organic ester. These transformers are used in situations where fire safety or protection of the environment (where other containment measures are not practical) are primary considerations.

New transformers are supplied in compliance with Vector's Standard ENS-0093. The 11kV/415V distribution transformers are generally rated between 15kVA and 1,500kVA. All the transformers in that range are three phase. The three phase transformer windings are connected delta/star in accordance with the vector group reference Dyn11. There are also a small number of single phase transformers rated at 1.5kVA, 5kVA, 7.5kVA, 10kVA, 15kVA, 30kVA and 50kVA.

The 22kV/415V distribution transformers are three phase and are rated between 300kVA and 1,000kVA. The transformer windings are connected delta/zigzag in accordance with vector group reference Dzn2.

Transformers are either ground or pole mounted. The ground mounted transformers can be further categorised into the following types

- Industrial type: both HV and LV termination bushing flags and the cable connections are fully enclosed inside separate HV and LV cable boxes, but the HV and LV cables entering into the cable boxes are exposed;
- Cubicle type: the transformer has dedicated HV and LV compartments in which both the termination bushing flags, cable connections and the cables are completely contained inside these compartments;

- Package type: ALL termination bushing flags, cables connections and cables are fully exposed. Shrouds and covers can be applied to shield the exposed live parts.

The majority of 11kV ground mounted transformers are connected to the MV and LV networks by cable lugs and bolted connections to the transformer bushing flags. They are installed either as a stand-alone unit, or as a part of a compact distribution substation which includes not only the transformer, but also the MV and LV switchgears enclosed in metallic or fibreglass canopies, or in a building.

There are 2 different types of cable connections to the HV bushing flags for the cubicle style transformers. For the 22kV/415V distribution transformers, the cables are connected to the HV side of the transformer by dead-break screened plug-in cable connectors. For the 11kV/415V distribution transformers, the cables are connected to the HV side of the transformer by cable lugs and bolted connections. Cable connections to the LV bushing flags of all cubicle style transformers are through cable lugs and bolted connections.

Pole mounted transformers are installed on single or double poles. The transformers are connected to the HV and LV networks by cable lugs and bolted connections to the transformer bushing flags.

In addition to the standard distribution transformers, Vector owns two ground mounted auto transformers and one phase shifting transformer on Vector's network. All are installed on the Southern network. One auto transformer is 11kV/6.6kV and the other is 22kV/11kV. Both were manufactured by ABB.

- The 11kV/6.6kV 750kVA auto transformer is used at MOTAT in Western Springs as a connection between Vector's 11kV network and MOTAT's 6.6kV network that supplies the rectifiers for their trams;
- The 22kV/11kV 1.5MVA auto transformer is used as a backup supply from Counties Power to the Vector network; and
- The 11kV/11kV 5MVA phase shifting transformer is installed at Avondale zone substation within the Southern area and is used as a backup 11kV connection for the Northern area, Brickworks zone substation. The unit was manufactured in 2006 and remains in as new condition.

The design life of distribution transformers, is typically 25 to 40 years based on loading, and if a transformer is well maintained this life can be extended to 60 years or more.

Asset Condition and Systemic Issues

In general the condition of the distribution transformers is good. Since 2001 many of those that were in poor condition have been replaced as part of renewal programmes which have been implemented across the network.

A systemic issue with corrosion and oil leakage leading to premature asset replacement has, however, been identified with some types of units:

- Some transformers installed between 1998 and 2001 have been identified as prematurely rusting. This is estimated to be about 2% of the population;
- Ground mounted transformers about 25 years old have increased risk of excessive rust or oil leaks. This is estimated to be about 5% of the population; and
- A greater number of mini substations installed on the Northern network have corrosion issues compared to those on the Southern network. The reason is thought to be the manufacturer's inadequate preparation of the steel surface prior to painting and the subsequent inferior painting coating system.

These transformers are being systematically replaced in accordance with Vector's current renewal process.

Specific to pole transformers, it has been found that crossarm king-bolts have been rusting in the section of the bolt where it is encased by the crossarm. While this affects all king-bolts it is not a major safety issue for conductor crossarms as there will, in most cases, be secondary supports such as conductors and straps that will act to prevent the arm falling to the ground. Pole transformer king-bolt deterioration is a much more serious issue, as these are under a much heavier load and the failure of the bolt will lead to the transformer falling from the pole. As replacement of transformer bearer arm king-bolts requires almost as much effort as replacing the bearer arm, a more efficient solution has been devised by using a retro-fit clamping support that allows the transformer arm to be supported without having to rely on the king-bolt. A high priority programme is currently underway to install them on all associated overhead transformers that rely on a bearer arm.

Inspection and Maintenance Approach

Visual inspection of distribution transformers is carried out in accordance with Vector Standard ENS-0188. The frequency of inspection is presently five-yearly for pole mounted transformers and four-yearly for ground mounted transformers.

Electrical testing is not carried out on distribution transformers unless there is a specifically identified issue that needs to be investigated and resolved.

Testing of the insulating oil in a customer transformer for the presence of polychlorinated biphenyls (PCB) is carried out on request from customers and customers' insurance companies. All the test results to date have shown less than 50 parts per million of PCB in the oil. This result means that the oil is classed as a non-PCB liquid.

Thermal imagining and testing for partial discharge (PD) is presently carried out on only ground mounted transformers as part of the transformer inspection programme.

Transformer Condition Analysis (TCA) on oil samples from the 22kV/11kV auto transformer is also carried out. It is planned that this test will also be added as a standard requirement for the phase shifting transformer.

Refurbishment and Replacement Criteria

Maintenance on distribution transformers is on a time-based inspection regime carried out in accordance with Vector Standard ENS-0051. Onsite repairs are generally minor and include such items as oil top up, replacement of holding down bolts, repair of minor oil leaks, minor rust treatment and paint repairs. Where it is uneconomical or impractical to complete onsite maintenance, or the transformer poses a safety or reliability risk before the next inspection cycle, the transformer is replaced and, where economic, refurbished and returned to stock.

In general, Vector's approach is to assess the condition of distribution transformers and proactively replace these based on the assessment (or where a change in capacity is required).

Transformers removed from service that are still in salvageable condition are assessed and refurbished if the assessment criteria to refurbish are met. The assessment also includes consideration of Vector's stock requirements at the time. The assessment criteria are detailed in Vector Standard ENS-0170. It is expected a transformer will attain another 25 to 30 years of service after refurbishment. Transformers that do not meet the assessment criteria for refurbishment are scrapped.

6.4.12 Voltage Regulators

A voltage regulator is a device that automatically produces a regulated output voltage from a varying input voltage. The regulators on Vector's network are step-voltage regulators and a tap changer in the regulator is used to achieve the regulation.

Voltage regulators are installed at two sites on the Southern network and four sites on the Northern network.

Asset Condition and Systemic Issues

Presently there is no refurbishment programme for voltage regulators as they are relatively new (1997 being the oldest installation). It is expected that the existing installations will be on the network for some time (20 or more years).

Inspection and Maintenance Approach

Inspection of voltage regulators is carried out in accordance with Vector Standard ENS-0188. The frequency of inspection is four-yearly.

Electrical testing is not carried out on voltage regulators unless there is a specific issue that needs to be investigated and resolved.

Thermal imaging is presently carried out on ground mounted voltage regulators as part of the inspection programme.

Transformer Condition Analysis (TCA) on oil samples from the voltage regulators is not presently carried out. It is planned that this test will be added to the activities carried out by the field service provider.

Refurbishment and Replacement Criteria

Maintenance on voltage regulators is on a time-based inspection regime carried out in accordance with Vector Standard ENS-0188. Onsite repairs are generally minor and include such items as oil top up, replacement of holding down bolts, repair of minor oil leaks, minor rust treatment and paint repairs. Where it is uneconomical or impractical to complete onsite maintenance, or the voltage regulator poses a safety or reliability risk before the next inspection cycle, the unit is replaced and, where economic, refurbished and returned to stock.

In general, Vector's approach is to assess the condition of voltage regulators and proactively replace these based on the assessment (or where a change in capacity is required).

6.4.13 Ground Mounted Distribution Switchgear

Ground mounted distribution switchgear operates at 22kV and 11kV and is installed in buildings or enclosures on road reserves and private property. It excludes switchboards and circuit breakers located within zone substations. Ring main units, isolators, composite units and circuit breakers (CBs) are used to connect underground cables. Fused switches and CBs are used to protect distribution transformers. Switches may be operated manually or by a motorised mechanism.

New switchgear is supplied in compliance with Vector Standard ENS-0103.

Vector's distribution switchgear comprises oil, SF_6 and resin insulated equipment of varying ages and manufacturers. The arc-quenching mediums used in the equipment are air, oil, SF_6 and vacuum. The majority of the switchgear is rated at 12kV and is deployed in Vector's 11kV distribution network. There is also a small but growing population of 24kV-rated switchgear being installed in Vector's 22kV distribution network in the Auckland CDB and Highbrook Business Park as this network continues to expand.

Asset Condition and Systemic Issues

For legacy reasons, historical records and the resulting age profiles are not completely accurate.

In general the condition of switchgear is good, although there are oil-filled units whose mechanical condition, due to corrosion, is poor. Many of those units have been replaced. Additionally, other replacements have been driven by transformer replacement through either being physically attached to a transformer requiring replacement or, where there is synergy opportunity to replace the switchgear, during other work. Other general causes for replacement are minor oil leaks and, to an even lesser degree, vehicle damage.

Systemic issues leading to premature replacement (or parts) of the assets include the following:

- There are considerable numbers of oil-filled fused switches installed on pre-cast concrete pads where movement of the ground under the pad has caused the switchgear to lean to varying degrees. Excessive lean may result in the rear clip of an HV fuse holder in a fused switch not being fully immersed in insulating oil and hence an increased risk of a flashover in the switch. When it becomes uneconomical or impractical to straighten the unit, replacement is considered as an alternative solution; and
- There is no indication of the oil level in Andelect Series 1 SD switchgear. A low oil level in a switch unit due to oil leaks could result in an explosion in the unit.

Inspection and Maintenance Approach

Inspection of distribution switchgear is carried out in accordance with Vector Standard ENS-0188. The frequency of inspection is four-yearly.

Thermal imaging and testing for PD is also carried out as part of the inspection programme.

Electrical testing is not carried out on distribution switchgear unless there is a specific issue with a switch unit which needs to be investigated and resolved. However, for oil-filled switchgear that has had an internal inspection and maintenance carried out, a live tank oil sample (LTOS) is taken from a switch unit during the scheduled inspection and analysed. The procedure is carried out in accordance with Vector Standard ENS-0052. The results determine when maintenance needs to be carried out on the internals of the unit or when further oil samples should be taken and analysed.

Refurbishment and Replacement Criteria

Preventative maintenance of distribution switchgear is on a time-based inspection regime and is carried out in accordance with Vector Standard ENS-0052.

Onsite repairs are generally minor and include such items as rust treatment, patching of holes, paint repair, oil top up and replacement of mounting bolts. Where it is uneconomical to complete onsite maintenance or the switch unit poses a safety or reliability risk before the next inspection cycle, the switchgear is replaced.

Prior to September 2009, oil-filled switchgear that was removed from service was transported to the company that refurbished Vector's switchgear for assessment and refurbishment or scrapping. This procedure has now stopped as Vector has transitioned from the installation of oil-filled to SF_6 switchgear.

In addition to replacement of switchgear due to corrosion, leaks or the results of LTOS tests, it is intended to implement a replacement strategy for the Andelect Series 1 SD family of switch units. Andelect Series 1 SD switch units have a history of failure and unreliability due to a poor design that cannot be economically rectified.

6.4.14 Distribution Cables

Older 400V cables on the Vector network are paper-insulated and lead-sheathed while the newer 400V cables are either PVC or XLPE insulated. The 6.6 kV rated and the older 11 kV cables are PILC or paper-insulated aluminium sheath (PIAS) construction, with the more recent 11 kV and the 22 kV cables having XLPE insulation.

Asset Condition and Systemic Issues

- Medium voltage distribution 22 kV cables: These cables are still very new, with the first having been installed in 2005. As would be expected, to date there have been no known issues. Life expectancy of these cables is 60 years but this is dependent upon factors such as the electrical load, the installation conditions and the number and magnitude of any downstream faults;
- Medium voltage distribution 11 kV cables: The 11 kV rated PILC cables are generally operating satisfactorily. However, in the early 1970s natural polyethylene insulated 11 kV cable was installed on the Northern network. This type of cable has a high fault incidence and Vector's current practice is to repair the cable when it faults to restore supply, followed by corrective works to replace the cable in a programmed manner. Past experience has shown that once faulted, subsequent faults soon follow. Programmed replacement of this specific type of cable has significantly reduced the fault incidence being experienced. Other XLPE insulated cables are in good condition;
- Medium voltage distribution 6.6 kV cables: In the past some cables have been upgraded to operate at 11 kV. This is now creating issues such as failure of the joints, likely caused by poor jointing workmanship and insufficient cable insulation. The replacement priority for these cable sections is based on the consequence of failure, the observed failure rates, and number of joints per cable section;
- The issues are compounded by the fact historical records of the cables are not always correct, with some cables incorrectly indicated as being rated for 11 kV. The full extent of the issue is not known as confirmation of the actual voltage rating of an operating cable requires it be opened up and the insulating papers counted to confirm suitability for operation at 11 kV. Cables are treated on a case by case basis as faults occur;
- Low voltage distribution 400V cables: Faulted breech joints on to the streetlight pilot cables occur frequently. As proactive location and replacement of these joints is not practical, they will continue to be replaced as they fail; and
- Earthing cables: An ongoing issue with earthing cables for pole-mounted equipment is conductor theft for the scrap value of the copper. Copper plated steel earthing cables are now installed to combat this.
- Outdoor 3M cable pole terminations installed about 15 years ago are failing. The problem appears to be caused by poor sealing around the lugs, allowing water to enter the termination. Vector has pole mounted cable terminations where the connection between the underground cable and the overhead reticulation jumper is by two lugs bolted together at a standoff insulator. At some installations a steel nut has been placed between the two lugs, resulting in a high resistance connection between the underground cable and the jumper. Vector's Overhead Network Condition Assessment ENS-0187 Standard specifically targets the identification of 3M terminations and of interposing nut/washer terminations to facilitate their replacement.
- Several years ago some PILC cables manufactured with an HDPE sheath were installed. After a short time it was found that Raychem terminations on these cables leaked compound. The vast majority of these terminations were replaced by a pressure resistant termination and any remaining leaking terminations are replaced when found.
- Older terminations were contained in a cast iron enclosure. This changed to cast aluminium and finally to hot shrink or cold applied alternatives. Because of safety concerns regarding 11kV cast metal terminations, they have been progressively removed from the Vector network. A small number of 33kV metal terminations will continue in service specifically as sub-transmission oil pressurised cable terminations, these will be removed in coordination with the cable replacement.

Inspection and Maintenance Approach

In practice only the terminations of underground cables are able to be inspected. Pole mounted cable terminations are inspected annually during the overhead network condition assessment, in accordance with Vector Standard ENS-0187.

Yearly

- Visual inspection to ensure the termination and supports are secure, undamaged and free from corrosion, with no visible leaks of insulating compound or oil;
- Visual inspection to confirm a nut and/or washer has not been inserted between the two cable lugs on the standoff insulators/arresters;
- Visual inspection of all electrical connections including earthing secure, undamaged and not showing signs of overheating;
- LV XPLE cables shall be visually inspected to confirm that ultra-violet protection shrink tube has been installed over the XPLE insulation of the cores above the break-out udder; and
- Visual inspection of cable covers or protective duct is not damaged and riser cables securely attached to the pole.

Outdoor terminations in zone substations are similarly inspected annually as per the Vector Standard ENS-0191.

There is no regular testing of distribution power cables. Techniques such as PD mapping claim to be able to predict the health of cables. However, Vector's experience thus far is inconclusive and the technology requires further development. Long-term continuous monitoring of PD levels shows promise but is currently impractical given the large number of cables involved.

- The life of an underground cable is difficult to predict because it is dependent upon several factors. These are the cable construction, natural environment, public access, the electrical loads and the quantity and severity of downstream faults that the cable has experienced. In general, the best indicator of remaining life is the incidence of failures.

Underground cables are replaced when the failure rate becomes unacceptable. The benchmark level of unacceptability is more than one fault per annum. At present Vector is targeting cables exhibiting the most frequent faults and exceeding this level.

Northern region poly cable replacements have been historically included in the replacement programmes and it has been assumed this will continue at a constant rate. This rate has been falling as the population of cables of this type has diminished.

Maintenance of the underground cable network is limited to work identified during the visual inspections of cable terminations and exposed earthing cables. Power cables are operated to failure, after which sections are repaired or replaced as indicated by previous fault history.

6.4.15 Earthing Systems

Earthing systems are required to minimise the risk of electric shock, limit earthing system related over-voltages on the network, ensure the operation of protection and carry earth fault currents safely.

All asset installations with conductive equipment have their own independent earthing systems. In general, the earthing systems comprise a set or sets of pins (electrodes) driven into the earth connected together via bare copper conductor, copper is both an excellent electrical conductor and mechanically ideal in regard to in-ground corrosion.

The nature of the surrounding soil and surface covering play an integral part in the performance of the earthing system. The effects of local soil resistivity and covering (eg. metal chip, asphalt) must be included in the overall analysis of earth system performance and are covered by step and touch voltage measurement.

Asset Condition and Systemic Issues

Vector has a wide range of earthing systems that vary in age, condition and construction for both zone substation and distribution earthing.

Theft of above ground copper earth conductor and buried earth rods is an ongoing issue. Vector has moved to copper clad steel earth rods and copper clad steel earth conductor for some publicly accessible distribution earthing sites.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector’s earthing systems are prescribed in the Vector Network Standards ENS-0187 Overhead Network Condition Assessment, ENS-0068 Maintenance of Distribution Earthing Systems and ENS-0076 Maintenance of Zone Substation Earthing Systems.

In summary ENS-0187, ENS-0068 and ENS-0076 define the following routine actions:

<u>Annual</u>

- Zone substation temporary earthing equipment; general visual inspection of leads and clamps, earthing lead contact resistance measurement;
- Zone substation earth system; visual inspection, physical assessment of above ground earth conductors and connections and tags; and
- Distribution earth system; visual inspection of mechanical protection, connections, signs of damage or overheating, covering all pole mounted overhead transformers, pole mounted capacitors, air break switches, gas break switches, sectionalisers, reclosers, riser cables, and low voltage distribution neutral earthing locations.

<u>Three-Yearly</u>

- Distribution earth system; visual inspection, physical assessment of above ground earth conductors and connections and tags, covering all low voltage distribution pits, pillars and network boxes.

<u>Five-Yearly</u>

- Distribution earth system; visual inspection and remote earth testing of overall earthing system resistance, each earth bank resistance and step and touch voltage measurement. Marginally non-compliant sites require step and touch voltage retesting using high current off-frequency injection, covering all pole mounted overhead transformers, pole mounted capacitors, air break switches, gas break switches, sectionalisers, reclosers, riser cables, and low voltage distribution neutral earthing locations; and
- Zone substation earth system; visual inspection and testing, bonding resistance measurements between primary assets, control cabinets and support structures to reference earth bar/grid, remote earth testing of overall earthing system resistance and independent main earth resistance testing if accessible and step and touch voltage measurement using off-frequency heavy current injection.

Six-Yearly

- Distribution earth system; visual inspection and remote earth testing of overall earthing system resistance, each earth bank resistance and step and touch voltage measurement. Marginally non-compliant sites require step and touch voltage retesting using high current off-frequency injection, covering all ground mounted substations, transformers, and ground mounted switch units.

Refurbishment and Replacement Criteria

Earthing cables are only maintained if they are visibly unsound, missing, under-sized or test results fall outside the limits given in Vector's distribution earthing maintenance standard or zone substation earthing maintenance standard.

Predicted future expenditure is based on the assumption the replacement/refurbishment rate will continue at the present rate.

6.4.16 Pillars and Pits

Pillars and pits provide the point for a customer cable to connect to Vector's reticulation network. They contain the fuses that isolate the service cable from the network distribution cable and which prevents major potential damage to the service cable following a fault in the consumer installation.

For loads up to 100 Amp, an underground pit has largely superseded the above ground pillar for new work, although there are still some applications where a pillar will be preferred. Pits are manufactured from polyethylene, as are most of the newer pillars. Earlier pillars have made use of concrete pipe, steel and aluminium.

Asset Condition and Systemic Issues

The condition of customer pits and pillars range from very poor to new condition. The age and range of installation condition is such that it is difficult to determine any primary cause for deterioration. Unsound units are identified through proactive inspection and maintenance programmes and are replaced accordingly.

Underground low voltage network link boxes used in the Auckland CBD are generally in poor condition and require replacement. Also many of the pavement lids and their supporting surrounds have been damaged. Off the shelf like-for-like replacements are not available for this equipment. Where possible the boxes are to be removed and the cables jointed through. Where underground network boxes are still required, a new modern equivalent fit for purpose will be installed.

The older aluminium pillars are generally adequate for their purpose although many have suffered knocks and minor vehicle impact.

Many metal bodied pillars do not have an independent earth connection to the body. These missing earths have been programmed for installation.

Certain types of plastic pillars have fuse base plate attachment bolts which can be livened due to leakage current across internal components. These bolts protrude through the body of the pillar lid to the back face of the pillars. A maintenance programme has been initiated to securely cover these attachment bolts.

Removal of mushroom type pillars has been a priority in the Northern network; this programme has addressed the removal of mushroom pillars in all clustered areas of the network e.g. subdivisions, any remaining ad-hoc mushroom pillars that are found in the Northern region are being replaced with a polyethylene pillar for safety reasons.

Installation of service pits began over ten years ago and comprehensive inspections to date have not shown up any significant maintenance issues.

Inspection and Maintenance Approach

The routine inspection, maintenance and testing requirements for Vector's pits and pillars are prescribed in Vector Network Standard ENS-0175 Maintenance of Pits and Pillars. Loop impedance is measured when service pillars and pits are first installed, but there is no regular testing of these components of the distribution system.

In summary ENS-0175 defines the following routine actions:

Three-Yearly

- Visual inspection; encompasses the following assets, pillars, pits, link boxes, network boxes and fuse boxes. External inspection to ensure safe operation and emergency assessment of vegetation ingress, build up around assets, burial of assets, vandalism. Internal inspection covering loose or poor connections, water ingress, heating effects.

Refurbishment and Replacement Criteria

The remaining life of a pillar or pit is difficult to predict because it is dependent upon a number of factors. These are the pillar construction, natural environment, public exposure, access and the electrical loads supplied by the pillar.

Pillars are normally operated until they fail the inspection criteria, which are generally based on whether the condition of the pillar is creating a hazard.

Where practicable, pillars are repaired on site following faults or reports of damage or the results of the inspection programme. Otherwise a new pillar or pit or network box is installed.

Pillars with a high likelihood of future repeat damage by vehicles are replaced with pits. Older pillars are targeted for planned replacement as repair becomes impractical or uneconomic, or where they present an unacceptable safety risk.

Replacement of underground network boxes is considerably more expensive than other pits or pillars, however the overall volume of these is significantly lower.

6.4.17 Low Voltage Switchboards and Frames

An LV switchboard consists of a number of fuses or circuit breakers (CBs) mounted on a panel. The fuses and CBs are connected to cables which supply power and lighting circuits in the building in which the switchboard is located. The LV supply to the switchboard is either single phase or three phases.

An LV frame consists of a number of fuses and solid links mounted on three phase bus bars supported on a frame. There are two types of fusing installed on LV frames - JW type and DIN type. The frame is supplied from the 415V terminals of a distribution transformer via cables connected to the transformer terminals and the solid links on the frame. The fuses are connected to cables which supply customers.

LV frames are supplied in compliance with Vector's Standard ENS-0113 Specification for Low Voltage Distribution Pillars and Panels.

Asset Condition and Systemic Issues

LV frames of both types are generally in good condition, however on both types of LV frame there have been incidents (overheating and fires).

There have also been operational issues and incidents with JW type LV frames and resultant from those incidents no work is permitted to be carried out on solid links on JW LV frames unless the frame is de-energised in accordance with the design intention. That work includes the tightening and loosening of the solid link securing bolts.

Inspection and Maintenance Approach

LV switchboards and frames are visually inspected as per Vector standards. Thermal imaging is carried out on LV frames every four years.

Refurbishment and Replacement Criteria

There are no specific maintenance standards or programmes for LV switchboards or frames. The units are generally replaced when they fail.

However, LV frames which are equipped with JW type fusing and solid links are replaced with frames equipped with DIN type fusing when the distribution transformer associated with the LV frame is replaced.

To address the operational constraint identified in the Asset Condition and Systemic Issues section above, a frame replacement programme is planned to be carried out over the next ten years.

6.4.18 Power Protection, Automation and Control Systems

The function of a protection relay is to initiate the disconnection of any faulty section of the power system from service. The protection relay senses the abnormal condition and the task of isolation of the faulty section is achieved through a circuit breaking device which is capable of disconnecting the faulty section. Protection schemes can be categorised in three groups of protection, line protection, transformer protection for transformer fault conditions and feeder protection on outgoing feeders. There are three distinct types of protection relays used on the system detailed as follows:

- Electromechanical protection devices which tends to be older and which can be set to detect one particular abnormal condition;
- Static analogue electronic based protection devices, the first generation of electronic protection devices; and
- Microprocessor based devices, which is a fully programmable electronic unit providing greater functionality in a single unit. These are called Intelligent Electronic Devices (IED).

Asset Condition and Systemic Issues

There is a wide range of age profiles and therefore a spread of condition ranging from good to poor. Electromechanical relays are still in an average condition despite their age but the failure rate of these relays is increasing. There are only a few Static relays left on the network which are in an average condition with a fairly low failure rate. The Numerical relays are mainly in a good condition. The first generation of Numerical relays are now coming to the end of their designed life and an increased failure rate has been noticed.

Inspection and Maintenance Approach

The regular testing ensures that the relays continue to function within their prescribed limits and as required for the installation situation. Tests will include for example functional test, visual inspections and setting configuration checks. The test intervals are outlined in the table below.

	Numerical Self Monitoring	Digital Non-Self Monitoring	Analogue (electro-mechanical or non-numerical electronic)	Measuring / Trip Circuit	AUFLS
Grid Interface	10	4	2	4	4
Other Stations	10	4	6	4/6/10**	4
Trf. Mech. Protection			**		
Transformer Voltage Regulating Relay, OTI and WTI			**		

(shaded)	Required by Electricity Industry Participation Code
**	Align with associated protection relay (eg. Buchholz) maintenance interval.

Refurbishment and Replacement Criteria

The deterioration of the older Electromechanical relays starts to influence its reliability after being in service for around 30 years. Modern IED's are the new standard of protection devices and providing multiple functions within one device and providing valuable information to SCADA and the protection engineers to assist in fault finding.

As part of all switchboard replacement projects state of the art IED's will be installed and replacing old electromechanical protection devices. Recovered protection devices that are still functional will be kept as spares to support legacy devices in service.

Electromechanical and static relays will only be replaced with a numerical relay if they fail or if a certain type is shown a high failure rate.

A program to replace the first generation of IED's has been developed and will be rolled out over the next 10 years.

6.4.19 Supervisory control and Data Acquisition (SCADA) & Communications

Vector's SCADA system provides 24/7 situation awareness of the electricity network to the operators in Vector's control room. It has communication links into all GXP's and Zone Substations as well as to around 250 pole top and ground mounted distribution substations.

Communications systems consists of:

- IP [4]Network via fibre or copper pilot cables

[4] IP: Internet Protocol

- PDH[5] and OTN[6] systems on fibre cables
- UHF and Microwave data radio systems
- VHF voice and low speed data radio system
- 3G/2G [7]private networks

The SCADA system communicates via front end processors to RTU[8]'s and IED's on mainly standardised protocols like DNP3 and IEC 61850. A small amount of devices is using ModBus or Conitel.

Asset Condition and Systemic Issues

The SCADA system is in an average condition which is mainly related to older hardware. There are no systemic issues except the odd hard disc failure which to expect with the time they are in service.

Remote Terminal Units are mainly in a good condition as there is a replacement project underway to replace all legacy devices. There is an increasing failure rate on the legacy devices which is mainly due to age.

As the communication systems are from different vintages the conditions reaching from poor to good. Legacy systems due to age fail more often like copper pilot cables, PDH and OTN. The IP network devices including the fibre optic cables are in good condition.

Inspection and Maintenance Approach

Systems are mostly self-monitoring and don't need pro-active maintenance activities. Radio systems and legacy communication systems have regular inspections which are mainly around power supplies, batteries and visual inspections. All modern communication devices are monitored by the Network Operations Centre (NOC) and will provide alarms if action is required.

Refurbishment and Replacement Criteria

The SCADA system will require an update within the next years to refresh the hardware and to keep up to date with the latest version of the software. An investigation is underway to identify the best options.

RTU's are being replaced currently and this project will be finished by FY18. After this individual RTU's that will show signs of an increased failure rate will be replaced.

Legacy communication systems will become obsolete once all legacy RTU's are replaced. There is a migration plan from copper pilot cables to fibre optical cables for the next 10 years but as long as the copper pilot cables are still in a good condition they will be used. Especially in areas where there is no fibre optical cable available.

Modern communication devices like routers, switches and 3G/2G modems are being replaced on an age based criteria or when they fail.

6.4.20 Power Quality Meters

Power quality is defined as "any voltage, current or frequency deviation that exceeds regulatory standards and may result in failure or mal-operation of customer equipment

[5] PDH: Plesiochronous Digital Hierarchy

[6] OTN: Open Transport Network

[7] 3G/2G: 3rd Generation/2nd Generation Cellular Network (eg Vodafone, Spark)

[8] RTU: Remote Terminal Unit

(Electrical Power System Quality)". Power quality addresses the quality and consistency of the voltage waveform; outages are not included as a part of power quality issues.

The voltage waveform quality is defined in terms of the following parameters:

- Harmonics
- Flicker
- Voltage unbalance
- Voltage transients and voltage sags
- Under voltage and over voltage issues

Power quality monitoring (PQM) is by permanently installed ION meters at GXP and zone substations for HV and MV network monitoring for compliance. Portable Elspec meters are used for temporary installations at sites with suspected power quality issues or requiring complaint response investigation.

There are five different models of ION meters currently installed on the Vector network, comprising the 65 PQM devices that perform combined HV and MV network energy and power quality measurements.

At GXP level, the meters are deployed to provide a check-metering function to compare against Transpower's revenue metering installations.

All power quality meters are monitored in real-time for power conditions, analyse power quality and reliability by an ION Enterprise software application and the data is stored in a database for post event analysis.

Asset Condition and Systemic Issues

The majority of the installed base of PQM's were commissioned over the last 12 years. Older models currently in use are obsolete with manufacturer support now limited to supply of compatible replacement modules.

Inspection and Maintenance Approach

Currently power quality meters and associated equipment are not subject to any maintenance or diagnostic inspection. The majority of these devices do offer self-monitoring capability.

Refurbishment and Replacement Criteria

No active replacement program is currently in place and PQMs are being replaced or installed in conjunction with other projects such as switchboard replacements and green field projects.

6.4.21 Capacitor Banks

In 1999 Vector installed 11kV capacitor banks within the Vector Northern and Southern regions in response to Transpower requiring added voltage support for the Auckland and North Auckland transmission network.

In the Southern region 153MVAr was installed in 25 zone substations, connected to the 11kV switchboard with up to three 3MVAr banks (9MVar) per substation. In the Northern region 58 pole-mounted 11kV capacitor banks each rated at 750kVAr were installed.

Now with improved generation capacity close to Auckland, cooling towers at Huntly thermal power station allowing increased generation capacity, and changes to maximum demand on Vector's network, there is currently no business justification for replacement of capacitor banks and they are decommissioned on failure or if unsafe.

Vector does continue to use capacitors as one of its network solutions for feeder voltage support.

Asset Condition and Systemic Issues

At 15 years old the capacitor banks in both regions are nearing the end of their design life and are run to failure without replacement.

To date around 25% of pole-mounted banks have been removed because of failure/corrosion, overhead improvement projects or third-party car-vs-pole incidents.

The zone substation 11kV capacitor banks are in good condition, apart from those located outdoors where their enclosures are deteriorating due to rust at ground level. Failures have been caused by rainwater entering the outdoor enclosures. Rather than replace CT's with a redesigned mounting system, installations have been decommissioned where the existing CT mounting has caused damage to its sealing compound. The capacitors at Liverpool suffered a reactor fault and have been removed.

Inspection and Maintenance Approach

Pole-mounted capacitors banks are inspected annually as part of the overhead inspection maintenance programme.

Zone substation capacitor banks are inspected every two months as part of the zone substation maintenance programme. (Vector Standard ENS-0192).

Refurbishment and Replacement Criteria

11kV pole-mounted capacitors are maintained at eight-yearly intervals by exterior cleaning, checking connections, measuring capacitance of the cans, and replacing controller batteries in the switched units. (Vector Standard ENS-0048).

11kV zone substation capacitors are maintained every two years, bushings and filters cleaned and connections checked. A four-yearly testing cycle measures capacitance of the cans, secondary injection tests the protection relays, and CB's are ductor tested and measured for insulation resistance (Vector Standard ENS-0192).

Components in good condition are recovered from decommissioned capacitor banks and used to maintain existing banks.

6.4.22 Tunnels

Vector owns and operates a number of power cable tunnels in its Southern network.

The most significant of these is the 9.6km, 3m diameter Penrose-Hobson Tunnel commissioned in 2001 to provide 110kV and 33kV power supply from Transpower's Penrose GXP to Vector's Hobson, Liverpool and Newmarket CBD substations.

in mid-2014 under the Vector-Transpower Tunnel Agreement, Transpower commissioned a single circuit 220kV supply to the North Auckland and Auckland Network (NAaN). Via the tunnel Transpower's Penrose 220kV GXP supplies Vector at the Hobson St GXP (220/110kV), Wairau Road GXP (220/33kV), and Albany GXP (220/110kV). The Tunnel Agreement has spatial provision for a second Transpower circuit.

Transpower has access to the Tunnel in accordance with Vector operational authorisation and the Vector-Transpower Emergency Response Plan.

There are three main vertical shafts at Penrose, Newmarket and Hobson St. The Newmarket site is mid-way along the tunnel, dictated by operational logistics for the ventilation outlet plant room and personnel/emergency access efficacy. Three smaller vertical shafts at Liverpool substation connect Liverpool to cables from Penrose and to Hobson St. At Gillies Avenue there is a 300mm shaft with two 33kV cables from Penrose exiting the tunnel to supply Newmarket substation.

Ancillary tunnel equipment essential for its operation and maintenance includes:

- Radio telephone communication system providing RT to RT communication, RT to surface access controller communication, and RT broadcast communication;
- Atmospheric oxygen and noxious gas detection system;
- Ventilation plant room at Newmarket with airlocks at shaft access points;
- Water deluge/sprinkler operated fire suppression system for cable protection;
- rainage system comprising drainage sumps and submersible pumps;
- Personnel lift at Newmarket and egress ladders at the four main shafts; and
- A 750mm gauge railway and locomotive.

The railway is used for cable installation, plus maintenance and fault response. The railway operates under NZTA jurisdiction with Vector required to submit an annual Rail Safety Case to NZTA and licensensed train drivers under the Rail Safety Case.

The tunnel has been designed with capacity for more circuits than presently installed.

The other tunnels on Vector's network are:

- *Swanson Street Tunnel* – Hobson 22kV, 11kV CBD distribution, 350m along Swanson St;
- *Victoria Street* (11kV CBD distribution);
- *Britomart Place* (Quay-Liverpool 22kV interconnector, and Quay 11kV CBD distribution;
- *Kingsland north-western motorway crossing* (Kingsland 22kV, 11kV distribution); and
- May Road south-western motorway crossing (Roskill-Liverpool 110kV cable).

Vector Assets Installed at Transpower GXP's

The Penrose end of the Penrose-Hobson Tunnel is located within the Penrose GXP site boundary. The assets include the shaft, cable support structures, deluge fire suppression system, gas detection system, two in-tunnel drainage pumps and discharge outlets, and the tunnel ventilation inlet room.

Asset Condition and Systemic Issues

The Penrose-Hobson tunnel and primary assets are in good condition. Structural inspections show no signs of deterioration or further development of construction shrinkage cracking, with groundwater ingress consistent according to pumping outflows.

The other Vector tunnels now require preventative maintenance to manage flooding issues that are causing deterioration of cable sheathes and ancillary services. The tunnel structures although aged are in serviceable condition.

For all tunnels, flooding is the main failure mode effect (FME) for safe operation since in-tunnel controls and cable joints at that time were not designed for water submersion. Replacement control systems and Transpower cable joints are designed for submersion.

Inspection and Maintenance Approach

For the Penrose-Hobson Tunnel overall inspection and maintenance is per the MUSA Penrose-Hobson Tunnel - Planned Maintenance Plan, with the rail track specifically to Vector EOS-018.

Maintenance standards and schedules are being issued/reissued in conjunction with replacement of ancillary systems.

Refurbishment and Replacement Criteria

With the Penrose-Hobson Tunnel now 16 years old and the ancillary systems that monitor and control the tunnel continue are at their end of their expected economic and safe operating life. This is comparable to industry norms for this type of equipment and the high humidity environment of tunnels.

Consequently, the FY15/FY16 capital expenditure plan replaced the atmospheric sensors and the ventilation secondary systems essential for safety of personnel, with the latter reducing corrosion by moisture condensate and providing optimal cable rating; a backup power supply to the tunnel plant room; monitoring and replacement of drainage pumping controls; and replacement of PLC monitoring systems.

Planned Vector expenditure in FY17 and FY18 includes:

- Continuation of the programme for replacement of Tunnel light-rail track anchors
- Completing the Tunnel communications ‘ring-main’ (Penrose fire outcome)
- Addition of a ventilation damper for fire suppression (Penrose fire outcome)
- Procurement for replacing the analogue radio communication system with digital
- Purchase of strategic spares for the Tunnel shaft fire detection system
- Completion of UPS replacement for control systems power failure support
- New on-site tunnel access controller (TAC) and local SCADA cubicle
- Replacement of airlock door drive/controller at three portal access sites
- Integration of Transpower’s DTS fire/temperature alarms and controls

The other Vector tunnel structures are in serviceable condition. Replacement is confined to failed ancillary systems.

6.4.23 Mobile Generator Connection Unit (MCGU)

Vector owns two MGCUs purchased in 2006. The units are used to provide supply backup support to the network during emergency situations and to avoid outages at distribution substations during maintenance works.

The MGCUs are mounted in self-contained 20-foot containers on skids for rapid deployment. The MGCUs units provide an interface between the 11 kV network and multiple or single 415V diesel generators. Each unit has the capacity to inject up to 2.5MVA into the 11 kV network connecting to either overhead lines or underground cable networks.

Each MGCU comprises a 2.5MVA transformer, high and low voltage CBs, protection control, monitoring and auxiliary supply. The units are shown schematically below in Figure 6-2.

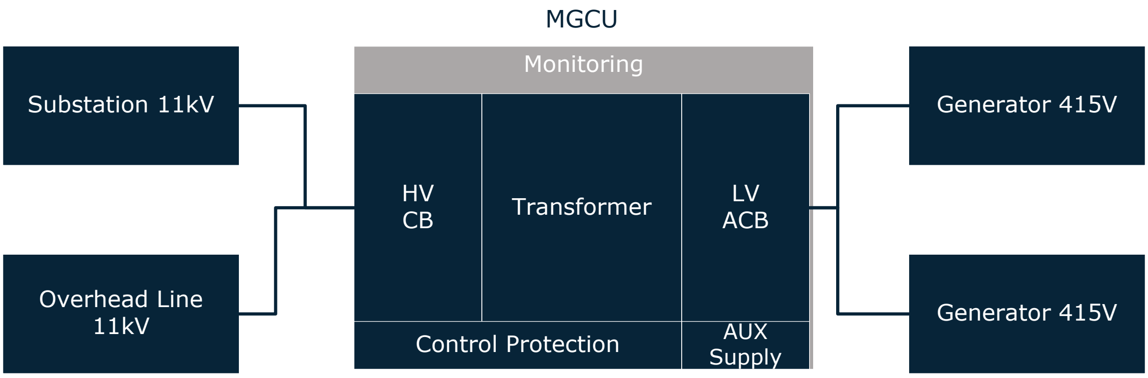

Figure 6-2 : Mobile generator connection diagram

Asset Condition and Systemic Issues

The units are maintained by Vector approved generator services provider. The units are inspected before dispatch to site.

Inspection and Maintenance Approach

The units are stored at, and maintained by the approved generator services provider.

Refurbishment and Replacement Criteria

Refurbishment or replacement is initiated based on the condition assessment by Vector's approved generator services provider.

6.5 Asset Risk and Performance Improvement Opportunities

The Asset Resilience team have developed a risk methodology as a foundation for asset management decision making, with a particular focus on improving Vector's management of HILP (High Impact Low Probability) events.

The framework is documented in asset risk reports developed for each asset class.

Asset engineers have developed FMEA registers encompassing all stages of asset service life from the inception through planning, design, procurement, installation, commissioning, operation, maintenance, and decommissioning. Site specific risk assessments are then performed on critical assets to feed into future inspection, maintenance and renewal plans.

6.5.1 Asset Management Data Limitations

Vector asset management relies on the accuracy and completeness of its asset data to determine the asset risks and their controls. SAP represents the main source of asset data, including equipment attributes and conditions. There are limitations generally related to the storage of asset conditional data. Asset condition information may come in digital or analogue formats such as reports, commentary, photographs, and defect notifications. Not all records can be stored in SAP and this create difficulty to a comprehensive risk analysis.

There are a number of initiatives in place in order to improve asset condition data capture, storage, communication and analysis. In such the new Maintenance Standards will specify data requirements and their fit in the data warehouse development which will provide clearer interface amongst SAP, GIS and other asset registers. Vector Networks teams are now working on the development of a comprehensive asset data management framework stipulated by EPA002 Asset Information Management Policy and Asset Data Standards suite.

6.6 Innovations deferring asset replacement

Vector Asset Strategy team approve and review all network fittings and apparatus to be used on the networks according to EPA005 Asset Selection Policy and document the list of the approved fittings in the standard ESS001. An important function of this work is continuous research of the market and finding new, improved and emerging technologies, with a view to optimising overall asset life-cycle costs. Important examples of how this has occurred in practice are discussed below.

6.6.1 Sub-Transmission Systems

Circuit Breakers and Switchboards

Vector was the first New Zealand network operator to adopt fixed pattern technology for its MV indoor zone substation switchboards. Specifically, new switchboards must comply with Vector Equipment Specification ENS-0005 and to IEC 62271. This standard was chosen due to its high level of operator safety and long periods between maintenance activities. Coupled with modern relaying and control systems, the modern zone substation has little need for operator intervention over its design life. This life is primarily based on life-time fault operations rather than traditional time-based parameters.

In addition, equipment complying with these standards is also rated to contain faults and contain no oil or other combustible products.

Power Transformers

The basic transformer construction materials and methodology has changed little over the past 100 years, notwithstanding significant improvements in insulating oils and manufacturing techniques. However, there have been developments in control monitoring and tap changing technologies.

Vector is currently evaluating the long-term cost-benefit of advancements in technologies such as vacuum tap changers, on-line PD and key gas monitoring technologies. Vacuum tap changers are a continuation from VCB technology developed over the past 20 years.

The newest technologies available today use SF_6 gas in place of mineral insulating oil. This technology, however, is very expensive and specialised and has thus far been limited to the HV VHV (220 kV and above) levels and is not likely to be economic for electricity distribution networks for many years.

For Vector, traditional oil-filled transformers with Kraft paper insulation will likely continue to be the norm in the foreseeable future.

6.6.2 Distribution Systems

Partial Discharge

PD measurement in cables and other distribution apparatus can give an indication of the health of the equipment. To date, results have been mixed and it is not possible to say categorically that any equipment with PD above a certain level will fail. The science around PD monitoring and reacting to this is still developing. It may become a useful tool for the prediction of imminent asset failure or faulty equipment in the future.

6.7 Material Projects over next 12 Months

Projects for Reactive Distribution Plant Replacement

There are several reactive asset replacement projects for Northern and Auckland parts of Vector Network covering replacement of distribution switchgear, transformers and OH line hardware which reached the end of their service life. The decision making methodology to replace the assets is described in details in Chapters 6.4 and 6.5.

Project for Replacement of Liverpool St Primary Switchgear

This project replaces both 11kV and 22kV switchboards based on the asset risk analysis related to the condition, age and serviceability of the plant, and network risk analysis related to the criticality of the Auckland CBD area fed from the substation.

Project for Replacement of Hobson St 11kV Primary Switchgear

This substation has critical importance in supply of Auckland CBD area. Reliability analysis indicates that 11kV switchgear is reaching the end of its service life. It is planned to conduct a feasibility study for the option of asset renewal (replacement or/and retrofitting). This analysis will also include the future planning for 22kV switchboard.

Project for Replacement of Mt Albert 11kV Primary Switchgear

It is planned to retrofit 5 panels of an aged oil switchgear based on the asset risks analysis (mainly arc flash containment).

Project for Replacement of Orakei 11kV Primary Switchgear

This project is to replace an old Brush 11kV oil field switchboard at the end of its service life.

Project for Replacement of Browns Bay T2 Replacement

This project is to replace an aged power transformer based on the asset risks (condition) and network risks (continuity of supply).

Project for Replacement of Drive 11kV Primary Switchgear

The Brush 11kV oil filled switchgear has approached the end of its service life and needs replacement. The project will also address the condition of the heritage listed building.

Project for Replacement of Manurewa 11kV Primary Switchgear

Based on the asset risk analysis, the 11kV switchgear has approached the end of its service life and needs replacement.

Project for Replacement of Wairau Valley 11kV Primary Switchgear

South Wales 11kV switchgear has approached the end of its service life and its rated capacity. Furthermore, the growth in the area can be no longer supported by extension of this obsolete switchgear.

Project for Replacement of Howick 11kV Primary Switchgear

Oil filled Reyrolle LMT 11kV portion of the switchboard needs replacement based on its condition.

6.8 Material changes from the 2015 AMP

Previous maintenance and renewals plans have materially been completed as proposed in the previously published AMP, with only minor variations in budgets and timing.

However, asset replacement and maintenance programs are updated when new information is received. Significant change in priorities may be caused by conclusions of an asset failure investigation, report from another organisation or overseas on a significant incident related to similar asset type, or rapid deterioration of the asset condition.

One change of note has been an increasing rate of deterioration and failure of non-Vector owned assets deployed on service lines along Right of Ways within the city. Vector is not able to determine who the owner of these assets is in many circumstances, and given the safety concerns relating to these assets, Vector has elected to negotiate with affected parties to either agree which party owns the asset, or for the assets to be formally transferred to Vector and Vector will upgrade to ensure public safety is maintained. In 2014/15 Vector re-allocated approximately $6m of investment into Right of Way maintenance to address the emerging safety issues from non-Vector owned assets.

Electricity
Asset Management Plan
2016 – 2026

Non-Network Assets – Section 7

[Disclosure AMP]

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7 Non-Network Assets

7.1 IT Technical Reference Architecture

Vector implements and manages all its Information Systems and their related infrastructure components according to an overall IT Technical Reference Architecture. This ensures that each Information Technology component has clear boundaries, which ensures that the technology used to support these components are "fit-for-purpose". It also helps make sure that Vectors Information Systems environment maintains a "separation of concerns" between its information systems and infrastructure. The Vector IT Technical Reference Architecture is shown in the following diagram.

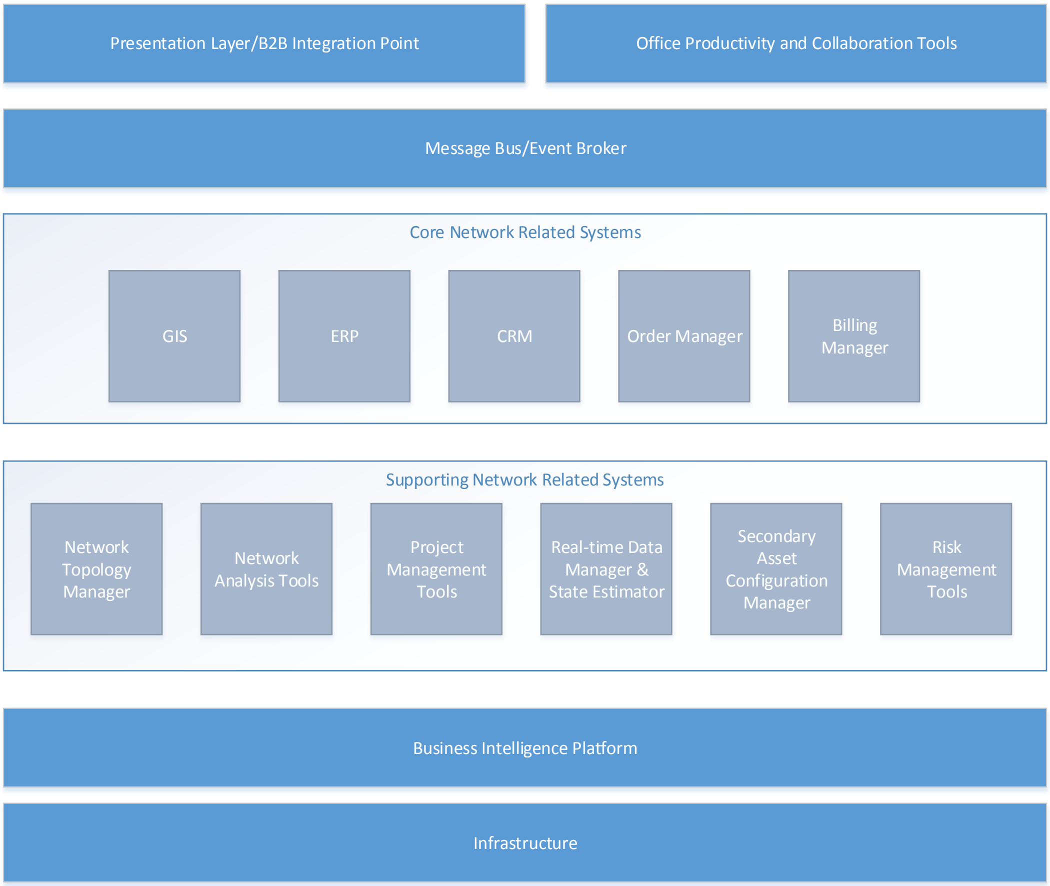

Figure 7-1 : Vector's IT Technical Reference Architecture

7.2 Information Systems

The components within the IT Technical Reference Architecture are made up of information technology and information systems. These can be divided into three categories relating to the type of business capabilities that they support;

- **Core Network Related Systems:** These systems support capabilities that manage information directly relating to Vectors network assets and their operation and management
- **Supporting Network Related Systems:** These are smaller systems that support capabilities that manage information that also directly relates to Vectors network assets and their operation and management.

- **Supporting IT Infrastructure Systems:** These are systems that support the integration and operation of both the Core Network Related Systems and the Supporting Network Related Systems.

The following diagram illustrates the relationship between Vectors business functions and processes, hereafter referred to as business capabilities, and its Core Network Related Systems.

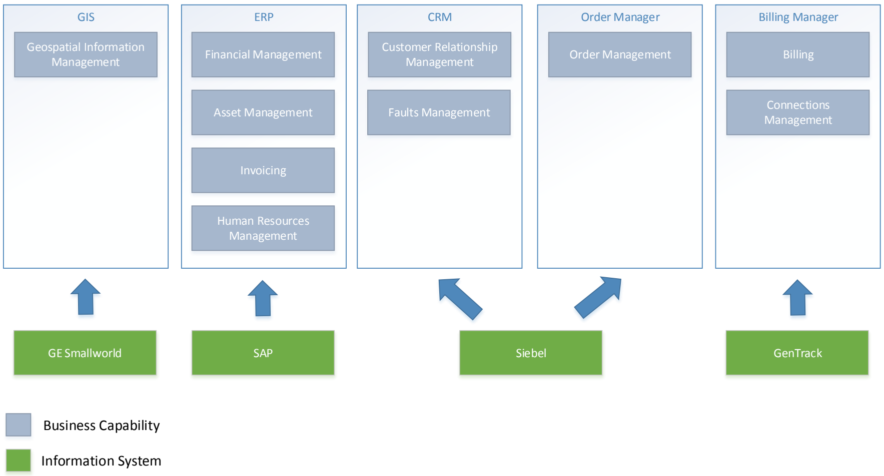

Figure 7-2 : Business Capabilities and Core Network Related Systems

The following diagram illustrates the relationship between Vector's business functions and processes, hereafter referred to as business capabilities, and its Supporting Network Related Systems.

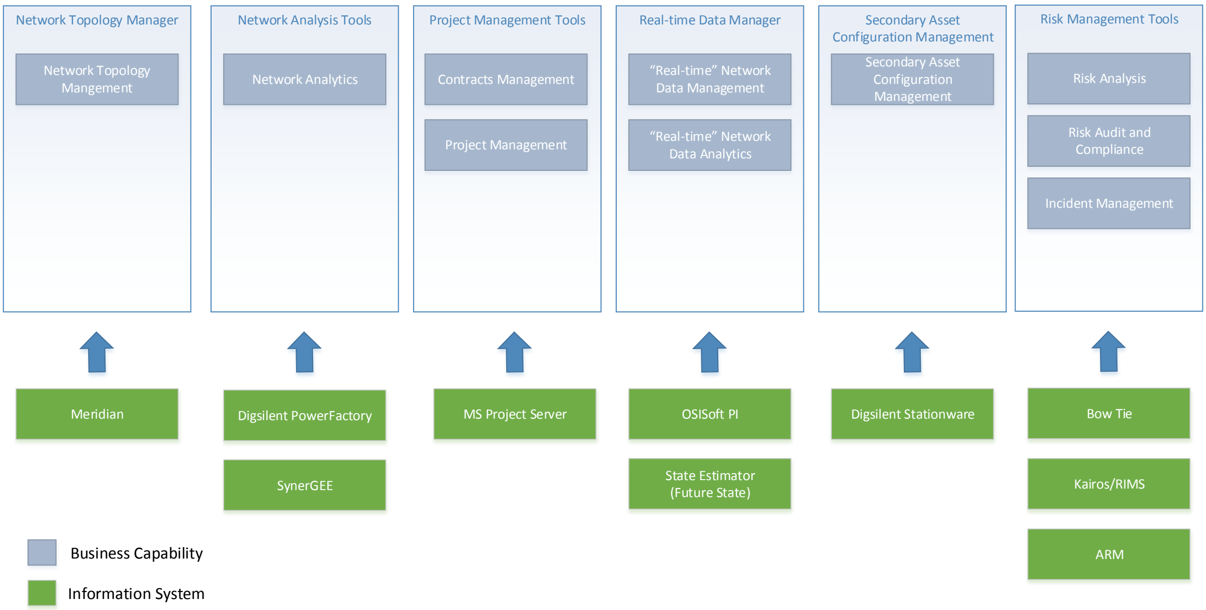

Figure 7-3 : Business Capabilities and Supporting Network Information Systems

Vector also manages and maintains other information systems in addition to its Core Network and Supporting Network Related systems. These Supporting IT Infrastructure systems support other Business capabilities that supplement the other main systems basic functionality. These systems are shown in the following diagram along with the additional features that they provide.

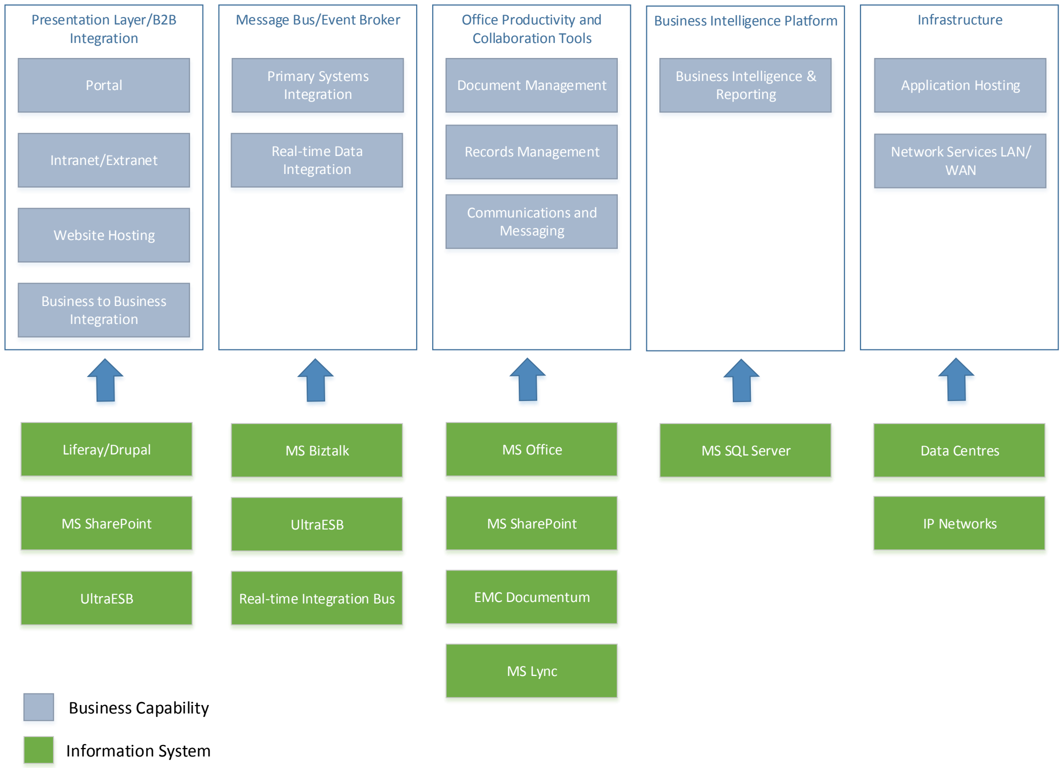

Figure 7-4 : Business Capabilities and Supporting IT Infrastructure Systems

7.3 Information and Data

Vectors Core Network and Supporting Network Information systems are used to manage data that is necessary for the effective day-to-day operation of its network assets and the ongoing planning activities relating to those assets.

The information can be divided into several categories;

- Asset
- Location
- Customer
- Order
- Financial
- Faults and Maintenance
- Real-time Data and Measurements

These information categories are managed by Vectors information systems as shown in the following diagram

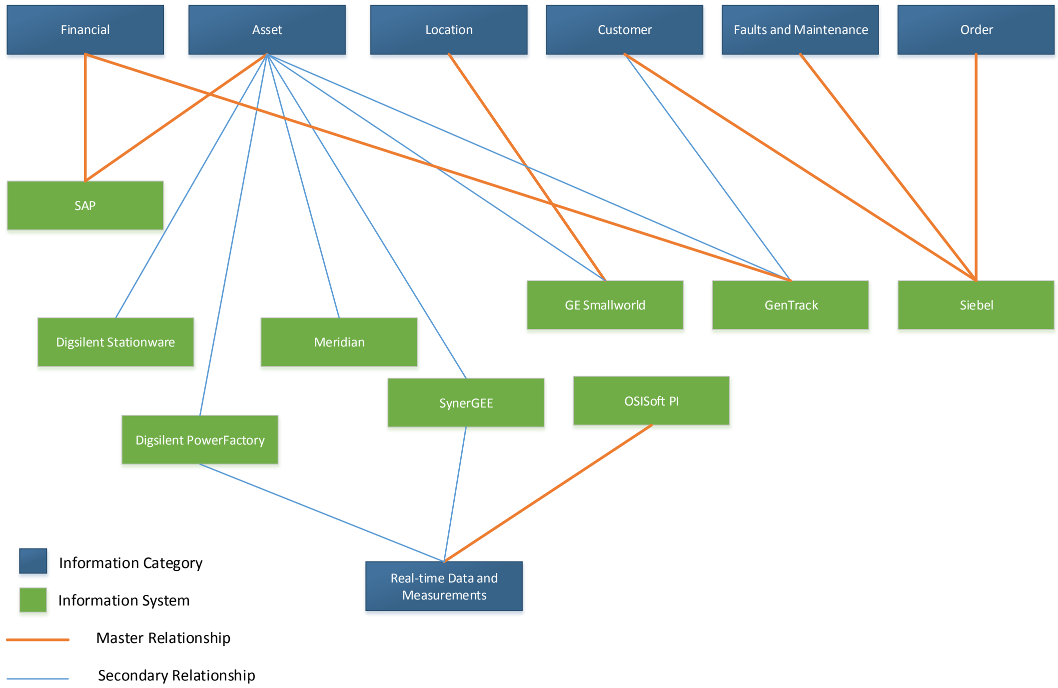

Figure 7-5 : Information and Systems Relationships

7.4 Information Systems Planning

Each component within the Vector IT Technical Reference Architecture has a collection of supporting architecture documents. These documents are referred to as "Architecture Artefacts". They are used to define the strategy, roadmap, and detailed reference architecture specific to each component.

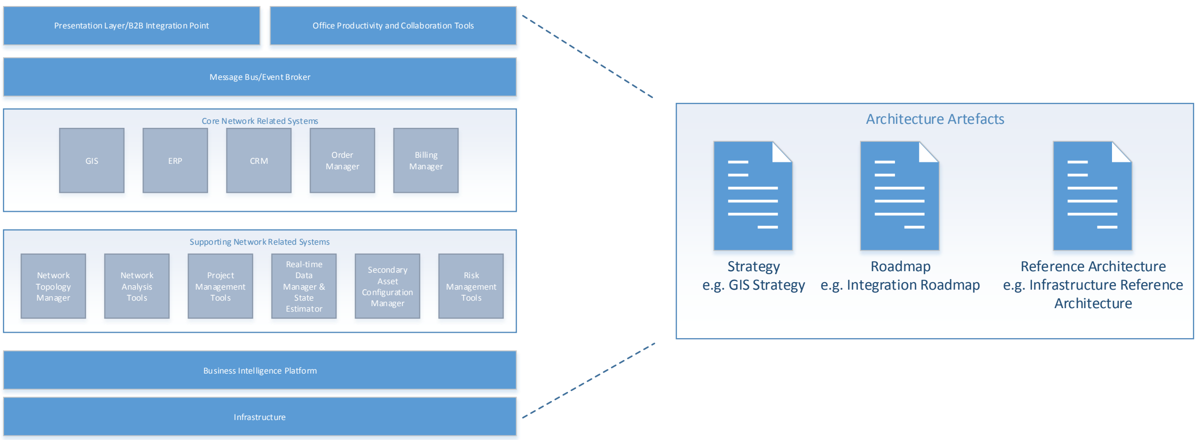

Figure 7-6 : Architecture Artefacts

These "Architecture Artefacts" are used to inform the investment planning for each Information Technology System and Infrastructure Component.

Financial modelling is also used in addition to these artefacts to ensure that IT investment decision making takes into account financial constraints such as total cost of ownership and IT asset depreciation.

7.5 Core Network Systems Planning

7.5.1 GIS

Vectors Geospatial Information (GIS) Systems Strategy is to ensure that all GIS solutions are fit for purpose and cost effective to maintain. Fit for Purpose GIS Solutions will allow Vector to leverage its spatial information assets without the systems becoming overly complex and costly. It will enable Vector to use its spatial information assets to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for GIS in the context of Electricity Distribution is to maintain the current platform, GE Smallworld, whilst investing in supporting technology components that will enable Vector to leverage its spatial information, for example integration and web viewing.

7.5.2 ERP

Vectors Enterprise Resource Planning (ERP) Systems Strategy is to ensure that all ERP solutions are fit for purpose and cost effective to maintain. Fit for Purpose ERP Solutions will allow Vector to leverage its asset information without the systems becoming overly complex and costly. It will enable Vector to use its asset information to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for ERP in the context of Electricity Distribution is to maintain the current platform, SAP (Plant Maintenance), whilst investing in supporting integration components.

7.5.3 CRM

Vectors Customer Relationship Management (CRM) Systems Strategy is to ensure that all CRM solutions are used “as designed” with the minimal amount of customisation. “As Designed” CRM Solutions will allow Vector to better serve its customers without the systems becoming overly complex and costly. It will enable Vector to interact with its customers effectively and efficiently so as to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for CRM in the context of Electricity Distribution is to instigate a review of the way the Siebel is used throughout the business and based on that review identify opportunities to improve the way the system used, and upgrade/replace components and customisations as required.

7.5.4 Order Manager

Vectors Order Manager Systems Strategy is to ensure that all Order Management solutions are used “as designed” with the minimal amount of customisation. “As Designed” Order Management Solutions will allow Vector to better fulfil its customers’ requirements without the systems becoming overly complex and costly. It will enable Vector to interact with its customers effectively and efficiently so as to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Order Manager in the context of Electricity Distribution is to instigate a review of the way the Siebel is used throughout the business and based on that review identify opportunities to improve the way the system used, and upgrade/replace components and customisations as required.

7.5.5 Billing Manager

Vectors Billing Manager Systems Strategy is to ensure that all Billing Management solutions are used "Fit for Purpose" for the billing requirements of the business. "Fit for Purpose" Billing Management Solutions will allow Vector to better control its billing processes without the systems becoming overly complex and costly. It will enable Vector execute its billing processes effectively and efficiently so as to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Billing Manager in the context of Electricity Distribution is to instigate a review of the way the Gentrack is used throughout the business and based on that review identify opportunities to improve the way the system used, and upgrade/replace components and customisations as required.

7.6 Supporting Network Systems Planning

7.6.1 Network Topology Manager

Vectors Network Topology Manager Systems Strategy is to ensure that all Network Topology Management solutions are "Fit for Purpose" and governable. "Fit for Purpose" Network Topology Management Solutions will allow Vector to optimise its network planning and operation processes. It will enable Vector to maintain its high standards of network planning and management so as to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Network Topology Manager in the context of Electricity Distribution is to complete the current review of the systems and processes that are used throughout the business and based on that review identify opportunities to improve the way these systems used, and upgrade/replace components as required.

7.6.2 Network Analysis Tools

Vectors Network Analysis Tools Strategy is to ensure that all Network Analysis solutions are "Fit for Purpose". "Fit for Purpose" Network Analysis Solutions will allow Vector to optimise its network planning and operation processes. It will enable Vector to maintain its high standards of network planning and management so as to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Network Analysis Tools in the context of Electricity Distribution is to complete the current review of the systems and processes that are used throughout the business and based on that review identify opportunities to improve the way these systems used, and consolidate these systems on to a single Network Analysis technology platform. This review will be informed by the fact that as Distributed Generation increase, more constraints will be placed on the LV network assets. The review will involve an assessment of LV analysis functionality.

7.6.3 Project Management Tools

Vectors Project Management Tools Strategy is to review the current toolset, that is, MS Project Server and ensure that it is still "fit-for-purpose". Based on the outcome of that review, Vector will either upgrade MS Project Server or migrate onto another project management toolset.

7.6.4 Real-time Data Manager and State Estimator

Vectors Real-time Data Manager and State Estimator Strategy is to ensure that all Real-time Data Management and Analysis solutions are "Fit for Purpose". "Fit for Purpose" Real-time Data Management and Analysis solutions will allow Vector to optimise its network planning and operation processes. It will enable Vector to maintain its high standards of network planning and management so as to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Real-time Data Management and Analysis solutions in the context of Electricity Distribution is to instigate a review of the current Data Historian system and based on that review identify opportunities to improve the way these systems used, and upgrade/replace components as required. Once the Real-time Data Historian review and improvements are complete Vector will then start the process of deciding whether or not a State Estimator solution is required.

7.6.5 Secondary Asset Configuration Manager

Vectors Secondary Asset Configuration Manager Strategy is to maintain the current fit for purpose toolset, that is, Digsilent Stationware.

7.6.6 Risk Management Tools

Vectors Risk Management Tools strategy is to maintain the current framework and implement a new platform for risk analysis, assessment, management and reporting. The current toolset for Risk Analysis is Bow Tie, the current platform used for Incident Management is Kairos/RIMS. The new IT platform for Risk, Audit and Compliance is ARM which is under implementation.

7.7 Supporting IT Infrastructure Systems

7.7.1 Presentation Layer/B2B Integration

Vectors Presentation Layer/B2B Integration Strategy is to implement a consistent, cost effective, and supportable Portal and B2B technology set that will allow the Vector to expose the functionality of its systems to the appropriate stakeholders.

Development, Maintenance & Renewal Roadmap

The roadmap for Presentation Layer/B2B Integration in the context of Electricity Distribution is to migrate from our existing Portal Platform based on Liferay, to a CMS based portal solution. Vector will then migrate all relevant Intranet and Extranet sites onto the new platform. Alongside this Vector will continue to extend our B2B platform based on UltraESB and the migration of its current B2B interfaces onto that new platform.

7.7.2 Message Bus/Event Broker

Vectors Integration Strategy is to ensure that all systems integration solutions are user requirements lead, cost effective, and maintainable. User Requirements Lead Integration Solutions will allow Vector to leverage its information assets across its systems without the integration component becoming overly complex and costly. It will enable Vector to leverage the benefits of an integrated systems environment to achieve our customer & regulatory outcomes, increase our operational efficiency, to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Integration in the context of Electricity Distribution is to continue to use the current UltraESB platform. All current integration points between corporate systems will continue to be migrated to this platform over time. The Real-time Integration Bus used in the operational technology environment will continue to be maintained as the strategic integration platform for network device integration.

7.7.3 Office Productivity and Collaboration Tools

Vectors Office Productivity and Collaboration Tools Strategy is to maintain the current fit for purpose toolset, that is, MS Office and MS SharePoint. Vector will migrate all Records Management functionality and information off EMC Documentum over the next year and onto MS SharePoint. EMC Documentum will be retired once this migration is complete. Cloud options are currently being assessed and it is possible that some of the minor office productivity solutions may be migrated into a cloud solution.

7.7.4 Business Intelligence

Vectors Business Intelligence Strategy is to ensure that all Business Intelligence solutions are business requirements lead, cost effective, and maintainable. Requirements Lead Business Intelligence Solutions will allow Vector to report on its day to day operations effective and optimise the mechanisms that it uses to fulfil its compliance reporting obligations. It will enable Vector to understand the details of its operations and inform decision making relating to the achievement of our customer & regulatory outcomes, improvements in operational efficiency, and enable Vector to identify opportunities for disciplined growth and improvements in our cost efficiency.

Development, Maintenance & Renewal Roadmap

The roadmap for Business Intelligence in the context of Electricity Distribution is maintain and extend the use of the MS SQL Server platform and toolset. Visualisation tools will also be introduced over time as the tools and platform become embedded in the way reporting is performed by the business.

7.7.5 IT Infrastructure Strategy

Vectors IT Infrastructure Strategy is to maintain the current fit for purpose IT infrastructure environment which includes servers, network hardware, security specific hardware/software, operating systems, and other supporting infrastructure tools. The infrastructure will be invested in to ensure that it is able to support the growth of Vector but not exceed the actual infrastructure requirements. It is likely that Vector may need to assess its data centre investments at the 5 year point and decide whether or not investing in another data centre is necessary.

Electricity
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2016 – 2026

Risk Management– Section 8

[Disclosure AMP]

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8 Risk Management

Vector’s goal is to maintain robust and innovative risk management practices, consistent with the ISO31000 standard and implement those practices in a manner appropriate for a leading New Zealand publicly-listed company that supplies critical infrastructure and manages potentially hazardous products.

Risk and assurance management also underpins Vector’s ability to meet its compliance obligations. Vector takes this responsibility seriously and has effective risk management processes in place covering hazard identification (see below), risk assessment and the treatment, monitoring and review of hazards.

8.1 Enterprise Risk Management

Risk management is integral to Vector’s asset management process and core operational capabilities. Vector’s risk management policy sets out the company’s intentions and directions with respect to risk management, including its objectives and rationale around decision making.

Vector’s Enterprise Risk Management (ERM) framework provides the method and processes to be applied Vector-wide to manage risk and assess opportunities against the company’s objectives. The framework is based on AS/NZS ISO31000:2009 and is illustrated in Figure 8-1 below.

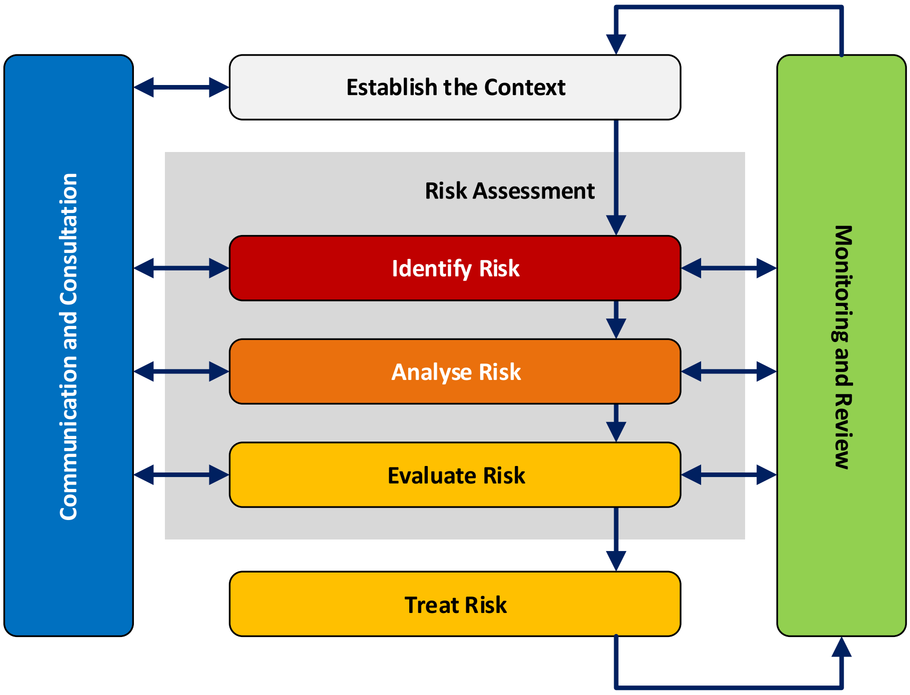

Figure 8-1 : Vector’s risk management process (based on ISO31000: 2009)

The level of a risk is determined by considering the combination of the “likelihood” (i.e. rare, unlikely, likely or almost certain) and “consequences” (i.e. minor, moderate, major or catastrophic) of the risk occurring, given its existing controls, and applying the risk matrix assessment (a 4x4 heat map) in Figure 8-2, below.

	Minor	Moderate	Major	Catastrophic
Almost Certain	M	H	VH	VH
Likely	L	M	H	VH
Unlikely	L	M	H	VH
Rare	L	L	M	H

Very High	Risks significantly exceed Vector's risk appetite; immediate escalation for Board attention along with detailed treatment plans to reduce overall risk
High	Risks exceed Vector's risk appetite; escalation for Board attention along with detailed treatment plans to reduce overall risk
Medium	Risks within Vector's risk appetite; but active monitoring required by Management
Low	Risks that can be managed as part of business as usual

Figure 8-2 : Vector's risk assessment matrix

Best practice with respect to setting risk appetite starts with a top-down view from the board (which has an enterprise-wide perspective) in order to set the cultural context for the organisation. As the board holds the ultimate accountability for risk governance and oversight, this approach enables the board to facilitate the alignment of risk management to the group strategy.

Vector has controls in place to manage key risks and has internal review processes associated with these controls. A key component of the assurance process is Vector's internal audit programme which provides assurance around significant controls in the business including organisation-wide 'risk management' – for example, business continuity management. The Internal Audit programme is overseen by the BRAC (Board Risk and Assurance Committee).

8.1.1 Key Operational Risks

The most significant electricity risks reported to the board that Vector has identified in its asset management risk register are noted below (in no particular order). While control and mitigation measures are in place to address these (through various programmes of work and capital projects), work is always ongoing to improve the controls and to ensure they remain effective.

- Network Disruption
- Serious injury, chronic disease or fatality
- Potential for a higher frequency of existing asset failure during network transformation

In addition the management team specifically track emerging risks that may threaten the business in the near future. The current register of emerging risks (in no particular order) is:

- Negative impacts of regulation including
    - Not adequately catering for future business risks;
    - Not reflecting customers changing needs ; and
    - Not adequately recognising environmental variability (eg: weather)
- Unsuccessful end to end delivery of key programmes of work
- Speed of technology change impacting the value of or positioning of regulated networks including
    - Customers energy requirements changing rapidly and unpredictably
    - Customer adoption of alternative non-regulated products
    - Increasing impact of cyber-security threats
- Mis-alignment of field service provider engagement model with Networks' strategy
- Material breach of regulatory requirements
- Organisational impacts of business changes and failure to build a leadership culture that supports strategic objectives
- Inability to forecast future needs of customers

8.1.2 Failure Mode Analyses and Control Mechanisms

In addition to the executive level risks above, Vector's Asset Resilience group has also completed detailed risk reviews that assess the possible modes of failure of each asset type. The risks identified are analysed and controlled through maintenance standards and operational controls (e.g. cable ratings).

Vector's Network Services group manages the operational delivery of the strategy. This includes delivery in the field of the requisite levels of maintenance and capital development to ensure the network meets the stated risk rated reliability, safety, environmental and performance standards. The Network Services group also manages the safe and reliable operation of the network to predefined levels.

8.2 High Impact, Low Probability Risks

Vector has recently undertaken a risk review at all Transpower supply points (or Grid Exit Points) focused specifically on Vector assets. The supply points exhibit a high level of potential risk due to the large number of customers that are fed from each supply point. This review, which included a detailed site visit by Vector and Transpower engineers, specifically looked to assess the vulnerability of assets to possible high impact, low probability (HILP) events and focused on identifying and documenting risks that pose a significant threat to Vector assets. The review highlighted a number of key observations that could lead to possible HILP events; a summary of the most significant are recorded below:

- Fire risks: An inconsistency was observed in the use of fire doors to separate critical assets. Fire stopping material was also inconsistently applied around assets that passed through internal fixtures (e.g. walls or bulkheads).
- Segregation / Single Point of Failure risks: Observations were made regarding the design and layout of some areas within sites where multiple assets were located in close proximity.
- Seismic risks: Inconsistencies were observed in the use of bracing on panels and seismic support for assets.
- Other individual HILP related observations were noted that were specific to each site.

Asset management controls are implemented where possible across the network in the form of design practices and standards to maintain a resilient network and to mitigate the possibility of HILP events occurring. However, in some cases, suitable controls are not economically practical (noting the very low likelihood of these risks materialising). It was also noted that the controls in some areas are inconsistently applied (in part due to differing age of construction works and the standards in use at that time). In light of the recent HILP assessment, Vector is currently undergoing a review to revise all possible HILP event controls where applicable and practical.

Similar reviews are also currently being conducted at Vector's zone substations. With over 100 zone substations located throughout the greater Auckland area, a risk strategy has been adopted to prioritise the reviews based on the possible consequence of a HILP event occurring / significant loss of supply at each site. The prioritisation criteria includes the following categories which are weighted and scored for each zone substation:

- Current level of redundancy through backfeed.
- Number of customers supplied by the substation.
- Current demand on the substation (kWh)
- Installed capacity of the substation (MVA)
- Voltage level of the substation (kV)

By adopting this approach, the most critical zone substations have already been assessed through the review of sites with the highest scores (completed 31 March 2016). The remaining sites are expected to be assessed over the next two years. Each risk review includes a detailed on-site inspection by Vector engineers to assess the vulnerability of assets to a HILP event. All risks are recorded and controlled where practical.

8.2.1 Projects & Initiatives

Vector continues to look to enhance the integration of the risk management process into its core planning and prioritisation activities. It is recognised that many of the risk control or mitigation measures require capital investments that is largely driven by risk-associated factors.

Anticipated asset and infrastructure risks identified in the risk register that can be treated by capital investment are included in the 10 year capital works programme (capital expenditure forecasts). Other residual risks are controlled / mitigated through a maintenance programme of works. These projects are part of the corrective or reactive maintenance programme.

Vector is currently reviewing its systems to improve the linkage and integration of risk management into its investment approval processes. A dedicated role was created within Vector's asset management function to lead this initiative. The role, Principal Advisor – Network Performance and Risk, took effect in early FY 2016 and has focused on further developing Vector's risk profile and investment strategy.

8.3 Emergency Response and Contingency Plans

Vector has a number of plans to cover emergency situations. These plans are reviewed and updated regularly to ensure they are current. The more pertinent of these plans are further described below.

8.3.1 Emergency Response Plan

The purpose of the emergency response plan is to ensure Vector is prepared for, and responds quickly to, any major incident that occurs or may occur on the electricity network. The plan describes the actions required and the responsibilities of staff during a major incident.

A key component of the plan is the formation of the emergency response team. This team includes senior staff who are required to oversee the management of potential loss (and restoration) of supply following a significant event. The team undertakes exercises periodically, at least annually.

This plan will be reviewed annually to ensure there is continuous improvement and a standardised approach to all operational incidents across the group.

8.3.2 Switching Plans

For all major distribution feeders, the network is designed to allow reconfiguration by switching so supply can be restored through an alternative path if there is a failure or a need to shift load. Distribution switching may be carried out remotely via SCADA at all zone substations and selected distribution sites. Vector has an ongoing programme to increase the number of remotely operated distribution High Voltage (HV) switches. This enables faster restoration of the power supply by not having to send field staff to operate switches.

In the event of a supply failure on any distribution feeder, the control room staff undertake network analysis and restore power to as many customers as possible by a combination of remote switch operations from the control room; they also instruct field staff to manually operate field switches.

The control room has pre-prepared contingency switching plans for major outages such as complete loss of a zone substation.

There are 210 contingency plans for the Auckland region. Generally these relate to events that have a "very high" classification within the risk matrix (see Figure 8-2), which corresponds with the loss of a zone substation or critical sub-transmission feeder. These contingency plans are reviewed once a year.

8.3.3 Electricity Operations Centre Emergency Evacuation Plan

The purpose of the electricity operations centre emergency evacuation plan is to ensure that Vector's network control centre is prepared for, and responds quickly to, any incident that requires the short, medium or long-term evacuation of the electricity operations centre.

The plan describes actions and responsibilities of staff during an evacuation and focuses on continuously improving systems and communications (internal and external) to ensure the management and operation of the electricity network is maintained.

The Vector network control centre has a fully operational disaster recovery site. Regular evacuation exercises are held to ensure evacuation of the control centre can proceed smoothly and at any time.

8.3.4 Emergency Load Shedding Obligations

Vector is required, under the Electricity Industry Participation Code (2010), to provide two forms of load-shedding. The first is the Rolling Outage Plan which is designed to reduce system load during a grid emergency, when requested by System Operator. This process is achieved by tripping selected feeders until the target load reduction nominated by the System Operator is achieved. The second form of load-shedding occurs automatically (Automatic Under-frequency Load Shedding (AUFLS)) when the grid frequency drops below frequency thresholds set out in the Electricity Industry Participation Code. Vector's response to the fall in frequency is to shed two blocks of pre-selected load each comprising of 16% of the total load on Vector at the time of initiation. Its purpose is to maintain the electrical security of the grid and avoid cascade tripping under emergency conditions.

8.3.5 Participant Outage Plan

As a result of the Electricity Industry Participation Code 2010 (Code), the System Operator has prepared a System Operator Rolling Outage Plan (SOROP). Vector is a specified participant and is required to produce a Participant Rolling Outage Plan (PROP), as specified in the SOROP.

Under the Code, PROPs are required to specify the actions that would be taken to reduce the consumption of electricity in order to:

- Reduce electricity consumption when requested by the System Operator;
- Comply with requirements of the SOROP;
- Comply with the Code; and
- Supplement the SOROP.

8.3.6 Business Continuity Management

Business continuity management (BCM) is integral to Vector's risk management framework. BCM provides the support the organisation needs to respond to, and be prepared for, any disruptive or critical incidents that might otherwise prevent Vector from achieving its objectives.

To achieve this, Vector strives to ensure that its BCM aims to:

- Ensure the continuity of critical business functions;
- Establish controls, processes and procedures to improve business continuity and to deliver results;
- Monitor and review performance against the policy objectives so that any necessary remedial actions can take place;
- Provide testing and training on a cyclical basis to help keep staff, roles and responsibilities up to date and prepared;
- Integrate BCM within wider corporate risk management approaches, policies, and procedures; and
- Ensure that Vector's approach is consistent with the following:
    - Australian / New Zealand Standard AS/NZ 5050/2010 Business Continuity – Managing disruption-related risk;
    - Civil Defence and Emergency Management (CDEM) Act 2002
    - AS/NZS ISO 31000:2009 Risk Management – Principles and guidelines.

The overall BCM framework and plan is developed and monitored by the Chief Risk Officer. Vector's overall BCM capability and programme activities are overseen by the ERAC.

The head of each business and functional unit is responsible for maintaining the appropriate BCM capability and compliance requirements for their areas. All employees are responsible for contributing to the maintenance of the BCM capability and to assist with the emergency/crisis response and recovery efforts in a real situation.

With respect to individual Business Continuity Plans (BCP) Vector's policies require appropriate governance aspects to be in place as well as each plan to have certain components.

Call Centre Business Continuity Plan

Vector's call centre provider is Telnet Services. Telnet's business relies heavily on various computer and telephony technologies that, by their very nature, have the potential to fail.

The purpose of the call centre BCP is to assess the potential risks and planned workarounds for those risks in order that Telnet's core business can continue in the event of any failure or disaster. In addition to the general BCP strategy employed at Telnet, there are a number of specific provisions as part of Telnet's relationship with Vector to provide additional services to ensure the continuity of service is maintained, specifically the handling of safety critical and emergency calls.

8.3.7 Crisis Management Plan

The crisis management plan (CMP) identifies procedures for a crisis affecting Vector, its customers and/or its employees, contractors and other stakeholders. The plan and procedures outlined in this document identify how Vector will manage the consequences of a crisis. It is designed to establish clear lines of communication and reporting, as well as action guidelines for the Vector Group.

The CMP is an "all hazards" plan as it encompasses the management of all possible crisis events. While the CMP procedures have been developed to cover a broad set of circumstances, Vector is mindful that every crisis has its own unique set of circumstances. Thus, each crisis relies on the good judgement of Vector employees to tailor the response and management to what is most appropriate given the circumstances at hand.

The CMP is not intended to cover operational emergency response requirements, as these are covered by the relevant emergency response plans – Vector has individual emergency response plans for major events. Together the CMP plan and emergency response plans better enable staff to fulfil their roles as efficiently and safely as possible, and to ensure the wider public implications of an emergency are identified and addressed.

Crisis Communication Plan

Vector's crisis communications plan aims to ensure that it is prepared to manage unforeseen events and gain, or retain, public confidence in its management of the situation and is part of the overarching CMP.

The Plan seeks to achieve this by ensuring that in any emergency, crisis or business continuity event affecting Vector, Vector's customers, the affected community and other stakeholders are kept well-informed and up-to-date of:

- The status of the crisis;
- Any actions they can or should take to mitigate the effect or consequences of the emergency / crisis;
- When the situation is expected to be (or is) resolved;
- Updates to the above to reflect any changes to the situation; and
- Post-crisis debriefs or any follow up information.

The plan is designed as a template that can be tailored to the management response requirements determined by the particular nature of the emergency, crisis or business continuity event. It is designed to provide a consistent, robust and scalable approach to communications.

8.3.8 Civil Defence and Emergency Management

As a "lifeline utility" under the Civil Defence and Emergency Management Act 2002 (CDEM), Vector is required to be "able to function to the fullest possible extent, even if this may be at a reduced level, during and after an emergency". Vector also is required to have plans regarding how it will function during and after an emergency and to participate in the development of a CDEM strategy and BCPs.

As discussed above, Vector has a number of BCPs in place as well as an overall crisis plan. Vector participates in CDEM emergency exercises on a regular basis to ensure CDEM protocols are understood, as well as to test aspects of Vector emergency and BCP plans.

Vector is a member of the Auckland Lifelines Group (ALG), as well as a number of lifeline groups throughout New Zealand. Membership in the ALG helps ensure Vector keeps abreast of developments in the CDEM area and that it is fully prepared for emergencies arising from identified threats including volcanic eruption, tsunami, earthquake, tropical cyclones and storms, both in general and in particular as they relate to Auckland where it has network assets.

A key area of focus for Vector is to better utilise information from the ALG and from other Lifelines groups around the country.

Vector is also a member of the National Engineering Lifelines Committee and keeps abreast of national issues and initiatives through this forum.

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Financial Performance & Forecasts – Section 9

[Disclosure AMP]

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9 Financial Performance & Forecasts

This section describes the capital and operational expenditure forecasts for the electricity distribution network assets for the next 10 year planning period (2016-2026), and provides a comparison with the 10 year forecast prepared and disclosed in the 2015 AMP Update (disclosed in March 2015). These forecasts are applicable to the development, maintenance, replacement and management of network assets.

9.1 Capital Expenditure

Vector's electricity distribution capex forecast for the next ten financial years (ending 30th June) is presented in graphical form in Figure 0-1 below in 2017 prices and is broken down by regulatory category as per Schedule 11a (see Appendix).

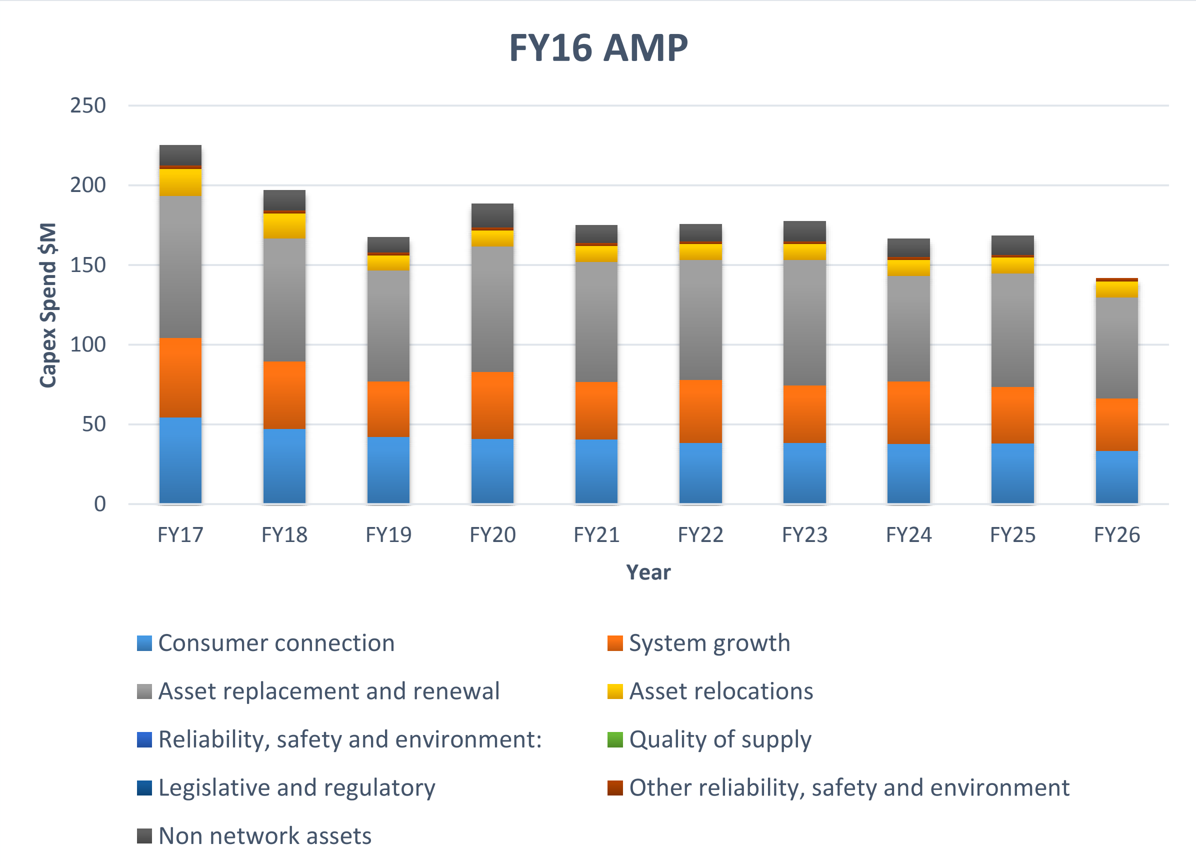


Figure 0-1 : Forecast capital expenditure

9.1.1 Comparison to Previous AMPs

This section highlights the significant changes to the 2015 disclosed expenditure forecasts[1]. Figure 0-2 below shows the difference between the 2015 and 2016 AMP expenditure forecasts, with Figure 0-3 breaking down the variance by expenditure categories.

[1] The figures are inflation adjusted.

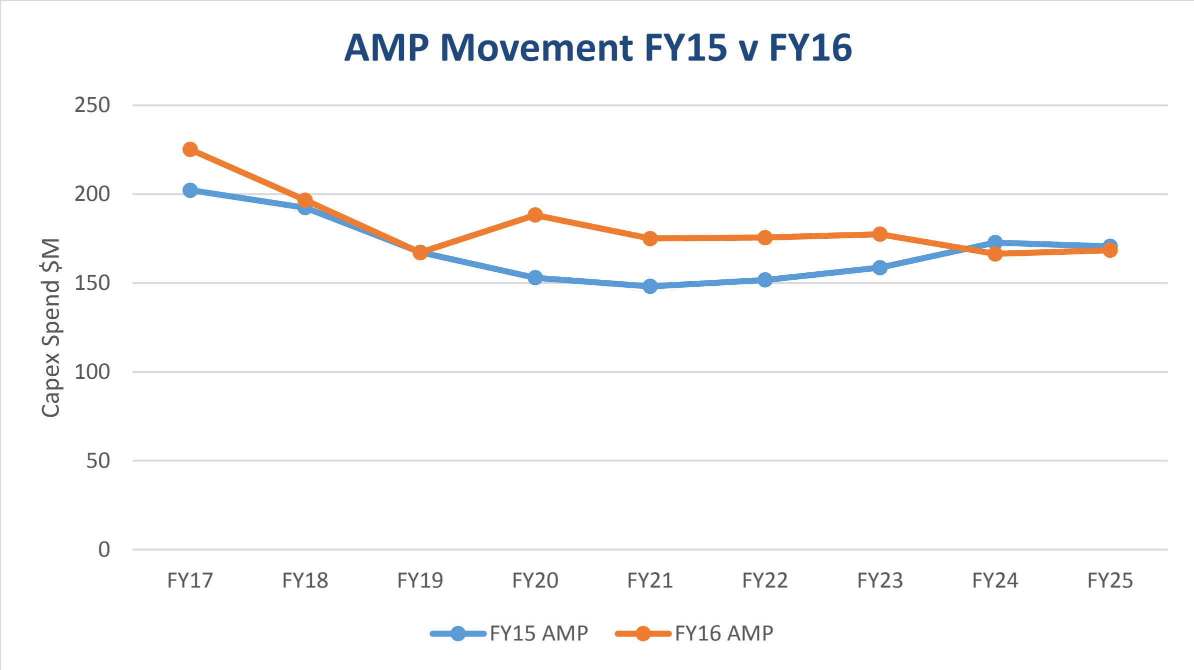


Figure 0-2 : Comparison between this AMP and the previous AMP's capex forecast

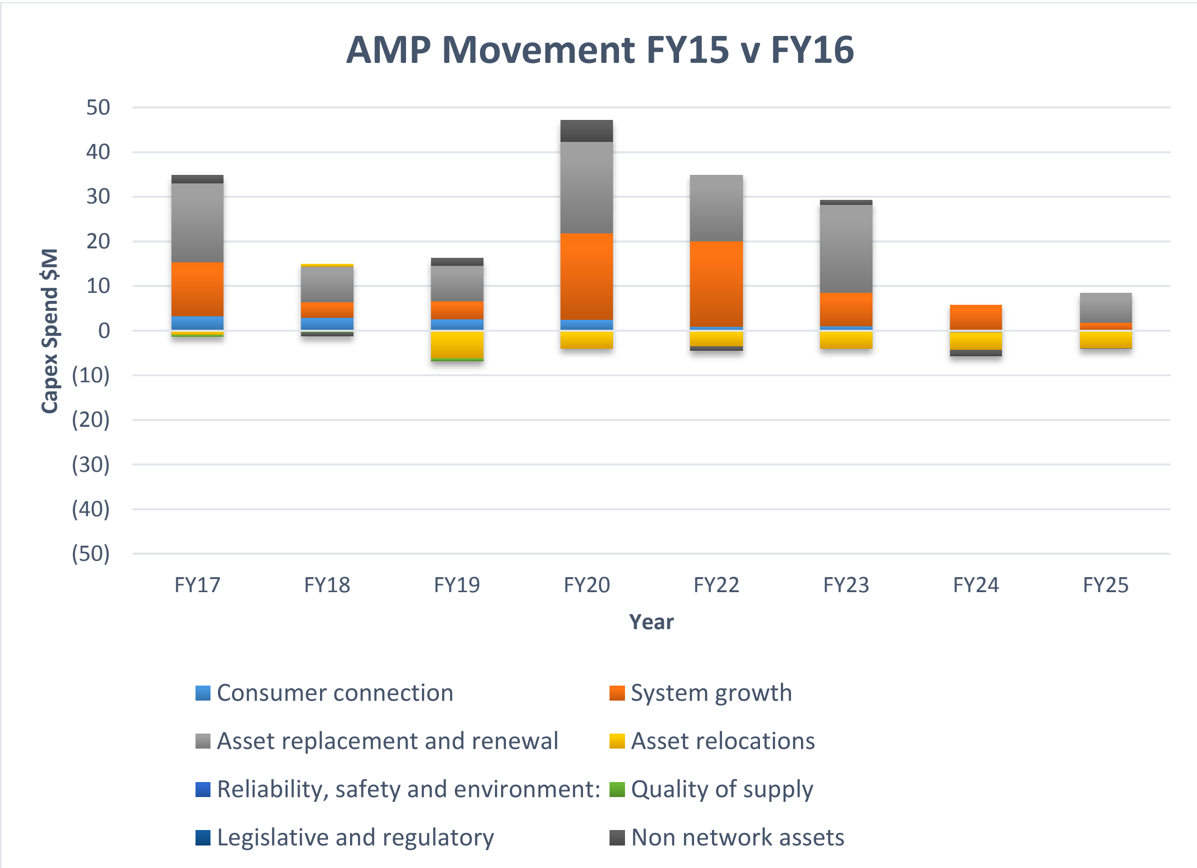


Figure 0-3 : Variance between this AMP and the previous AMP's capex forecast

As noted earlier in the AMP, there is increased uncertainty in future consumer needs and the impact of new technologies on Vector's investment strategy. The movements above represent the results of updated forecast assumptions and asset condition profiles.

9.2 Maintenance and Operational Expenditure

The maintenance expenditure forecast for the AMP planning period is presented in Figure 9-4 below, broken down into the asset categories defined in clause 4.5 of Attachment A of the Commerce Commission's Electricity Distribution Information Disclosure Determination. All forecasts are expressed in real 2017 dollars, and is repeated in tabulated form in Schedule 11b (see Appendix).

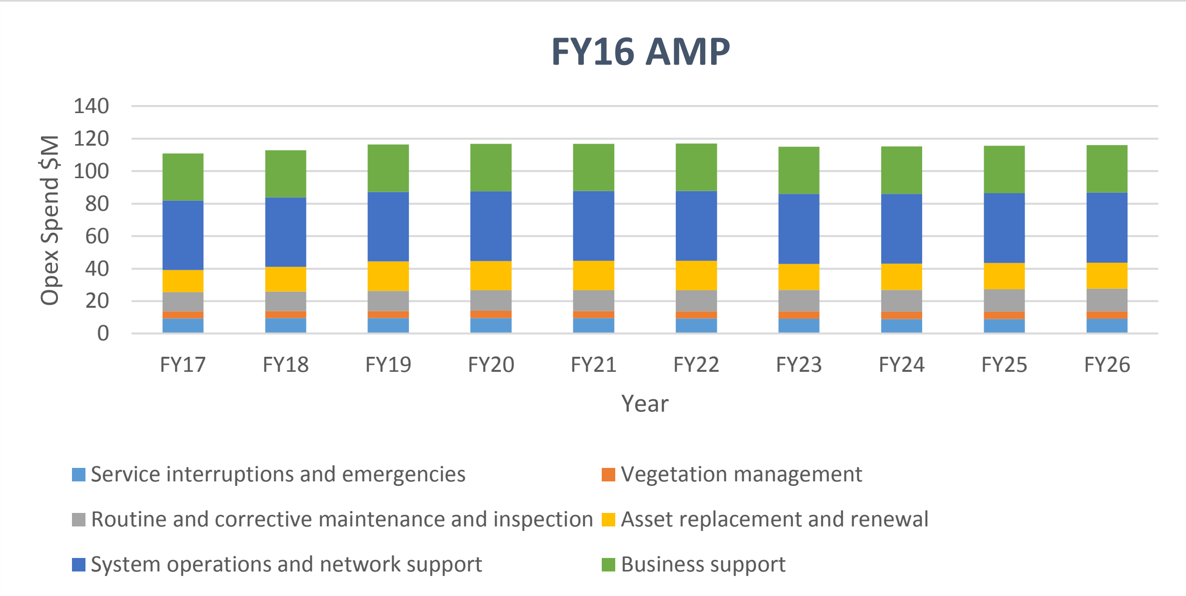
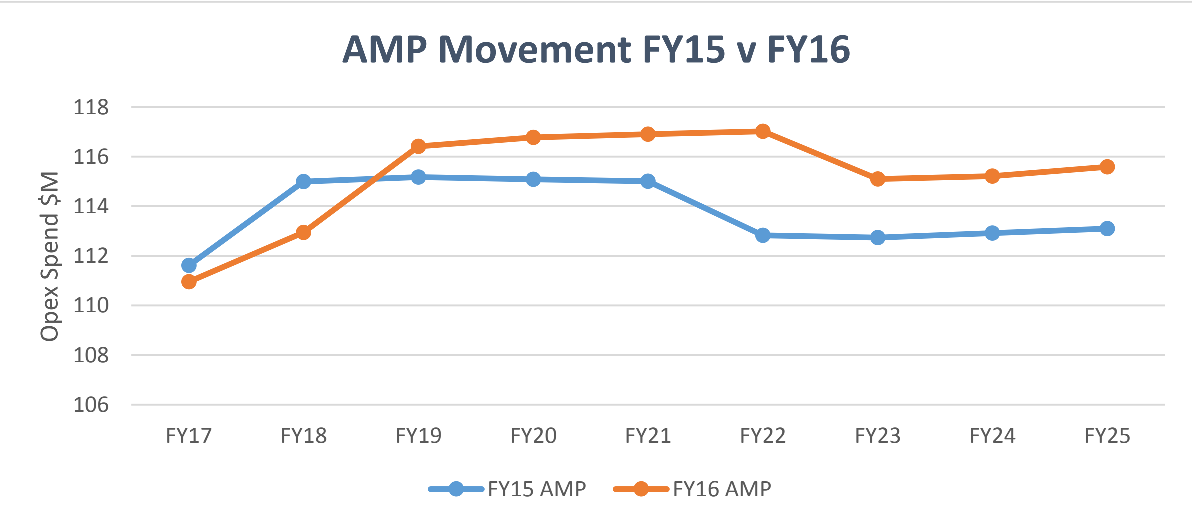


Figure 0-4 : Operational Expenditure Forecast for next 10 years

9.2.1 Comparison to Previous AMPs

This section highlights the significant changes to the 2015 disclosed expenditure forecasts[2].



[2] The figures are inflation adjusted.

Figure 0-5 below shows the difference between the 2015 and 2016 Schedule 11b expenditure forecasts, with Figure 0-6 breaking down the variance by expenditure categories.

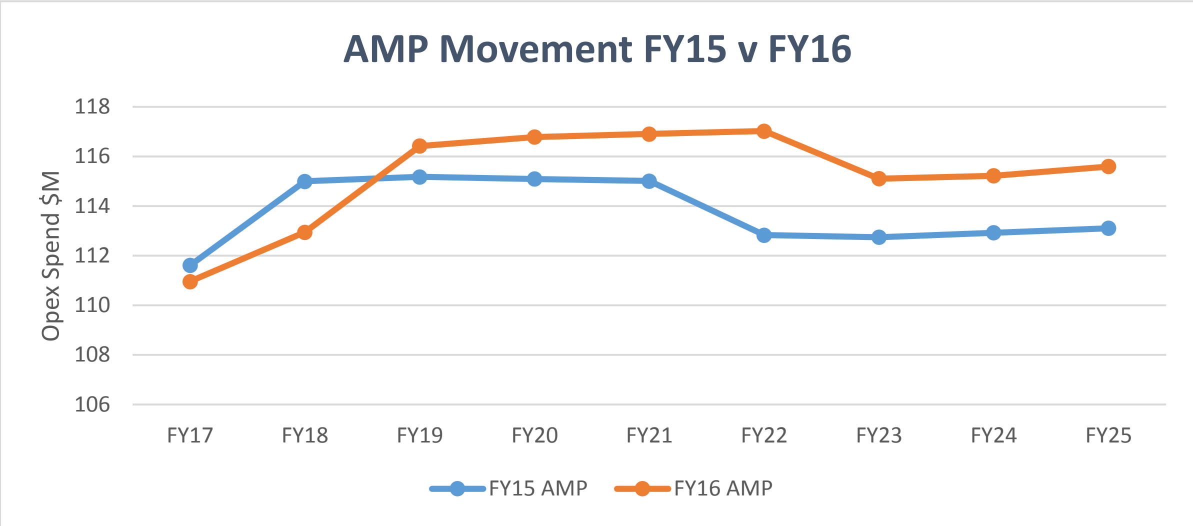


Figure 0-5 : Comparison between this AMP and the previous AMP's opex forecast

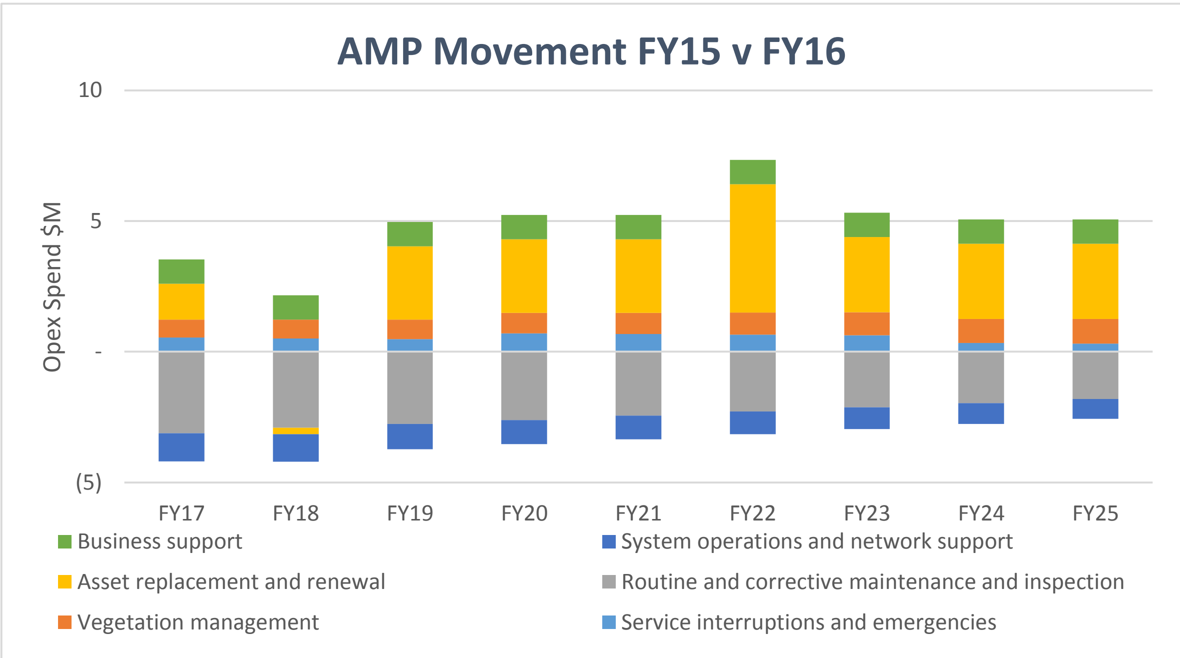


Figure 0-6 : Variance between this AMP and the previous AMP's opex

Changes are generally minor and representative of updated assessment data on asset condition and minor changes in failure and performance statistics for the network.

Electricity Asset Management Plan 2016-2026

Appendices

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Appendices

Appendix 1
IDD Schedules 11-14a

Schedule 11a Report on Forecast Capital Expenditure

Company Name: Vector Electricity
AMP Planning Period: 1 April 2015 to 31 March 2026

SCHEDULE 11a: REPORT ON FORECAST CAPITAL EXPENDITURE

This schedule requires a breakdown of forecast expenditure on assets for the current disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms. Also required is a forecast of the value of commissioned assets (i.e., the value of RAB additions)
EDBs must provide explanatory comment on the difference between constant price and nominal dollar forecasts of expenditure on assets in Schedule 14a (Mandatory Explanatory Notes).
This information is not part of audited disclosure information.

sch ref			Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
8			RY16	RY17	RY18	RY19	RY20	RY21	RY22	RY23	RY24	RY25	RY26
9		**11a(i): Expenditure on Assets Forecast**	**$000 (in nominal dollars)**										
10		Consumer connection	41,873	40,292	49,485	44,650	43,247	43,609	42,694	43,130	43,564	44,649	41,426
11		System growth	26,035	46,490	41,637	36,193	40,966	39,358	41,278	40,344	42,448	41,459	39,015
12		Asset replacement and renewal	64,499	73,887	79,928	73,576	80,598	82,184	82,900	87,743	79,840	81,999	78,602
13		Asset relocations	19,214	18,609	14,858	11,166	10,201	10,862	11,107	11,351	11,596	11,850	12,114
14		Reliability, safety and environment:											
15		Quality of supply	775	-	-	-	-	-	-	-	-	-	-
16		Legislative and regulatory	768	82	-	-	-	-	-	-	-	-	-
17		Other reliability, safety and environment	1,358	1,457	1,872	1,739	1,733	1,771	1,811	1,851	2,083	2,005	1,975
18		**Total reliability, safety and environment**	2,901	1,539	1,872	1,739	1,733	1,771	1,811	1,851	2,083	2,005	1,975
19		**Expenditure on network assets**	154,522	180,817	187,780	167,324	176,745	177,784	179,790	184,419	179,531	181,962	173,132
20		Non-network assets	7,440	11,356	12,508	10,308	14,047	13,292	12,522	12,083	13,726	13,561	14,208
21		**Expenditure on assets**	161,962	192,173	200,288	177,632	190,792	191,076	192,312	196,502	193,257	195,523	187,340
22													
23	*plus*	Cost of financing	3,034	4,117	4,036	3,542	3,851	3,800	3,885	3,898	3,954	3,944	3,755
24	*less*	Value of capital contributions	34,322	35,790	40,821	36,162	34,855	35,743	35,379	35,842	36,179	37,038	35,033
25	*plus*	Value of vested assets											
26													
27		**Capital expenditure forecast**	130,674	160,500	163,503	145,012	159,788	159,133	160,818	164,558	161,032	162,429	156,062
28													
29		Value of commissioned assets	161,506	158,795	163,878	156,896	153,552	161,073	150,103	177,590	168,232	156,913	168,226

sch ref			Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
32			**$000 (in constant prices)**										
33		Consumer connection	41,873	39,541	47,536	41,964	39,786	39,252	37,583	37,149	36,732	36,839	33,435
34		System growth	26,035	45,623	39,997	34,016	37,687	35,426	36,336	34,749	35,791	34,207	31,489
35		Asset replacement and renewal	64,499	72,509	76,780	69,150	74,147	73,973	72,975	75,575	67,319	67,656	63,440
36		Asset relocations	19,214	18,262	14,273	10,494	9,385	9,777	9,777	9,777	9,777	9,777	9,777
37		Reliability, safety and environment:											
38		Quality of supply	775	-	-	-	-	-	-	-	-	-	-
39		Legislative and regulatory	768	80	-	-	-	-	-	-	-	-	-
40		Other reliability, safety and environment	1,358	1,430	1,798	1,634	1,594	1,594	1,594	1,594	1,756	1,654	1,594
41		**Total reliability, safety and environment**	2,901	1,510	1,798	1,634	1,594	1,594	1,594	1,594	1,756	1,654	1,594
42		**Expenditure on network assets**	154,522	177,445	180,384	157,258	162,599	160,022	158,265	158,844	151,375	150,133	139,735
43		Non-network assets	7,440	11,144	12,015	9,688	12,923	11,964	11,023	10,407	11,573	11,189	11,467
44		**Expenditure on assets**	161,962	188,589	192,399	166,946	175,522	171,986	169,288	169,251	162,948	161,322	151,202
45													
46		**Subcomponents of expenditure on assets (where known)**											
47		Energy efficiency and demand side management, reduction of energy losses											
48		Overhead to underground conversion	8,697	3,537	4,716	4,716	4,716	4,716	4,716	4,716	4,716	4,716	4,716
49		Research and development	-	5,485	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	-

sch ref			Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
58													
59		**Difference between nominal and constant price forecasts**	**$000**										
60		Consumer connection	-	751	1,949	2,686	3,461	4,357	5,111	5,981	6,832	7,810	7,991
61		System growth	-	867	1,640	2,177	3,279	3,932	4,942	5,595	6,657	7,252	7,526
62		Asset replacement and renewal	-	1,378	3,148	4,426	6,451	8,211	9,925	12,168	12,521	14,343	15,162
63		Asset relocations	-	347	585	672	816	1,085	1,330	1,574	1,819	2,073	2,337
64		Reliability, safety and environment:											
65		Quality of supply	-	-	-	-	-	-	-	-	-	-	-
66		Legislative and regulatory	-	2	-	-	-	-	-	-	-	-	-
67		Other reliability, safety and environment	-	27	74	105	139	177	217	257	327	351	381
68		**Total reliability, safety and environment**	-	29	74	105	139	177	217	257	327	351	381
69		**Expenditure on network assets**	-	3,372	7,396	10,066	14,146	17,762	21,525	25,575	28,156	31,829	33,397
70		Non-network assets	-	212	493	620	1,124	1,328	1,499	1,676	2,153	2,372	2,741
71		**Expenditure on assets**	-	3,584	7,889	10,686	15,270	19,090	23,024	27,251	30,309	34,201	36,138
72													

sch ref			Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
74		**11a(ii): Consumer Connection**						
75		*Consumer types defined by EDB**	**$000 (in constant prices)**					
76		Service Connection	11,395	12,114	16,961	16,221	15,711	15,825
		Customer Substations	5,744	5,190	6,920	6,920	6,920	6,920
77		Business subdivisions	2,517	1,819	2,392	1,864	1,674	1,674
78		Residential Subdivisions	18,118	17,587	17,693	13,389	11,911	11,263
		Capacity Changes	2,962	2,148	2,863	2,863	2,863	2,863
79		Street Lighting	1,126	683	707	707	707	707
		Relocations	6	-	-	-	-	-
80		Easements	5	-	-	-	-	-
81		**include additional rows if needed*						
82		**Consumer connection expenditure**	41,873	39,541	47,536	41,964	39,786	39,252
83	*less*	Capital contributions funding consumer connection	27,368	26,002	32,889	30,164	28,976	28,823
84		**Consumer connection less capital contributions**	14,505	13,539	14,647	11,800	10,810	10,429
85		**11a(iii): System Growth**						
86		Subtransmission	3,424	2,850	2,886	4,872	5,815	5,205
87		Zone substations	8,321	18,947	18,147	11,768	13,206	14,113
88		Distribution and LV lines	197	772	143	-	-	-
89		Distribution and LV cables	8,499	12,110	7,306	5,914	6,885	6,582
90		Distribution substations and transformers	1,395	3,147	3,754	5,595	6,673	4,763
91		Distribution switchgear	925	2,449	3,200	2,910	2,852	2,877
92		Other network assets	3,274	5,348	4,561	2,957	2,256	1,886
93		**System growth expenditure**	26,035	45,623	39,997	34,016	37,687	35,426
94	*less*	Capital contributions funding system growth						
95		**System growth less capital contributions**	26,035	45,623	39,997	34,016	37,687	35,426

sch ref			Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
104								
105		**11a(iv): Asset Replacement and Renewal**	**$000 (in constant prices)**					
106		Subtransmission	1,480	8,030	5,185	4,203	5,324	5,402
107		Zone substations	18,276	22,049	14,732	11,483	12,108	12,361
108		Distribution and LV lines	21,571	21,062	28,083	25,830	25,079	25,436
109		Distribution and LV cables	5,586	3,046	4,167	4,120	5,199	5,294
110		Distribution substations and transformers	6,112	5,911	8,422	8,036	11,056	8,099
111		Distribution switchgear	5,642	6,704	8,899	8,886	8,872	11,669
112		Other network assets	5,832	5,707	7,292	6,592	6,509	5,712
113		**Asset replacement and renewal expenditure**	64,499	72,509	76,780	69,150	74,147	73,973
114	*less*	Capital contributions funding asset replacement and renewal						
115		**Asset replacement and renewal less capital contributions**	64,499	72,509	76,780	69,150	74,147	73,973

116	**11a(v):Asset Relocations**						
117	*Project or programme**						
118	Overground to underground conversions	8,697	3,537	4,716	4,716	4,716	4,716
119							
120							
121							
123	**include additional rows if needed*						
124	All other asset relocations projects or programmes	10,517	14,725	9,557	5,778	4,669	5,061
125	**Asset relocations expenditure**	19,214	18,262	14,273	10,494	9,385	9,777
126	*less* Capital contributions funding asset relocations	6,954	9,121	6,324	3,823	3,089	3,349
127	**Asset relocations less capital contributions**	12,260	9,141	7,949	6,671	6,296	6,428
128							
129	**11a(vi):Quality of Supply**						
130	*Project or programme**						
131							
132							
133							
134							
135							
136	**include additional rows if needed*						
137	All other quality of supply projects or programmes	775	-	-	-	-	-
138	**Quality of supply expenditure**	775	-	-	-	-	-
139	*less* Capital contributions funding quality of supply						
140	**Quality of supply less capital contributions**	775	-	-	-	-	-
141							
142	**11a(vii): Legislative and Regulatory**						
143	*Project or programme**						
144							
145							
146							
147							
148							
149	**include additional rows if needed*						
150	All other legislative and regulatory projects or programmes	768	80	-	-	-	-
151	**Legislative and regulatory expenditure**	768	80	-	-	-	-
152	*less* Capital contributions funding legislative and regulatory						
153	**Legislative and regulatory less capital contributions**	768	80	-	-	-	-
161							
162		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
163	**11a(viii): Other Reliability, Safety and Environment**						
164	*Project or programme**	**$000 (in constant prices)**					
165							
166							
167							
168							
169							
170	**include additional rows if needed*						
171	All other reliability, safety and environment projects or programmes	1,358	1,430	1,798	1,634	1,594	1,594
172	**Other reliability, safety and environment expenditure**	1,358	1,430	1,798	1,634	1,594	1,594
173	*less* Capital contributions funding other reliability, safety and environment						
174	**Other reliability, safety and environment less capital contributions**	1,358	1,430	1,798	1,634	1,594	1,594
175							
176							
177							
178	**11a(ix): Non-Network Assets**						
179	**Routine expenditure**						
180	*Project or programme**						
181							
182							
183							
184							
185							
186	**include additional rows if needed*						
187	All other routine expenditure projects or programmes	2,753	4,373	4,779	3,920	5,114	4,760
188	**Routine expenditure**	2,753	4,373	4,779	3,920	5,114	4,760
189	**Atypical expenditure**						
190	*Project or programme**						
191							
192							
193							
194							
195							
196	**include additional rows if needed*						
197	All other atypical projects or programmes	4,687	6,771	7,236	5,768	7,809	7,204
198	**Atypical expenditure**	4,687	6,771	7,236	5,768	7,809	7,204
199							
200	**Non-network assets expenditure**	7,440	11,144	12,015	9,688	12,923	11,964

Schedule 11b Report on Forecast Operational Expenditure

Company Name: Vector Electricity
AMP Planning Period: 1 April 2016- 31 March 2026

SCHEDULE 11b: REPORT ON FORECAST OPERATIONAL EXPENDITURE

This schedule requires a breakdown of forecast operational expenditure for the disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms.
EDBs must provide explanatory comment on the difference between constant price and nominal dollar operational expenditure forecasts in Schedule 14a (Mandatory Explanatory Notes).
This information is not part of audited disclosure information.

sch ref		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
8												
9	**Operational Expenditure Forecast**	**$000 (in nominal dollars)**										
10	Service interruptions and emergencies	7,888	9,387	9,676	9,965	10,263	10,361	10,388	10,409	10,426	10,665	10,986
11	Vegetation management	4,580	4,426	4,427	4,559	4,695	4,834	4,978	5,126	5,279	5,436	5,598
12	Routine and corrective maintenance and inspection	12,145	11,951	12,302	12,816	13,337	13,883	14,449	15,033	15,636	16,259	16,903
13	Asset replacement and renewal	13,351	13,529	14,999	18,120	19,334	19,759	20,194	18,898	18,721	19,133	19,554
14	**Network Opex**	37,963	39,294	41,404	45,459	47,628	48,837	50,008	49,466	50,062	51,492	53,040
15	System operations and network support	47,886	42,469	43,702	44,757	45,791	46,833	47,900	48,991	50,107	51,248	52,416
16	Business support	29,651	29,109	29,702	30,356	31,023	31,706	32,403	33,116	33,845	34,589	35,350
17	**Non-network opex**	77,537	71,578	73,404	75,112	76,814	78,539	80,303	82,107	83,952	85,838	87,767
18	**Operational expenditure**	115,500	110,872	114,809	120,572	124,442	127,376	130,311	131,573	134,013	137,330	140,807
19		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
20												
21		**$000 (in constant prices)**										
22	Service interruptions and emergencies	7,888	9,212	9,300	9,372	9,444	9,329	9,152	8,974	8,795	8,802	8,872
23	Vegetation management	4,580	4,344	4,256	4,288	4,320	4,353	4,386	4,419	4,453	4,486	4,521
24	Routine and corrective maintenance and inspection	12,145	11,728	11,825	12,053	12,274	12,501	12,730	12,959	13,189	13,420	13,651
25	Asset replacement and renewal	13,351	13,277	14,416	17,041	17,791	17,791	17,791	16,291	15,791	15,791	15,791
26	**Network Opex**	37,963	38,561	39,797	42,754	43,829	43,974	44,059	42,643	42,228	42,500	42,835
27	System operations and network support	47,886	41,677	42,005	42,093	42,138	42,170	42,202	42,234	42,266	42,298	42,331
28	Business support	29,651	28,566	28,549	28,549	28,549	28,549	28,549	28,549	28,549	28,549	28,549
29	**Non-network opex**	77,537	70,243	70,554	70,641	70,687	70,719	70,750	70,782	70,815	70,847	70,880
30	**Operational expenditure**	115,500	108,805	110,350	113,395	114,516	114,693	114,809	113,426	113,043	113,347	113,715
31	**Subcomponents of operational expenditure (where known)**											
32	Energy efficiency and demand side management, reduction of											
33	energy losses											
34	Direct billing*											
35	Research and Development											
36	Insurance	2,494	2,496	2,496	2,496	2,496	2,496	2,496	2,496	2,496	2,496	2,496
37	* Direct billing expenditure by suppliers that direct bill the majority of their consumers											
38												
39		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
40												
41	**Difference between nominal and real forecasts**	**$000**										
42	Service interruptions and emergencies	-	175	376	593	819	1,032	1,236	1,436	1,631	1,862	2,114
43	Vegetation management	-	83	172	271	374	481	592	707	826	949	1,077
44	Routine and corrective maintenance and inspection	-	223	478	763	1,064	1,382	1,719	2,073	2,447	2,839	3,252
45	Asset replacement and renewal	-	252	582	1,079	1,542	1,968	2,402	2,606	2,929	3,341	3,762
46	**Network Opex**	-	733	1,608	2,706	3,799	4,863	5,949	6,823	7,834	8,993	10,205
47	System operations and network support	-	792	1,697	2,664	3,653	4,663	5,698	6,757	7,841	8,950	10,085
48	Business support	-	543	1,153	1,807	2,475	3,157	3,855	4,568	5,296	6,041	6,802
49	**Non-network opex**	-	1,335	2,850	4,471	6,127	7,821	9,553	11,325	13,137	14,991	16,887
50	**Operational expenditure**	-	2,067	4,458	7,177	9,926	12,684	15,502	18,147	20,971	23,983	27,092

Schedule 12a Report on Asset Condition

SCHEDULE 12a: REPORT ON ASSET CONDITION

sch ref

sch ref	Voltage	Asset category	Asset class	Units	Grade 1	Grade 2	Grade 3	Grade 4	Grade unknown	Data accuracy (1–4)	% of asset forecast to be replaced in next 5 years
7					Asset condition at start of planning period (percentage of units by grade)						
10	All	Overhead Line	Concrete poles / steel structure	No.	0.0 %	0.2 %	62.5 %	37.3 %		4	6.1%
11	All	Overhead Line	Wood poles	No.	0.1 %	2.6 %	73.6 %	23.8 %		4	9.7%
12	All	Overhead Line	Other pole types	No.				100.0 %		4	-
13	HV	Subtransmission Line	Subtransmission OH up to 66kV conductor	km			87.4 %	12.6 %		3	-
14	HV	Subtransmission Line	Subtransmission OH 110kV+ conductor	km			72.1 %	27.9 %		3	-
15	HV	Subtransmission Cable	Subtransmission UG up to 66kV (XLPE)	km		0.2 %	11.3 %	88.5 %		2	0.5%
16	HV	Subtransmission Cable	Subtransmission UG up to 66kV (Oil pressurised)	km			82.9 %	17.1 %		2	-
17	HV	Subtransmission Cable	Subtransmission UG up to 66kV (Gas pressurised)	km			100.0 %			2	100.0%
18	HV	Subtransmission Cable	Subtransmission UG up to 66kV (PILC)	km			91.8 %	8.2 %		2	17.6%
19	HV	Subtransmission Cable	Subtransmission UG 110kV+ (XLPE)	km			0.0 %	100.0 %		2	-
20	HV	Subtransmission Cable	Subtransmission UG 110kV+ (Oil pressurised)	km			67.0 %	33.0 %		2	-
21	HV	Subtransmission Cable	Subtransmission UG 110kV+ (Gas Pressurised)	km						N/A	
22	HV	Subtransmission Cable	Subtransmission UG 110kV+ (PILC)	km						N/A	
23	HV	Subtransmission Cable	Subtransmission submarine cable	km			4.8 %	95.2 %		2	-
24	HV	Zone substation Buildings	Zone substations up to 66kV	No.		2.0 %	7.0 %	91.0 %		4	2.0%
25	HV	Zone substation Buildings	Zone substations 110kV+	No.			28.6 %	71.4 %		4	-
26	HV	Zone substation switchgear	22/33kV CB (Indoor)	No.			20.9 %	79.1 %		4	-
27	HV	Zone substation switchgear	22/33kV CB (Outdoor)	No.		1.2 %	65.9 %	32.9 %		4	1.2%
28	HV	Zone substation switchgear	33kV Switch (Ground Mounted)	No.						N/A	
29	HV	Zone substation switchgear	33kV Switch (Pole Mounted)	No.			96.0 %	4.0 %		4	-
30	HV	Zone substation switchgear	33kV RMU	No.				100.0%		4	
31	HV	Zone substation switchgear	50/66/110kV CB (Indoor)	No.				100.0%		4	
32	HV	Zone substation switchgear	50/66/110kV CB (Outdoor)	No.				100.0%		4	
33	HV	Zone substation switchgear	3.3/6.6/11/22kV CB (ground mounted)	No.		9.9 %	47.1 %	43.1 %		4	9.9%
34	HV	Zone substation switchgear	3.3/6.6/11/22kV CB (pole mounted)	No.						N/A	

sch ref	Voltage	Asset category	Asset class	Units	Grade 1	Grade 2	Grade 3	Grade 4	Grade unknown	Data accuracy (1–4)	% of asset forecast to be replaced in next 5 years
42					Asset condition at start of planning period (percentage of units by grade)						
45	HV	Zone Substation Transformer	Zone Substation Transformers	No.		2.4 %	52.4 %	45.2 %		4	4.8%
46	HV	Distribution Line	Distribution OH Open Wire Conductor	km		0.0 %	67.5 %	32.5 %		3	0.3%
47	HV	Distribution Line	Distribution OH Aerial Cable Conductor	km						N/A	-
48	HV	Distribution Line	SWER conductor	km						N/A	-
49	HV	Distribution Cable	Distribution UG XLPE or PVC	km	0.0 %	0.1 %	5.2 %	94.7 %		2	1.1%
50	HV	Distribution Cable	Distribution UG PILC	km	0.1 %	0.3 %	42.4 %	57.2 %		2	0.8%
51	HV	Distribution Cable	Distribution Submarine Cable	km			86.1 %	13.9 %		2	-
52	HV	Distribution switchgear	3.3/6.6/11/22kV CB (pole mounted) - reclosers and sec	No.	2.9 %		0.4 %	96.7 %		4	11.4%
53	HV	Distribution switchgear	3.3/6.6/11/22kV CB (Indoor)	No.			50.6 %	49.4 %		4	-
54	HV	Distribution switchgear	3.3/6.6/11/22kV Switches and fuses (pole mounted)	No.	1.8 %	1.8 %	53.9 %	42.5 %		4	9.1%
55	HV	Distribution switchgear	3.3/6.6/11/22kV Switch (ground mounted) - except RM	No.	0.7 %	1.1 %	68.3 %	29.9 %		3	8.0%
56	HV	Distribution switchgear	3.3/6.6/11/22kV RMU	No.	0.7 %	1.1 %	52.5 %	45.7 %		3	3.9%
57	HV	Distribution Transformer	Pole Mounted Transformer	No.	0.9 %	0.7 %	35.1 %	63.3 %		3	8.1%
58	HV	Distribution Transformer	Ground Mounted Transformer	No.	4.6 %	1.5 %	36.2 %	57.8 %		3	6.1%
59	HV	Distribution Transformer	Voltage regulators	No.				100.0 %		4	
60	HV	Distribution Substations	Ground Mounted Substation Housing	No.	2.5 %	2.0 %	74.7 %	20.8 %		4	4.4%
61	LV	LV Line	LV OH Conductor	km		0.0 %	78.3 %	21.7 %		3	0.2%
62	LV	LV Cable	LV UG Cable	km	0.0 %	0.2 %	37.8 %	62.0 %		2	0.2%
63	LV	LV Streetlighting	LV OH/UG Streetlight circuit	km					100.0%	1	0.1%
64	LV	Connections	OH/UG consumer service connections	No.					100.0%	1	-
65	All	Protection	Protection relays (electromechanical, solid state and numeric)	No.		2.4 %	52.2 %	45.4 %		3	2.4%
66	All	SCADA and communications	SCADA and communications equipment operating as a	Lot		7.7 %	30.9 %	61.4 %		4	7.7%
67	All	Capacitor Banks	Capacitors including controls	No.			83.7 %	16.3 %		3	-
68	All	Load Control	Centralised plant	Lot			100.0 %			4	-
69	All	Load Control	Relays	No.						N/A	-
70	All	Civils	Cable Tunnels	km			8.6 %	91.4 %		4	-

Schedule 12b Forecast Capacity

7 **12b(i): System Growth - Zone Substations**

Row	Existing Zone Substations	Current Peak Load (MVA)	Installed Firm Capacity (MVA)	Security of Supply Classification (type)	Transfer Capacity (MVA)	Utilisation of Installed Firm Capacity %	Installed Firm Capacity +5 years (MVA)	Utilisation of Installed Firm Capacity + 5yrs %	Installed Firm Capacity Constraint +5 years (cause)	Explanation
9	[1] *Extend forecast capacity table as necessary to disclose all capacity by each zone substation*									
10	Atkinson Road	18.5	24	N-1	18.5	77%	24	66%	No constraint within +5 years	Meets Vector security criteria
11	Auckland Airport	16.0	23	N-1	0.0	70%	25	80%	Other	Meets Customer security criteria, any upgrade is initiated by customer
12	Avondale	30.0	24	N-1 switched	21.3	125%	24	105%	No constraint within +5 years	Meets Vector security criteria
13	Bairds	23.4	24	N-1	21.6	98%	24	113%	No constraint within +5 years	Meets Vector security criteria
14	Balmain	8.2	-	N-1 switched	12.8	-	-	-	No constraint within +5 years	Meets Vector security criteria
15	Balmoral	14.7	23	N-1	16.0	64%	24	55%	No constraint within +5 years	Meets Vector security criteria
16	Belmont	14.4	14	N-1 switched	11.2	103%	14	80%	No constraint within +5 years	Meets Vector security criteria
17	Birkdale	22.5	24	N-1	16.1	94%	24	85%	No constraint within +5 years	Meets Vector security criteria
18	Brickworks	10.1	-	N-1 switched	12.1	-	18	86%	No constraint within +5 years	Meets Vector security criteria
19	Browns Bay	16.4	10	N-1 switched	17.2	164%	14	105%	No constraint within +5 years	Meets Vector security criteria
20	Bush Road	23.9	24	N-1 switched	14.1	100%	24	87%	No constraint within +5 years	Meets Vector security criteria
21	Carbine	15.8	22	N-1	7.0	73%	22	78%	No constraint within +5 years	Meets Vector security criteria
22	Chevalier	24.2	19	N-1 switched	17.6	128%	19	119%	No constraint within +5 years	Meets Vector security criteria
23	Clendon	22.5	24	N-1	21.1	94%	24	92%	No constraint within +5 years	Meets Vector security criteria
24	Clevedon	2.7	-	N-1 switched	2.8	-	-	-	No constraint within +5 years	Meets Vector security criteria
25	Coatesville	9.4	-	N-1 switched	9.6	-	12	75%	No constraint within +5 years	Meets Vector security criteria
26	Drive	24.0	24	N-1	24.0	100%	24	105%	No constraint within +5 years	Meets Vector security criteria
27	East Coast Road	15.5	-	N	13.8	-	-	-	No constraint within +5 years	Meets Vector security criteria
28	East Tamaki	19.5	22	N-1	7.6	89%	22	106%	No constraint within +5 years	Meets Vector security criteria
29	Flatbush	0.0	24	N-1	7.0	-	24	67%	No constraint within +5 years	Meets Vector security criteria
	Forrest Hill	17.4	20	N-1	15.6	87%	20	77%	No constraint within +5 years	Meets Vector security criteria
30	Freemans Bay	19.7	22	N-1	16.9	91%	22	114%	No constraint within +5 years	Meets Vector security criteria
31	Glen Innes	11.6	13	N-1	12.5	87%	24	46%	No constraint within +5 years	Meets Vector security criteria
32	Greenhithe	11.2	-	N-1 switched	12.5	-	-	-	No constraint within +5 years	Meets Vector security criteria
33	Greenmount	39.9	48	N-1	28.8	83%	48	113%	No constraint within +5 years	Meets Vector security criteria
34	Gulf Harbour	7.9	-	N-1 switched	12.3	-	-	-	No constraint within +5 years	Meets Vector security criteria
35	Hans	27.6	19	N	5.4	142%	19	164%	No constraint within +5 years	Planned Greenwood substation will reduce the load; a third transformer is planned at a later date
36	Hauraki	8.1	-	N-1 switched	9.6	-	-	-	No constraint within +5 years	Meets Vector security criteria
37	Helensville	14.1	9	N-1 switched	9.3	157%	9	150%	No constraint within +5 years	Meets Vector security criteria - Kaukapakapa substation planned to reduce the load after 5 years
38	Henderson Valley	17.2	15	N-1 switched	24.1	113%	15	136%	No constraint within +5 years	Meets Vector security criteria
39	Highbrook	7.7	23	N-1	0.0	33%	23	76%	No constraint within +5 years	Switching Station; Meets Vector security criteria
40	Highbury	13.0	-	N	12.6	-	-	-	No constraint within +5 years	Meets Vector security criteria
41	Hillcrest	22.0	24	N-1	23.6	92%	24	100%	No constraint within +5 years	Meets Vector security criteria
42	Hillsborough	19.7	24	N-1	21.1	82%	24	79%	No constraint within +5 years	Meets Vector security criteria
43	Hobson 110/11kV	22.6	30	N-1	13.7	75%	30	85%	No constraint within +5 years	Meets Vector security criteria
44	Hobson 22/11kV	20.6	18	N-1 switched	8.1	114%	18	132%	No constraint within +5 years	Meets Vector security criteria, planned CBD 11kV to 22kV load transfer will progressively reduce the load at Hobson 11kV bus
45	Hobson 22kV	47.9	40	N-1 switched	28.0	120%	80	99%	No constraint within +5 years	Meets Vector security criteria
46	Hobsonville	22.3	16	N-1 switched	12.6	139%	16	416%	No constraint within +5 years	Hobsonbille Point and Westgate substations planned to reduce Hobsonville load
48	Howick	37.6	46	N-1	13.3	82%	46	71%	No constraint within +5 years	Meets Vector security criteria
49	James Street	19.2	16	N-1 switched	18.7	120%	16	106%	No constraint within +5 years	Meets Vector security criteria
50	Keeling Road	16.0	-	N-1 switched	19.5	-	-	-	No constraint within +5 years	Meets Vector security criteria
51	Kingsland	22.5	24	N-1	19.6	94%	24	104%	No constraint within +5 years	Meets Vector security criteria
52	Laingholm	8.5	9	N-1	9.4	94%	9	83%	No constraint within +5 years	Meets Vector security criteria
53	Liverpool	35.4	48	N-1	16.3	74%	48	80%	No constraint within +5 years	Meets Vector security criteria
54	Liverpool 22kV	97.2	135	N-1	52.6	72%	135	80%	No constraint within +5 years	Meets Vector security criteria
55	Mangere Central	28.2	24	N-1 switched	15.4	118%	48	67%	No constraint within +5 years	Planned Greenwood substation will reduce the load; a third transformer is planned at a later date
56	Mangere East	25.5	24	N-1 switched	15.4	106%	24	104%	No constraint within +5 years	Planned Greenwood substation will reduce the load
57	Mangere West	17.6	36	N-1	4.9	49%	36	103%	No constraint within +5 years	Planned Greenwood substation will reduce the load
58	Manly	18.9	14	N-1 switched	14.5	135%	14	122%	No constraint within +5 years	Meets Vector security criteria
59	Manukau	40.8	43	N-1	30.6	95%	43	135%	No constraint within +5 years	Meets Vector security criteria
60	Manurewa	47.3	47	N-1 switched	27.1	101%	47	100%	No constraint within +5 years	Meets Vector security criteria
61	Maraetai	7.4	18	N-1	4.1	41%	18	46%	No constraint within +5 years	Meets Vector security criteria
62	McKinnon	16.4	24	N-1	13.7	69%	24	108%	No constraint within +5 years	Meets Vector security criteria
63	Mcleod Road	10.1	-	N-1 switched	10.2	-	-	-	No constraint within +5 years	Meets Vector security criteria
64	McNab	42.4	48	N-1	23.2	88%	48	104%	No constraint within +5 years	Meets Vector security criteria
65	Milford	7.9	-	N	6.4	-	-	-	No constraint within +5 years	Once the Northshore hospital is moved to a dedicated feeder (in 2 years) Milford will have full backstopping capacity
66	Mt Albert	6.7	-	N-1 switched	6.9	-	-	-	No constraint within +5 years	Meets Vector security criteria
67	Mt Wellington	19.7	24	N-1	20.1	82%	24	83%	No constraint within +5 years	Meets Vector security criteria
68	New Lynn	14.3	14	N-1 switched	13.9	102%	14	130%	No constraint within +5 years	Meets Vector security criteria
69	Newmarket	33.5	48	N-1	29.0	70%	48	135%	No constraint within +5 years	Meets Vector security criteria
70	Newton	20.9	19	N-1 switched	20.8	111%	19	113%	No constraint within +5 years	Meets Vector security criteria
71	Ngataringa Bay	7.7	-	N-1 switched	9.6	-	-	-	No constraint within +5 years	Meets Vector security criteria
72	Northcote	6.2	-	N-1 switched	7.4	-	-	-	No constraint within +5 years	Meets Vector security criteria
73	Onehunga	11.3	15	N-1	10.8	77%	24	48%	No constraint within +5 years	Meets Vector security criteria
74	Orakei	21.9	22	N-1 switched	14.0	101%	22	96%	No constraint within +5 years	Meets Vector security criteria
75	Oratia	5.0	-	N-1 switched	5.3	-	-	-	No constraint within +5 years	Meets Vector security criteria
76	Orewa	17.5	15	N-1 switched	10.3	115%	24	85%	No constraint within +5 years	Meets Vector security criteria
77	Otara	34.8	31	N-1 switched	25.8	113%	31	126%	No constraint within +5 years	Meets Vector security criteria
78	Pacific Steel	54.7	44	N	0.0	-	44	35%	Other	Meets Customer security criteria, any upgrade is initiated by customer
79	Pakuranga	21.7	24	N-1	12.3	90%	24	78%	No constraint within +5 years	Meets Vector security criteria
80	Papakura	27.8	24	N-1 switched	13.7	116%	24	125%	No constraint within +5 years	Meets Vector security criteria
81	Parnell	9.9	13	N-1	11.1	74%	24	49%	No constraint within +5 years	Meets Vector security criteria
82	Ponsonby	15.5	14	N-1 switched	9.7	108%	18	76%	No constraint within +5 years	Meets Vector security criteria
83	Quay	23.8	24	N-1	18.9	99%	24	134%	No constraint within +5 years	Meets Vector security criteria
84	Quay 22kV	40.4	120	N-1	34.2	34%	120	47%	No constraint within +5 years	Meets Vector security criteria
85	Ranui	11.2	-	N-1 switched	14.3	-	-	-	No constraint within +5 years	Meets Vector security criteria
86	Red Beach	18.9	24	N-1	15.1	79%	24	87%	No constraint within +5 years	Meets Vector security criteria
87	Remuera	28.6	24	N-1 switched	23.1	119%	24	132%	No constraint within +5 years	Meets Vector security criteria, planned new feeders from Newmarket substation will off load Remuera
88	Riverhead	10.3	9	N-1 switched	12.6	114%	9	138%	No constraint within +5 years	Meets Vector security criteria, planned Westgate, Red Hills, Whenuapai and Kumeu substations will reduce the load on this substation
	Rockfield	21.5	24	N-1	25.1	90%	24	94%	No constraint within +5 years	Meets Vector security criteria
89	Rosebank	21.3	26	N-1	18.1	83%	26	110%	No constraint within +5 years	Meets Vector security criteria
90	Rosedale	13.6	-	N-1 switched	15.9	-	24	76%	No constraint within +5 years	Meets Vector security criteria
91	Sabulite Road	22.1	14	N-1 switched	23.1	158%	14	132%	No constraint within +5 years	Meets Vector security criteria
92	Sandringham	22.9	24	N-1	21.3	95%	24	86%	No constraint within +5 years	Meets Vector security criteria
93	Simpson Road	5.2	-	N	5.1	-	-	-	No constraint within +5 years	Meets Vector security criteria
94	Snells Beach	7.9	-	N-1 switched	8.0	-	-	-	No constraint within +5 years	Meets Vector security criteria
95	South Howick	31.0	24	N-1 switched	17.9	129%	24	119%	No constraint within +5 years	Meets Vector security criteria
96	Spur Road	10.3	-	N-1 switched	21.9	-	14	186%	No constraint within +5 years	Meets Vector security criteria, Second transformer installation is planned within the next 5 years

7	**12b(i): System Growth - Zone Substations**									
8	*Existing Zone Substations*	**Current Peak Load (MVA)**	**Installed Firm Capacity (MVA)**	**Security of Supply Classification (type)**	**Transfer Capacity (MVA)**	**Utilisation of Installed Firm Capacity %**	**Installed Firm Capacity +5 years (MVA)**	**Utilisation of Installed Firm Capacity + 5yrs %**	**Installed Firm Capacity Constraint +5 years (cause)**	**Explanation**
9	*[1] Extend forecast capacity table as necessary to disclose all capacity by each zone substation*									
97	St Heliers	21.4	21	N-1 switched	18.2	102%	21	99%	No constraint within +5 years	Meets Vector security criteria
98	St Johns	18.5	24	N-1	17.5	77%	24	81%	No constraint within +5 years	Meets Vector security criteria
99	Sunset Road	16.3	14	N-1 switched	13.3	116%	14	111%	No constraint within +5 years	Meets Vector security criteria
100	Swanson	10.2	-	N-1 switched	11.5	-	-	-	No constraint within +5 years	Meets Vector security criteria
101	Sylvia Park	20.7	24	N-1	16.1	86%	24	138%	No constraint within +5 years	Meets Vector security criteria
102	Takanini	17.2	18	N-1	15.3	96%	18	163%	No constraint within +5 years	Meets Vector security criteria
103	Takapuna	9.3	-	N-1 switched	10.0	-	-	-	No constraint within +5 years	Meets Vector security criteria
104	Te Atatu	21.2	14	N-1 switched	13.4	151%	14	135%	No constraint within +5 years	Meets Vector security criteria
105	Te Papapa	23.3	24	N-1	12.4	97%	24	105%	No constraint within +5 years	Meets Vector security criteria
106	Torbay	7.3	-	N-1 switched	8.3	-	-	-	No constraint within +5 years	Meets Vector security criteria
107	Triangle Road	16.6	12	N-1 switched	16.3	138%	18	106%	No constraint within +5 years	Meets Vector security criteria - Transformer upgrade planned within 5 years
108	Victoria	24.0	22	N-1 switched	19.1	107%	22	114%	No constraint within +5 years	Meets Vector security criteria, planned CBD 11kV to 22kV load transfer will progressively reduce the load at Victoria substation
109	Waiake	8.4	-	N-1 switched	8.5	-	-	-	No constraint within +5 years	Meets Vector security criteria
110	Waiheke	10.7	15	N-1	3.3	71%	15	86%	No constraint within +5 years	Meets Vector security criteria
111	Waikaukau	7.0	-	N-1 switched	7.2	-	-	-	No constraint within +5 years	Meets Vector security criteria
112	Waimauku	9.4	-	N-1 switched	9.5	-	-	-	No constraint within +5 years	Meets Vector security criteria
113	Wairau Road	17.9	16	N-1 switched	20.1	112%	16	123%	No constraint within +5 years	Meets Vector security criteria
114	Warkworth	19.2	18	N-1 switched	15.4	107%	18	122%	No constraint within +5 years	Meets Vector security criteria
115	Wellsford	8.2	9	N-1	5.4	91%	9	76%	No constraint within +5 years	Meets Vector security criteria
116	Westfield	22.8	24	N-1	7.9	95%	24	134%	No constraint within +5 years	Meets Vector security criteria, planned new feeders from McNab will off load Westfield substation pending customer driven development at Westfield
117	White Swan	27.5	32	N-1	16.2	85%	32	76%	No constraint within +5 years	Meets Vector security criteria
118	Wiri	63.1	48	N-1 switched	17.4	131%	48	161%	No constraint within +5 years	Meets Vector security criteria; new zone substation planned within 5 years
119	Woodford	9.3	-	N-1 switched	9.6	-	-	-	No constraint within +5 years	Meets Vector security criteria

Schedule 12c Forecast Network Demand

Company Name **Vector**
AMP Planning Period **1 April 2016 – 31 March 2026**

SCHEDULE 12C: REPORT ON FORECAST NETWORK DEMAND

This schedule requires a forecast of new connections (by consumer type), peak demand and energy volumes for the disclosure year and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumptions used in developing the expenditure forecasts in Schedule 11a and Schedule 11b and the capacity and utilisation forecasts in Schedule 12b.

sch ref

7	**12c(i): Consumer Connections**						
8	*Number of ICPs connected in year by consumer type*			**Number of connections**			
9		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
10							
11	*Consumer types defined by EDB**						
12	Residential & Small Medium Enterprise (SME)	9,992	10,146	10,317	9,846	9,971	10,110
13	Industrial & Commercial	173	173	173	173	173	173
14							
15							
16							
17	**Connections total**	10,165	10,319	10,490	10,019	10,144	10,283
18	**include additional rows if needed*						
19	**Distributed generation**						
20	Number of connections	765	788	827	885	992	1,140
21	Installed connection capacity of distributed generation (MVA)	5.4	6.5	7.5	8.5	10	11.5
22	**12c(ii) System Demand**						
23		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
24	**Maximum coincident system demand (MW)**						
25	GXP demand	1,746	1,761	1,803	1,828	1,839	1,851
26	*plus* Distributed generation output at HV and above	7	7	7	7	7	7
27	**Maximum coincident system demand**	1,753	1,768	1,810	1,835	1,846	1,858
28	*less* Net transfers to (from) other EDBs at HV and above	-	-	-	-	-	-
29	**Demand on system for supply to consumers' connection points**	1,753	1,768	1,810	1,835	1,846	1,858
30	**Electricity volumes carried (GWh)**						
31	Electricity supplied from GXPs	8,644	8,601	8,630	8,665	8,688	8,707
32	*less* Electricity exports to GXPs						
33	*plus* Electricity supplied from distributed generation	98	113	124	124	124	124
34	*less* Net electricity supplied to (from) other EDBs						
35	**Electricity entering system for supply to ICPs**	8,742	8,715	8,754	8,789	8,812	8,831
36	*less* Total energy delivered to ICPs	8,420	8,361	8,399	8,432	8,454	8,471
37	**Losses**	322	353	355	357	358	359
38							
39	**Load factor**	57%	56%	55%	55%	54%	54%
40	**Loss ratio**	3.7%	4.1%	4.1%	4.1%	4.1%	4.1%

Schedule 12d Report on Forecast Interruptions and Duration

Company Name	**Vector**
AMP Planning Period	**1 April 2016 – 31 March 2026**
Network / Sub-network Name	**Vector Limited**

SCHEDULE 12d: REPORT FORECAST INTERRUPTIONS AND DURATION

This schedule requires a forecast of SAIFI and SAIDI for disclosure and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumed impact of planned and unplanned SAIFI and SAIDI on the expenditures forecast provided in Schedule 11a and Schedule 11b.

sch ref		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
8							
9	for year ended	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**
10	**SAIDI**						
11	Class B (planned interruptions on the network)	10.2	10.2	10.2	10.2	10.2	10.2
12	Class C (unplanned interruptions on the network)	85.8	85.8	85.8	85.8	85.8	85.8
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.06	0.06	0.06	0.06	0.06	0.06
15	Class C (unplanned interruptions on the network)	1.23	1.23	1.23	1.23	1.23	1.23

Company Name	**Vector**
AMP Planning Period	**1 April 2016 – 31 March 2026**
Network / Sub-network Name	**Southern Network**

SCHEDULE 12d: REPORT FORECAST INTERRUPTIONS AND DURATION

This schedule requires a forecast of SAIFI and SAIDI for disclosure and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumed impact of planned and unplanned SAIFI and SAIDI on the expenditures forecast provided in Schedule 11a and Schedule 11b.

sch ref		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
8							
9	for year ended	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**
10	**SAIDI**						
11	Class B (planned interruptions on the network)	3.0	3.0	3.0	3.0	3.0	3.0
12	Class C (unplanned interruptions on the network)	58.7	58.7	58.7	58.7	58.7	58.7
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.30	0.30	0.30	0.30	0.30	0.30
15	Class C (unplanned interruptions on the network)	0.80	0.80	0.80	0.80	0.80	0.80

Company Name	**Vector**
AMP Planning Period	**1 April 2016 – 31 March 2026**
Network / Sub-network Name	**Northern Network**

SCHEDULE 12d: REPORT FORECAST INTERRUPTIONS AND DURATION

This schedule requires a forecast of SAIFI and SAIDI for disclosure and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumed impact of planned and unplanned SAIFI and SAIDI on the expenditures forecast provided in Schedule 11a and Schedule 11b.

sch ref		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
8							
9	for year ended	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**
10	**SAIDI**						
11	Class B (planned interruptions on the network)	21.0	21.0	21.0	21.0	21.0	21.0
12	Class C (unplanned interruptions on the network)	126.5	126.5	126.5	126.5	126.5	126.5
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.10	0.10	0.10	0.10	0.10	0.10
15	Class C (unplanned interruptions on the network)	1.88	1.88	1.88	1.88	1.88	1.88

Schedule 13 Report on Asset Management Maturity

APPENDIX 9

Company Name: Vector Limited
AMP Planning Period: 1 April 2016 - 31 March 2026
Asset Management Standard Applied:

SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY

This schedule requires information on the EDB'S self-assessment of the maturity of its asset management practices .

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
3	Asset management policy	To what extent has an asset management policy been documented, authorised and communicated?	2			Widely used AM practice standards require an organisation to document, authorise and communicate its asset management policy (eg, as required in PAS 55 para 4.2 i). A key pre-requisite of any robust policy is that the organisation's top management must be seen to endorse and fully support it. Also vital to the effective implementation of the policy, is to tell the appropriate people of its content and their obligations under it. Where an organisation outsources some of its asset-related activities, then these people and their organisations must equally be made aware of the policy's content. Also, there may be other stakeholders, such as regulatory authorities and shareholders who should be made aware of it.	Top management. The management team that has overall responsibility for asset management.	The organisation's asset management policy, its organisational strategic plan, documents indicating how the asset management policy was based upon the needs of the organisation and evidence of communication.
10	Asset management strategy	What has the organisation done to ensure that its asset management strategy is consistent with other appropriate organisational policies and strategies, and the needs of stakeholders?	2			In setting an organisation's asset management strategy, it is important that it is consistent with any other policies and strategies that the organisation has and has taken into account the requirements of relevant stakeholders. This question examines to what extent the asset management strategy is consistent with other organisational policies and strategies (eg, as required by PAS 55 para 4.3.1 b) and has taken account of stakeholder requirements as required by PAS 55 para 4.3.1 c). Generally, this will take into account the same polices, strategies and stakeholder requirements as covered in drafting the asset management policy but at a greater level of detail.	Top management. The organisation's strategic planning team. The management team that has overall responsibility for asset management.	The organisation's asset management strategy document and other related organisational policies and strategies. Other than the organisation's strategic plan, these could include those relating to health and safety, environmental, etc. Results of stakeholder consultation.
11	Asset management strategy	In what way does the organisation's asset management strategy take account of the lifecycle of the assets, asset types and asset systems over which the organisation has stewardship?	3			Good asset stewardship is the hallmark of an organisation compliant with widely used AM standards. A key component of this is the need to take account of the lifecycle of the assets, asset types and asset systems. (For example, this requirement is recognised in 4.3.1 d) of PAS 55). This question explores what an organisation has done to take lifecycle into account in its asset management strategy.	Top management. People in the organisation with expert knowledge of the assets, asset types, asset systems and their associated life-cycles. The management team that has overall responsibility for asset management. Those responsible for developing and adopting methods and processes used in asset management	The organisation's documented asset management strategy and supporting working documents.
26	Asset management plan(s)	How does the organisation establish and document its asset management plan(s) across the life cycle activities of its assets and asset systems?	2			The asset management strategy need to be translated into practical plan(s) so that all parties know how the objectives will be achieved. The development of plan(s) will need to identify the specific tasks and activities required to optimize costs, risks and performance of the assets and/or asset system(s), when they are to be carried out and the resources required.	The management team with overall responsibility for the asset management system. Operations, maintenance and engineering managers.	The organisation's asset management plan(s).

Company Name: Vector Limited
AMP Planning Period: 1 April 2016 - 31 March 2026
Asset Management Standard Applied:

SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
27	Asset management plan(s)	How has the organisation communicated its plan(s) to all relevant parties to a level of detail appropriate to the receiver's role in their delivery?	3			Plans will be ineffective unless they are communicated to all those, including contracted suppliers and those who undertake enabling function(s). The plan(s) need to be communicated in a way that is relevant to those who need to use them.	The management team with overall responsibility for the asset management system. Delivery functions and suppliers.	Distribution lists for plan(s). Documents derived from plan(s) which detail the receivers role in plan delivery. Evidence of communication.
29	Asset management plan(s)	How are designated responsibilities for delivery of asset plan actions documented?	3			The implementation of asset management plan(s) relies on (1) actions being clearly identified, (2) an owner allocated and (3) that owner having sufficient delegated responsibility and authority to carry out the work required. It also requires alignment of actions across the organisation. This question explores how well the plan(s) set out responsibility for delivery of asset plan actions.	The management team with overall responsibility for the asset management system. Operations, maintenance and engineering managers. If appropriate, the performance management team.	The organisation's asset management plan(s). Documentation defining roles and responsibilities of individuals and organisational departments.
31	Asset management plan(s)	What has the organisation done to ensure that appropriate arrangements are made available for the efficient and cost effective implementation of the plan(s)? (Note this is about resources and enabling support)	2			It is essential that the plan(s) are realistic and can be implemented, which requires appropriate resources to be available and enabling mechanisms in place. This question explores how well this is achieved. The plan(s) not only need to consider the resources directly required and timescales, but also the enabling activities, including for example, training requirements, supply chain capability and procurement timescales.	The management team with overall responsibility for the asset management system. Operations, maintenance and engineering managers. If appropriate, the performance management team. If appropriate, the performance management team. Where appropriate the procurement team and service providers working on the organisation's asset-related activities.	The organisation's asset management plan(s). Documented processes and procedures for the delivery of the asset management plan.
33	Contingency planning	What plan(s) and procedure(s) does the organisation have for identifying and responding to incidents and emergency situations and ensuring continuity of critical asset management activities?	3			Widely used AM practice standards require that an organisation has plan(s) to identify and respond to emergency situations. Emergency plan(s) should outline the actions to be taken to respond to specified emergency situations and ensure continuity of critical asset management activities including the communication to, and involvement of, external agencies. This question assesses if, and how well, these plan(s) triggered, implemented and resolved in the event of an incident. The plan(s) should be appropriate to the level of risk as determined by the organisation's risk assessment methodology. It is also a requirement that relevant personnel are competent and trained.	The manager with responsibility for developing emergency plan(s). The organisation's risk assessment team. People with designated duties within the plan(s) and procedure(s) for dealing with incidents and emergency situations.	The organisation's plan(s) and procedure(s) for dealing with emergencies. The organisation's risk assessments and risk registers.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
37	Structure, authority and responsibilities	What has the organisation done to appoint member(s) of its management team to be responsible for ensuring that the organisation's assets deliver the requirements of the asset management strategy, objectives and plan(s)?	3			In order to ensure that the organisation's assets and asset systems deliver the requirements of the asset management policy, strategy and objectives responsibilities need to be allocated to appropriate people who have the necessary authority to fulfil their responsibilities. (This question, relates to the organisation's assets eg, para b), s 4.4.1 of PAS 55, making it therefore distinct from the requirement contained in para a), s 4.4.1 of PAS 55).	Top management. People with management responsibility for the delivery of asset management policy, strategy, objectives and plan(s). People working on asset-related activities.	Evidence that managers with responsibility for the delivery of asset management policy, strategy, objectives and plan(s) have been appointed and have assumed their responsibilities. Evidence may include the organisation's documents relating to its asset management system, organisational charts, job descriptions of post-holders, annual targets/objectives and personal development plan(s) of post-holders as appropriate.
40	Structure, authority and responsibilities	What evidence can the organisation's top management provide to demonstrate that sufficient resources are available for asset management?	2			Optimal asset management requires top management to ensure sufficient resources are available. In this context the term 'resources' includes manpower, materials, funding and service provider support.	Top management. The management team that has overall responsibility for asset management. Risk management team. The organisation's managers involved in day-to-day supervision of asset-related activities, such as frontline managers, engineers, foremen and chargehands as appropriate.	Evidence demonstrating that asset management plan(s) and/or the process(es) for asset management plan implementation consider the provision of adequate resources in both the short and long term. Resources include funding, materials, equipment, services provided by third parties and personnel (internal and service providers) with appropriate skills competencies and knowledge.
42	Structure, authority and responsibilities	To what degree does the organisation's top management communicate the importance of meeting its asset management requirements?	3			Widely used AM practice standards require an organisation to communicate the importance of meeting its asset management requirements such that personnel fully understand, take ownership of, and are fully engaged in the delivery of the asset management requirements (eg, PAS 55 s 4.4.1 g).	Top management. The management team that has overall responsibility for asset management. People involved in the delivery of the asset management requirements.	Evidence of such activities as road shows, written bulletins, workshops, team talks and management walk-abouts would assist an organisation to demonstrate it is meeting this requirement of PAS 55.
45	Outsourcing of asset management activities	Where the organisation has outsourced some of its asset management activities, how has it ensured that appropriate controls are in place to ensure the compliant delivery of its organisational strategic plan, and its asset management policy and strategy?	2			Where an organisation chooses to outsource some of its asset management activities, the organisation must ensure that these outsourced process(es) are under appropriate control to ensure that all the requirements of widely used AM standards (eg, PAS 55) are in place, and the asset management policy, strategy objectives and plan(s) are delivered. This includes ensuring capabilities and resources across a time span aligned to life cycle management. The organisation must put arrangements in place to control the outsourced activities, whether it be to external providers or to other in-house departments. This question explores what the organisation does in this regard.	Top management. The management team that has overall responsibility for asset management. The manager(s) responsible for the monitoring and management of the outsourced activities. People involved with the procurement of outsourced activities. The people within the organisations that are performing the outsourced activities. The people impacted by the outsourced activity.	The organisation's arrangements that detail the compliance required of the outsourced activities. For example, this this could form part of a contract or service level agreement between the organisation and the suppliers of its outsourced activities. Evidence that the organisation has demonstrated to itself that it has assurance of compliance of outsourced activities.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
48	Training, awareness and competence	How does the organisation develop plan(s) for the human resources required to undertake asset management activities - including the development and delivery of asset management strategy, process(es), objectives and plan(s)?	2			There is a need for an organisation to demonstrate that it has considered what resources are required to develop and implement its asset management system. There is also a need for the organisation to demonstrate that it has assessed what development plan(s) are required to provide its human resources with the skills and competencies to develop and implement its asset management systems. The timescales over which the plan(s) are relevant should be commensurate with the planning horizons within the asset management strategy considers e.g. if the asset management strategy considers 5, 10 and 15 year time scales then the human resources development plan(s) should align with these. Resources include both 'in house' and external resources who undertake asset management activities.	Senior management responsible for agreement of plan(s). Managers responsible for developing asset management strategy and plan(s). Managers with responsibility for development and recruitment of staff (including HR functions). Staff responsible for training. Procurement officers. Contracted service providers.	Evidence of analysis of future work load plan(s) in terms of human resources. Document(s) containing analysis of the organisation's own direct resources and contractors resource capability over suitable timescales. Evidence, such as minutes of meetings, that suitable management forums are monitoring human resource development plan(s). Training plan(s), personal development plan(s), contract and service level agreements.
49	Training, awareness and competence	How does the organisation identify competency requirements and then plan, provide and record the training necessary to achieve the competencies?	2			Widely used AM standards require that organisations to undertake a systematic identification of the asset management awareness and competencies required at each level and function within the organisation. Once identified the training required to provide the necessary competencies should be planned for delivery in a timely and systematic way. Any training provided must be recorded and maintained in a suitable format. Where an organisation has contracted service providers in place then it should have a means to demonstrate that this requirement is being met for their employees. (eg, PAS 55 refers to frameworks suitable for identifying competency requirements).	Senior management responsible for agreement of plan(s). Managers responsible for developing asset management strategy and plan(s). Managers with responsibility for development and recruitment of staff (including HR functions). Staff responsible for training. Procurement officers. Contracted service providers.	Evidence of an established and applied competency requirements assessment process and plan(s) in place to deliver the required training. Evidence that the training programme is part of a wider, co-ordinated asset management activities training and competency programme. Evidence that training activities are recorded and that records are readily available (for both direct and contracted service provider staff) e.g. via organisation wide information system or local records database.
50	Training, awareness and competence	How does the organization ensure that persons under its direct control undertaking asset management related activities have an appropriate level of competence in terms of education, training or experience?	3			A critical success factor for the effective development and implementation of an asset management system is the competence of persons undertaking these activities. organisations should have effective means in place for ensuring the competence of employees to carry out their designated asset management function(s). Where an organisation has contracted service providers undertaking elements of its asset management system then the organisation shall assure itself that the outsourced service provider also has suitable arrangements in place to manage the competencies of its employees. The organisation should ensure that the individual and corporate competencies it requires are in place and actively monitor, develop and maintain an appropriate balance of these competencies.	Managers, supervisors, persons responsible for developing training programmes. Staff responsible for procurement and service agreements. HR staff and those responsible for recruitment.	Evidence of a competency assessment framework that aligns with established frameworks such as the asset management Competencies Requirements Framework (Version 2.0); National Occupational Standards for Management and Leadership; UK Standard for Professional Engineering Competence, Engineering Council, 2005.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
53	Communication, participation and consultation	How does the organisation ensure that pertinent asset management information is effectively communicated to and from employees and other stakeholders, including contracted service providers?	3			Widely used AM practice standards require that pertinent asset management information is effectively communicated to and from employees and other stakeholders including contracted service providers. Pertinent information refers to information required in order to effectively and efficiently comply with and deliver asset management strategy, plan(s) and objectives. This will include for example the communication of the asset management policy, asset performance information, and planning information as appropriate to contractors.	Top management and senior management representative(s), employee's representative(s), employee's trade union representative(s); contracted service provider management and employee representative(s); representative(s) from the organisation's Health, Safety and Environmental team. Key stakeholder representative(s).	Asset management policy statement prominently displayed on notice boards, intranet and internet; use of organisation's website for displaying asset performance data; evidence of formal briefings to employees, stakeholders and contracted service providers; evidence of inclusion of asset management issues in team meetings and contracted service provider contract meetings; newsletters, etc.
59	Asset Management System documentation	What documentation has the organisation established to describe the main elements of its asset management system and interactions between them?	3			Widely used AM practice standards require an organisation maintain up to date documentation that ensures that its asset management systems (ie, the systems the organisation has in place to meet the standards) can be understood, communicated and operated. (eg, s 4.5 of PAS 55 requires the maintenance of up to date documentation of the asset management system requirements specified throughout s 4 of PAS 55).	The management team that has overall responsibility for asset management. Managers engaged in asset management activities.	The documented information describing the main elements of the asset management system (process(es)) and their interaction.
62	Information management	What has the organisation done to determine what its asset management information system(s) should contain in order to support its asset management system?	3			Effective asset management requires appropriate information to be available. Widely used AM standards therefore require the organisation to identify the asset management information it requires in order to support its asset management system. Some of the information required may be held by suppliers. The maintenance and development of asset management information systems is a poorly understood specialist activity that is akin to IT management but different from IT management. This group of questions provides some indications as to whether the capability is available and applied. Note: To be effective, an asset information management system requires the mobilisation of technology, people and process(es) that create, secure, make available and destroy the information required to support the asset management system.	The organisation's strategic planning team. The management team that has overall responsibility for asset management. Information management team. Operations, maintenance and engineering managers	Details of the process the organisation has employed to determine what its asset information system should contain in order to support its asset management system. Evidence that this has been effectively implemented.
63	Information management	How does the organisation maintain its asset management information system(s) and ensure that the data held within it (them) is of the requisite quality and accuracy and is consistent?	2			The response to the questions is progressive. A higher scale cannot be awarded without achieving the requirements of the lower scale. This question explores how the organisation ensures that information management meets widely used AM practice requirements (eg, s 4.4.6 (a), (c) and (d) of PAS 55).	The management team that has overall responsibility for asset management. Users of the organisational information systems.	The asset management information system, together with the policies, procedure(s), improvement initiatives and audits regarding information controls.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
64	Information management	How has the organisation's ensured its asset management information system is relevant to its needs?	2			Widely used AM standards need not be prescriptive about the form of the asset management information system, but simply require that the asset management information system is appropriate to the organisations needs, can be effectively used and can supply information which is consistent and of the requisite quality and accuracy.	The organisation's strategic planning team. The management team that has overall responsibility for asset management. Information management team. Users of the organisational information systems.	The documented process the organisation employs to ensure its asset management information system aligns with its asset management requirements. Minutes of information systems review meetings involving users.
69	Risk management process(es)	How has the organisation documented process(es) and/or procedure(s) for the identification and assessment of asset and asset management related risks throughout the asset life cycle?	3			Risk management is an important foundation for proactive asset management. Its overall purpose is to understand the cause, effect and likelihood of adverse events occurring, to optimally manage such risks to an acceptable level, and to provide an audit trail for the management of risks. Widely used standards require the organisation to have process(es) and/or procedure(s) in place that set out how the organisation identifies and assesses asset and asset management related risks. The risks have to be considered across the four phases of the asset lifecycle (eg, para 4.3.3 of PAS 55).	The top management team in conjunction with the organisation's senior risk management representatives. There may also be input from the organisation's Safety, Health and Environment team. Staff who carry out risk identification and assessment.	The organisation's risk management framework and/or evidence of specific process(es) and/ or procedure(s) that deal with risk control mechanisms. Evidence that the process(es) and/or procedure(s) are implemented across the business and maintained. Evidence of agendas and minutes from risk management meetings. Evidence of feedback in to process(es) and/or procedure(s) as a result of incident investigation(s). Risk registers and assessments.
79	Use and maintenance of asset risk information	How does the organisation ensure that the results of risk assessments provide input into the identification of adequate resources and training and competency needs?	3			Widely used AM standards require that the output from risk assessments are considered and that adequate resource (including staff) and training is identified to match the requirements. It is a further requirement that the effects of the control measures are considered, as there may be implications in resources and training required to achieve other objectives.	Staff responsible for risk assessment and those responsible for developing and approving resource and training plan(s). There may also be input from the organisation's Safety, Health and Environment team.	The organisations risk management framework. The organisation's resourcing plan(s) and training and competency plan(s). The organisation should be able to demonstrate appropriate linkages between the content of resource plan(s) and training and competency plan(s) to the risk assessments and risk control measures that have been developed.
82	Legal and other requirements	What procedure does the organisation have to identify and provide access to its legal, regulatory, statutory and other asset management requirements, and how is requirements incorporated into the asset management system?	3			In order for an organisation to comply with its legal, regulatory, statutory and other asset management requirements, the organisation first needs to ensure that it knows what they are (eg, PAS 55 specifies this in s 4.4.8). It is necessary to have systematic and auditable mechanisms in place to identify new and changing requirements. Widely used AM standards also require that requirements are incorporated into the asset management system (e.g. procedure(s) and process(es))	Top management. The organisations regulatory team. The organisation's legal team or advisors. The management team with overall responsibility for the asset management system. The organisation's health and safety team or advisors. The organisation's policy making team.	The organisational processes and procedures for ensuring information of this type is identified, made accessible to those requiring the information and is incorporated into asset management strategy and objectives

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
88	Life Cycle Activities	How does the organisation establish implement and maintain process(es) for the implementation of its asset management plan(s) and control of activities across the creation, acquisition or enhancement of assets. This includes design, modification, procurement, construction and commissioning activities?	3			Life cycle activities are about the implementation of asset management plan(s) i.e. they are the "doing" phase. They need to be done effectively and well in order for asset management to have any practical meaning. As a consequence, widely used standards (eg, PAS 55 s 4.5.1) require organisations to have in place appropriate process(es) and procedure(s) for the implementation of asset management plan(s) and control of lifecycle activities. This question explores those aspects relevant to asset creation.	Asset managers, design staff, construction staff and project managers from other impacted areas of the business, e.g. Procurement	Documented process(es) and procedure(s) which are relevant to demonstrating the effective management and control of life cycle activities during asset creation, acquisition, enhancement including design, modification, procurement, construction and commissioning.
91	Life Cycle Activities	How does the organisation ensure that process(es) and/or procedure(s) for the implementation of asset management plan(s) and control of activities during maintenance (and inspection) of assets are sufficient to ensure activities are carried out under specified conditions, are consistent with asset management strategy and control cost, risk and performance?	2			Having documented process(es) which ensure the asset management plan(s) are implemented in accordance with any specified conditions, in a manner consistent with the asset management policy, strategy and objectives and in such a way that cost, risk and asset system performance are appropriately controlled is critical. They are an essential part of turning intention into action (eg, as required by PAS 55 s 4.5.1).	Asset managers, operations managers, maintenance managers and project managers from other impacted areas of the business	Documented procedure for review. Documented procedure for audit of process delivery. Records of previous audits, improvement actions and documented confirmation that actions have been carried out.
95	Performance and condition monitoring	How does the organisation measure the performance and condition of its assets?	3			Widely used AM standards require that organisations establish implement and maintain procedure(s) to monitor and measure the performance and/or condition of assets and asset systems. They further set out requirements in some detail for reactive and proactive monitoring, and leading/lagging performance indicators together with the monitoring or results to provide input to corrective actions and continual improvement. There is an expectation that performance and condition monitoring will provide input to improving asset management strategy, objectives and plan(s).	A broad cross-section of the people involved in the organisation's asset-related activities from data input to decision-makers, i.e. an end-to end assessment. This should include contactors and other relevant third parties as appropriate.	Functional policy and/or strategy documents for performance or condition monitoring and measurement. The organisation's performance monitoring frameworks, balanced scorecards etc. Evidence of the reviews of any appropriate performance indicators and the action lists resulting from these reviews. Reports and trend analysis using performance and condition information. Evidence of the use of performance and condition information shaping improvements and supporting asset management strategy, objectives and plan(s).
99	Investigation of asset-related failures, incidents and nonconformities	How does the organisation ensure responsibility and the authority for the handling, investigation and mitigation of asset-related failures, incidents and emergency situations and non conformances is clear, unambiguous, understood and communicated?	3			Widely used AM standards require that the organisation establishes implements and maintains process(es) for the handling and investigation of failures incidents and non-conformities for assets and sets down a number of expectations. Specifically this question examines the requirement to define clearly responsibilities and authorities for these activities, and communicate these unambiguously to relevant people including external stakeholders if appropriate.	The organisation's safety and environment management team. The team with overall responsibility for the management of the assets. People who have appointed roles within the asset-related investigation procedure, from those who carry out the investigations to senior management who review the recommendations. Operational controllers responsible for managing the asset base under fault conditions and maintaining services to consumers. Contractors and other third parties as appropriate.	Process(es) and procedure(s) for the handling, investigation and mitigation of asset-related failures, incidents and emergency situations and non conformances. Documentation of assigned responsibilities and authority to employees. Job Descriptions, Audit reports. Common communication systems i.e. all Job Descriptions on Internet etc.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
105	Audit	What has the organisation done to establish procedure(s) for the audit of its asset management system (process(es))?	2			This question seeks to explore what the organisation has done to comply with the standard practice AM audit requirements (eg, the associated requirements of PAS 55 s 4.6.4 and its linkages to s 4.7).	The management team responsible for its asset management procedure(s). The team with overall responsibility for the management of the assets. Audit teams, together with key staff responsible for asset management. For example, Asset Management Director, Engineering Director. People with responsibility for carrying out risk assessments	The organisation's asset-related audit procedure(s). The organisation's methodology(s) by which it determined the scope and frequency of the audits and the criteria by which it identified the appropriate audit personnel. Audit schedules, reports etc. Evidence of the procedure(s) by which the audit results are presented, together with any subsequent communications. The risk assessment schedule or risk registers.
109	Corrective & Preventative action	How does the organisation instigate appropriate corrective and/or preventive actions to eliminate or prevent the causes of identified poor performance and non conformance?	2			Having investigated asset related failures, incidents and non-conformances, and taken action to mitigate their consequences, an organisation is required to implement preventative and corrective actions to address root causes. Incident and failure investigations are only useful if appropriate actions are taken as a result to assess changes to a businesses risk profile and ensure that appropriate arrangements are in place should a recurrence of the incident happen. Widely used AM standards also require that necessary changes arising from preventive or corrective action are made to the asset management system.	The management team responsible for its asset management procedure(s). The team with overall responsibility for the management of the assets. Audit and incident investigation teams. Staff responsible for planning and managing corrective and preventive actions.	Analysis records, meeting notes and minutes, modification records. Asset management plan(s), investigation reports, audit reports, improvement programmes and projects. Recorded changes to asset management procedure(s) and process(es). Condition and performance reviews. Maintenance reviews
113	Continual Improvement	How does the organisation achieve continual improvement in the optimal combination of costs, asset related risks and the performance and condition of assets and asset systems across the whole life cycle?	2			Widely used AM standards have requirements to establish, implement and maintain process(es)/procedure(s) for identifying, assessing, prioritising and implementing actions to achieve continual improvement. Specifically there is a requirement to demonstrate continual improvement in optimisation of cost risk and performance/condition of assets across the life cycle. This question explores an organisation's capabilities in this area—looking for systematic improvement mechanisms rather that reviews and audit (which are separately examined).	The top management of the organisation. The manager/team responsible for managing the organisation's asset management system, including its continual improvement. Managers responsible for policy development and implementation.	Records showing systematic exploration of improvement. Evidence of new techniques being explored and implemented. Changes in procedure(s) and process(es) reflecting improved use of optimisation tools/techniques and available information. Evidence of working parties and research.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
115	Continual Improvement	How does the organisation seek and acquire knowledge about new asset management related technology and practices, and evaluate their potential benefit to the organisation?	2			One important aspect of continual improvement is where an organisation looks beyond its existing boundaries and knowledge base to look at what 'new things are on the market'. These new things can include equipment, process(es), tools, etc. An organisation which does this (eg, by the PAS 55 s 4.6 standards) will be able to demonstrate that it continually seeks to expand its knowledge of all things affecting its asset management approach and capabilities. The organisation will be able to demonstrate that it identifies any such opportunities to improve, evaluates them for suitability to its own organisation and implements them as appropriate. This question explores an organisation's approach to this activity.	The top management of the organisation. The manager/team responsible for managing the organisation's asset management system, including its continual improvement. People who monitor the various items that require monitoring for 'change'. People that implement changes to the organisation's policy, strategy, etc. People within an organisation with responsibility for investigating, evaluating, recommending and implementing new tools and techniques, etc.	Research and development projects and records, benchmarking and participation knowledge exchange professional forums. Evidence of correspondence relating to knowledge acquisition. Examples of change implementation and evaluation of new tools, and techniques linked to asset management strategy and objectives.

Schedule 14a Mandatory Explanatory Notes on Forecast Information

1. This Schedule requires EDBs to provide explanatory notes to reports prepared in accordance with clause 2.6.5.

2. This Schedule is mandatory—EDBs must provide the explanatory comment specified below, in accordance with clause 2.7.2. This information is not part of the audited disclosure information, and so is not subject to the assurance requirements specified in section 2.8.

Commentary on difference between nominal and constant price capital expenditure forecasts (Schedule 11a)

3. In the box below, comment on the difference between nominal and constant price capital expenditure for the current disclosure year and 10 year planning period, as disclosed in Schedule 11a.

Box 1: Commentary on difference between nominal and constant price capital expenditure forecasts
Vector has used the NZIER (New Zealand Institute of Economic Research) September 2015 PPI (Producer Price Index-outputs) forecast from 2015 to 2019. Thereafter we have assumed a long term inflation rate of 2.21%. The constant price capital expenditure forecast is then inflated by the above mentioned PPI forecast to nominal price capital expenditure forecasts.

Commentary on difference between nominal and constant price operational expenditure forecasts (Schedule 11b)

4. In the box below, comment on the difference between nominal and constant price operational expenditure for the current disclosure year and 10 year planning period, as disclosed in Schedule 11b.

Box 2: Commentary on difference between nominal and constant price operational expenditure forecasts
Vector has used the NZIER (New Zealand Institute of Economic Research) September 2015 PPI (Producer Price Index-outputs) forecast from 2015 to 2019. Thereafter we have assumed a long term inflation rate of 2.21%. The constant price operating expenditure forecast is then inflated by the above mentioned PPI forecast to nominal price operating expenditure forecasts.

Electricity Asset Management Plan 2016-2026

Information Disclosure Appendices

Appendix 2
Certificate for Year Beginning Disclosures

Schedule 17 Certification for Year-beginning Disclosures

Clause 2.9.1 of section 2.9

We, JAMES CARMICHAEL and

BOB THOMSON, being directors of Vector Limited certify that, having made all reasonable enquiry, to the best of our knowledge:

a) the following attached information of Vector Limited prepared for the purposes of clause 2.6.1 of the Electricity Distribution Information Disclosure Determination 2012 in all material respects complies with that determination.

b) The prospective financial or non-financial information included in the attached information has been measured on a basis consistent with regulatory requirements or recognised industry standards.

Director

Director

22/3/16

Date