Electricity
Asset Management Plan
2013 – 2023

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Electricity
Asset Management Plan
2013 – 2023

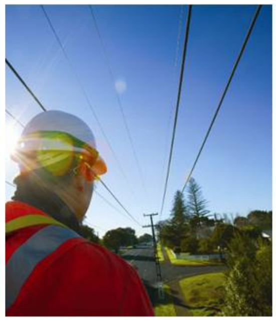
Executive Summary

[Disclosure AMP]

Summary of the Asset Management Plan

Vector aims to be:

"New Zealand's first choice for integrated infrastructure solutions that build a better, brighter future"

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 2012. It covers a ten year planning period starting from 1st April 2013.

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 programmes[2] 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;

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

[2] Vector acknowledges that the Commission's Information Disclosure Determination suggests that a full options analysis should be provided for all material growth projects over the whole AMP planning period. However, given the size of the Vector network, the annual growth expenditure and the number of projects such an analysis would have to include, we do not believe that it would be economically prudent to expand our team just for this purpose. Vector has therefore decided to only focus its option analysis for AMP purposes on nearer term, large projects. A full option analysis is carried out on all projects as part of our business case planning and approval process.

- 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:

- 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.

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. This AMP does therefore not commit Vector to any of the individual projects or initiatives or the defined timelines described in the plan.

Economic Factors

Economic cycles impact on business activities and hence electricity demand particularly on business sectors. GDP figures published by Statistics NZ over the past three years ending March 2012 show a period of moderate to low growth (1.7%. 1.5% and -0.4% for the years ending March 2012, March 2011 and 2010). During the same period, electricity delivered through the Vector network recorded low growth rates[3] of 1.1%, 0.0% and 1.0% respectively. More recent economic indicators such as consumer and business confidence, unemployment rate and housing construction point towards a cautious recovery, although the full impact of this on the electricity network is still to be realised. Overseas, various economies are facing uncertainties caused by state debt burden, the fading effect of economic stimulus packages and low consumer confidence leading to low rates of job creation and economy activities. The full impact of this on New Zealand's export earnings and therefore the state of its economy is still uncertain.

Analysis of energy consumption patterns on the Vector network over the last 8 years indicates that the average energy consumption of consumers across all categories is declining. The overall energy consumption trend has been flat. This trend does not appear to be replicated to the same extent in individual energy peak demand usage, and overall peak demand is still growing. Peak demand, rather than energy volumes conveyed through the network, is a key factor for investment decisions.

[3] Figures based on Vector's information disclosure.

For the purposes of this AMP, Vector has assumed that economic growth will resume at relatively modest to low levels in the short to medium term and that new connection growth patterns will continue at historical rates. As energy volumes do not directly drive asset investment decisions, no forecast in this regard has been made for the AMP.

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. Part 4 was amended in 2008 with objectives including the promotion of regulatory certainty and incentives for regulated businesses to invest in infrastructure.

The Commerce Commission, with input from stakeholders including Vector, is in the process of implementing Part 4. Vector does not believe that the Input Methodologies for Electricity Distribution Services, determined in December 2010, provide an adequate level of certainty or investment incentives. In particular, the cost of capital input methodology would not permit commercially realistic returns on investment and the asset valuation input methodology does not allow for a robust asset valuation to be developed at the start of the new regulatory regime. The Commission's decisions on the input methodologies and the regulatory process have been subject to a series of legal challenges, including from Vector.

Greater certainty should emerge once the legal challenges are complete. However, these may not be settled until late 2013. As the next regulatory price reset is scheduled for 2015, it is likely that considerable regulatory uncertainty will remain a feature of the investment environment until 1 April 2015 and possibly beyond.

Should Vector be unsuccessful in its challenge to the allowed return on investment, it is likely that the investment plan set out in the AMP will be reduced. Vector does not believe that the current allowed regulated rate of return adequately compensates shareholders for the risk associated with investing in electricity distribution businesses and, should the existing situation persist, it is therefore likely to reduce its network investments to minimum safe levels.

It is also not clear whether the regulatory regime and/or customer expectations will support investment in reliability improvements or energy efficiency. The quality requirements for electricity distribution businesses focus only on maintaining the current level of quality of supply, not on improving it. The Commerce Act (Section 54Q) requires the Commission to promote investment by electricity distribution businesses in energy efficiency. However, the Commission has yet to implement this requirement. In the absence of quality or efficiency incentives, investment may only maintain, not improve, energy efficiency or quality of supply on regulated networks such as Vector's. Vector views this as an important deficiency in the regulations that should be addressed by the Commerce Commission.

Technical Factors

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 (2013) AMP builds on the previous Plans and incorporates further developments in Vector's approach to and thinking on asset management as well as comments from the Commerce Commission's 2012 AMP review. It also incorporates the changes required under the new information disclosure requirements.

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.
- 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.
- Vector's asset management maturity assessment results are included.
- The appendices to the AMP contain the other forecast schedules required in terms of the Requirements.

Vector's Network

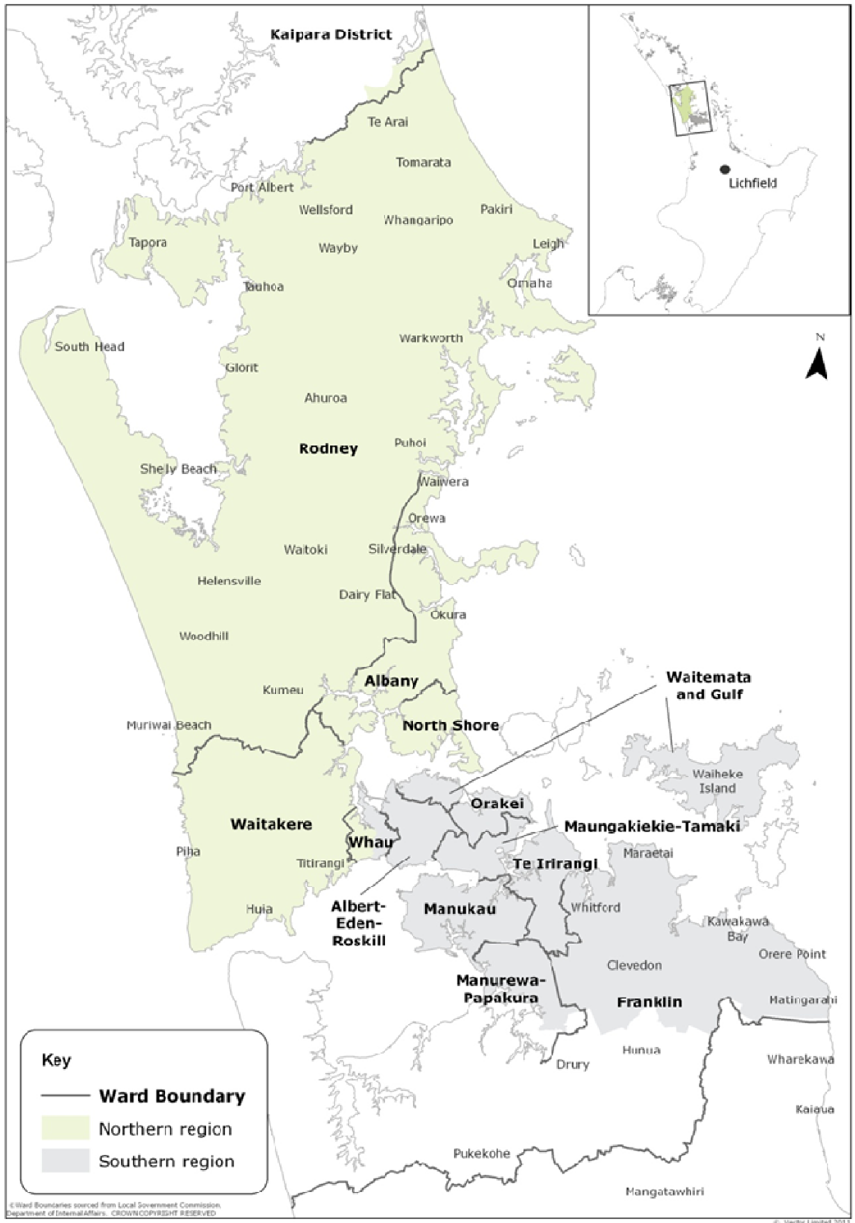
Vector's supply area covers most of the area administered by the Auckland Council as shown in the map below. Vector operates an electrically contiguous network[4] from Papakura in the south to Rodney in the north. While Vector operates this as a single network, for legacy reasons, it is convenient to 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 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.

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



Network Summary (Year ending 31st March 2012)

Description	Quantity
Consumer connections	534,713
Network maximum demand (MW)*	1,941
Energy injected (GWh)*	8,774
Lines and cables (km)**	17,758
Zone substations***	104
Distribution transformers	21,059

*   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. As noted before, Vector is observing short-term fluctuations in annual peak demand. 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 2011/12 (regulatory year) is given below.

	Peak Demand* (MW)	Total Energy Injected (GWh)
From grid exit points	1,927	8,664
From embedded generation**	14	110
Total	1,941	8,774

* 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.

This plan details the anticipated electricity demand in the various parts of the Auckland region for the next ten years. 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 especially detailed for the first five years of the plan.

Service Commitment

Vector operates two forms of supply contracts with its customers. In the Southern region, Vector contracts directly with the end users for line services. In the Northern region Vector contracts with energy retailers for line services, while end users contract with energy retailers for both energy and line services (interpose arrangement).

In the Southern region, Vector promotes its service commitment through the "Vector promise" under which Vector provides its customers a prescribed supply quality and service standard, or a level of compensation where this is not achieved. The level of service delivered to customers depends on the location of the customer. Homes in the city or urban areas generally have better reliability than those in rural areas. This is mainly due to the extensive use of overhead networks in rural areas, and the associated length and exposure to the environment of these. While urban networks are not immune, rural networks are more prone to interference from factors that are largely outside Vector's control, such as severe weather conditions, bird strikes, car versus pole accidents and other environmental factors. (Note that incidents arising as a result of bulk supply failures – generation or transmission – or of extreme events are excluded from this scheme).

A similar "Charter payment" arrangement operates in the Northern region under which Vector provides the end users a prescribed supply quality through the retailers, with a level of compensation (channelled through the retailer) where this is not achieved.

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.

Vector has developed 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 is continually monitoring local and international developments in asset maintenance. Based on surveys and advice from experts, Vector has identified the substantial benefits that leading utilities are achieving though adopting a formal condition-based risk management (CBRM) framework for the renewal and maintenance of their electricity network assets. As part of its ongoing improvement programme, Vector is therefore in the process of adopting this approach for the future prioritisation of its 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. 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; 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. Over the past three years 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.

The passing of the Electricity Amendment Act 2006 required companies in New Zealand engaged in the distribution of electricity to develop, implement and maintain a safety management system that will ensure their distribution networks do not pose a significant risk of serious harm to members of the public or of significant damage to public property. Vector complies with this requirement, and had our safety management system independently audited in 2012.

Environment

Vector's environmental policy is contained in Section 8 of this AMP. In summary, the policy is 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 fuel as efficiently as practicable;
- Mitigate, where economically feasible, fugitive emissions and in particular greenhouse gas emissions;
- Wherever practicable use ambient and renewable energy; and
- Work with consumers to maximise energy efficiency.

Approval of the AMP and Reporting on Progress

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. No update of the AMP is made between publication dates.[5]

[5] In future, following changes to the required AMP publication dates under the new information disclosure requirements, Vector's AMP approval process will be amended to reflect the years in which an AMP update only is required.

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.

Budget and Expenditure Forecast (FY) (Portfolio forecasting approach)	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Customer connection	$24.6 m	$24.1 m	$24.1 m	$24.1 m	$24.0 m	$24.0 m	$23.5 m	$23.5 m	$23.4 m	$23.3 m	$23.3 m
System growth	$60.2 m	$48.0 m	$41.7 m	$38.8 m	$33.9 m	$34.8 m	$24.1 m	$26.0 m	$28.3 m	$24.0 m	$28.2 m
Asset replacement and renewal	$67.4 m	$56.9 m	$61.9 m	$56.3 m	$61.4 m	$57.9 m	$61.6 m	$57.7 m	$54.7 m	$52.0 m	$53.5 m
Asset relocations	$24.2 m	$21.3 m	$22.6 m	$19.7 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m
Reliability, safety & environmental	$7.6 m	$6.5 m	$5.6 m	$5.8 m	$5.0 m	$4.9 m	$5.8 m	$4.5 m	$3.6 m	$3.6 m	$3.6 m
Non-system fixed assets (Asset IT)	$0.0 m	$2.8 m	$3.4 m	$2.6 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m
Asset Capital Expenditure total	**$184.0 m**	**$159.6 m**	**$159.3 m**	**$147.4 m**	**$145.9 m**	**$143.1 m**	**$136.4 m**	**$133.2 m**	**$131.5 m**	**$124.5 m**	**$130.1 m**

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Components of system growth											
Network reinforcement		$42.4 m	$37.8 m	$34.4 m	$32.0 m	$33.7 m	$22.9 m	$23.8 m	$25.9 m	$21.4 m	$27.3 m
Large customer connections		$5.6 m	$3.8 m	$4.4 m	$1.9 m	$1.2 m	$1.2 m	$2.2 m	$2.4 m	$2.7 m	$1.0 m
Asset replacement and renewal											
Large asset replacement projects		$14.5 m	$19.2 m	$16.0 m	$18.0 m	$17.0 m	$18.5 m	$14.8 m	$12.7 m	$12.4 m	$13.3 m
Mass asset replacement projects		$37.8 m	$37.8 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m
Protection & control assets		$4.7 m	$5.0 m	$2.6 m	$5.7 m	$3.2 m	$5.5 m	$5.2 m	$4.3 m	$1.9 m	$2.5 m
Components of reliability, safety & environmental											
Quality		$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m
Legislative and regulatory		$3.6 m	$2.7 m	$3.0 m	$2.3 m	$2.2 m	$3.1 m	$1.8 m	$0.9 m	$0.9 m	$0.9 m
Other reliability, safety & environmental		$1.7 m	$1.7 m	$1.5 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m
Components of asset relocation											
Overhead to underground		$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m
Other asset relocation		$8.0 m	$9.3 m	$6.4 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m

* Figures are in 2014 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

Capital Expenditure Forecast - Revised (Portfolio) Forecasting Methodology (Vector Financial Years)

Budget and Expenditure Forecast (FY)	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Asset Replacement & Renewal	$10.5 m	$11.5 m	$11.5 m	$11.5 m	$11.1 m	$11.2 m	$11.3 m	$11.4 m	$11.5 m	$11.7 m	$11.8 m
Routine & Corrective Maintenance & Inspection	$11.4 m	$12.5 m	$11.6 m	$11.7 m	$11.8 m	$11.9 m	$12.1 m	$12.2 m	$12.4 m	$12.7 m	$12.9 m
Service Interruptions & Emergencies	$6.6 m	$7.1 m	$7.1 m	$7.0 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m
System Operations & Network Support	$10.7 m	$11.1 m	$11.4 m	$11.4 m	$11.4 m	$11.4 m	$11.0 m	$11.0 m	$11.0 m	$11.0 m	$11.0 m
Vegetation Management	$4.2 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m
Direct Operational Expenditure Subtotal	**$43.4 m**	**$46.9 m**	**$46.2 m**	**$46.3 m**	**$46.0 m**	**$46.2 m**	**$46.2 m**	**$46.5 m**	**$46.8 m**	**$47.2 m**	**$47.6 m**

* Figures are in 2014 real New Zealand dollars (million);

** The year reference indicates the end date of the Vector financial year

Direct Operational Expenditure Forecast (Vector Financial Years)

Electricity
Asset Management Plan
2013 – 2023

Background and Objectives – Section 1

[Disclosure AMP]

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1. Background and Objectives

1.1 Context for Asset Management at Vector

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, as well as the safety management system that is currently being enhanced from the present well developed systems.

The Asset Management framework adopted for Vector's electricity distribution business is illustrated in Figure 1-1.

This is a generic asset management model widely adopted by many types of infrastructure businesses. The framework is superimposed on the environment within which Vector operates.

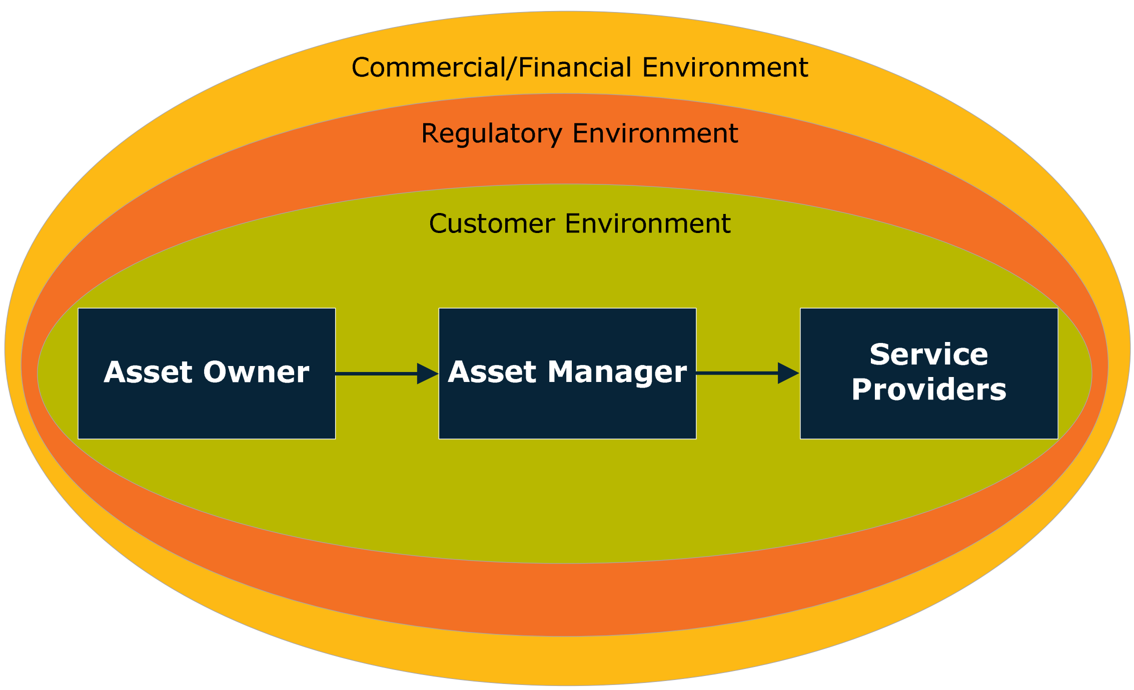

Figure 1-1 : Vector's asset management framework

In this model, the Asset Owner is the highest level of management within the organisation that owns the assets. In Vector's case this is the Vector executive, with oversight from the Vector board. The Asset Owner determines the operating context for the asset manager, focusing on corporate governance and goals, and the relationship with regulators and other stakeholders. The Asset Owner also pays close attention to risk management and the need to ensure that overall legislative requirements in respect to health and safety, risk and environmental compliance are met.

The Asset Manager develops the asset management strategy, directs asset risk management, asset investment and asset maintenance planning, and decides where and how asset investment is made in accordance with directions set by the Asset Owner. The Asset Manager sets policies, standards and procedures for the service providers to implement. In Vector the Asset Manager function is, broadly, the responsibility of the Asset Investment (AI) group.

The Service Providers are responsible for delivering asset investment programmes, to maintain and operate the assets based on the guidelines set by the Asset Manager.

Vector's Service Providers are a combination of the Service Delivery (SD) group - capital programmes, network operations and service operations - and the external contractors and consultants supporting them (see Section 1.7 for a discussion).

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[1]. These standards balance customer requirements and the value they place on reliability of supply with the level of service Vector can economically and safely provide;[2]

  Most direct interaction with customers occurs through the Commercial group. Asset management involves close interaction with the Commercial group 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

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

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

efficient and prudent investment. Importantly, Vector also has to attract capital both locally and from offshore;[3]

Direct contact with the regulators is generally maintained through the Regulation and Pricing 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; and

- 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 and maintenance in the network, including 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 Service Delivery 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 path for Vector's electricity network capital investment and maintenance needs and how we intend to address these.

While this Asset Management Plan's emphasis is on electricity network asset management, it is a document used Vector-wide. It supports the achievement of the vision and goals of the wider company through maximising the efficiency of asset management activities. Rather than being prepared in isolation by and for the electricity business only, the Plan is guided by Vector's overall goals, relies extensively on inputs from all areas within Vector, and one of its key functions is to provide visibility on the asset investment strategies and forecasts to the entire company.

This Plan is also publicly disclosed to satisfy Vector's regulatory obligation. To satisfy the Information Disclosure requirements, the contents of this AMP are presented in accordance with the requirements stated in the Electricity Distribution Information Disclosure Determination 2012.

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

1.1.1 Relationship between Asset Management and Vector's Strategies and Goals

As indicated above, 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 1-2 illustrates the relationship between Vector's corporate strategies and goals with its asset management policy framework.

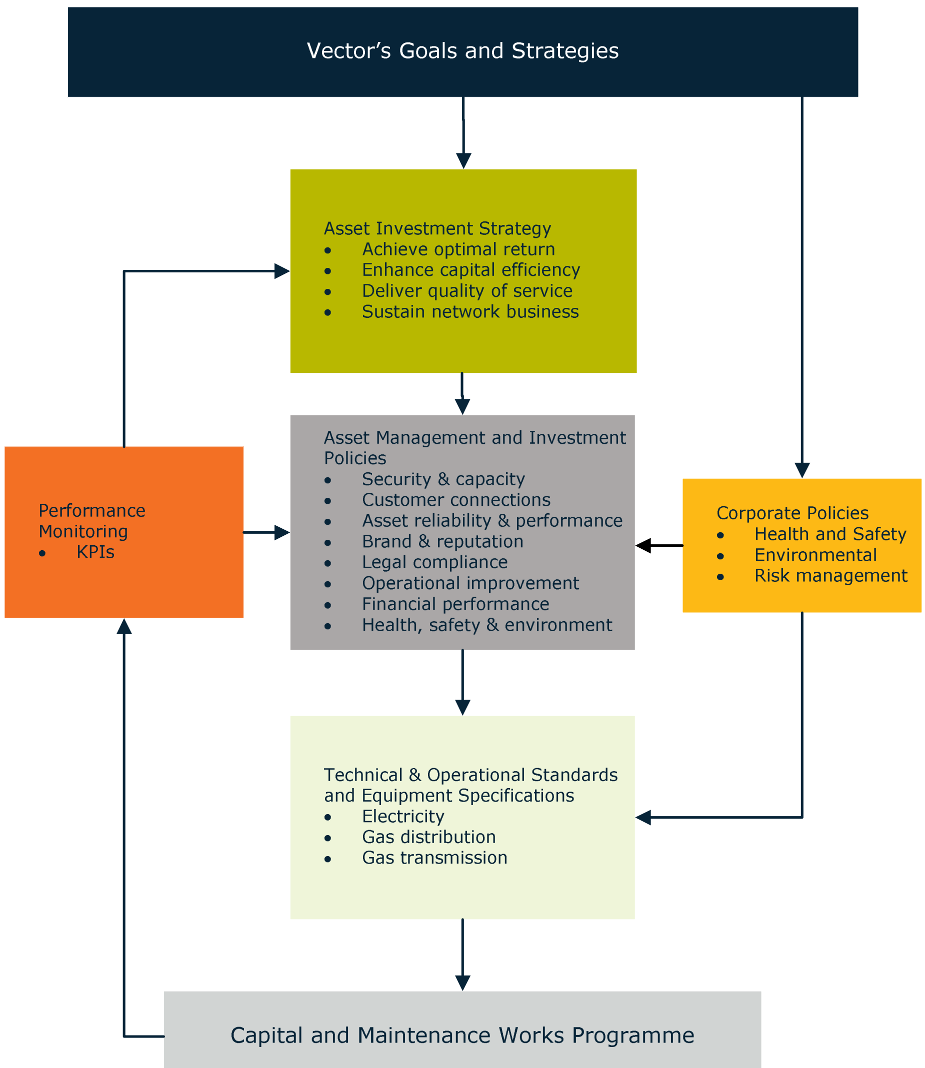

Figure 1-2 : How Vector's asset management strategies and policies relate to the strategic goals

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.

1.2 Planning Period and Approval Date

This AMP covers a ten year planning period, from 1st April 2013 through to 30th June 2023[4] and was approved by the board of directors on 13th March 2013.

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 in the medium to long-term future of network development.

1.3 Purpose of the Plan

This regulatory AMP has been developed as part of the requirements under Clause 2.6 of the Electricity Distribution Information Disclosure Determination 2012 and covers ten years starting on 1st April 2013. 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.

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[4] 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, 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 2013 to 30th June 2023 as well as the three months prior to the start of the 2014 financial year.

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.

1.3.1 Asset Management in Support of Vector's Vision

Vector's strategic vision is to be:

"New Zealand's first choice for integrated infrastructure solutions that build a better, brighter future"

To support Vector in achieving this vision a number of group goals have been defined as follows:

- Public, employee and contractor safety;
- Vector Customer Index;
- Environmental compliance;
- Business line specific goals, including:
    - PRE for gas distribution business
    - Availability of core network for telecommunications
    - SAIDI for electricity business
    - Reliability of smart meters; and
- EBITDA.

These group goals are also used as key performance indicators to assess and award staff performance bonuses.

The group goals are supported by the strategies of the various Vector business units. Asset management, as captured in this AMP, is a key part of the wider Asset Investment group 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 Figure 1-3.

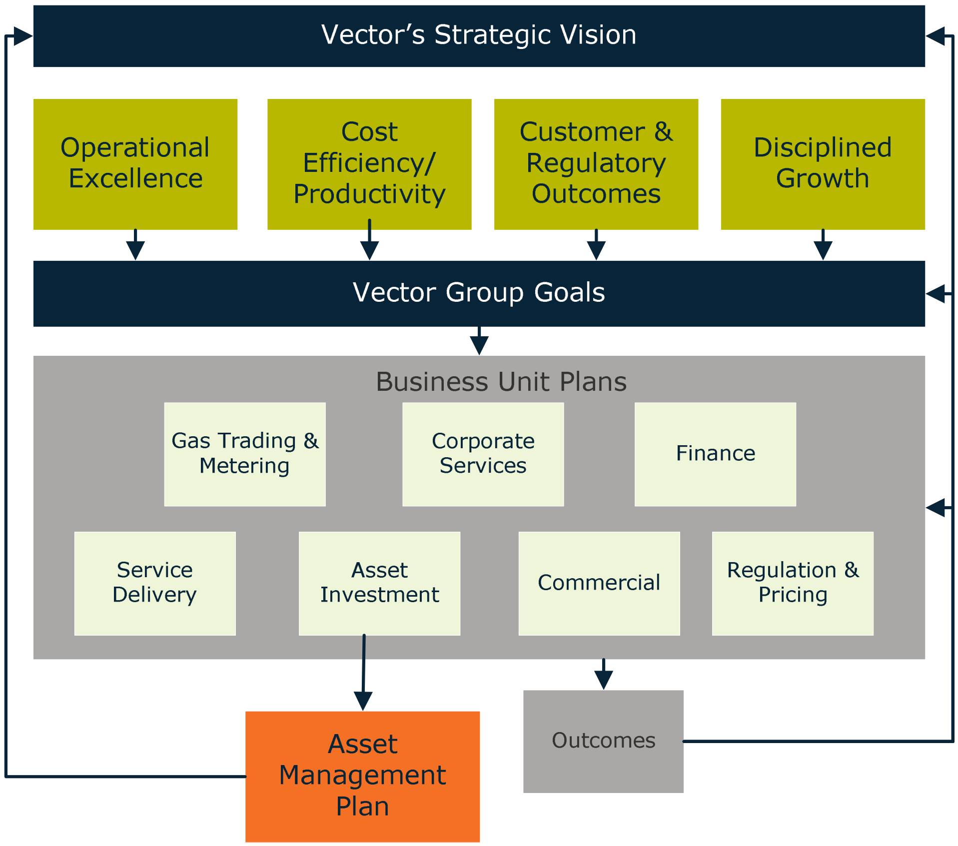

Figure 1-3 : The AMP in support of the overall Vector strategic vision

Table 1-1 below demonstrates how asset management supports Vector to achieve its strategic objectives[5].

Group Goal	← **Asset Management in support of**
Disciplined 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
Customer and Regulatory Outcomes	• Providing safe and reliable services • Fit-for-purpose network designs • Understanding and reflecting customer needs in designs • Security and reliability levels adapted to customer needs • Meeting regulatory requirements • Maintaining appropriate price/quality trade-off • Detailed five-year expenditure budgets • Strategic scenario planning

[5] The group goals and initiatives are not in any priority order.

Group Goal	Asset Management in support of
Operational Excellence, Cost Efficiency & Productivity	• Safety is a top priority • 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
People Engagement (enabler for the goals)	• Health and safety, environmental and risk management principles implemented at an asset investment level • Asset management and performance expectations clearly set • Clear roles and responsibilities

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

1.3.2 Vector's Vision Driving Asset Management

The previous section indicated how asset management at Vector supports the group's overall vision and goals. Conversely, and very importantly for this AMP, the Vector vision and goals also sets the framework and fundamental parameters for asset management[6]. This is illustrated in Table 1-2.

Group Goal driving	Asset Management
Disciplined Growth	• Keep abreast of technology changes • Seek optimal commercial outcomes in investment decisions • Innovation and capital efficiency • Optimised network solutions • Optimised investment timing • New product development and investment where economically viable
Customer & Regulatory Outcomes	• Understanding customer needs and recognising this in decisions • Good project communications • Appropriate price/quality trade-off • Soundly justified investment programme • High quality asset data management • Fit-for-purpose solutions • Security of supply levels appropriate to customer needs • Respond to regulatory quality incentives (when they are introduced) • Keep abreast of technology changes

[6] The group goals and initiatives are not in any priority order.

Group Goal driving	Asset Management
Operational Excellence, Cost Efficiency & Productivity	• Effective consideration of HS&E in investment and maintenance decisions • Asset decisions reflects safe networks as top priority • Implement high priority projects only • Appropriate to network environment • Maintain appropriate risk levels • Fit-for-purpose solutions • Easy-to-maintain and operate networks • Consistent project prioritisation • Minimising asset environmental impact • Standardisation • Clear roles and responsibilities • Strong, well-documented asset management processes • Clear forward view on upcoming work • Consider service providers' capacity
People Engagement (enabler for the goals)	• Setting KPIs for company and individual performance • Technical training and development • Leadership development

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

1.3.3 Key Premise for the AMP

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[7], listed in Table 1-3 below, reflect the manner in which the Asset Investment group understands and implements Vector's 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.[8] • 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.

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

[8] 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. (Alternative approaches for field services provision were investigated prior to the current field services contracts being awarded. The commercial model for these contracts is continually tested and refined. Any change to the provisions of the contract requires negotiation with the field services providers.)
Current supply reliability levels remain unchanged	• Under the current regulatory arrangement in New Zealand, there is no clear 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. • 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 obsolescent, 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. • 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	• This may change, depending on the Commerce Commission's decisions in relation to an s-factor regime to improve quality and the Commission's final interpretation of Section 54Q of the Commerce Act and the regulatory incentives (or disincentives) this brings about. • At present there is no regulatory incentive to improve efficiency, reliability and quality of supply.
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	• In exceptional cases breaches may be accepted, as long as this is consciously accepted, explicitly acknowledged and contingency plans prepared to cater for asset failure. The security standards are based on the optimal trade-off between providing an economically efficient network and Vector's best understanding of customer requirements and the price/quality trade-offs they would like to make.
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.
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 has always actively pursued innovative solutions to address changing consumption patterns, and is in the process of widening out its application of intelligent network devices, making use of the opportunities that the new technologies offer. Subject to economic justification and sufficient regulatory incentives, Vector will therefore continue to invest in its evolution of the intelligent electricity network. In future this may include load shifting or rerouting, to reduce peak demand.

Table 1-3 : 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.

1.4 Changing External Outlook

The Auckland region has yet to experience a strong economic recovery following the recession of 2008/09. Recent events around the world, and in particular in Europe where several countries face sovereign debt issues, could influence the economic recovery in New Zealand. Acceleration in the current slow growth trend for electricity demand in Auckland is therefore not anticipated in the foreseeable future (see Section 5.3 of the AMP for a discussion).

1.5 Asset Management in the Wider Vector Context – Internal Stakeholders

Asset management at Vector is not practised in isolation. It is heavily reliant on inputs from the various parts of the company, either directly or indirectly. The AMP provides visibility of asset management activities to the rest of the company, for incorporation into the broader business plans and strategies. This two-way support flow is illustrated in Figure 1-4 and Figure 1-5.

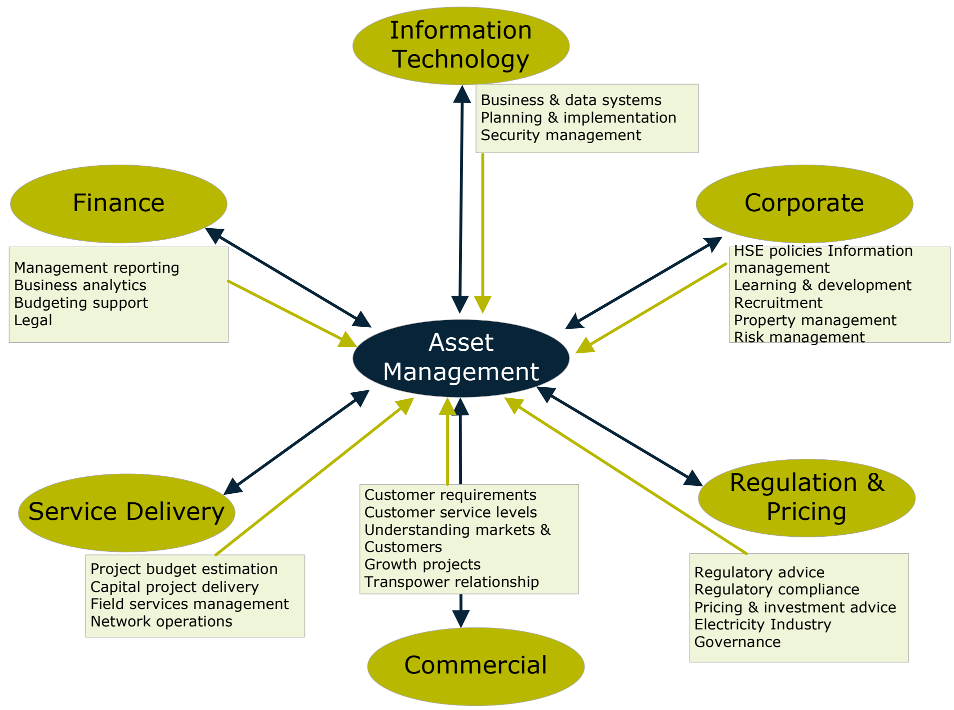

Figure 1-4 : Interaction with the rest of Vector - the flow into asset management

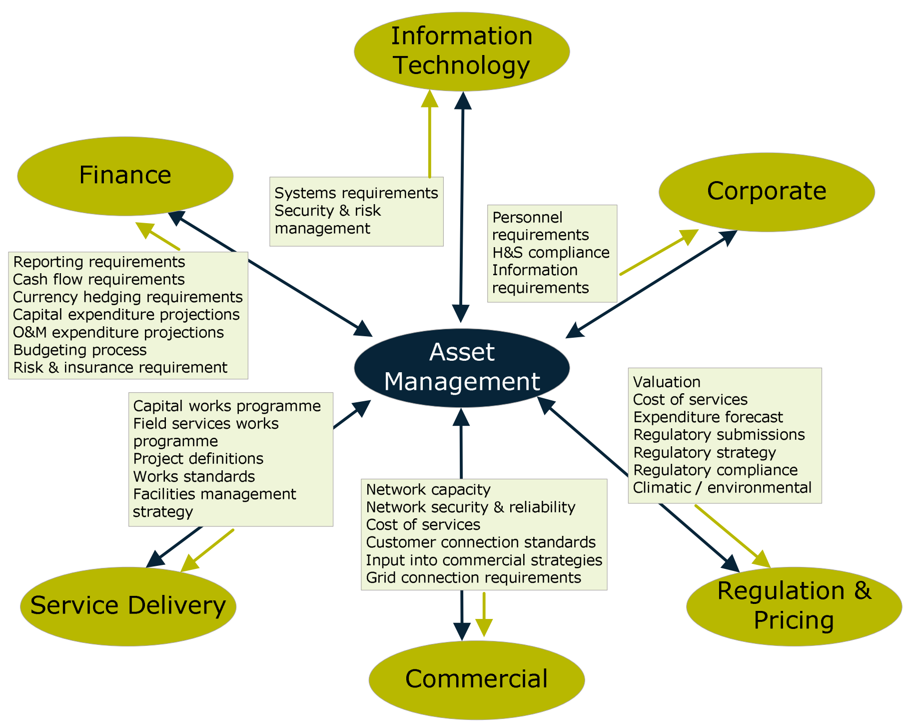

Figure 1-5 : Interaction with the rest of Vector - the flow from asset management

1.5.1 Communication and Business Participation in Preparing the AMP

As part of business-as-usual, there is ongoing close communication and cooperation between the various business units in Vector and the asset management team. This is considered key to the success of the larger Vector.

With respect to the preparation of the AMP, the following action plan has been prepared to guide its development and implementation, and to communicate the strategies and activities to the relevant parties.

Step	Description
1	Inform staff involved in the preparation of the AMP of the evolving information disclosure requirements (what information to be provided) and definitions of terms used to ensure consistency in the presentation of the AMP.
2	Reinforce the asset management strategies (risk assessment, maintenance strategies, network development standards, etc) and how these relate to the corporate goals. This strengthens the focus of the Asset Management Plan on the objectives of the Plan.
3	Information requirements include: • Reiteration of requirements under the previous regime (that are still required under the current regime) that require attention • New or additional (to the previous regime) requirements • Key issues include (but not limited to): ➢ Definition of capex and opex categories ➢ Asset categories and asset classes ➢ Planning period and disclosure year ➢ Price inflation factor ➢ Key assumptions ➢ Options analysis and justifications for near term projects ➢ Service levels targets and performance level ➢ Capability to deliver works programme ➢ AMMAT.
4	Identify data and information requirements.
5	Notify relevant parties of information systems and accounting structure needed to provide the required information in the required format.
6	Inform staff of the structure of the disclosure AMP and the time line for preparing the AMP.
7	Identify the assumptions to be used in preparing the disclosure AMP (demand forecast, cost estimation, escalation, etc.).
8	Assess the deliverability of the works programme (within the next two years). Seek input from project managers and field service providers.
9	Allocate responsibilities for preparation of the AMP.
10	Engage with staff and field service providers to seek input prior to finalising the AMP.
11	Circulate the drafts of the AMP to interested parties (Commercial, SD, Finance, Regulatory, IT) within Vector for inputs and comments.

Step	Description
12	Seek staff input / comments on risk assessment and service performance aspects of the AMP.
13	Finalise the AMP taking into account relevant inputs and comments received.
14	Seek comments and approval from executives prior to seeking board approval.
15	Upon approval of the AMP (and associated budgets), organise staff to prepare works programme (including detailed designs, etc) for the next two years and communicate the works programme to staff and service providers.
16	Present highlights of the AMP (asset management strategies and policies, how they support Vector's goals, works programmes, etc) to staff and field services partners involved in asset management activities.
17	Reiterate the company's aim for achieving capital efficiency (including its goals and past achievements and respective staff KPIs).
18	Monitor project and works programme progress against plan. Monitor expenditure against budget.

Table 1-4 : AMP Action Plan

1.6 Asset Management in the Wider Vector Context – External Stakeholders

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 1-6, 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.

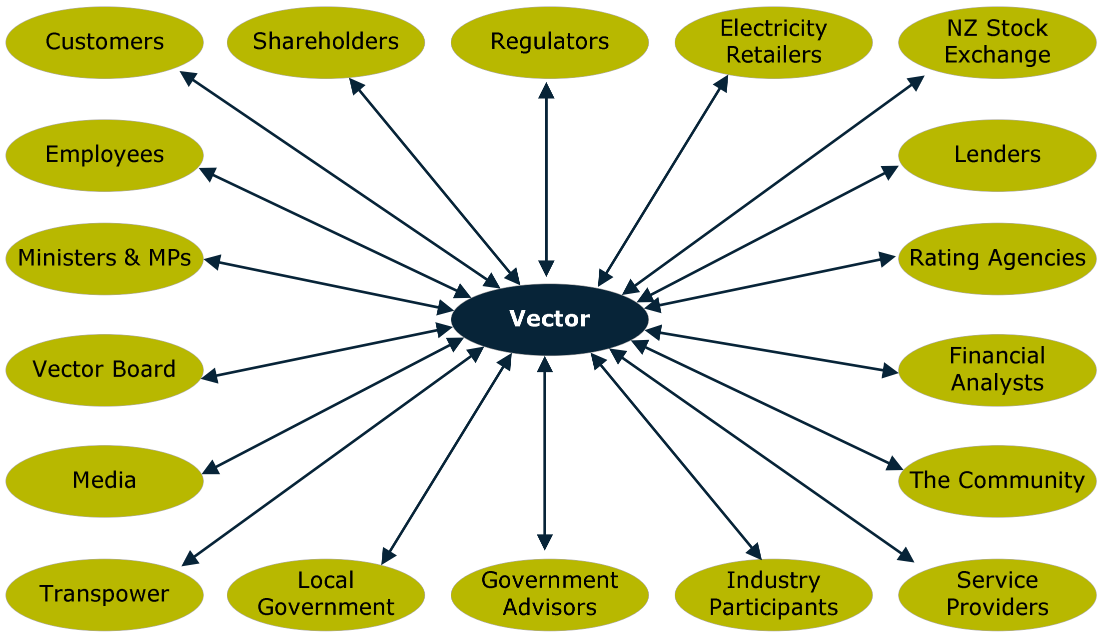

Figure 1-6 : Vector's key external stakeholders

1.6.1 Stakeholder Expectations

Important stakeholder expectations[9] are listed in Table 1-5 below.

Customers (and End-Use Consumers)	
Health and safety	Reliable supply of electricity
Quality of supply	Planned outages
Security of supply	Timely response to complaints and queries
Efficiency of operations	Information in fault situations
Reasonable price	Environment
Timely response to outages	Timely connections
Innovation, solution-focus	
Shareholders	
Health and safety	Regulatory and legal compliance
Sustainable growth	Prudent risk management
Sustainable dividend growth	Good reputation
Reliability	Good governance
Confidence in board and management	Clear strategic direction
Accurate forecasts	Return on investment
Retailers	
Reliability of supply	Information in fault situations
Quality of supply	Ease of doing business
Managing any customer issues	Good systems and processes

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

Regulators	
Statutory requirements Accurate and timely information	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 Reduction in emissions
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 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 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	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 1-5 : Stakeholder expectations

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

- Meetings and discussion forums;
- Consumer engagement surveys;
- Engagement with legislative consultation processes;
- Employee engagement surveys;
- 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.

1.6.2 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 the list in Section 1.3);
- 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. At an investment decision level, a project prioritisation matrix (Table 9.1) has been developed to provide guidance on the selection of projects for implementation.

1.7 Asset Management Structure and Responsibilities

1.7.1 Senior Level Organisation Structure

The Vector senior level organisation structure is provided in Figure 1-7 below. The Vector group is split into several functional areas, each with a responsible general manager.

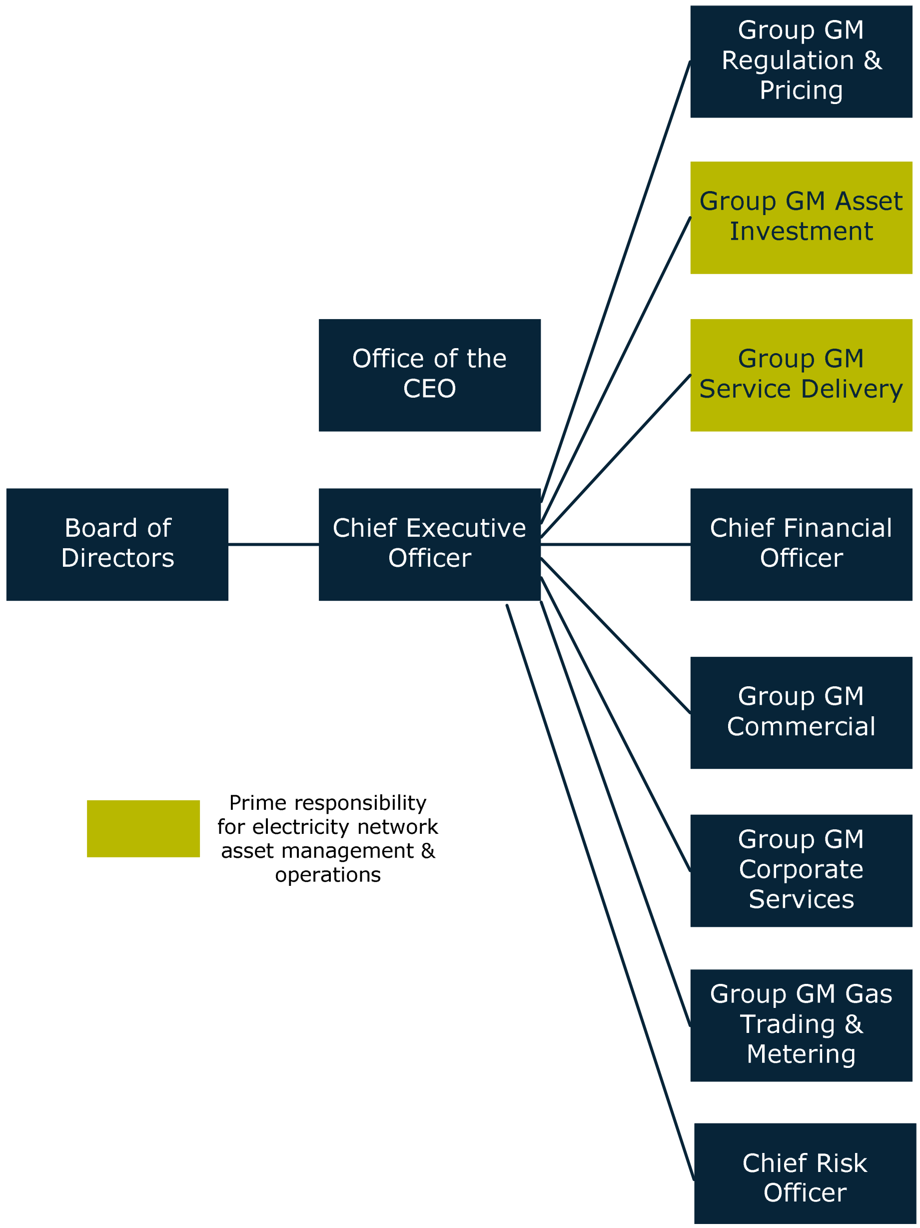

Figure 1-7 : The Vector senior management structure

The primary responsibility for the asset management of the electricity distribution network lies with the Group General Manager Asset Investment. The service provider function for the electricity network is primarily fulfilled by the Service Delivery group, under the Group General Manager Service Delivery. The role these two sections play in asset management is further discussed in Section 1.7.2 and Section 1.7.3.

In summary, the responsibilities of the other groups are as follows:

- Office of the CEO

  Public affairs; company secretary; corporate risk management; economic advisor and corporate growth initiatives.

- Regulation and Pricing

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

- Finance

  Financial accounting and reporting, budgeting, treasury, management accounting, group legal services, investor relations, business analytics and insurance.

- Commercial

  Key customer relationships, mass market customer relationships, customer connections, commercial strategies, Vector's Fibre and Communications business and energy consumption projections.

- Corporate Services

  Human resource management support, training and development, recruitment, health, safety and environmental policies, personnel performance management, property services, business and data systems, IT support, computer hardware and software support and maintenance, cyber-security and communication networks.

- Gas Trading and Metering

  Wholesale gas business, liquid petroleum gas (LPG) business and metering services.

1.7.2 The Asset Investment Group

As the Asset Manager, the primary responsibility for the management of the electricity network and preparation of the AMP lies with the Asset Investment (AI) group. In broad terms, this group is responsible for:

- Setting electricity network security standards;
- Supporting Vector's development and implementation of a Safety Management System;
- Ensuring asset investment is efficient and provides an appropriate commercially sustainable return to the company's shareholders;
- Ensuring the configuration of the electricity network is technically and economically efficient, meets customer requirements, and is safe, reliable and practical to operate;
- Planning network developments to cater for increasing electricity demand and customer requirements;
- Ensuring the integrity of the existing asset base, through effective renewal, refurbishment and maintenance programmes;
- Preparing detailed engineering design for projects, including engagement of design consultants;
- Keeping abreast of technological and consumption trends, assessing the potential impact thereof and devising strategies to effectively deal with this in the long-term network planning;

- Maintaining current and accurate information about the extent and performance of the network and assets;
- Maintaining strategic relationships with local government bodies and major infrastructure providers to support the long-term protection of Vector's assets by ensuring that obligations (from all perspectives) are well understood and met, works are co-ordinated and best mutual outcomes are sought; and
- Ensuring that Vector's obligations to the Auckland Electricity Consumer Trust (AECT) with regard to undergrounding networks in the Southern region are met.

The AMP is the prime document that captures how the above functions are discharged.

In Figure 1-8 the structure of the AI group is expanded, emphasising the electricity network asset management responsibilities.

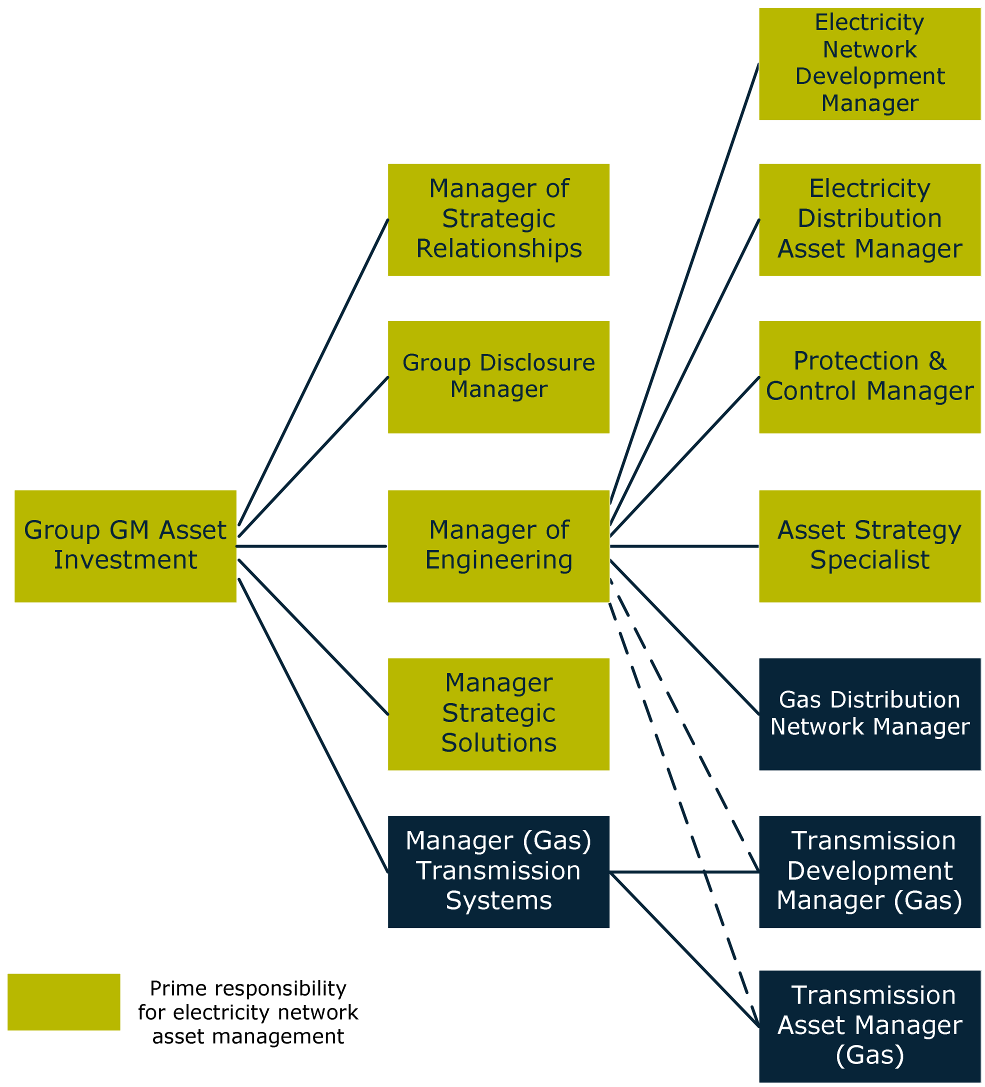

Figure 1-8 : The Asset Investment management structure supporting the AMP

1.7.3 The Service Delivery Group

In Vector's asset management model, the service provider function is predominantly fulfilled by the SD group. In conceptual terms, the AI team defines what assets are required, when and where, and how these should be operated and maintained, while the SD group delivers on providing, operating and maintaining the assets.

The SD group has a wide brief but the key functions as far as it relates to asset management, or the provision of the service provider function for the electricity network, are illustrated in Figure 1-9 and further expanded below.

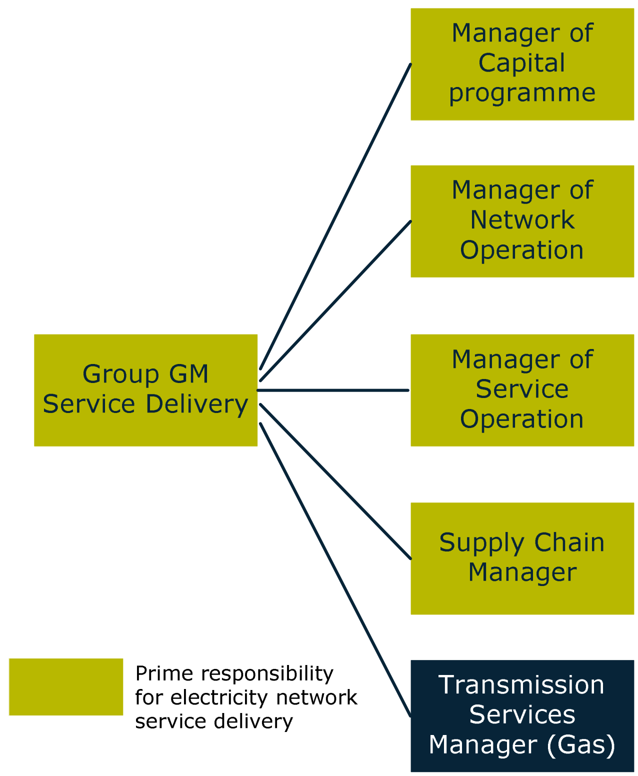

Figure 1-9 : Service Delivery as an asset management service provider

1.7.3.1 Network Operations

The Network Operations section 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, reporting and investigating outages; switching on the network to ensure optimal configuration or to maintain supply during asset outages; and network switching during commissioning of new assets.

As the prime "operator" of the network, this team interacts closely with the Asset Manager, particularly on the following:

- Setting safe asset operation levels (short and long-term);
- Planning network configuration;
- Defining user requirements;
- Investigating outages and the root causes – especially if asset-related; and
- Contingency management.

1.7.3.2 Capital Programme

The Capital Programme section is responsible for the delivery of large infrastructure projects and is a key partner to AI in the end-to-end asset creation/replacement processes. The Capital Programme team provides programme and project management expertise into the end-to-end capex delivery process and has the accountability to lead the development of the works programme, in addition to managing individual projects from kick-off to close-out. Vector does not have an in-house construction section for the electricity network - construction work is predominantly undertaken through external providers through a competitive tender process, or by Vector's contracted service providers Northpower and Electrix (who were also selected through a competitive tender process).[10]

The Capital Delivery team and AI group have numerous touch-points, particularly the following:

- Input to the AMP in terms of resource capacity and outage requirements;
- Development of an annual works programme that balances asset, resources and outage requirements;
- Managing the end-to-end project delivery process;
- Work scopes and project briefs;
- Detailed project cost estimation;
- Reporting on project progress;
- Expenditure tracking and forecasting;
- Construction and commissioning standards; and
- Project close-out and capturing learning.

The AI Engineering group manages the overall capital budget and is responsible for setting and controlling this, including obtaining the necessary expenditure approvals through the Vector governance process. After expenditure is approved, Capital Delivery manages the individual projects and associated expenditure.

1.7.3.3 Service Operations

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. This section is also responsible for managing customer service processes and operations relating to outage management, customer complaints (including EGCC), mass market connections and value-adding services.

The Service Operations section interacts with Asset Management in various areas, including:

- Implementation of asset maintenance and vegetation management policies;
- Providing asset information to AI for engineering analysis, condition and performance assessment, renewal and refurbishment programmes and to set maintenance and renewal budgets;
- Managing replacement of mass assets (eg. poles, cross-arms or distribution transformers)[11], including project progress and expenditure reporting;
- Feedback on asset performance and customer issues; and
- Investigating asset failures.

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[10] Works provided by our contracted service providers are still managed through a competitive bid process, although it may not be put out to open tender on a project by project basis.

[11] These mass-replacement works are not included in the large projects that are managed through the Capital Delivery group.

1.7.3.4 Procurement

The Procurement section manages procurement of major assets for Vector. Since the bulk of these assets are procured for capital delivery projects this activity is closely linked to Asset Management, including:

- Preparation of asset (contract) specifications;
- Selection of equipment suppliers;
- Supply line negotiation;
- Tender awards; and
- Equipment cost-estimation.

1.7.4 Asset Management Activities by Other Groups

While the bulk of electricity network asset management activities are performed by the AI group, supported by the SD group, as noted in Section 1.5 the rest of Vector has many inputs. Most of these inputs are indirectly related to the assets themselves, but there are the following exceptions, where electricity-related assets are directly sourced and incorporated by others.

1.7.4.1 Commercial

The Commercial group is responsible for new customer connections and the revenues derived from these assets. For large connections, which require core network extensions or could have material capacity implications, the installations are generally managed by AI and SD groups as part of the normal core network growth projects[12]. Provision of smaller, non-standard connections is directly managed by the Commercial group – through the Vector service providers. Routine connections are managed by the SD group (through the Vector service providers), under the guidance of the Commercial section.

The Commercial group is also responsible for setting and measuring the service experience that customers on Vector's networks should receive for connections and faults.

Lastly, the Commercial group manages Vector's relationship with retailers, large customers and Transpower (which is a key service provider).

1.7.4.2 Information Technology (part of Corporate Services)

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. Increased cyber-security of both SCADA and Communications has to be provided for.

Procurement and implementation of Asset Management and IT support systems, and the core SCADA equipment, is managed by the Information Technology group.

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[12] The Commercial group remains responsible for the contractual and commercial arrangements with customers.

1.7.4.3 Vector Communications (part of Commercial)

Vector Communications manages Vector's fibre optic network, for internal and external clients. They provide a major part of the SCADA network – the communication link between field devices and the central control stations.[13] Provision of this service is on a strict commercial basis, with the AI group treated similar to external clients and charged on the same basis.

1.7.5 Field Service Model

Vector's business model for operating and maintaining its electricity network assets is to outsource this work to Field Services Providers (FSPs).

After an extensive investigation in 2008/09 it was decided to retain the outsourcing model. Through a competitive process, Vector selected two FSPs, viz., Electrix Ltd as the maintenance contractor for the Northern region and Northpower Ltd as the maintenance contractor for the Southern region. These two FSPs are responsible for the preventative, corrective and reactive maintenance works of the electricity network.

Other outcomes of the review included establishing new key performance indicators (KPIs) and a new framework with guiding principles to manage the working relationships between Vector and the FSPs. The objective of the new business model is to improve the efficiency and quality of the delivered services to Vector and its customers.

1.8 AMP Approval Process

Approval of the disclosure AMP is sought at the March board meeting.

The AMP is subject to a rigorous internal review process, initially within the AI group (the developer of the Plan), and then by the Regulatory, Commercial, Financial and SD groups as well as external experts. Finally, the AMP is reviewed and certified by the board, in accordance with the Electricity Distribution Information Disclosure Determination[14].

1.8.1 Alignment with the Vector Budgeting Process

Vector operates under a July to June financial year. The Asset Management planning processes and documents form a key input into the budgeting process. These contain detailed, prioritised breakdowns of the electricity network expenditure requirements identified by AI for the next five years, with supporting evaluation for the individual projects or programmes. This is intended to assist the executive with the budget process, clarifying the electricity network priorities and also prioritising these along with other business investment needs.[15] 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.

The Information Disclosure Determination requires the disclosure AMP to be prepared for a regulatory timeframe that differs from Vector's financial year. The asset management activities in this AMP are prepared on the basis of the Vector financial year (July to June year) to ensure they are consistent with all the financial and management reporting information. To satisfy the regulatory requirements, the summary financial information

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[13] Not all of the SCADA communication is provided over fibre optic communications. There is still a substantial pilot wire system in place and radio links are also used.

[14] Schedule 17 of the Electricity Distribution Information Disclosure Determination 2012

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

contained in Section 9 of this AMP is converted and presented on the basis of the disclosure year (April to March year). This Plan therefore covers the period between 1st April 2013 and 30th June 2023 to meet both Vector's internal and regulatory requirements.

1.8.2 The Expenditure Forecasting Process

In Figure 1-10 the forecast process for capex projects in the AMP is illustrated. This process follows the following steps:

- The overall capital works programme is divided into different work categories. A plan covering the next five-year period is first developed for each work category (based on the asset management criteria for that work);
- A works programme is then drawn up and the corresponding capex to implement the works programme is developed. This is an unconstrained estimate;
- The prioritisation process described in Section 9 is then applied to the projects and programmes within the work category. This identifies projects that could be left out from the programmes without undue negative consequences. Through this, it is possible to set an upper and lower boundary for the expenditure levels;
- Discussions then take place with Service Delivery (and Service Providers) to ensure the required resources and skills to complete the works programme are available, and appropriate adjustments made prior to the works programme being finalised; and
- An overall prioritisation process is then applied to the combined suite of network projects, to develop the final AMP forecast for combined capex.

As noted before, the accuracy of forecasts further out in the planning period diminishes. The capital forecasts for years six to ten are based on a combination of projects foreseen at this stage and trend analysis for other types of projects. Project prioritisation for this period is indicative only.

A similar process is adopted for the operation and maintenance expenditure forecasts, which are prepared in conjunction with Service Delivery.

1.9 Asset Management Decisions and Project Expenditure Approval

Implementation of the AMP requires decisions to be made by management and staff 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.

Investment decisions are budget-based, with the board approving yearly budgets before any commitment can be made. Preliminary project approval is normally given through the annual (one-year) budgeting process, but projects are not individually assessed in detail at this stage. Project-specific capex approval therefore still has to be granted for all projects prior to committing capital, despite these having been included in the approved annual budget. The detailed project approval process has been developed in accordance with the Vector DFA system.

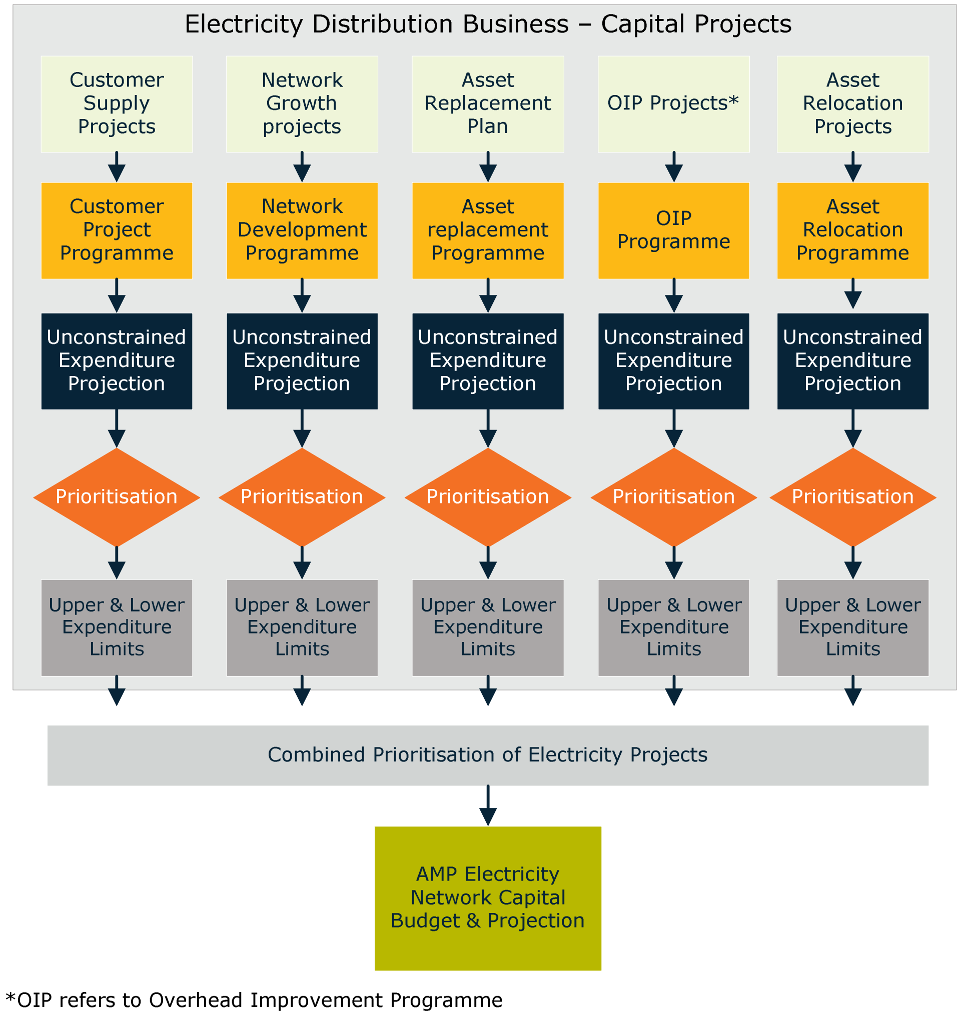

Figure 1-10 : Capex forecasting process adopted for the AMP

Critical unbudgeted investments will be taken to the Board for consideration at any stage of the financial year, if supported by a robust business case or arising from an urgent safety, reliability or compliance issue.

Applications for expenditure approval must be supported by formal business cases. Each business case contains information on the expenditure objective, constraints and assumptions, strategic fit, options investigated, project time line, resources required and available, project deliverability, cost benefit analysis, return on investment and risk assessment. This assists Vector management to assess and approve investment applications.

1.10 Progress Reporting

Performance against the annual budgets is closely monitored, with formalised change management procedures in place. Regular reports are sent to the Vector board regarding:

- Health, safety and environmental issues;
- Monthly report on 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).

1.11 Asset Management Processes

The diagram in Figure 1-11 shows the high level asset investment process within Vector. This highlights the relationship between the different asset creation and evaluation processes within Vector.

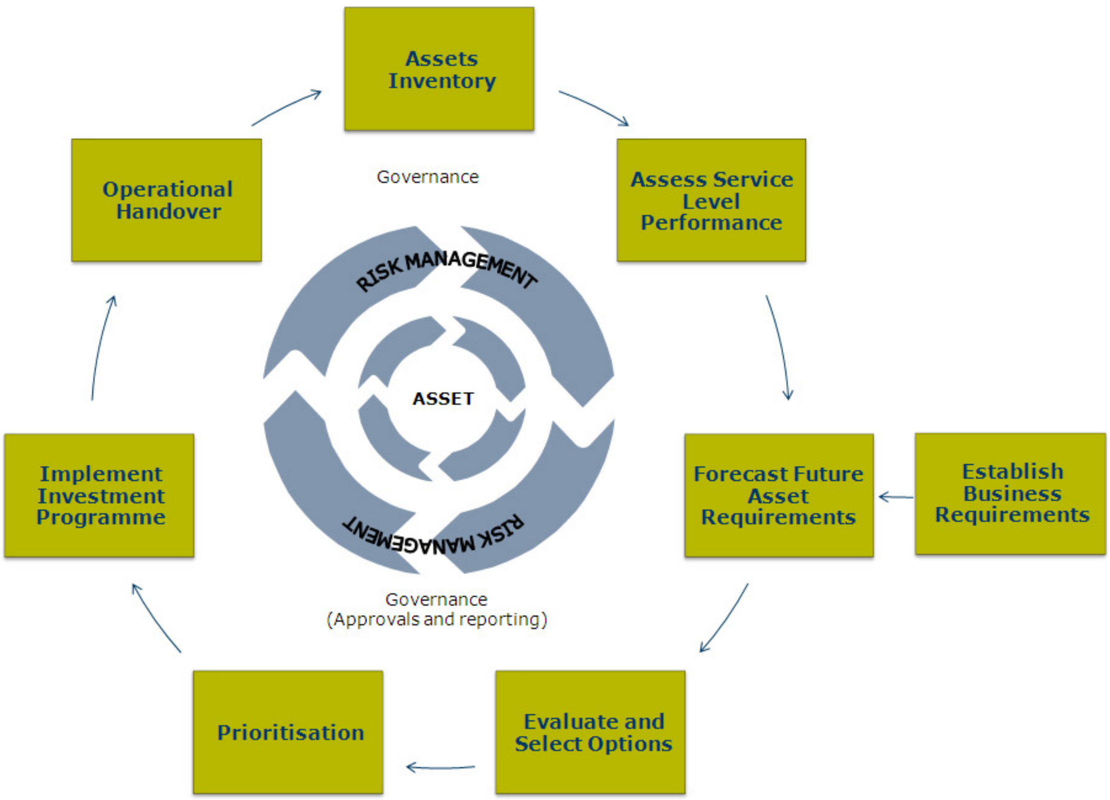

Figure 1-11 : High-level overview of the Vector asset investment process

Assets Inventory

Information on the quantity, age and capability of existing assets is essential to understand and effectively manage the asset base. Information on the existing assets and network configuration is set out in Section 2 and Section 6 of this AMP.

The asset register, geographical information system (GIS) and associated databases store cost information and technical characteristics for all assets, including their location, history and performance. The way in which IS support Asset Management processes is described in Section 7.

Assess Service Level Performance

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). Information on the condition and performance of existing assets and on the network configuration is set out in Section 4, Section 5 and Section 6.

Establish Business Requirements

The levels of service required from the electricity network are guided by the wider business requirements. 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.

Section 1 sets out the background and business requirements that drive the AMP. Service levels are described in Section 4, Section 5 and Section 6.

Forecast Future Asset Requirements

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. Section 4, Section 5 and Section 6 discuss this information.

Vector operates an electricity network in a changing environment, and future requirements are likely to differ materially from the situation faced today. Such changes have to be anticipated in current development plans. Section 3 discusses the anticipated impact of future technology on the network, and Vector's development strategies to position for this.

Evaluate and Select Options

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 loadflow 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

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 – which encompass commercial, safety and technical considerations - 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.

The way Vector prioritises electricity capital investment projects is discussed in Section 5, Section 6 and Section 9.

Implement Investment Programme

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. While most projects are delivered in the financial year, the delivery of larger projects, such as new zone substations (a substation containing equipment at sub-transmission voltage, sub-transmission voltage includes 110kV, 33kV and 22kV), may straddle financial years. Budgetary provision is made in the year expenditure will be incurred.

The implementation of solutions identified as part of the Asset Replacement (Section 6) or Planning Process (Section 5) are managed by the SD and Commercial (for customer connections) groups. For larger projects, the Capital Programme team, as part of the SD group, develops the conceptual solution into a detailed design suitable for implementation. Contracts are awarded to accredited service providers (following a competitive tender process) for the execution of these projects.

Service Operations (a team within the SD group) manages the bulk replacement and maintenance programmes, liaising directly with the service providers while the Customer Solutions team in the Commercial Group manages the customer connections with the service providers.

Operational Handover

Once construction and installation is completed, a formal handover process takes place. The process is designed to check the quality of work and equipment meets Vector's standards and the assets are constructed to allow maintenance in accordance with Vector's Operation and Maintenance Manuals. It also includes a walkover between the Project Manager, a network operations representative and the asset specialists who take assets over and implement the maintenance regime and the contractors who manage the assets on Vector's behalf. The GIS record is updated with the new assets as well as the Asset Life Information System (ALIS) database.

Governance (Approvals and Reporting)

Formal approval (budgets and expenditures) and reporting (progress and risks) processes are in place to satisfy Vector's Corporate Governance requirements.

Risk Management

Risk management underpins all Asset Management business processes and forms an important part in defining project requirements (discussed in Section 8).

1.12 Works Coordination

1.12.1 Internal Coordination

Over the last few years, Vector has put extensive effort into continuously improving the coordination of the various activities associated with the delivery of the capital works programme with the objectives of better utilisation of resources, enhancing capital efficiency and delivering improved customer outcomes. Improvement initiatives have included:

- Introduction of Integrated Works Planning across the end-to-end capex process – this is to drive an efficient and deliverable works plan that coordinates work to optimise outage impacts and resource requirements;
- Introduction of Early Contractor Involvement to drive:
  - Improved risk evaluation/mitigation/management/allocation;
  - Clear understanding and development of scope and delivery sequence;
  - Early constructability input and reviews;
  - Earlier operational, maintenance and operability acceptance, at product specification and design stage rather than at hand-over;
  - Improved innovation; and
  - Better price definition for raising budgets – improved cost certainty and a well run job with less variations;
- Significant refinement of the end-to-end capex process to better define accountabilities across all involved parties;
- Roll out of a standard Project Management Institute (PMI) process for all Project Managers; and
- Refinement of project server to improve project and programme planning and management.

In addition to its electricity networks, Vector operates gas distribution networks, a gas transmission system and a fibre optic telecommunication network. To maximise the synergy benefits that can be achieved from cooperation and to deliver projects in the most effective, least disruptive manner, effective coordination of capital works between these business units is essential. Significant improvement in delivery has been achieved over the last couple of years through the implementation of these initiatives.

1.12.2 External Coordination

As well as internal coordination, new processes have also been put in place to improve coordination between Vector and other utilities, roading authorities, local councils and their service providers. These works coordination processes are focused on maintaining effective communication channels with external agencies, identifying cost effective future proofing opportunities, minimising disturbance to the public as a result of infrastructure works, streamlining works processes and meeting Vector's regulatory obligations.

It is important for Vector to be cooperative and supportive in its relationships with other agencies. In the past this has resulted in a number of win-win outcomes, with Vector for example obtaining access to motorway corridors for laying cables.

1.13 Other Asset Management Documents and Policies

Vector has a number of other documents used to capture Asset Management policies and procedures. Including all of these in one document would produce an unwieldy, impractical plan. In addition, there are a number of company-wide policies that have a direct bearing on asset management.

1.13.1 Other Asset Management Documents

The AMP is supported by a collection of detailed Asset Management documents, guidelines and policies in the following areas (not in any order of priority):

- Asset management and investment;
- Network security;
- Detailed asset maintenance;
- Network design;
- Network architecture;
- Risk management;
- Asset ownership;
- Contracts management;
- Procurement;
- Health and safety;
- Environmental;
- Asset rehabilitation;
- Load management;
- Asset settlement;
- Network contingency plans;
- Network projects quality assurance; and
- Drug and alcohol management.

In addition to the policies, Vector has also developed a suite of work practice standards and guidelines and equipment specifications to guide its service providers in the course of implementing the works programme. These standards, guidelines and specifications can be found on Vector's internal communications website.

1.13.2 Other Company Policies Affecting Asset Management

Vector has a number of business policies[16] designed to help the business to operate efficiently and effectively. Many of these interact with, or impact on, the Asset Management policies and this AMP.

Business:

- Code of conduct;
- Legal compliance policy;
- Protected disclosure policy;
- Remuneration policy;
- Customer credit policy;
- Foreign exchange policy;
- Expense management policy;
- Network WIP (work-in-progress) management policy;
- Drug and Alcohol policy;
- Network fixed asset creation and disposal policy; and
- Capex policy.

[16] These policies are not listed in any order of priority.

Information Technology:

- Access policies;
- Password and authentication policy;
- Network management policy;
- Internet use policy;
- E-mail policy;
- Access control policy;
- Antivirus policy;
- Communications equipment policy;
- Computer systems and equipment use policy;
- Cyber crime and security incident policy;
- E-commerce policy;
- Firewall policy;
- Hardware management policy;
- Information technology exception policy; and
- Information technology general user policy.

1.14 Review of Vector's Asset Management Practice

1.14.1 Asset Management Maturity Assessment (AMMAT)

In terms of the Electricity Distribution Information Disclosure Determination 2012, the Commerce Commission now requires its Asset Management Maturity Tool (AMMAT) to be applied by all electricity distribution businesses. This tool, which is an extract from the internationally used British Standards Institute PAS55 (2008) Asset Management Model, is intended to facilitate a self-reflection on the maturity of asset management at each business and to highlight areas for possible improvement.

Vector is not convinced that the AMMAT, or indeed PAS55, is necessarily an appropriate tool to measure asset management maturity for New Zealand electricity distribution businesses. Over the years Vector has been striving to strike an appropriate balance between operating efficiency and the increased workload and bureaucracy associated with adopting formal quality standards. As discussed in Section 1.14.2, our asset management practices have are independently audited on a regular basis, and have repeatedly been found to be aligned with best industry practices.

Nonetheless, to comply with the Information Disclosure Determination (2012), Vector has applied the AMMAT. Vector's self-assessment was undertaken in a workshop setting by managers responsible for the various facets of asset management at Vector. The results were reviewed by senior executives responsible for the Asset Investment and Service Delivery groups. The assessment was undertaken in accordance with guidelines provided by the Commerce Commission and also the Electricity Engineers' Association (EEA) [17].

[17] Electricity Engineers' Association, "Guide to Commerce Commission Asset Management Maturity Assessment Tool (AMMAT)", October 2012

The AMMAT is a series of questions against which a business has to assess its maturity level. Maturity is measured on a 5-point scale, defined as follows (by the EEA):

<u>Maturity Level 0</u>

The elements required by the function are not in place. The organisation is in the process of developing an understanding of the function.

<u>Maturity Level 1</u>

The organisation has a basic understanding of the function. It is in the process of deciding how the elements of the function will be applied and has started to apply them.

<u>Maturity Level 2</u>

The organisation has a good understanding of the function. It has decided how the elements of the function will be applied and work is progressing on implementation.

<u>Maturity Level 3</u>

All elements of the function are in place and are being applied and are integrated. Only minor inconsistencies may exist.

<u>Maturity Level 4</u>

All processes and approaches go beyond the requirements of PAS 55. The boundaries of Asset Management Development are pushing to develop new concepts and ideas.

As part of its self-assessment, Vector also considered the maturity level it desires to achieve. On all assessment questions, the company goal is set at maturity level 3. In Vector's assessment this level would assist the optimal level of safe and efficient network operation while avoiding the substantial additional cost and effort that would be required to further improve asset management practices (to beyond general good industry practice). If, during future assessments it is found that in some aspects of asset management achieving maturity level 4 would be desirable, the goal will be re-assessed.

The result of Vector's self-assessment is provided in Table 1-6 below. The full assessment criteria for the individual questions are included in Appendix 9.

Question No.	Function	Question	Rating				
			0	1	2	3	4
3	Asset management policy	To what extent has an asset management policy been documented, authorised and communicated?					
10	Asset management policy	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?					
11	Asset management policy	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?					
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?					
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?					
29	Asset management plan(s)	How are designated responsibilities for delivery of asset plan actions documented?					

Question No.	Function	Question	Rating				
			0	1	2	3	4
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)					
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?					
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)?					
40	Structure, authority and responsibilities	What evidence can the organisation's top management provide to demonstrate that sufficient resources are available for asset management?					
42	Structure, authority and responsibilities	To what degree does the organisation's top management communicate the importance of meeting its asset management requirements?					
45	Outsourcing of asset management activities	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)?					
48	Training, awareness and competence	To what extent has an asset management policy been documented, authorised and communicated?					
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?					
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?					
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?					
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?					
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?					
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?					
64	Information management	How has the organisation ensured its asset management information system is relevant to its needs?					
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?					
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?					
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?					
88	Life Cycle Activities	How does the organisation establish implement and					

Question No.	Function	Question	Rating				
			0	1	2	3	4
		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?					
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?					
95	Performance and condition monitoring	How does the organisation measure the performance and condition of its assets?					
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?					
105	Audit	What has the organisation done to establish procedure(s) for the audit of its asset management system (process(es))?					
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?					
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?					
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?					
		OVERALL RATING					

Table 1-6 : Asset management maturity assessment ratings

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. Two broad areas in particular have been identified where improvement in Vector's asset management could be achieved:

a. Formalising Processes and Documentation

Vector's asset management practices were developed over several decades and help to ensure a high-quality, safe electricity supply to its customers. However, formal documentation relating to these practices is somewhat incomplete and distributed across the organisation, or exist in varying formats and degrees of detail. There are also some gaps in documented asset management processes, and the board approves asset management policy at the same time as it approves an Asset Management Plan (rather than work to a formal stand-alone policy).

Current best practice asset management (as espoused in PAS55), requires significantly more focus on formal documentation and processes. For this reason Vector is systematically reviewing and updating asset management documentation and processes. This includes better documentation and documentation management, improved communication of formal asset management documentation and requirements, documenting the resource and training requirements for asset management and more formally measuring performance against asset management requirements. In addition, a formal asset management policy document is being developed which will be formally approved by the Vector board, and widely communicated to stakeholders.

b. Information Management

Vector owns a number of legacy information systems with data stretching back to early in the 20th century. Consolidating these systems into an effective, integrated data management system poses an ongoing challenge, which Vector is actively addressing. Current improvement initiatives include upgrading the GIS system; consolidating asset performance information into the SAP Plant Maintenance system and developing asset management reporting systems that will extract information directly from verifiable source data – see Section 4 for a discussion.

Accurate data is important to support modern asset management practices. Vector currently relies on historical asset data, which is sometimes inaccurate or incomplete, and asset performance information currently retained may not be fully sufficient for modern asset management practices. Accordingly, as discussed in Section 4, Vector has several initiatives underway to improve its asset data quality, including the systematic analysis of historical asset records and rectification of data anomalies; to develop processes to cross-check and validate field-information; and to expand the extent of asset performance information being collected in the field.

Vector's progress against the AMMAT will be measured in future AMPs – with the goal to achieve a minimum of "3" rating on the bulk of all measures by 2015, and on all measures by 2016.

1.14.2 External Asset Management Reviews

Vector has, over an extended period, engaged external expert technical advisers on an annual basis to review its asset management practices. These reviews have been very positive in their feedback – confirming good industry practice asset management at Vector – and Vector has taken note of the feedback and recommendations received, and where practical and beneficial, reflected these in asset management practices.

a. 2010 Asset Management Practice Review

During 2010 Vector engaged SKM Australia to carry out an independent specialist review of Vector's asset management practices. This resulted in a very positive endorsement, confirming that Vector's practices match the very best in Australasian network management in most areas. Highlight findings included:

- Vector's asset management planning is of high quality and its AMP is the most comprehensive witnessed;
- The general condition and serviceability of the assets were good and assets were well maintained in accordance with sound industry practice;
- Planning and processes for implementing new capital works are sound and security and reliability of the power system will likely be sustained or enhanced over the next 10 years;
- Based on current budgets and demand forecasts security, Vector's capital work programme and budgets appear sufficient to sustain capacity; and
- Vector has adopted appropriate asset management practices to minimise risk of failure on the network.

b. 2010 Asset Management Plan Review

During 2010 Vector also engaged Utility Consultants, to review its AMP both from a content and regulatory compliance point of view. The review provided very positive endorsement of its electricity network asset management practices and strategic thinking. In particular, the consultant endorsed the approach taken to improve capital efficiency and encourage innovation, and in future-proofing the network against any adverse impact of future technologies.

Suggestions were also made on the presentation of the AMP, particularly on its alignment with regulatory disclosure requirements. These suggestions are accounted for in this current AMP.

c. 2011 Maintenance Strategies Review

During 2011 Vector engaged an Australian consultant (Chris Brennan and Associates) to review its asset maintenance strategies. This review focused on current maintenance standards, approach to asset maintenance and asset condition information.

The review concluded that Vector’s asset maintenance approach compares well with good industry practice, and in particular with how this is applied by the major electricity distribution businesses in Australia. It also concluded that Vector’s maintenance expenditure is at the most efficient end of that of the peer group of Australian electricity distribution businesses considered, comparing well with the most efficient Australian electricity distribution companies.

It was suggested that Vector should consider adopting an enhanced condition-based risk management (CBRM) approach to asset maintenance (and renewal), as well as some small possible further cost and performance improvements that could be made by modifying some of Vector’s inspection and maintenance programmes and audits of preventative maintenance work and prioritisation of work identified through inspection programmes.

As a result of the review, Vector has embarked on the development of an enhanced CBRM approach for life-cycle network asset management. This is described in more detail in Section 6 of the AMP.

d. 2012 Asset Management Practice Review

During July/August 2012 Vector engaged Sinclair Knight Mertz (SKM) Australia to carry out an independent specialist review on the state of the electricity network. The review focused on maintenance programmes and the appropriateness of expenditure levels, any need for upgrading of network assets taking into account what was already being planned, the capacity of the network in relation to the forecast demand, and any risks to the assets. Highlights of SKM’s findings included:

- The condition and serviceability of Vector’s assets is good, and assets are well maintained in accordance with sound industry practice. Any serious defects or safety issues are addressed promptly as key priorities;
- Vector’s assets are relatively young and future AMP forecast provisions for maintenance and refurbishment are appropriate;
- Security and planning criteria match “leading edge” industry practice;
- Vector’s approach to use cyclic ratings as a guide to security planning is prudent from a risk management perspective;
- Vector’s contingency planning processes and documentation is comprehensive, sufficiently detailed and up to date;

- Vector's Asset Lifecycle Information System (ALIS) provides an effective enterprise asset management system consistent with distribution utilities employing SAP;
- Vector's strategy of keeping abreast of the various potential smart network applications without committing to large scale capital investment is a prudent approach; and
- Vector's capital efficiency programme and the manner in which staff are encouraged to contribute new ideas, new design concepts and improved work practices have been very effective.

1.15 Cross Reference to the Information Disclosure Requirements

As indicated earlier (Section 1.3), one of the key purposes of this disclosure AMP was to also inform internal stakeholders on how Vector intends to manage its asset management activities. As such the order of presentation of this disclosure AMP is somewhat different from that presented in Attachment A of the Electricity Distribution Information Disclosure Determination 2012.

The following table provides a cross reference between the disclosure requirements and the sub-sections in this AMP.

ID Determination Attachment A		Disclosure Contents Requirements	AMP Section
3		The AMP must include the following:	
3.1		A summary that provides a brief overview of the contents and highlights information that the *EDB* considers significant	Executive Summary
3.2		Details of the background and objectives of the *EDB*'s asset management and planning processes	1.1 and 1.3
3.3		A purpose statement which:	
	3.3.1	• Makes clear the purpose and status of the AMP in the EDB's asset management practices. The purpose statement must also include a statement of the objectives of the asset management and planning processes	1.1, 1.3, 1.5 and 1.6
	3.3.2	• States the corporate mission or vision as it relates to asset management	1.1 and 1.3
	3.3.3	• Identifies the documented plans produced as outputs of the annual business planning process adopted by the *EDB*	1.3 and 1.13
	3.3.4	• States how the different documented plans relate to one another, with particular reference to any plans specifically dealing with asset management	1.3, 1.8 and 1.13
	3.3.5	• Includes a description of the interaction between the objectives of the AMP and other corporate goals, business planning processes, and plans *The purpose statement should be consistent with the EDB's vision and mission statements, and show a clear recognition of stakeholder interest.*	1.1, 1.3, 1.5, 1.6, 1.8, 1.9, 1.10, 1.11, 1.12 and 1.13
3.4		Details of the AMP planning period, which must cover at least a projected period of 10 years commencing with the disclosure year following the date on which the AMP is disclosed *Good asset management practice recognises the greater accuracy of short-to-medium term planning, and will allow for this in the AMP. The AMPs for the second 5 years of the AMP planning period need not be presented in the same detail as the first 5 years*	1.2
3.5		The date that it was approved by the directors	1.2

ID Determination Attachment A		Disclosure Contents Requirements	AMP Section
3.6		A description of stakeholder interests (owners, consumers etc) which identifies important stakeholders and indicates:	1.5 and 1.6
	3.6.1	• How the interests of stakeholders are identified	1. 6
	3.6.2	• What these interests are	1.5 and 1.6
	3.6.3	• How these interests are accommodated in asset management practices	1.6
	3.6.4	• How conflicting interests are managed	1.6
3.7		A description of the accountabilities and responsibilities for asset management on at least 3 levels, including:	1,1, 1.7, 1.8, 1.9, 1.10 and 1.12
	3.7.1	• Governance—a description of the extent of Director approval required for key asset management decisions and the extent to which asset management outcomes are regularly reported to directors	1.1, 1.8, 1.9 and 1.10
	3.7.2	• Executive—an indication of how the in-house asset management and planning organisation is structured	1.1 and 1.7
	3.7.3	• Field operations—an overview of how field operations are managed, including a description of the extent to which field work is undertaken in-house and the areas where outsourced contractors are used	1.1, 1.7 and 1.12
3.8		All significant assumptions	1.3 and 1.4
	3.8.1	• Quantified where possible	1.3 and 9.3
	3.8.2	• Clearly identified in a manner that makes their significance understandable to interested persons, including	1.3, 1.4 and 6.6
	3.8.3	• A description of changes proposed where the information is not based on the EDB’s existing business	3.1, 3.2 and 3.3
	3.8.4	• The sources of uncertainty and the potential effect of the uncertainty on the prospective information	5.3, 5.4, 6.6, 9.3 and 9.5

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
3.8.5	• The price inflator assumptions used to prepare the financial information disclosed in nominal New Zealand dollars in the Report on Forecast Capital Expenditure set out in Schedule 11a and the Report on Forecast Operational Expenditure set out in Schedule 11b	9.6 and Appendices 1 and 2
3.9	A description of the factors that may lead to a material difference between the prospective information disclosed and the corresponding actual information recorded in future disclosures	5.3 and 6.6
3.10	An overview of asset management strategy and delivery *To support the AMMAT disclosure and assist interested persons to assess the maturity of asset management strategy and delivery, the AMP should identify:* • *How the asset management strategy is consistent with the EDB's other strategy and policies;* • *How the asset strategy takes into account the life cycle of the assets;* • *The link between the asset management strategy and the AMP; and* • *Processes that ensure costs, risks and system performance will be effectively controlled when the AMP is implemented*	1.1 and 1.3
3.11	An overview of systems and information management data *To support the AMMAT disclosure and assist interested persons to assess the maturity of systems and information management, the AMP should describe:* • *The processes used to identify asset management data requirements that cover the whole of life cycle of the assets;* • *The systems used to manage asset data and where the data is used, including an overview of the systems to record asset conditions and operation capacity and to monitor the performance of assets;* • *The systems and controls to ensure the quality and accuracy of asset management information; and* • *The extent to which these systems, processes and controls are integrated*	1.11, 7.1 and 7.2
3.12	A statement covering any limitations in the availability or completeness of asset management data and disclose any initiatives intended to improve the quality of this data *Discussion of the limitations of asset management data is intended to enhance the transparency of the AMP and identify gaps in the asset management system.*	6.3, 7.4 and 7.5
3.13	A description of the processes used within the *EDB* for:	

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
3.13.1	• Managing routine asset inspections and network maintenance	6.2
3.13.2	• Planning and implementing network development projects	5.2 and 5.3
3.13.3	• Measuring network performance.	4.1
3.14	An overview of asset management documentation, controls and review processes *To support the AMMAT disclosure and assist interested persons to assess the maturity of asset management documentation, controls and review processes, the AMP should:* • *Identify the documentation that describes the key components of the asset management system and the links between the key components;* • *Describe the processes developed around documentation, control and review of key components of the asset management system;* • *Where the EDB outsources components of the asset management system, the processes and controls that the EDB uses to ensure efficient and cost effective delivery of its asset management strategy;* • *Where the EDB outsources components of the asset management system, the systems it uses to retain core asset knowledge in-house; and* • *Audit or review procedures undertaken in respect of the asset management system*	7.2 and 7.3
3.15	An overview of communication and participation processes *To support the AMMAT disclosure and assist interested persons to assess the maturity of asset management documentation, controls and review processes, the AMP should:* • *Communicate asset management strategies, objectives, policies and plans to stakeholders involved in the delivery of the asset management requirements, including contractors and consultants; and* • *Demonstrate staff engagement in the efficient and cost effective delivery of the asset management requirements*	1.5
3.16	The AMP must present all financial values in constant price New Zealand dollars *except where specified otherwise*	5, 6, 7 and 9
3.17	The AMP must be structured and presented in a way that the *EDB* considers will support the purposes of AMP disclosure set out in clause 2.6.2 of the determination	

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
	Assets covered	
4	The AMP must provide details of the assets covered, including:	
4.1	A high-level description of the service areas covered by the *EDB* and the degree to which these are interlinked, including:	
4.1.1	• The region(s) covered	2.1
4.1.2	• Identification of large consumers that have a significant impact on network operations or asset management priorities	2.1
4.1.3	• Description of the load characteristics for different parts of the network	2.1 and 2.2
4.1.4	• Peak demand and total energy delivered in the previous year, broken down by sub-network, if any	2.2
4.2	• A description of the network configuration, including:	2.3
4.2.1	• Identifying bulk electricity supply points and any embedded generation with a capacity greater than 1 MW. State the existing firm supply capacity and current peak load of each bulk electricity supply point	2.3
4.2.2	• A description of the sub-transmission system fed from the bulk electricity supply points, including the capacity of zone substations and the voltage(s) of the sub-transmission network(s). The AMP must identify the supply security provided at individual zone substations, by describing the extent to which each has n-x sub-transmission security or by providing alternative security class ratings	2.3 and Appendix 4
4.2.3	• A description of the distribution system, including the extent to which it is underground	2.3
4.2.4	• A brief description of the network's distribution substation arrangements	2.3
4.2.5	• A description of the low voltage network including the extent to which it is underground	2.3

ID Determination Attachment A		Disclosure Contents Requirements	AMP Section
	4.2.6	• An overview of secondary assets such as protection relays, ripple injection systems, SCADA and telecommunications systems *To help clarify the network descriptions, network maps and a single line diagram of the sub-transmission network should be made available to interested persons. These may be provided in the AMP or, alternatively, made available upon request with a statement to this effect made in the AMP.*	2.3
4.3		If sub-networks exist, the network configuration information referred to in sub-clause 4.2 above must be disclosed for each sub-network	2.3
		Assets by Category	
4.4		The AMP must describe the network assets by providing the following information for each asset category:	6.3
	4.4.1	• Voltage levels	6.3
	4.4.2	• Description and quantity of assets	6.3
	4.4.3	• Age profiles	6.3
	4.4.4	• A discussion of the condition of the assets, further broken down into more detailed categories as considered appropriate. Systemic issues leading to the premature replacement of assets or parts of assets should be discussed	6.3
	4.4.5	• The asset categories discussed in sub-clause 4.4 above should include at least the following:	6.3
4.5		The asset categories discussed in sub-clause 4.4 above should include at least the following:	6.3
	4.5.1	• Sub transmission	6.3
	4.5.2	• Zone substations	6.3

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
4.5.3	• Distribution and LV lines	6.3
4.5.4	• Distribution and LV cables	6.3
4.5.5	• Distribution substations and transformers	6.3
4.5.6	• Distribution switchgear	6.3
4.5.7	• Other system fixed assets	6.3
4.5.8	• Other assets	6.3
4.5.9	• Assets owned by the EDB but installed at bulk electricity supply points owned by others	2.3
4.5.10	• EDB owned mobile substations and generators whose function is to increase supply reliability or reduce peak demand	6.3
4.5.11	• Other generation plant owned by the EDB	6.3
	Service Levels	
5	The AMP must clearly identify or define a set of performance indicators for which annual performance targets have been defined. The annual performance targets must be consistent with business strategies and asset management objectives and be provided for each year of the AMP planning period. The targets should reflect what is practically achievable given the current network configuration, condition and planned expenditure levels. The targets should be disclosed for each year of the AMP planning period	4
6.	Performance indicators for which targets have been defined in clause 5 above must include SAIDI and SAIFI values for the next 5 disclosure years	4.1
7.	Performance indicators for which targets have been defined in clause 5 above should also include:	4

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
7.1	• *Consumer oriented indicators that preferably differentiate between different consumer groups*	4.1
7.2	• *Indicators of asset performance, asset efficiency and effectiveness, and service efficiency, such as technical and financial performance indicators related to the efficiency of asset utilisation and operation*	4.2 and 4.3
8.	The AMP must describe the basis on which the target level for each performance indicator was determined. Justification for target levels of service includes consumer expectations or demands, legislative, regulatory, and other stakeholders' requirements or considerations. The AMP should demonstrate how stakeholder needs were ascertained and translated into service level targets	4.1 and 4.2
9.	Targets should be compared to historic values where available to provide context and scale to the reader	4.1 and 4.2
10.	Where forecast expenditure is expected to materially affect performance against a target defined in clause 5 above, the target should be consistent with the expected change in the level of performance. *Performance against target must be monitored for disclosure in the Evaluation of Performance section of each subsequent AMP*	N/A
	Network Development	
11.	AMPs must provide a detailed description of network development plans, including:	5
11.1	A description of the planning criteria and assumptions for network development	5.3 and 5.4
11.2	*Planning criteria for network developments should be described logically and succinctly. Where probabilistic or scenario-based planning techniques are used, this should be indicated and the methodology briefly described*	5.3
11.3	A description of strategies or processes (if any) used by the EDB that promote cost efficiency including through the use of standardised assets and designs	2.4 and 5.2
11.4	The use of standardised designs may lead to improved cost efficiencies. This section should discuss:	2.4
11.4.1	• The categories of assets and designs that are standardised; and	2.4

ID Determination Attachment A		Disclosure Contents Requirements	AMP Section
	11.4.2	• The approach used to identify standard designs	2.4
11.5		*A description of strategies or processes (if any) used by the EDB* that promote the energy efficient operation of the network. *The energy efficient operation of the network could be promoted, for example, though network design strategies, demand side management strategies and asset purchasing strategies*	3.1
11.6		A description of the criteria used to determine the capacity of equipment for different types of assets or different parts of the network. *The criteria described should relate to the EDB's philosophy in managing planning risks*	2.4 and 5.2
11.7		A description of the process and criteria used to prioritise network development projects and how these processes and criteria align with the overall corporate goals and vision	1.8, 5.4 and 9.4
11.8		Details of demand forecasts, the basis on which they are derived, and the specific network locations where constraints are expected due to forecast increases in demand	5.3 and Appendix 4
	11.8.1	• Explain the load forecasting methodology and indicate all the factors used in preparing the load estimates	5.3
	11.8.2	• Provide separate forecasts to at least the zone substation level covering at least a minimum five year forecast period. Discuss how uncertain but substantial individual projects/developments that affect load are taken into account in the forecasts, making clear the extent to which these uncertain increases in demand are reflected in the forecasts	5.3 and 5.4
	11.8.3	• Identify any network or equipment constraints that may arise due to the anticipated growth in demand during the AMP planning period	5.6 and Appendix 4
	11.8.4	• Discuss the impact on the load forecasts of any embedded generation or anticipated levels of distributed generation in a network, and the projected impact of any demand management initiatives	5.5
11.9		Analysis of the significant network level development options identified and details of the decisions made to satisfy and meet target levels of service, including:	5.6
	11.9.1	• The reasons for choosing a selected option for projects where decisions have been made	5.6

ID Determination Attachment A		Disclosure Contents Requirements	AMP Section
	11.9.2	• The alternative options considered for projects that are planned to start in the next five years and the potential for non-network solutions described	5.6
	11.9.3	• Consideration of planned innovations that improve efficiencies within the network, such as improved utilisation, extended asset lives, and deferred investment	3
11.10		A description and identification of the network development programme including distributed generation and non-network solutions and actions to be taken, including associated expenditure projections. The network development plan must include:	
	11.10.1	• A detailed description of the material projects and a summary description of the non-material projects currently underway or planned to start within the next 12 months	5.6, 5.7, 5.10, 5.12 and 5.13
	11.10.2	• A summary description of the programmes and projects planned for the following four years (where known)	5.6, 5.7 5.10, 5.12 and 5.13
	11.10.3	• An overview of the material projects being considered for the remainder of the AMP planning period. *For projects included in the AMP where decisions have been made, the reasons for choosing the selected option should be stated which should include how target levels of service will be impacted. For other projects planned to start in the next five years, alternative options should be discussed, including the potential for non-network approaches to be more cost effective than network augmentations*	5.6, 5.7, 5.10, 5.12 and 5.13
11.11		A description of the EDB's policies on distributed generation, including the policies for connecting embedded generation. The impact of such generation on network development plans must also be stated	5.5
11.12		A description of the EDB's policies on non-network solutions, including:	5.5
	11.12.1	• Economically feasible and practical alternatives to conventional network augmentation. These are typically approaches that would reduce network demand and/or improve asset utilisation	5.5
	11.12.2	• The potential for non-network solutions to address network problems or constraints	5.5
		Lifecycle Asset Management Planning (Maintenance and Renewal)	

ID Determination Attachment A		Disclosure Contents Requirements	AMP Section
12		The AMP must provide a detailed description of the lifecycle asset management processes, including:	6.1 and 6.2
12.1		The key drivers for maintenance planning and assumptions	6.1 and 6.2
12.2		Identification of routine and corrective maintenance and inspection policies and programmes and actions to be taken for each asset category, including associated expenditure projections. This must include:	6.2 and 6.3
	12.2.1	• The approach to inspecting and maintaining each category of assets, including a description of the types of inspections, tests and condition monitoring carried out and the intervals at which this is done	6.2 and 6.3
	12.2.2	• Any systemic problems identified with any particular asset types and the proposed actions to address these problems	6.2 and 6.3
	12.2.3	• Budgets for maintenance activities broken down by asset category for the AMP planning period	6.2
12.3		Identification of asset replacement and renewal policies and programmes and actions to be taken for each asset category, including associated expenditure projections. This must include:	6.3
	12.3.1	• The processes used to decide when and whether an asset is replaced or refurbished, including a description of the factors on which decisions are based, and consideration of future demands on the network and the optimum use of existing network assets	6.3
	12.3.2	• A description of innovations made that have deferred asset replacement	6.5
	12.3.3	• A description of the projects currently underway or planned for the next 12 months	6.3 and 6.6
	12.3.4	• A summary of the projects planned for the following four years (where known)	6.3 and 6.6
	12.3.5	• An overview of other work being considered for the remainder of the AMP planning period	6.3 and 6.6
12.4		The asset categories discussed in sub-clauses 12.2 and 12.3 above should include at least the categories in sub-clause 4.5 above	6.3 and 6.6

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
13	AMPs must provide a summary description of material non-network development, maintenance and renewal plans, including:	7
13.1	A description of non-network assets	7.1 and 7.2
13.2	Development, maintenance and renewal policies that cover them	7.4
13.3	A description of material capital expenditure projects (where known) planned for the next five years	7.4 and 7.6
13.4	A description of material maintenance and renewal projects (where known) planned for the next five years	7.4, 7.5 and 7.6
	Risk Management	
14	AMPs must provide details of risk policies, assessment, and mitigation, including:	8
14.1	Methods, details and conclusions of risk analysis	8.1, 8.2 and 8.3
14.2	Strategies used to identify areas of the network that are vulnerable to high impact low probability events and a description of the resilience of the network and asset management systems to such events	8.3, 8.4 and 8.5
14.3	A description of the policies to mitigate or manage the risks of events identified in sub-clause 14.2	8.1 and 8.3
14.4	Details of emergency response and contingency plans *Asset risk management forms a component of an EDB's overall risk management plan or policy, focusing on the risks to assets and maintaining service levels. AMPs should demonstrate how the EDB identifies and assesses asset related risks and describe the main risks within the network. The focus should be on credible low-probability, high-impact risks. Risk evaluation may highlight the need for specific development projects or maintenance programmes. Where this is the case, the resulting projects or actions should be discussed, linking back to the development plan or maintenance programme.*	8.4
	Evaluation of performance	

ID Determination Attachment A	Disclosure Contents Requirements	AMP Section
15	AMPs must provide details of performance measurement, evaluation, and improvement, including:	
15.1	A review of progress against plan, both physical and financial; • *Referring to the most recent disclosures made under* Section 2.6 of this determination*, discussing any significant differences and highlighting reasons for substantial variances;* • *Commenting on the progress of development projects against that planned in the previous AMP and provide reasons for substantial variances along with any significant construction or other problems experienced; and* • *Commenting on progress against maintenance initiatives and programmes and discuss the effectiveness of these programmes noted*	5.13 6.6 9.7
15.2	An evaluation and comparison of actual service level performance against targeted performance *In particular, comparing the actual and target service level performance for all the targets discussed under the Service Levels section of the AMP in the previous AMP and explain any significant variances*	4.1 and 4.2
15.3	An evaluation and comparison of the results of the asset management maturity assessment disclosed in the Report on asset management Maturity set out in Schedule 13 against relevant objectives of the EDB's asset management and planning processes	1.14 and Appendix 9
15.4	An analysis of gaps identified in sub-clauses 15.2 and 15.3 above. Where significant gaps exist (not caused by one-off factors), the AMP must describe any planned initiatives to address the situation	1.14, 4.1 and 4.2
	Capability to Deliver	
16	AMPs must describe the processes used by the EDB to ensure that:	
16.1	The AMP is realistic and the objectives set out in the Plan can be achieved;	1.8
16.2	The organisation structure and the processes for authorisation and business capabilities will support the implementation of the AMP Plans.	1.7, 1.8, 1.9 and 1.12

Table 1-7 : Cross reference between disclosure requirements and sub-sections of the AMP

Clause 2.6.1 of the Electricity Distribution Information Disclosure Determination 2012 requires Vector to include the following information schedules in this Asset Management Plan:

Information Disclosure Schedule	Title	AMP Appendix
Schedule 11a Schedule 14a	Report on Forecast Capital Expenditure Mandatory Explanatory Notes On Forecast Information	Appendix 1
Schedule 11b Schedule 14a	Report on Forecast Operational Expenditure Mandatory Explanatory Notes On Forecast Information	Appendix 2
Schedule 12a	Report on Asset Condition	Appendix 3
Schedule 12b	Report on Forecast Capacity	Appendix 4
Schedule 12c	Report on Forecast Network Demand	Appendix 5
Schedule 12d	Report on Forecast Interruptions and Duration (Vector)	Appendix 6
	Report on Forecast Interruptions and Duration (Southern region)	Appendix 7
	Report on Forecast Interruptions and Duration (Northern region)	Appendix 8
Schedule 13	Report on Asset Management Maturity Assessment	Appendix 9

Table 1-8 : Information schedules included in the AMP

Electricity
Asset Management Plan
2013 – 2023

Assets Covered by This Plan – Section 2

[Disclosure AMP]

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2. Assets Covered by This Plan

2.1 Distribution Area

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 2-1 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.

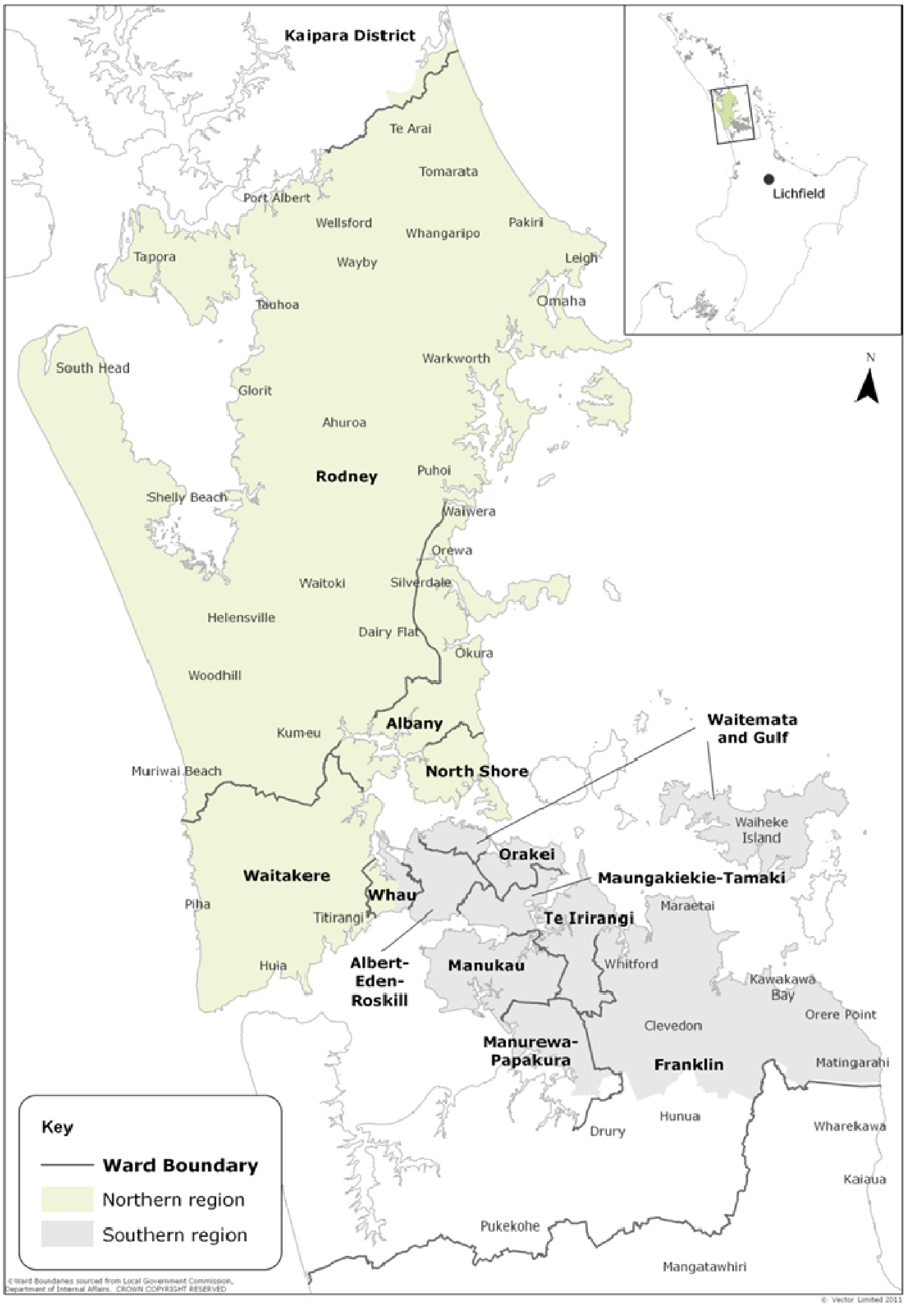

Figure 2-1 : Vector electricity supply area

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

2.1.1 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.

2.1.2 Southern Region

The Southern region covers areas administered by the previous Auckland City Council, Manukau City Council and Papakura District Council. 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.

2.1.3 Major Customer Sites on the Vector Network

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;

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

- Owens Illinois at Penrose;
- 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.

2.2 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 equipment 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 twice the summer peak load but it is expected this gap will close over the next ten years. The typical daily load profiles for residential and commercial loads for summer and winter are illustrated in Figure 2-2 to Figure 2-5 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 2-2 : Typical summer load profile for residential customers

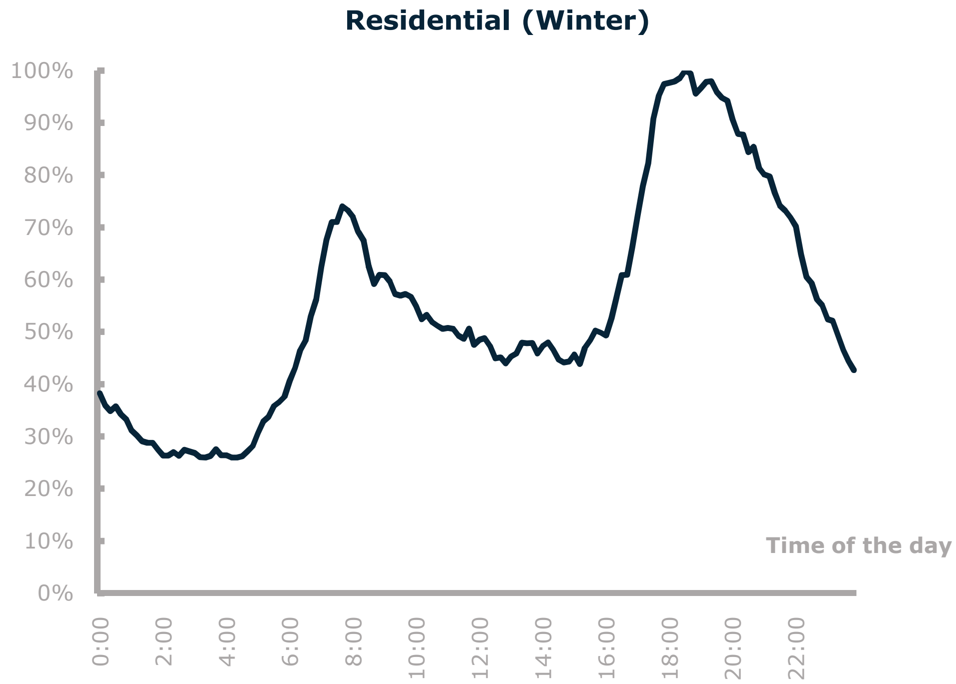

Figure 2-3 : Typical winter load profile for residential customers

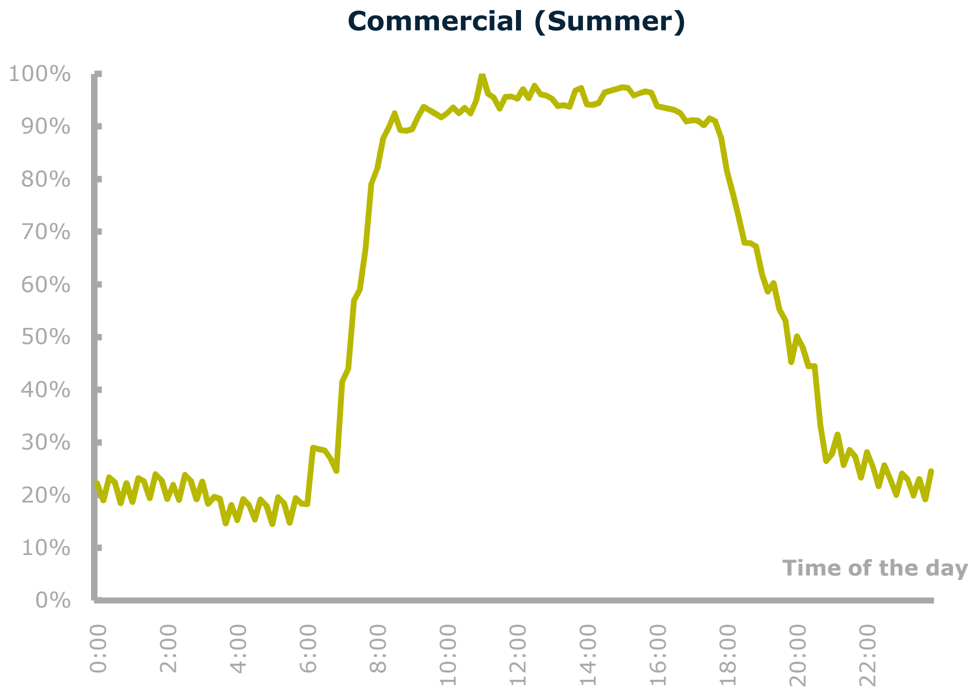

Figure 2-4 : Typical summer load profile for commercial customers

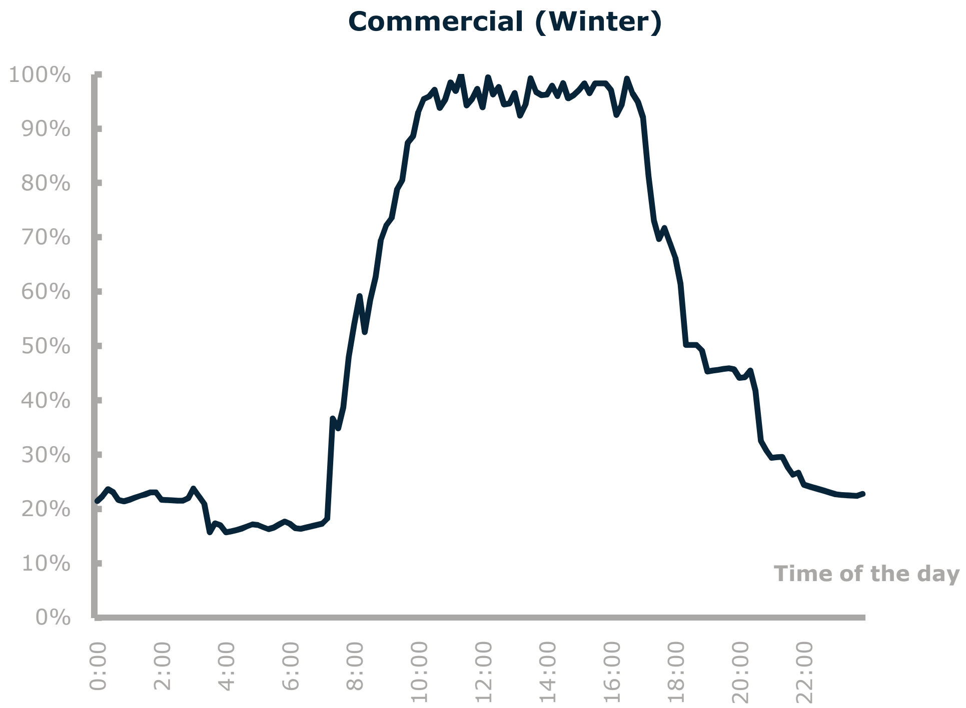

Figure 2-5 : Typical winter load profile for commercial customers

A measure of load diversity is achieved with residential customers providing peaks in the morning and early evening, with the commercial load filling in the trough between these peaks. Clearly the mix of customer types on a feeder influences the size and duration of the peaks.

Demand curves for industrial customers are far more variable – conforming closely to the nature of the customer's business. A typical industrial load curve is, therefore, not a meaningful concept.

The half-hour peak demand on the regional networks and the energy delivered for the past three years are listed in Table 2-1. The individual demand forecasts for zone substations on Vector's network are detailed in Section 5.4.

Regulatory Year	Northern Regional Peak Demand (MW)	Southern Regional Peak Demand (MW)	Vector Peak Demand (MW)	Northern Energy Delivered (GWh)	Southern Energy Delivered (GWh)
2009/10	613	1162	1775	2598	5713
2010/11	594	1128	1722	2710	5969
2011/12	686	1255	1941	2745	6029

Table 2-1 : 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 embedded generation with net export into the Vector distribution network. It can be seen that during peak demand times, there is very little diversity between the regions and the total Vector demand.

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

Embedded Generation

The major embedded generators[2] on the network (capacity > 1MW) are at Greenmount, Whitford, Redvale and Rosedale landfill sites, Mangere Waste Treatment Plant, and at Auckland Hospital, but excludes Southdown which is a notionally embedded generator (connected at 220kV to the Transpower Otahuhu to Henderson line, with no direct physical connection to the Vector network). Generation at the Auckland Hospital and Mangere Waste Treatment Plant is used to offset the local demand and does not export into the Vector distribution network. Over time, when gas production at landfill sites becomes depleted, the gas generators will be relocated and feeder reinforcement will have to be considered to maintain security of supply in the local areas. The generation capacities of embedded generators will be closely monitored to ensure sufficient forewarning of reinforcements.

2.3 Network Configuration

The overall architecture of the Vector network is shown in Figure 2-6.

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

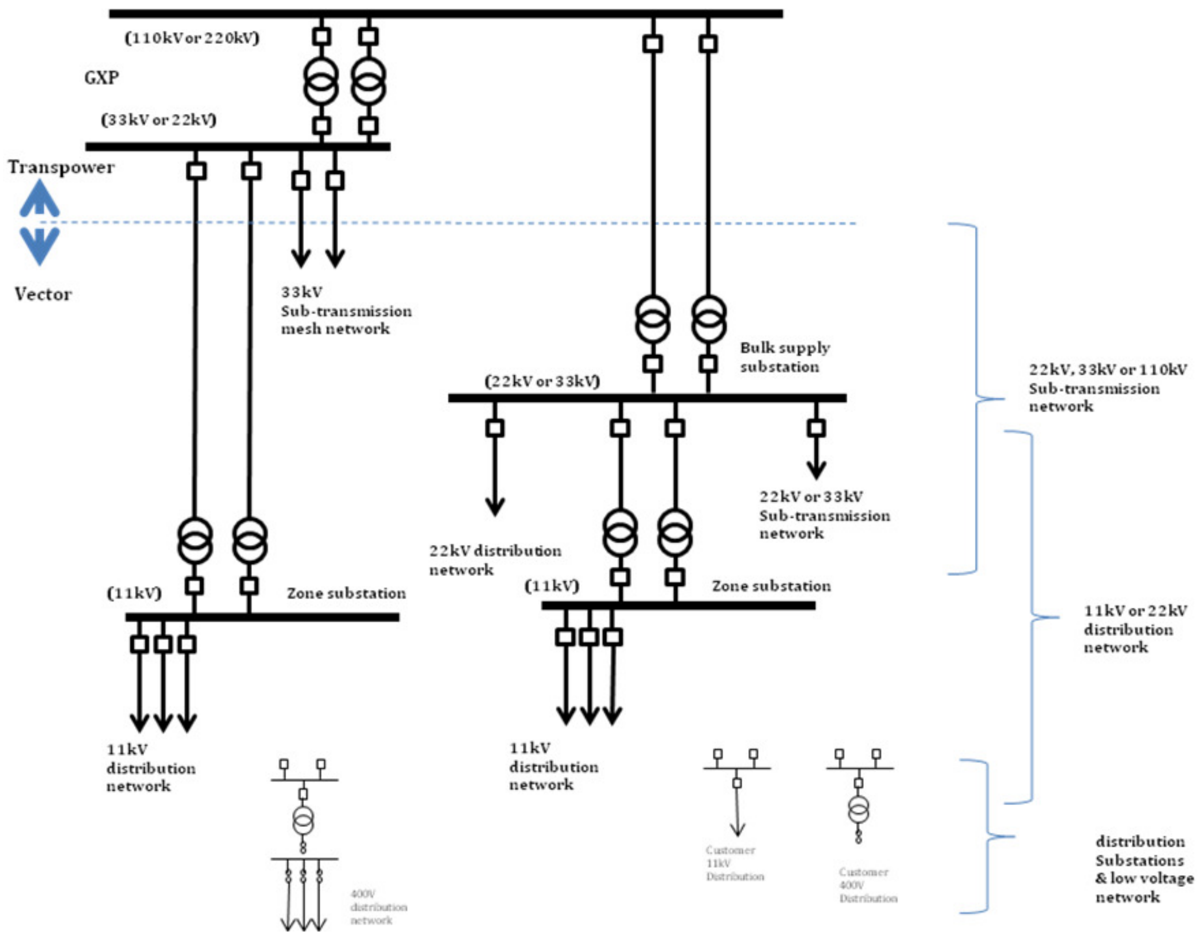

Figure 2-6 : Schematic of Vector's network

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[2] This includes only those generators connected to the Vector network at 11kV or above, capable of injecting energy into the Vector network and metered with half-hourly meters.

2.3.1 The Transmission Grid around Auckland

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 12 GXPs to supply its sub-transmission network in Auckland. A thirteenth GXP (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 2-2 to Table 2-5 show the winter and summer peak demands at GXPs and bulk supply substations. The tables also show the installed capacity and firm capacity at each of these supply points. For completeness, the tables also show the GXP at Lichfield in Tokoroa where Vector takes supply from Transpower to supply the Fonterra cheese factory.

Grid Exit Point	Supply Voltage	Installed Transformer Capacity (MVA)	Firm Capacity[3] (MVA)	2012 Winter Peak Demand (MVA)
Albany	110kV			123
Albany	33kV	2x100 + 1x120	234	158
Henderson	33kV	2x120	135	110
Hepburn	33kV	1x85 + 2x120	245	131
Lichfield	110kV			9
Mangere	110kV			55
Mangere	33kV	2x120	118	93
Otahuhu	22KV	2x50	59	57
Pakuranga	33kV	3x120	261	128
Penrose	110kV			192
Penrose	22kV	3x45	89	51
Penrose	33kV	2x200 + 2x160[4]	383	306[5]
Roskill	110kV			59
Roskill	22kV	2x70 + 1x50	141	116
Silverdale	33kV	1x120 + 1x100	109	75
Takanini	33kV	2x150	126	101
Wellsford	33kV	2x30	31	31
Wiri	33kV	2x100	106	77

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

[3] Firm capacities supplied by Transpower

[4] One of the 160MVA transformers operates normally open.

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

Grid Exit Point	Supply Voltage	Installed Transformer Capacity (MVA)	Firm Capacity (MVA)	2012 Summer Peak Demand (MVA)
Albany	110kV			82
Albany	33kV	2x100 + 1x120	234	105
Henderson	33kV	2x120	135	77
Hepburn	33kV	1x85 + 2x120	239	92
Lichfield	110kV			9
Mangere	110kV			52
Mangere	33kV	2x120	118	60
Otahuhu	22KV	2x50	59	47
Pakuranga	33kV	3x120	261	92
Penrose	110kV			203
Penrose	33kV	1x200 + 2x160[6]	372	259[7]
Penrose	22kV	3x45	89	47
Roskill	110kV			37
Roskill	22kV	2x70 + 1x50	141	77
Silverdale	33kV	1x120 + 1x100	109	50
Takanini	33kV	2x150	126	63
Wellsford	33kV	2x30	31	25
Wiri	33kV	2x100	106	69

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

Bulk Supply Substation	Supply Voltage	Transformer Installed capacity (MVA)	Firm Capacity (MVA)	2012 Winter Peak Demand (MVA)
Hobson[8]	22kV	2x40 + 1x60[9]	80[10]	44.1[11]
	11kV	2x25 +2x15	55	20.4
Kingsland	22kV	2x60	60	59.5
Lichfield	11kV	2x20	24	8.5
Liverpool	22kV	2x75+1x60	114[12]	99.7
Pacific Steel	33kV	70+40	40	55.8
Quay	22kV	2x60	48	38.3
Wairau Road	33kV	3x80	160	123.1

Table 2-4 : Bulk Supply Substations for Auckland and Lichfield winter loads

[6] One of the 160MVA transformers operates normally open.

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

[8] The 22kV windings of the two 65MVA three winding transformers operate in parallel with the 60MVA transformer (unit T3B) at Quay substation via 22kV interconnector cables.

[9] This 60MVA transformer is physically installed at Quay substation.

[10] Firm capacity of 80MVA includes the capacity of unit T3B (60MVA) at Quay substation.

[11] The load includes Hobson substation 22kV, Liverpool substation 22kV lower bus and Quay substation 22kV lower bus.

[12] Firm capacity reduced due to uneven sharing of transformers.

Bulk Supply Substation	Supply Voltage	Transformer Installed capacity (MVA)	Firm Capacity (MVA)	2012 Summer Peak Demand (MVA)
Hobson	22kV	2x40 + 1x60	80	44.5
	11kV	2x25 +2x15	55	22.1
Kingsland	22kV	2x60	60	37.6
Lichfield	11kV	2x20	24	8.7
Liverpool	22kV	2x75+1x60	114	101.1
Pacific Steel	33kV	70+40	40	52.2
Quay	22kV	2x60	33	39.2
Wairau Road	33kV	3x80	160	81.6

Table 2-5 : Bulk Supply Substations for Auckland and Lichfield summer loads

The following map in Figure 2-7 shows the locations of the GXPs and the main 110kV and 220kV lines supplying into and across Auckland.

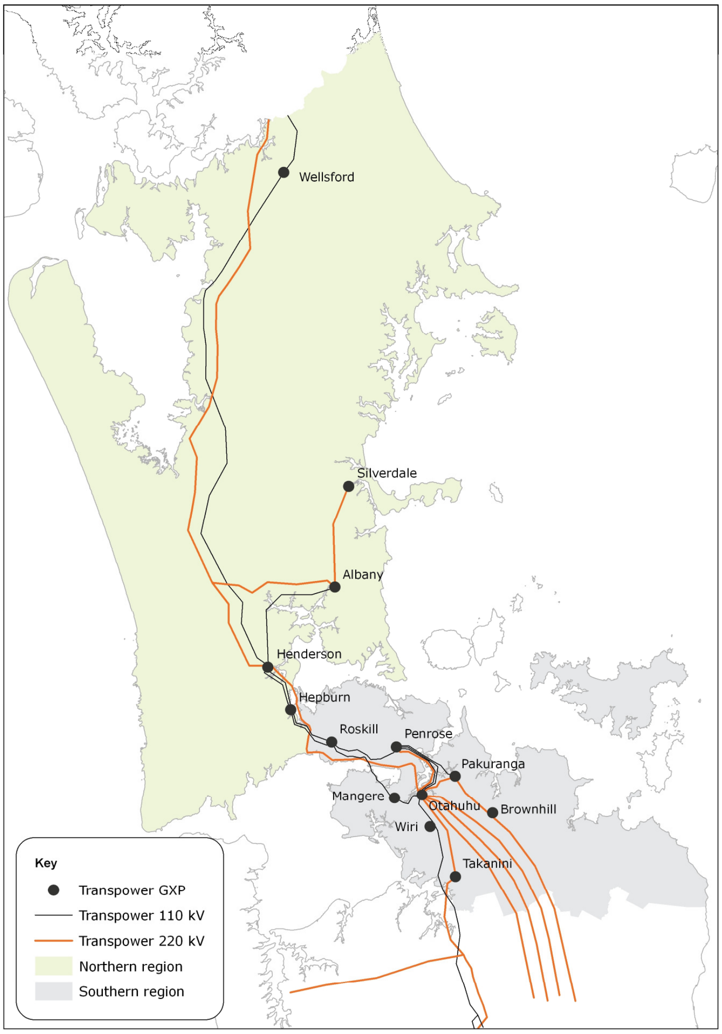

Figure 2-7 : Locations of GXPs and major transmission lines supplying Vector

2.3.2 Sub-Transmission Network

The sub-transmission networks for the Northern and Southern regions have been developed differently. The Northern network has a mixture of interconnected 33kV ring and radial circuits (largely overhead lines) connected to the Transpower GXPs. It is a common practice to have 33kV switches at zone substations. This has allowed some interconnection between GXPs.

The Southern region is largely radial circuits supplying two to three transformer zone substations. These are largely supplied by underground cables. Sub-transmission voltages range from 110kV in the Auckland CBD and supply to Kingsland, through to 33kV and 22kV elsewhere in the Southern region.

Capacities of existing zone substations in the Southern region are larger (typically two or three 20MVA transformers at each substation) whereas about half of the Northern region's zone substations are single transformer substations (with transformer size ranging from 5MVA to 20MVA). Since 2005, new transformers purchased for urban zone substations are rated at 20MVA whereas those for rural areas are 10MVA.

Typically zone substations in the Northern region are equipped with a 33kV switchboard (or outdoor busbar), an 11kV switchboard and transformers. Zone substations in the Southern region typically do not have 33kV (or 22kV) switchboards except for those that are established as part of a bulk in-feed substation or switching station.

A description of the development plan for the sub-transmission network and the zone substations is given in Section 5 of this Plan.

The list of Vector's zone substations as at the end of the 2013 disclosure year, together with their existing and forecast installed firm capacities, security of supply classification, the 2012 winter peak demands, transfer capacities, existing and forecast utilisation is given in schedule 12b (report on forecast capacity) contained in Appendix 4 of this AMP.

2.3.2.1 Outdoor Versus Indoor Substations

All new zone substations have switchgear installed indoors.

Some older substations still have outdoor equipment. The condition of these outdoor 33kV switchyards is monitored and where economically or technically justifiable they are being replaced with indoor switchgear.

2.3.2.2 Undergrounding

The Northern region has a large percentage of overhead lines, particularly in the rural areas. The sub-transmission system in this region is largely constructed overhead. This makes the network much more vulnerable during strong winds and storms. On the other hand, the Southern region sub-transmission network is all underground except for the supply to Maraetai. This makes the sub-transmission network very secure from winds and storms, but vulnerable to dig-ins and ground movement.

Since the ownership of the Northern network changed to Vector in 2003, all new sub-transmission circuits have been installed underground except for the rural areas which will remain overhead. As at the end of March 2012, 90% of the sub-transmission network is underground in the Southern region and 27% in the Northern region. Overall, 59% of Vector's sub-transmission network is underground. It should be noted that 22kV has been used in the Southern region for both sub-transmission and distribution purposes.

2.3.2.3 Electrical vector Grouping[13]

Due to historical development, the power transformers supplying different parts of Vector's sub-transmission network are configured to different vector groups.[14] Using the grid (220kV and 110kV) as reference, the phase angles of the sub-transmission network in the different parts of the Vector network are shown in the vector diagrams in Figure 2-8 to Figure 2-10.

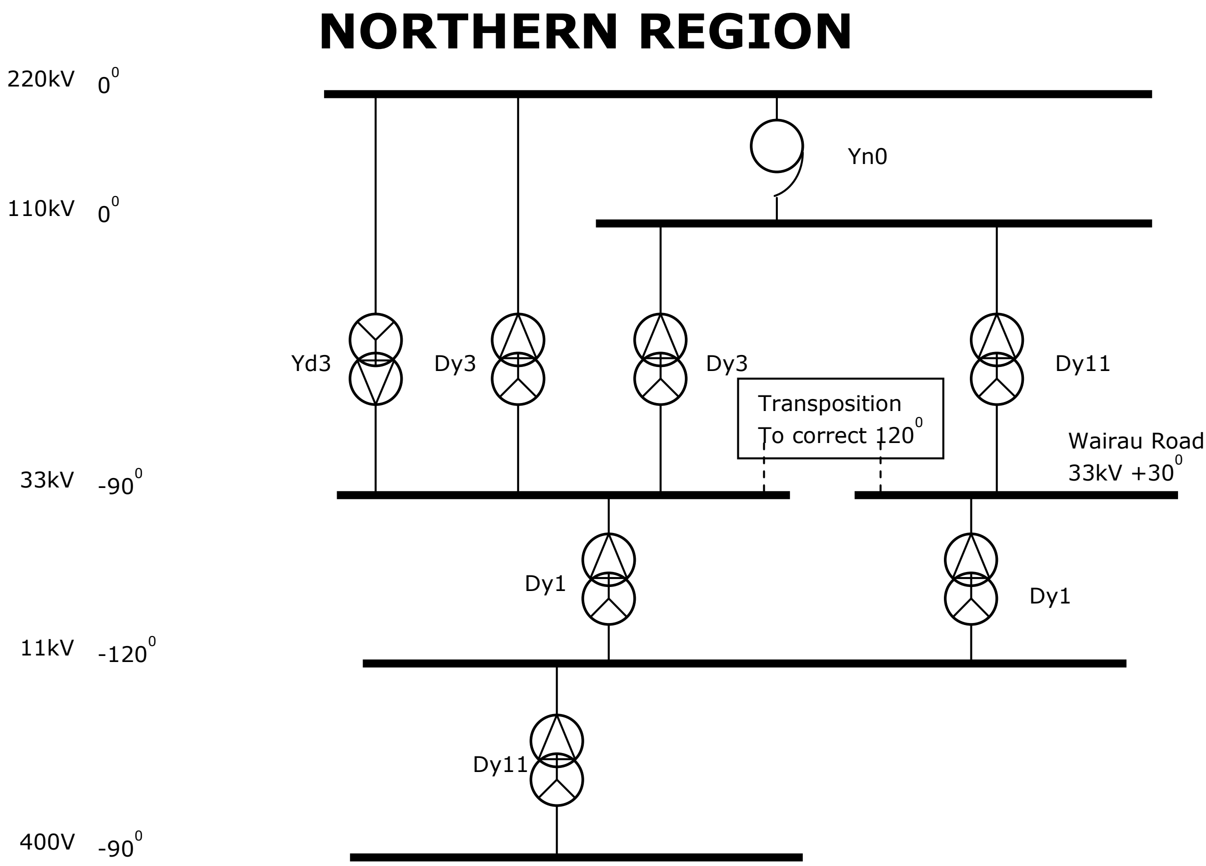

Figure 2-8 : Vector groups of transformers supplying the Northern region

[13] To avoid confusion, in this context the vector grouping refers to the internal winding configuration of a transformer and has nothing to do with Vector as a company or group.

[14] Ibid.

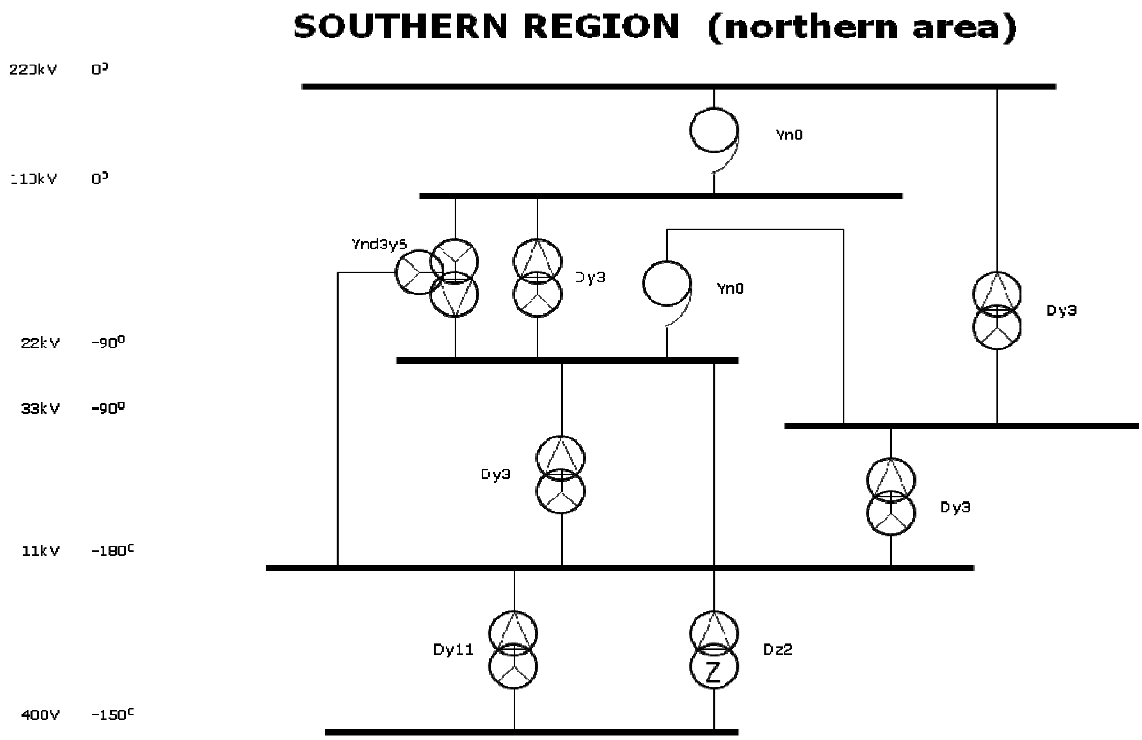

Figure 2-9 : Vector groups of transformers supplying the Southern region (northern area)

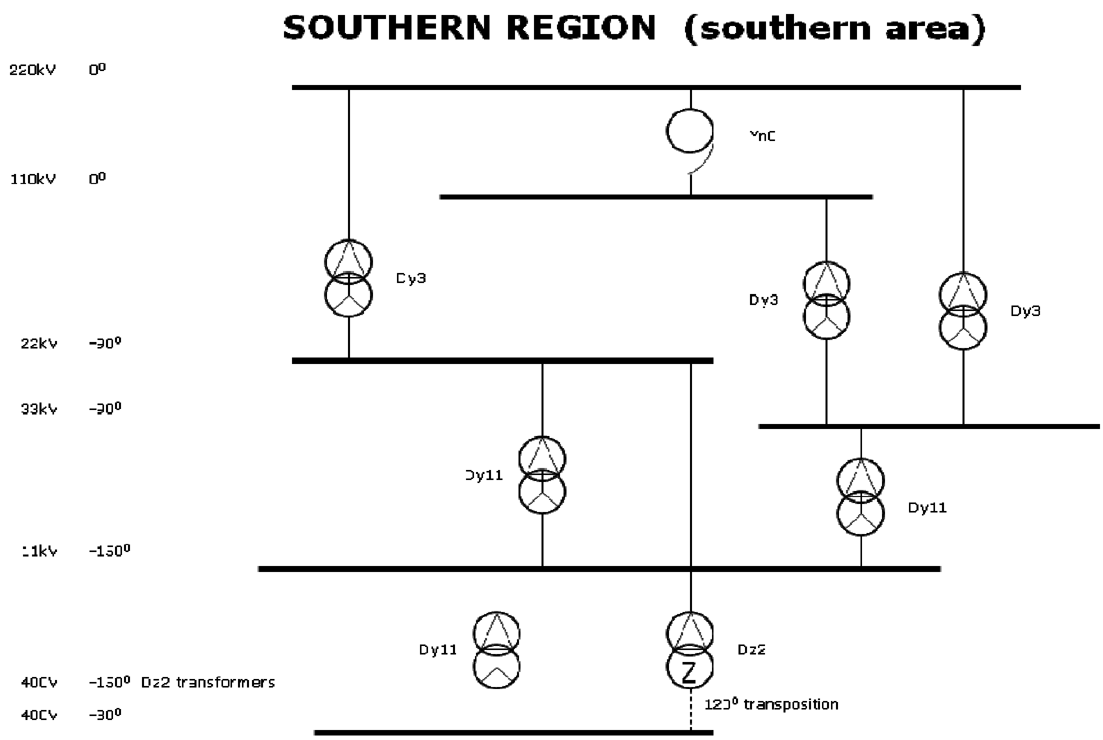

Figure 2-10 : Vector groups of transformers supplying the Southern region (southern area)

From the vector diagrams, it can be seen that the sub-transmission network in all regions is all in phase except at Wairau Road substation where the 110/33kV transformers are Dy11. Rotation of the 33kV feeders supplied by the Dy11 transformers by 120° before connecting to the network fed from other substations enable them to operate in parallel with the rest of the sub-transmission network. This rotation will be corrected when the new 220/33kV transformer and 33kV switchboard are commissioned (scheduled to be completed by April 2013). This vector diagram will be updated to reflect the new connection in the next AMP.

The 11kV network between the northern area and southern area of the Southern region is 120° out of phase. A rotation of 120° has already been made at the 11kV network supplied by the two areas to allow them to operate in parallel. The same rotation applies to the 400V network. The phase angle between the 11kV network in the Northern region and Southern region is 60°. Phase correction between the two regions can only be made via a phase correction transformer. The 22kV/400V transformers in the Auckland CBD are Dz2 units to enable them to run in parallel with the existing LV network supplied from the 11kV network. The 22kV/400V transformers used at Highbrook development are Dz2 units. The 400V network is, therefore, 120° out of phase with the LV network supplied from neighbouring 11kV network and has to be rotated by 120° before parallel operation is feasible.

2.3.2.4 Prospective Fault Currents

Prospective fault currents at the various zone substation busbars were calculated using DigSilent Power Factory version 14.0 with the network configuration as at January 2012. The source fault levels were obtained from Transpower. Known significant embedded generation were included in the model.

The DigSilent Complete Methodology was used in the fault current calculation. This is a superposition method where load flows are performed to determine the pre-fault condition of the network such as the busbar voltage and tap changer positions. The winter demand forecasts in Section 5.4 of this Plan have been used for the load flow study.

Vector’s 11kV circuit breakers have historically been specified to break fault currents of 13.1kA, although some individual circuit breakers purchased from certain manufacturers recently may have higher capabilities. It is essential to recognise the prospective fault currents when designing the fault ratings of equipment.

Table 2-6 summarises the prospective fault currents (expressed in kA) at the various zone substations with the 11kV bus sections at multi transformer substations closed.

Zone Substation	Fault Current (kA)								
	2013			2018			2023		
	3P	P-P	P-E	3P	P-P	P-E	3P	P-P	P-E
Atkinson Road	9.3	8.1	10.4	9.3	8.1	10.4	9.3	8.1	10.4
Auckland Airport	11.2	9.7	1.9	11.2	9.7	1.9	11.2	9.7	1.9
Avondale	7.7	6.7	8.3	7.7	6.7	8.3	7.7	6.7	8.3
Bairds	8.8	7.6	9.3	8.8	7.6	9.3	8.8	7.6	9.3
Balmain	6.5	5.6	7.1	6.5	5.6	7.1	6.5	5.6	7.1
Balmoral	8.7	7.5	9.5	8.7	7.5	9.5	8.7	7.5	9.5
Belmont	11.8	10.1	13.1	11.8	10.1	13.1	11.8	10.1	13.1
Birkdale	11.8	10.2	**13.2**	11.8	10.2	**13.2**	11.8	10.2	**13.2**
Brickworks	6.6	5.8	7.2	6.6	5.8	7.2	6.6	5.8	7.2
Browns Bay	7.6	6.6	8.0	7.6	6.6	8.0	7.6	6.6	8.0

Zone Substation	Fault Current (kA)								
	2013			2018			2023		
	3P	P-P	P-E	3P	P-P	P-E	3P	P-P	P-E
Bush Road	12.2	10.5	13.0	12.2	10.5	13.0	12.2	10.5	13.0
Carbine	8.5	7.3	8.9	8.5	7.3	8.9	8.5	7.3	8.9
Chevalier	8.8	7.6	10.2	8.8	7.6	10.2	8.8	7.6	10.2
Clendon	9.5	8.3	10.6	9.5	8.3	10.6	9.5	8.3	10.6
Clevedon	3.8	3.3	4.2	3.8	3.3	4.2	3.8	3.3	4.2
Coatesville	6.5	5.6	6.9	6.5	5.6	6.9	6.5	5.6	6.9
Drive	8.8	7.6	9.1	8.8	7.6	9.1	8.8	7.6	9.1
East Coast Road	6.6	5.7	7.0	6.6	5.7	7.0	6.6	5.7	7.0
East Tamaki	12.2	10.6	1.9	12.2	10.6	1.9	12.2	10.6	1.9
Forrest Hill	10.6	9.2	11.8	10.6	9.2	11.8	10.6	9.2	11.8
Freemans Bay	8.7	7.5	9.9	8.7	7.5	9.9	8.7	7.5	9.9
Glen Innes	7.8	6.8	8.8	7.8	6.8	8.8	7.8	6.8	8.8
Greenhithe	4.9	4.2	5.4	4.9	4.2	5.4	4.9	4.2	5.4
Greenmount	**13.8**	11.9	**14.3**	**13.8**	11.9	**14.3**	**13.8**	11.9	**14.3**
Gulf Harbour	5.3	4.6	5.8	5.3	4.6	5.8	5.3	4.6	5.8
Hans	8.3	7.1	8.8	8.3	7.1	8.8	8.3	7.1	8.8
Hauraki	6.7	5.8	7.1	6.7	5.8	7.1	6.7	5.8	7.1
Helensville	5.0	4.3	6.0	5.0	4.3	6.0	5.0	4.3	6.0
Henderson Valley	7.1	6.1	7.5	7.1	6.1	7.5	7.1	6.1	7.5
Highbrook	20.2	17.5	21.0	20.2	17.5	21.0	20.2	17.5	21.0
Highbury	6.4	5.6	7.0	6.4	5.6	7.0	6.4	5.6	7.0
Hillcrest	12.4	10.8	**13.4**	12.4	10.8	**13.4**	12.4	10.8	**13.4**
Hillsborough	5.2	4.5	5.6	5.2	4.5	5.6	5.2	4.5	5.6
Hobson 110/11kV	12.5	10.8	1.0	12.5	10.8	1.0	12.5	10.8	1.0
Hobson 22/11kV	8.0	6.9	8.3	8.0	6.9	8.3	8.0	6.9	8.3
Hobson 22kV distribution	20.7	17.9	1.5	20.7	17.9	1.5	20.7	17.9	1.5
Hobsonville	11.7	10.1	12.9	11.7	10.1	12.9	11.7	10.1	12.9
Hospital	5.3	4.6	5.5	5.3	4.6	5.5	5.3	4.6	5.5
Howick	**13.6**	11.8	**14.2**	**13.6**	11.8	**14.2**	**13.6**	11.8	**14.2**
James Street	10.0	8.7	11.7	10.0	8.7	11.7	10.0	8.7	11.7
Keeling Road	6.3	5.4	7.6	6.3	5.4	7.6	6.3	5.4	7.6

Zone Substation	Fault Current (kA)								
	2013			2018			2023		
	3P	P-P	P-E	3P	P-P	P-E	3P	P-P	P-E
Kingsland	7.9	6.8	8.7	7.9	6.8	8.7	7.9	6.8	8.7
Kingsland 22kV	12.9	11.2	13.4	12.9	11.2	13.4	12.9	11.2	13.4
Laingholm	7.7	6.6	8.6	7.7	6.6	8.6	7.7	6.6	8.6
Liverpool 11kV	10.9	9.5	11.9	10.9	9.5	11.9	10.9	9.5	11.9
Liverpool 22kV Dst Lower Bus	21.0	18.2	1.5	21.0	18.2	1.5	21.0	18.2	1.5
Liverpool 22kV Dst Upper Bus	21.0	18.2	1.5	21.0	18.2	1.5	21.0	18.2	1.5
Liverpool 110kV	24.9	21.5	28.5	24.9	21.5	28.5	24.9	21.5	28.5
Mangere Central	8.1	7.0	8.6	8.1	7.0	8.6	8.1	7.0	8.6
Mangere East	8.1	7.0	8.6	8.1	7.0	8.6	8.1	7.0	8.6
Mangere West	10.4	9.0	1.0	10.4	9.0	1.0	10.4	9.0	1.0
Manly	9.7	8.4	11.2	9.7	8.4	11.2	9.7	8.4	11.2
Manukau	12.3	10.7	**13.2**	12.3	10.7	**13.2**	12.3	10.7	**13.2**
Manurewa	11.2	9.7	12.3	11.2	9.7	12.3	11.2	9.7	12.3
Maraetai	6.0	5.2	7.5	6.0	5.2	7.5	6.0	5.2	7.5
McKinnon	12.0	10.4	12.9	12.0	10.4	12.9	12.0	10.4	12.9
McLeod Road	7.1	6.1	7.5	7.1	6.1	7.5	7.1	6.1	7.5
McNab	12.7	11.0	1.5	12.7	11.0	1.5	12.7	11.0	1.5
Milford	7.2	6.2	7.7	7.2	6.2	7.7	7.2	6.2	7.7
Mt Albert	4.9	4.2	5.2	4.9	4.2	5.2	4.9	4.2	5.2
Mt Wellington	12.0	10.4	12.7	12.0	10.4	12.7	12.0	10.4	12.7
New Lynn	11.2	9.7	12.4	11.2	9.7	12.4	11.2	9.7	12.4
Newmarket	12.7	11.0	**13.5**	12.7	11.0	**13.5**	12.7	11.0	**13.5**
Newton	8.3	7.2	8.9	8.3	7.2	8.9	8.3	7.2	8.9
Ngataringa Bay	6.7	5.8	7.2	6.7	5.8	7.2	6.7	5.8	7.2
Northcote	6.5	5.7	7.0	6.5	5.7	7.0	6.5	5.7	7.0
Onehunga	8.1	7.0	9.0	8.1	7.0	9.0	8.1	7.0	9.0
Orakei	9.1	7.8	9.5	9.1	7.8	9.5	9.1	7.8	9.5
Oratia	5.1	4.4	5.4	5.1	4.4	5.4	5.1	4.4	5.4
Orewa	9.2	8.0	10.5	9.2	8.0	10.5	9.2	8.0	10.5
Otara	9.6	8.3	10.2	9.6	8.3	10.2	9.6	8.3	10.2
Pacific Steel furnace 33kV	7.9	6.8	8.2	7.9	6.8	8.2	7.9	6.8	8.2

Zone Substation	Fault Current (kA)								
	2013			2018			2023		
	3P	P-P	P-E	3P	P-P	P-E	3P	P-P	P-E
Pacific Steel 33kV	4.3	3.7	4.3	4.3	3.7	4.3	4.3	3.7	4.3
Pakuranga	9.0	7.8	9.2	9.0	7.8	9.2	9.0	7.8	9.2
Papakura	8.2	7.1	8.7	8.2	7.1	8.7	8.2	7.1	8.7
Parnell	11.9	10.3	**13.4**	11.9	10.3	**13.4**	11.9	10.3	**13.4**
Ponsonby	6.9	6.0	7.6	6.9	6.0	7.6	6.9	6.0	7.6
Quay	8.5	7.3	9.1	8.5	7.3	9.1	8.5	7.3	9.1
Quay 22kV	21.4	18.6	1.5	21.4	18.6	1.5	21.4	18.6	1.5
Quay 22kV distribution	21.4	18.6	1.5	21.4	18.6	1.5	21.4	18.6	1.5
Ranui	5.5	4.8	5.9	5.5	4.8	5.9	5.5	4.8	5.9
Red Beach	6.3	5.4	6.6	6.3	5.4	6.6	6.3	5.4	6.6
Remuera	8.7	7.5	9.2	8.7	7.5	9.2	8.7	7.5	9.2
Riverhead	5.1	4.4	6.2	5.1	4.4	6.2	5.1	4.4	6.2
Rockfield	8.8	7.6	9.2	8.8	7.6	9.2	8.8	7.6	9.2
Rosebank	9.0	7.8	9.5	9.0	7.8	9.5	9.0	7.8	9.5
Sabulite Road	10.3	8.9	11.0	10.3	8.9	11.0	10.3	8.9	11.0
Sandringham	8.6	7.5	9.3	8.6	7.5	9.3	8.6	7.5	9.3
Sandringham 22kV	19.0	16.5	20.1	19.0	16.5	20.1	19.0	16.5	20.1
Simpson Road	4.1	3.6	4.4	4.1	3.6	4.4	4.1	3.6	4.4
Snells Beach	2.7	2.3	3.2	2.7	2.3	3.2	2.7	2.3	3.2
South Howick	9.5	8.2	9.8	9.5	8.2	9.8	9.5	8.2	9.8
Spur Road	6.7	5.8	7.2	6.7	5.8	7.2	6.7	5.8	7.2
St Heliers	8.9	7.7	9.3	8.9	7.7	9.3	8.9	7.7	9.3
St Johns	10.8	9.4	11.7	10.8	9.4	11.7	10.8	9.4	11.7
St Johns 33kV	21.3	18.4	21.7	21.3	18.4	21.7	21.3	18.4	21.7
Sunset Road	7.2	6.2	7.5	7.2	6.2	7.5	7.2	6.2	7.5
Swanson	7.0	6.0	7.4	7.0	6.0	7.4	7.0	6.0	7.4
Sylvia Park	8.9	7.7	9.3	8.9	7.7	9.3	8.9	7.7	9.3
Takanini	9.3	8.0	10.0	9.3	8.0	10.0	9.3	8.0	10.0
Takapuna	6.5	5.6	6.8	6.5	5.6	6.8	6.5	5.6	6.8
Te Atatu	11.5	10.0	12.9	11.5	10.0	12.9	11.5	10.0	12.9
Te Papapa	8.6	7.4	9.0	8.6	7.4	9.0	8.6	7.4	9.0

Zone Substation	Fault Current (kA)								
	2013			2018			2023		
	3P	P-P	P-E	3P	P-P	P-E	3P	P-P	P-E
Torbay	6.2	5.3	6.8	6.2	5.3	6.8	6.2	5.3	6.8
Triangle Road	11.5	9.9	12.3	11.5	9.9	12.3	11.5	9.9	12.3
Victoria	8.2	7.1	8.8	8.2	7.1	8.8	8.2	7.1	8.8
Waiake	6.5	5.7	7.0	6.5	5.7	7.0	6.5	5.7	7.0
Waiheke	5.6	4.9	7.1	5.6	4.9	7.1	5.6	4.9	7.1
Waikaukau	4.4	3.9	4.6	4.4	3.9	4.6	4.4	3.9	4.6
Waimauku	4.4	3.8	5.6	4.4	3.8	5.6	4.4	3.8	5.6
Wairau	12.9	11.2	**13.9**	12.9	11.2	**13.9**	12.9	11.2	**13.9**
Wairau 33KV	18.8	16.3	20.5	18.8	16.3	20.5	18.8	16.3	20.5
Warkworth	5.6	4.8	7.2	5.6	4.8	7.2	5.6	4.8	7.2
Wellsford	5.6	4.8	6.6	5.6	4.8	6.6	5.6	4.8	6.6
Westfield	9.1	7.9	10.2	9.1	7.9	10.2	9.1	7.9	10.2
White Swan	12.2	10.6	**13.5**	12.2	10.6	**13.5**	12.2	10.6	**13.5**
Wiri	12.3	10.7	**13.2**	12.3	10.7	**13.2**	12.3	10.7	**13.2**
Woodford	6.5	5.6	7.0	6.5	5.6	7.0	6.5	5.6	7.0

Table 2-6 : Fault levels at Vector zone substations

The zone substations where the calculated prospective fault currents are in excess of the 13.1kA standard (for 11kV) equipment rating (Birkdale, Hillcrest, Howick, Greenmount, Manukau, Parnell, Newmarket, Wairau, Wiri and White Swan) are highlighted in bold. Details of the reasons for the increase in fault levels in these substations and the solution options are discussed in Section 5 of this AMP.

The capacity for connecting distributed generation to the network is also impacted by the fault levels, as such connection increases the total potential fault current. Where fault level constraints exist, this therefore limits Vector's ability to accommodate distributed generation (unless significant network reinforcement is carried out).

2.3.3 Distribution Network

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 11kV 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.

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. Approximately 30 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 11kV distribution network was originally constructed as an overhead network with interconnected radial feeders. However, since the mid-1960s most new subdivisions have been constructed with underground cables and any new 11kV feeder cables in urban areas are installed underground. The same applies to the 400V distribution network. The 22kV distribution network (around Highbrook industrial development and the Auckland CBD) is newly established and 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 owns the transformer(s), any outgoing switchgear and associated protection, and the building.

A more detailed description of the distribution network is given in Sections 5 and 6 of this AMP.

2.3.3.1 Undergrounding

Vector has an obligation to its majority shareholder, the Auckland Electricity Consumer Trust[15], to conduct an undergrounding programme for the Southern region and the percentage of overhead network is gradually reducing. All new subdivisions have been reticulated underground (distribution and LV networks) for the past 40 years. This is required by the local authorities.

As at the end of March 2012, 69% of the distribution (11kV and 22kV) network was underground in the Southern region and 30% in the Northern region. Overall, 46% of Vector's distribution network is underground.

2.3.4 Low Voltage Network

While substantial parts of the existing Vector distribution network are still overhead, all new subdivisions are reticulated underground. Vector has an ongoing undergrounding programme in the Southern region.

Distribution transformers are designed to supply a predetermined number of customers based on an expected after diversity maximum demand (ADMD) and can withstand some cyclic overloading, based on industry standards. 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). In the event that a transformer fails, a mobile generator will be deployed to restore supply while the transformer is replaced. Alternatively, a temporary cable can be installed provided capacity is available from neighbouring substations.

As at the end of March 2012, 63% of the LV distribution network was underground in the Southern region and 48% in the Northern region. Overall, 56% of Vector's LV distribution network is underground.

2.3.5 Protection, Automation, Communication and Control Systems

2.3.5.1 Power System Protection

The main role of protection relays is to detect network faults and initiate power circuit isolation upon detection of abnormal conditions. All new and refurbished substations are equipped with multifunctional intelligent electronic devices (IEDs). Each IED combines

[15] Vector is listed on the New Zealand Stock Exchange. The Auckland Energy Consumer Trust (AECT) is the majority shareholder with voting rights of 75.4%.

protection, control, metering monitoring, and automation functions within a single hardware platform. It also communicates with the substation computer or directly to SCADA central computers over the IP based communication network using industry standard communication protocols.

2.3.5.2 Substation DC Auxiliary System

A substation's DC auxiliary system is the most vital component of each substation - it provides power supply to the substation protection, control, and communication systems, including circuit breaker (CB) control and tripping. 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.

Vector's standard DC auxiliary systems consist of a dual string of batteries, battery charger, a number of DC/DC converters and a battery monitoring system. The major substations are equipped with a redundant DC auxiliary system.

Vector uses Valve-Regulated Lead-Acid (VRLA) batteries which are safer for personnel, more cost effective and require less routine maintenance. The VRLA batteries are charged with a temperature compensated charger.

To increase system reliability, reduce maintenance costs and increase maintenance personnel safety, a battery monitoring system is fitted to all new installations.

2.3.5.3 Substation Automation (SA)

Substation automation (SA) describes the collection of infrastructure within a substation enabling the coordination of protection, automation, monitoring, metering and control functions, and utilising substation internal communications network infrastructure. Vector's substation automation system is based on resilient optical ethernet local area network running IEC 61850 compliant IEDs.

2.3.5.4 Feeder Automation (FA)

Feeder automation (FA) can be defined as schemes of equipment (automated switches, auto-reclosers etc) that are capable of acting without human intervention in order to minimise outages, restore supply or carry out other network/asset automation functions eg. substation off-loading.

The feeder automation schemes are frequently interfaced to the network control centre for remote indication, control and data acquisition (SCADA functions).

The feeder automation in its present implementation state enables SCADA functionalities, auto-reclosing, auto-sectionalising, feeder reconfiguration, fault detection and voltage control.

2.3.5.5 Supervisory Control and Data Acquisition - SCADA

A typical SCADA system is hierarchically architected and consists of:

- Master Station – centralised computer systems with SCADA application software, workstation and HMI (Human Machine Interface);
- Communication protocols;
- Communication systems; and
- Field Installed Intelligent Electronic Devices (Remote Terminal Units, IEDs).

A SCADA system enables remote control (telecontrol) of power system equipment (eg. switchgear, power transformers) and remote measurements (telemetry) of power system current and voltages.

The migration from the Foxboro system to the Siemens Spectrum Power TG system for the Northern region has been completed. The Siemens Spectrum Power TG master station is now used for monitoring and control of whole Vector electricity network.

2.3.5.6 Remote Terminal Units (RTU)

An RTU is a microprocessor controlled electronic device which interfaces objects in the physical world (eg. switchgear, power transformers) to a distributed control system or SCADA system by transmitting telemetry data to the system and/or altering the state of connected objects based on control messages received from the system.

For remote control, the traditional RTU solution has been to install an RTU device as an interface between the network control SCADA master station and the substation primary equipment (switchgears, power transformers). This functionality is in modern SA systems being distributed to IEDs installed within substations.

Over time a number of different RTUs have been installed in Vector's network, many of which are nearing the end of their technical life or are obsolete. Vector has embarked on a replacement programme enabling a standard RTU to be deployed across the network.

2.3.5.7 Communication Protocols

A variety of SCADA communication protocols are presently used to communicate between the various SCADA systems and different types of IEDs installed on the network. Vector's current standard for internal and external communication systems is IEC 61850 standard. DNP3 is also used as an interim solution.

2.3.5.8 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.

2.3.5.9 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.

The metering system provides Vector with essential information about the quantity, quality and reliability of the power delivered to Vector's customers, and is currently used to:

- Improve asset utilisation by managing network peak demands;
- Provide PQ and load data for network management and planning purposes;

- Provide information to assist in the resolution of customer-related PQ issues; and
- Contribute to the power system stability by initiating instantaneous load shedding during under-frequency events.

2.3.5.10 Load Control Systems

Vector's load control systems consist of audio frequency ripple, pilot wire and cyclo control types. 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.

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. (See Section 3 for a discussion.)

2.3.6 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 two transformers are Y-y vector group (the only Y-y units within the Vector network). The map in Figure 2-11 shows the location of Lichfield GXP.

2.3.7 Vector Assets Installed at Transpower GXPs

For practical reasons Vector has installed some of its equipment at Transpower GXPs, with agreement from Transpower. These assets are described below.

2.3.7.1 Power Equipment

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. Vector has responsibility for their maintenance and operations.

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.

The Penrose end of the CBD tunnel (owned by Vector for connecting Penrose GXP to the Auckland CBD) is constructed within the Penrose GXP site boundary. This tunnel accommodates Vector's 33kV and 110kV cables.

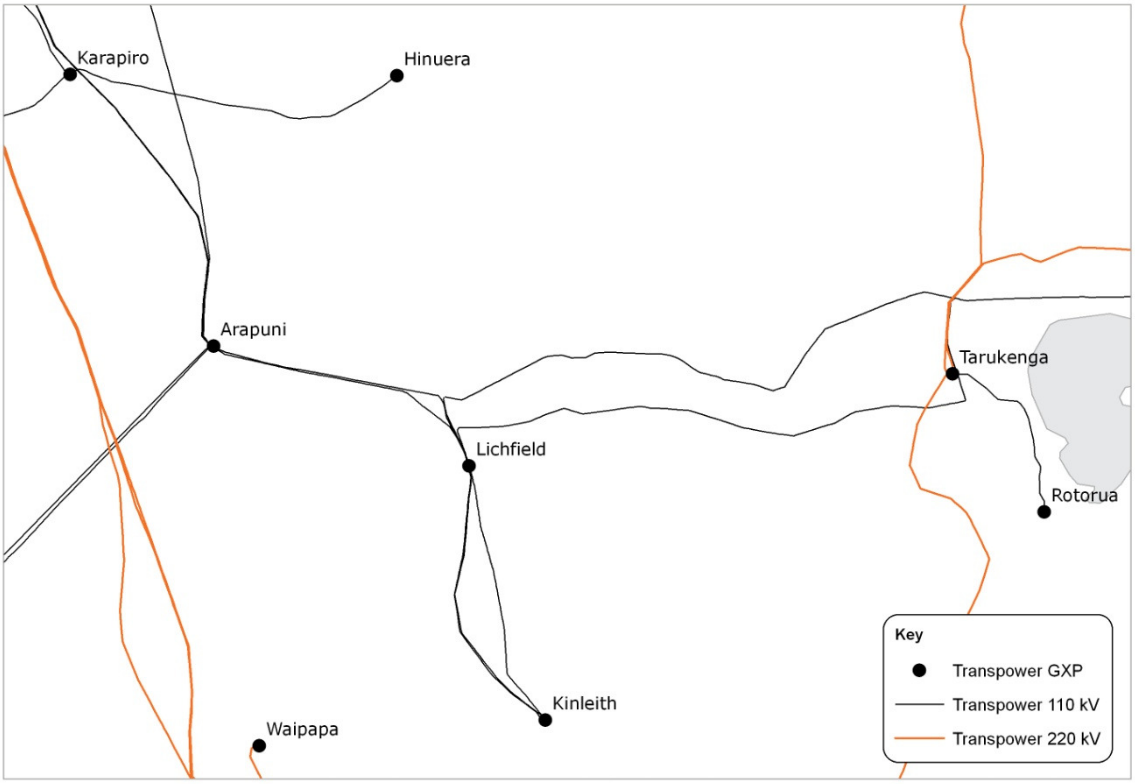

Figure 2-11 : Location of Lichfield GXP

2.3.7.2 Protection and Communications Equipment

Vector uses unit protection schemes as primary protection for its sub-transmission network. As part of the unit protection schemes, protection relays are installed at GXPs where the sub-transmission circuits are connected. Other parts of the protection schemes include control wiring, batteries and chargers. Communications equipment including RTUs, pilot wires are also installed as part of Vector's SCADA and control system.

Vector has installed power quality meters and check meters at GXPs to monitor power quality and energy injected into Vector's distribution network.

2.3.7.3 Load Control Equipment

Vector's ripple injection plants in the Southern region are connected to its sub-transmission network. For zone substations supplied from the sub-transmission network connected to a Transpower GXP, the ripple injection plants are located at the respective GXP. For zone substations supplied from the sub-transmission network connected to 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.

2.4 Justification of Assets

Network assets are created for a number of reasons. While asset investment is often the most effective and convenient means of addressing network issues, Vector also considers other solutions to network issues and applies these where practical and economic. Such alternatives may include network reconfiguration, asset refurbishment, adopting non-network solutions (such as distributed generation) or entering into load management arrangements with customers.

The key factors (not listed in any order of priority) leading to asset investment at Vector are:

- Health and safety: Where health and safety concerns indicate the need for asset investment, this takes priority;
- Legal and regulatory compliance: Ensuring Vector is not in breach of statutory obligations of electricity service providers or regulatory requirements such as satisfying the voltage limits;
- Capacity: Maintaining sufficient network capacity to supply the needs of consumers is a key driver for asset investment;
- New developments: Where new building or urban development occur, or existing developments are extended, this usually requires investment in network assets;
- Security of supply standards: Vector is committed to meeting its security of supply standards, and potential breaches of these often indicate a need for asset investment. Network assets are constructed to provide both capacity and security;
- Reliability: Vector's customers expect a certain level of reliability of supply. Decisions in the optimal expenditure to achieve the target reliability often involve optimising the capex/opex mix. On occasions, more assets are required to reduce opex with the overall result of reducing costs in the long term;
- Customer requirements: Assets are often installed at the request of customers (who then contribute to the investment cost) such as requiring higher security;
- Renewal: Assets are usually replaced when they have deteriorated to the extent that they pose a safety or reliability risk, or have reached the end of their useful lives (where maintenance or refurbishment start to be more expensive than replacing an asset);
- Refurbishment: Investing to prolong the useful lives of assets when it is economic and safe to do so; and
- Technology improvements: When technology becomes obsolete and assets can no longer fulfil the basic requirements of a modern, effective network, this may give rise to replacement expenditure.

Vector's network investment has always been prudent, meeting only realistic network requirements. This is also illustrated by the most recent Optimised Deprival Valuation (ODV) of the electricity network carried out in 2004. For this ODV, Vector recorded $51.6 million of optimisation for its Auckland (excluding Wellington) assets, being assets deemed unnecessary for current requirements due to stranding, over-capacity for current demand or other similar factors. This figure equates to 3.4% of the corresponding ODV, a very small margin.[16] Of the assets affected, all were optimised down to a lower capacity and not optimised out. With the demand growth in the past seven years, should network optimisation be reinstituted, a significant portion of these optimised assets would be reinstated.

In submitting business cases for project approvals, planners are required to develop credible and viable options (including network and non-network options) for evaluation. Evaluation criteria included in the business case include economic efficiency, financial viability, technical suitability, strategic fit and a risk assessment. This further ensures prudent investment decisions.

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[16] Even this figure gives an over-estimate of "stranded assets" given the unrealistic asset planning horizons (from an engineering/economic perspective) provided for in the ODV Handbook.

Several factors influence how assets are selected and the manner in which they are implemented.

- **Network design standards**

  Vector has developed a detailed network security standard, which sets out the basic requirements for network planning for the distribution and sub-transmission networks (refer to Section 5 of this AMP for details). These standards define largely the stage at which network reinforcement (ie. new assets) becomes essential, and the capacity to which new installations should be built.

  Vector has adopted a probabilistic security standard (although the standard is expressed in deterministic language to allow easier understanding by the reader) rather than the more conventional deterministic standards used by most distribution utilities. Vector's security standard is comparable with, but more cost-effective than, that of most other distribution utilities in New Zealand and Australia.

  In practice, the security standard allows Vector to operate its sub-transmission network to a level marginally below N-1 for a small number of peak-demand hours during a year (except in the Auckland CBD, where higher standards apply).

  To manage supply risk, Vector has put in place a system of operational contingency plans (which are regularly updated). In addition, assets are used to their cyclical rating capacity – generally allowing short-term loading to exceed the normal long-term equipment rating. This approach allows Vector to maximise asset utilisation.

  Capacity and security are not the only criteria for the design of the distribution network. In Section 5 other planning criteria are also described.

- **Optimising installations**

  When a potential network issue or constraint is identified, project options will be developed and the optimal (usually least life cycle cost) solution will be adopted. The optimal solution may not have the lowest initial capital cost or be the lowest capacity solution.

- **Very long term network development plan**

  Vector has developed a very long term (50+ years) plan to guide the development of the electricity network. This plan is based on the growth strategy for the region prepared by the (previous) councils of the region which identifies the location and extent of growth in the various parts of the region and allows a spatial load distribution plan to be developed covering Vector's supply area. From this spatial load distribution plan, a very long term network configuration is developed to ensure there is optimal capacity and security to supply the region and to avoid piece meal development of the network.

- **Equipment standardisation**

  To minimise cost in the long-term and to ensure optimally rated equipment is installed to meet a range of possible situations, Vector has a policy of using standardised equipment on its network. For example, Vector has standardised on 20MVA and 10MVA for power transformers. 20MVA transformers are used in higher load density urban areas whereas 10MVA transformers are used in lower load density rural areas.

  Standardisation helps to reduce design and procurement costs during the establishment phase, increase operational flexibility and makes equipment maintenance more effective. It also allows more effective strategic spares management.

- **Customer-specific assets**

  From time to time, Vector builds dedicated assets to supply customers to meet their anticipated demand growth at their requests based on agreed commercial terms. Examples are Lichfield and Auckland International Airport (AIAL).

- **Life-cycle considerations**

  Vector adopts a life cycle cost approach to choosing network solutions and assets. This means the lowest cost short-term solution may not always be adopted. For example, Vector builds indoor substations within concrete buildings to accommodate switchgear and auxiliary equipment, although outdoor equipment is initially cheaper to install. Over time the initial additional costs are offset by lower maintenance costs, more secure and reliable operations and longer life-spans.

- **Historical considerations**

  Load growth, load density and historical network architecture and equipment standards can result in varying types of assets, states of security and asset condition throughout the network. While historical network architectures and equipment standards converge over time, replacing well-functioning assets to achieve such alignment in the short term can generally not be economically justified. However, as failing assets are replaced or new assets added to the network, these are generally designed to comply with the present specifications.

- **Equipment utilisation**

  The utilisation (the ratio between the peak demand on an equipment over its capacity) of Vector's feeders and zone substations are generally high. The utilisation graphs shown in Section 4.2 indicate that the majority of zone substations are utilised well above traditional n-1 security levels. Vector is able to achieve this higher utilisation by making effective use of the higher short-term ratings of equipment and through the high degree of interconnection of its zone substations. The utilisation graphs also show a significant increase in substation and feeder utilisation over the past ten years.

  The network architecture of the networks in the two regions inherently causes a higher utilisation in the Northern region. This higher utilisation also reflects the largely residential characteristics of the region (compared to the high concentration of industrial and commercial load in the Southern region).

2.4.1 Determination of Capacity of New Equipment

As stated earlier, Vector has a policy of using standard equipment on its network to minimise long-term cost.

The key factor in deciding the standard capacities (20MVA and 10MVA) of power transformers is the load density of the area being supplied. While economy of scale suggests the use of large capacity transformers, higher capacity zone substations will result in a larger supply catchment area (for the same load density) and longer distribution feeders. Larger supply catchment areas will also result in zone substations further away from GXPs, thus requiring longer sub-transmission feeders. Deciding the optimal economic capacity of standard urban transformers requires optimisation between cable and transformer costs to achieve the lowest overall cost per MVA of network capacity. Scenario analysis (of different transformer capacities and feeder lengths), considering a range of equipment costs and load densities, supported a decision on standardising urban transformer capacity at 20MVA. Other factors considered included the impact of transformer capacity on fault level, transformer impedance, reactive power and tap changer / voltage control.

For power transformers used in rural zone substations, voltage performance of the distribution network is another important factor in addition to those stated above. The result of the analysis for these areas indicates that here 10MVA is the optimal transformer capacity.

Apart from the capacity of power transformers, most of the equipment installed on the Vector network is standardised. This includes:

- Protection and control equipment;
- Zone substation buildings;
- Sub-transmission switchgear;
- Distribution transformers;
- Distribution switching equipment;
- Distribution cables; and
- Poles.

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Future Vision and Strategy – Section 3

[Disclosure AMP]

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3. Future Vision and Strategy

3.1 Overview

The environment within which electricity distribution businesses operate is undergoing considerable change:

- From a technological perspective, developing trends in consumer appliances, technology convergence, renewable generation and an increasing ability to build distributed intelligence into networks have major potential for improving the customer experience and network efficiency and reliability. However, it also holds a very real risk of forcing major network augmentations[1] and/or causing stranded assets[2]; and
- Societal changes are also having a marked impact on network operations and asset management decisions due to changing customer expectations and increased awareness of energy-related matters.

Making investment decisions on major, long-life assets in a changing environment poses challenges. Vector has developed a future vision to help guide asset management strategy to ensure its networks can cope with the anticipated changes and it is well-positioned to make best use of the opportunities offered. This vision will be regularly reviewed to take into account ongoing changes to the environment Vector operates in.

Through its ownership of Advanced Metering Services (AMS), a leading provider of smart meters for the industry, and by virtue of its long-term involvement in installing fibre optic networks in the Auckland region, Vector is ideally placed to maximise the benefits from developing technology for its distribution network. This also supports the Vector asset management strategy for an all encompassing continual efficiency improvement drive to providing a reliable, safe and affordable electricity supply while achieving commercially sustainable returns on investments.

3.1.1 Focus on Investment Efficiency

Vector seeks to continually improve the efficiency of its investment decisions. To help drive this, specific business-wide targets have been established to improve capital efficiency. The targets are achieved through a combination of continual improvement and innovation:

- Keeping an open mind ("how we can" not "why we can't");
- Broadening thinking around potential asset solutions, including multiple utility and non-network solutions;
- Leveraging previous smart solutions into new areas of application;
- Keeping abreast of solutions others are applying and relating these to Vector's challenges;
- Taking advantage of new technologies that enable solutions not previously possible;
- Making better decisions through better information and analysis;
- Enhanced, robust decision-making processes (a "value engineering" type approach) which seek broad and effective input to potential solutions and includes review steps to support continuous improvement; and

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[1] Through increasing electricity demand peaks.

[2] When equipment becomes obsolete at an early date, or demand shifts lead to redundant capacity.

- Making continuous incremental improvements in project planning and delivery.

These efficiency factors are reflected at all levels of asset management at Vector – from the asset design phase, through the procurement and construction phase and into the lifecycle operational phase.

Systems and processes have been established to track efficiency progress and to ensure that enhanced efficiency considerations are built into asset decision making processes at all levels.

3.1.2 Clear Understanding of Future Network Demands and Challenges

Recent worldwide development trends in consumer technology and renewable generation make it imperative for Vector to understand the potential impact of these emerging technologies on the network and to develop strategies so that Vector's network is ready to cater for these technologies and meet new consumer demand.

Vector has therefore:

- Considered emerging technologies that are likely to have significant impacts on the electricity and gas networks;
- Developed a view as to how the network may be affected by these technologies in 5-20 years time; and
- Developed strategies to mitigate potential adverse impacts on the network, capture opportunities and to shape the development of the network.

3.1.3 Leverage Technology

Developments in information, communication and automation technology present opportunities to introduce greater levels of intelligence into the distribution network.

To date, cost factors have limited the intelligence in the network to the higher voltage (11kV and above) parts. Technology developments are now making it operationally feasible and economically viable to extend to the lower voltage parts of the network.

The outcomes from this offer the potential to:

- Improve asset utilisation resulting in deferred investment expenditure;
- Increase network reliability and reduce restoration times; and
- Lower operational costs.

A number of trials of potential technologies will progress over the coming months to test performance and integration with Vector's existing systems, which will inform future strategies in this regard. In areas where specific benefits can be identified, targeted deployment of trialled and proven technologies will be programmed for progressive implementation.

One area of concern that will have to be addressed is the regulatory and pricing implications of investment in emerging technologies. From a consumer perspective there may be clear efficiency gains achievable through adopting the emerging technologies, but it is less clear the regulatory framework and the New Zealand electricity market structure will provide appropriate incentives or rewards for any particular sector of the market, including electricity lines business, to unlock the full available potential. This is because distributors recover a large portion of their revenues through volumetric charges and any reduction in volume or volume growth due to new technologies would reduce allowable revenues of distribution businesses. If the correct regulatory long-term incentives are not in place the efficiency gains may not be made.

Vector's "intelligent network" strategy is detailed in Section 3.3 below.

3.1.4 Constraints on Implementing New Solutions

Vector is actively pursuing optimal investment and energy efficiency through embracing innovation, new technology and solutions. However, it is noted that some aspects of the electricity market structure in New Zealand and the commercial regulation of electricity distribution business constrains Vector's ability to maximise the potential benefit that could be derived not only for its customers, but also for the wider New Zealand economy. These factors are being discussed in other forums, but the main aspects impacting on asset management planning, are summarised below:

- While Section 54Q of the Commerce Act directs the Commerce Commission to encourage energy efficiency, the Commission has yet to implement specific policies to meet the requirements of this section and few incentives exist for electricity distribution business to alter their investment practices in this regard;
- Vector's asset investment decision-making involves consideration of a broad range of factors to ensure the most efficient outcome. Due to lack of incentives, energy efficiency is not specifically considered. In some cases however, the investment decision may result in energy efficiency benefits as a secondary result. If there is future regulatory change to incentivise energy efficient investments (as contemplated by Clause 54Q of the Commerce Act), energy efficiency would be included in the decision making factors;
- The separation of the retail and distribution functions has led to a distance between electricity distribution businesses and their customers, especially where interposed relationship models exist. Many of the potential efficiency benefits that are likely to arise from technology changes will rely on close interaction between distribution businesses and end-users, including:
  - Interfacing smart home devices with network management tools;
  - Creating pricing structures that incentivise customers to shift consumption to off-peak periods (and providing them the means to effectively do so) and having these signals flow through to customers[3]; and
  - Better understanding of customer consumption patterns, allowing optimal network planning and utilisation.

  To fully embrace the opportunities offered by evolving technology will require a much closer relationship between lines companies and end-users;
- The current regulation of network quality is aimed at maintaining historical performance levels and there is no incentive to improve on this. A key attraction of improving technology is the ability to improve network reliability and fault response time, but absent an incentive to do so, it is not commercially viable to invest in this ability; and
- Under current price-setting arrangements it is only commercially feasible to invest in energy-efficient network solutions where these are cheaper than (on a life-cycle basis) or allow deferment of conventional network investments. These are narrow benefits, accruing to the electricity distribution business (and ultimately to its customers), but many opportunities to realise wider economic benefits are likely to be foregone. Downstream benefits such as allowing deferment of transmission or generation investments are not reflected in the business cases for investments that have to be funded solely by the distribution companies.

[3] The ability of electricity distribution businesses to effective pass through price-signals to consumers is however limited by the fact that these are amalgamated in retailer charges. Retailers may for example choose not to pass on time-of-use rates if this has economic implications on their operations.

3.2 Future Technology Assessment

A broad scan of technologies that could impact on Vector's network has been undertaken. The technologies that are more likely to have significant impact on the electricity network in the short to medium-term are:

- Heat pumps;
- Photo-voltaic (PV) panels;
- Electric vehicles (EV);
- Light emitting diode (LED) lighting;
- Battery storage; and
- Smart home technologies.

It is also noted that fuel cells and V2G (vehicle to grid) application could have significant impacts on how the electricity network operates. Fuel cells have not been included in the current list pending a technological breakthrough to enable practical application and to reduce cost of production. V2G application is dependent on the uptake of electric vehicles and future development of battery and charging technologies. Development of both these technologies are being monitored.

3.2.1 Understanding the Impact of New Technologies

Extensive research has been carried out to analyse the experience of overseas utilities facing similar opportunities and threats from emerging technologies. These have then been reconciled with local situations to ensure the relevant and appropriate experience has been applied.

Technology change could have a significant impact on the load profile of Vector's electricity network over the next 10-15 years. Some technologies are likely to increase peak loads (and/or energy usage), others will reduce it and still others will change the time of day at which energy is used, resulting in significant potential changes in peak demand patterns and overall electricity usage. These changes could have significant flow on effects on Vector's asset investment strategy.

Some of the developments that are most likely to have a material impact in the near to medium-term future are discussed below.

3.2.1.1 Solar PV

Photovoltaic (PV) panels convert sunlight into electricity. Distributed PV refers to the installation of the panels on buildings that are already connected to an electricity distribution grid, with the panels connected to the grid. By drawing power off the PV panels, households and commercial buildings reduce their purchases of electricity from the grid, thus saving money. They can also sell any excess electricity into the grid[4], thus improving the economics of the PV installation.

Technology developments over the past five years have seen the cost of photovoltaic panels reduced from around $15 per watt in 2005 to around $1.50 per watt in 2012. The cost reduction has been achieved through advances in the chemistry of the panels, manufacturing efficiencies and through overcoming material and manufacturing capacity bottlenecks.

It is widely forecast that the price of installing solar PV systems will continue to fall, albeit at a slower rate and are likely to provide an economically attractive alternative to

[4] On the proviso that certain technical and safety requirements are met.

grid electricity in the next 4-5 years. For some remote locations, even today a PV solution (including backup batteries) provides the most cost-effective solution (compared to the cost of extending the conventional supply network).

Internationally, incentives (subsidies, feed in tariffs, etc) offered by governments such as Germany, Spain, California and Australia have accelerated the uptake of PV. This increase in demand in turn drives down the cost of manufacturing and provides incentives to further develop the technology. Although it is not foreseen that the New Zealand government will offer similar incentives in the near future, the downward trend in price could eventually provide sufficient incentives for PV uptake.

The introduction of PV on the network is expected to reduce average feeder loading (utilisation). PV output is however intermittent, and without further energy storage or other localised forms of generation, is not a reliable energy source. During periods where PV units are producing little or no energy (for example at night, or during heavy cloud conditions) electricity would be drawn from the grid. Should this occur during peak consumption periods, as is likely from time to time, the resulting peak demand may not change from current levels. From a distribution network perspective, assuming existing reliability levels would be maintained, it is, therefore, not foreseen that the delivery capacity can be reduced as PV is introduced (unless the system is combined with battery or other storage devices).

Distributed generation from PV may impact on network security, as the effective load reduction would increase the backstop capability at zone substations. This, however, would again be intermittent (unless additional energy storage devices are available) and, therefore, is not a reliable alternative to network capacity.

Network modelling has been undertaken by Vector to understand the impact on the network of PV under various "penetration rates" (capacity of installed PV as a percentage of total network demand) scenarios. Of interest is the amount of PV that would need to be installed beyond which there could be two way power flow (flow back up the network) and associated over-voltage issues. The analysis found very high penetration rates (above 20%) would be required for there to be general network issues. It is recognised, however, that there may be localised issues in areas of high concentration of PV eg. very large PV installations on a number of commercial buildings in one area or large PV installations on a long rural line. Potential technical solutions to such issues are being explored, with battery storage and energy management solutions being the principal areas of focus.

3.2.1.2 Electric Vehicles

Most major car manufacturers are planning launches of plug-in electric vehicles in 2013/2014. While energy cost per kilometre travelled are falling, electric vehicles currently require a battery, which adds around $10,000 per vehicle compared to equivalent petrol powered vehicles. This premium is expected to reduce as design and manufacturing improvements to electric vehicles and batteries are made. In addition, increases in oil price due to scarcity and demand are likely to make electric vehicle options more attractive in future.

Based on vehicle sales data, studies by the Ministry of Economic Development (MED) and international EV forecasts, it is expected that there may be in the order of 50,000 electric vehicles in Auckland by 2020 and 150,000 by 2025. There is however significant uncertainty around these numbers, since they will be impacted by oil prices, efficiency gains in petrol engine vehicles and the rate of cost decreases in electric vehicle technology. There is also considerable uncertainty around the likely impact electric vehicle charging may have on the network. The reasons for this are:

a. **Plug in hybrid versus pure electric**: While some vehicles to be introduced will be pure electric (eg. Nissan Leaf), others will be hybrid vehicles (Toyota and

Honda) which have a smaller battery capacity for short trips (30km) and a conventional petrol engine for longer trips.

b. **Charging location and time:** Charging will likely be achieved through a mix of public or work place charging stations and at home charging. Depending on vehicle usage, charging may occur in early evening (if used as a work commute vehicle) or at any time during the day if the owner is home based.

c. **Charging rate:** Vehicle manufacturers may provide both "normal charge" options (10 amps) and rapid charge (60 amps).

Vector has considered a variety of scenarios and modelled the network impacts for each. For the scenario where 80% of vehicles are plugged-in to charge at peak times (at normal charging rates), additional network investment of $120m over 15 years would be required to manage the additional demand. While pricing signals may provide incentive for customers to charge at off-peak times, the level of incentive able to be provided through distribution tariffs may not be sufficient to change consumer behaviour. The average daily charging cost (based on 40km daily usage) would be around $1.50 at 25c per kWh.

Potential direct control of charging is being considered as part of a wider project to develop a strategy for demand management (see Section 3.2.1.4).

3.2.1.3 Heat Pumps

Heat pumps are becoming a popular option for space heating and cooling Auckland homes. The Building Research Association of New Zealand (BRANZ) has undertaken comprehensive research of heat pump uptake and is forecasting the trend to accelerate. Currently around 20% of Auckland homes have a heat pump installed and this is modelled to increase to 50% by 2025.

The principal impact on the electricity network will be a significant increase in summer load in residential areas on days when heat pumps are used for cooling. The current maximum heat pump demand in summer is around 30MW. This is forecast to increase to 190MW in 15 years (maximum network demand for Vector's network is currently around 1,800MW). During summer, the capacity of underground cables is reduced by around 30% due to temperature effects. At the expected rate of penetration, heat pump cooling loads are likely to introduce summer peaks (higher than winter peak demand) in residential areas (commercial feeders already experience these peaks). The additional investment needed to reinforce the network to meet the forecast increase in summer demand is estimated to be $100m over the next 10 years. Winter peak demand is expected to drop initially as heat pumps are installed to replace existing less efficient resistance heaters. Over time, however, winter peak demand is expected to creep up as consumers start to utilise the heat pumps for longer periods to raise home comfort levels.

3.2.1.4 Advanced Meters and Smart Home Technologies

Technology which supports intelligent management of energy is being deployed globally. The current roll out of advanced meters is a foundational step. In their most basic form, the meters will provide consumers with improved visibility of their energy use and provide a platform to support "time of use" rates for electricity consumption. International experience of smart meter deployments have shown savings of 5% energy consumption and 2% peak demand reduction following installation of smart meters.

Vector (through AMS) is a leading provider of smart meters to the New Zealand market. By virtue of using a highly flexible, advanced meter type for its roll-out, several further benefits can be realised from the meters[5], including:

- Load control applications, using conventional ripple control (Decabit), radio-based, GPRS-based or fibre-optic based means of communication. This can be used on conventional hot-water control systems, or as an interface to other home appliances;
- Interface to Home Area Networks (HAN), supporting customer-based load control or energy-saving applications;
- Signalling electricity costs and usage rates to customers;
- Providing real-time energy flow data to be used in smart network applications;[6]
- Measurement of two-way power-flow – accommodating distributed generation sources;
- Measuring power quality and voltage levels; and
- Providing an exact location and record of power outages.

Other potential future developments of smart home technologies include:

a. **In-home displays:** Dedicated displays or internet displays (eg. Google Powermeter), providing consumers with greater understanding of their energy use. They will typically include analysis tools to identify potential savings through altering times that appliances are used, or savings from investing in more energy efficient options.

b. **Smart plugs/thermostats:** These devices communicate with a suitably equipped smart meter or an energy management hub to turn power on or off to wall sockets or to adjust the thermostat by a programmed amount. For example, adjusting the thermostat of a heat pump from 24 to 22 degrees during winter peak periods.

c. **Smart appliances:** Include communication capability such that they can respond to signals from smart meters or energy management hubs. For example, signal not to run refrigerator's defrost cycle during a certain time period.[7] The appliances will also report their energy consumption.

d. **Energy management "hubs":** Energy management hubs provide central control and communication to a number of appliances or other loads/energy sources at the customer's premises. The hubs allow the consumer and/or power companies to set rules as to how energy is to be managed. Communication with the hub is either through a smart meter, or directly. Several major companies are developing products to provide the above functions. The rules can be set to respond to the customers' needs as well as any pricing incentives from power companies.

While the potential for advanced demand management systems exist, high levels of uncertainty remain regarding communication standards. Until this is resolved investments in such technologies will be risky. Vector is closely following developments in this area.

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[5] This may require the meters to be fitted with some additional hardware devices, but the potential to do so is in place.

[6] This requires a fast two-way communication medium.

[7] A switch in the time the defrost cycle occurs will have little or no negative impact on consumers, while it could offer benefits to the operation of the network.

3.2.1.5 Battery Storage

Battery technology has been the subject of major development over the past five years. This has been driven both by electric vehicle developments and by recognition of the challenges of incorporating intermittent renewable energy into electricity networks. There are a number of different battery technologies being developed for different applications including sodium sulphide, flow batteries, lithium ion as well as traditional lead acid batteries. Technology improvements as well as manufacturing efficiencies have seen costs falling significantly over the last two years.

Projects to evaluate the potential of battery storage as a network solution have been completed. The projects have provided understanding of the sizing and economics of using batteries at zone substations, distribution substations and customer premises to provide either security of supply or load shifting advantages. Various battery technologies were evaluated.

A pilot programme of battery storage implementations at both the premises and network levels will be undertaken during 2013.

3.2.1.6 LED Lighting

Technology developments in light emitting diodes (LED) lighting have led to LED replacements for most standard domestic and commercial applications. LED bulbs use around 10%-15% of the energy of incandescent and halogen bulbs and around 70% of typical commercial fluorescent tubes. As well as being energy efficient LED bulbs last for around 30,000 hours, which reduces replacement costs (because they don't need replacing as often). While providing similar energy savings to compact fluorescents (CFL's), it is anticipated that LED bulbs will prove more popular in the longer-term because of light quality, instant brightness, improved aesthetics and the absence of mercury.

Currently LED bulbs are expensive (around $25 for a standard 60W bulb equivalent) which is limiting uptake. Prices are however forecast to continue to reduce in the foreseeable future. At current prices, payback in energy savings is only around two years and bulb life is expected to be 15 years. Lighting accounts for around 20% of peak residential network demand. Currently CFL's only account for around 5% of light bulbs in homes. There is, therefore, scope for a significant reduction in peak demand if there is widespread uptake of LED bulbs in residential areas.

Field trials of retrofitting LED bulbs to replace halogen and incandescent bulbs will be undertaken in 2013. These trials will evaluate both the technology and the customer aspects of this initiative.

3.3 Evolution of the Smart Network

Worldwide there is an immense volume of literature, research and development being produced on the so-called "smart grid" (or smart network, from a distribution utility perspective). Inevitably, widely diverging views abound about what constitutes "smartness" in electricity distribution, and about the nature of future networks. While consensus has yet to emerge, there are a few common themes about the changes that make an evolution to smart networks possible, the main ones being:

- The ability to access more real time information on the status of the network as a result of smart meters being rolled out and the falling cost of various network measuring and monitoring devices;
- Two way communications – interaction between distribution devices such as meters, substations, electronic protection systems, switches and home area networks;

- The ability to provide far greater monitoring, automation, optimisation and fault responsiveness on the network;
- Technological step changes associated with fibre optic communications and other information-based technology/next generation telecommunications; and
- Integration of power systems infrastructure with information and communication systems.

Vector takes a broad view of a smart network as the application of information and communications technology to enhance the network. The elements of the smart grid are summarised in Figure 3-1 below.

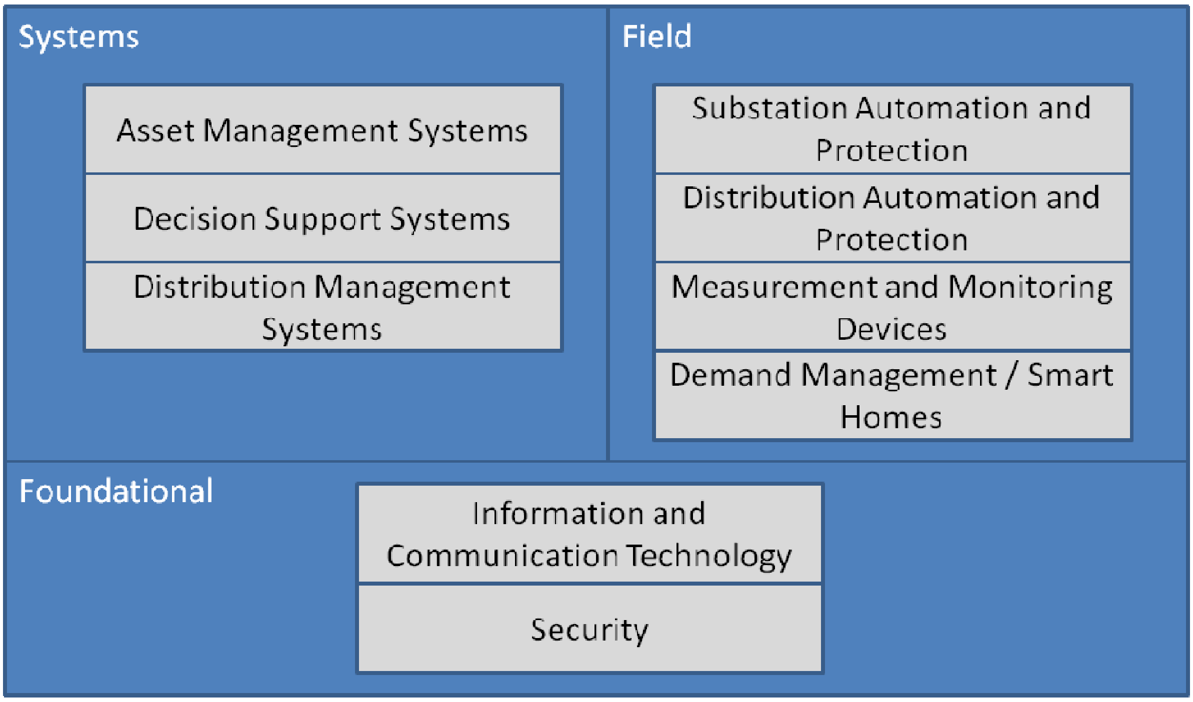

Figure 3-1 : Elements of the Vector smart grid

While there are undeniably many exciting developments underway offering various opportunities for enhancing the operation of electricity distribution networks, Vector is somewhat sceptical about the "hype" that seems to surround many discussions on smart networks. Many applications that are now widely being touted as "smart" have already been successfully adopted by Vector (and others) in the past.[8] Vector prides itself on having been "smart" in the past as well and does not see smart networks as a new development, a new type of asset, or a sudden step-change in behaviour. In Vector's view it is rather a further evolution in the long history of distribution networks.

Vector sees the potential benefit from the evolving smart network technology to distribution utilities mainly in the opportunities that these provide in:

- Supporting an efficient asset investment response to an ongoing increase in electricity demand, by increasing the utilisation of existing assets and by better managing peak demand through more effectively spreading the use of electricity[9];

[8] This includes automation of substations, automatic load sharing between adjacent substations, bus-automation, asset condition and status monitoring etc.

[9] This spreading could be over time, reducing peak demand, or by spreading load over adjacent assets.

- Providing customers with better means of controlling their use of electricity and utilities with the means of conveying effective price signals to customers to encourage this efficiency;
- Supporting the safe uptake of increasing levels of distributed generation and two-way energy flows in distribution networks[10];
- Improving network reliability through increased automation and flexibility, as well as the ability to rapidly pinpoint fault locations; and
- Improved asset management resulting from increased levels of asset performance information.

Vector is keeping fully abreast of the continuing evolution of smart applications in distribution networks. However, it is noted that:

- Under current regulatory arrangements (in spite of the intent of Section 54Q), it is not clear that a strong business case can be made in the New Zealand regulatory environment for major investment in many of the more attractive features of smart networks, specifically where these are intended to improve network reliability and response to outages.[11] These applications include self-healing networks, widespread use of fault locating devices, etc;
- The "hype" that still surround smart networks and the lack of consensus on technology standards or the manner in which various applications will interface leads us to believe it is more appropriate to at this stage focus on particular applications where Vector sees direct economic value, but to still retain a wait-and-see attitude towards a wider investment in smart technologies; and
- At present, the prime benefit of adopting "smart" applications to Vector is the ability it offers to allow network capacity increases to be deferred, by increasing the utilisation of network assets, or by shifting load demand peaks.[12] However, in general the structure of the New Zealand electricity market does not support a sound business case for these investments. This is partly because the full cost involved with the solutions lie with the distribution utility but it can only realise a portion of the downstream benefits realised. The rest of these benefits accrue to the transmission system provider and to the electricity generators. In theory contractual agreements between the parties could allow a portion of these wider system benefits to be captured by the investing party, but this has not been a common occurrence in the industry to date.

Taking this into account, Vector will continue on its historical evolution path for smart technologies rather than committing to a large-scale adoption and roll-out of any of the "smart network" technologies.

Likely key areas of focus over the coming 12 months will be:

- Development and testing of network load transfer schemes;
- Evaluation and trialling of intelligent equipment rating;
- Analysis of opportunities relating to Volt / VAr (reactive power flow) control;
- Continued evaluation and trialling of premises and network battery storage;
- Implementation of continued field monitoring devices; and
- Analysis of premise energy management opportunities.

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[10] This occurs when customers sell electricity back into the grid.

[11] There is no certainty Vector will be able to recover its investment in applications intended predominantly to improve network reliability or efficiency.

[12] Shifting load peaks means more growth can be accommodated before Vector's network security standards are compromised.

To successfully address future challenges and opportunities electricity distribution businesses need to develop not only their power networks, but also the information and control networks supporting this. Future network applications are likely to lead to continuously increasing network-complexity, necessitating incremental deployment and integration of more sophisticated protection and control equipment, widespread use of sensors and IED and improved information and communication technologies.

Figure 3-2 and Figure 3-3 show the parallels between the power and information infrastructures that utilities have to manage.

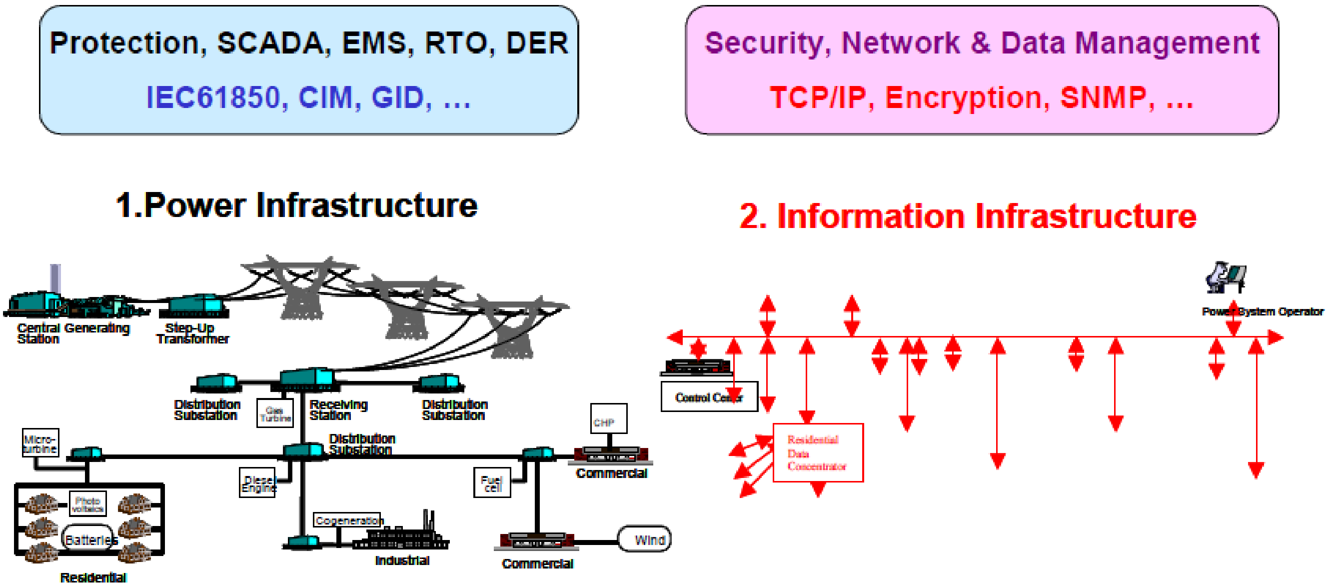

Figure 3-2 : Mirroring the power and information infrastructures at a utility

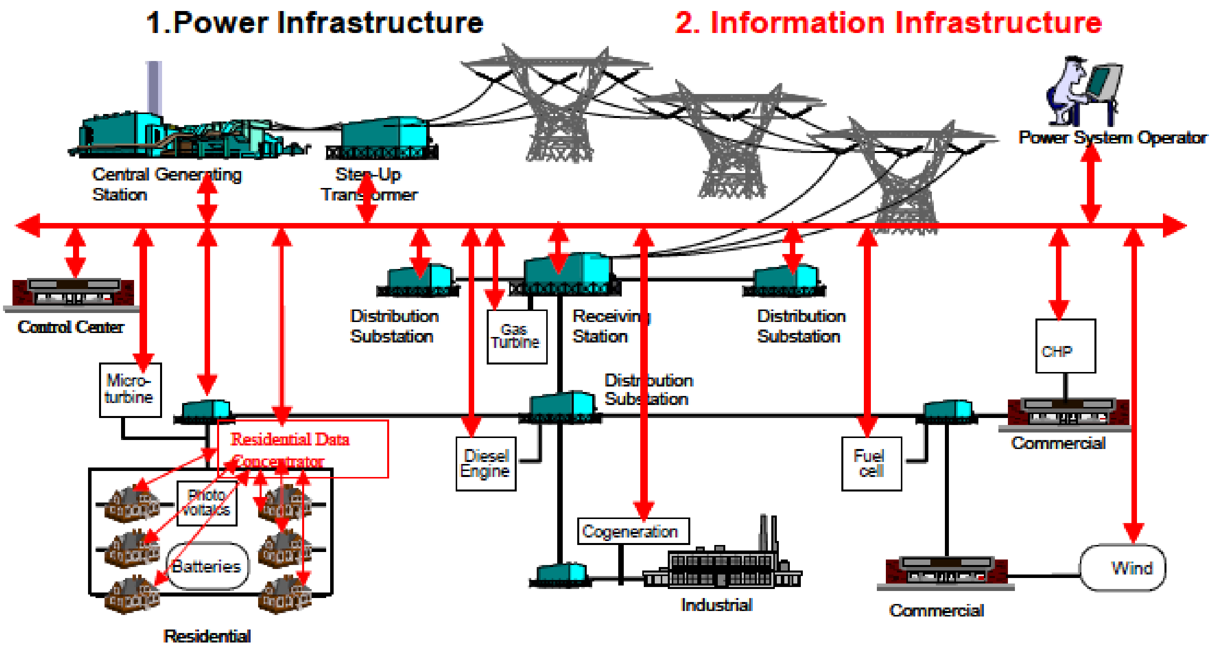

Figure 3-3 : Power system infrastructure with integrated information and communication systems

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Service Levels – Section 4

[Disclosure AMP]

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4. Service Levels

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

Following commissioning of Vector's Asset Lifecycle Information System (ALIS) in 2010 (see Section 7 for details), Vector is now collecting more disaggregated asset performance data. This will be incorporated in an extended set of asset-based performance measures that will form part of future AMP's.

4.1 Consumer Oriented Performance Targets

Vector is committed to providing a high standard of service and a safe, reliable and secure electricity supply. This challenge requires effective and efficient network solutions to enable Vector to meet this goal with the optimum investment. As such, Vector recognises communication is essential in order to improve and understand what services and products our customers like, what they do not like and what they need.

Customers are widely consulted and are able to provide feedback about their expectations through a variety of contact points:

- Call centre representatives;
- Customer service team representatives;
- Operations and project representatives;
- Service provider/contracting representatives;
- Customer service feedback surveys;
- Customer engagement surveys;
- Social media and websites; and
- Dedicated account management for the very large customers.

4.1.1 Customer Expectations

Keeping engaged and aligned with changing customer expectations is fundamental to optimal asset investment and asset management practices.

Individual customers have different and diverse needs and expectations around supply reliability. For some, interruption frequency is a key consideration. For others, the duration of interruption has real consequences. Vector aims at minimising any inconvenience to customers caused by supply interruptions.

In terms of individual requirements, the most significant feedback comes from customer surveys. The results of these surveys provide a basis for setting customer service levels, by drawing out customer preferences around the quality of supply, including the number of and duration of outages, as well as the extent to which customers would be prepared to pay for improved reliability.

Results from the 2006, 2008 and 2012 surveys are summarised in Table 4-1 below. Participants were identified as the "person most responsible for making decisions relating to electricity."

The most recent engagement survey, conducted in January 2012, indicates an improvement in customers' overall perception of Vector in the last few years and continues to validate the following general preferences:

- A substantial majority of customers rate the service provided by Vector as adequate or better;
- Most customers are highly satisfied with the value for money experienced regarding their electricity supply; and
- A substantial majority of customers express no desire to pay an additional amount to receive a service with reduced number of outages or reduced duration of outages.

Customer Survey Date	**Mar-06**	**Jan-08**	**Jan-12**	**Jan-12**
		Residential		**Commercial**
Sample size	**2141**	**1500**	**1497**	**160**
Rate the current service provided by Vector as adequate or better	84%	87%	96%	99%
Satisfied with the value for money regarding their electricity supply	81%	76%	81%	95%
Do not wish to pay an additional amount for shorter duration outages	85%	89%	91%	98%
Do not wish to pay an additional amount for fewer outages	79%	84%	89%	99%
Do not wish to pay an additional amount for NO outages	82%	84%	84%	99%
Rate the frequency of outages experienced to be acceptable	76%	62%	71%	70%
Believe they have experienced less than 3 outages over 12 months	71%	58%	58%	91%
Believe they have experienced less than 6 outages over 12 months	89%	78%	79%	98%
Rate the duration of the last outage experienced to be acceptable	66%	56%	52%	38%
Believe the last outage they experienced was less than 3 hours	55%	53%	59%	46%
Believe the last outage they experienced was more than 3 hours	11%	28%	8%	6%

Table 4-1 : Summary of survey results

The first of these two preferences was expressed by a marginally greater proportion of customers in urban areas or in the Southern region than in rural areas or in the Northern region; conversely, rural or Northern customers were even more reluctant than urban or Southern customers to pay more for fewer or shorter outages.

No clear opinion was apparent from the surveys regarding the acceptability of the number or the duration of outages experienced.

There are some clear insights from the 2012 survey that will be developed into initiatives at a later stage:[1]

[1] The 2012 survey results were only received in January and February 2012 and are still being analysed. A list of possible initiatives based on that feedback will be prepared and the relevant aspects will be addressed in the next Vector AMP.

- Residential customers place more importance on the duration of outages rather than the frequency;
- The most important measure of quality for residential customers is a high quality power supply – free of voltage dips and surges;
- For commercial customers, the duration and outage of power cuts are equally the most important measures of quality; and
- Commercial customers rate Vector's performance more highly than residential customers, but also have higher expectations in terms of quality of supply.

In addition to these surveys, Vector's larger scale engagements tend to focus on councils and community groups. Vector also surveys its industrial and commercial customers as part of an ongoing initiative to provide effective and responsive account management in line with customers' expectations. More broadly, Vector has implemented a company-wide measure of customer satisfaction and experience. Vector also operates an on-line residential customer feedback panel, which is used to guide certain initiatives.

4.1.2 Customer Service

4.1.2.1 Vector's Customer Service Commitment

Vector has a target set for customer service levels. If these are breached, customers are entitled to a compensatory payment (see Section 4.1.7).

The service standards are specific to the customer/retailer relationship model adopted on the various parts of our network, as indicated in Table 4-2 below.

Vector Target					
Customer/Retailer model	**Conveyance (Southern)**			**Interposed (Northern)**	
Service level type	**CBD/ Industrial**	**Urban**	**Rural**	**Urban**	**Rural**
Maximum interruption frequency (per year)	4	4	14	4	14
Maximum interruption duration (hours)	2.5	2.5	3	3	6

Table 4-2 : Vector's service targets

Note that incidents arising as a result of generation and transmission bulk supply failures, or of extreme events (see Section 4.1.6) are excluded from this scheme. While Vector will respond to breaches in terms of the service commitment when they come to its attention, in some cases this may require notification by the affected customer. Figure 4-1 is a map indicating performance against customer service thresholds, at the distribution transformer level, for outage duration based on the 12 months to the end of August 2012. Figure 4-2 shows performance against outage frequency thresholds based on the same period.

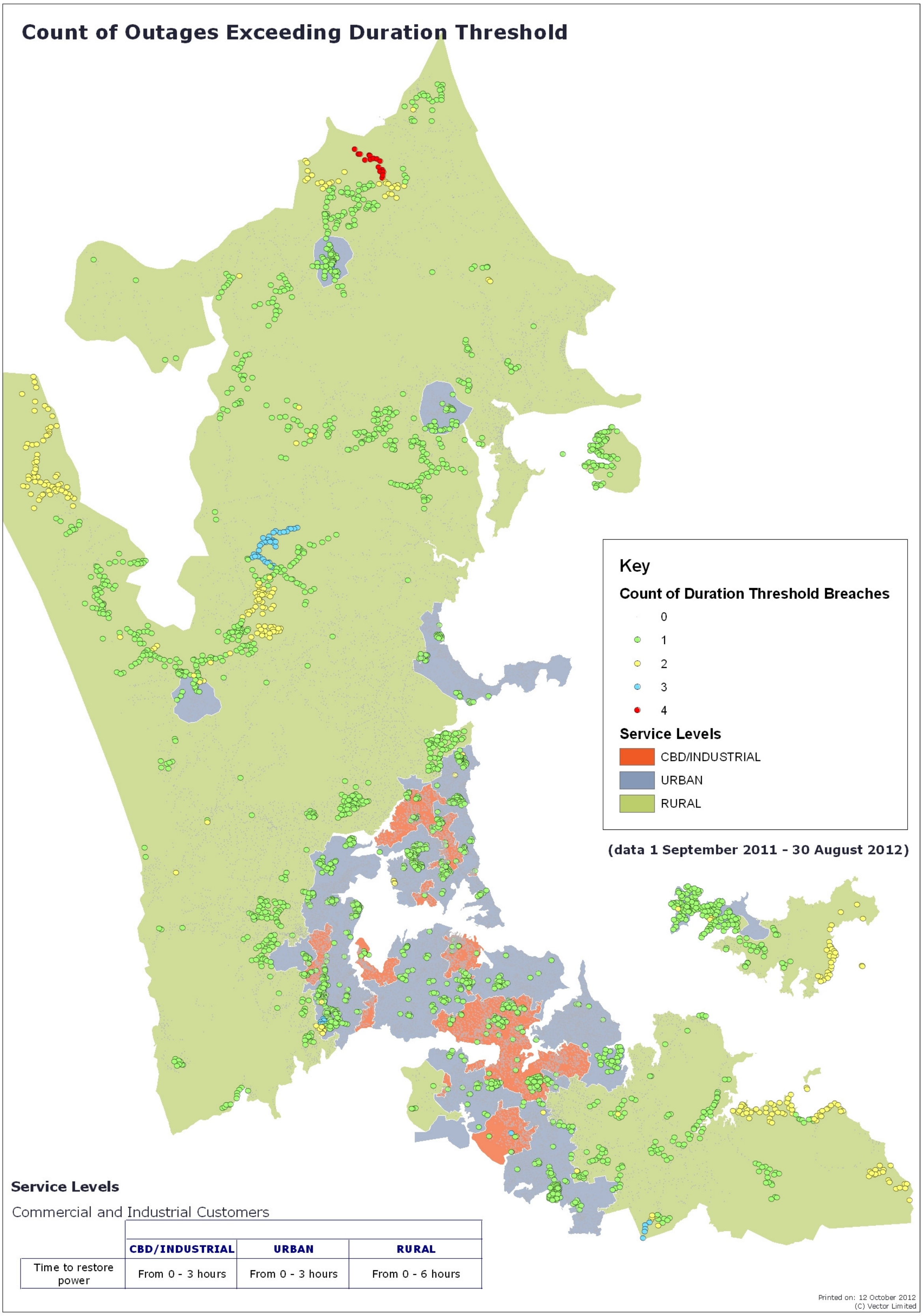

Figure 4-1 : Count of outages exceeding duration threshold

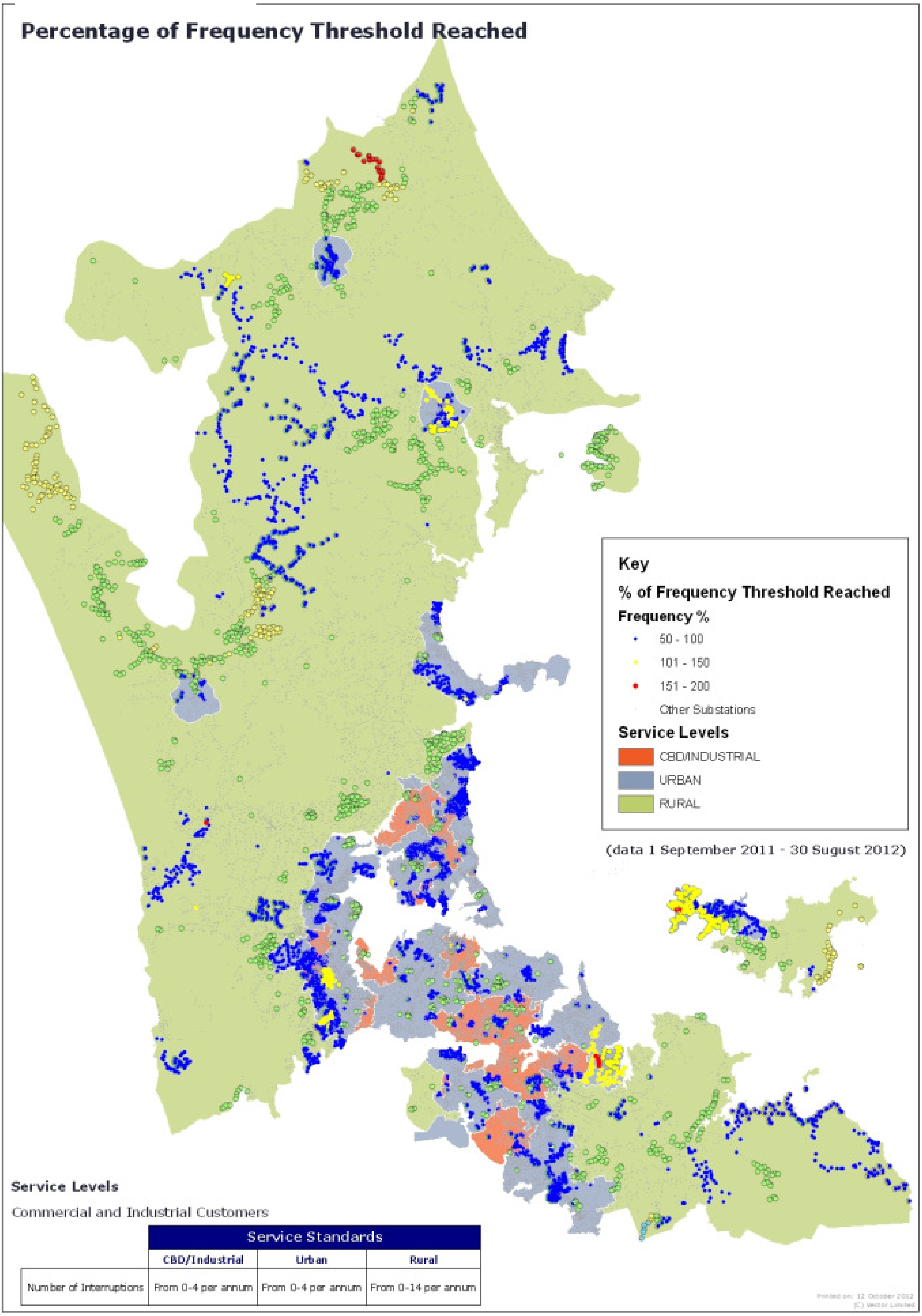

Figure 4-2 : Count of outages expressed as a percentage of frequency threshold

4.1.2.2 Customer Feedback

Vector obtains feedback from customer service monitors, through which we contact a sample of customers who have initiated contact with Vector through our faults management process or customer services team.

The survey is divided into a number of sections:

- Overall satisfaction with Vector;
- Satisfaction with the call centre (Telnet) for key performance indicator (KPI) purposes; and
- Satisfaction with Vector's field service providers' (FSPs') service technician for KPI purposes.

It also includes some branding questions and reliability expectations and occasionally includes a few extra questions about relevant topics we seek the customer's opinion on.

The call centre and FSP service technician performance scores are divided by region and also further divided by FSP if required. Vector uses this data for monthly performance measures for FSP and call centre contracts.

Vector Customer Satisfaction Target

Targets for the field services providers and call centre are 85% whilst the target for the Vector overall score is currently 83%.

In deciding the target level of service, Vector takes into account typical industry practice, level of service over the immediate past few years and compliance with targets set by the Electricity and Gas Complaints Commission (EGCC).

Figure 4-3, Figure 4-4 and Figure 4-5 show the historical overall customer satisfaction trends against target by region, the call centre satisfaction against target by region and the service technician satisfaction against target by region.

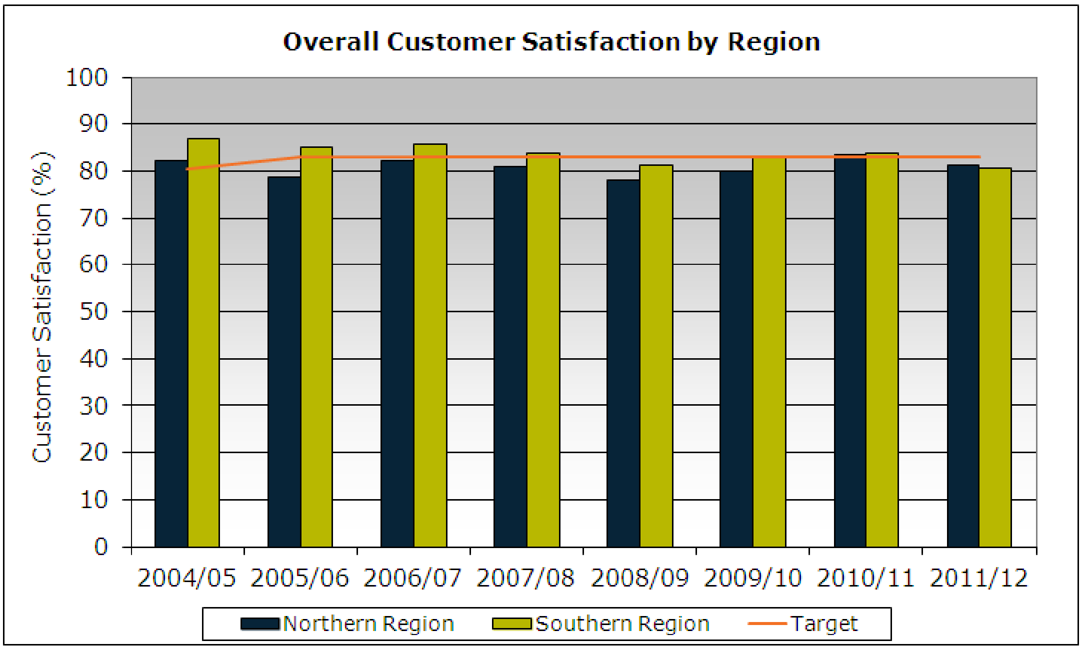

Figure 4-3 : Vector's service targets

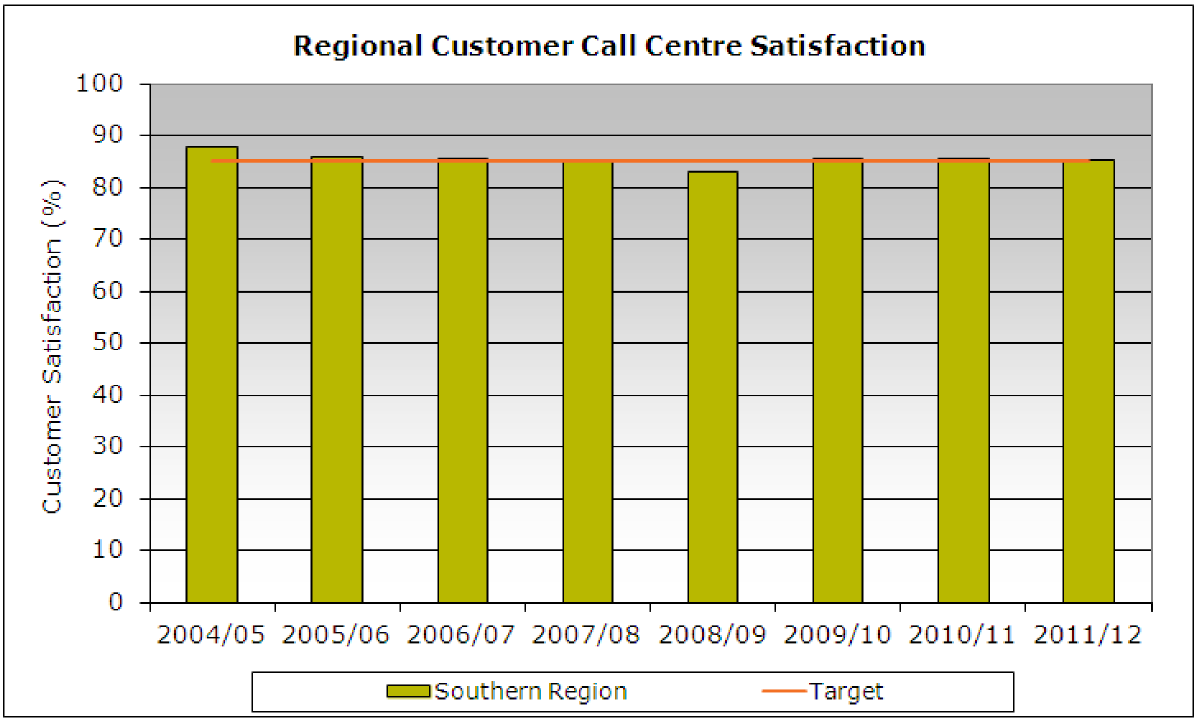

Figure 4-4 : Customer call centre satisfaction

(Only Southern region results are shown as the Northern region's interposed use-of-system agreements with energy retailers means that customers do not have direct contact with Vector's call centre)

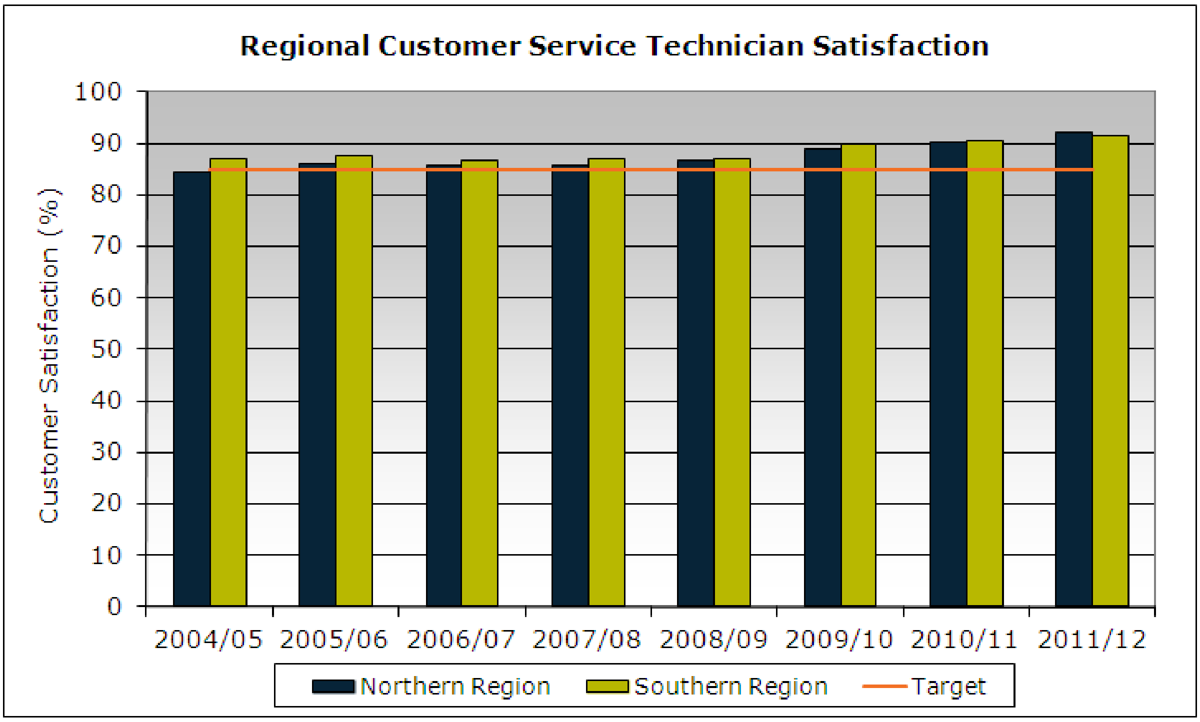

Figure 4-5 : Customer service technician satisfaction

Note that Vector continues with two different business models for customer interaction based on existing use-of-system agreements with energy retailers. In the Southern region customers contact Vector directly for supply interruptions and general enquiries around pricing and service. In the Northern region the customer interaction is managed via the customer's energy retailer. Customers contact Vector directly across all networks with tree enquiries, mapping requests and any connection requests around network assets.

4.1.3 Customer Complaints

4.1.3.1 Overall Approach

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. In these instances, Vector's customer service team is ready to take appropriate actions to manage these concerns, log all reported compliance in relation to the distribution network and coordinate closely with all appropriate areas of the business in resolving complaints and improving the customer experience.

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.

4.1.3.2 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:

- Southern region (and other customers who contact Vector directly):
  - Acknowledgement in two working days; and
  - Resolved in ten working days.
- Northern region (where the complaint comes via a retailer):
  - Response to retailer in five working days.

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

Vector Target

Vector's response time target is to resolve >90% of complaints within the prescribed timeframes.

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.

For 2011/12 1,652 customer complaints were received, of which 1,562 (95%) 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.

4.1.3.3 Customer Complaints – 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 2011/12, 63 (3.8%)[2] complaints went to the EGCC, of which 45 were resolved under Vector's standard resolution process.

The remaining 18 complaints required interaction with the EGCC with the following outcomes:

- 15 were resolved by settlement; and
- Three went to the Complaints Commissioner.

4.1.4 Call Centre Performance

Vector has two main call centre lines managed by Telnet: the 24/7 faults line (0508 VECTOR) and the general enquiries line (09 303-0626) which is available 7am to 6pm, Monday to Friday.

Vector Target

Service level agreements (SLAs) are set as follows for each line based on time to answer a call:

- Faults line:

  80% of calls answered within 20 seconds on 80% of the days of the month.
- General enquiries

  80% of calls answered within 20 seconds on 90% of the days of the month.

The SLAs reflect the fact that the faults line has a highly variable and unpredictable call volume. Telnet is incentivised to achieve these targets through Vector's KPI programme. Figure 4-6 below shows actual response times compared against the targets for both types of enquiries.

[2] This was a higher proportion than last year (1.5%), and may well have resulted from the changes in the scheme rules, in June 2011, which included a requirement to promote the service

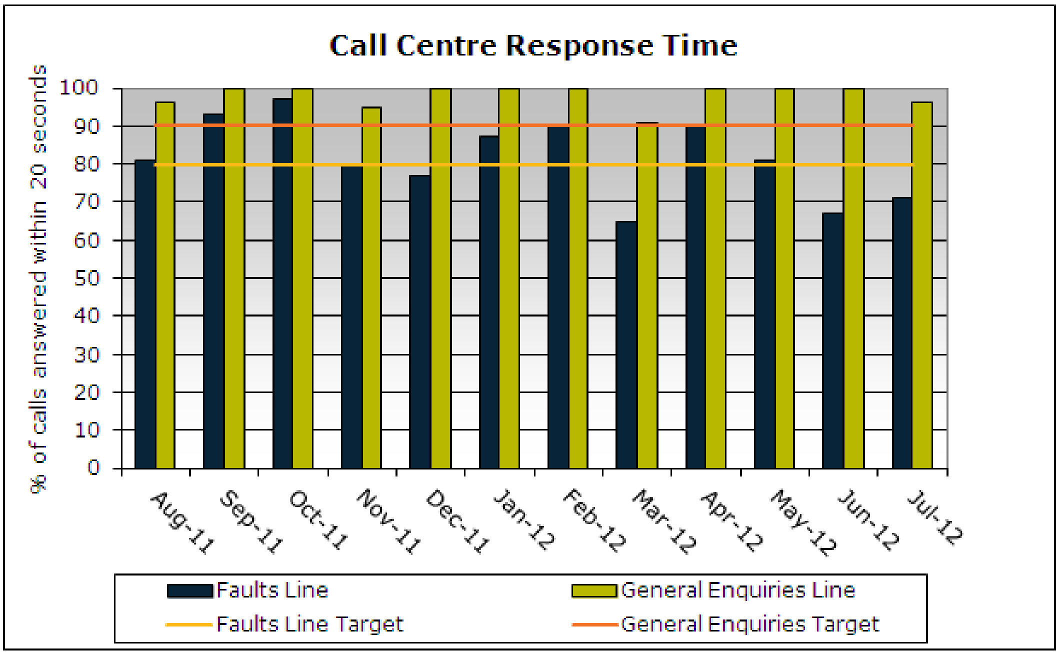

Figure 4-6 : Call centre response time

The call centre response time has shown a similar pattern to last year. Generally response has been on or above target with an increase in supply interruptions during the winter months impacting seasonal performance. The call centre continues to operate an "avalanche" messaging system to improve the speed at which notification of our knowledge of an incident on the network can be conveyed to callers.

Work is continuing to look at various ways in which the communication of supply interruptions to customers can be improved, particularly focussing on the internet connected devices.

4.1.5 Supply Quality Standards

Vector's supply quality objectives are focused on ensuring the required service levels are achieved and maintained in accordance with regulatory requirements. In this context supply quality refers to the magnitude, shape, phase and frequency of the supplied voltage waveform. Vector's supply quality targets are highlighted in Table 4-3.

Vector Target

Supply Quality Parameter	**Standard**
Voltage at point of supply (single phase 230V)	± 6% from nominal
Voltage at point of supply (three phase 400V)	± 6% from nominal
Frequency of supply (50 Hz)	± 1.5% from nominal
Total harmonic distortion (of supply voltage) NZECP 36	≤ 5%

Table 4-3 : Supply quality targets

Electricity distribution networks remain subject to supply quality disturbances, the most typically observed phenomena being momentary voltage sags.

The source of these disturbances can be highly localised, affecting few customers, or could be generated from distant locations that permeate throughout the supply network. It is impossible to guarantee a perfect power supply free from voltage sags, or other quality of supply issues such as voltage surges or harmonic distortion.

The number of disturbances experienced by any individual customer depends largely on the geographic location of their power supply network. Vector's CBD supply area is served by underground cables and is less exposed to disturbances. Rural or outlying suburban areas typically served by long overhead lines are more susceptible to environmental factors and third party interruptions and are subject to a greater number of disturbances.

Vector's focus is on understanding the cause and effects and dealing with these on a case-by-case basis. Long-term harmonic distortion trends are also monitored at various positions on the network to provide early warning should distortion levels approach maximum acceptable levels. In some areas counter measures have been implemented, such as the installation of neutral earthing resistors (NERs) and enhanced protection schemes.

4.1.5.1 Momentary Voltage Sags

Momentary sag is defined as any recorded event measured at the 11kV zone substation bus which falls below 80% of nominal voltage, regardless of the event's duration. These momentary sags are typically associated with faults on and around the Vector network along with transmitted disturbances from the national grid.

Vector has established supply quality service standards, as shown in Table 4-4, that reflect the different experience and expectation of supply quality of different customer groups, and recognises that business customers have a higher reliance on disturbance-free supply.

Vector Target

Location	Target (sags per year below 80% of nominal voltage)
CBD	≤ 20
Industrial	≤ 20
Urban	≤ 30
Rural	≤ 40

Table 4-4 : Targets for momentary voltage sags

Vector has been proactively monitoring momentary voltage sags at the zone substation 11kV bus level since 2004, and now includes 55 power quality monitors (PQMs) located in key zone substations covering Auckland CBD, industrial, urban and rural locations (plus four mobile units).

Table 4-5 provides a summary of compliance to the published service standards disaggregated by location.

Zone Sub	Location	2006	2007	2008	2009	2010	2011	Target
Bairds	Urban	39.0	25.0	27.0	9.0	9.0	13.0	≤30
Carbine	Industrial	18.0	7.0	10.0	6.0	7.0	5.0	≤20
Howick	Urban	22.0	12.0	20.0	2.0	5.0	6.0	≤30
Manurewa	Urban	23.0	33.0	22.0	9.0	20.0	20.0	≤30
McNab	Industrial	14.0	5.0	-	16.0	11.0	11.0	≤20
Otara	Rural	25.0	17.0	17.0	8.0	17.0	7.0	≤40
Quay	CBD	26.0	11.0	29.0	3.0	7.0	8.0	≤40
Rockfield	Industrial	13.0	4.0	12.0	5.0	9.0	4.0	≤20
Rosebank	Industrial	17.0	14.0	13.0	12.0	10.0	7.0	≤20
St John	Urban	0.0	0.0	0.0	0.0	10.0	10.0	≤30
Takanini	Rural	26.0	28.0	23.0	31.0	27.0	30.0	≤40
Victoria	CBD	16.0	9.0	6.0	-	2.0	7.0	≤40
Wiri	Industrial	15.0	13.0	18.0	6.0	4.0	5.0	≤20
East Coast Rd	Urban	-	-	-	4.0	14.0	11.0	≤30
Greenmount	Industrial	-	-	-	4.0	6.0	12.0	≤20
Hillcrest	Urban	-	-	-	18.0	30.0	10.0	≤30
McKinnon	Commercial	-	-	-	7.0	9.0	11.0	≤40
Orakei	Urban	-	-	-	4.0	7.0	10.0	≤30
Oratia	Rural	-	-	-	32.0	30.0	22.0	≤40
Red Beach	Urban	-	-	-	12.0	30.0	14.0	≤30
Remuera	Urban	-	-	-	16.0	17.0	17.0	≤30
Westfield	Industrial	-	-	-	0.0	6.0	10.0	≤20
Atkinson	Urban	-	-	-	-	-	25.0	≤30
Avondale	Industrial	-	-	-	-	-	13.0	≤20
Helensville	Rural	-	-	-	-	-	32.0	≤40
Kingsland	Urban	-	-	-	-	-	1.0	≤30

Table 4-5 : Momentary voltage sags per year at monitored locations

Typical responses to non-compliance to service standards include targeted maintenance (such as vegetation control), network inspections (such as thermal imaging to detect hot spots and weak links), asset renewal/replacement, network re-configuration and protection upgrades (including the installation of additional monitoring and/or protection equipment.

4.1.5.2 Harmonic Distortion

The PQMs also track total harmonic distortion (THD) measured at the 11kV zone substation bus. Excessive THD can adversely affect the expected lifetime of some of Vector's network assets (such as transformers) as well as customers' plant and equipment and may cause sensitive electronic or IT equipment to fail.

The causes of THD may be specific (in the case of an electrically "noisy" or non-linear large industrial load) or dispersed (as in the increasingly widespread use of equipment with electronic power supplies and fluorescent lamps). Table 4-6 shows mean THD calculated as a percentage value on an hourly basis.

Zone Sub	2006	2007	2008	2009	2010	2011	Target
Bairds	1.6	1.9	1.3	1.2	1.0	1.0	≤5.0
Carbine	3.6	3.5	2.2	2.1	2.2	2.2	≤5.0
Howick	2.6	2.9	2.3	2.2	2.1	1.9	≤5.0
Manurewa	3.4	3.7	2.6	2.5	2.1	1.9	≤5.0
McNab	1.1	1.6	0.9	0.8	0.8	0.7	≤5.0
Otara	1.4	2.2	1.4	1.3	1.1	1.0	≤5.0
Quay	1.6	1.6	0.7	1.0	0.9	0.8	≤5.0
Rockfield	3.1	3.2	2.9	2.7	2.5	2.2	≤5.0
Rosebank	3.5	3.3	2.0	2.0	2.0	1.8	≤5.0
Takanini	2.6	2.7	1.7	1.6	1.6	1.5	≤5.0
Victoria	1.6	1.4	0.7	-	0.6	0.6	≤5.0
Wiri	2.2	2.1	1.2	1.6	1.9	2.2	≤5.0
East Coast Rd	-	-	2.5	2.4	2.3	2.0	≤5.0
Hillcrest	-	-	2.1	2.0	1.8	1.6	≤5.0
McKinnon	-	-	1.7	1.7	1.6	1.4	≤5.0
Oratia	-	-	1.4	1.5	1.4	1.4	≤5.0
Greenmount	-	-	-	1.5	1.4	1.1	≤5.0
Orakei	-	-	-	2.0	1.9	1.9	≤5.0
Red Beach	-	-	-	2.2	2.0	1.9	≤5.0
Remuera	-	-	-	2.0	1.8	1.7	≤5.0
St John	-	-	-	1.4	1.1	1.1	≤5.0
Westfield	-	-	-	0.9	0.8	0.8	≤5.0
Atkinson	-	-	-	-	-	1.9	≤5.0
Avondale	-	-	-	-	-	2.2	≤5.0
Helensville	-	-	-	-	-	2.3	≤5.0
Kingsland	-	-	-	-	-	1.9	≤5.0
Mangere Central	-	-	-	-	-	1.8	≤5.0
Newton	-	-	-	-	-	1.3	≤5.0

Table 4-6 : Mean THD calculated as a percentage value on an hourly basis

THD for most sites have remained fairly constant year on year with no significant changes.

Vector's objective is to have PQM coverage at all zone substations over the next nine years, in order to gain a comprehensive understanding of the causes and impacts of power quality (PQ) issues. The necessary measuring devices are being progressively installed over the planning period and all new zone substations will be equipped with PQ meters.

4.1.6 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 indicated in Table 4-7.

Vector Target

Disclosure Year	11/12	12/13	13/14	14/15	15/16	+5 yrs
SAIDI (Minutes)	114	114	114	114	91	91
SAIFI (Interruptions)	1.66	1.66	1.66	1.66	1.10	1.10

Table 4-7 : Reliability targets

The step increases in SAIDI and SAIFI thresholds from 2010/2011 reflect the reset regulatory regime from 1 April 2010. Figure 4-7 shows the comparison of SAIDI for the current regulatory year to date against the regulatory target expressed as a straight line.

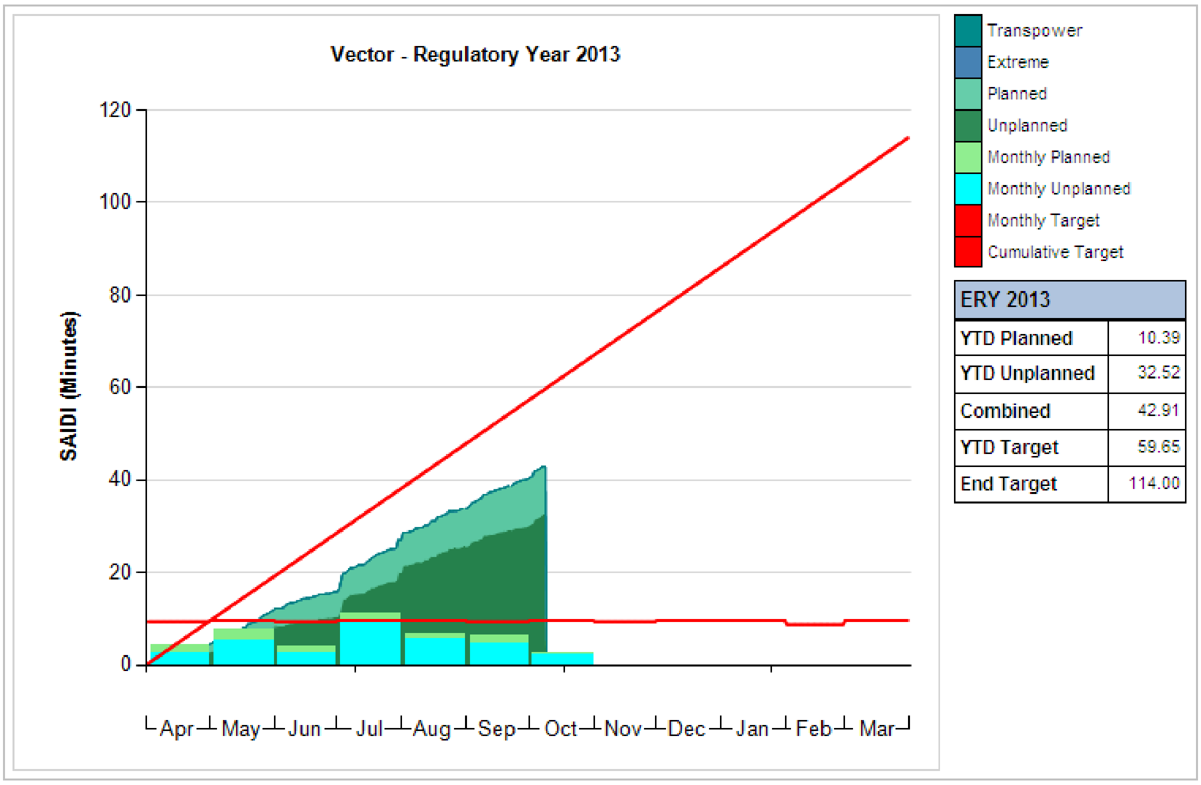

Figure 4-7 : SAIDI during regulatory year 2011/12 compared to regulatory target

In the cumulative graph, the upper light green area represents SAIDI resulting from planned shutdowns. Planned SAIDI has remained similar in the last two years. The lower dark green area shows SAIDI arising from unplanned interruptions. The volatile nature of SAIDI is evident from the month-to-month fluctuations in the monthly bar chart.

4.1.6.1 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 4-8 shows Vector's SAIDI since the inception of information disclosure 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.

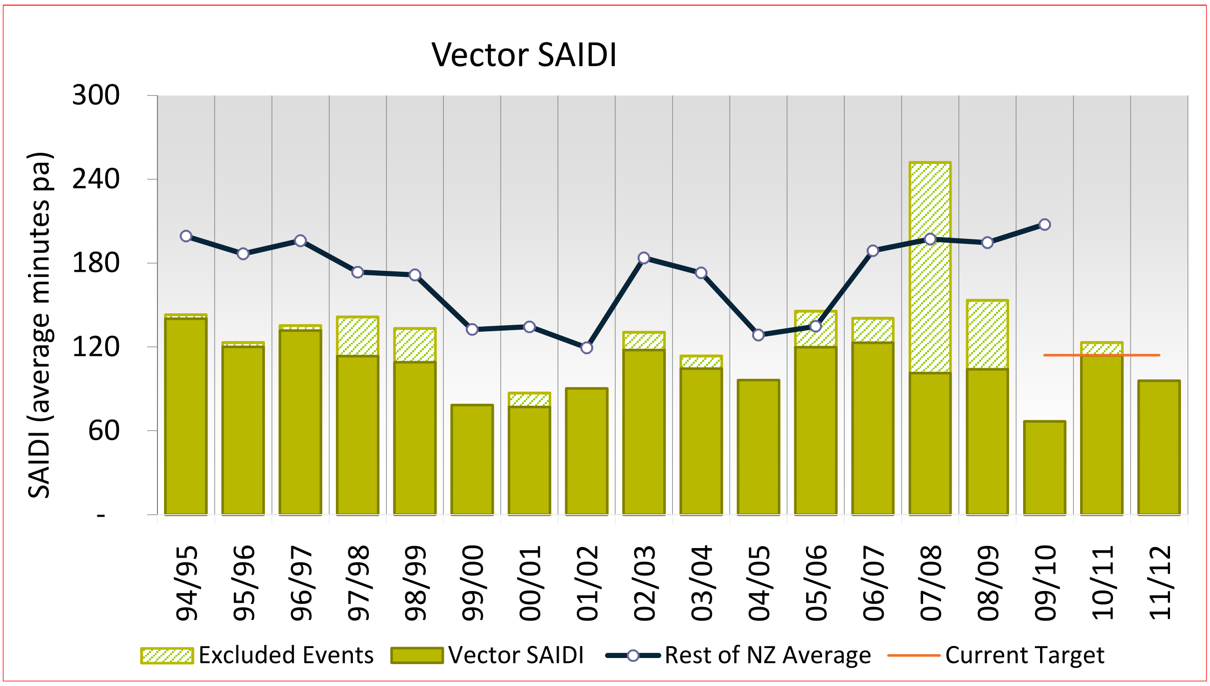

Figure 4-8 : Vector SAIDI

Vector's SAIDI compares well against other New Zealand electricity distribution businesses (EDBs). Performance highs and lows are closely mirrored by the rest of New Zealand, indicating underlying country-wide factors, such as weather events.

The exceptional performance in 2009/10 was attributed to a combination of settled weather, the inherent variability of SAIDI, enhanced vegetation control and the benefits of judicious investment in automated protection devices in recent years, the impact of which may have been somewhat obscured in the prior two to three years by events associated with poor weather. The 2010/11 regulatory year saw a return of more typical weather patterns and SAIDI close to the long run average.

Figure 4-9 below shows each region's historical contribution to Vector's normalised SAIDI ie. excluding extreme events.

Vector's historic SAIFI performance is presented in Figure 4-10.

In the current regulatory year, 2011/12, both SAIDI and SAIFI are trending towards a lower outturn than in 2010/11.

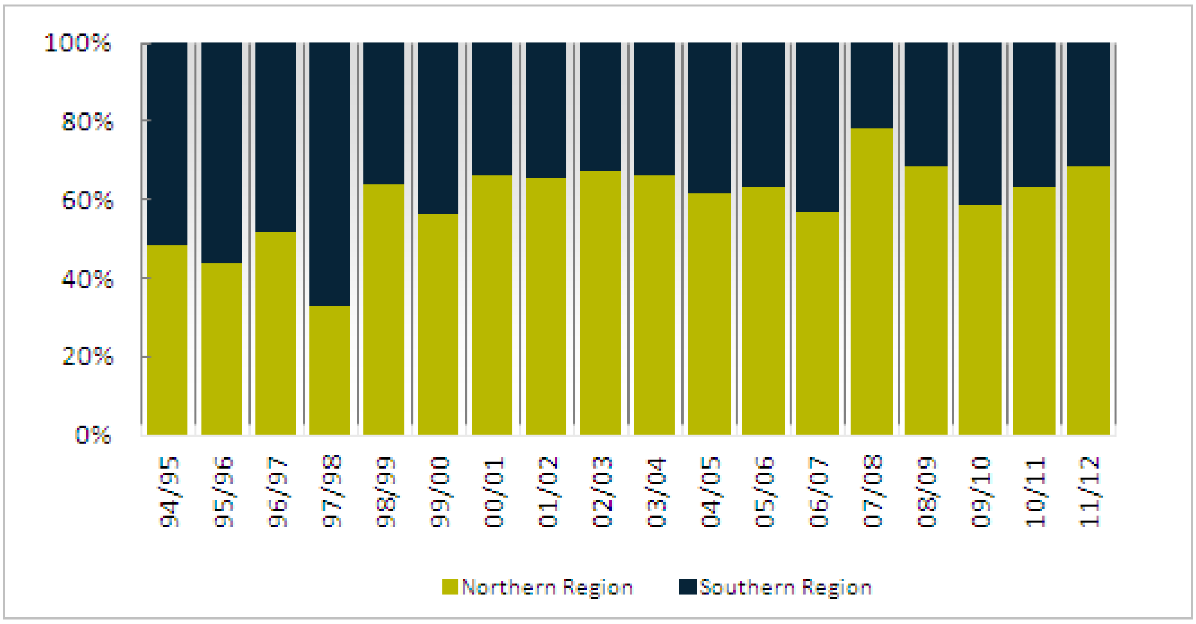

Figure 4-9 : Normalised SAIDI contribution by region

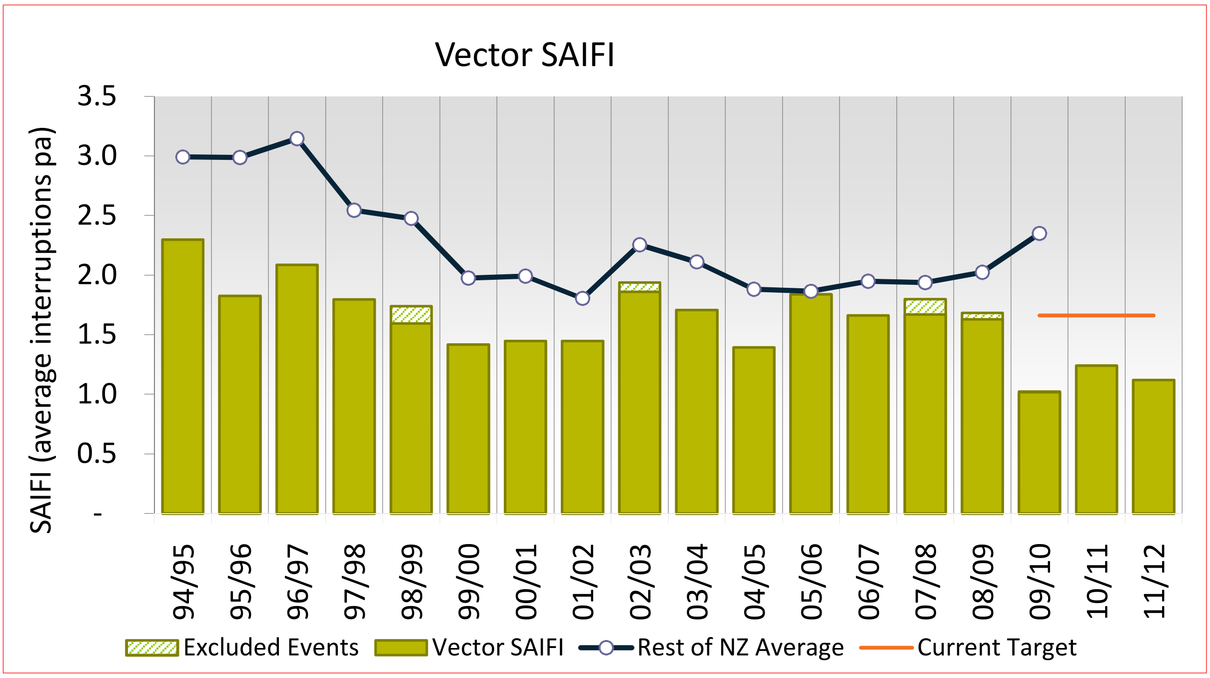

Figure 4-10 : Vector SAIFI

4.1.6.2 Causes of Interruptions to Supply

There are a number 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 4-11 shows how the impact of major causes of network interruptions has changed over the last 15 years. Each of these causes is considered in depth below:

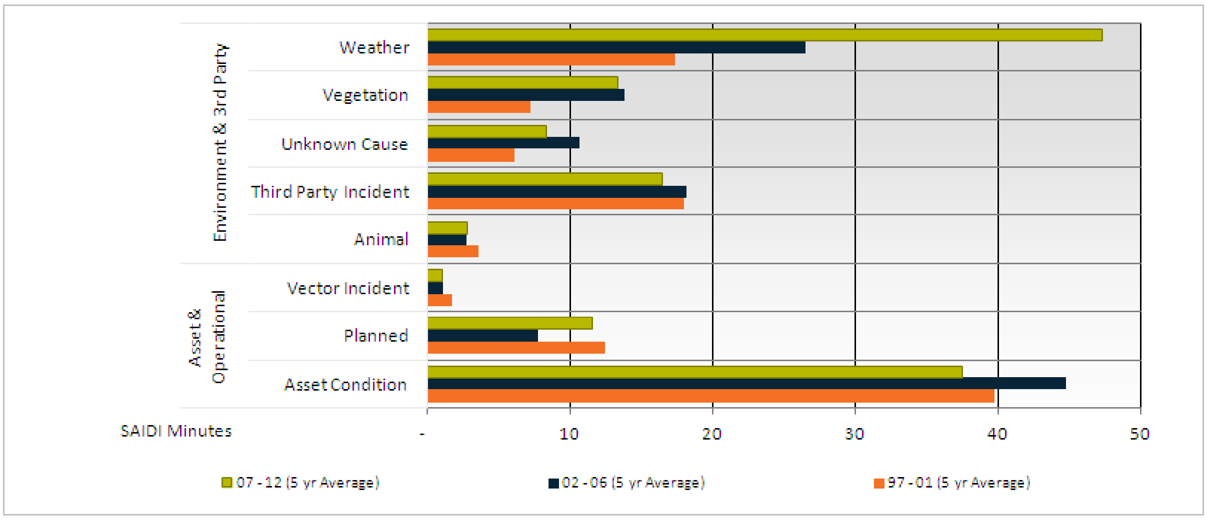

Figure 4-11 : Impact of major causes of network interruptions

- **Weather:** This includes events caused by lightning and wind. The weather represents the single most unpredictable and significant cause of interruptions to the Vector network, with a dramatic increase in events related to extreme weather over recent years (2009/10 being the exception);
- **Vegetation:** This includes faults resulting from overhanging branches and trees caught in power lines. Vector has dedicated a substantial amount of maintenance effort into its cyclic tree cutting and vegetation control programmes. The Electricity (Hazards from Trees) Regulations 2003 have clarified some of the uncertainty around clearance responsibilities and have forced much tighter management and increased education and public awareness. Vector is, however, concerned about some aspects of the regulations which we consider to be unworkable. Vector is actively participating in an industry working group to review the regulations;
- **Third party incidents:** These are caused by external interference, including cars colliding with power poles, vandalism, underground assets dug up by other authorities or trees cut down onto power lines by members of the public. Controls that continue to be put in place include additional network protection devices, increased public education, better coordination around locating and digging near underground assets and relocation or under-grounding of prone or repeatedly-affected assets;
- **Animals:** In most cases sustained interruptions are due to birds or possums. Possums climb along power lines whereas birds will often perch on overhead assets, creating a short circuit when bridging live parts. Many initiatives have contributed to a gradually reducing risk of animal failures, such as vegetation clearance, possum guards on new pole installations in wooded areas, replacement of air-break switches (ABSs) with fully enclosed gas insulated switches and replacement of pin insulators by post insulators with additional clearance;
- **Asset condition:** Although individually extremely reliable, the high quantity of assets installed across the network means that despite all practical efforts there will be some failures related to asset condition. In terms of contributing to the improvements in interruption time, assets with excessive failure rates are targeted for maintenance and renewal programmes, thermal and ultraviolet surveying continues to detect hot and potential breakdown spots, increased network protection devices limit the impact of interruptions and new non-invasive condition based detection techniques help direct risk based maintenance decisions. While underground assets are very reliable, being buried away from the weather and

external influences such as trees or cars, overhead asset condition-related failures can be precipitated by weather and third party causes; and

- **Planned interruptions:** The five-year average planned SAIDI is low by historical standards, mainly due to live-line "glove and barrier" work practices and the increased use of back-up generation; however in the past three years this trend has reversed, partly due to the implementation of safety-driven operating restrictions on certain equipment types, which necessitated expanded isolation areas. Vector has a programme in place to upgrade the affected equipment.

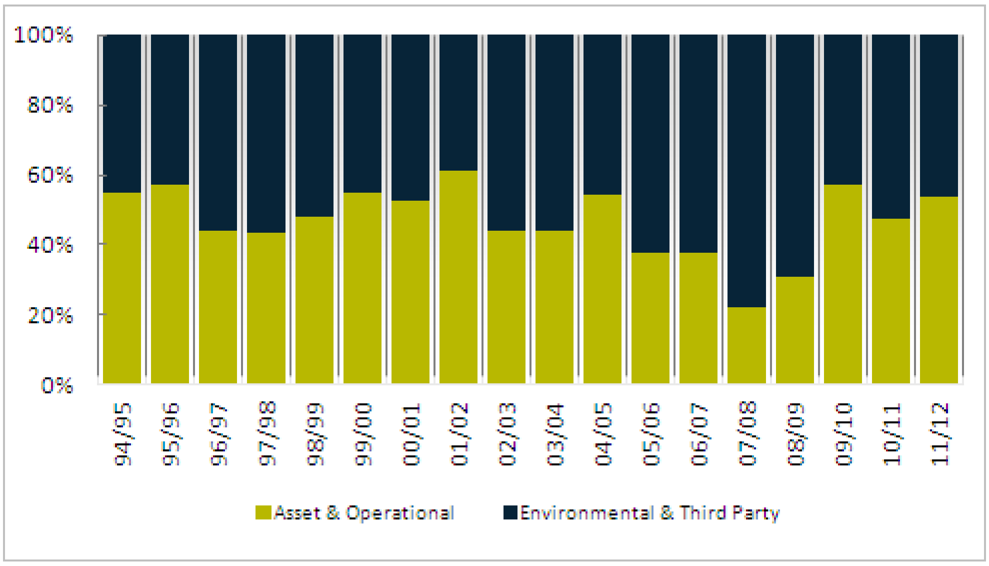

Figure 4-12 : Proportion of SAIDI associated with environmental and third party incidents

4.1.6.3 Factors outside Vector's Control

The proportion of SAIDI associated with environmental and third party incidents is illustrated in Figure 4-12. Overall, around half of all faults currently stem from environmental and external factors such as extreme weather, lightning, and third party interference (vehicular collisions with power poles, dig-ins, vandalism, un-escorted high load contacting overhead lines).

These are random events and largely beyond Vector's control. Certain operational and network design measures are taken to mitigate the risk. A sustained reduction in failure rate for these fault types would require significant scale penetration of any technical solution, which generally are well down the viability scale in terms of cost/benefit.

Note that while the settled weather of 2009/10 resulted in an increased proportion of asset and operational outages, this is a reflection of the reduced impact of environmental damage, rather than a higher number of other types of faults.

4.1.6.4 Mitigation of Interruptions to Supply

Measures to prevent faults and mitigate their impact include the application of appropriate and effective preventive and corrective maintenance strategies, together with proactive asset replacement programmes. Generally, improved maintenance and asset replacement effort will, over time, result in decreasing numbers of failures.

Approximately half of all faults are considered to be preventable. For example, equipment failure, human error and vegetation contact (other than in storms). The cost/benefit relationship of increased maintenance and asset replacement effort to reduce controllable fault frequency is, however, highly non-linear, with diminishing returns becoming apparent.

4.1.6.5 Reducing Restoration Time

Restoration and repair time is a function of many factors including time to locate the fault, network configuration, switching time, real-time information feeding into the control room, number, skill set and location of fault response field staff and availability of additional resource if the complexity of fault dictates.

Dependent on fault location and time of day travel time can be a significant factor. For car versus pole incidents involving fatalities, the police now often restrict access to the site for several hours while they complete their crash investigation, which significantly delays the repair and restoration effort.

Vector works with its contracting partners to ensure there is a constant focus on improving fault response times by placing the right staff with the right skill sets in the right places and focussing the response on restoring as many customers as possible, as quickly as possible.

Fault finding time has been reduced through the use of carefully placed automation devices, fault indicators and the use of sophisticated protection relays.

Switching time for fault isolation and supply restoration could be reduced with additional switching staff or control room-administered distributed automation devices, or the deployment of intelligent field switching devices. Should a sufficient incentive exist in future to improve network reliability[3], this will be further pursued.

Finally, repair time is very much a function of fault complexity and available field resources. There is a trade off between a temporary repair with by-pass options such as local generation, or complete repair and restoration. Situations are assessed on a case-by-case basis to determine the most appropriate response.

4.1.6.6 Reducing the Number of Customers Affected by an Outage

To reduce the impact of a network failure, one solution is essentially to break up the network into smaller sections, ie. with fewer customers between control devices.

This can be achieved by building additional zone substations between existing substations to shorten the feeders, adding additional feeders to reduce the number of customers per feeder or installing additional control devices into feeders to reduce the number of customers affected by any given failure. Automation of these control devices with local intelligence (so-called self-healing network) will also speed up restoration time.

Network automation projects already implemented over the last three years at a cost of around $10 million are saving over 30 SAIDI minutes per annum on an on-going basis, as described below.

4.1.6.7 SAIDI Avoided by Automated Protection Devices

Over the past years Vector has invested heavily in automated protection devices. Between 2006 and 2008, 202 automation devices were commissioned for a total expenditure of $7.85 million. Of the units installed:

- 70 sites operate as functional reclosers;
- 38 sites operate as functional sectionalisers; and

[3] Current quality regulation does not support investments in improving network reliability.

- 94 sites operate as intelligent control points, mostly interconnecting neighbouring feeders.

These units augment the 50 pre-existing reclosers on the network. All sites were selected on the basis of greatest SAIDI benefit per dollar cost.

Vector monitors the performance of these devices in terms of operations and SAIDI which would have been incurred if the device were not installed. The plot in Figure 4-13 is updated daily and available to all Vector staff on the company intranet.

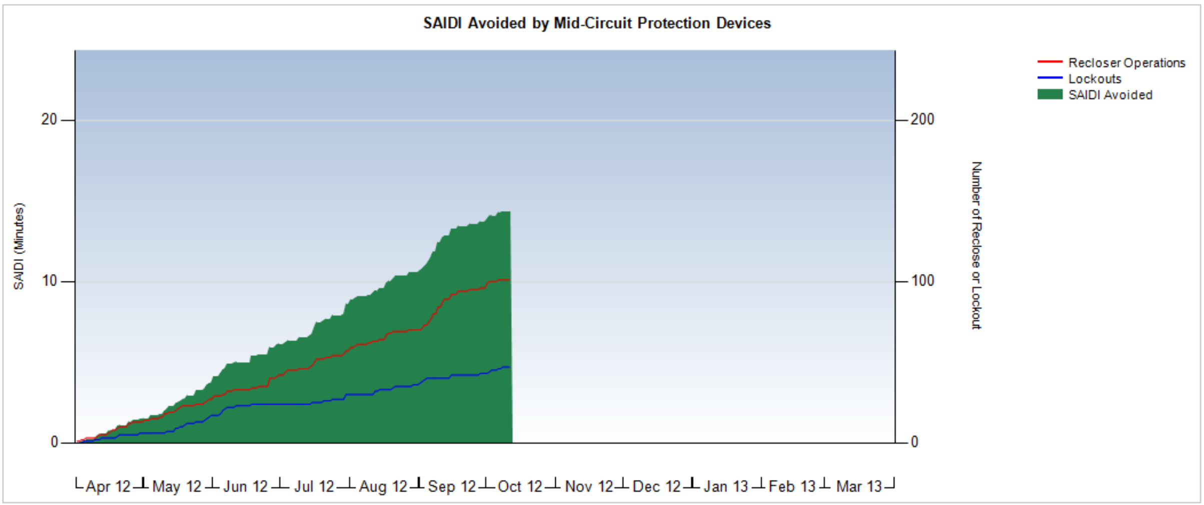

Figure 4-13 : SAIDI avoided by mid-circuit protection devices

(Lockouts are operations where a fault could not be cleared by the operation of the recloser)

Figure 4-14 shows the historical SAIDI benefits derived over the course of the programme.

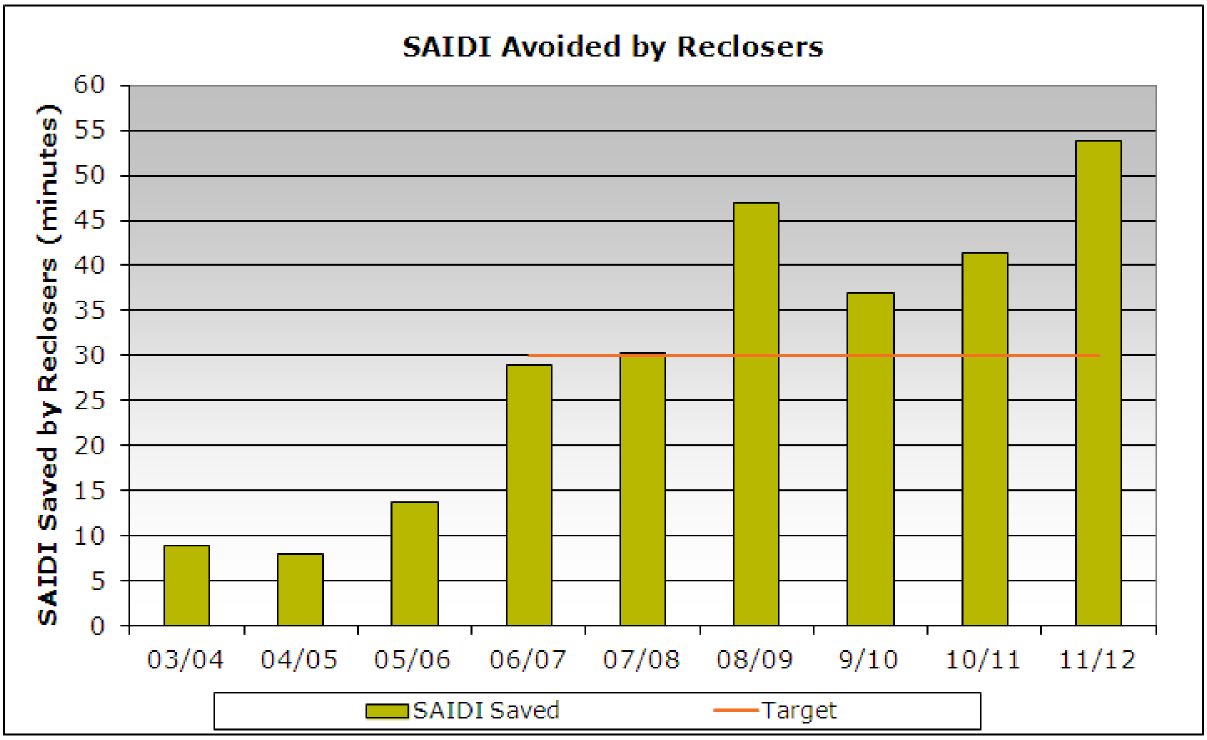

Figure 4-14 : SAIDI avoided by reclosers

4.1.7 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.

4.1.7.1 Vector Promise and Charter Payments

If Vector fails to meet these service commitment targets, compensation schemes exist to acknowledge the inconvenience to the customer. As per the service targets as summarised in Table 4-2, these compensation schemes are specific to the regional customer/retailer models.

The Southern region scheme is known as the "Vector Promise", under which a payment of $50 for residential customers and $200 for commercial customers (excluding large commercial customers) may be claimed by the customer on Vector's failure to achieve target.

The Northern region scheme is the "Charter Payment" system, under which Vector makes a payment of $40 for residential customers and $100 for commercial customers to the retailer.

Vector takes this commitment seriously and compensation payments of approximately $2 million have been paid in the last eight years as shown in Figure 4-15 below.

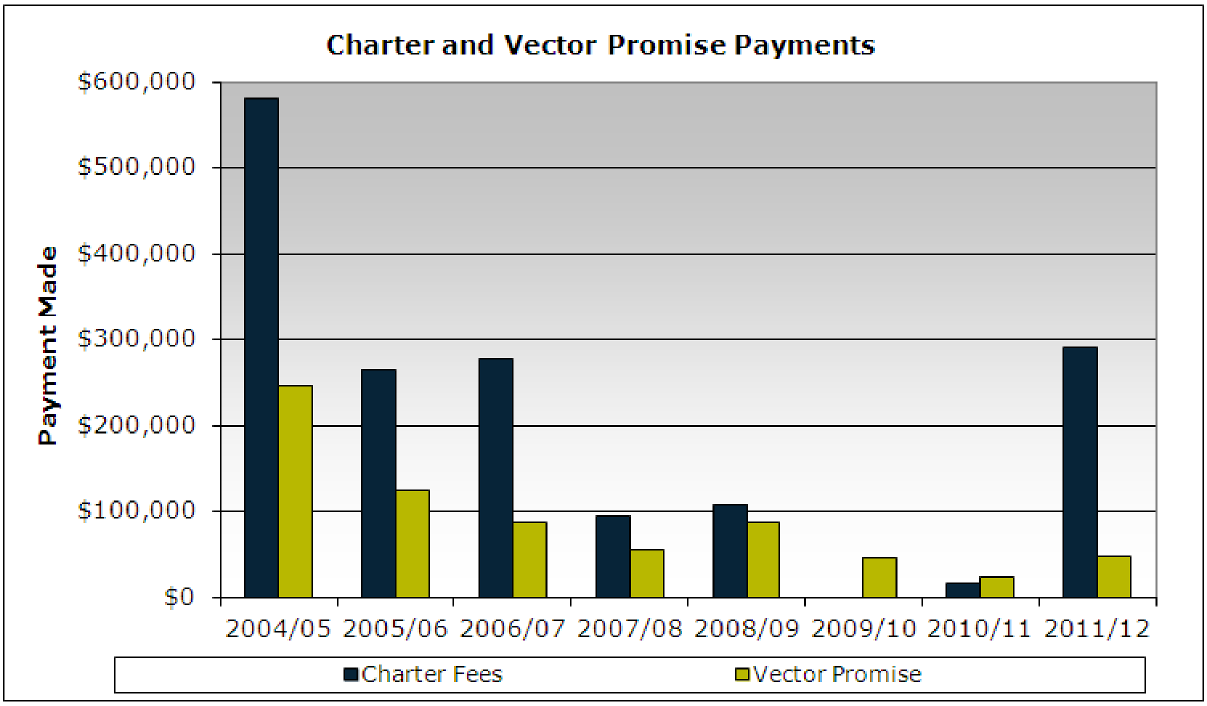

Figure 4-15 : Historic Service Commitment Compensation Payments

4.1.7.2 Enhancing our Performance for the Future

Supply reliability performance improvement programmes continue to address the following:

- Reducing the number of interruptions experienced by customers;
- Reducing the time customers are without electricity (including through expanding the use of remote monitoring and control to allow faster response and restoration times);
- Improving delivered supply quality (including introducing new technologies to reduce the impact of momentary voltage sags);
- Upgrading assets in the worst performing areas;
- Targeting major cause contributors to reduce the frequency of customer interruptions;
- Minimising the use of planned shutdowns by continuing to work live line where possible, and increase the use of generators to avoid outages; and
- Improvements in network and asset management information and related IT systems.

4.1.8 Process for Recording Network Outage Information

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, 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 Gentrack 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 4-16 shows the process for recording outage information and the process for auditing the quality of the recorded data.

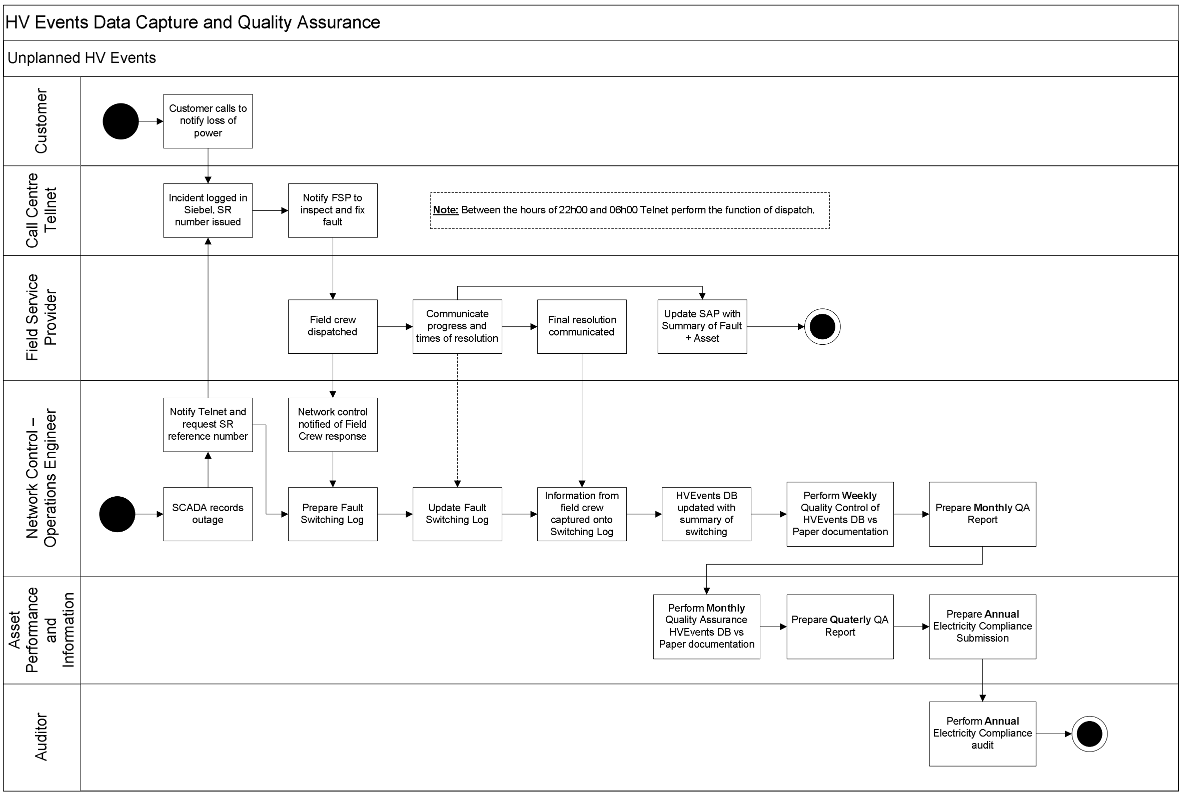

Figure 4-16 : Process for capture and QA of outage information

4.2 Network Performance

4.2.1 Failure Rate

Asset failure (or fault) rate is a direct measure of the number of recordable events per system length, and provides a tool for understanding trends and anomalies in underlying network performance, and is defined as:

> *"The failure rate per 100 km of network length associated with MV distribution and sub-transmission faults."*

The failure rate in 1997/98 was just over 12.5 faults per 100km, increasing to 18.5 faults per 100km for the 2008/09 year. To counter further increases various initiatives have been launched, including cable upgrades and a coordinated "Dig Safe" programme with other utilities and local authorities. It should be noted that the performance in the period 2005 to 2009 were significantly influenced by extreme weather events.

The last two years' solid performance reflects a combination of the period's benign weather and Vector's initiatives taking effect.

Figure 4-17 below shows the Vector network equipment failure rate from 1994/95 through to 2011/12. The figures before the merger of UnitedNetworks and Vector (1994/95 to 2002/03) were the combined results of UnitedNetworks and Mercury Energy[4]/Vector.

[4] Pre-sale of Vector's retail business and the brand name Mercury Energy.

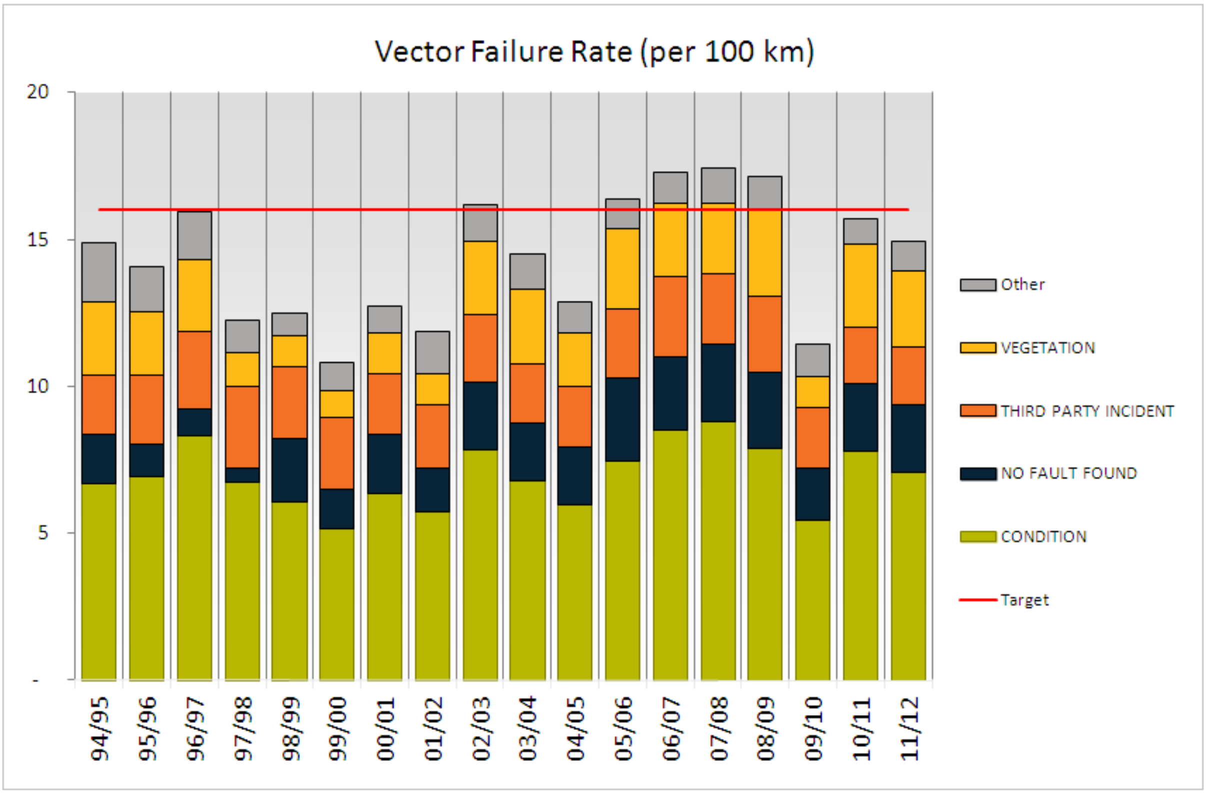

Figure 4-17 : Vector equipment failure rate

Vector has investigated its line failure rate, which appears to lie at the higher end of the New Zealand average. Beyond a few obvious contributing factors (such as weather), to date no single compelling cause could be identified. The statistic appears counter-intuitive to Vector's overall reliability performance, which is significantly better than the New Zealand average.

Underlying this anomaly could be non-technical factors such as measurement and reporting accuracy, or the measurement methodology. Work continues to determine whether there are technical root causes for the fault rate and, should this prove to be the case, a strategy will be developed to address any underlying asset performance issues.

Vector's Network failure rate target is given in Table 4-8.

Vector Target

Disclosure Year	12/13	13/14	14/15	15/16	16/17	+ 5 Years
Failure rate (per 100 km)	16	16	16	16	16	16

Table 4-8 : Target for limit of network failure rates

It should be noted that not all asset failures lead to supply interruptions. Asset failure rate provides a measurement of how the network performs. Reliability indices such as SAIDI and SAIFI, on the other hand, provide an indication of how often a customer loses supply and how long would it take to restore supply when an interruption occurs.

4.2.1.1 Causes of Network Failures

In general, the reasons for network failures are broadly similar to the reasons for interruptions to customers' supply, as illustrated in Figure 4-18.

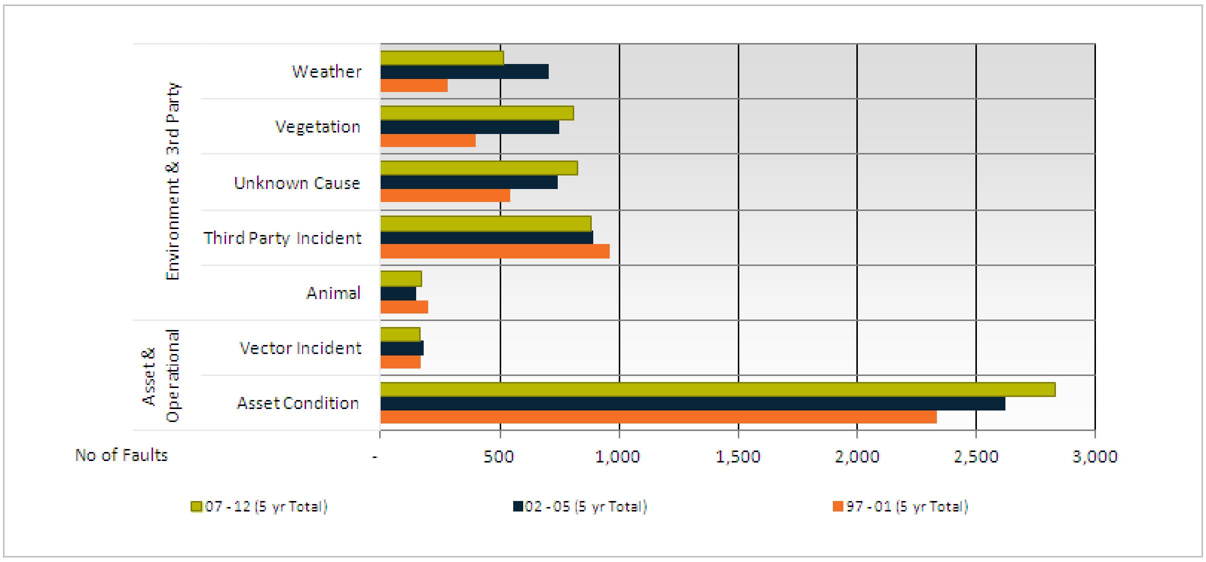

Figure 4-18 : Reasons for network failures

This shows the number of asset failures in each five year period, not the annualised failure rate normalised to the prevailing network length as per the definition.

Three specific causes of network failures are considered in more detail below:

1. Faults due to Vector incidents: These are the result of mistakes such as switching errors, accidental contact, dig-ins and accidental protection tripping, whether by Vector or Vector's FSPs or other contracting partners.

   Figure 4-19 below shows that these incidents remain relatively static at around 35 events per year, corresponding to a failure rate of 0.4/100km.

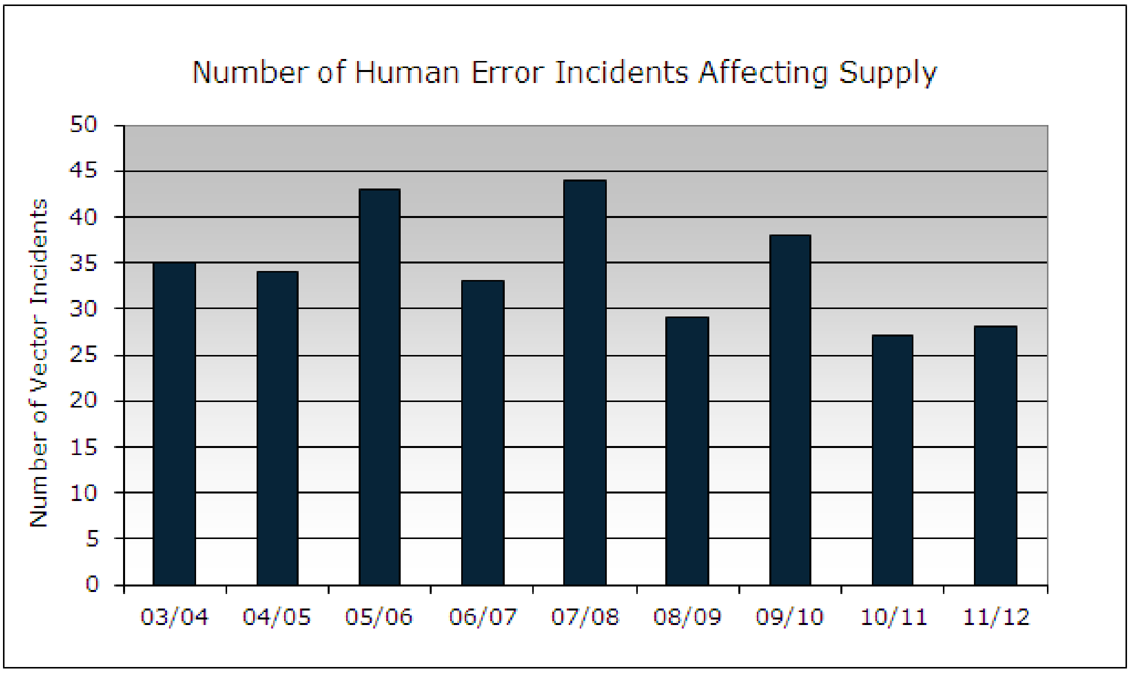

Figure 4-19 : Number of human error incidents affecting supply

This represents approximately 2% of the total failure rate (and a similar proportion of SAIDI and SAIFI). Nevertheless, as these events are within Vector's control, all such incidents are investigated thoroughly, especially those with health and safety or environmental implications. Permanent corrective actions are implemented where applicable;

2. Reported protection malfunctions: Vector tracks failures where protection either fails or operates in a manner inconsistent with the Control Room Engineer's expectation. In most instances the apparent protection failure is not the cause of the outage but is a complicating factor. Figure 4-20 shows annual protection malfunction counts and their proportion of total faults.

   Each instance where protection is thought to have malfunctioned is flagged to Vector's protection and control team for investigation. Corrective actions (including operator training) are implemented to avoid repeat incidents, where applicable.

   Historically, the rate of protection malfunctions was considered high. This was partly as a result of the complex, meshed nature of the Northern network and the associated need for sophisticated protection schemes. To address this, Vector embarked on a systematic programme to upgrade the protection schemes for the Northern network to computer-based systems, conforming to best industry practice. The impact of this is starting to show in the improving trend shown in Figure 4-20 below.

   Failure rates by type of equipment are being developed and will be progressively introduced now that the ALIS project has been implemented and exhaustive fault data is being collected (refer to Section 7). This will also allow the monitoring and analysis of defect rates; and

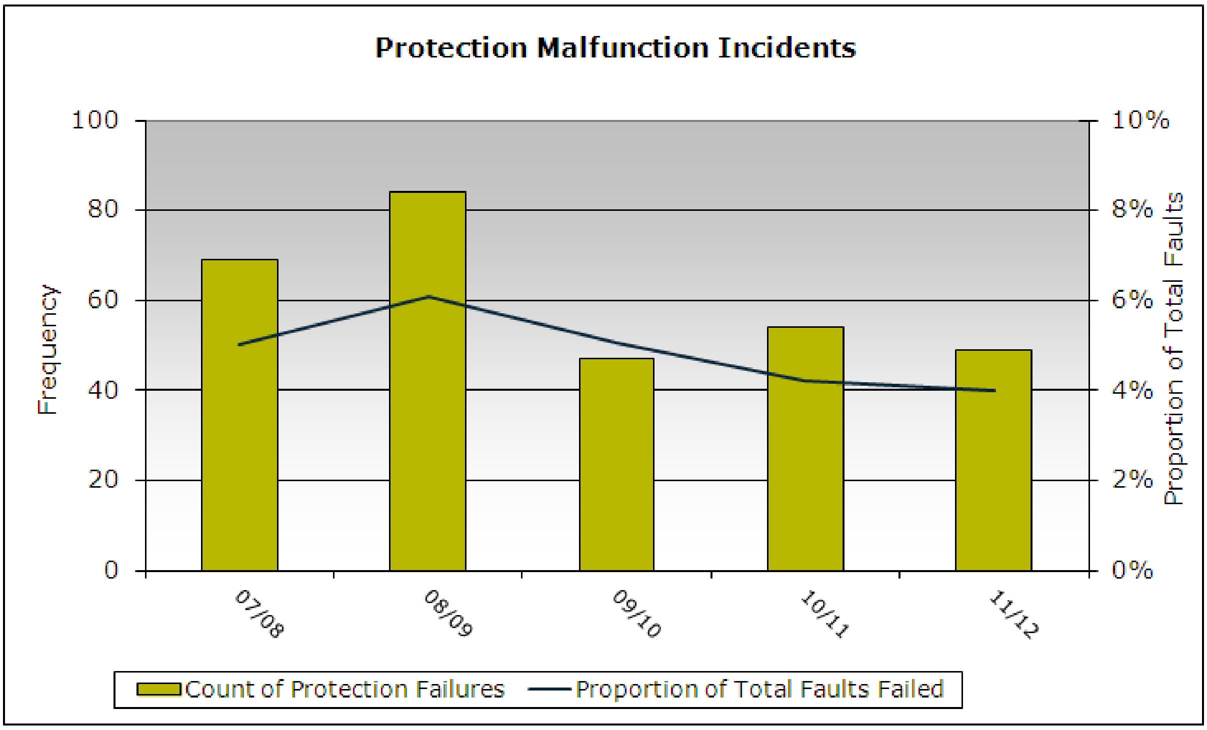

Figure 4-20 : Protection malfunction incidents

3. Failures due to unknown causes (see Figure 4-21) – these occur when circuit protection devices operate to initiate interruption to customers but, after fault finding and line patrol, no cause can be isolated or observed and the circuit is re-energised. The interruption cause is recorded as unknown although there

may be a suspected cause, such as vegetation brushing overhead lines or conductors clashing in stormy weather.

The 2011/12 value remains similar to the historical trend following a dip in 2009/10 regulation year (which showed a decline in both the count of unknown faults and their proportion of total faults). This decrease is most likely a result of benign weather conditions (stormy conditions result in higher numbers of unknown faults) and does not necessarily demonstrate a declining trend.

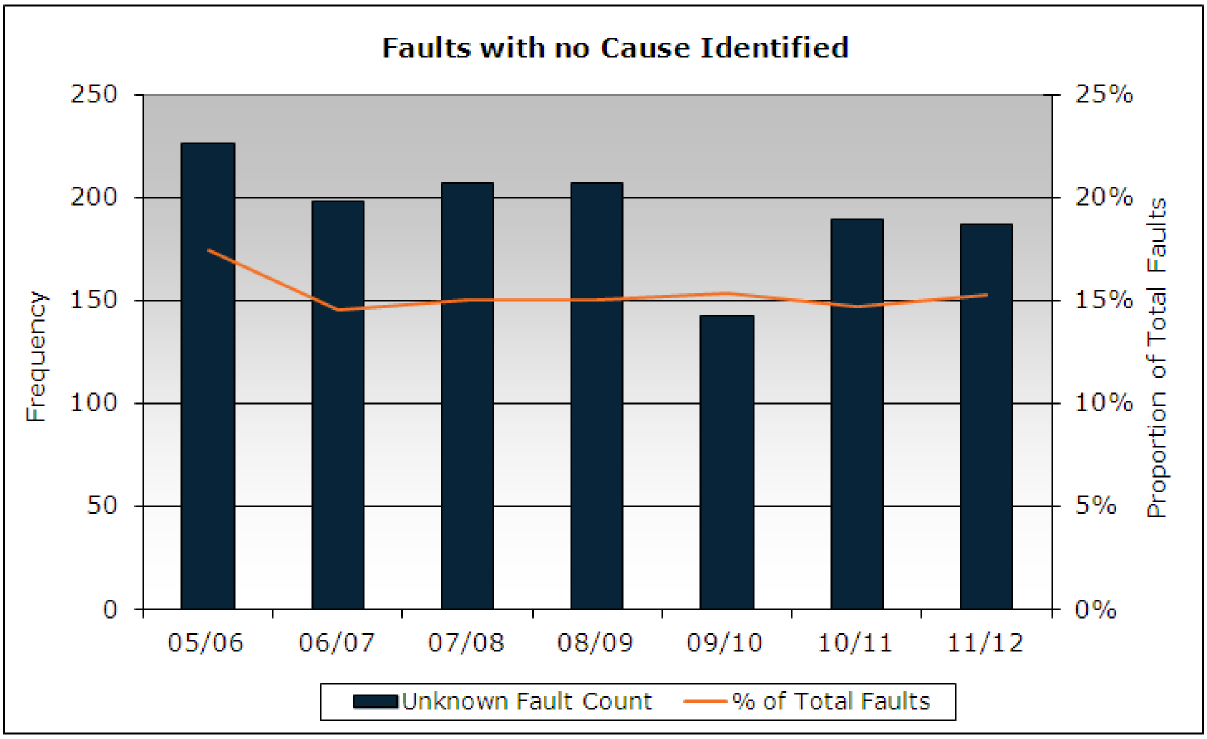

Figure 4-21 : Faults with no cause identified

4.2.1.2 Reporting and Analysis of Network Faults

Vector records interruptions to its HV and medium voltage (MV) network in a fault reporting system, HVEvents (described in detail in Section 7). This system enables analysis of trends and anomalies in the performance of the network down to the distribution transformer level. In Figure 4-22 to Figure 4-24 examples of extracts from HVEvents are illustrated.

In this way, supply reliability performance improvement programmes can be prioritised to address the more significant issues, focussing on those that are theoretically preventable, as described above.

From:	01 Oct 2012	To:	31 Oct 2012
Region:	Auckland	Event Type:	Unplanned

1 of 1 | 100% | Find | Next

Monthly Outages

Vector

Report Description: Monthly Outages Report

Report Parameters: From: 01/10/2012 To: 31/10/2012

Region: Auckland

Event Type: Unplanned

KEY:	Cust Affec	Vector SAIDI	Max Time Off (mins)
	0	0	0
	1-200	0-0.1	0-120
	200-500	0.1-0.2	120-150
	500-1000	0.2-0.5	150-180
	>1000	>0.5	>180

Event ID	Date	Time	Region	System Level	Location	Substation	Main Reason	Sub Reason	Event Cust Affec	Vector SAIDI	Event Max Time Off
204943	01/10/2012	00:09	Auckland	Feeder	OTAR K05	Otara	THIRD PARTY INCIDENT	VEHICLE DAMAGE	440	0.095	300
204947	01/10/2012	13:18	Auckland	Feeder	MCEN 11	Mangere Central	THIRD PARTY INCIDENT	VEHICLE DAMAGE	339	0.048	85
204952	01/10/2012	19:04	Auckland	Feeder	TPAP 15	Te Papapa	EQUIPMENT - UG	CABLE	1	0.003	1494
204965	03/10/2012	06:39	Auckland	Feeder	CLEV R140	Clevedon	THIRD PARTY INCIDENT	VEHICLE DAMAGE	761	0.272	277
204968	03/10/2012	11:33	Auckland	Feeder	WIRI 15	Wiri	EQUIPMENT - UG	CABLE	107	0.010	56
204971	03/10/2012	22:06	Auckland	Feeder	MCEN 13	Mangere Central	EQUIPMENT - UG	CABLE TERMINATION	1,477	0.341	452
204991	07/10/2012	06:08	Auckland	Feeder	AVON 1	Avondale	THIRD PARTY INCIDENT	VEHICLE DAMAGE	1,824	0.062	29

Figure 4-22 : Example report from HVEvents showing unplanned events in the Northern region during October 2012

Daily HVEvents Summary

Vector

Report Description: Summary of the HV Events for the specified date range

Report Parameters: From: 05/10/2012

To: 05/10/2012

KEY:	Cust Affec	Vector SAIDI	Max Time Off (mins)	Recent Trend vs SLA
	0	0	0	
	1-200	0-0.1	0-120	OK
	200-500	0.1-0.5	120-150	< SLA
	500-1000	0.5-1	150-180	= SLA
	1000+	>1.0	180+	> SLA

Unplanned Events

Event ID	Event Start Date Time	Region	System Level	Location	Location code	Main Reason	Sub Reason	Customer Affected	Vector SAIDI	Max Time Off	Faults Last 12 Months	FAIFI	Event Reviewed
204984	05/10/2012 20:16:00	Northern	Feeder	Spur Road	29REDV	EQUIPMENT - OH	CROSSARM	3	0.002	309	9	3.0	Yes
204982	05/10/2012 13:34:00	Northern	Feeder	Woodford Ave	19POMA	EQUIPMENT - UG	CABLE TERMINATION	917	0.308	506	3	2.3	Yes
204981	05/10/2012 08:56:00	Northern	Feeder	Triangle Road	14COLW	EQUIPMENT - OH	CONDUCTOR	42	0.004	57	4	3.0	Yes

Planned Events

Event ID	Event Start Date Time	Region	System Level	Location	Location code	Main Reason	Sub Reason	Customer Affected	Vector SAIDI	Max Time Off	Event Reviewed
204983	05/10/2012 09:03:00	Northern	Feeder	Wellsford	39TEHA	MAINT/REPLM'T - O/H PLANNED	TREE CUTTING	6	0.003	266	Yes
204980	05/10/2012 08:32:00	Auckland	Feeder	Takanini	TAKA 17	MAINT/REPLM'T - O/H PLANNED	POLE	24	0.019	473	Yes
204979	05/10/2012 00:30:00	Auckland	Feeder	Chevalier	CHEV 1	NEW WORK PLANNED	O/H -> U/G CONVERSION	255	0.005	11	Yes

Recloser Events

There were no Recloser Events for this date range

Figure 4-23 : Example of daily fault report from HV Events reporting system

UNPLANNED HV EVENT DETAILS	
Event ID	204982
Date	05/10/2012 13:34 p.m.
Region	Northern
System Level	Feeder
Substation	Woodford Ave
Location Code	19POMA
Location Name	POMARIA RD
Main Reason	EQUIPMENT - UG
Sub Reason	CABLE TERMINATION

Operational Details	
Contractor	Electrix
Operations Engineer	Rex Newton
Field Person	Calvin Pickett
Comments	crusifix flashed over cnr Lincoln & Pomaria Ave , insulators & lightning arrestor damaged
Service Request Nr	1-416945371
Defect Number	

Location Details	
Street Address	186 LINCOLN ROAD
Suburb	HENDERSON NORTH
Closest Asset 1	pole 76593
Closest Asset 2	

Fault Trip Details	
Fault Trips	1
Trip Device	Scada CB
Device Nr	K06
Protection Operation	OK
Function	Over Current
Protection Comments	
FPI Operation	OK
FPI Comments	

Performance Measure for Event			
Customer Mins	165,054	**Vector SAIDI**	0.3077
Customers Affec	917	**Vector SAIFI**	0.0017
Max Time Off for some customers	506	**Customers over Restoration SLA**	269

Figure 4-24 : Example of detailed information captured for an individual event in HVEvents

4.2.1.3 Enhancing our Performance for the Future

Ongoing initiatives directed at reducing network failures include the following:

- Making improvements in Vector's management of asset lifecycle information (as described in Section 7);
- Development of network monitoring and control, and related IT systems;
- Upgrading assets in the worst performing areas;
- Evaluating technological developments in network monitoring, protection and control systems and in primary and secondary plant and equipment and implementing where appropriate; and
- Targeting major cause contributors to reduce the frequency of failures.

4.2.2 Asset Utilisation

Asset utilisation in a distribution network is defined as the ratio between the peak demand conveyed by an asset (such as a feeder or a zone substation) and the capacity of the asset. It is a measure of what an asset is actually delivering against what it is capable of delivering. At Vector utilisation of an asset is measured as the single highest peak demand (after removing any temporary loading due to operational activities) divided by its installed capacity. In the case of substation utilisation, the maximum continuous ratings (MCR) of transformers installed are used. In the case of feeders, the cyclic ratings of the cables or overhead lines are used. The following graphs (Figure 4-25, Figure 4-26, Figure 4-27 and Figure 4-28) show the utilisation of zone substation and feeder in the Southern and Northern regions.

These graphs aim at showing the utilisation of the whole zone substation and feeder population across the two regions to give a view of the utilisation profile of the two regional networks. The utilisation profiles for the past three years (2010, 2011 and 2012) are plotted. Vector has chosen to monitor asset utilisation using a profile approach instead of a single average or median figure as this gives a more holistic picture of the network.

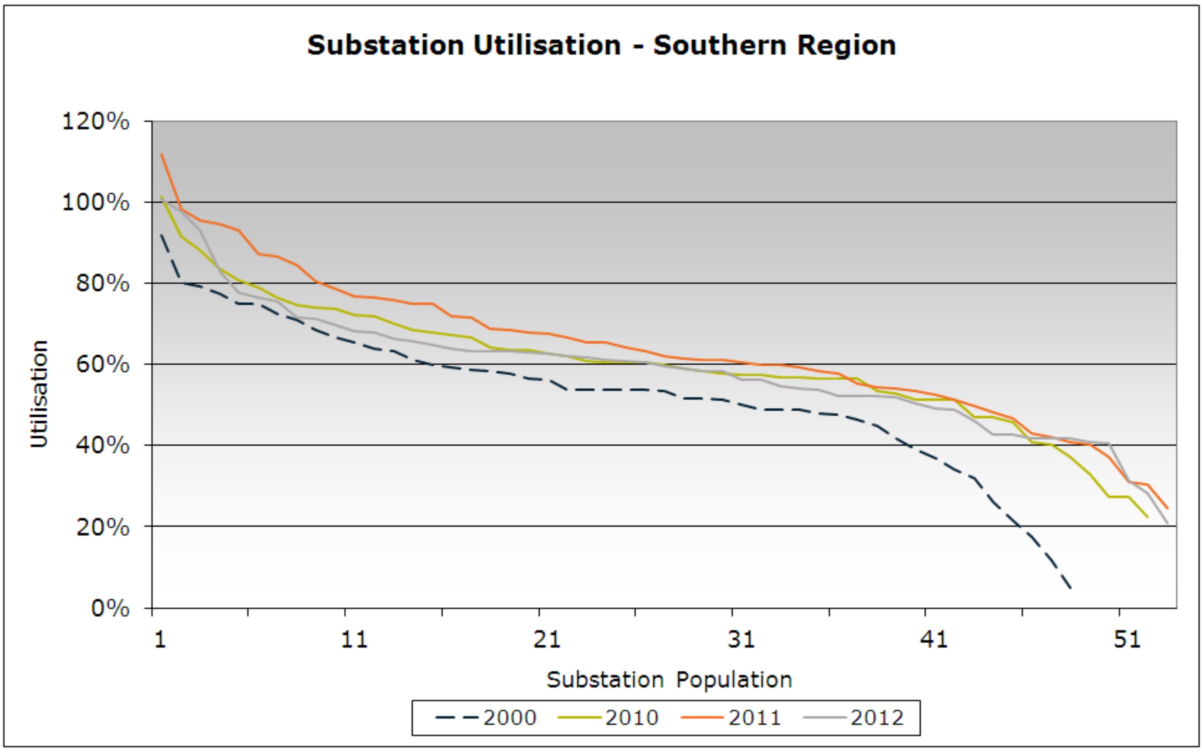

Figure 4-25 : Substation utilisation - Southern region

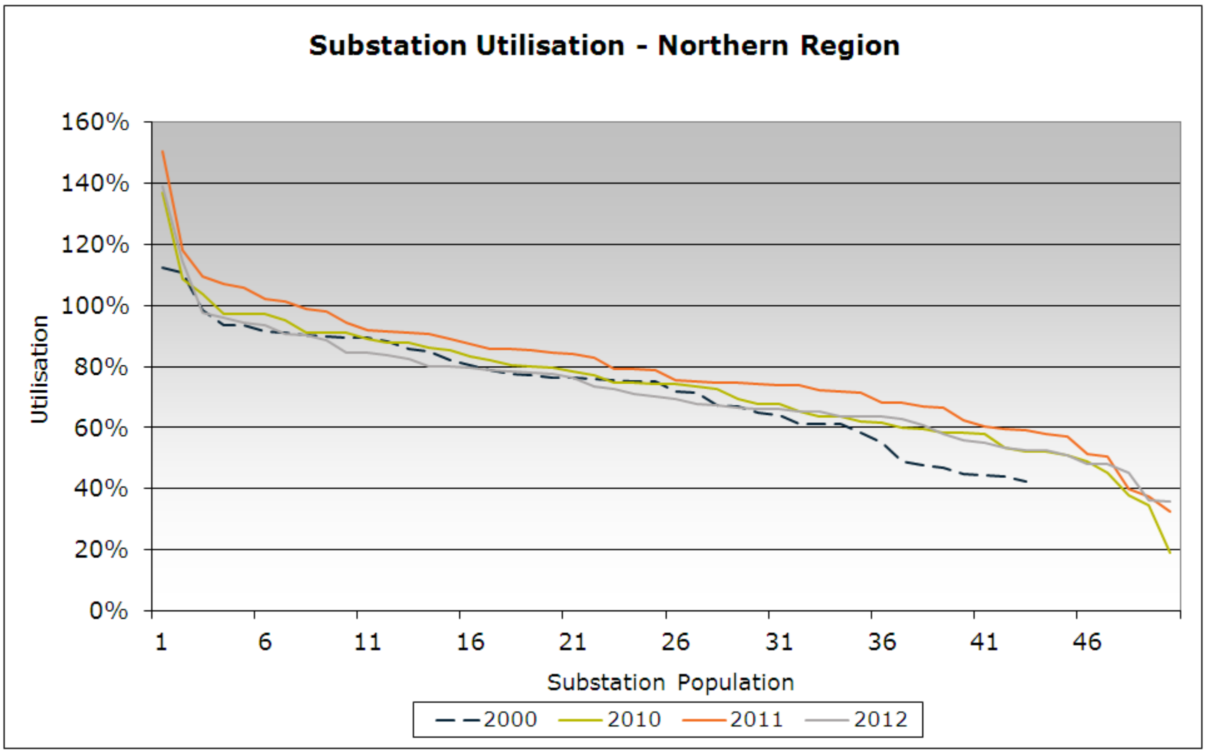

Figure 4-26 : Substation utilisation - Northern region

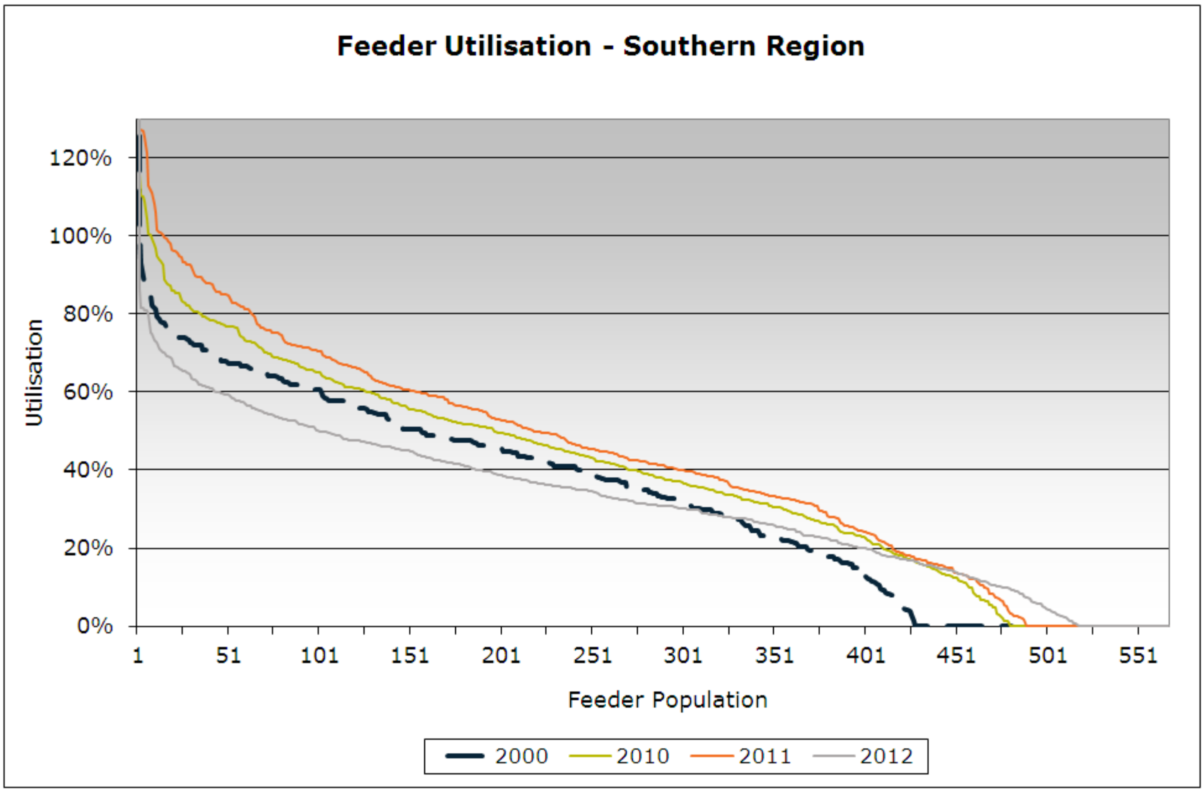

Figure 4-27 : Feeder utilisation - Southern region

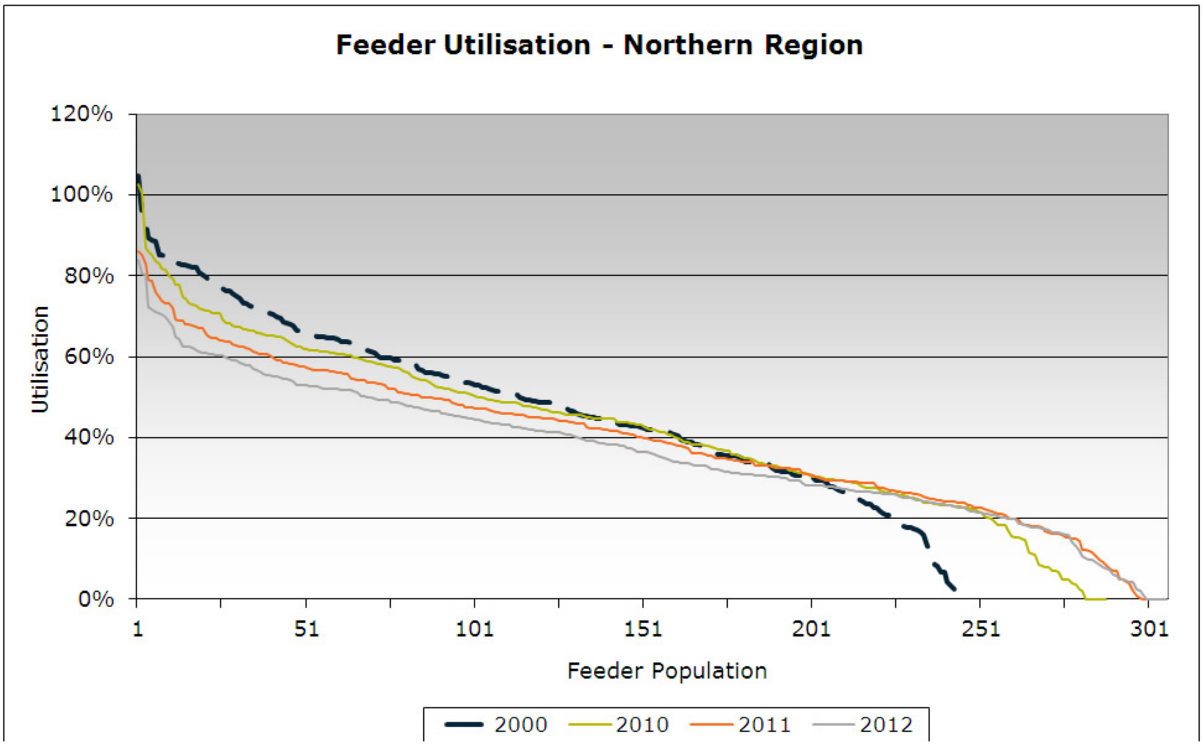

Figure 4-28 : Feeder utilisation - Northern region

The graphs demonstrate that within a network the utilisation of the assets are not uniform. Some substations (and feeders) are better utilised than others. While the ideal situation would be to have the utilisation profile as a flat horizontal line close to the limit of acceptable risk, in practice geographical and physical constraints and economic factors often preclude network planners from achieving such a goal. The utilisation profile, however, provides the planner an indication of areas where assets are under or over-utilised (a security risk) so appropriate actions (such as load transfer, demand side management and network reinforcements) can be taken.

The year-on-year utilisation profiles may move up or down due to the effect of weather on peak demands, but as a trend the utilisation of feeders and substations has increased over the years observed. For example, the median utilisation of substations in the Southern region increased from 54% in 2000 to 63% in 2010. This represents a six percentage point increase (or a 17% increase in utilisation over the past eight years). As the substation capacity used in utilisation calculation is the MCR, utilisation above 100% is acceptable subject to the cyclical nature of the load.

Note that at the lower end of the graph, the results are not entirely reliable due to loss of data in the plant information (PI) system collecting and storing the load information. This is currently being addressed by upgrading PI to provide instant notification of missing or non-valid data.

The graphs also show marked difference in utilisation between the two regions. This is largely as a result of legacy issues – the architecture of the networks largely determines the utilisation.

For example, the Northern region has a significantly higher substation utilisation than the Southern region. This reflects the historical differences in sub-transmission design philosophy of the two regions before the Vector/UnitedNetworks merger and the manner in which supply quality and risk is managed.

The apparent higher risk to the Northern region sub-transmission system, as reflected through higher utilisation, is compensated for by the extensive interconnection at distribution level, which is not available on the Southern network. (This is not something that can be identified by utilisation graphs alone.) Caution must therefore be exercised in making simple judgements based on utilisation figures. More than a single measure is required to form a holistic view on the performance of a complex business such as an electricity distribution network.

While Vector is broadly striving to improve utilisation levels, currently no fixed target for utilisation has been set. A fixed target is not realistic given the significant difference in geographical and network topological characteristics, consumption patterns and customer categories served. Instead Vector has chosen to regularly monitor asset utilisation and use the information to focus on assessment of the risks faced by certain parts of the network.

4.2.3 Network Security

"Security" is defined as the ability to supply network load following a fault (or more than one fault) and can be categorised deterministically or probabilistically.

Deterministic security operates in discrete levels, typically defined as having sufficient capacity to supply customers following a single fault ("N-1") or two faults ("N-2").

Probabilistic security takes into account load curves and the likelihood of faults as well, allowing for intermediate security levels between the discrete levels set by deterministic practices.

For Vector's network a combination of deterministic and probabilistic criteria are used. This is described in detail in Section 5.3.

The term "capacity" is used to define the rating of assets caused by physical limitations of the equipment and is generally determined by heating effects.

Three most common ratings are:

- Maximum continuous rating (MCR): Equivalent to a constant load applied continuously to the circuit;
- Cyclic rating: Maximum load that can be applied based on the daily cyclic load profile; and
- Emergency rating: Short-term rating (generally two hours) which allows assets to be overloaded for a short period (followed by a cooling period).

Both security and capacity, as means of characterising the network, are very distinct measures from reliability, which is a measure of the ability of the network to supply consumers' requirements as and when required (usually measured in terms of SAIDI/SAIFI), as described in Section 4.1.

As illustrated in Figure 4-29, under normal conditions maximum demand can be delivered. After a network fault has occurred demand can generally still be met. However, if the fault occurs during peak load times, there may be some interruption governed by the following design standards:

- Commercial - up to 2% of the time; and
- Residential - up to 5% of the time.

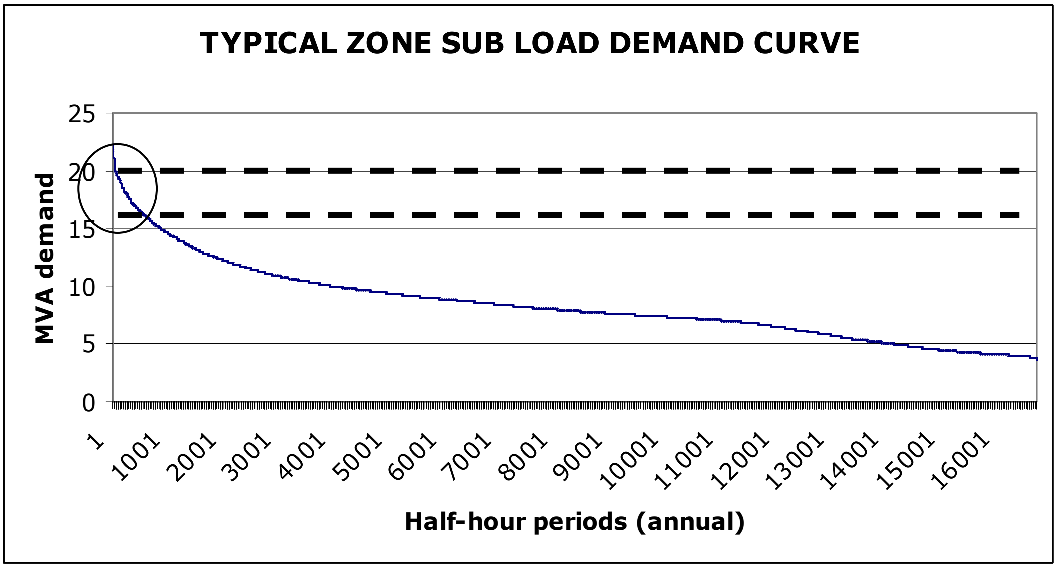

Figure 4-29 : Typical zone sub load demand curve

The upper line indicates normal capacity; the lower line indicates capacity after a single contingency (sub-transmission fault).

Vector's capacity standard is to maintain sufficient network capacity to supply consumers' normal requirements under normal network conditions. In some cases short-term component overloading is accepted, as shown in Figure 4-30 below.

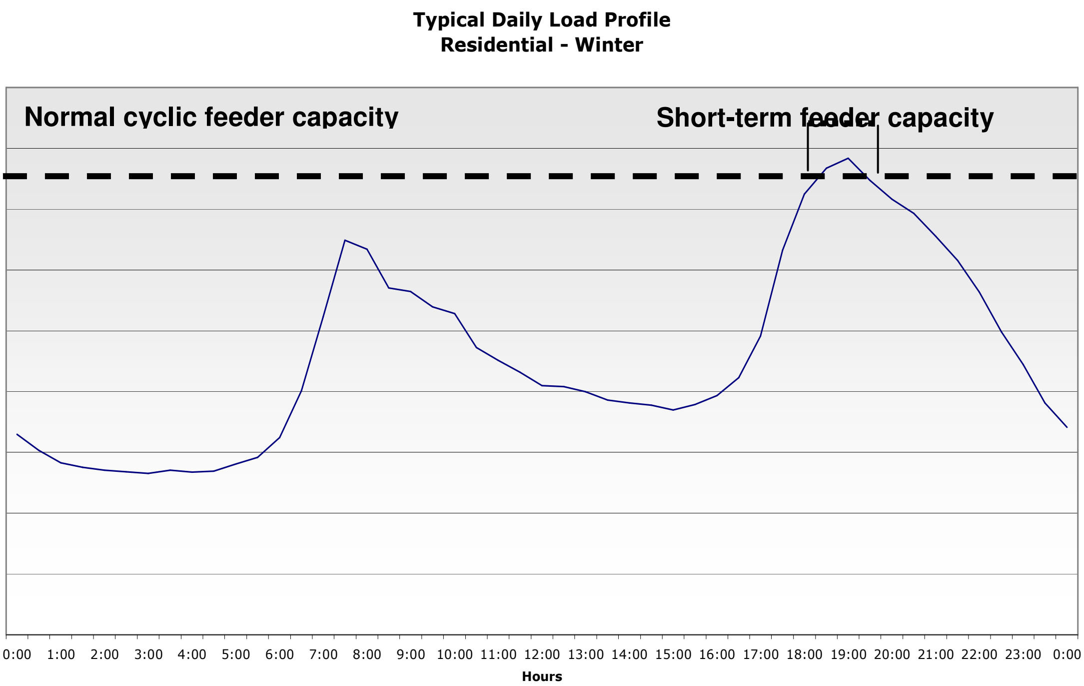

Figure 4-30 : Typical residential (winter) daily load profile

This daily load profile curve illustrates short-term feeder capacity above normal cyclic feeder capacity.

Figure 4-31 below shows the historic number of zone substations operating outside Vector's security criteria during peak demand times.

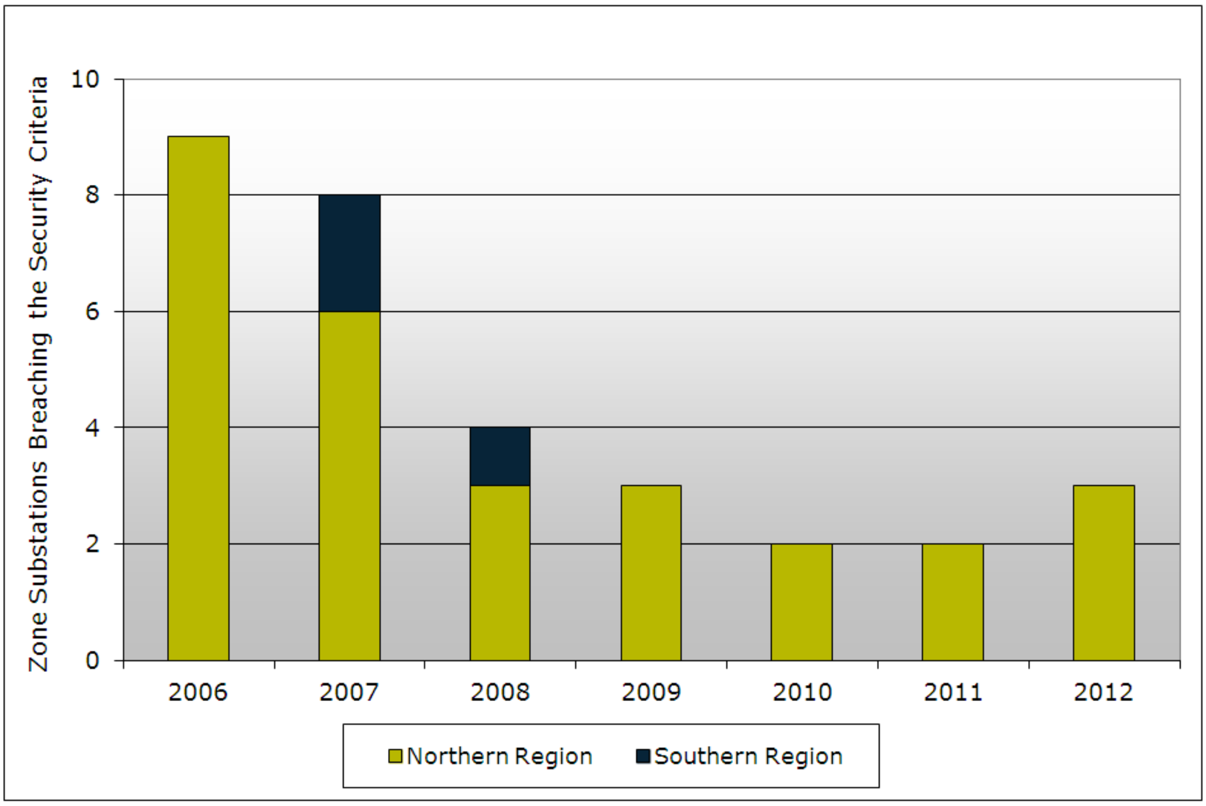

Figure 4-31 : Number of zone substations outside Vector security criteria

The downwards trend demonstrates the effectiveness of Vector's asset investment programme, which over the last 24 months has included three new zone substations and numerous HV feeders. Projects to address the causes of the 2010 and 2011 security breaches are underway through the installation of additional transformers and load transfer via new HV feeders.

4.3 Works Performance Measures

4.3.1 Capital Efficiency

Vector has embarked on a major capital efficiency drive – this is one of the Asset Investment (AI) group's key short and medium-term business goals. Metrics are being established to track progress.

- **Growth Capex Efficiency**

  This metric is designed to track the efficiency of investments made to support growth on the network. The metric needs to take account of investments which are implemented to reduce demand, new technologies (such as distributed generation), as well as smart thinking applied to more traditional solutions.

  The metric will relate to the ratio of annual increase in "effective capacity" to annual capex investment.

  The effective capacity measure will include both actual network capacity and demand side capacity managed eg. through load control.

- **Asset Integrity Capex Efficiency**

  Replacement of assets due to condition presents a more complex metric, due to the diversity of efficiency measures that may be applied eg. assets with longer life, lower cost of projects, refurbishment rather than replacement etc.

The metric will relate to the ratio of annual increase in "asset life value" to annual capex investment.

The asset life value will be calculated from consideration of asset replacement cost and asset remaining life.

- **Performance Monitors**

  It is important to ensure the drive for capital efficiency does not result in undesirable outcomes. For this reason, the above metrics will be considered in combination with metrics such as SAIFI and asset utilisation percentage.

4.3.2 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 stage gates that state delivery expectations from defining the solution, through to final commissioning and close out. These stage gates are monitored monthly and reported to general manager level. Project initiators, engineers and contract managers meet on a monthly basis to discuss project progress and issues and roadblocks are quickly escalated.

Once a project is past the solution defining stages and into delivery, the physical and financial forecasts are reviewed and re-set if appropriate. From this time, each part of the project is reviewed in terms of actual delivery against forecast.

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.

4.3.3 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 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.

4.3.3.1 Network Performance

The network performance KPI comprises Vector's regulatory SAIDI target (excluding any extreme events that are excluded by the Commerce Commission) and a target around response time to network faults as measured against the various customer service levels.

The targets for onsite response to electricity distribution faults in each customer category are shown in Table 4-9 below.

Customer Category	Target for Onsite Response (minutes)	
	HV Faults	LV Faults
Commercial customers	60	70
Urban residential customers	70	80
Rural customers	80	90

Table 4-9 : Electricity distribution fault targets

4.3.3.2 Delivery and Quality of Works

The KPI for delivery and quality of works provides for assessment of:

- Completion of all reactive, corrective and planned maintenance works to the agreed plans within the agreed timeframes;
- Customer connections from customer initiation within the target periods defined below or to the schedule agreed with the customer;
- Completing Vector initiated network projects within the agreed schedule; and
- Completion of works compliant to industry construction standards, Vector's network standards, national and local codes of practice, resource consents and other conditions without the need for corrective rework.

Vector Target

Customer connections' targets:

- For LV connections, provide the quotation back to the customer within five business days of the application being made and complete the installation within ten business days of the customer accepting the quote and all road access approvals, or on date agreed with the customer.
- For larger customer connections, provide proposals to Vector within ten business days once the works scope is agreed with the customer. Vector to package appropriate approvals and forward the offer to the customer within five business days of receiving the proposal.
- Complete the project within the timeframe agreed with the customer.

4.3.3.3 Health, Safety, Environmental and People (for FSPs)

This KPI is defined around minimising lost time injuries, incidents causing injury to a member of the public and environmental incidents resulting in an infringement notice. Implementing employee health initiatives and keeping employee competencies up to date are also included in the measure.

Health and safety management is a core element of Vector's strategic objective of operational excellence and the target or standard for safety excellence is zero injuries. Vector is continuing to work with its FSPs and contracting partners to identify effective ways to further improve the safety of its electrical networks.

4.3.3.4 Customer Experience

This is rated in terms of keeping appointment times, avoiding EGCC rulings against Vector and maintaining Vector's reputation in the media (taking into account adverse weather that may have affected our ability to perform) and implementing behaviour-based customer service training to the agreed plan.

4.3.3.5 Cost Management and Efficiency

The cost management and efficiency KPI depends on invoicing accurately and on time and providing accurate information to assist Vector with third party damage claims. There is also a target to deliver annual productivity improvements through developing and implementing initiatives that drive efficiencies in either Vector's or the FSP's business.

4.3.3.6 Information Quality

Finally, the information quality KPI is determined by assessing the accuracy, completeness and timeliness of updates to Vector's information systems, before, during and after the completion of works. Special consideration is given to safety or other significant incidents caused by any network assets not being shown in the correct location in GIS.

Vector Target

The target times for updating Vector's information systems are:

Services	3 business days after livening
Subdivisions	2 weeks after livening
Faulted asset repairs	3 business days after livening
Asset replacements	3 business days after replacement
Fault data	1 business day after fault resolution
Zone Substations	2 weeks after livening

4.3.4 Health, Safety and Environment

Vector's policy and overall approach to Health, Safety and Environment (HS&E) is described in Section 8.

In addition to the specific performance measures relating to HS&E 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.

Figure 4-32 below shows the long-term trend in lost time injuries at Vector (including Vector staff, contractors and FSPs) over the last seven years. The figures include both electricity and gas network activities.

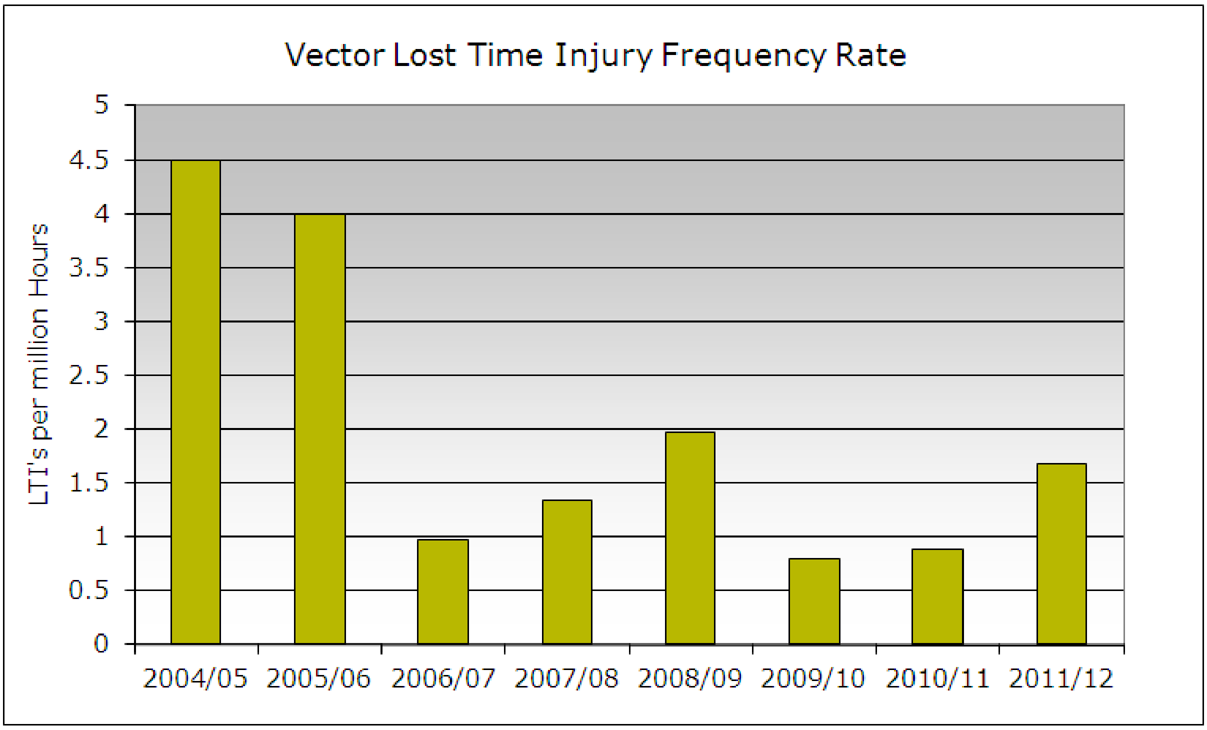

Figure 4-32 : Lost time injuries at Vector (including gas networks)

Note that activities performed in the Wellington electricity network (divested on 23 July 2008) are also included in this data.

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

Vector Target

Vector's overall health and safety target is to achieve zero lost time injuries.

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.

To progress towards Vector's target of zero injuries in the workplace, Vector is continuing to place a strong focus on ensuring hazards, where ever possible, are eliminated during the design phase, Vector's policies and procedures assist the workforce to deliver the right action at the right time, and to focus on personal behaviours to encourage an individual and team safety culture.

Electricity
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Network Development Planning – Section 5

[Disclosure AMP]

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5. 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]

5.1 Background

Auckland is the largest city in New Zealand with a population of 1.48 million[2] people, or nearly a third of the total New Zealand population. The maximum electricity demand in Auckland in 2012 was 1713MVA.

Network development planning is the forward-looking activity by which Vector ensures that sufficient electricity network capacity is available to meet customers' present and future requirements safely, efficiently and reliably. While it is predominantly a Vector-driven activity, it is also guided by external strategies such as those documented in the Auckland Plan and the New Zealand Energy Strategy.

The draft Auckland Plan, prepared by the Auckland Council, was made available for consultation in September 2011. The Plan forecasts a population increase in Auckland from the current 1.4 million people to upwards of 2 million people over the next 20 years. This expansion is expected to bring with it a corresponding increase in commercial and industrial enterprise growth.

The New Zealand Energy Strategy[3] was released by the Ministry of Economic Development in August 2011. This document outlines a number of key strategies including ensuring a reliable electricity supply, improving energy security by reducing energy demand, reducing greenhouse gas emissions and energy conservation.

The New Zealand Energy Efficiency and Conservation Strategy (2011)[4] targets improving home insulation and clean heating levels in existing homes to at least 188,500 homes, including 70,000 lower income households, swift uptake of new energy technologies and the use of smart electricity network technologies.

These strategies will have an impact on the manner and level at which electricity will be used in the future by Auckland customers.

5.2 Network Development Processes

Vector's network development process involves the planning of the network, solutions identification, budgeting, solution prioritisation, programme and implementing the planning solutions. This process has been reviewed by a number of independent external specialists in the past few years, with only minor improvements being suggested. These suggestions have been incorporated in our asset management planning.

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[1] The main requiring authorities are local authorities, KIWIRAIL and NZTA.

[2] Based on estimated population figures, Statistics New Zealand.

[3] http://www.med.govt.nz/sectors-industries/energy/pdf-docs-library/energy-strategies/nzes.pdf

[4] http://www.eeca.govt.nz/sites/all/files/nz-energy-strategy-2011.pdf

5.2.1 Network Planning Process

Vector's primary objectives in network planning are to identify foreseeable network related security,[5] capacity and power quality (PQ) (voltage levels and distortion) problems and solve in a safe, technically efficient and cost effective manner. These include:

- Power quality, security or capacity issues that may prevent Vector from delivering its target service levels;
- Adequacy of supply to new developments or areas requiring electricity connections; and
- The need to relocate assets, when reasonably required by third parties.

The diagram in Figure 5-1 shows the high level planning and programme implementation processes.

Knowledge of asset capacity and accurate demand forecast enables an assessment of the network's ability to deliver the required level of security and service. Input data comprising past demand information, forecast customer growth, technology trends, demographics and industry trends are used to produce the demand forecast.

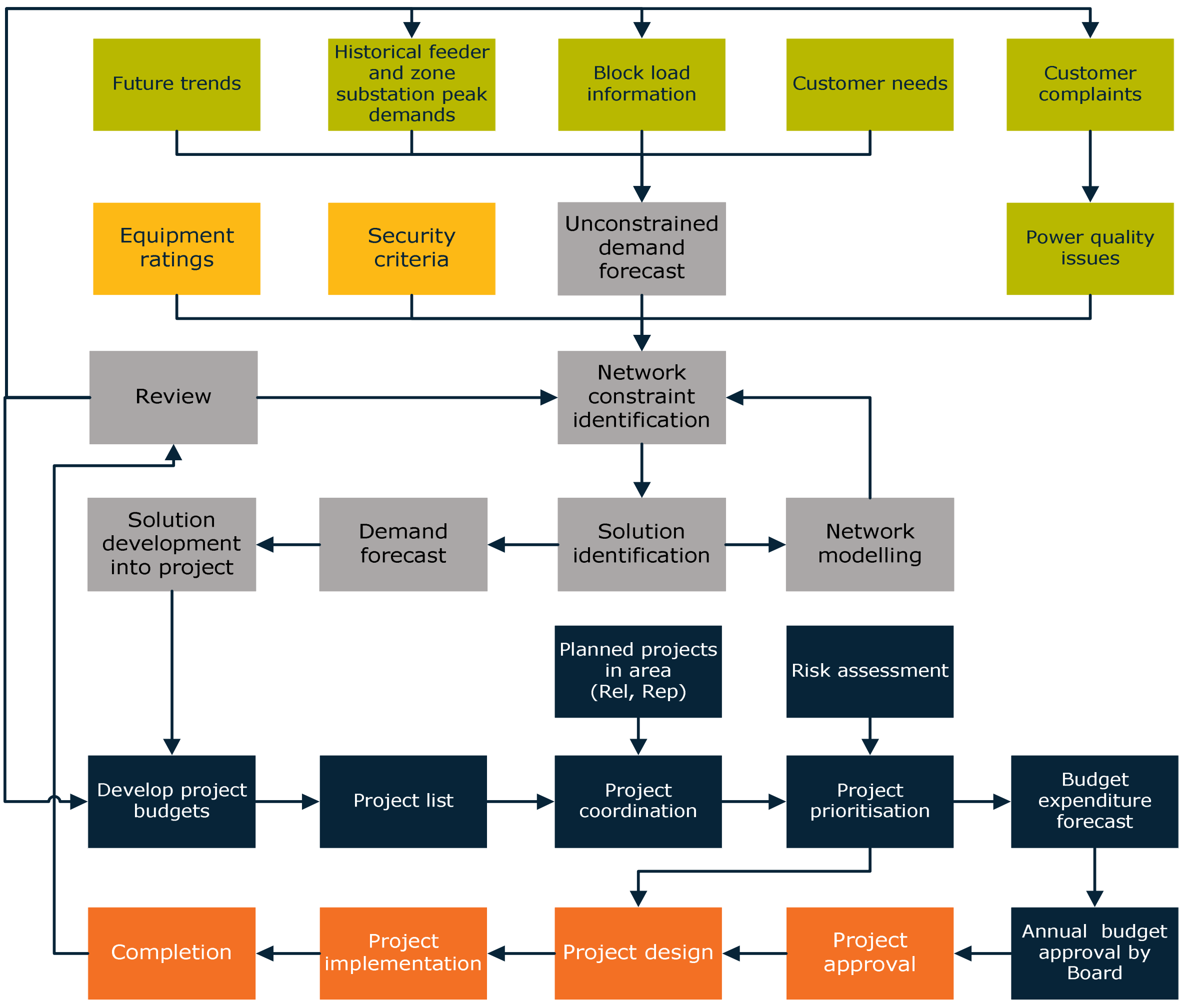

Figure 5-1 : Network development and implementation process

[5] "Security" as used in a planning context means the security of the electricity supply ie. the likelihood that supply may be lost.

Network capacity and security constraints are addressed with a combination of both asset or non-asset solutions, where the optimal solution may not necessarily result in network augmentation. In evaluating the solutions, the following factors are considered:

- The demand forecast and asset capacity to test against the security criteria to ensure the suitability and adequacy of solutions for security or capacity issues;
- Demand-side options such as load management or customised pricing to reduce demand on the network;
- Automation to expedite load transfer and restoration times;
- Capacitor banks to boost low voltage and provide added capacity in low growth areas;
- Upgrade of specific network assets to relieve capacity constraints eg. upgrade a transformer connection to increase the overall capacity of a substation;
- Using the diversity arising from different demand profiles (residential/ industrial/commercial) to reduce overall demand;
- Targeted solutions to satisfy the specific requirements of customers eg. provide a higher security supply across two GXP's to meet customers' security needs;
- Ensuring that, where possible, short-term solutions will meet the long-term needs without asset stranding;
- Considering any operational constraints created by a particular solution eg. a solution may solve a security issue but impose a higher SAIDI penalty under fault conditions;
- Evaluating projects taking into account the time-value of money to ensure the optimal solution is determined;
- Coordinating the network development programme with other work programmes such as asset replacement to achieve synergy benefits;
- Avoiding reputation damage and consequential financial loss arising from the loss of supply to customers;
- Reviewing major assets due for retirement to ensure their direct replacement meets future network needs; and
- Ensuring recommended solutions are commercially appropriate.

5.2.2 Budget Expenditure Forecast Process

Vector has developed a sophisticated cost estimator model that is used to forecast project expenditure.

This model uses observed material and installation unit rates from historic and recent projects to build project estimates. The unit rates are controlled by annual updates against actual project and procurement costs (the same actual costs that are fed into the Vector asset registers). Between these annual updates, where outliers, unusual conditions or new technology/methodologies apply, quantity surveyors, suppliers and/or constructors are engaged to provide added certainty and updates to the unit rates. Specialist consultant advice is sought from time-to-time when major market shifts or volatility are forecast.

Economic factors such as the regulatory weighted average cost of capital (WACC), producer price index (PPI) and foreign exchange rates are sourced from the Vector Finance group (consistent with that used for other business purposes). These are applied within the model to escalate historical values as well as for future estimates. Further estimating validity is provided by including contingency allowances that reflect the cost uncertainty associated with individual line items. Base data is not changed, thereby retaining the integrity of source data.

For each project cost estimate a challenge session between project sponsor, estimator and the project delivery team is undertaken. The challenge considers current knowledge of comparable projects and their actual costs, as well as the proposed project methodology, resource availability, and market conditions. Estimates are then measured against actual project costs during project delivery and at project closure, with variances fed back to the Design and Estimation Manager for assessment to update the model's dataset.

Vector's Electricity Asset Management Plan uses a further AMP budget estimation worksheet overlaid onto the cost estimator model (CEM) described above. This simplifies the creation of high-level estimates for the AMP's proposed projects by consolidating the component materials, installation and ancillary unit rates of the CEM into asset specific building blocks. Having the high-level AMP budget estimation model use the same cost data and factors as the CEM retains data integrity across the estimation process.

5.2.3 Standardisation

Wherever possible, Vector uses standardised design and equipment on its network. This approach 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, 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, cables, poles, installation practices and zone substation buildings. With this latter item, Vector may apply differing architectural treatments to better align with local architecture, whilst ensuring construction techniques and materials and fit-outs align with well-established standards.

Pre-approving material designs allows for streamlined procurement, while pre-approving and short-listing suppliers impacts positively on quality, delivery timeframes and price. Pre-approved consultants ensure uniformity of quality and designs without the loss of external innovation and value-added features to the design. Vector has pre-selected contractors who are authorised to carry out work on Vector's network. This process has the overall benefit of avoiding the high costs of repeatedly training contractors, consultants and suppliers of Vector's requirements and expectations.

5.2.4 Project Implementation

An effective delivery of the capital works programme, based on an end-to-end delivery process, has been established between Vector's Asset Investment (AI) and Service Delivery (SD) groups. The process tracks each project from conceptual design through to site construction and commissioning.

5.3 The Triggers for Network Development Decisions

Network development planning is concerned with ensuring that in the face of changing network requirements, Vector's network performance continues to meet (a) the capacity needs of our customers and (b) prudent safety and reliability requirements as encapsulated in the network policies and standards set by the asset owner. When it is foreseen that any of these criteria are likely to be breached, that would normally constitute grounds for further network development.[6] The network development criteria considered when deciding whether a development investment is required are illustrated in Figure 5-2, and summarised below:

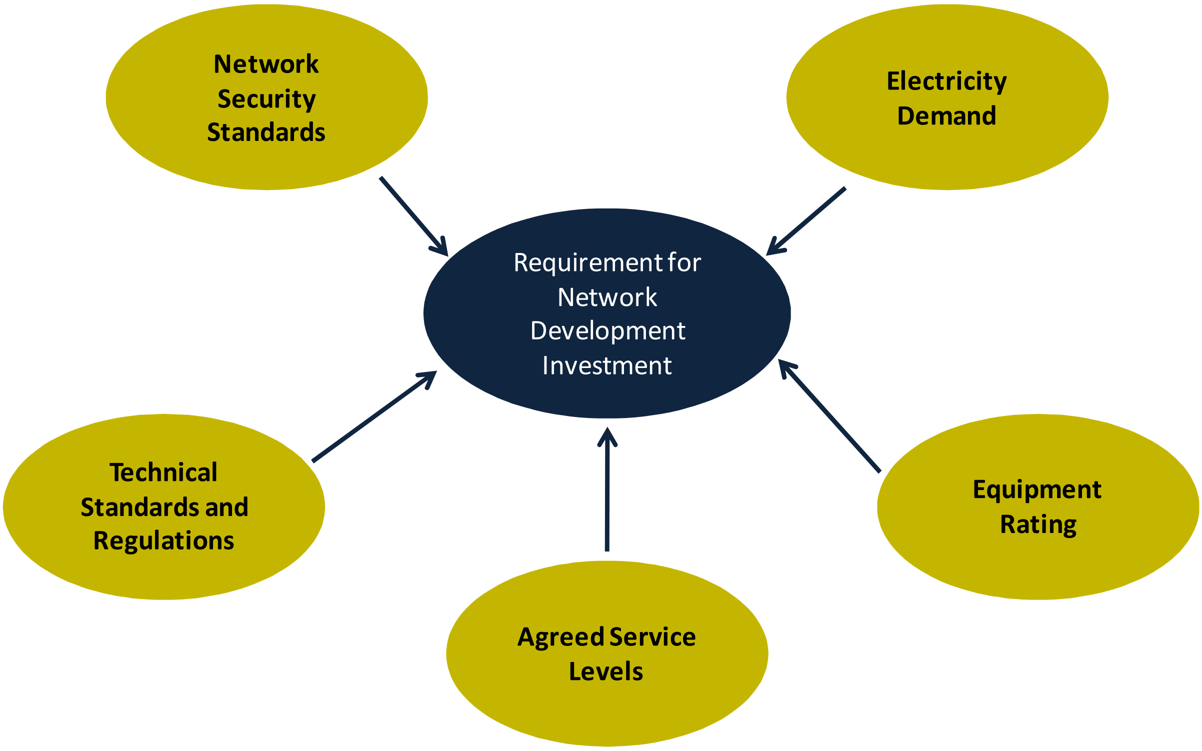

Figure 5-2 : Network development criteria

- **Network security standard:** Vector's security standard specifies the minimum levels of network capacity and levels of asset redundancy required to meet required network security levels (see Section 5.3.1);
- **Electricity demand:** This is the maximum level of electricity required by customers. In the longer term, electricity demand usually changes over time due to changes in consumer numbers or changes in the electricity consumption levels and patterns of existing customers (driven in turn by factors such as increased or decreased activity, technological changes in connected equipment, societal trends, etc.). In the short term, demand can fluctuate greatly between seasons and years, based on factors such as the weather (temperature is a significant factor), economic activity and energy savings campaigns (see Section 5.3.2);
- **Equipment rating:** All equipment (transformers, cables, switchgear, etc) has a rated load carrying capacity depending on the demand characteristics and the environment in which the equipment operates. If the ratings are exceeded, assets may malfunction or become unsafe to operate (see Section 5.3.3);
- **Technical standards and regulations**: These are the regulations and standards that describe the requirements for safely operating the network, as well as the requirements customers must adhere to when connecting to the Vector distribution network, and the design standards that Vector applies to its network and the assets used. They include aspects of network design such as subdivision design,

[6] Development investments are caused by growth in electricity demand, changing or new customer requirements or the need to relocate services. It is distinct from network integrity investments (mainly renewal), which are required to ensure that the condition and performance of existing assets remain in accordance with design specifications. The latter type of investments is described in Section 6 of the AMP.

acceptable fault levels, voltage levels, power factor, etc to ensure safety while meeting expected service levels (see Section 5.3.4), and

- **Agreed service levels:** Service levels are established as part of the use of network agreement with retailers and customers. The service levels reflect expected restoration timeframes and fault frequencies (see Section 5.3.5);

Ideally effective network development planning identifies potential breaches of these criteria before they occur, allowing sufficient time for a solution to be found and implemented to avoid actual breaches. At the same time, it is inefficient to upgrade networks too far in advance as this leads to under-utilised assets. Accurate demand forecasting, understanding energy usage and other trends is therefore an essential part of network development planning.

Key principles which underlie Vector's network development decision making process include (not in any order of priority):

- Network assets will not present a safety risk to staff, contractors or the public;
- Network assets will be operated within their design rating to ensure they are not damaged by overloading;
- The network is designed to meet statutory requirements including acceptable voltage and power quality levels;
- Customers' reasonable electricity capacity requirements will be met.[7] In addition, the network is designed to include a prudent capacity margin to cater for foreseeable near-term demand growth;
- Equipment is purchased and installed in accordance with network standards to ensure optimal asset life and performance;
- Varying security standards apply to different areas and customer segments, broadly reflecting customers' price/quality trade-off; and
- Network investment will provide an appropriate commercial return for the business.

In the sections below, the criteria for network development decision making, and how these apply to the Vector electricity network, are discussed in more detail.

5.3.1 Network Security Standards

Normal deterministic approach to planning accepts an N, N-1[8], etc level of security. This approach ensures there is a clear understanding of the availability and capability of supporting network assets to meet the network demand in the event of a network fault.

Vector has accepted a marginally lower level of security for certain parts of the network, such that supply cannot be maintained at all times following a fault (for a very small proportion of the time, during peak demand periods). The application of this criterion is shown in the security standards table in the following section (Table 5-1).

The purpose of this approach is to support more efficient network reinforcement investments. The combination of maximum demand and security standards set the design threshold that triggers the need for network reinforcement. By accepting the small risk of not maintaining supply should a fault occur exactly at peak times, the

[7] This includes customers with non-standard requirements, where special contractual arrangements apply.

[8] An N-1 security level, for example, means supply will still be maintained after one network component fails.

design maximum demand can be materially reduced.[9] This offers a significant opportunity to improve asset utilisation and defer network reinforcement.[10]

The Security Standards used for Network Planning are summarised in Table 5-1.

Network Element	Load Type	Primary Voltage	Load Magnitude	Security Limits[11,12]	Ability to Meet Demand after Outage (% of year)	Customer Interruption Duration for Outage
Bulk supply substation	CBD (Quay, Hobson, Liverpool)	110kV	Any	N-1 N-2	100% (1st outage) 100% (second outage)	Nil (1st outage) < 5min (second 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% (second outage)	Nil (1st outage) < 5min (second outage)
	Urban (Wairau, Kingsland)	110kV	Any	N-1	100%	Nil
	Urban & Rural	33kV, 22kV	> 10MVA	N-1	95% (residential), 98% (commercial/ industrial)	< 5 min
	Urban	33kV, 22kV	< 10MVA	N	Nil	Repair time
		Backstop capacity is, however, 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.				
	Rural	33kV, 22kV	< 10MVA	N	Nil	Repair time
Zone substation	CBD (Quay, Hobson, Liverpool)	22kV	Any	N-1 N-2	100% (1st outage) 100% (second outage)	Nil (1st outage) < 5min (second outage)
	Urban & Rural	33kV, 22kV	> 10MVA	N-1	95% (residential), 98% (commercial/ industrial)	< 5 min
	Urban	33kV, 22kV	< 10MVA	N	Nil	< 5 min
		Backstop capacity is, however, 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.				
	Rural	33kV, 22kV	< 10MVA	N	Nil	Repair time
Distribution feeder	CBD	22kV, 11kV	Any	N-1	100%	< 2 hrs
	Urban	11kV	> 2.5MVA overhead	N-1	95% (residential),	< 3 hrs Northern

[9] The extent of reduction depends on the duration for which such a risk would be deemed acceptable.

[10] The conventional deterministic approach requires sufficient asset capacity to meet full peak demand, even if this occurs for a few half hours per year.

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

[12] Applies to "credible contingencies" only

Network Element	Load Type	Primary Voltage	Load Magnitude	Security Limits[11,12]	Ability to Meet Demand after Outage (% of year)	Customer Interruption Duration for Outage
			> 400kVA underground		98% (commercial/ industrial)	< 2.5 hrs Southern
	Urban	11kV	< 2.5MVA overhead < 400kVA 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

Table 5-1 : Network security standards

Security standards are specified by broad groupings based on load magnitude, encompassing sub-transmission and distribution. Network security at each of these levels is typically in line with international industry best practice. Where the highest level of security is required, multiple concurrent faults must occur before customer supply is lost. In Vector's case, this level of security is reserved solely for the sub-transmission within the Auckland Central Business District (CBD).

Outside the CBD a higher level of risk is accepted. The network is designed such that for urban commercial or industrial areas should a sub-transmission, distribution feeder or zone substation fault occur, supply can be fully restored 98% of the time.[13,14] For 2% of the time, at peak demand periods, it may not be possible to fully restore supply until repairs have been carried out. For urban residential areas supplies can be fully restored 95% of the time.

As noted above, this approach implies a security level marginally lower than the more conventional N-1 design approach, but from a network utilisation and economic efficiency perspective, it is far superior. The added risk that an outage may occur during peak demand periods is low.

An exception is made to this security standard for urban or rural feeders with low demand[15], where the installation of redundant assets cannot be financially justified[16]. In these cases restoration of supply generally requires repairing the fault.

[13] Restoration may, in some instances, lead to a short (less than 5 minute) outage, to allow network switching.

[14] Note that this applies to sub-transmission, zone substation or feeder faults only. Should a fault occur on a distribution substation or on the low voltage network, the same level of network redundancy does not exist, and outages may be experienced while fault repairs are carried out.

[15] <2.5MVA total peak load for areas fed from overhead circuits and <400kVA for areas fed from underground networks. The difference in load magnitude reflects the average time required to restore supply on overhead and underground networks.

[16] Unless specifically required by customers, in which case special commercial arrangements are made to recover the additional costs from the requiring customer(s).

Zone substation security levels are based on a threshold of 10MVA. For substations with a demand smaller than 10MVA, single transformer substations are used that only provide an N level security. In these cases the design philosophy is to restore supplies after a fault from adjacent zone substations, using the 11kV distribution network backstop capability, up to the maximum level of 10MVA. (Zone substations with demand higher than 10MVA will have more than one power transformer, providing N-1 security.)

Due to legacy reasons a number of single transformer substations, particularly on the Northern network, have peak demands in excess of 10MVA. These substations are either supplied by transformers larger than 10MVA or have distribution backup capability sufficient to meet required service levels. Vector is not actively initiating projects to duplicate sub-transmission circuits or transformers to meet the required 10MVA limit adopted in the planning criteria, but rather addresses these legacy issues when network reinforcement is required. This is considered a more economically rational investment strategy.

Another important consideration in the security standard is the design restoration times (as distinct from service level targets). These relate to the time required to restore supply after a network fault. For the sub-transmission networks these times are generally short (see Table 5-1) and are based on automated switching that will transfer load automatically following a fault, or through remote switching initiated by Operations staff. At distribution feeder and substation levels, automated switching facilities are not as readily available and manual field switching may be required, resulting in longer possible restoration times.

5.3.1.1 Accepted Breaches of the Security Standards

Vector accepts a small number of instances where the distribution network security standards will be breached, which affect our network designs. These generally relate to one of the following four situations:

- Loss of bulk supply to all or part of Vector's network. Vector cannot realistically mitigate against a major loss of generation or transmission capacity. Such events will, therefore, lead to outages on the distribution network;
- The network development programme is generally 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 however, external factors (such as more demand growth than foreseen at the time of planning or severe weather conditions leading to demand peaks higher than prudent system design levels allow for) 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;
- The security standards are based on an optimal trade-off between network reliability and the cost of providing electricity distribution services.[17] This, in turn, requires an evaluation of the energy at risk during credible outage events and the expenditure needed to reduce the risk. There are (a small number of) 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 consumer and/or consumption density, often remote from our main distribution network. To upgrade supplies to these areas to Vector's normal security standards would, therefore, require material additional recovery contributions from the customers

[17] 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.

affected. For these areas, the security standards may, therefore, be relaxed[18,19]; and

- There are a number of credible but highly unlikely contingency events that may occur on a distribution network that would almost inevitably give rise to extensive and extended outages. These are the so-called HILP (high-impact, low-probability) events that would have a widespread impact, but would be inordinately expensive to avoid (if indeed possible) and where the likelihood of their occurring is so low this expenditure cannot be realistically justified. HILP events that Vector, therefore, accepts which could lead to major power outages include:
    - Destruction of the Penrose/Liverpool tunnel and all circuits within. This would leave the CBD supply exposed[20];
    - Failure of a tower or structure on the double circuit 110kV overhead line feeding Wairau substation in the North Shore, which would leave a shortfall in supply capacity for the North Shore[21];
    - 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. In theory, a single event could, therefore, damage more than one circuit[22];
    - Complete failure of a 110kV, 33kV, 22kV, or 11kV busbar at a substation, which would affect multiple circuits[23]; and
    - Total loss of a zone substation (single or multiple transformers) through a force majeure event such as an earthquake, volcanic activity, flood or plane crash[24].

For all these cases, the risks are managed to the fullest practical extent possible and contingency plans are in place to minimise the impact of the event.

5.3.1.2 Impact of Network Configuration on Security Levels

Vector takes supply from the transmission grid at the various GXPs. The sub-transmission network of the two Vector network regions has developed using different configurations, due to legacy network designs. Dual radial-fed transformer feeders have been widely used in the Southern region whereas a mesh configuration has been the dominating Northern region design.

There are a number of substations in the Northern region equipped with a single transformer. These substations rely on the distribution network to provide the necessary

[18] 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.

[19] 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.

[20] Work is underway for the creation of a new GXP at Hobson St in the CBD. Once this is in place (planned for mid 2014) the risk will be fully mitigated.

[21] Work is underway for the creation of a new GXP at Wairau Park substation. Once this is in place (planned for mid 2013) the risk will be fully mitigated.

[22] 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.

[23] 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.

[24] All substations are designed to stringent earthquake and flood level requirements, but it is not possible to completely mitigate against major external events. This has been graphically illustrated in the recent Christchurch earthquake.

back-up to maintain the required security level. The distribution network (in both regions) is configured in radial formation. The radial feeders are interconnected via normally open switches to provide backstops from either the same substation or a neighbouring substation.

5.3.2 Electricity Demand Forecasting

The electricity demand forecast is a projection of future demand based on historical demand information, known and anticipated consumption trends and demographic factors that influence the manner in which electricity is used. It is a key factor in network development decisions.

For forecasting purposes it is useful to split demand into two distinct categories – mass market (residential and small commercial ICPs) and the large consumers (industrial and large commercial).

5.3.2.1 Forecasting for the Mass Market Customers

The dominant factors driving mass market demand over time are connection numbers, the type of connections and the average individual electricity demand curve[25] associated with the different types of connections (which varies between areas).

Traditionally, residential connection numbers closely follow population trends, although the average number of people per connection can vary over time and between areas. Small commercial ICP numbers also tend to follow population size. Over a long period, there has been a strong correlation between population growth and ICP numbers, on a network-wide as well as GXP-wide level.

The average demand curves for customers vary between the types of customer and between different areas. There is also a material difference between summer and winter demand curves. Traditionally the curves themselves have remained remarkably consistent over time and for the purpose of forecasting over the AMP planning window, demand can reasonably be assumed to remain constant on a per ICP basis[26].

There are some further statistically significant factors that influence short-term demand, such as weather patterns and economic cycles. Weather patterns tend to have an immediate impact on demand (for example, the highest ever demand on Vector's network occurred on 15 August 2011, which was also one of the coldest days on record), but do not have a significant long-term impact (at least in the timeframes measured) as they vary greatly from year to year. The impact of economic cycles on electricity demand is more longer term, but the correlation has been an order of magnitude below that between long-term population growth and demand[27]. Annual reviews, as part of the AMP process, ensure that the forecast is adjusted to take into account long-term trends[28].

ICP forecasts are, therefore, the primary factor for mass market electricity demand forecasts, while other trends, including economic cycles, are annually reviewed to test whether these are likely to have a significant impact on demand (and adjustments made if appropriate). The population forecasts are largely based on population growth data

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[25] Note that the term "demand curve" in an electrical engineering context refers to the maximum actual electricity consumed, measured over time, usually shown in specific time intervals. (See Section 2.2 for examples.) It is not to be confused with the economist interpretation of a demand curve (which is usually read in conjunction with a supply curve).

[26] There is some evidence of minor growth in the average demand curve in some areas, or of a shift from winter to summer peaks, but this is not sufficient to have a material impact on investment decisions over the forecasting period.

[27] Based on a study by Sapere "Development of Vectors Forecasting Capabilities" Feb 2011

[28] The forecasting methodology has been reviewed by both SKM and Siemens as part of the annual review for the AECT Trust

provided by Statistics New Zealand household projections. Vector's distribution area is divided into small pockets of land aligning with Census Area Units (CAUs). Population, employment and load composition (eg. proportion of residential and commercial/industrial) is determined per CAU area and are pro-rated across the feeders supplying the particular CAU.

The average peak demand per ICP for an area is derived from historical demand levels, and is assumed to remain constant for the planning period. The average figure is reviewed on an annual basis.

It should be noted that this situation is not replicated when energy consumption (volume) is analysed – Vector's evidence suggests that average energy consumed per ICP, both residential and small commercial, has been trending down since 2005 (although total energy volumes remain flat). Energy consumption is not taken into account for network reinforcement purposes.

5.3.2.2 Forecast for Large Customers

On average, Vector receives only a few new large-customer connection requests (or requests for substantial demand increases from existing customers) every year. These customers are identified when their proposed load increase will have a significant impact on available spare capacity and therefore security of the existing network. Demand information, advised by consultants or developers, is added to the normal mass market demand forecast and captured in the year the load will be connected.

Our Key Account Managers play an important role identifying potential demand increases through their ongoing engagement with our larger customers. This ensures that we engage at an early stage with customers to ensure capacity is available when required.

In instances where Vector is aware of future developments (eg. subdivisions) allowance would be made in the demand forecast even if individual capacity requirements are not yet finalised. In cases of significant developments where the decisions by the developer to proceed are still uncertain, Vector uses its judgement based on past experience with the particular developer, the prevailing property market condition, information on demand for such development in the local area, etc. to decide if the total (or a portion of the) demand as requested by the developer should be included in the demand forecast.

In some cases the estimated impact of the development will be spread out to minimise the impact of the uncertainty. Uncertainty in timing of customer projects may mean that budgeted expenditure around a specific project may be postponed to the following financial year.

5.3.2.3 New Customer Connections Forecast

As noted above, the dominant drivers for electricity demand in the Auckland region are the number of ICPs on the network and the "one-off" changes due to, in large, customer demand. The bulk of ICPs are constituted by residential and, to a lesser degree, commercial customers.

Historical population and ICP growth in Vector's distribution area is indicated in Table 5-2. Over time there has been a small increase in the overall population/ICP ratio (2.6 to 2.7), although wider variability is seen when with annual population-ICP ratios (2.7 to 9.1).

	FY07	FY08	FY09	FY10	FY11	FY12	FY13[29]
Auckland population ('000)	1340.5	1362.9	1385.4	1407.8	1430.2	1452.4	1474.7
Vector ICP's ('000)	512	518	523	528	533	535	539
Population /ICP ratio	2.6	2.6	2.6	2.7	2.7	2.7	2.7
Annual population growth ('000)	22.4	22.4	22.4	22.4	22.4	22.2	22.2
Annual ICP growth ('000)	8.3	6.0	4.9	4.9	4.4	2.6	3.7
Ratio of annual population growth/annual ICP growth	2.7	3.7	4.6	4.6	5.1	8.5	5.9

Table 5-2 : Population and ICP trends in the Vector distribution area

Statistics NZ has projected population growth figures that will see the population of Auckland exceed 2 million people by 2031, which translates to 1.87 million within the Vector distribution area[30].

To closely reflect the differing growth on the Northern and Southern networks, ICP forecasts have been calculated for each network. The aggregated Vector forecast is shown in Table 5-3. The supporting ICP numbers are shown in Table 5-3. While this represents some risk of security level breaches should growth be more rapid than assumed, this is deemed acceptable given the significant degree of redundancy on the network (and hence that a security of supply breach is unlikely to automatically cause an outage). In addition, the asset investment plan is updated on an annual basis, reflecting actual ICP growth in the previous year. At the relatively low ICP growth rate foreseen, the impact of a one-year delay in investment is unlikely to be severe.

	FY12 Actual	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Population forecast ('000)	1452	1475	1497	1519	1541	1563	1586	1608	1630	1652	1674	1696
Population forecast growth ('%)	1.6%	1.5%	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%
Forecast Net ICP Connections ('000)	2.6	3.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.9	4.9
Forecast Total ICP Connections ('000)	535	539	544	549	554	559	564	569	574	579	584	588
ICP growth ('%)	0.5%	0.7%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.8%	0.8%

Table 5-3 : Vector ICP forecast

5.3.2.4 Impact of Embedded Generation on Electricity Demand

The number of generation applications processed in the 12 months to the end of September 2012 is given below:

- 10kW or less : 55
- greater than 10kW : 1

[29] FY13 values are a combination of actual and forecast values as the actual values were not known at the time of compiling this document

[30] Part of Franklin District is classified as within the Auckland region but is outside Vector's reticulation area

The below 10kW generators are generally photo-voltaic (PV) installations whereas the greater than 10kW are generally larger PV or fossil fuelled generators. This low level of fossil-fuelled distributed generation development (compared to the rate of demand growth) is expected to continue until the cost of embedded generation becomes sufficiently attractive to encourage investment. At present, and in the near future, the impact of embedded fossil-fuelled generation on Vector's future demand projection is expected to be small.

The installation of PV panels on the other hand is expected to grow at an increasing rate as the cost of PV reaches network-parity over the next few years. However the impact of PV on demand forecast at this stage is expected to be relatively minor as PV generation does not generally coincide with the network peak demand.

5.3.2.5 Impact of Demand Management on Electricity Demand

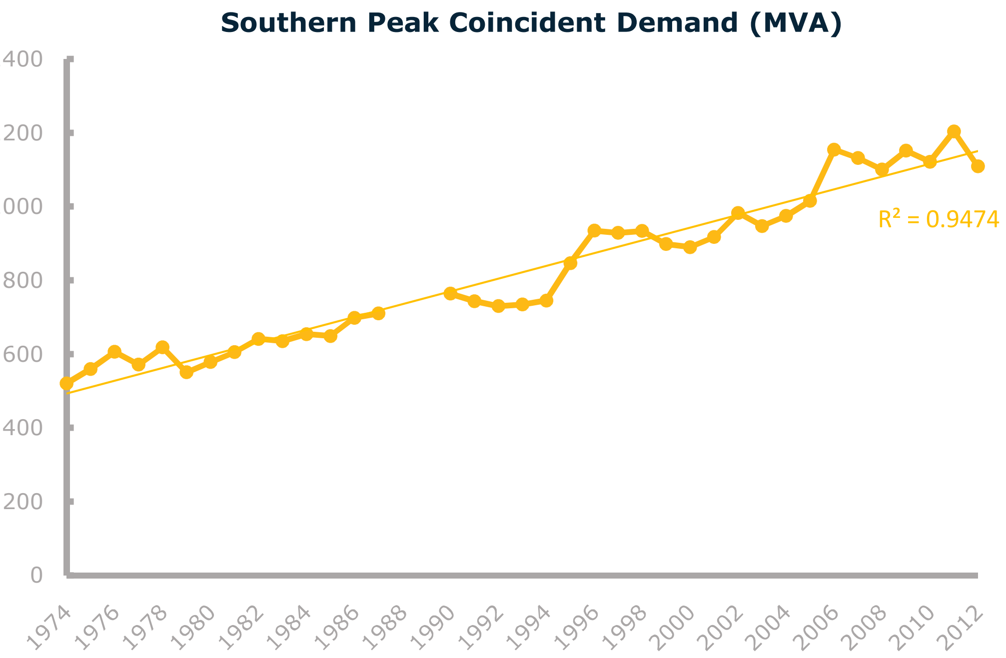
Vector has been using load control systems (ripple control systems, pilot wires, cyclo load control system) to manage network demand (by switching residential water heating systems) for over fifty years. Load control systems are also used to control street lighting. The effect of demand reduction due to the existing load control systems has already been captured in the current demand forecast on the basis that the load control strategy is not expected to change in the foreseeable future[31].

5.3.2.6 Historical Long-Term Electricity Demand Trend

In Figure 5-3 and Figure 5-4 below the long-term demand growth on the Southern and Northern distribution networks is indicated. As will be noted, although there are significant short-term fluctuations in demand, over time the growth is remarkably closely correlated with time (R^2 levels around 95%). Over this period the population in Vector's supply areas has grown at a relatively linear rate as well. The figures, therefore, confirm the strong relationship that exists between electricity demand and population, and by implication, ICP numbers. The trends also indicate that over time, at a highly aggregated network level, the influence of large customers on demand also tend to grow with population levels.

The demand trends could change over time, but such changes are likely to be very gradual and are unlikely to have a material impact on the short to medium-term planning window.

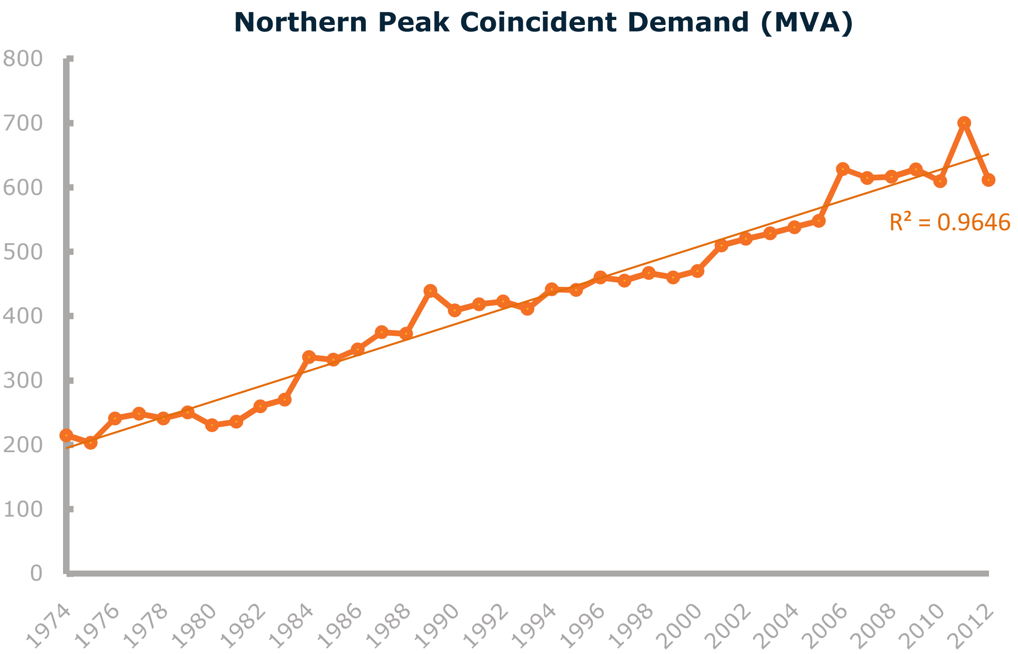
[31] This view will be revisited should the incentives or requirements of the market or regulatory environment change materially with respect to controlling network peak demand.



Notes : (a) Due to data problems, demand for 1988 and 1989 was not available

(b) The indicated correlation is with time

Figure 5-3 : Southern electricity network demand trend



Note : The indicated correlation is with time

Figure 5-4 : Northern electricity network demand trend

Figure 5-5 provides a schematic overview of Vector's electricity demand forecasting approach at different levels of network aggregation. A spreadsheet based model has been developed in which the actual forecasts are currently prepared.

Due to natural short-term variability in electricity demand and the inherent uncertainties associated with demand forecasting, consistently achieving an optimal investment point for network reinforcements is unlikely and situations may still arise where actual demand exceeds forecast demand and the security standards are therefore breached (for short periods). However, with the level of redundancy and switching flexibility that exists in the network, the ability to shed some load, and the relatively slow rate of growth, this does not represent a material risk to network operations or reliability[32].

5.3.2.7 Demand Forecasting at a Network or GXP Level

For forecasting electricity demand at a network or GXP level, the following factors are important:

- As illustrated in Figure 5-3 and Figure 5-4, the historical demand growth trends on the Vector network have been remarkably linear over time. Although the fluctuations around the linear growth trend are material, they tend to be relatively short-term in nature – certainly much shorter than the average life of electricity distribution assets.

  The results are replicated at a GXP level[33];
- Vector is continually monitoring emerging trends in energy demand and appliances. At present, we have not identified any factor that should materially influence average individual peak demand in the near future – although it is recognised that in the medium term factors such as increased use of electric vehicles are likely to materially impact demand[34]; and
- Population forecasts for Auckland indicate a relatively constant growth rate for the next 20 years.

Given the above, Vector believes that asset investment decisions at a network or GXP-level can be realistically based on assuming a linear demand growth pattern, using historical growth rates as basis. Investments at this level would typically relate to new GXPs or major sub-transmission reinforcements.

5.3.2.8 Demand Forecasting at a Disaggregated Level

Almost without exception, Vector's growth-related investments are required at a much more disaggregated network level.

a. Zone Substation and Feeder Level

At a zone substation or feeder level, factors such as changes in the customer mix (for example when commercial activity in a previously mainly residential area increases), or the impact of single large customers, can be material on overall forecasting. In addition, as part of network development, it is often necessary to reconfigure the network, thus moving customers between zone substations or feeders. The short-term impact of external factors such as weather patterns or economic cycles is also more noticeable at a zone-substation level – where customers often tend to be quite similar in nature, and spread over a limited geographical area, and hence likely to be subject to, and respond to, the same factors in the same manner.

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[32] A lower-risk approach could be to bring investments somewhat forward from the programme indicated by consideration of the demand forecasts and required security levels. Vector's analysis indicates that this would in general not be economically prudent.

[33] There are incidents when major load shifts at a GXP level can occur – for example when a new GXP is connected to the network – but these are infrequent, discrete step-changes which can be relatively easily accounted for in the forecasts.

[34] This is in the absence of major expansion of load shedding schemes, or incentives for consumers to reduce peak demands.

However, even at a zone substation or feeder level of disaggregation, the underlying demand patterns are still relatively stable and predominantly based on ICP numbers. Taking the above into account, Vector's demand forecasting approach at this level can be summarised as follows:

- In the absence of specific information that would indicate material changes in future demand (such as the addition or removal of a large customer, or a new subdivision planned for an area), future demand is forecast to be based on historical demand trends (with an emphasis on experience over the last five years), while adding the forecast future demand resulting from ICP growth;
- Where substantial additional (or reduced) demand is likely to arise over the planning period, this is superimposed over the underlying demand trend for a substation or feeder. Such loads are generally forecast based on discussions that Vector has with its large customers, developers and consultants about possible forthcoming developments, and an internal assessment is made about the likelihood of such developments. Significant demand pattern changes can also occur due to network reconfigurations;
- The potential demand impact of short-term fluctuating factors, such as weather patterns and economic cycles are not individually accounted for, but are taken into account through considering historical demand curves, specifically the potential that these have to add to demand peaks[35]. The degree of redundant supply capacity that exists is also taken into account:
    - For dual transformer substations – where a high degree of supply capacity redundancy exists, future demand forecasts will generally be set at the average of the indicated historical demand trends (a P50 level, or 50% probability of exceedance). This implies a relatively high likelihood that demand may exceed the N-1 capacity (or security standard) of a substation for a short period prior to it being reinforced. However, given the security is compromised rather than capacity, it is unlikely to lead to outages; and
    - For single transformer substations, the demand forecasts are set at a P90 level of the indicative historical demand curve range (a 10% probability remains that capacity may be exceeded). This reflects the lower capacity of these substations to manage higher than rated demand – thereby effectively bringing forward the point at which they have to be reinforced. If the substation is reinforced with a second transformer and sub-transmission circuit, the substation reverts to a P50 forecast;

[35] Networks have to be able to adequately cope with peak demand periods, and demand troughs are, therefore, of less interest for planning purposes.

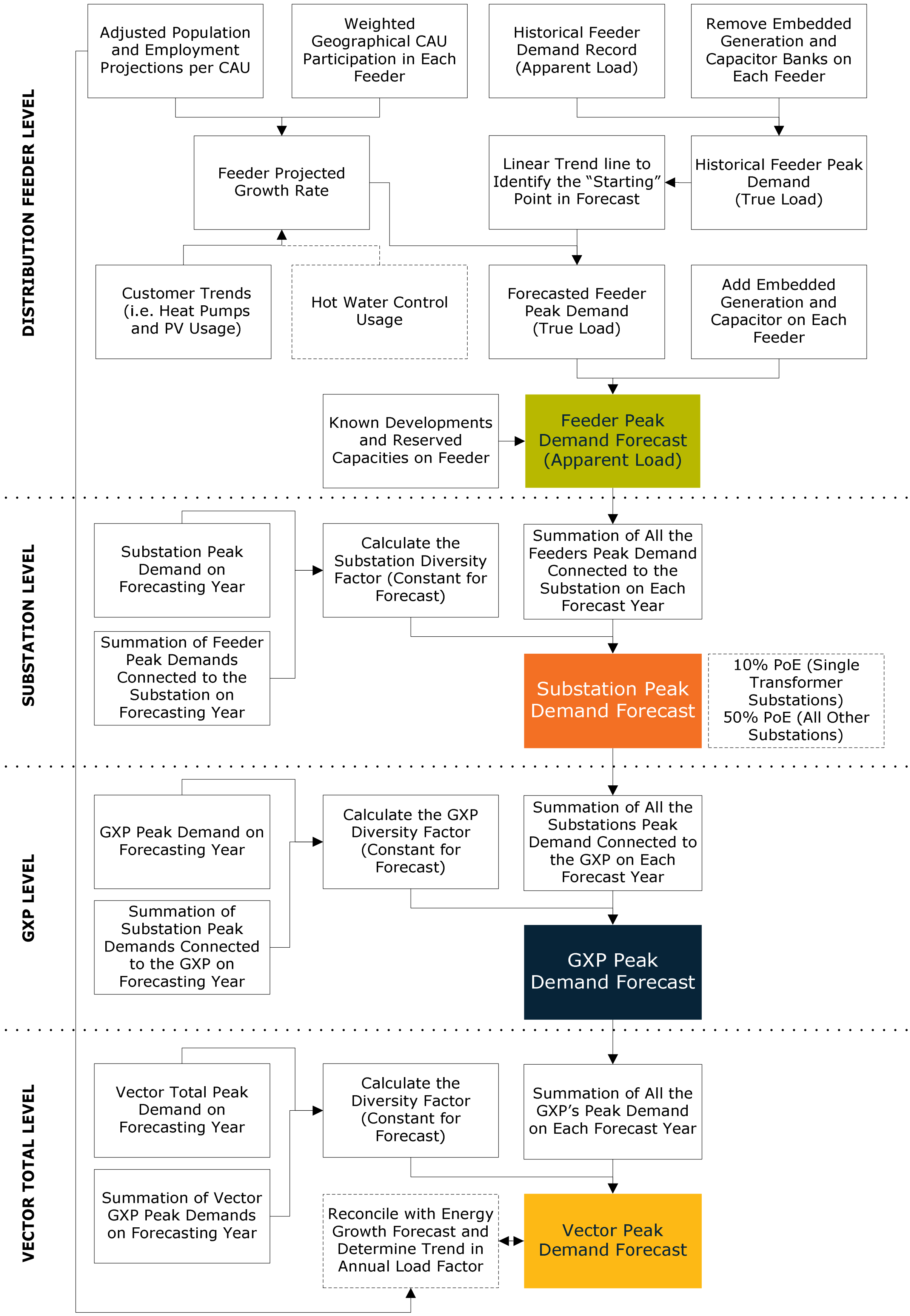

Figure 5-5 : Schematic representation of the Vector demand forecasting process

- Feeder demand is forecast on a P50 principle. Forecast demand is matched against spare backstop capacity from adjacent feeders to ensure there is sufficient capacity to meet the security requirements as shown in the Security Standards (Table 5-1). The ability to move "open-points" and shift load to adjacent feeders ensures that unexpected load caused by short-term effects, such as adverse weather, can adequately be catered for with a P50 model, avoiding a more conservative P90 forecast approach;
- Both summer and winter demand forecasts are prepared. The summer demand forecast is required to reflect the lower network capacity during warm periods;
- Adjustments are made for known, one-off network demand distortions such as brief high load due to load transfers, large demand increases/decreases and the installation of capacitor banks or embedded generation. Evident errors in historical data are also corrected;
- Network-connected, embedded generators are assumed to maintain current operating patterns. The impact of new embedded generation will be reflected in forecasts as information becomes available. Existing generation at landfill sites is monitored and decommissioning plans are reflected in the demand forecast;
- Vector has a load management system that can influence demand at an aggregated Vector level, and which is sometimes used for short-term network reinforcement deferral (see section 5.5.1 for further discussion); and
- The impact of emerging technologies and associated possible changes in energy consumption patterns are continually being assessed. Vector's best current view on this (see Section 3 for a discussion) has been accounted for in the demand forecasts[36]. Vector also conducts a what-if analysis on the demand forecasts to test the impact on investment plans should material changes in energy consumption occur. Realistic scenario assumptions do not indicate a need for material changes in the current investment plan.

b. Distribution Transformer and Low Voltage Level

At the lowest level of disaggregation demand forecasting is generally only done at the time of installing the assets – based on the anticipated final number of customers that will be connected. Should demand exceed the capacity of installed assets, the assets will be replaced (eg. transformers) or the local low-voltage network will be reinforced.

5.3.2.9 Demand Forecast for the AMP Period

The forecast zone substations and bulk in-feed substations demand is provided in Table 5-5 and Table 5-6 for summer and winter peak demand projections, respectively. Overall network demand forecast is indicated in Table 5-4. The total demand forecasts are an aggregation of P50 demand forecasts. These forecasts are based on the ICP forecasts discussed above and known large customer changes. The tables below provide the actual summer peak demand for the period November 2011 to February 2012 (FY12) and the actual winter peak demand for the period June 2012 to September 2012 (FY13).

[36] At present, the only technology potentially causing a material impact on demand within the planning period is the increased use of heat pumps.

Substation	Actual	Forecast Coincident Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Total Vector	1307	1344	1372	1400	1417	1422	1438	1452	1466	1474	1485
Total Southern	923	953	970	987	999	999	1010	1020	1029	1036	1044
Total Northern	433	441	454	466	471	476	482	487	491	494	497
Substation	**Actual**	**Forecast Coincident Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Total Vector	1714	1761	1783	1806	1832	1853	1876	1896	1914	1926	1938
Total Southern	1109	1135	1150	1166	1185	1200	1216	1230	1243	1251	1259
Total Northern	615	636	643	651	657	664	671	676	682	686	690

Table 5-4 : Vector network demand forecast (coincident peak)

Substation	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Atkinson Road	11.7	11.1	11.4	11.8	11.8	11.9	12.0	12.1	12.2	12.3	12.3
Auckland Airport	16.5	17.8	18.8	19.9	21.0	23.3	25.6	26.7	27.7	28.6	33.1
Avondale	18.5	18.7	18.8	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7
Bairds	17.0	17.0	17.2	17.5	17.6	17.7	17.9	18.0	18.1	18.2	18.3
Balmain	5.6	5.4	5.6	5.8	5.8	5.9	5.9	6.0	6.1	6.1	6.1
Balmoral[37]	9.8	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.1	13.1	13.1
Belmont	7.0	6.8	7.0	7.2	7.3	7.3	7.4	7.4	7.5	7.5	7.5
Birkdale	14.2	13.9	14.3	14.7	14.8	14.9	15.0	15.1	15.2	15.3	15.4
Brickworks	7.3	8.1	8.2	8.3	8.4	8.5	8.5	8.6	8.6	8.7	8.7
Browns Bay	10.5	10.6	11.0	11.4	11.5	11.6	11.7	11.8	12.0	12.0	12.1
Bush Road	22.5	22.8	25.4	25.5	25.7	25.8	25.9	26.0	26.1	26.2	26.3
Carbine	19.3	18.5	19.4	19.5	19.5	19.5	19.6	19.6	19.7	19.7	19.8
Chevalier	10.8	10.9	10.9	11.0	11.0	11.1	11.1	11.2	11.2	11.2	11.3
Clendon	12.4	12.6	12.8	13.1	13.1	13.2	13.3	13.4	13.4	13.5	13.5
Clevedon	2.0	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3
Coatesville	6.5	6.4	6.7	6.9	7.0	7.0	7.1	7.2	7.3	7.3	7.4
Drive	16.6	16.7	17.0	17.3	17.5	17.8	18.0	18.1	18.2	18.2	18.3

[37] St Lukes load increase

Substation	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
East Coast Road	9.9	10.2	10.4	10.7	10.7	10.8	10.9	11.0	11.0	11.1	11.1
East Tamaki	14.2	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3
Forrest Hill	9.7	9.7	10.1	10.4	10.5	10.5	10.6	10.7	10.8	10.8	10.9
Freemans Bay	18.1	18.2	18.9	19.6	19.7	19.8	20.0	20.1	20.2	20.3	20.4
Glen Innes	5.7	6.0	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4	6.5
Greenhithe	9.2	9.4	9.9	10.3	10.5	10.8	11.0	11.3	11.5	11.7	11.9
Greenmount	35.3	35.0	35.2	35.4	35.5	35.6	35.6	35.7	35.8	35.7	35.7
Gulf Harbour	4.3	4.5	4.6	4.7	4.8	4.8	4.9	4.9	4.9	5.0	5.0
Hans	22.1	21.9	22.1	22.4	22.5	22.7	22.8	23.0	23.1	23.2	23.3
Hauraki	7.4	7.7	7.9	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.6
Helensville	9.5	9.5	9.9	10.2	10.3	10.4	10.6	10.7	10.9	11.0	11.1
Henderson Valley	15.3	16.6	16.9	17.3	17.4	17.6	17.8	17.9	18.1	18.2	18.3
Highbrook	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Highbury	7.6	8.9	9.1	9.3	9.4	9.5	9.6	9.7	9.8	9.8	9.9
Hillcrest	16.9	17.4	17.7	18.1	18.3	18.5	18.7	18.9	19.0	19.1	19.2
Hillsborough	8.9	9.0	9.1	9.1	9.2	9.2	9.3	9.3	9.4	9.4	9.4
Hobson 110/11kV	22.1	21.7	22.0	22.3	22.4	22.5	22.6	22.7	22.8	22.9	23.0
Hobson 22/11kV	19.9	20.2	20.5	20.9	21.0	21.2	21.3	21.5	21.6	21.8	21.9
Hobson 22kV	63.0	72.3	74.3	76.7	78.1	79.5	80.4	81.3	82.2	83.1	84.0
Hobson 22kV distribution	6.5	7.6	8.3	9.4	10.5	11.6	12.1	12.7	13.3	13.8	14.4
Hobsonville	12.0	12.4	12.7	13.1	13.2	13.4	13.5	13.7	13.8	13.9	14.0
Hospital	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Howick	21.6	20.8	21.2	21.6	21.8	21.9	22.1	22.3	22.4	22.5	22.6
James Street	13.4	14.0	14.4	14.7	14.8	14.9	15.1	15.2	15.3	15.3	15.4
Keeling Road	14.2	14.3	14.5	14.8	15.0	15.1	15.2	15.4	15.5	15.6	15.7
Kingsland	17.5	17.9	18.2	18.5	18.6	18.7	18.8	19.0	19.1	19.2	19.3
Kingsland 22kV	37.6	36.7	37.1	37.5	37.7	37.9	38.1	38.3	38.5	38.6	38.8
Laingholm	5.6	5.6	5.8	6.0	6.0	6.0	6.1	6.1	6.2	6.2	6.2

Substation	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Liverpool	42.7	44.5	45.2	45.8	46.0	46.2	46.5	46.7	46.9	47.2	47.4
Liverpool 22kV	79.0	80.2	81.7	83.2	84.4	85.6	86.3	87.0	88.0	89.0	90.0
Liverpool 22kV distribution	10.4	11.3	12.0	12.7	13.6	14.4	14.8	15.1	15.8	16.4	17.0
Mangere Central	20.0	19.3	19.6	19.9	20.0	20.1	20.3	20.4	20.5	20.5	20.6
Mangere East	16.5	15.8	16.3	16.8	17.0	17.3	17.6	17.9	18.1	18.4	18.6
Mangere West	18.7	16.9	16.9	17.0	17.0	17.0	17.1	17.1	17.1	17.1	17.1
Manly	9.5	10.1	10.4	10.6	10.7	10.8	10.9	11.0	11.0	11.1	11.2
Manukau	22.5	22.2	22.5	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.1
Manurewa	32.5	31.6	32.1	32.7	32.9	33.1	33.4	33.6	33.8	33.9	34.1
Maraetai	3.7	3.8	4.0	4.2	4.3	4.4	4.5	4.6	4.7	4.7	4.8
McKinnon	20.9	23.8	24.4	25.0	25.4	25.8	26.3	26.7	27.2	27.4	27.5
Mcleod Road	9.0	9.8	10.1	10.3	10.4	10.5	10.6	10.7	10.8	10.9	10.9
McNab	39.8	40.4	40.6	41.3	41.8	42.4	42.9	43.0	43.2	43.3	43.4
Milford	5.0	5.2	5.3	5.5	5.6	5.7	5.7	5.8	5.9	5.9	5.9
Mt Albert	5.7	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.6	4.6	4.6
Mt Wellington	17.7	18.5	18.7	18.9	19.0	19.1	19.1	19.2	19.3	19.4	19.5
New Lynn	8.9	9.4	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.4	10.5
Newmarket[38]	32.2	40.1	40.7	41.4	42.4	43.4	44.4	45.4	46.4	47.4	48.3
Newton	15.7	16.2	16.3	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2
Ngataringa Bay	7.2	7.1	7.2	7.3	7.3	7.3	7.3	7.3	7.3	7.4	7.4
Northcote	5.2	4.8	4.9	5.0	5.1	5.1	5.1	5.2	5.2	5.2	5.3
Onehunga	9.9	10.9	10.9	11.0	11.1	11.1	11.2	11.2	11.3	11.4	11.4
Orakei	12.6	12.8	13.2	13.6	13.7	13.7	13.8	13.8	13.9	13.9	14.0
Oratia	3.6	3.8	3.9	4.0	4.0	4.0	4.1	4.1	4.1	4.2	4.2
Orewa	9.5	10.1	10.7	11.3	11.8	12.2	12.6	12.8	12.9	13.0	13.1
Otara	28.7	22.7	23.8	26.7	28.1	29.5	30.9	32.4	33.8	35.3	36.7
Pacific Steel	52.2	52.2	52.2	52.2	52.2	52.2	52.2	52.2	52.2	52.2	52.2

[38] 309 Broadway load increase

Substation	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Pakuranga	13.7	13.6	14.1	14.5	14.7	15.0	15.3	15.5	15.8	16.0	16.3
Papakura	18.6	18.1	18.4	18.6	18.7	18.9	19.0	19.1	19.2	19.2	19.3
Parnell	8.6	8.6	8.8	8.9	8.9	9.4	9.8	10.3	10.7	10.8	10.9
Ponsonby	8.9	9.5	9.6	9.7	9.7	9.7	9.8	9.8	9.9	9.9	9.9
Quay	22.6	23.1	24.5	26.0	27.6	27.7	27.8	27.9	28.0	28.2	28.3
Quay 22kV	31.1	31.5	33.0	34.5	36.2	36.7	37.3	37.9	38.4	38.6	38.8
Quay 22kV distribution	8.0	7.8	7.9	8.1	8.1	8.2	8.3	8.3	8.4	8.4	8.5
Ranui	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Red Beach	8.7	9.4	10.1	10.7	11.3	11.9	12.0	12.2	12.2	12.3	12.4
Remuera	14.1	15.0	15.7	16.4	17.2	18.1	18.9	19.7	20.2	20.3	20.4
Riverhead	7.2	7.7	7.9	8.2	8.3	8.5	8.6	8.8	8.9	9.0	9.1
Rockfield	14.5	16.4	16.5	16.6	17.7	18.8	19.9	21.0	21.0	21.1	21.1
Rosebank	18.9	18.0	18.1	18.2	18.3	18.3	18.4	18.5	18.5	18.6	18.7
Sabulite Road	11.5	10.9	11.2	11.6	11.7	11.8	11.9	12.0	12.2	12.2	12.3
Sandringham	13.5	13.4	13.5	13.5	13.6	13.6	13.7	13.8	13.8	13.9	13.9
Sandringham 22kV	24.4	26.8	26.9	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8
Simpson Road	5.2	4.9	5.0	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.5
Snells Beach	4.4	4.4	4.5	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1
South Howick	17.3	15.9	16.3	16.6	16.7	16.7	16.8	16.9	17.0	17.0	17.0
Spur Road	9.6	9.9	10.3	10.6	10.8	11.0	11.2	11.4	11.5	11.7	11.8
St Heliers	12.2	12.2	12.3	12.4	12.5	12.5	12.6	12.7	12.7	12.8	12.9
St Johns	12.2	13.6	15.0	15.8	16.6	17.4	18.1	18.9	19.5	19.7	20.0
St Johns 33kV	37.3	39.1	41.0	42.3	43.3	44.2	45.1	46.0	46.7	47.1	47.4
Sunset Road	14.4	14.9	15.2	15.4	15.5	15.5	15.6	15.7	15.8	15.9	15.9
Swanson	8.7	8.8	9.1	9.4	9.6	9.7	9.8	9.9	10.0	10.1	10.2
Sylvia Park	15.0	17.7	17.8	18.7	19.7	20.6	21.5	22.0	22.5	22.6	22.6
Takanini	10.6	11.6	11.8	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7
Takapuna	9.0	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.0

Substation	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Te Atatu	15.3	15.2	15.6	16.1	16.3	16.5	16.7	16.9	17.1	17.2	17.3
Te Papapa	22.7	24.3	24.4	24.6	24.7	24.7	24.8	24.9	25.0	25.1	25.1
Torbay	4.3	5.0	5.2	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.8
Triangle Road	11.9	12.5	12.8	13.2	13.4	13.6	13.7	13.9	14.0	14.1	14.2
Victoria	26.2	26.8	27.1	27.5	27.6	27.7	27.9	28.0	28.1	28.2	28.4
Waiake	5.3	5.8	5.9	6.1	6.2	6.2	6.3	6.4	6.4	6.4	6.5
Waiheke	6.8	7.1	7.3	7.6	7.7	7.8	7.8	7.9	8.0	8.1	8.1
Waikaukau	6.1	5.7	5.9	6.1	6.2	6.2	6.3	6.4	6.4	6.5	6.5
Waimauku	4.5	4.5	4.6	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.2
Wairau	14.8	14.5	14.7	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.6
Wairau 110kV	81.6	82.3	104.1	106.5	107.4	108.3	109.2	110.1	111.0	111.5	112.0
Warkworth	12.9	13.3	13.6	14.0	14.1	14.3	14.5	14.6	14.8	14.9	15.0
Wellsford	6.4	5.6	5.7	5.8	5.9	6.0	6.0	6.1	6.1	6.2	6.2
Westfield	29.9	30.5	30.7	31.0	31.1	31.2	31.4	31.5	31.6	31.8	31.9
White Swan	17.5	18.3	18.4	18.5	18.6	18.7	18.8	18.9	19.0	19.0	19.1
Wiri	38.0	38.3	38.6	38.9	39.2	39.4	39.7	40.0	40.2	40.4	40.6
Woodford	10.0	8.8	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.6	9.7

Table 5-5 : Summer peak demand projection for the bulk supply substations and zone substations for the Northern and Southern regions

Substation	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Atkinson Road	18.1	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9
Auckland Airport	15.7	16.0	17.0	18.1	19.2	20.3	22.6	24.9	25.9	26.9	27.9
Avondale	27.8	29.9	30.1	30.4	30.6	30.8	31.0	31.3	31.5	31.6	31.8
Bairds	26.3	26.6	26.7	26.9	27.0	27.2	27.3	27.5	27.6	27.7	27.8
Balmain	9.7	8.6	8.6	8.7	8.8	8.8	8.9	8.9	9.0	9.0	9.0
Balmoral	14.9	17.8	17.9	18.0	18.1	18.2	18.3	18.3	18.4	18.5	18.6
Belmont	13.1	13.7	13.7	13.8	13.9	13.9	14.0	14.0	14.1	14.2	14.2
Birkdale	22.6	23.1	23.2	23.3	23.4	23.6	23.7	23.8	23.9	24.0	24.1

Substation	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Brickworks	8.1	7.7	7.8	7.9	7.9	8.0	8.0	8.1	8.1	8.2	8.2
Browns Bay	16.4	16.9	17.0	17.2	17.3	17.5	17.6	17.8	17.9	18.0	18.1
Bush Road	23.5	26.1	26.2	26.3	26.4	26.6	26.7	26.8	26.9	27.0	27.1
Carbine	17.0	16.2	17.0	17.1	17.1	17.2	17.3	17.4	17.4	17.5	17.5
Chevalier	19.5	19.6	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.3	20.4
Clendon	18.4	18.5	18.6	18.7	18.7	18.8	18.9	18.9	19.0	19.1	19.1
Clevedon	3.0	3.2	3.2	3.2	3.3	3.3	3.3	3.3	3.4	3.4	3.4
Coatesville	9.7	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0
Drive	26.5	28.2	28.6	29.0	29.4	29.8	30.2	30.3	30.4	30.5	30.6
East Coast Road	16.7	17.4	17.5	17.6	17.7	17.7	17.8	17.9	18.0	18.1	18.1
East Tamaki	16.7	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
Forrest Hill	17.8	18.5	18.6	18.7	18.8	18.9	19.0	19.1	19.2	19.3	19.3
Freemans Bay	19.8	20.4	21.1	21.8	22.0	22.3	22.5	22.7	23.0	23.1	23.2
Glen Innes	10.0	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.3
Greenhithe	13.2	13.5	13.9	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.2
Greenmount	38.0	38.8	38.9	39.1	39.1	39.2	39.3	39.3	39.4	39.3	39.3
Gulf Harbour	7.1	7.5	7.6	7.6	7.7	7.7	7.8	7.8	7.9	7.9	8.0
Hans	24.5	24.9	25.1	25.3	25.4	25.6	25.7	25.9	26.1	26.2	26.3
Hauraki	8.9	9.1	9.2	9.3	9.3	9.4	9.5	9.6	9.6	9.7	9.7
Helensville	13.3	13.4	13.6	13.7	13.9	14.1	14.2	14.4	14.6	14.7	14.8
Henderson Valley	16.7	17.8	18.0	18.1	18.3	18.4	18.6	18.7	18.9	19.0	19.1
Highbrook	5.2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Highbury	10.5	13.6	13.8	13.9	14.0	14.1	14.2	14.3	14.5	14.5	14.6
Hillcrest	22.5	23.5	23.8	24.0	24.2	24.4	24.7	24.9	25.1	25.2	25.4
Hillsborough	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3
Hobson 110/11kV	20.4	18.3	18.6	18.8	19.1	19.3	19.6	19.8	20.1	20.2	20.3
Hobson 22/11kV	16.8	17.2	17.5	17.9	18.2	18.5	18.9	19.2	19.6	19.8	19.9

Substation	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Hobson 22kV[39]	59.2	68.0	70.0	72.4	74.3	76.2	77.8	79.3	80.9	81.8	82.7
Hobson 22kV distribution	7.5	7.7	8.3	9.4	10.5	11.6	12.3	12.9	13.6	14.2	14.7
Hobsonville	19.0	21.6	21.8	22.1	22.3	22.5	22.7	22.9	23.1	23.3	23.5
Hospital	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Howick	38.3	40.8	41.0	41.2	41.4	41.6	41.8	42.0	42.2	42.4	42.6
James Street	19.7	20.2	20.3	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2
Keeling Road	13.7	14.8	14.9	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.8
Kingsland	21.9	22.1	22.4	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.1
Kingsland 22kV	59.5	59.9	60.5	61.0	61.4	61.8	62.2	62.6	62.9	63.3	63.6
Laingholm	9.1	9.5	9.5	9.5	9.6	9.6	9.7	9.7	9.7	9.7	9.8
Liverpool	40.9	41.0	41.6	42.2	42.8	43.4	44.0	44.6	45.2	45.4	45.6
Liverpool 22kV[40]	92.3	87.1	88.3	89.6	90.9	92.3	93.8	95.2	97.0	98.1	99.2
Liverpool 22kV distribution	9.7	10.1	10.3	10.5	10.9	11.4	11.8	12.2	12.9	13.6	14.2
Mangere Central	25.1	25.5	25.7	26.0	26.1	26.2	26.4	26.5	26.6	26.7	26.8
Mangere East	25.3	26.1	26.4	26.7	27.1	27.5	27.8	28.2	28.6	29.0	29.4
Mangere West	16.9	16.9	16.9	17.0	17.0	17.0	17.0	17.1	17.1	17.1	17.1
Manly	18.4	19.2	19.3	19.5	19.6	19.7	19.8	19.9	20.1	20.2	20.3
Manukau	28.5	28.7	29.0	29.2	29.5	29.8	30.0	30.3	30.6	30.8	31.0
Manurewa	45.3	45.9	46.2	46.4	46.7	46.9	47.2	47.4	47.7	47.9	48.1
Maraetai	6.3	5.9	6.1	6.2	6.3	6.4	6.5	6.6	6.8	6.9	7.0
McKinnon	21.6	22.3	22.7	23.2	23.6	24.0	24.4	24.8	25.3	25.5	25.7
Mcleod Road	12.0	13.0	13.1	13.2	13.3	13.5	13.6	13.7	13.8	13.9	14.0
McNab	46.7	47.4	47.7	48.5	49.2	50.0	50.8	51.1	51.4	51.6	51.7
Milford	7.6	7.6	7.7	7.7	7.8	7.9	8.0	8.1	8.1	8.2	8.2
Mt Albert	7.6	7.6	7.7	7.7	7.8	7.8	7.9	7.9	8.0	8.0	8.0
Mt Wellington	19.7	20.2	20.4	20.6	20.8	21.0	21.2	21.4	21.6	21.7	21.8

[39] Load transfer from Liverpool
[40] Load transfer to Hobson

Substation	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
New Lynn	13.9	14.5	14.6	14.7	14.8	15.0	15.1	15.2	15.3	15.4	15.6
Newmarket	35.1	41.9	42.7	43.5	44.5	45.5	46.6	47.6	48.6	49.6	50.5
Newton	18.7	18.9	19.1	19.4	19.6	19.8	20.0	20.3	20.5	20.6	20.8
Ngataringa Bay	7.9	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.6	8.6
Northcote	8.4	7.3	7.4	7.4	7.5	7.6	7.6	7.7	7.7	7.8	7.8
Onehunga	14.7	15.2	15.4	15.6	15.7	15.8	16.0	16.1	16.3	16.4	16.5
Orakei	21.8	22.3	22.9	23.4	23.8	23.9	24.0	24.1	24.2	24.2	24.3
Oratia	5.3	5.7	5.7	5.8	5.8	5.8	5.9	5.9	6.0	6.0	6.0
Orewa	14.6	16.2	17.2	18.2	19.1	20.1	21.1	21.3	21.6	21.7	21.9
Otara	30.2	31.6	33.6	39.3	42.2	45.1	48.1	51.1	54.2	57.3	60.3
Pacific Steel	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
Pakuranga	22.5	23.7	24.0	24.3	24.6	25.0	25.4	25.8	26.2	26.5	26.9
Papakura	25.2	25.9	26.0	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.8
Parnell	9.9	10.5	10.6	10.7	10.8	11.4	11.9	12.5	13.1	13.1	13.2
Ponsonby	15.7	15.7	15.8	15.9	16.0	16.0	16.1	16.2	16.2	16.3	16.4
Quay	21.6	21.9	23.3	24.7	26.3	26.6	26.9	27.2	27.5	27.6	27.8
Quay 22kV	32.2	33.8	35.4	37.0	38.8	39.7	40.5	41.4	42.3	42.6	42.8
Quay 22kV distribution	6.8	7.3	7.5	7.6	7.8	7.9	8.1	8.2	8.4	8.4	8.5
Ranui	10.2	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7
Red Beach	14.8	15.9	17.0	18.1	19.2	20.3	20.5	20.8	20.9	21.1	21.2
Remuera	27.1	27.7	28.7	29.8	30.8	31.9	32.9	34.0	34.6	35.2	35.3
Riverhead	10.4	10.9	11.1	11.3	11.5	11.7	11.9	12.0	12.2	12.4	12.5
Rockfield	21.5	20.8	21.0	21.1	22.3	23.5	24.8	26.0	26.1	26.2	26.3
Rosebank	21.7	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6
Sabulite Road	19.9	19.5	19.7	19.9	20.0	20.2	20.4	20.6	20.8	20.9	21.1
Sandringham	20.7	20.8	20.9	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.7
Sandringham 22kV	35.0	38.0	38.2	38.4	38.6	38.7	38.9	39.1	39.3	39.4	39.6
Simpson Road	4.7	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.3	4.3

Substation	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Snells Beach	6.0	6.2	6.2	6.3	6.4	6.4	6.5	6.6	6.6	6.7	6.7
South Howick	28.6	29.9	30.0	30.1	30.1	30.2	30.3	30.4	30.4	30.5	30.5
Spur Road	9.9	10.0	10.2	10.4	10.6	10.7	10.9	11.1	11.2	11.3	11.5
St Heliers	21.9	22.0	22.2	22.3	22.4	22.6	22.7	22.8	22.9	23.1	23.2
St Johns	16.4	18.2	20.2	21.3	22.5	23.8	25.1	26.4	27.5	27.9	28.3
St Johns 33kV	60.6	62.6	65.2	67.0	68.7	70.2	71.7	73.2	74.6	75.2	75.8
Sunset Road	17.6	17.7	17.8	17.9	18.0	18.1	18.1	18.2	18.3	18.4	18.4
Swanson	9.8	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5
Sylvia Park	16.2	17.6	17.7	18.7	19.6	20.6	21.5	22.1	22.6	22.7	22.8
Takanini	13.9	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.6
Takapuna	8.7	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.7
Te Atatu	20.6	21.5	21.8	22.0	22.3	22.5	22.8	23.0	23.3	23.4	23.5
Te Papapa	23.6	23.7	23.9	24.0	24.2	24.3	24.5	24.6	24.8	24.8	24.9
Torbay	7.2	8.6	8.7	8.8	8.9	9.0	9.0	9.1	9.2	9.3	9.3
Triangle Road	16.0	16.7	16.9	17.1	17.3	17.4	17.6	17.8	18.0	18.1	18.2
Victoria	24.3	24.7	25.1	25.5	25.8	26.2	26.5	26.9	27.3	27.4	27.5
Waiake	9.1	9.6	9.7	9.8	9.8	9.9	10.0	10.1	10.2	10.2	10.2
Waiheke	10.7	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0
Waikaukau	7.1	7.1	7.1	7.2	7.2	7.3	7.4	7.4	7.5	7.5	7.6
Waimauku	6.8	7.0	7.0	7.1	7.2	7.3	7.4	7.5	7.5	7.6	7.7
Wairau	15.9	16.0	16.1	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0
Wairau 110kV[41]	123.1	161.9	163.0	164.2	165.3	166.4	167.5	168.6	169.7	170.5	171.2
Warkworth	17.5	17.5	17.7	17.9	18.1	18.3	18.5	18.7	18.9	19.0	19.1
Wellsford	7.9	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.5	8.5	8.6
Westfield	28.7	30.2	30.5	30.8	31.0	31.3	31.5	31.7	32.0	32.1	32.3
White Swan	29.1	30.8	30.9	31.1	31.3	31.5	31.6	31.8	32.0	32.1	32.3
Wiri	37.0	37.2	37.5	37.8	38.0	38.3	38.5	38.8	39.0	39.2	39.4

[41] Load transfer from Albany following commissioning of Wairau Rd GXP

Substation	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Woodford	10.6	10.4	10.5	10.6	10.6	10.7	10.8	10.9	11.0	11.1	11.1

Table 5-6 : Winter peak demand projection for zone substations for the Northern and Southern regions

5.3.3 Equipment Rating

To enable the capacity of the delivery points (zone substations and feeders) to be assessed, it is necessary to have a reliable assessment of the capacities of the major network components.

All equipment (transformers, cables, switchgear, etc) has a rated load carrying capacity depending on the demand characteristics (flat, fluctuating or cyclic) of the load they serve and the environment in which the equipment operates (ambient temperature, proximity with other equipment, ability for heat dissipation, etc.). The overall capacity of a circuit is based on the capacity constraint of the individual components.

Where load patterns allow, the circuit capacity takes into account cyclical or short-term capacity ratings, rather than the flat, long-term rating. This allows lower capacity equipment to be used in areas where peak demands do not persist for extended periods.

Peak and cyclical demands are, therefore, taken into account in Vector's demand forecasts.

The major network components include:

- Underground cables;
- Overhead lines;
- Transformers; and
- Switchboards.

Determining the capacities of these network components requires a detailed assessment of each sub-component. (For example, in assessing the capacity of a transformer, ratings of the bushings, tap changer and other accessories are also assessed to ensure the sub-component with the lowest rating which determines the overall asset rating is identified.)

The following paragraphs describe how the capacities of the network components are assessed. In all cases, asset capacities are not only assessed at normal full-load ratings, but also the cyclical and/or short-term ratings are determined.

5.3.3.1 Cables

The analysis of MV cable ratings is complex, due to the major influence of external factors such as cable type and circuit configuration, installation practices, surrounding soil composition and moisture content, solar gain, proximity of other circuits and preloading conditions. Vector uses the cable rating modelling tool "CYMCAP," a product of CYME Corp of Canada to perform ampacity and temperature rise calculations for power cable installations. This software tool is used to determine the maximum current power cables can sustain without causing deterioration or failure of their electrical properties.

5.3.3.2 Overhead Lines

Environmental and operating conditions play a large part in determining the capacity of overhead lines. Factors such as temperature (minimum, maximum, average), wind velocity and solar gain, coupled with initial sag and tension calculations, determine maximum operating ratings, while factors such as humidity, pollution level, altitude and rain levels affect the insulation and support designs. Vector uses the methodology defined in IEEE Standard 738:1993 for calculating conductor ratings.

A computer package called "CONAMP" is used to determine the maximum rating of OH conductors.

5.3.3.3 Transformers

Technical specifications for the purchase of power transformers reflect Vector's network planning standards and network operating practices. Transformer specifications have varied over the years from the very early versions of British Standard BS-171 to the latest Australian Standard AS-2374, resulting in different thermal and loading guides for transformers conforming to the various standards.

Southern region power transformers have been designed around a base rating (usually ONAN) with a two hour extended operating (emergency) rating. The intent of the extended operating range is to provide overload capacity for a limited time to allow time for network switching to mitigate the conditions[42].

Northern region power transformers were specified following a British standard based on a 12/24 hour cyclic rating scheme. This is interpreted as a maximum operating rating without additional overload or emergency rating.

Power transformers purchased since 2004 have been based on Vector Standard ENS-0120 which is an adaption of AS-2374 to Vector's specific requirements. Under this specification, transformers can operate up to 150% of nameplate rating for up to two hours (provided that the pre-contingent loading is no more than 75% of the nameplate rating), with a 120% of ONAN for normal cyclic loading.

Regardless of the transformer specification, Vector has three operating temperature limits:

- Top oil temperature - 105ºC;
- Conductor hot-spot temperature - 125ºC; and
- Metallic part temperature - 135ºC.

Subject to the transformer operating within these temperature limits, the transformer capacities are reviewed in accordance with demand profiles to determine whether higher ratings may be achieved without marked degradation of transformer lives.

5.3.3.4 Switchboards and Switchgear

Indoor electrical distribution switchboards and outdoor switchgear are manufactured and tested to varying international and domestic electrical standards. Switchboard testing is based on nominal (environmental) operating conditions whereas switchgear (primarily outdoor apparatus) takes into consideration an outdoor operating environment.

Switchboards and switchgear on the Vector network can be operated to the manufacturers' nameplate values. These ratings are derived by the OEM type tests performed to the standards specified when the equipment is purchased.

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[42] It should be noted that the two hour emergency rating is not the same on all power transformers on the network. The OEM type test certificates and design specification need to be referred to determine the two hour emergency rating.

5.3.3.5 Fault Level

A fault on the network would generally result in high current flowing into the faulty component. The maximum current that can flow determines the required fault level of components. The effects of a fault current impact on the network component in the following manner:

- Heating effect: The fault current creates localised heating in the vicinity of the fault. The magnitude of the heating varies in proportion to the duration of the fault, resistance of the network component and the square of the fault current;
- Magnetic force: The large magnetic field caused by the fault current manifests itself as mechanical stress on the components leading to mechanical failure; and
- Arc breaking: The ability of the network isolation devices on the network to isolate the fault and interrupt the fault current.

Network components have to be designed to withstand the mechanical forces and heating effects that will be experienced during fault conditions. If, during a fault, fault levels are exceeded, this can lead to catastrophic failure of equipment with severe associated health and safety risks. Equipment is, therefore, purchased to meet the maximum fault levels (prospective fault level) expected on the network. These are shown in Table 5-7.

Supply Voltage	Prospective Fault Current
110kV	31.5kA
33kV	25.0kA
22kV sub-transmission	25.0kA
22kV distribution	20.0kA
11kV distribution	13.1kA

Table 5-7 : Fault levels

Fault levels are determined through a combination of factors, mainly by the fault capacity of the bulk supply points, the impedance between a fault and the point of supply and the type of fault that occurs. Vector's distribution network is designed and built around the values stated in the above table. (In Section 2.3.2.4 the actual calculated fault levels at Vector's zone substations are listed.)

Fault levels can be exceeded in localised areas where substantial levels of distributed generation (including solar cell generation) are connected to the distribution network. Vector, therefore, has to monitor the impact of generation devices, and consider limits on how much capacity can be connected to the network (without requiring investment in fault limiting devices).

5.3.4 Technical Standards and Regulations

The distribution of electricity in New Zealand is regulated though a number of standards and codes. These have to be adhered to and therefore taken into account as part of the network planning process. Some of the key requirements that impact significantly on network planning are discussed below.

In addition, Vector has also published a distribution code, in which it sets out the obligations on customers that connect to its distribution network and explains network parameters that customers should be aware of when designing their own installations and connection points.

5.3.4.1 Voltage Limits

Regulation 28 of the Electricity (Safety) Regulations 2010 requires that standard LV supply voltages (230V single phase or 400V three phase) must be kept within +/-6% of the nominal supply voltage, calculated at the point of supply except for momentary fluctuation. Supplies made at other voltages are by agreement with the retailer or the customer and must be kept within +/-6% of the agreed nominal supply voltage, except for momentary fluctuation, unless agreed otherwise with the retailer or the customers.

Design of the network takes into account the voltage variability due to changes in loading and embedded generation under normal and contingency conditions.

5.3.4.2 Power Factor

The Electricity Authority is proposing to amend the Connection Code, incorporated into the Electricity Industry Participation Code 2010 by reference, to set a minimum power factor of 0.95 lagging for all regions[43]. This pragmatic outcome recognises that the maintenance of the current unity power factor requirement is impractical in practice, and not economically efficient when compared with the small benefit it brings[44]. Vector has an agreement on non-compliance with the Connection Code with Transpower[45].

5.3.4.3 Power Quality

AS/NZS 6100 - Electromagnetic Compatibility, Parts 3.2 – 3.7 specify levels of harmonic content and voltage flicker which are acceptable on the network. These have been adopted by Vector.

5.3.4.4 Distribution Code

Vector has published the Distribution Code[46] on its website. The code specifies the requirements that customers connected to the distribution network must comply with to ensure safety of other users of the network and the quality of the service delivered. It also provides reference to earthing, connection to Vector's network, load signalling equipment and frequencies, requirements for the connection of embedded generation, demand control and management, contingency planning and operational coordination between parties using the network, network safety and general planning information.

5.3.5 Service Levels

Vector has developed a set of standards that specify the minimum service levels that apply to customers connecting to its network[47]:

- These service levels are described in the "Use of Network Agreement" (UNA) on the Northern network between Vector and retailers, and the "Network Access

[43] Transmission pricing methodology review, Overview of issues and the Electricity Authority's proposal p6, dated 10 October 2012.

[44] Due to the fluctuating nature of electricity loads (even at peak), the difficulty of fine-tuning reactive compensation schemes and the sophisticated in-time response that will be required to remain operating at even near unity power factor, the current ruling is impractical. On top of this, it is likely to be very expensive, which may lead to material increases in electricity pricing to our customers.

[45] The agreement is conditional on Vector maintaining an aggregated power factor across all points of service during regional coincident peak demand periods of not less than 0.975 lagging or 0.97 leading. The agreement expires on 1 April 2013 but Vector is in talks with Transpower to renew the agreement until the proposed changes to the Code come into effect.

[46] http://www.vector.co.nz/sites/vector.co.nz/files/090227%20Distribution%20Code%20update%20Feb%2009.pdf

[47] More demanding service levels can be provided should customers require. For these situations special contracts and associated pricing arrangements are agreed to.

Agreement" (NAA) on the Southern network between Vector and our customers. They reflect the expected restoration timeframes and fault frequencies[48] [49] as mentioned on our website;

- The restoration timeframes are shown in Table 5-1 in the column "customer interruption outage duration" as targets for evaluating solutions to network security constraints. By factoring in target restoration timeframes into the network solutions, it ensures that we continue to meet service levels; and
- Fault frequencies are managed through targeted maintenance and asset replacement programmes and are described separately in Section 4 and Section 6 of this Asset Management Plan.

5.4 Project Prioritisation

The planning process results in a list of network projects and non-network solutions. These projects, along with others submitted from other groups (asset replacement, overhead to underground conversions, customer connections, etc) are evaluated against a project prioritisation matrix (see Section 9). The project prioritisation matrix considers company-wide factors such as operational, health and safety, environmental, legal, financial, reputational and regulatory risk to develop a priority ranking for the project.

The resulting list of projects becomes an input for the capital works programme. For network growth projects, the project priority is generally in the following order (from high to low):

- Consideration of wider company capex requirements;
- Return on investment;
- Avoiding capacity breaches that could lead to asset damage/eliminating unsafe situations;
- Avoiding breaches of electricity regulations (such as LV levels, etc);
- Avoiding capacity breaches that do not result in damage to assets;
- Avoiding supply security breaches;
- Enhancing network efficiency (including works programme synergy); and
- Opportunist implementation of long-term development opportunities (such as installation of cable ducts when other authorities do trenching work and are prepared to accommodate Vector in this).

5.4.1 Planning Under Uncertainty

A number of precautions are taken to mitigate the risks of long-term investments in an uncertain environment. Apart from normal business risk avoidance measures, specific actions taken to mitigate the risks associated with investing in networks include:

- Acting prudently: Make small incremental investments and defer large investments as long as reasonably possible (reinforce distribution feeders rather than build zone substations). The small investments must however conform with the long-term investment plan for a region and not lead to future asset stranding;
- Multiple planning timeframes: Produce plans based on near, medium and long-term views. The near-term plan is the most accurate and generally captures

[48] Residential service standards on the Southern network.
http://www.vector.co.nz/sites/vector.co.nz/files/Service%20Standards%20Residential%201009.pdf

[49] Commercial service levels on the Southern network.
http://www.vector.co.nz/sites/vector.co.nz/files/Service%20Standards%20Business%201009.pdf

demand growth for the next three years. This timeframe identifies short-term growth patterns and leverages off historical trends. It allows sufficient time for planning, approval and network construction to be implemented ahead of the new network demand.

The medium-term plan looks out ten years, capturing regional development trends such as land rezoning, new transport routes and larger infra-structure projects. The medium-term plan also captures society's behavioural changes such as the adoption of heat pumps and new technologies (eg. PV panels, electric vehicles (EVs), etc) and global trends (eg. climate change, energy conservation, etc).

The long-term plan looks at growth patterns within the region at the end of the current asset lifecycle, say 40 years. A top-down approach predicts 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 future zone substation and GXP requirements;

- Review significant replacement projects: For large network assets, rather than replace existing end-of-life assets with the modern equivalent, a review is carried out to confirm the need for the assets, the size and network configuration that will meet Vector's needs for the next asset lifecycle; and
- Use of non-network solutions where possible, to improve network utilisation and capital efficiency. Load control or shifting is a good example – moving demand from one time segment to another or from one feeder or substation to another without adversely affecting the customer, while deferring the need for new network investment.

The larger customer initiated projects can have a significant impact on the demand forecast and, therefore, the timing of capital investments. However unlike network growth projects where the timing is determined by Vector, the timing of the customer projects is dictated by the customer. Except for the near-term projects, there is often a high degree of uncertainty both in terms of required demand and the date the demand will be required. Including new customers' demand forecasts without critically evaluating these very often leads to an over-optimistic assessment of forecast demand which, if followed, would lead to premature investment in additional capacity.

Vector's approach to these projects is to apply a weighting to the customers demand expectations, based on an assessment of the likelihood of the project proceeding in any particular year. This weighted demand assessment is included in the demand forecast. While some projects will still not proceed in the expected year, this tends to balance out the conservative provision included for those that do proceed.

5.5 Non-Traditional Network Solutions

While most of network development solutions tend to result in conventional asset investments – extensions of existing networks, using current (but traditional) assets – non-traditional solutions are also considered, and often applied, as part of the network development planning process. The most often-used forms of non-traditional options are discussed below.

5.5.1 Demand Management

Vector's demand management strategy aims to offer:

- Network performance improvements by shedding interruptible loads (with customer agreement) in the event of faults. This allows load to be reduced without depriving customers of supply altogether;
- Tariffs that take advantage of off-peak electricity consumption; and

- Managing demand peaks at an aggregated Vector-level to lower Transpower charges to customers.

Some of the existing load management assets have been in service since the early 1950's. Changes to the transmission pricing methodology since 2006 has meant that load control to contain GXP demands is no longer the key driver, nor the revenue earner it used to be to support the load control system.

Vector's load management system can influence demand at an aggregated Vector level. It is used to manage network peaks to lower Transpower charges to customers. As Transpower charges are a "pass-through" to the customer, Vector receives no revenue for this service.

However, at a disaggregated zone substation level the impact of load control only affects those substations with local injection capability. Even at these substations it is rarely used for capex reinforcement deferral. Where the substation security standards are breached, the operational tendency is to allow the remaining network security to be "consumed," and only then use load control to avoid a capacity breach. Network reinforcement is planned to address security shortfalls well before there is a threat of a capacity breach.

The main use of load control is to manage network demand during contingency situations (faults) where there is a short-term risk that network capacity may be exceeded. Load control allows non-critical load to be shed, reducing the need for customer outages.

5.5.2 Embedded Generation

Embedded generation refers to generation connected to the Vector network either directly or via a customer's installation which is capable of exporting electricity.

Local generation is generally installed to provide a higher level of security than that offered by the network. The generation capacity is usually less than the customer's demand and is designed to support critical loads during contingency situations until the mains supply is restored.

There are a number of generators on the network but most are designed to operate as either back-up supplies in the event of power outages (these generators are not normally connected to the network) or are small (eg. residential PV installations). The characteristics of back-up generation are generally 50kVA to 500kVA diesel generator sets which may or may-not have network synchronising capability to allow for no-break changeover when power is restored. They are designed to run for a few hours during short duration power outages.

A number of the larger premises (such as Auckland Hospital, Watercare (Mangere)) have back-up generation with synchronising capability and can operate in parallel with the network but the owners choose to use these plants either for emergencies or to offset their own power needs rather than export energy.

Generation plants that export energy within Vector's network in significant quantities are the land-fill generation plants at Rosedale, Whitford, Redvale and Greenmount. This generation has been factored into the demand forecast but due to the location of their respective connection points to the network, they have not offset any reinforcement projects.

Currently the uptake of residential PV has been very low with very few applications being received. Their connection is randomly distributed throughout the network rather than clustered in any localised area and is therefore having minimal effect on the network.

5.5.2.1 Embedded Generation Connection Policy

To facilitate connection of embedded generation, Vector has posted its embedded generation connection procedures on its website. The procedures are based on the requirements contained in Part 6 of the Electricity Industry Participation Code 2010. The website also contains information to help the customer to understand the requirements for connection.

Vector's policy for connection of embedded generation to its network includes:

- The presence of embedded generation must not restrict Vector's switching operations on the network;
- Metering equipment installed at embedded generating stations must comply with the requirements of the Electricity Industry Participation Code;
- Embedded generation connected to the Vector network must comply with the requirements of all relevant Regulations and Electrical Codes of Practice, and the relevant requirements specified in the Electricity Industry Participation Code;
- Installation and operation of embedded generation equipment must comply with Vector's Distribution Code;
- Installation and operation of embedded generation equipment must comply with all requirements as specified in Vector's "Technical Requirements for Connection of Distributed Generation", and
- That appropriate monitoring and control is in place to ensure:
    a. The network is not overloaded should generation be lost;
    b. The generation does not compromise Vector's regulatory compliance (eg. voltage and automatic under-frequency load shedding);
    c. The generation does not compromise equipment and personnel safety (eg. excessive fault levels, appropriate network protection to prevent "islanding" and/or unintended back-feed).

One of Vector's main concerns is the injection of harmonics on the network and ensuring operating voltages are maintained within the regulatory limits.

5.5.2.2 Standby Generation Guidelines

Vector's main concern in its electricity distribution business is the security and reliability of supply to its customers. Local generation is often considered as an alternative to network reinforcement. Vector's guideline in this regard is to use distributed generation when it is an economical or technical alternative to capital investment for network reinforcement.

Moreover, from time to time, Vector deploys mobile generating units to supply its end user customers during contingency situations. The generators used in planned and emergency situations are deployed for backup purpose and do not fit the definition of distributed generation. To facilitate the deployment of these backup generators to supply large affected areas, Vector has constructed two mobile generator connection units, each containing a 2.5MVA 400V/11kV transformer that allows generators with 400V output to be connected to the 11kV network.

Vector's guideline on backup generation is to:

- Use generation during network emergencies where it is foreseeable that the customer services agreement will be breached and will result in a SAIDI impact of more than 0.075 minutes;

- Use generation for planned works requiring an outage that will result in the shutdown of commercial customers during normal business hours.

5.5.3 Non-Network and Non-Capacity Options

Vector considers solutions to meet customer's capacity and security requirements, other than investing in costly network solutions. Few of these get mentioned in the project section of Section 5 not because we do not consider them, but because they invariably do not deliver the whole solution or fail to deliver at a level of reliability that is required. However, a number of schemes such as load transfer, fast switching change-over and priority load shedding are implemented as a matter of course. Because these schemes are relatively low cost they fail to meet the threshold for specific recognition against the list of major projects.

Section 3 of this AMP considers some innovative trials Vector is carrying out to expand the range of non-network or demand side options available. Other global developments are being monitored with a view to being an early adopter (rather than first mover) of new technology once international evidence indicates that the technology is viable and reliable. Solutions adopted to avoid major network investment are described in the following sections.

5.5.3.1 Automatic Load Transfer Schemes (Non-Capacity)

By making use of the different demand profiles (residential/industrial) of neighbouring substations, Vector has been able to develop an automatic load transfer scheme to transfer load from a substation to another (of different demand characteristics) with only a small increase in the demand of the recipient substation. The automation also enables the load transfer to take place within a fraction of a minute allowing the use of short-term (higher) ratings of the assets.

5.5.3.2 Load Shedding (Non-Capacity)

Vector has the capability of shedding load via its ripple plant. This plant was used successfully in 2012 to reduce peak demand across the network and for the management of demand on live feeders during fault conditions. The coarseness and magnitude of the load shed, particularly where the ripple plant injection point is at GXP level, however, means that load control is not a suitable management tool for network security breaches. Significant load would have to be shed for what may be a minor (say less than 1 MW) security breach.

The use of intelligent numerical relays interconnected via a common communications bus allows the opportunity to pre-select feeders and turn these off in a predetermined sequence should there be a shortage of capacity at the substation. This allows a controlled reduction in load to a safe operating level for the healthy equipment and prevents the wholesale loss of the substation load due to overload. This solution has been implemented at a number of zone substations. This scheme allows the deferral of investment in the network for events that are relatively rare, ensuring better utilisation of assets whilst retaining supply to the maximum number of customers.

5.5.3.3 Renewable Solutions (Non-Network)

PV panels, wind driven micro turbines and solar water heating all offer the potential for customers to reduce energy purchases from the grid. Currently PV panels are too expensive for widespread uptake for residential applications but the cost of these panels is reducing rapidly. Solar water heating is another means of utilising natural resources to reduce energy supplied from the network, but compared to PV it is not as versatile and this is expected to limit its development. Micro wind turbines have not yet proved economically viable.

Solutions such as these contribute to an overall reduction in energy consumption but will not always reduce peak demands. An energy storage system (such as rechargeable batteries) will help to utilise the renewable energy to reduce peak demand (refer Chapter 3). Vector is undertaking a programme of integrated solar PV/battery systems to test this solution.

5.5.3.4 Interruptible Load (Non-Capacity)

An ability to interrupt customer demand during network contingencies or peak demand periods will enable Vector to avoid significant network reinforcements. Viable commercial arrangements are required to encourage customers to offer their load for shedding. An alternative is to invite load aggregators to offer "sheddable" customer load and make it available at times when the network capacity is constrained. Aggregation is carried out by third parties who would contract with Vector to guarantee a minimum quantity of sheddable load.

This scheme has been successfully applied by Transpower in the management of load in the upper South Island and allowed the deferral of significant capital projects. However, this model has not been used on Vector's distribution network due to the limited choice of suitable customers who can make load available within the affected network and the cost of implementing the short-term solution against the savings arising from deferring the permanent solution.

5.5.3.5 Smart Metering (Non-Network)

Retailers are replacing their mechanical residential electricity meters with electronic "smart" units. Current smart metering technology allows two way communications between the meter and the meter owner, which gives huge potential for improving meter reading accuracy and frequency, a better understanding of load patterns, time-of-use tariffs, outage notification etc.

These meters can also offer opportunities for demand side management. Not only can load control signals be issued to domestic appliances (including hot water cylinders presently controlled through load control systems), but customers can also be provided with a continuous indication of their energy usage. The latter, combined with tariff structures that encourage off-peak consumption, can lead to a win-win situation for consumers and distribution utilities – lower energy costs and better load factors.

Full realisation of these benefits is still some way off, but Vector is developing trials to assess what potential exists and will also work with retailers on developing more effective tariff structures.

5.5.3.6 Smart Technologies (Non-Network)

Investigations on a number of technologies, such as smart appliances, home energy management systems and smart networks, are ongoing to identify how Vector can use these technologies to help manage peak demands on the network. (See Section 3 for a more in-depth discussion.)

5.5.3.7 Mobile Generator Connecting Unit (Non-Network)

To defer large network investments, Vector considers the use of generation to make up any security shortfall and has applied this in the past. Modular generation of 200kVA - 1MVA generator capacity are generally sized for ease of transportation and have the capability to connect onto the LV network. The motor/generator fits into a 20ft container, making transport to site easy. These units are ideal to support load during LV network faults, while repairs are made to the network.

Vector has developed two mobile generator connection units (MGCUs) each capable of connecting up to 2.5MW of generation for feeding into the 11kV network during emergencies. These units are used to provide a shortfall in capacity generally following a fault or during a substation or network upgrade project. Significant generator standby and fuelling costs are, however, currently preventing these from being more widely used.

5.5.3.8 Energy Substitution (Non-Network)

Energy substitution is the transference of consumption from one energy source to another. Examples include using reticulated gas or LPG instead of electricity for cooking and water or space heating. While the commercial and industrial sectors are receptive to multi-fuel options, particularly where financial benefits result, the residential sector is less enthusiastic to change, largely due to the initial investment required and the limited availability of gas reticulation close to their premises.

Vector encourages developers to include gas reticulation as part of the subdivision design with periodic marketing campaigns carried out by Gas Retailers offering incentives for the use of gas.

Substantial penetration of gas is achieved if it is installed during the initial reticulation of green-fields subdivisions. Higher gas penetration lowers the electricity ADMD for the development. This is factored into the design of the subdivision through the use of smaller substations, larger distances between substations, etc. notionally lowering reticulation costs. In areas where gas has been left out of the development, the corresponding electricity ADMD is higher and the electricity reticulation design needs to reflect this.

5.5.3.9 Voltage Regulator/Capacitors (Non-Capacity)

Capacitors are installed on the network as a means of injecting reactive power to improve the network power factor and mitigate excess voltage drop. Traditional approaches rely on banks of capacitors switched into the network as the voltage drops outside preset limits. Technology advancements with fast switching power electronics has resulted in the development of static VAR[50] compensators (SVC), static compensators (STATCOM) and more recently dynamic VAR compensators (D-VAR) as refinements on capacitor banks.

Voltage regulators are used to boost the voltage on distribution circuits and are generally used in conjunction with capacitor banks. Their key application is on long distribution lines where significant LV problems are experienced. Capacitors and voltage regulators are effective means of solving LV problems in remote areas. If the voltage problem is caused by excessive loading, other solutions such as increasing the size of conductors need to be carefully considered.

Vector has a number of capacitors and voltage regulators in use on its network and will continue to use them in appropriate situations.

5.5.3.10 Remote Area Power System (Non-Network)

Electricity supply to remote areas with very low load densities using a conventional network approach is very expensive. Alternatives such as local generation with a combination of diesel, mini hydro, renewable generation, PV, micro wind, batteries, bottled gas, etc could be a more economically attractive alternative.

[50] VAR is volt ampere reactive.

The application of these alternative technologies is very dependent on the specific circumstance and needs to be assessed on a case-by-case basis.

5.5.3.11 Energy Efficiency

There is potential to reduce network demand through the replacement of existing inefficient appliances at premises with more efficient devices. Arguably the largest opportunity is with residential lighting where the use of energy efficient LED bulbs whose light output is comparable with more commonly used incandescent and halogen bulbs but require significantly less energy to operate. A secondary effect is a potential overall reduction in the residentially-driven network peak demand. Vector is currently evaluating the potential for LED lighting. Details of this are provided in Section 3.

Network losses are considered in the design and operation of the network although not generally as a primary consideration. The most significant network energy efficiency saving arises though the reduction in circuit losses. As these are primarily related to the square of the load current, reducing demand on a feeder keeps losses down. This, however, can be counter to the drive for increasing utilisation and economic efficiency of the network, so careful balancing of considerations is required.

5.6 Network Development Plan

The network development plan for the planning period is discussed in the following sections. The development projects are discussed per GXP or per sub-transmission network. Only major projects are separately discussed – those with an estimated value of more than $250,000.

5.6.1 Transmission

Vector takes supply from Transpower at twelve GXPs in the Auckland region to supply its sub-transmission networks. A thirteenth GXP supplies the Fonterra factory (Lichfield GXP) at Tokoroa. Auckland also has five bulk supply substations as part of its sub-transmission network to supply the various metropolitan population and business centres. 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 bus and 110kV bus respectively at Transpower's Otahuhu substation and GXP. Two major generating stations exist in Auckland, namely Southdown and Otahuhu. No significant operative generation exists north of Auckland.

The Northern network has five GXPs, viz: Wellsford, Silverdale, Albany, Henderson and Hepburn and one bulk supply point, namely Wairau Road substation.

The Southern network has seven GXPs, viz: Takanini, Wiri, Otahuhu, Pakuranga, Mangere, Penrose and Roskill. Hepburn is shared with the Northern network. Vector has four bulk supply substations that services the larger Auckland City area. These are Kingsland substation and within the CBD (Liverpool, Quay and Hobson substations).

Transmission into Auckland, existing GXPs in Auckland and the cross-isthmus 220kV (NAaN) cable that will supply two new GXPs at Hobson and Wairau substations, are shown in the geo-schematic Figure 5-6.

Recognising the demand growth in the region, Transpower is undertaking a major reinforcement of the grid to Northern Auckland and Northland (NAaN project).

The NAaN project comprises a 220kV cable circuit from Transpower's Pakuranga substation to Penrose, through to the Albany substation via two new GXP's at Vector's Hobson and Wairau substations. The new GXP's will maintain network security and allow for long-term demand growth in the Auckland's CBD (Hobson) and on Auckland's North Shore (Wairau). These projects are presently underway.

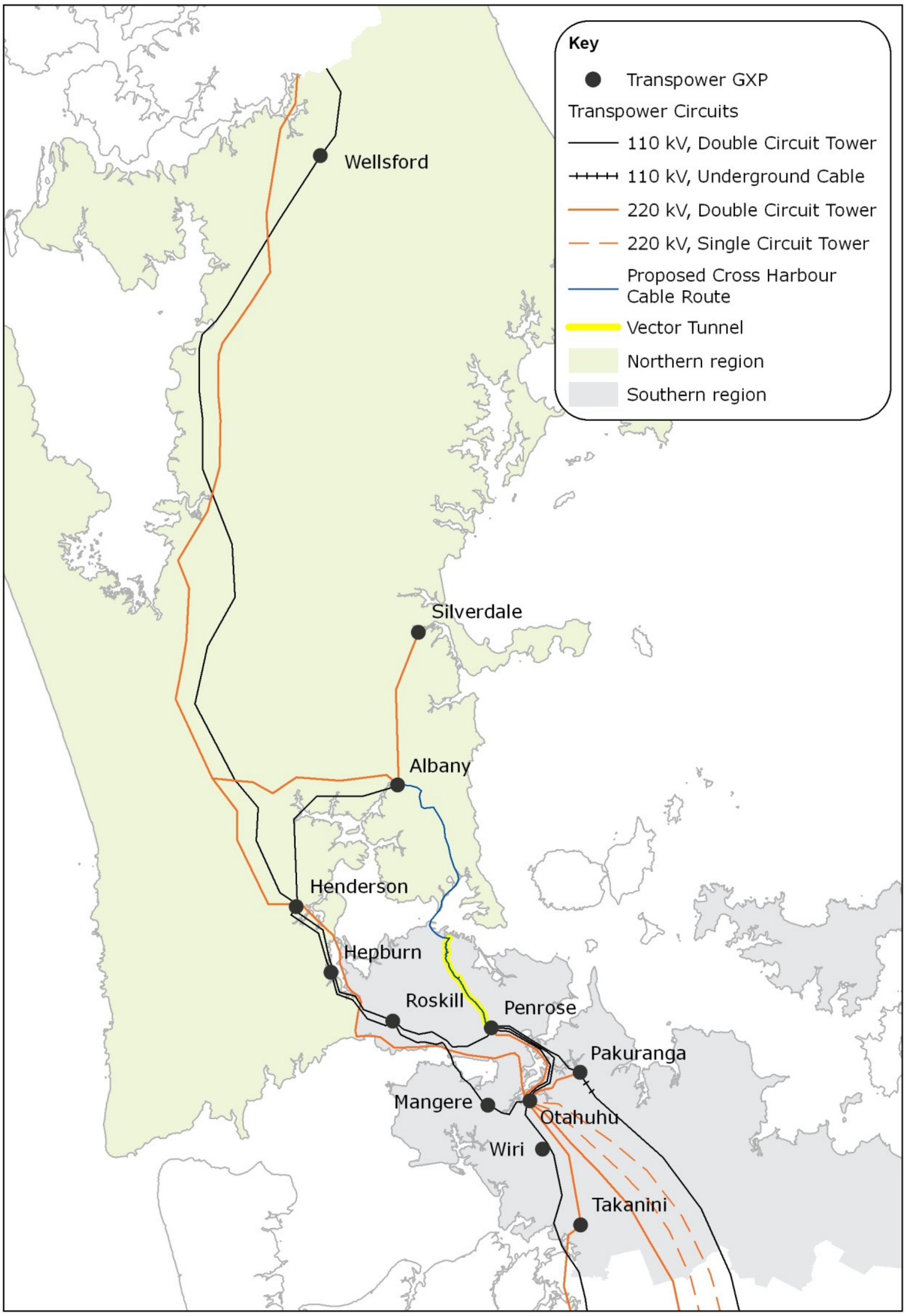

Figure 5-6 : Transmission into Auckland and GXPs in Auckland

The Wairau GXP is scheduled for completion in July 2013 and the Hobson GXP by November 2013. Figure 5-7 shows the NIGUP and NAaN projects (in red).

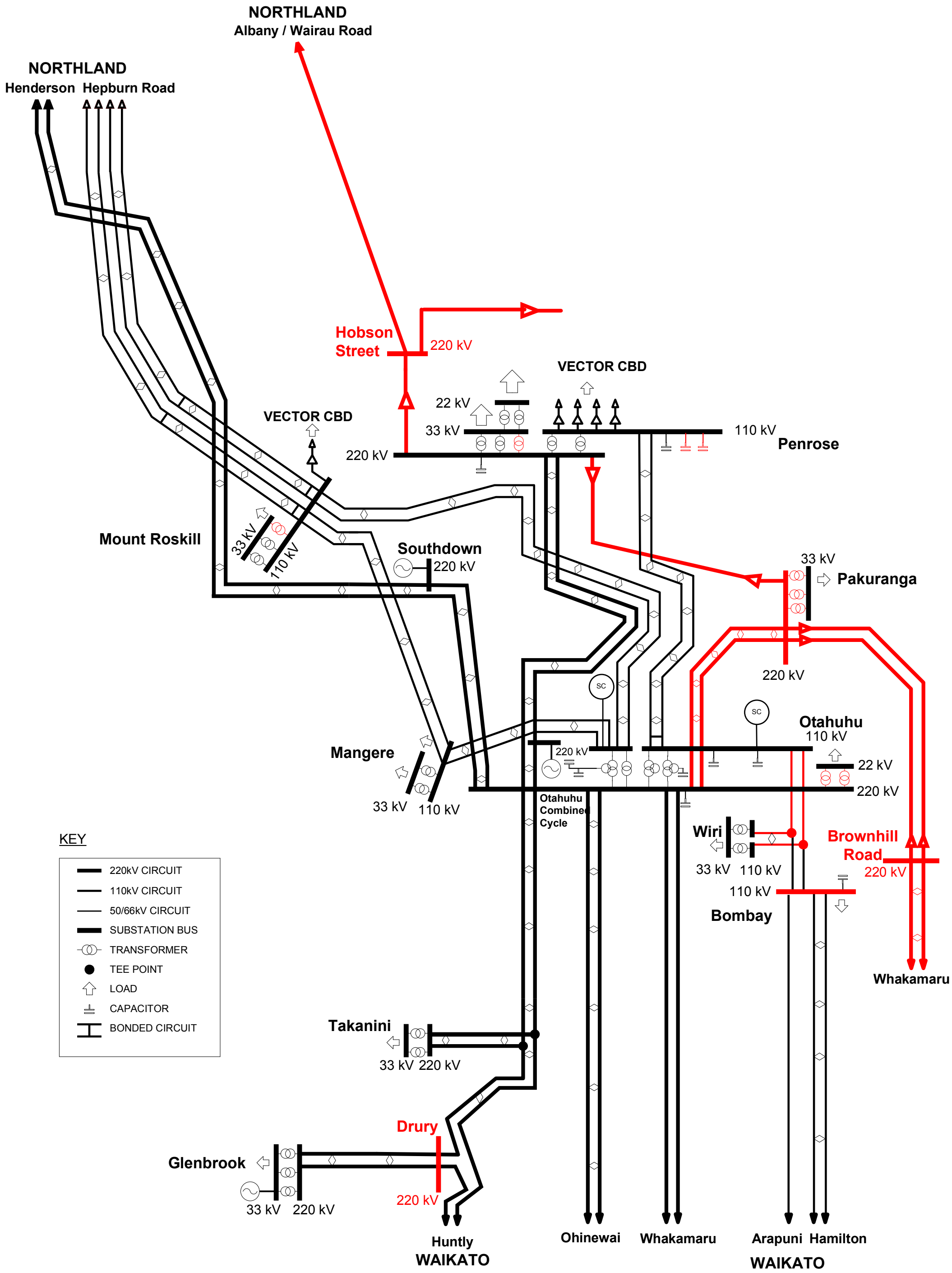

Figure 5-7: Auckland Transmission: NIGUP and NAaN circuits[51]

5.6.2 Northern Grid Exit Points

Security of supply to Wairau Rd will be enhanced by connecting the Hobson/Albany 220kV circuit to this site to establish a new GXP. This will address an existing HILP risk associated with a pole failure on the double circuit 110kV line currently feeding Wairau substation. Construction work commenced in 2011, with a scheduled commissioning

[51] Used with the permission of Transpower.

date of July 2013. In 2014, after completion of the NAaN 220kV cable between Penrose and Albany, Wairau will be able to be supplied from either Penrose or Albany.

No further new GXPs or extensions to the sub-transmission network are planned in the Northern area for the AMP planning period.

5.6.2.1 Projects Planned

a. Projects – Next Five Years

- **Wairau - Upgrade of Wairau Substation and GXP (FY14)**

Background

The establishment of a 120MVA 220/33kV GXP in conjunction with Transpower is well underway with commissioning of the first section of the NAaN cable from Albany to Wairau scheduled for the first half of 2013 with commissioning of the GXP scheduled by the end of July 2013. Vector's new indoor GIS 33kV switchboard installation is complete and is presently operated in parallel with the existing outdoor switchyard. The outdoor switchyard will be decommissioned after all 33kV circuits have been transferred to the indoor board and the connection to the GXP completed. (Minor works will still be required in early part of FY14).

- **Henderson Substation – 33kV Switchgear (FY15)**

Background

The existing 33kV outdoor switchboard at Henderson has a mixed ownership model. Incomer circuit-breakers are owned by Transpower and feeder circuit-breakers by Vector. Replacement of the circuit-breakers has been identified in Transpower's 2012 annual planning report for the period 2014-2016. The Vector owned circuit-breakers have been identified for replacement and rather than Vector replacing circuit-breakers singly, discussions are being held with Transpower to advance their outdoor-to-indoor 33kV switchboard conversion project and include Vectors breakers as well.

Recommended Solution

Timing of replacement of the switchgear is subject to discussion with Transpower but Vector is keen to bring this project forward, preferably no later than 2015. Vector is in discussion with Transpower to confirm the timing.

- **Hepburn Substation – 33kV switchgear (FY16)**

Background

The existing 33kV outdoor switchgear at Hepburn has a mixed ownership model. Incomer circuit-breakers are owned by Transpower and feeder circuit-breakers by Vector. Replacement of the circuit-breakers has been identified in Transpower's 2012 annual planning report for the period 2014-2016. The Vector owned circuit-breakers have been identified for replacement and rather than Vector replacing circuit-breakers singly, discussions are being held with Transpower to advance their outdoor-to-indoor 33kV switchboard conversion project and include Vector's breakers as well.

Recommended Solution

Timing of replacement of the switchgear is subject to discussion with Transpower but Vector is keen to bring this project forward, preferably no later than 2015. Vector is in discussion with Transpower to confirm the timing.

b. Projects – Long Term

This section records the larger but foreseeable projects that will occur beyond the 10 year AMP timeframe but have no firm commitment at this time.

- **GXP at Rodney**

The development of a generation plant in the Rodney area has been mooted but no commitment has been made. A new GXP is planned, if the generation station should eventuate. No timeframe has been set for this at this time.

- **GXP at Huapai**

A new GXP is planned at Huapai to support the long 33kV feeders from Henderson GXP. No timeframe has been set for this project at this time.

5.6.3 Southern Grid Exit Points

The Southern region of Auckland is supplied via seven GXPs; Roskill, Penrose, Pakuranga, Mangere, Otahuhu, Wiri and Takanini. Although the CBD is geographically viewed as being in the Southern region it is described separately below for the reason that the network in and to the city is more complex, extensive and load intensive. Vector owns and operates two 110kV oil-filled cables with summer/winter ratings of 80/51MVA from Roskill GXP to Kingsland substation. The cables connect to two 60MVA 110/22kV transformers.

With the completion of Hobson GXP, Newmarket will be the next GXP to be developed (circa 2020) followed by Southdown (circa 2024). Both are designed to off-load Penrose GXP, which will, over time, be reduced to a maximum 33kV bus demand of 240MVA.

5.6.3.1 Projects Planned (Transpower Projects)

- **Mangere 33kV – Re-termination of 33kV Cables (FY17)**

Background

Transpower plans to convert their existing outdoor 33kV switchyard to indoor switchgear within the planning period. The Vector related works will be the transfer of 33kV feeder cables to the new indoor switchgear.

Recommended Solution

Transpower have not given a firm indication of the timing of this project so the inclusion of this project in the AMP is provisional and dependant on Transpower's installation date. It is likely that the project will commence in FY17.

- **Penrose 33kV – Re-termination of 33kV Cables (FY14/15)**

Background

Transpower's project to transfer the outdoor 33kV switchyard to an indoor 33kV GIS switchboard will require Vector to transfer its 33kV cables to the new indoor switchboard. Construction of the switchgear building by Transpower was originally set to commence in 2012, but because of other concurrent projects construction of building facilities for the 33kV indoor switchboard will now only commence in 2013 and the switchboard commissioned in 2014.

Recommended Solution

Vector's initial works will be the relocation of a number of 22kV and 33kV cables and cable trays prior to the start of construction works by Transpower to make way for Transpower's new switchgear building. The design of the relocation works is largely complete. The transfer of Vector's feeder cables from the existing outdoor switchgear to indoor switchgear will likely not commence before 2014. Vector will continue to liaise closely with Transpower over this project.

- **Penrose 33kV Statcom Plant – Reactive Power Measurement, Relocation of Cables (FY13)**

  Background

  Transpower commenced construction of a statcom plant at Penrose substation in 2012 to provide voltage support on the Penrose 33kV bus. The plant is scheduled to be commissioned in early 2013. Vector will need to measure the reactive power flow to the 33kV bus as part of its check metering installation. There might also be a need to relocate one or two Vector cables out of the way of the 33kV cables that will run from the statcom plant to the existing outdoor 33kV switchyard.

  Recommended Solution

  Vector will engage early with Transpower to plan the supply and installation of 33kV CTs by Transpower, and the integration and measurement of reactive power flow into Vector's existing check metering installation. This project is expected to be completed towards the end of FY13. Vector will liaise with Transpower to plan the relocation of any electricity or communications circuits.

- **Takanini 33kV – Re-termination of 33kV Cables (FY15)**

  Background

  Transpower plans to convert their existing outdoor 33kV switchyard to indoor switchgear within the planning period. The Vector related works will be to re-terminate existing outdoor 33kV cables to the new switchgear.

  Recommended Solution

  Transpower's indicative timing for this project in their 2012 annual planning report is around 2014–2016. Vector's inclusion of this project is provisional and dependant on Transpower's final programme. Vector will continue to liaise with Transpower in this regard.

a. Projects – Within Five to Ten Years

- **Mt Roskill 22kV – Re-termination of 22kV Cables (FY17)**

Transpower plans to replace their existing outdoor 22kV switchyard with indoor switchgear, and to replace existing transformer T3. Vector related works includes the transfer of the existing circuits to the new switchgear. Vector plans include upgrading its sub-transmission voltage at Roskill from 22kV to 33kV. Discussions are to be held with Transpower over the proposed rating of equipment to be used and timing of the transformer and switchgear conversion projects.

- **Mangere 33kV – Additional 33kV Incomer CB (FY17)**

The winter peak demand will exceed the firm capacity of Transpower's GXP transformers by 2018. A number of solutions are being investigated:

  - Future demand growth to be supplied from other zone substations by Vector; and
  - Installation of a third transformer by Transpower for which Vector will have to allow a 33kV incomer CB.

An option has not been selected yet.

- **Wiri 33kV – Re-termination of 33kV Cables (FY16)**

Transpower plans replacing the outdoor 33kV switchyard with indoor switchgear and one of the supply transformer. Vector related works will be the transfer of the existing 33kV feeder cables to the new indoor switchgear. Vector will liaise with Transpower over the timing of this project.

- **Newmarket - Newmarket South GXP (FY20)**

Establish a 110/33kV bulk supply point in Newmarket to supply Newmarket, Newmarket South, Drive and Remuera demand.

Projects – Long-Term

This section records the larger but foreseeable projects that will occur beyond the 10 year AMP timeframe but have no firm commitment at this time.

- **Southdown**

Establish a new GXP at Southdown to supply Onehunga, Te Papapa, Westfield and Carbine demand.

- **Brown Hill**

Establish a new 220/33kV GXP at Brown Hill.

5.6.4 Northern Sub-transmission

5.6.5 Wellsford 33kV

5.6.5.1 Background

Vector takes supply from the Wellsford 33kV bus via two 220/33kV 30MVA transformers. The N-1 cyclic capacity (winter/summer) of this GXP is 31/31MVA and three zone substations are supplied from this 33kV bus, viz, Wellsford, Warkworth and Snells Beach.

The summer and winter demand forecasts are listed in Table 5-8.

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Wellsford 33kV	25	23	24	25	25	25	25	26	26	26	27
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Wellsford 33kV	31	31	31	32	32	33	33	33	34	34	34

Table 5-8 : Wellsford 33kV summer and winter demand projections

The current peak demand on Wellsford GXP is on the verge of exceeding the N-1 capacity. This has been communicated with Transpower and a project is underway to increase the capacity of this GXP.

There are two 33kV overhead lines supplying the Warkworth substation. As the circuits are close together in places, there is a risk of both circuits being taken out by the same event (common mode failure such as a tree falling over the lines). This risk is currently being managed. In the longer term it is planned to construct a third 33kV circuit between Wellsford and Warkworth substations on a different route.

There are three sites for future zone substations supplied from this GXP – one at Big Omaha (Leigh Road), one at Tomarata (opposite Domain) and one in Warkworth (Glenmore Drive).

There is planned growth in the Mangawhai Heads and Te Arai areas which may affect the timing of the Tomarata substation. Proposals for developing Te Arai have been scaled back and may not be a significant load in future. Voltage drop on the rural 11kV network has been identified as a growing issue and additional 11kV voltage regulators and/or capacitor banks will be investigated and installed as required.

A new substation will be required at Sandspit in 2018 to offload and backstop Snells Beach substation. Snells Beach substation is a single transformer substation and the demand in the area peaks over the summer period. Options for a 33kV ring (Southern Ring) between Warkworth, Sandspit, Snells Beach, Glenmore Drive and back to Warkworth have been investigated and a preferred option selected.

The geo-schematic diagram in Figure 5-8 shows the proposed supply arrangement in the Wellsford area.

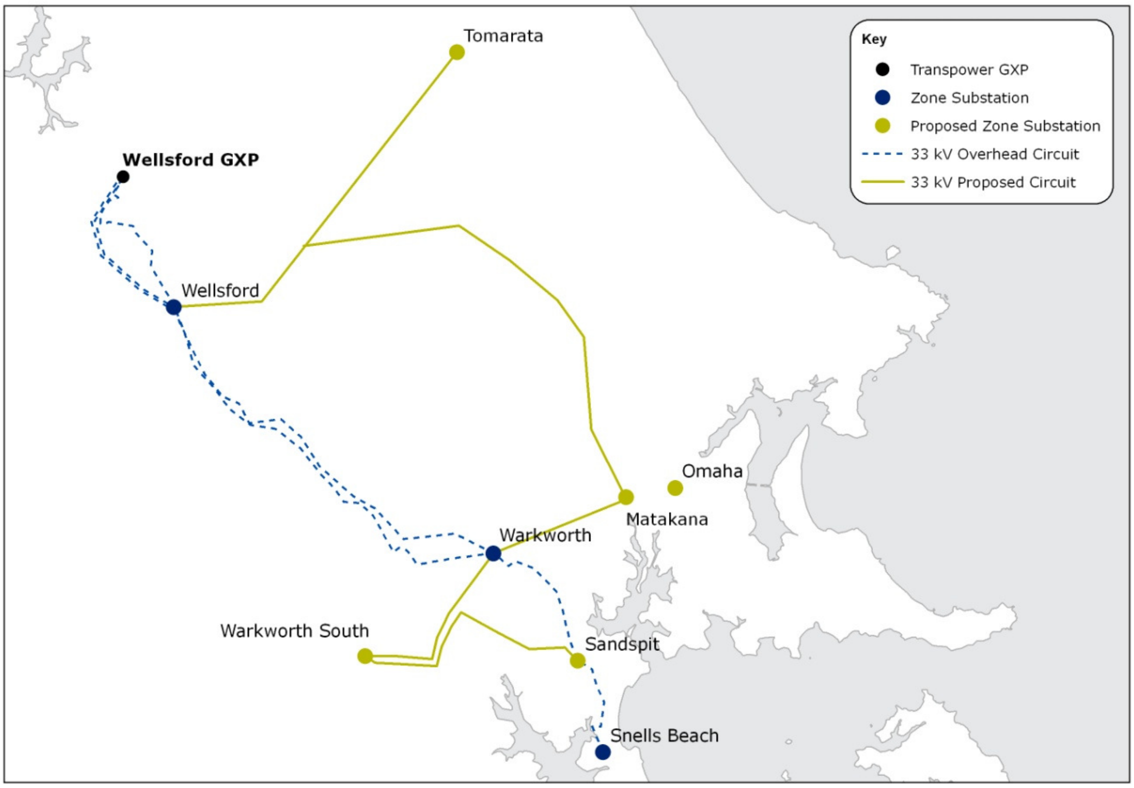

Figure 5-8 : Existing and proposed supply arrangement in the Wellsford area

5.6.5.2 Projects Planned

a. Projects – Within the Next Five Years

- **Matakana – Land Purchase (FY14)**

The site at Omaha South was purchased some time ago and the load has developed further to the south at Matakana. It would be desirable to sell the Omaha South site and purchase a new site closer to the load centre at Matakana. This new site would simplify the 33kV network and allow the 11kV feeders to easily integrate into the existing network. This land purchase will reserve a substation site for Vector to build on when this substation is required. The timing of this substation is dependent on local demand growth and other reinforcements in this area.

- **Warkworth - Matakana 11kV Feeder Reinforcement (FY15)**

Background

Matakana 11kV feeder from Warkworth substation is a very long semi-rural feeder with limited backstopping. The demand on this feeder is quite high and growing. 2012 winter peak demand was 5.2MVA and the capacity of this feeder is 8.7MVA. This feeder is the 11th longest feeder on the Vector network.

While the long-term plan is to install Matakana substation, the medium-term solution is to reduce the number of customers supplied from this feeder. Matakana feeder is one of the main backstopping feeders to Snells Beach substation.

Issues

- High demand on Matakana feeder (Rural);
- Length of the feeder, high number of customers; and
- Low backstopping capacity to Snells Beach.

Options Considered

- Construct Matakana substation – which cannot be justified at this stage;
- Transfer load away from Matakana township - not recommended due to the long feeder lengths in the area; and
- Reinforce Matakana feeder (preferred).

Recommended Solution

It is proposed to split the Matakana feeder into two and improve the backstopping to Snells Beach. The proposed solution proposes adding a further 11kV circuit to the existing poles and upgrading the existing 11kV circuit to 33kV[52] operation. This will allow the new feeder to be commissioned at 11kV whilst allowing the existing 11kV feeder to be uprated to 33kV to supply the new substation at Matakana in the future. By removing part of the Matakana township load, feeder capacity is released, reducing the customer count on this feeder whilst increasing the backstopping capacity to Snells Beach substation. This has the benefit of deferring the construction of Sandspit substation.

- **Warkworth - Whangateau 11kV Feeder Reinforcement (FY16)**

Background

The Whangateau 11kV feeder from Warkworth substation is a very long semi-rural feeder (8th longest feeder on the Vector network) with limited backstopping. The main backstop for this feeder is the Tomarata feeder from Wellsford and, during contingency events, low voltage is an issue.

Issues

- Length of the feeder, high customer numbers; and
- Limited backstopping capacity due to low voltage.

Options Considered

- Separate the Whangateau feeder into two sections;
- Install voltage regulator/capacitor banks; and
- Install a backstop circuit from Omaha Beach to Whangateau feeder (preferred).

[52] The existing 11kV on these poles was constructed for 33kV operation.

Recommended Solution

In conjunction with the Matakana feeder reinforcement project (see above) it is planned to install a backstop circuit from Omaha Beach (which is supplied by a spur line off the Matakana feeder) to the Whangateau feeder. This provides backstop capacity to Omaha Beach and the Whangateau feeder.

- **Warkworth South – New Zone Substation (FY17)**

Background

Warkworth zone substation was established about 5km to the east of Warkworth township. Demand growth on this substation is occurring within Warkworth township. As demand increases it is necessary to install additional feeders (three have been installed already) along the 5km route between the substation and the township.

Issues

- o Insufficient backstop capacity to the Warkworth industrial area;
- o Distance between the load centre in Warkworth township and Warkworth substation; and
- o Warkworth 11kV switchroom is fully utilised with no space for new 11kV feeders.

Options Considered

- o Extend the 11kV switchroom and install new 11kV feeders out of Warkworth;
- o De-commisssion Warkworth and re-establish at Warkworth South; and
- o Construct Warkworth South zone substation (preferred).

Recommended Solution

The long-term plan for supplying the Warkworth area is to establish a new zone substation at Warkworth South (Glenmore Rd) and at Sandspit. Warkworth South is a growing commercial and industrial load. Establishing a new zone substation at Warkworth South provides capacity at the load centre whilst enabling some of the longer feeders to be offloaded and shortened. This improves the reliability performance of these feeders.

It also has the added advantage of supplying Sandspit substation in the future. A 33kV line has been installed from Warkworth substation to Warkworth township but is currently operated at 11kV. Once Warkworth South is constructed this line will revert back to 33kV, acting as the supply to Warkworth South substation.

- **Sandspit – New Zone Substation (FY18)**

Background

The existing supply to the Sandspit and Snells Beach is from Snells Beach substation. This is a single transformer substation with a 7.5MVA transformer installed. The substation is currently about 80% loaded and will require reinforcement in the next few years. New subdivisions have been developed in this area and more are planned.

Issues

- o Limited capacity on the existing Snells Beach substation; and
- o Limited backstopping capacity to the Snells Beach substation.

Options Considered

There are two main reinforcement options for improving the supply to Snells Beach:

- Reinforce the Snells Beach substation with a second transformer. This would involve constructing a new 33kV line from Warkworth substation to Snells Beach to improve the security of supply; and
- Construct a new substation at Sandspit which is mid-way between Snells Beach substation and Warkworth substation. This new substation would be able to offload Snells Beach substation and make provision for future demand growth in the area. A new 33kV line would need to be constructed from the Sandspit substation to the Warkworth South substation to provide a secure supply to the substation (preferred).

Recommended Solution

Construction of a new substation at Sandspit is the more cost effective solution. This option will also allow the shortening of the 11kV feeders currently supplying the area, increasing network reliability.

The two 11kV feeder projects mentioned above (Matakana and Whangateau) will improve the backstopping to Snells Beach substation and potentially defer Sandspit substation beyond 2018.

5.6.6 Silverdale 33kV

5.6.6.1 Background

Vector takes supply from the Silverdale 33kV bus via two 220/33kV transformers, one rated at 100MVA and the other rated at 120MVA. The N-1 cyclic capacity (winter/summer) of this GXP is 109/109MVA and six zone substations are supplied from this 33kV bus, viz, Orewa, Manly, Spur Rd, Gulf Harbour, Red Beach and Helensville.

The summer and winter demand forecasts are listed in Table 5-9.

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Silverdale 33kV	50	52	55	57	59	60	61	62	63	64	64
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Silverdale 33kV	75	79	81	84	86	88	91	92	93	93	94

Table 5-9 : Silverdale 33kV summer and winter demand projections

Key development areas are expected to be around Waiwera, Orewa waterfront, Silverdale North and Whangaparaoa. This has been identified in the Auckland Council Area Plans.

Red Beach substation was commissioned in December 2007 and Gulf Harbour in January 2009. Kaukapakapa, Wainui (Silverdale North) and Waiwera are planned substations, also to be supplied from the Silverdale GXP. Kaukapakapa substation is planned for 2019 when network security at Helensville is forecast to be exceeded. There are no firm plans for the construction of Silverdale North (Wainui) substation but it is planned to purchase a site within the next few years. An area has been identified for the Waiwera substation but land has not been purchased.

The geo-schematic diagram in Figure 5-9 shows the proposed supply arrangement in the Silverdale area.

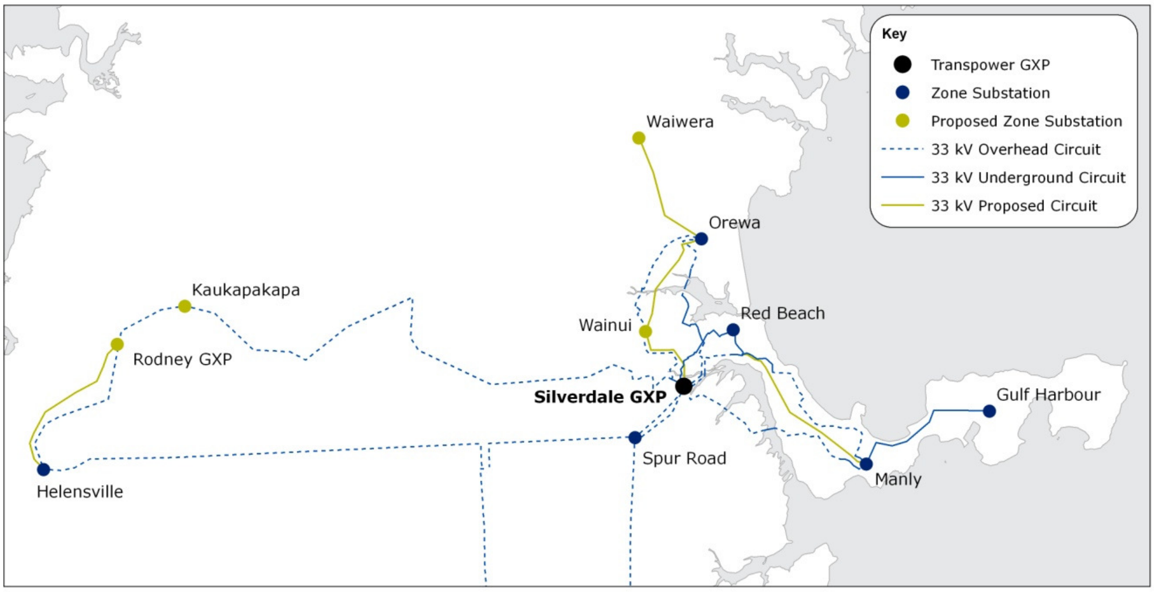

Figure 5-9 : Existing and proposed supply arrangement in the Silverdale area

5.6.6.2 Projects Planned

a. Projects – Within the Next Five Years

- **Red Beach – Second 33/11kV Transformer (FY15)**

Background

Red Beach substation was commissioned in 2007 with a single 33/11kV transformer. This substation has been able to offload the adjacent substations of Manly and Orewa and supply some of the new load coming on stream in the Silverdale North (Millwater) subdivision.

Issues

- o The Silverdale North demand is forecast to grow over the next few years. Demand at Orewa is expected to increase as a result of rezoning the Orewa waterfront, allowing for the construction of high–rise buildings; and
- o Demand growth at Silverdale North has reduced the backstopping capability of Red Beach. The 2012 winter peak demand was 13MVA. To maintain the current service levels to the customer some augmentation is required to ensure Red Beach backstopping capability remains adequate.

Options Considered

- o Offload Red Beach substation to neighbouring substations: Offloading Red Beach to neighbouring substations will only shift the network security problem to adjacent substations;
- o Bring forward the construction of Wainui substation: This would be an expensive and unnecessary option at this time; and
- o Install a second transformer at Red Beach substation (recommended).

Recommended Solution

The recommended solution is to install a second transformer at this substation.

- **Orewa – Savoy 11kV Feeder Reinforcement (FY15)**

Demand forecasts indicate that during this period, Savoy and Maire Rd feeders will require reinforcement to maintain security standards. It is expected that the northern end of the Silverdale North subdivision (Millwater) will develop quickly and require additional capacity. The District Plan allows high density development along the Orewa foreshore which will increase the demand significantly. The Fantail Court feeder from Red Beach substation supplies part of the Orewa business area and is approaching capacity.

Issues

- Limited backstopping capacity to Savoy and Maire feeders; and
- Highly loaded Fantail Court feeder.

Options Considered

- Redistribute the load on the existing feeders: Due to location of the existing switches and backstopping connections, redistributing the load on the existing feeders is not possible without equipment installation;
- Install a new 11kV feeder from Red Beach: This is a more expensive option than the one preferred, and will result in a sub-optimal network configuration; and
- Install a new 11kV feeder from Orewa (preferred).

Recommended Solution

Reinforcement from Orewa substation with a new feeder is a cost effective way of reinforcing the area. A feeder cable has been laid along a large part of the route and this project will take advantage of this cable.

The long-term plan for the Silverdale area indicates that a new zone substation will be required at Silverdale North (Wainui), especially when the business park proceeds.

With the economic downturn, demand growth has been slower than previously forecast, ensuring that Red Beach substation can supply the additional demand in the interim. Longer term, land purchase at Wainui (FY15) will secure a site for a future zone substation to reinforce Red Beach, Orewa and Spur Rd substations.

- **Waiwera – Substation Land (FY17)**

Waiwera is identified as an area for development in the Council's Area Plans. It is proposed to purchase land for a future zone substation in anticipation of this growth.

b. Projects – Within Five to Ten Years

- **Kaukapakapa – Establish Substation (FY19)**

Demand forecasts indicate that by 2019 a new zone substation will be required at Kaukapakapa to reinforce and offload Helensville substation.

- **Spur Road Substation - Second Transformer (FY19)**

Installation of a second transformer at Spur Road has been deferred many years by reinforcing the supply at adjacent substations. However opportunities for further deferral are limited and the installation of a second transformer at Spur Road is required.

- **Orewa Substation - Third 33kV Circuit (FY22)**

  Orewa is supplied by two 33kV circuits from Silverdale 33kV. The capacity of these circuits is restricted due to sections being undersized cable. Based on the current demand forecast and load flow analysis, augmentation is required to increase the sub-transmission capacity at Orewa substation. The preferred solution is to install a third 33kV circuit which can be extended to supply the future Waiwera substation.

5.6.7 Albany 33kV

5.6.7.1 Background

Vector takes supply from the Albany 33kV bus via three 220/33kV, 120MVA transformers. The N-1 capacity limit (winter/summer) of this GXP is 234/234MVA. Eleven zone substations are supplied, namely, Coatesville, Waimauku, Bush Rd, James St, Forrest Hill, Sunset Rd, East Coast Rd, McKinnon, Browns Bay, Waiake and Torbay.

Future substations are Albany, Rosedale, Glenvar, Northcross and Albany Heights. These substations will supply the proposed development areas indicated in Auckland Council Area Plans.

Forrest Hill and James St substations can be supplied from either Wairau GXP or Albany 33kV GXP. Originally they were included in the Albany group to reduce the demand on Wairau GXP. After commissioning the new Wairau GXP, Forrest Hill and James St will be transferred back to a Wairau GXP supply. These load movements are reflected in the "step" load changes in the demand forecast (Table 5-10).

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Albany 33KV	105	111	94	97	98	99	100	101	102	103	103
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Albany 33KV	159	132	133	134	136	137	138	140	141	142	143

Table 5-10 : Albany 33kV summer and winter demand projections

The geo-schematic diagram in Figure 5-10 shows the proposed supply arrangement in the Albany and Wairau areas.

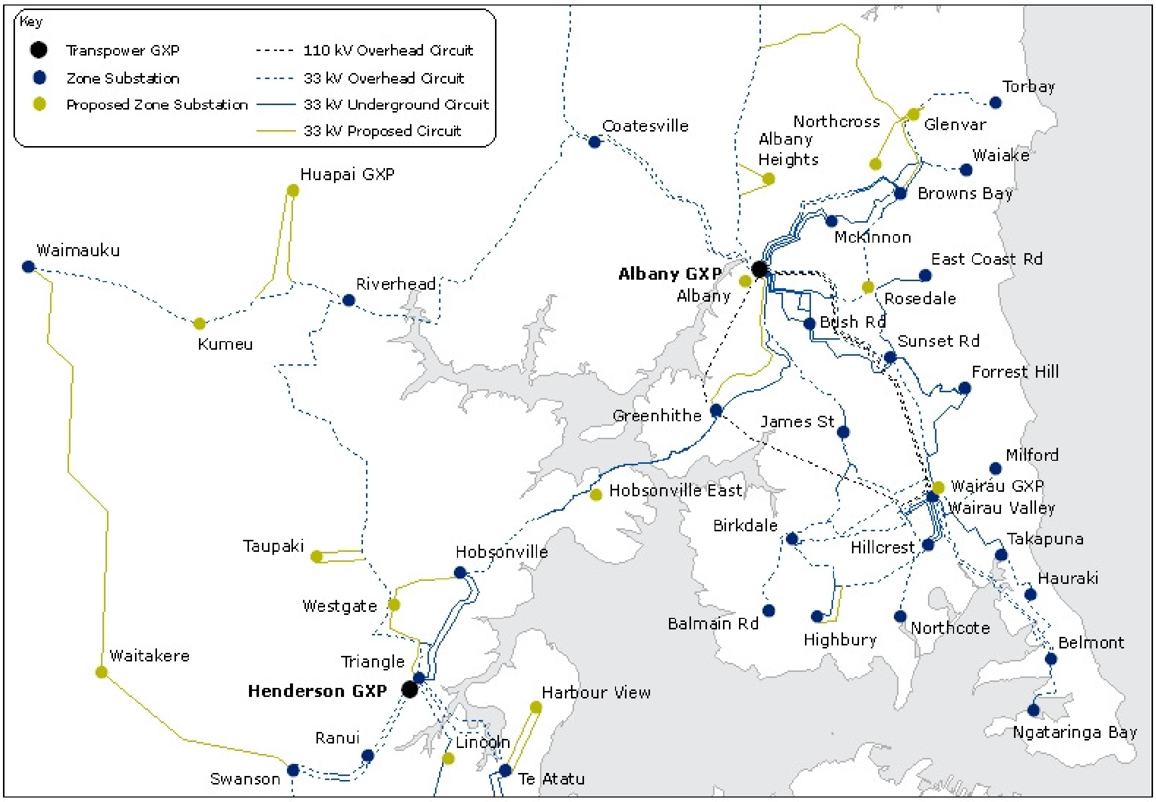

Figure 5-10 : Existing and proposed supply arrangement in the Albany and Wairau areas

5.6.7.2 Projects Planned

a. Projects – Within the Next Five Years

- **Rosedale Substation (FY14)**

Background

The area surrounding Rosedale Road, between the motorway and East Coast Road, has developed rapidly over the last five years. The bulk of this area is zoned for business activities and has been supplied from East Coast Rd and Sunset Rd substations. Output from the Rosedale landfill generation continues to decrease, adding additional demand to existing feeders. The 11kV feeders supplying this area are approaching capacity and need augmenting to maintain adequate backstopping capability. Additional network capacity is required as further land is opened for development.

Issues

- Vector security criteria is breached at East Coast Rd substation;
- Rosedale feeder does not have sufficient backstop capacity; and
- Sunset Road feeders do not have sufficient backstop capacity.

Options Considered

A new project comprising the construction of Rosedale substation was commenced in 2012 and is now in the construction phase. The following options were considered prior to committing to the construction of Rosedale substation:

- Establish a new zone substation in Old Rosedale Road. This site provided the ability to interconnect with Bush Road and McKinnon substations and backstop these adjacent substations. It also supports both East Coast Road and Sunset Road substations (recommended); and

- Increase the capacity at East Coast Road substation. This option is practical but a second 33kV supply would have been required to provide security to the substation. This could have been achieved with a cable from Rosedale Road about 1.5km away but would have required a 33kV switching station by the motorway. The cost difference between establishing Rosedale substation and reinforcing East Coast Road substation was minimal, albeit marginally favouring Rosedale substation. However, reinforcing East Coast Rd substation placed the network capacity on the edge of the load centre, rather than at the centre as was the case of Rosedale substation.

Both of these options would reinforce the area but the Rosedale option had the added benefits of being able to backstop and offload Bush Rd, Sunset Rd and McKinnon substations

- **Greenhithe – 33kV Reinforcement (FY15)**

Background

Auckland Transport has initiated a project to widen a 3.6km section of Albany Highway. This includes undergrounding existing electricity assets. The current 33kV supply to Greenhithe substation is teed off onto the Albany GXP-James St substation 33kV circuit. Once the road is widened, it will not be possible to retain this overhead tee connection.

Issues

- Albany Highway road widening will result in removal of all overhead circuits, including the overhead 33kV tee between Albany GXP and Greenhithe.

Options Considered

- Retain the 33kV tee: To do this would require ground mounted 33kV switchgear. Space is limited at this location and the equipment would be vulnerable to damage from traffic;
- Remove the Greenhithe-Albany circuit: This circuit is normally used as a backup to supply Greenhithe substation with the main supply from the Henderson 33kV bus. To maintain security once Greenhithe's second transformer is installed, a second 33kV supply is required. The single 33kV supply from Henderson cannot meet this need. A second supply from Henderson or retention of the Greenhithe-Albany connection is required. The Henderson option is substantially more costly than the Albany option. The proposed solution is a new cable from Albany (see option below); and
- Install a new cable to Albany GXP: This option has been a part of the long term plan for this area. Given the proposed road works, there will be an opportunity to extend the 33kV cable to Schnapper Rock Rd, address the issue of the teed off feeder with a robust solution that will result in a cable circuit back to Albany substation (recommended).

Recommended Solution

It is proposed to install a new cable from Schnapper Rock Rd through to Albany GXP, a distance of 2km. The installation of this cable will be concurrent with Auckland Transport's road widening project, reducing the overall cost of this project.

- **Glenvar Substation – New Substation (FY17)**

Background

Torbay substation has a single 33/11kV transformer and the transformer is more than 80% loaded. A shortfall of 3.6MVA of load cannot be backstopped upon the loss of the transformer. The Stapleford Crescent feeder reinforcement in FY12 allowed limited offloading of Torbay to Browns Bay substation.

A new subdivision is under construction to the north of Torbay substation (Long Bay subdivision) which will add a further estimated 7.5MVA of load. Further network reinforcement is therefore required.

Issues

  - Forecast capacity constraints at Torbay substation due to the Long Bay development; and
  - Limited back-stopping at Torbay substation.

Options Considered

  - Install a second transformer at Torbay. Torbay's location offers limited scope to utilise the full capacity of an upgraded substation and will only defer Glenvar substation for a short period; and
  - Establish a new zone substation at Glenvar: This option backstops Torbay substation, supplies part of the Long Bay subdivision and will supply new developments to the west of East Coast Road. A 33kV bus installed as part of this project will reinforce the 33kV supply and will provide a backup supply to the Browns Bay 33kV bus (recommended).

Recommended Solution

The recent installation of Stapleford feeder from Browns Bay substation has deferred the new zone substation at Glenvar. The trigger for the new substation will now be uptake of the residential housing at the Long Bay subdivision development. Glenvar substation has the advantage of being able to backstop Torbay substation, supply part of the new subdivisions at Long Bay and reinforce the west and north where further demand growth is expected.

Auckland Council is planning extensive road works in and around Glenvar Rd and ducts will be installed during these works for the future substation.

- **Coatesville – Second Transformer (FY18)**

Background

Coatesville is currently a single 12MVA transformer substation. The existing peak demand on Coatesville is 10MVA. The current demand forecast shows a limited backstopping at this substation after 2015.

Issues

  - As a single transformer substation Coatesville relies on the 11kV connections to adjacent substations for network security. Coatesville is currently backstopped using feeders from Spur Rd, Riverhead and McKinnon and is at risk of breaching network security criteria if it is not reinforced.

Options Considered

  - Upgrade the interconnecting feeders;
  - Install new interconnecting feeders; and
  - Install a second 10MVA transformer to increase N-1 cyclic capacity of this substation (recommended).

Recommended Solution

Installation of a second 10MVA transformer to increase N-1 capacity of Coatesville is the recommended solution. Due to very long feeder distances, upgrading interconnecting 11kV feeders or installing new ones are not considered cost effective. Many of the existing feeders traverse private property where occupancy is by "existing use" rights. Upgrading these feeders will result in loss of the "existing-use" rights and require re-negotiation with land owners for "right of occupancy". This substation has recently been modernised and the installation of a second transformer is the more cost effective option.

- **Waimauku – Second 33kV Circuit (FY19)**

Background

A second transformer has recently been commissioned at Waimauku to increase the capacity of this substation. However the substation is supplied from a single 33kV line. A second 33kV supply will be required as demand increases to maintain network security.

Issues

- Network security is compromised by the single sub-transmission supply to the substation.

Options Considered

- Install a second supply to Waimauku from Albany GXP: The distance between Waimauku and Albany is 23km. This option is more expensive than the other options presented below;
- Install a second supply to Waimauku from Henderson GXP: The distance between Waimauku and Albany is 18km, a shorter distance than the previous option. The cost of this option is still higher than the preferred option; and
- Install a second supply from Swanson to Waimauku via Waitakere substation (preferred).

Recommended Solution

Part of the route between Swanson and the Waitakere substation site (this substation has not been constructed yet) is built to 33kV construction. The 13km section of line from Waitakere to Waimauku would be new construction. This 33kV route has the advantage of providing a 33kV supply to Waitakere substation, whilst adding Swanson, Waimauku and Waitakere substations to a secure sub-transmission ring.

b. Projects – Within Five to Ten Years

- **Albany - New Zone Substation**

Vector's long term plan indicates a new zone substation will be required at Albany to offload Bush Road and McKinnon substations. Currently most of Bush Road feeders are backstopped by feeders from the same substation. Bush Road was offloaded by Greenhithe substation, but as demand is still growing in this area a new Albany substation adjacent to Transpower Albany is planned for 2022.

5.6.8 Albany 110kV (Wairau Substation)

5.6.8.1 Background

Wairau substation is supplied from Albany GXP at 110kV. Wairau substation, in turn, supplies eleven zone substations from the local 33kV bus, viz, Ngataringa Bay, Northcote, Highbury, Balmain, Birkdale, Milford, Wairau Valley, Takapuna, Hauraki, Belmont and Hillcrest.

The 110kV supply consists of a single circuit overhead line (circuit 3) via the suburbs of Greenhithe, Glenfield, Marlborough and Wairau Valley rated at 62MVA (summer) and a double circuit overhead line (circuits 1 and 2) via the suburbs of Albany, Meadowood, Forrest Hill and Wairau Valley. Each of the circuits on the double circuit line has a summer rating of 82MVA.

The three transformers each operate at a cyclic rating of 80MVA which provides a firm 160MVA capacity for N-1 transformer contingencies. However the substation is limited by the summer line rating rather than transformer capacities. James St and Forrest Hill demand has been moved to the Albany 33kV, to reduce the demand on the 33kV bus at Wairau to roughly 130MVA in anticipation of the construction of a GXP at Wairau Rd.

The GXP is under construction with commissioning scheduled July 2013. Once commissioned, the firm capacity will be 226MVA and new GXP will mitigate the risk of non-supply associated with the double circuit 110kV line failure. Load previously transferred to Albany 33kV, (Forrest Hill and James St) will be returned to Wairau Rd substation. The forecast 110kV demand is shown in Table 5-11.

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Albany 110KV	82	82	104	107	108	109	110	111	112	112	113
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Albany 110KV	123	162	163	165	166	167	168	170	171	172	173

Table 5-11 : Albany 110kV summer and winter demand projections

The GXP will consist of a single 220/33kV 120MVA transformer which will be supplied from a 220kV cable between Penrose and Albany. The GXP transformer can be supplied from either Penrose (via Hobson) or from Albany.

The long-term load for Wairau substation, beyond this planning period is expected to be 240MVA (fed from three 220/33kV 120MVA transformers).

Growth areas are Smales Farm and the adjacent North Shore Hospital site. High rise developments continue within the Takapuna town centre and it is expected that Takapuna substation will require a second transformer within the next five years. Demand transfers from Takapuna to adjacent substations such as Hillcrest are also anticipated.

5.6.8.2 Projects Planned

a. Projects – Within the Next Five Years

- **Birkdale – Increased Capacity (FY14)**

Background

The peak demand on Birkdale substation was 22.6MVA in FY12. This substation has two transformers, but larger capacity units are required to meet the growing demand. There are concerns with the seismic rating of the existing switchroom building and the indoor 11kV switchboard is inadequately rated for larger capacity transformers.

Issues

- Seismic issues with the existing switchroom building;

- Network security issues caused by inadequate capacity of the existing transformers for the current demand;
- Inadequately rated switchgear if the transformers are uprated; and
- Land subsidence.

Options Considered

- Upgrade the transformers and reinforce the existing building: The 11kV switchboard is not rated for the larger transformers and is at the end of its useful life. There is insufficient space to replace the 11kV switchboard in the existing building while keeping supply on to customers during construction works. Additionally, the substation cannot be fully backstopped;
- Offload the substation load to adjacent network: In order to reduce the demand to below the existing N-1 capacity of Birkdale substation, 9MVA of load has to be transferred to the neighbouring substations. Birkdale substation is surrounded by winter-peaking single-transformer substations which are loaded to capacity;
- Relocate the substation to a new site: This option considered purchasing another section near the existing substation and constructing a new seismically compliant substation while retaining the existing substation to supply customers during the construction phase. The cost of purchasing a new site and the cost of constructing and transferring services to the new substation outweighs the cost of reconstructing the substation on the existing site; and
- Upgrade transformers and 11kV switchboard, and rebuild the substation with a code compliant building: This solution is the lowest cost option that addresses all the issues raised (recommended).

Recommended Solution

A project to rebuild of the existing substation as proposed has been approved. Detailed design works have commenced with construction scheduled for next financial year.

- **Ngataringa Bay – Re-establish (FY16)**

The draft Auckland Spatial Plan identifies Devonport as an extension of the City Centre with demand expected to grow as this area is intensified (CBD style). Ngataringa Bay substation currently supplies Devonport and the Naval Base but is inadequately rated for any large scale intensification. The substation comprises a single 12.5MVA transformer with limited 11kV backstopping capability.

The location of this substation is not ideal, being in an area prone to liquefaction and tsunami risks. The building requires seismic strengthening and the 11kV switchboard needs to be replaced due to age and condition.

Issues

- Single transformer substation with limited back-up capability, unsuitable for CBD style load intensification;
- Liquefaction and tsunami risks associated with the site;
- Seismic condition of the existing building; and
- Switchboard approaching retirement.

Options Considered

- Rebuild or reinforce the existing building, replace the switchgear and reinforce the network to increase 11kV backstopping: This option needs to mitigate the liquefaction and tsunami risks, address forecast backstopping shortfalls whilst providing a continuous supply to existing customers while remedial works are completed; and

- Re-establish the substation to a less risk prone location.

Recommended Solution

Further work is required to establish the optimal solution. A provisional budget has been included in the 10 year capex plan.

- **Highbury – Second Transformer (FY18)**

New 11kV switchgear and three additional 11kV feeders were installed at Highbury in FY13. The demand forecast anticipates a second transformer being required in FY18 to ensure the substation security is maintained.

b. Projects – Within Five to Ten Years

- **Takapuna - 11kV Reinforcement (FY19)**

It is expected that three of the existing feeders supplied from Takapuna substation will require reinforcement. The timing of this project is dependent on demand growth in the area.

5.6.9 Hepburn Road 33kV

5.6.9.1 Background

Vector takes supply from the Hepburn 33kV bus via three 110/33kV transformers, (2x120MVA, 1x100MVA). The N-1 capacity limit (winter/summer) of this GXP is 245/239MVA. Eleven zone substations are supplied from Hepburn Rd, viz, Brickworks, New Lynn, Atkinson Rd, Laingholm, Oratia, Waikaukau, Henderson Valley, Keeling Rd, McLeod Rd, Sabulite and Rosebank. Future substations have been identified at Titirangi and Green Bay.

The summer and winter demand forecasts are listed in Table 5-12.

Name	Actual	Forecast Demand (MVA) – Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Hepburn 33kV	92	94	96	98	99	100	101	101	102	103	104
Name	**Actual**	**Forecast Demand (MVA) – Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Hepburn 33kV	131	135	136	137	138	139	140	141	142	143	144

Table 5-12 : Hepburn Road 33kV summer and winter demand projections

The geo-schematic diagram in Figure 5-11 shows the proposed supply arrangement in the Hepburn area.

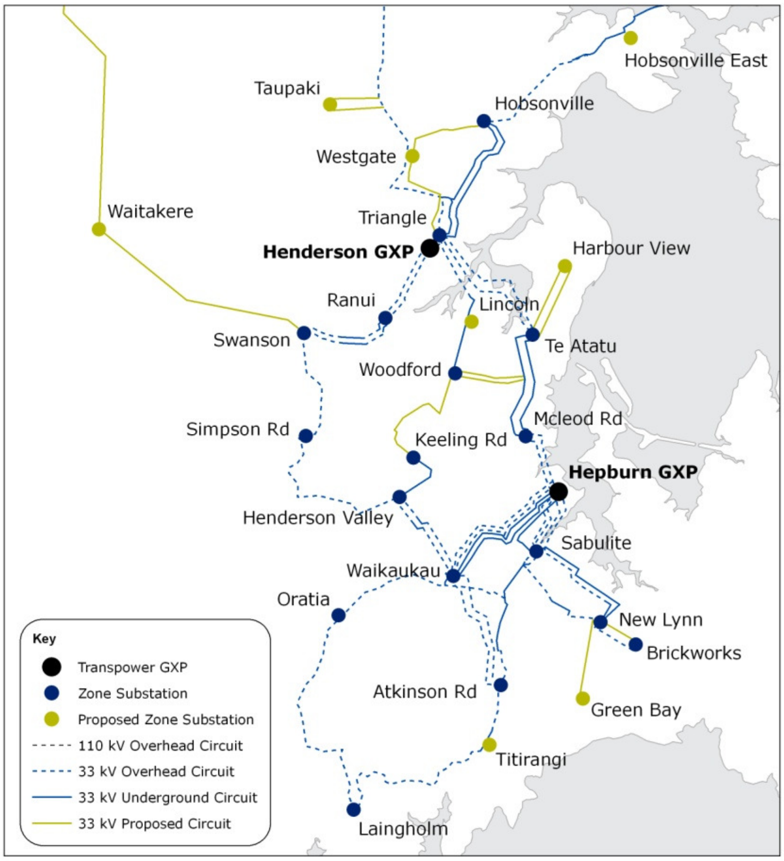

Figure 5-11 : Existing and proposed supply arrangement in the Hepburn area

5.6.9.2 Projects Planned

a. Projects – Within the Next Five Years

- **Brickworks – Upgrade the Existing Transformer (FY13)**

Background

The single 12.5MVA transformer at Brickworks substation has been loaded to 95% of its capacity. Brickworks substation is in poor condition and its reconstruction is underway (refer to Section 6 for details). As part of Brickworks substation renewal project, the existing 12.5MVA transformer will be replaced with a larger unit.

Issues

- o Insufficient capacity at this substation.

Options Considered

- o Remove the existing substation and supply the load from the adjacent network: The existing transformer is highly loaded, with the expectation of a further 4MVA demand increase from the proposed adjacent residential development. The neighbouring substations are not able to support this demand without expensive cabling work which is estimated to be higher than rebuilding the existing substation; and
- o Replace the existing substation with a code-compliant building and upgrade the transformer: This option includes replacing the switchboard and installing a new 15MVA transformer (with space for a second, when required). This option addresses the substation seismic issues and

provides additional capacity for the adjacent land re-development with provision for a second transformer in the future.

Recommended Solution

The recommended solution has been approved and on-site construction is about to commence, with completion expected in the current financial year.

- **Brickworks – Second Transformer (FY16)**

Background

Brickworks is currently being rebuilt with a new substation building (refer to previous project). The area adjacent to the substation is planned to be developed as a high density residential subdivision (1,500 dwellings) with an expected demand increase of around 4MVA. In addition, new business load is forecast to add a further 3MVA to Brickworks overall demand.

Issues

- Insufficient capacity to allow for forecast demand increases.

Options Considered

- Install a second 33/11kV 15MVA transformer at Brickworks substation: Provision has been made within the reconstruction of Brickworks for a second transformer in anticipation of further load (preferred);
- Install a second 33/11kV 15MVA transformer at Brickworks substation as part of the current reconstruction project: Installing the transformer as part of the reconstruction project results in an under-utilised asset and fails to realise the "time-value of money" savings arising from deferring this part of the project;
- Upgrade the 15MVA transformer to a larger unit: Upgrading the existing transformer to a larger unit is not preferred as the backstopping capacity to this substation is insufficient[53]; and
- Supply the additional load from other substations: Installing new feeders to adjacent substations is a wasteful option when Brickworks is already at the load-centre of the existing and proposed load and on the boundary of the proposed new development.

Recommended Solution

A second transformer at Brickworks is the preferred solution. It will maintain the security of supply whilst providing capacity for adjacent new load. A new 11kV feeder to supply the load of the new subdivision is required as part of this project. The second 33kV sub-transmission cable will be installed as part of the residential development. Project timing is dependent on the development.

- **Keeling Rd Substation – Install a Second Transformer (FY14)**

Background

Keeling Road substation was commissioned in 2003 with a single 24MVA transformer with the aim of off-loading Henderson Valley substation. The substation is supplied via a single 33kV line from Henderson Valley substation. Peak load in FY13 was 13.7MVA and is forecast to increase with planned load transfers from McLeod and Sabulite substations. Keeling Rd supplies the commercial area north of Henderson Valley and parts of the shopping centre. There are a number of reticulated, vacant lots around the substation site,

[53] The installation of a larger transformer than the proposed 15MVA unit was considered prior to the commencement of the current Brickworks upgrade project

potentially leading to a rapid load increase on this substation with minimal prior notice.

Issues

- There are currently N-1 backstopping security issues at Keeling Rd; and
- The potential for rapid load increase at Keeling Rd due to the availability of adjacent reticulated, vacant land ready for commercial buildings.

Options Considered

- Installing a second transformer at McLeod substation: This substation is heavily loaded and requires reinforcement or offloading. Installation of a second transformer at McLeod substation is sub-optimal due to the constrained distribution coverage caused by its location. Rather than reinforce McLeod, the preference is to transfer load to adjacent substations;
- Installing larger transformers at Woodford substation: Installation of a second transformer at Woodford Ave is part of the long-term plan as additional load is forecast for this area. However, the current load of 10MVA cannot justify expenditure on this project at this time; and
- Installing a second transformer at Keeling Rd substation: This substation has been designed to accommodate two transformers and there is space in the switchroom for 33kV switchgear. The substation is at the load centre and can take load from McLeod, Henderson Valley and Sabulite. It is planned to connect the 33kV through to Woodford substation. The second stage of this project will occur when the 33kV is connected from Woodford substation to Hepburn GXP, creating a 33kV ring from Hepburn GXP (preferred).

Recommended Solution

The recommended solution is to install a second transformer into Keeling Rd substation. This will restore N-1 security to Keeling Rd whilst offering the opportunity to offload McLeod substation. The substation has been designed for the second transformer.

- **Atkinson Rd – New 11kV Feeder (FY17)**

Background

Waikaukau substation is a single 7.5MVA transformer with a peak load in FY12 of 7.1MVA. Undersized conductor on the Kaurilands feeder, supplied from Atkinson Road, reduces the capacity of this feeder to 4.6MVA, leaving minimal spare capacity to backstop Waikaukau substation. The Kaurilands feeder also has one of the highest peak loads supplied from Atkinson Road (75% loaded).

Issues

- Increase the backstop capacity or reduce the load on Waikaukau substation. Currently interconnecting distribution feeders are heavily loaded and a transformer failure at Waikaukau may result in a capacity shortfall.

Options Considered

- Install a second transformer at Waikaukau substation: Installation of a second transformer at Waikaukau reduces the existing transformer loading. However, this substation is not centrally located and installing additional 11kV feeders to utilise the additional transformer capacity will be expensive;

- Upgrade Kaurilands feeder conductor rating: Upgrading the Kaurilands feeder conductor size will provide a marginal capacity increase but minimal benefit to the loading issues on Waikaukau substation; and
- Install a new feeder from Atkinson Rd substation (preferred).

Recommended Solution

Atkinson substation has recently been redeveloped with two 20MVA 33/11kV transformers, an increase over the previous two 12.5MVA units. The additional capacity can be used to offload Waikaukau substation and improve backstop capability subject to the installation of a new feeder connecting the substations.

- **Rosebank - 11kV Reinforcement to Improve Security at Rosebank North (FY16)**

Background

Rosebank substation is situated on a peninsula where, by virtue of its geography, the feeders installed to the north are connected to adjacent feeders, also from Rosebank substation. A major equipment failure at Rosebank could potentially leave Rosebank North customers without supply until repairs are completed.

Issues

- Limited 11kV backstopping capacity on the existing network; and
- Risk of extended outages for customers at Rosebank North.

Recommended Solution

It is proposed to install a new 11kV cable from Te Atatu substation to Rosebank to backstop the 11kV cables supplying the northern part of Rosebank peninsula. A phase shifting transformer is required at Te Atatu to compensate for the phase differences between the two networks.

The connecting cable will be installed along the North-Western motorway in conjunction with the NZTA SH16 motorway widening project.

- **Oratia – New 11kV Feeder (FY18)**

Background

The existing 11kV feeder supplying Piha is from Henderson Valley substation and has a large section of residential load on the feeder. The feeder is heavily loaded and requires reinforcement.

Recommended Solution

Oratia is physically closer to Piha than Henderson Valley substation and the new feeder will be supplied from Oratia. The new feeder would reduce the load on the Piha feeder and improve the reliability of supply. This new feeder will be an underground cable along Piha Rd (6km).

5.6.10 Henderson 33kV

5.6.10.1 Background

Vector takes supply from the Transpower Henderson 33kV bus via two 220/33kV 120MVA transformers. The N-1 capacity limit (winter/summer) of this GXP is 135/135MVA. Nine zone substations are supplied from this 33kV bus, viz., Triangle Rd, Ranui, Swanson, Woodford, Hobsonville, Te Atatu, Riverhead, Greenhithe and Simpson Rd.

The summer and winter load forecasts are listed in Table 5-13.

Name	Actual	Forecast Demand (MVA) – Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Henderson 33kV	77	76	79	81	82	84	85	86	87	88	89
Name	Actual	Forecast Demand (MVA) – Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Henderson 33kV	110	113	115	116	118	119	121	122	124	125	126

Table 5-13 : Henderson 33kV summer and winter load projections

Additional substations will be required at Westgate (2016) and Hobsonville Point (2019) with longer term substations proposed at Waitakere, Taupaki and Harbour View. Land in the Hobsonville area has recently been rezoned allowing more intensive development. A new GXP at Huapai is proposed, to split the Henderson load.

The geo-schematic diagram in Figure 5-12 shows the proposed supply arrangement in the Henderson area.

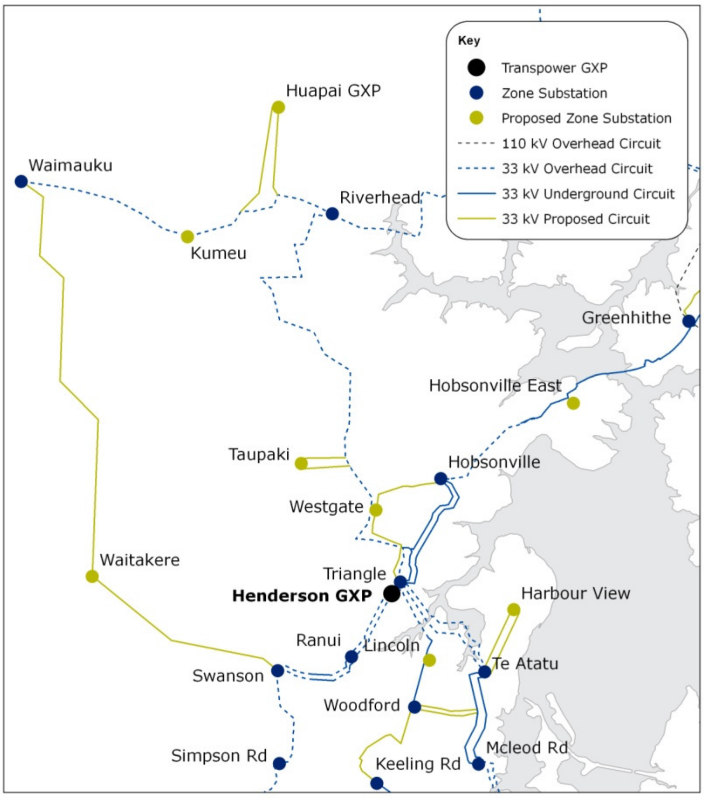

Figure 5-12 : Existing and proposed supply arrangement in the Henderson area

5.6.10.2 Projects Planned

a. Projects – Within the Next Five Years

- **Hobsonville - Land Purchase (FY13)**

Background

The long-term plan indicates that a zone substation will be required to supply new load developing between the existing Hobsonville substation and Greenhithe substation. Currently Greenhithe substation is supplying load across the

Greenhithe bridge to the old Hobsonville airbase. As this area is redeveloped, additional capacity will be required and this will be supplied temporarily by the new Clark Rd feeder mentioned below. However, in the medium to long-term a new substation will be required.

Recommended Solution

It is proposed that land is purchased for a proposed Hobsonville Point substation.

- **Hobsonville – Clark Road 11kV Feeder Reinforcement (FY14)**

Background

The area between Westgate and Hobsonville Airbase has been rezoned to allow for commercial and residential development adjacent to the new Greenhithe motorway. This will be a substantial load increase and will not be able to be supplied from the Hobsonville zone substation. Once Hobsonville Point substation is commissioned Clark Rd feeder load will be reduced and the same feeder can be used to supply the newly re-zoned area.

Most of the Clark Road feeder was decommissioned when the overhead line was uprated to 33kV to supply Greenhithe substation. The area currently supplied by this feeder is currently supplied from Greenhithe zone substation.

Issues

- The feeder supplying Hobsonville Point development is supplied from Greenhithe substation. This feeder peaked at 5.3MVA in winter 2011. The 2012 winter peak demand for this feeder was 3.8MVA. While this is a major drop, new load is expected as a result of the re-development of Hobsonville Point. Greenhithe substation has limited backstopping capacity throughout the year. Some reinforcement has to be done to increase its backstopping capacity and decrease the load on the feeder supplying Hobsonville Point development.

Options Considered

- Install a second transformer at Greenhithe substation: Installation of a second transformer at Greenhithe will not reduce the load on the feeder supplying the Hobsonville Point development. Given the expected load increase in the area, this option is not adequate to solve the existing issues;
- Construct Hobsonville Point substation: In the longer term, a new zone substation will be required at Hobsonville Point to meet the demand of the Hobsonville development; and
- Install Clark Road feeder: To delay the need for Hobsonville Point substation, a new underground Clark Road feeder will be installed between Hobsonville substation and the Hobsonville Point development. It was originally intended to install ducts for this cable during Auckland Transport road alterations in Hobsonville Rd. However Auckland Transport's project schedule is now postponed for 1-2 years which is beyond the timeframe for this necessary reinforcement. It is intended to install this feeder independently of Auckland Transport's plans.

Recommended Solution

Clark Road feeder will supply the Hobsonville Point development until the Hobsonville Point substation is needed. This feeder will then be split, with supplies from both Hobsonville and Hobsonville Point substations, and supply the load expected from developments associated with the recently rezoned land, north of Hobsonville Road.

- **Greenhithe - Installation of a Second Transformer (FY18)**

Background

Greenhithe substation was constructed in 2010 and was designed to accommodate two transformers. However loading at the time did not justify the installation of the second transformer. The peak load at Greenhithe substation in 2012 winter was 13.2MVA.

Issues

  - The Clark Rd feeder is planned to transfer 2MVA of load from Greenhithe to Hobsonville. This reduces the peak load at Greenhithe substation. However the N-1 capacity of this substation is still limited. Reinforcement is required to rectify the security breaches forecast for this substation.

Options Considered

  - Transfer more load from Greenhithe to Hobsonville: It is not possible to transfer more load from Greenhithe to Hobsonville as Hobsonville itself has a security breach;
  - Construct Hobsonville Point substation: Construction of Hobsonville Point substation alone does not fix the security issues at Greenhithe as there are no spare ducts available across the Greenhithe motorway bridge, limiting the ability to transfer additional load. Installing further 11kV feeders to Hobsonville Point will be expensive, requiring the installation of further ducts across the bridge (if practical) or resort to a marine crossing of the harbour; and
  - Install a second transformer at Greenhithe.

Recommended Solution

The installation of a second transformer at Greenhithe is recommended to increase the capacity of this substation and improve the security. Note the cost of this project is relatively low as this substation has been designed to accommodate a second transformer.

- **Westgate - Te Atatu/Henderson/Westgate Ducts (FY14)**

Background

It is proposed to install future-proofing ducts under the cycle-way currently being installed by NZTA as part of their SH16 widening project. The first section of the duct will be used when the existing overhead supply from Henderson 33kV to Te Atatu needs to be replaced due to age and condition. The second section will provide a supply from Henderson 33kV to the future substation site at Westgate. This is the shortest route between Te-Atatu and Henderson, and from Henderson to Westgate, ensuring the lowest cost sub-transmission option when commissioned.

- **Kumeu - Land Purchase (FY16)**

Background

Kumeu-Huapai has been identified as a centre for growth in the western part of Rodney with the population forecast to increase more than four-fold by 2021. Currently Kumeu is supplied from Waimauku and Riverhead substations.

Issues

  - The surrounding substations cannot support the forecast population and associated demand growth in the area.

Recommended Solution

Purchase land in Kumeu for a future substation.

- **Westgate – New Zone Substation (FY16)**

Background

The Massey North (Westgate) area has recently had a zoning change to allow for extended commercial and residential development. Discussions with developers indicate an expected load increase of around 25MVA within the next 5 years.

Issues

- The existing Hobsonville and Triangle Rd substations supplying this area are heavily loaded and additional capacity will be required to supply the new load.

Options Considered

- Increase the capacity at Hobsonville substation with larger transformers: The supply to the substation is limited by the capacity of the 33kV cables. Given the large loads expected in this area, upgrading the cables will deliver a short term solution only. A new substation is required and the net present cost (NPC) of an upgrade of Hobsonville exceeds the NPC of a new zone substation at Westgate (third option);
- Increase the capacity at Triangle Rd substation. The load centre is several kilometres north of this substation, making 11kV reinforcement expensive. In addition, there is limited space in the substation for additional 11kV circuit-breakers to supply new 11kV feeders and, as with the first option, the NPC of the Triangle Rd upgrade option exceeds the NPC of a new substation at Westgate; and
- Establish a new substation at Westgate. This option has the advantage of establishing new capacity at the load centre. This will release capacity at the adjacent Hobsonville substation to supply load further to the east until the Hobsonville Point substation is required and built. It is proposed to connect the Westgate 33kV cables with Hobsonville substation, so that the 33kV link to Greenhithe has sufficient capacity to supply both Hobsonville Point substation and Greenhithe (recommended).

Recommended Solution

The preferred solution is to establish a new zone substation at Westgate.

- **Te Atatu – Additional Transformer to Supply the Waterview Tunnel (FY16)**

Refer to "Te Atatu - Northern Portal Permanent Supply" (Section 5.6.14) for more information regarding this project.

- **Te Atatu – New Transformers (FY17)**

Background

Te Atatu substation was rebuilt several years ago and new 11kV switchgear installed whilst utilising the two existing 33/11kV 12.5MVA transformers.

Issues

- The peak load at Te Atatu substation in 2012 was 20.5MVA. The existing 12.5MVA transformers are inadequately sized for the load. The existing transformers were manufactured in 1966 or are 45 years old. With the combination of age and loading these transformers are approaching end of life. A condition test will confirm this.

Options Considered

- Offload the substation to adjacent substations: The three closest substations (McLeod Rd, Triangle Rd and Woodford Ave) do not have spare capacity. In fact, load is being transferred to Te Atatu substation to resolve adjacent network loading issues;
- Construct a new zone substation on the Te Atatu peninsula: This is the long term solution for reinforcing the area but this is an expensive option and is not justified at this stage;
- Install a second transformer at Woodford Ave substation and transfer load: Woodford Ave substation is currently supplied by a single 33kV cable. This option would require 33kV cabling work which would be costly compared to the other options (see Woodford Ave project below);
- Install a second transformer at McLeod Rd substation and transfer load: The site is very constrained and it is not practical to install a second transformer at McLeod Rd substation; and
- Upgrade the transformers at Te Atatu substation from 12.5MVA units to 20MVA units: This is the lowest cost option and allows Te Atatu to support the adjacent single transformer substations.

Recommended Solution

Replacing the existing transformers with 2 x 20MVA units at Te Atatu substation is the preferred solution.

b. Projects – Within Five to Ten Years

- **Hobsonville Point – New Substation (FY19)**

Load forecasts indicate that a new zone substation is required at Hobsonville Point to supply the new residential load and the new industrial area developing between Hobsonville Rd and the new motorway.

- **Kumeu – New Substation (FY21)**

A population, and corresponding demand, increase is expected at Kumeu. A substation is tentatively included for completion in FY21. The timing of the new substation will depend on other reinforcements in the area.

- **Lincoln Rd – Land Purchase (FY20)**

Development occurring in the Lincoln Rd area indicates that a new substation will be required. This project is to purchase land for the new zone substation. The timing of the new substation will depend on other reinforcements occurring in the area.

- **Woodford Ave – Additional Transformer (FY21)**

An additional 33/11kV transformer is planned for Woodford substation together with the associated 33kV switchgear and 33kV link from the Hepburn-Te Atatu 33kV cable.

5.6.11 Penrose 110kV (Auckland CBD)

5.6.11.1 Background

Bulk supply to the Auckland CBD is taken from Transpower's Penrose GXP at 110kV, together with a backstop 110kV cable from Transpower's Roskill 110kV bus. Sub-transmission in the CBD is at 22kV.

5.6.11.2 CBD - Sub-transmission

At present, Auckland CBD has three bulk supply substations, viz. Hobson, Liverpool and Quay substations, all supplied by Vector-owned 110kV cables. The load forecast for the Penrose CBD is shown in Table 5-14 below.

Name	Actual	Forecast Demand (MVA) – Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
CBD	207	212	218	224	228	232	234	236	239	241	243
Name	**Actual**	**Forecast Demand (MVA) – Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
CBD	203	204	209	215	220	224	229	233	237	239	242

Table 5-14 : CBD summer and winter load projections

The peak demand in Auckland's CBD traditionally occurs in the summer months and more specifically in the period January to around the end of March. Summer peak demand is primarily caused by air-conditioning, and the winter peak by heating load.

The bulk supply to the CBD is from Transpower's Penrose GXP by means of two 110kV 237MVA cable circuits in Vector's Penrose tunnel to 110kV GIS switchgear at Liverpool.

Three 110/22kV transformers (2 x 75MVA and 1 x 60MVA), supply a 22kV switchboard at Liverpool and the 22kV bus in turn supplies the 11kV bus via three 22/11kV transformers. Two zone substations in the CBD, Victoria and Newton substations, are also supplied from the 22kV switchboard at Liverpool. The total installed transformer capacity in Liverpool substation is 210MVA. Differing transformer impedances between the two new 75MVA transformers (T1 and T2) and transformer T3 (60MVA), cause sub-optimal load-sharing and reduce the theoretical N-1 capacity of 135MVA to 114MVA. Once T3 is replaced with a unit of similar rating and impedance to that of T1 and T2, the N-1 transformer capacity will increase to 150MVA.

The bulk supply to Hobson substation is from Vector's 110kV switchgear in Liverpool by two 110kV 150MVA cable circuits in the Liverpool-to-Hobson tunnel directly onto two 110/22/11kV transformers rated at 65MVA each (40MVA at 22kV and 25MVA at 11kV). The installed transformer capacity is 130MVA and the N-1 capacity is 65MVA. The 11kV switchboard at Liverpool is supplied directly from the 11kV windings and also from the 22kV bus via two 22/11kV transformers. Freeman's Bay 22kV substation is supplied directly from the 22kV bus at Hobson. The two 110/22/11 40/25MVA transformers are sufficient to provide N-1 security for the short-term, but projected load growth requires a third 110/22kV 60MVA transformer to be commissioned soon after completion of the GXP works in November 2013. An enclosure for the third transformer forms part of the construction works for the new GXP at Hobson.

Quay substation is supplied by a 110kV 100MVA cable which can be switched to either a Liverpool substation or Transpower's 110kV Mt Roskill GXP supply. The normal supply is via Liverpool substation, ie. supplied from the Penrose 110kV bus. The 110kV cable to Quay substation presently supplies two 60MVA 110/22kV transformers. The project to install a second 110/22kV transformer was completed in FY12. The two ageing gas-filled 110kV cables from Penrose to Quay substation, and the transformers that they supplied at Quay, were retired in FY12.

Figure 5-13 below is a schematic diagram of the existing sub-transmission network in the CBD. The diagram shows the 110kV sub-transmission circuits and the 22kV interconnectors.

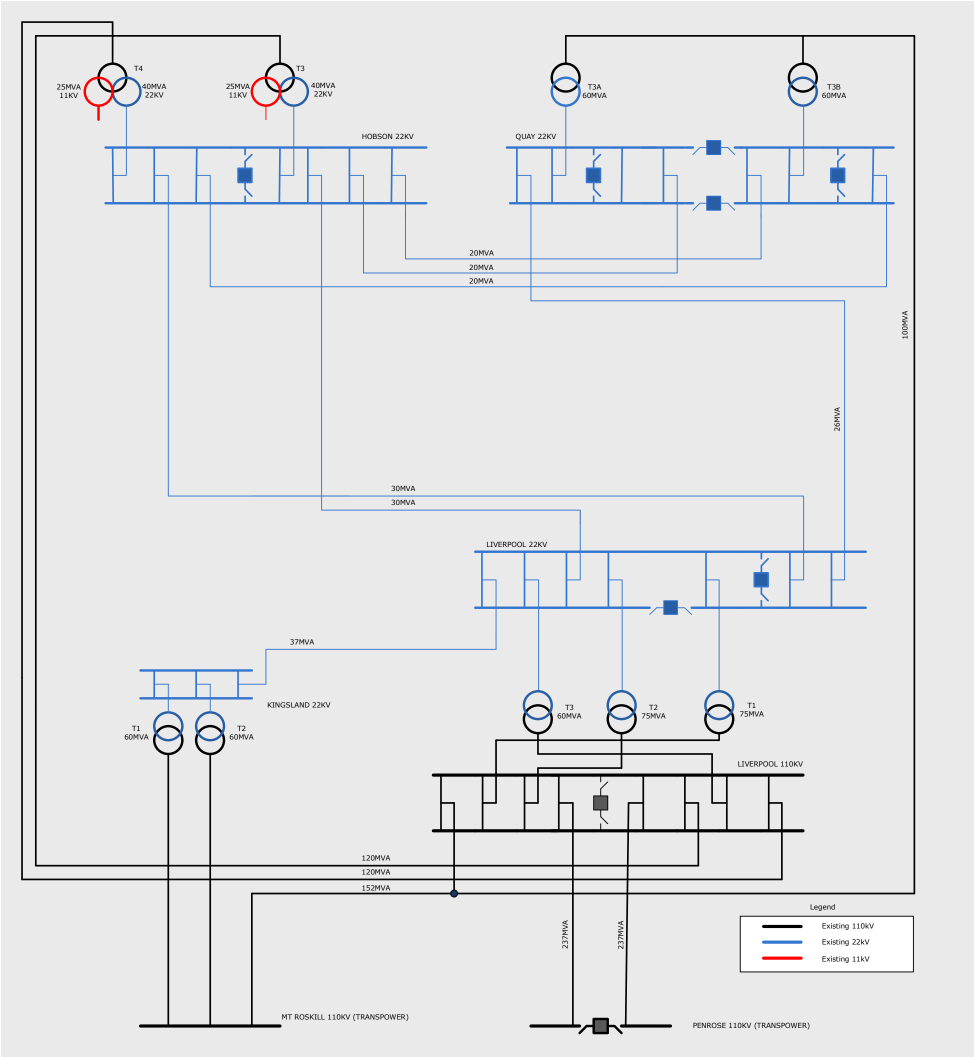

Figure 5-13 : Existing sub-transmission network in and to CBD – schematic

5.6.11.3 Medium-Term CBD Development Strategy

The security standard for the CBD sub-transmission network is "N-1 no break" and "N-2 switched". The design strategy for the CBD is to establish three 60MVA transformers at each bulk supply substation to provide 120MVA of firm installed transformer capacity with N-1 no-break operational configuration. To achieve N-2 switched security the design strategy for the sub-transmission in the CBD includes the completion of 22kV "express" interconnector cables between 22kV busbars with a capacity of 60MVA between the three bulk supply substation 22kV nodes. In the event of loss of a second transformer at a substation (N-2 scenario), transformer capacity will be down to 60MVA but the 22kV interconnectors from an adjacent substation have the capacity to supply 60MVA from the "neighbouring" bulk supply substation, ensuring the 120MVA load can continue to be supplied. Implementation will be through a staged approach, predicated on demand.

The CBD design strategy also envisages the establishment of a 110kV bus at each bulk supply substation with a 110kV cable between the 110kV buses to provide redundancy in the event of a failure of a 110kV cable-circuit.

With the recent retirement of the two gas-filled cables from Penrose to transformers T1 and T2 at Quay substation in 2012, the firm capacity at this substation is presently

60MVA which is sufficient to supply the load from Quay well into the future. The retirement of the gas-filled cables, although limited to 30MVA each, does make Quay substation vulnerable for a loss of the single 110kV cable (it should be noted that this circuit is new, only being completed in 2010). A second 110kV cable to Quay substation is planned from Hobson substation after the new GXP and 110kV switchboard is commissioned at Hobson in the last quarter of 2013). This second cable will provide full N-1 redundancy in terms of 110kV supply to Quay substation (the installation of underground ducts for this 110kV cable was completed in early 2011 in conjunction with a road rehabilitation project by Auckland City Council). As part of the installation of the second 110kV cable to Quay substation, the existing 110kV overhead bus will be retained but modified to be used to supply both transformers in the event of failure of one of the two 110kV cables.

A third 110/22kV transformer is required at Hobson substation to maintain security of capacity from circa 2015 when the load is expected to exceed the 65MVA firm transformer capacity. During commissioning sequencing studies in 2012, the decision was made to install this transformer one year earlier, in FY14, to ensure security of supply is maintained when each of the Hobson 110/22/11kV transformers are taken out of service to connect to the new 110kV GIS bus at Hobson.

The initial plan was to relocate existing transformer T3 from Liverpool to Hobson substation, to be used as the third 110/22kV transformer, but after due diligence of the risks it was decided that the unit from Liverpool, which has outdoor 110kV bushings for overhead lines, poses risks in an indoor enclosed installation. The project to replace transformer T3 at Liverpool will thus be postponed from FY14, to beyond FY18. The peak demand of 105MVA at Liverpool is still below the 114MVA firm transformer capacity and according to the load forecast this will allow some time before the replacement of this unit is warranted. A transformer of similar impedance and rating to T1 and T2 (75MVA) will increase the firm capacity at Liverpool from 114MVA to 150MVA (3 transformers each rated at 75MVA[54]).

At present, should the supply to the Auckland CBD from Transpower's Penrose 110kV bus fail, supply to the CBD will be maintained by means of the 110kV cable from Mt Roskill GXP to Liverpool substation and to Quay substation (the long-term cyclic rating of this cable is 204MVA) together with an existing 22kV cable from Kingsland to Liverpool substation rated 37MVA, to transfer load away to Kingsland[55]. A small amount of load can be transferred via 11kV backstop circuits to Newmarket and Kingsland substations if this is needed. The Auckland CBD will be at N-security under this scenario and any further failure of supply circuits would result in loss of supply to portions of the CBD.

This arrangement will suffice to supply the CBD for a complete loss supply from Penrose until completion of the Hobson GXP (scheduled late 2014). The NAaN 220kV cable will provide the option to supply Hobson (and Wairau substation) from either the north (via the western overhead circuit to Albany) or from the south. This will address loss of supply to the CBD arising from the loss of Transpower's Penrose 110kV bus or failure of both of Vector's 110kV cables in the tunnel. Transpower's 250MVA 220/110kV interconnecting transformer at Hobson substation is sufficiently rated to supply the combined loads of Hobson, Liverpool and Quay substations, albeit with N security.

Figure 5-14 below depicts the intended sub-transmission network into the CBD after completion of the new GXP at Hobson substation.

[54] It is reported earlier on that the "standard" for the CBD is three 60MVA transformers at each of the CBD bulk supply substations. However, at the time of procurement of transformers T1 and T2 75MVA units were offered at a very competitive price, hence Liverpool has 75MVA units rather than the "standard" 60MVA units.

[55] This cable has an earth screen rated 3kA and can thus not be used for parallel operation with Liverpool.

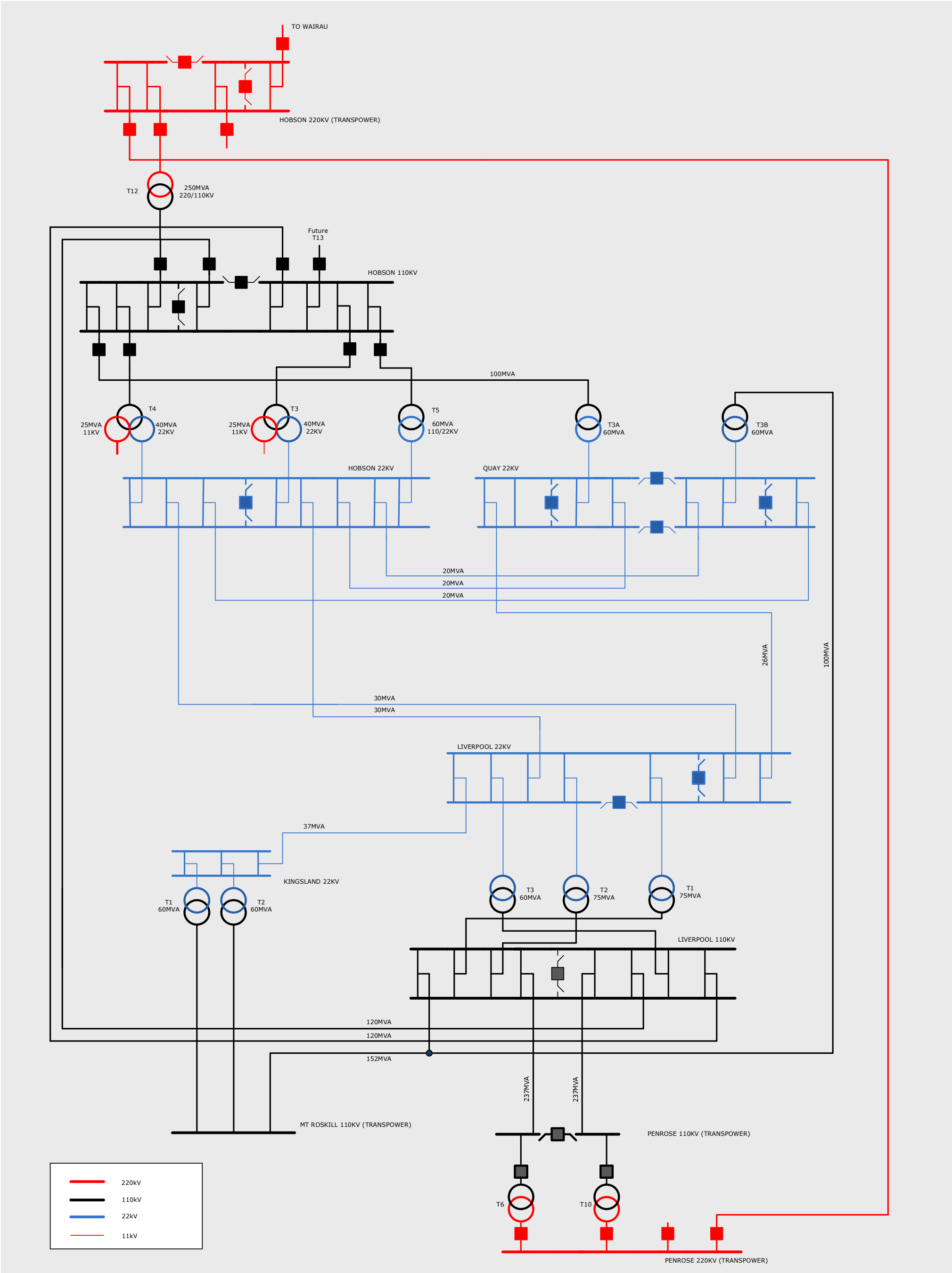

Figure 5-14 : Sub-transmission network in and to CBD - post 2015

5.6.11.4 Long-Term CBD Development Strategy

The long-term network development strategy for the CBD (10 years plus) foresees the establishment of a bulk supply substation in the south-western area of the CBD in an area bounded by Hobson, Nelson and Cook Streets. This substation is designated Hobson-West substation and will provide 22kV injection capability into the south-western part of the CBD. This substation will initially be developed as a 22kV node by connecting into the existing 22kV interconnector cables between Hobson and Liverpool substations, but as demand grows will be developed into bulk supply substation with a 110kV supply.

Hobson-West will be established when the load at Hobson substation approaches the firm transformer capacity (N-1) level of 120MVA[56].

The long-term plan makes provision for the installation of a 22kV switchboard at Victoria substation to create a 22kV node. At present Victoria substation is supplied from the Liverpool 22kV bus and supplies commercial/university and residential (apartments) load in the eastern parts of the Auckland CBD via two 22/11kV transformers. With the long-term strategy of migrating 11kV load to the 22kV distribution network in the CBD, this substation is strategically located as a marshalling point for the extension of the 22kV network in the CBD.

A section of the existing 22kV interconnector cable between Quay and Liverpool substations is an ageing gas-filled PILC STA cable joined onto 630mm² Al XLPE single-core cables. The gas-filled portion of this cable limits the capacity of the circuit to 24MVA in summer. This section of gas-filled cable will be replaced. In line with the strategy for the CBD to establish interconnectors rated at 60MVA between bulk supply substations, a second 22kV interconnector cable is planned between Liverpool and Quay substations. This cable will be installed via Victoria substation as a second supply to the 22kV bus.

In the long term, load-growth at Quay is expected to require the installation of a third transformer at which time a 110kV GIS switchgear bus will be established to enable the connection of a third transformer and provide the ability for fast transfer of 110kV supplies under contingent conditions. The present and forecast load for Quay is such that the installation of a third 60MVA transformer is still some years away.

The Liverpool 110kV GIS switchgear is not fitted with a bus-section switch which makes a planned double bus outage almost impossible to achieve. A double bus outage is not a regular requirement but is needed for certain types of intrusive maintenance/ replacement of components. One of the options being explored as a solution to mitigate this high-impact/low-probability risk, is to install a second but smaller suite of 110kV GIS at Liverpool connected via bus-section switches to the existing 110kV switchgear and to transfer one of the 110/22kV transformers at Liverpool from the existing 110kV GIS to this new GIS suite. This option will allow one 60MVA transformer to remain in service which, together with the 22kV interconnectors, will be able to meet the demand from this substation.

The two existing 110kV oil-filled cables from Roskill to Kingsland have been in service since March 1965 – a period of 47 years. These cables have proved reliable but replacement should be considered and planned for in the long term to coincide with the replacement of existing transformers at Kingsland. After the establishment of the new GXP at Hobson substation, the CBD will be less reliant on the Roskill-Liverpool 110kV cable for backstopping and using this cable to supply Kingsland is a feasible option that will be investigated further. One option being considered is to establish a 110kV GIS node at Kingsland using the existing Roskill to Liverpool 110kV cable.

Figure 5-15 depicts the long-term plan for the sub-transmission network in the CBD and includes a possible configuration for the 110kV supply to the proposed Newmarket-South bulk supply substation and the supply to Kingsland referred to earlier. This long-term view is subject to further detailed investigation, network studies and modelling and to external factors and developments as time goes on.

[56] The firm capacity at Hobson is 65MVA at present but will be boosted to 125MVA once the third 110/22kV transformer (60MVA) is installed.

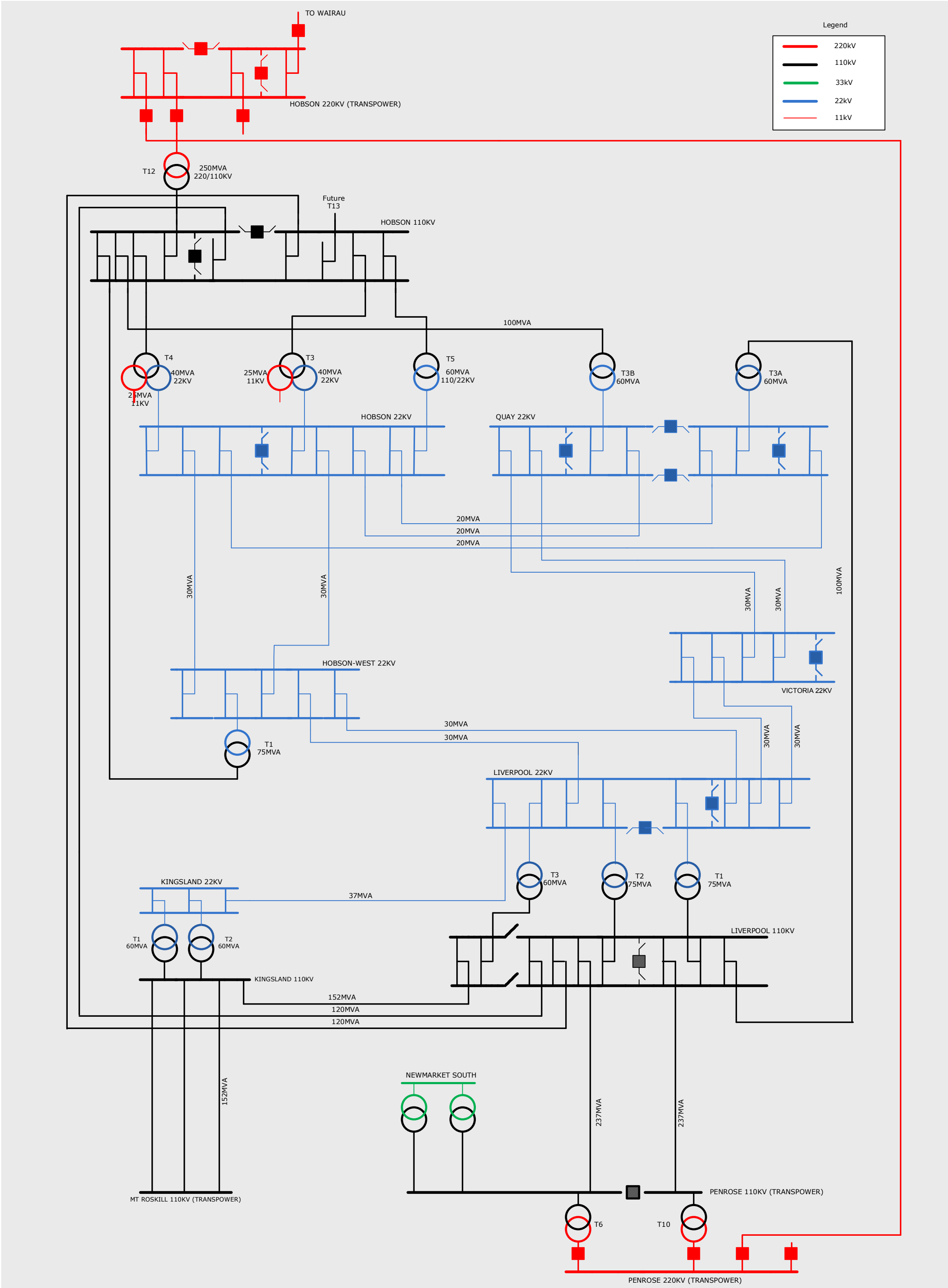

Figure 5-15 : Sub-transmission network in and to CBD – long-term

5.6.11.5 Operation of CBD Sub-transmission Network

The intention is to operate the new 110kV supply at Hobson with that of Liverpool and the 33kV supply from Transpower's 220/33kV transformer at Wairau Rd in parallel with the 33kV supply from Vectors 110/33kV transformers. Parallel operation of GXP's in this manner raises a number of issues around network protection, operational and compliance that need to be addressed. These are progressively being worked through with Transpower, the system operator and the Electricity Authority.

5.6.11.6 Projects Planned at Sub-transmission Level

a. Projects – Within Next Five Years

- **Penrose Tunnel - Completion of Fire-Sprinkler Installation (FY14)**

Completion of the installation of fire sprinklers at the location of 220kV and 110kV cable joints in the Penrose tunnel: This project commenced in FY13 but the fire sprinkler installation can only be completed after the 220kV cable-joints have been fully installed. This project will be completed towards the end of FY13/beginning of FY14.

- **Hobson - Completion of the GXP (FY13, FY14)**

This is the continuation of the project to establish a 250MVA 220/110kV GXP at Hobson substation in the lower CBD. Civil works for this project will be completed in the second half of FY13 as well as ancillary works, installation of a 110kV GIS switchboard and transfer of existing 110kV cables to the GIS switchboard. The contractual commissioning date for the GXP is June 2014 but the goal by both Transpower and Vector is to accelerate commissioning to be completed by November 2013. The project as a whole will be completed in FY14.

- **Hobson Substation – Third 110/22kV Transformer (FY13, FY14)**

Background

The western lower precinct of the Auckland CBD is serviced by Hobson bulk supply substation. This substation has two 110/22/11kV 65MVA transformers which provide a firm installed capacity of 65MVA and the two transformers provide N-1 no-break security augmented by 22kV interconnectors from neighbouring bulk supply substations. Load-growth in the CBD is predicted to reach the firm, installed capacity of the transformers by circa 2015. The existing transformers will be progressively transferred to the new 110kV GIS switchboard installed as part of the GXP. While a transformer is taken out of service, the security of supply to this precinct of the CBD is compromised. Additional 22kV transformer capacity at Hobson is needed during commissioning.

Issues

- Insufficient capacity for load-growth from circa 2015;
- Insufficient capacity to maintain security of supply from circa 2015; and
- Insufficient capacity to maintain security of supply during construction of the GXP during 2013 and 2014.

Options Considered

- Installation of a third 110/22kV 60MVA transformer at Quay substation;
- Transfer of load to neighbouring bulk supply substations; and
- Installation of a third 110/22kV 60MVA transformer at Hobson substation. The transformer will be energised from the new GXP interconnector.

Recommended Solution

The first option is exposed to single mode failure because a single 110kV circuit supplies the 110/22kV transformers at Quay. Even if a third transformer is installed at Quay substation the transformers will still be exposed to this single-mode failure. The second option exposes the Hobson supply to the same risk as the first option during construction when an existing transformer has to be taken out of service at Hobson. The third option will satisfy both the issue of load-growth and security of supply going into the future, while at the same time providing security of supply during commissioning from a totally separate source, namely the new interconnecting 220/110kV transformer installed as part of the GXP at Hobson substation.

- **Quay - Installation of a second 110kV Cable to Quay Substation (FY16)**

Background

Both 110/22kV 60MVA transformers at Quay are presently fed by a single 110kV cable from Roskill substation (via Liverpool substation). This exposes the transformers to a single-mode point of failure (it is noted that this cable is very new, being installed in 2010). However, the repair time for 110kV cables is lengthy and this single mode point of failure needs to be addressed after completion of the 110kV node at Hobson. Ducts and joint pits for this cable were installed in 2008.

Options Considered

  - Installation of additional 22kV interconnectors between Quay and Hobson is not an option because of insufficient spare circuit-breakers at Quay and extensive modifications that are required to extend this switchgear. The new 110kV GIS node at Hobson presents itself as the ideal solution from which to install an alternative 110kV supply to Quay substation.

Recommended Solution

Install a 110kV cable from Hobson substation to Quay substation.

- **Quay - Replacement of 22kV CTs in Two 22kV Interconnector Circuit-breakers at Quay (FY14)**

Background

The 22kV interconnectors between the 22kV busbars of Hobson and Quay substations are rated at 20MVA each. The combined rating of the circuits is thus 60MVA which provides N-2 switched security in the event of loss of a 110/22kV 60MVA transformer.

Issue

  - The CTs at the Quay end of two of the three circuits are rated 400/5 which restricts the capability of the circuits to roughly 18MVA.

Options Considered

  - The only option is to replace the CTs with higher ratio units to be able to use the interconnectors to their full rating during a contingency. Other options are not practical.

Recommended Solution

Replace the Quay end 400/5 CTs in two of the Hobson to Quay 22kV interconnectors (circuits 1 and 2) with CTs that match the long-term cyclic and emergency ratings of the cables.

- **Liverpool - Replacement of Transformer T3 at Liverpool Substation (FY18)**

Background

Transformers T1 and T2 were replaced in 2010 and 2011 respectively with transformers of higher impedance. Transformers of higher impedance were procured to ensure fault levels in the CBD are maintained at appropriate levels. The third transformer was not replaced, although the intention was to have three transformers at Liverpool with matching capacities and impedances. The intention was to relocate the existing ABB T3 transformer to Quay substation where a spare bay exists. It will then be available as a spare 110/22kV transformer for use under contingency in the network or utilised at Quay substation at such time that load warrants implementation of a third transformer.

Issue

- Existing transformer T3 is a low impedance 110/22kV transformer that was procured at the time of the CBD power crisis. This transformer needs to be replaced at Liverpool with one matching impedance of transformers T1 and T2 to ensure optimal load-sharing.

Options Considered

- An option that was considered was to relocate the ABB T3 transformer from Liverpool substation to Hobson St to become the third 110/22kV transformer at this substation. As described further above, because of the risks imposed by it being an outdoor unit, use at the constrained Hobson substation was discounted.

Recommended Solution

Procure a transformer of equal impedance to transformers T1 and T2 for installation at Liverpool substation. The firm transformer capacity is sufficient for this transformer to be replaced circa 2018.

- **Liverpool/Quay - Install a second 22kV Interconnector Between Liverpool and Quay Substations (FY16)**

Background

The CBD design strategy makes provision for the establishment of 22kV interconnectors between CBD bulk supply substations with 60MVA capacity. 60MVA interconnectors already exist between Hobson and Quay substations and between Hobson and Liverpool substations.

Issue

- A single 22kV interconnector exists between Liverpool and Quay substations of which a long section is an aged gas-filled cable. This circuit is limited to 24MVA in the summer. An additional interconnector needs to be installed between these two substations. Furthermore, the intention is to select a cable route which can be easily diverted into Victoria substation to establish a 22kV node from which to distribute 22kV feeders into the CBD.

Options Considered

- Installation of a third 22/11kV transformer at Victoria substation was considered as an option but this will not be in line with the master plan to convert the sub-transmission voltage in the CBD to 22kV. Rather than providing for 11kV expansion the focus will be on the conversion to 22kV.

Recommended Solution

Upgrade the capacity of 22kV interconnection between Hobson and Quay substations by installing an additional 22kV interconnector between the two substations.

- **Victoria - Establish a 22kV Node at Victoria Substation (FY19)**

Background

The 22kV radial distribution circuits within the CBD, double the capacity of the equivalent 11kV feeders but also double the numbers of customers affected by outages. To date the 22kV roll-out has focussed on connections between the major substations, but the plan is to establish a meshed 22kV network that allows switching load between 22kV nodes. This approach maximises the utilisation of the 22kV network when overlaid with a smart network to automatically manage the switching to optimise loading or redirect load arising from faults. Prior to the implementation of automatic switching, there is a need to establish further switching nodes and meshed network. Victoria substation is ideally located to be converted into a 22kV switching node.

Issue

- Victoria substation has two 22/11kV transformers rated at 20MVA each. The load on the 11kV network from Victoria substation has reached a point where the 22/11kV transformers will reach their limit in terms of N-1 security in the foreseeable future, in case one of the 22/11kV transformers experiences an outage.

Options Considered

- Rather than installing a third or increased capacity 22/11kV transformer at Victoria substation, the plan is to establish a 22kV node and advance the transfer of 11kV load to the 22kV network to keep within the security limits of the existing transformers.

Recommended Solution

Establish a 22kV switchgear node at Victoria substation.

- **Quay - Extend the 22kV Switchboard at Quay Substation (FY17)**

Background

To increase the coverage of 22kV distribution feeders within the CBD, additional 22kV switchgear needs to be installed at the main in-feed substations. Quay substation, in particular, is constrained because 22kV circuit-breakers are used for dedicated sub-transmission functions (eg. Parnell sub-transmission supply, 22/11kV zone substation transformers, 22kV incomers, 22kV express feeders to Liverpool and Hobson) leaving few spare breakers for distribution.

Issue

- The existing 22kV switchgear in Quay substation does not have any spare circuit breakers that can be used for additional 22kV distribution feeders into the CBD. Furthermore, there are no spare circuit breakers available for the proposed second 22kV interconnector to Liverpool substation (via Victoria substation).

Recommended Solution

Extend the existing 22kV switchgear to make provision for further 22kV distribution circuits and a 22kV interconnector. Timing of the extension of the switchgear is provisional at this time.

- **Quay - Relocation of Transformer T3A at Quay Substation (FY15)**

Background

A second 60MVA 110/22kV transformer was installed at Quay substation in FY12 as planned and reported in the previous AMP[57]. At the same time the two ageing gas-filled cables from the Transpower's Penrose 110kV bus to transformers T1 and T2 at Quay substation were retired. The intention was to install transformer T3A in the bay to be vacated by transformer T1. Following an assessment of the risks to the security of supply within the CBD, it was considered prudent to liven transformer T3A prior to the de-commissioning of the two 110kV gas-filled cables and their associated transformers (T1 and T2). To achieve this T3A was installed in a temporary location at Quay substation. The intention is to relocate T3A into the vacated T1 bay after completion of the new GXP at Hobson, as originally proposed.

Options Considered

  - Transformer T3A needs to be installed in its final bay and the consideration of other options is not applicable to this project.

Recommended Solution

Relocate transformer T3A into its final bay after the GXP at Hobson substation has been commissioned.

- **Quay - Reinstate the 22kV Oil Cable Between Quay and Hobson Substations for 22kV Ripple Signal (FY14)**

Background

At present the CBD is operated as two sub-transmission areas. The network is normally configured so that one area is supplied by the three 110/22kV transformers at Liverpool. Ripple signal is provided by the 22kV ripple plant at Liverpool. The second area normally consists of the two Hobson transformers in parallel with one transformer at Quay. The ripple plant at Quay provides the ripple signal to this second sub-transmission area. After the third transformer has been commissioned at Hobson substation, the CBD will be configured as three sub-transmission areas. The third area will likely be serviced by transformers T3 and T4 at Hobson substation.

Issue

  - The issue is that there is no 22kV ripple plant at Hobson substation and it depends on Quay for its ripple signal. There is an existing 22kV oil-insulated cable between Quay and Hobson substations, presently out of service but recently tested and found to be in good condition. This cable can be reinstated for the purpose of providing ripple signal and jointed to the switchgear at both substations.

Options Considered

  - An alternative option is to install a new 22kV ripple plant at Hobson substation. Hobson substation is constrained in terms of space and a ripple plant installation is a costly project compared to the solution proposed.

Recommended Solution

The existing 22kV cable will be reinstated to provide a path for 22kV ripple signal from Quay to Hobson substation.

[57] Refer 6th bullet point under clause 5.6.10.4 of the 2012 AMP.

b. Projects – Within Five to Ten Years

- **Newmarket South - Establish a GXP at Newmarket (FY20)**

Load in the Newmarket area is forecast to grow over the next number of years with developments proposed on the ex-Lion Brewery land and proposed extensions of the Westfield shopping mall in Broadway. A 110kV GXP is to be established at Newmarket when demand exceeds the capacity of the current Newmarket 33kV cables. A phased approach is proposed comprising of the following steps:

  - Establish Newmarket South zone substation: The Newmarket 33kV cables are terminated on a 33kV switchboard. Newmarket and Newmarket South 33/11kV transformers are supplied from this board;
  - 110kV GXP - single 110/33kV transformer substation: Once the network security on the 33kV cables is breached (circa 2020), install a single 60MVA 110/33kV transformer on the site, supplied from Hobson or Liverpool at 110kV. Back-up supplies are from Penrose via the 33kV cables;
  - 110kV GXP - second 110/33kV transformer: Once the load exceeds 60MVA install a second 110/33kV transformer, supplied from Penrose 110kV bus. Supply Drive and Remuera substations from the Newmarket GXP as existing sub-transmission cables reach end of life; and
  - The procurement of land in the Newmarket South area has made good progress but the supply configuration is still in the concept stage and still requires further study to confirm the proposed solution.

- **Projects – Long term**

- **Southdown - Establish a GXP at Southdown**

To further reduce load on the Penrose 33kV bus, the long term plan is to establish a GXP at Southdown with a 33kV bus from which to supply Vector’s Carbine, Onehunga, Te Papapa and Westfield zone substations. Timing is determined by the retirement of key sub-transmission assets.

- **Hobson West - Establish Hobson West Bulk Supply Substation**

Vector owns property identified for a future bulk supply substation in the area enclosed by Hobson, Nelson, Union Ave and Cook Streets. This south-western precinct of the CBD is presently serviced by distribution feeders from Hobson and Liverpool substations. A new bulk supply substation will be required in this area when the load on Hobson substation exceeds 120MVA, ie. exceeds the firm transformer capacity of the substation. The load is expected to reach this level at the end of the planning period or slightly beyond. This substation will be supplied with a single 110kV cable from Hobson substation directly onto a 110kV transformer to establish a 110kV cable-transformer feeder. 22kV interconnectors will provide backstop until such time that a second 110kV supply needs to be installed.

- **Kingsland - Establish a 110kV Switchboard at Kingsland Substation**

Kingsland substation is presently supplied by means of two gas-filled 110kV cables from Roskill substation directly connected to two 60MVA transformers. These two oil-filled cables have given many years of reliable service (installed in 1965, thus 47 years of service). The existing Roskill-Liverpool 110kV cable passes close to the Kingsland site. When the oil-filled cables require replacement, one option is to turn the Roskill-Liverpool cable into this substation and establish a 110kV bus. Alternate supplies to Kingsland would be from Roskill or Penrose, via Liverpool. A number of challenges need to be overcome including relocating the cable cross-bonding to ensure the cable is not derated. This proposal is a high level concept at this time.

- **Quay - Installation of a 110kV Switchboard at Quay Substation**

The installed transformer capacity at Quay substation is 120MVA giving a firm capacity of 60MVA. The risk of single mode point of failure due to the single 110kV cable will be mitigated by the installation of a 110kV cable from Hobson substation after completion of the Hobson GXP. When a third 110/22kV transformer is required at Quay substation a 110kV bus will have to be installed at this substation. This is not anticipated to happen within the next ten years covered by this AMP.

- **Liverpool - Extension of the 110kV Switchboard at Liverpool Substation**

The Liverpool 110kV GIS switchgear is not fitted with a bus-section breaker which makes a double bus outage almost impossible to achieve. A double bus outage is not a standard requirement but is necessary for the intrusive replacement of certain components. The impact of a double bus outage is loss of supply to the three 110/22kV transformers at Liverpool. Once the Hobson GXP is commissioned, 60MVA at 22kV can be transferred from Hobson, 24MVA from Quay and 37MVA from Kingsland substations. There is a risk with this as both the Quay and Kingsland load transfers are via older oil-filled 22kV cables.

One of the options being explored to mitigate this high-impact/low-probability risk is to install a second but smaller suite of 110kV GIS switchgear at Liverpool connected via bus-section switches to the existing 110kV switchgear and to transfer one of the 110/22kV transformers at Liverpool from the existing 110kV GIS to the new GIS suite.

This option will allow one 60MVA transformer to remain in service which, together with the 22kV interconnectors, will be able to provide the demand while the main suite is taken out of service.

It is recognised that there is a shortage of 110kV switchgear at Liverpool with the Quay substation cable on a double cable-box with the Roskill cable. Further to avoid the "tunnel collapse" HILP scenario at least one of the 110kV cables to Newmarket GXP should be from Liverpool or Hobson.

Further work is proposed to find the optimal solution.

5.6.11.7 CBD - Distribution

At present the bulk of the load in the Auckland CBD is supplied by the 11kV distribution network from four zone substations, Hobson, Liverpool, Victoria and Quay. The distribution network comprises 11kV radial feeders from the four zone substations, forming a meshed network with open switch points between feeders.

From 2004 extension of the 11kV distribution network in the Auckland CBD was suspended in favour of the progressive roll-out of a 22kV distribution network. This decision was based on providing capacity and security to meet the long-term CBD demand growth in a cost-effective manner.

22kV network reinforcement within the CBD is driven by 11kV feeder load and new connection requests. Existing 11kV substations are 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. Figure 5-16 indicates the extent of the 22kV network in the CBD and the location of the key substations.

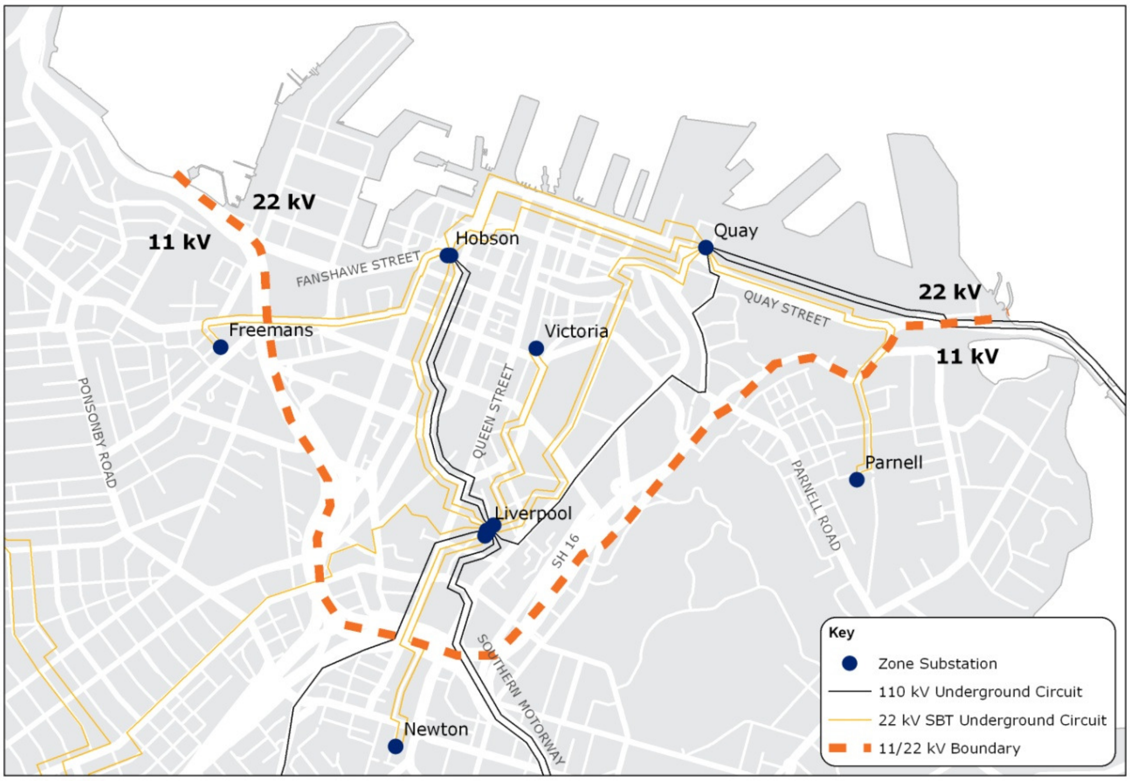

Figure 5-16 : CBD area designated for 22kV distribution

5.6.11.8 Projects Planned at Distribution Level (CBD)

- **Hobson - 22kV extension to Tank Farm (ongoing)**

The Auckland Waterfront Development Agency (AWDA) plans to progressively develop the tank farm area into a commercial hub over a 15 year timeframe. The 11kV network has insufficient capacity to supply the load resulting from this development. Two 22kV distribution feeders were installed from Hobson substation to the Fanshawe Street/Beaumont Street area in 2008 and were extended to Jellicoe Street/Halsey Street in 2012 to supply the ASB building. The long term plan is to establish a 22kV distribution network and progressively phase out the existing 11kV network in the area. Future-proofing 22kV cables and ducts are installed in conjunction with road improvement projects. A third 22kV feeder is planned, again driven by customers' demand requirements.

- **Auckland CBD 22kV Network Extension and 11kV to 22kV Load Transfer (ongoing)**

This project allows for the extension of the 22kV network in the CBD. The selection criteria for these projects are:

- Anticipated capacity shortfall or security breach with the existing 11kV network;
- New commercial developments eg. Wynyard Quarter, Waterfront;
- New customer connections are required and 22kV network is unavailable;
- Replacement of 11kV cables due to age and condition;
- Auckland Transport's roading alterations; and
- Network reconfiguration opportunities.

Load transfer projects arise through the need to transfer customers from the 11kV network to the 22kV network. The selection criteria for these projects are:

- Upgrading existing substations due to load increases;
- Retirement of aged 11kV substation equipment; and
- Availability of 22kV network. Note that even if the 22kV network isn't available replacement substation equipment will be rated for 22kV.

- **Hobson – Nelson St 22kV Feeder (FY13)**

Background

A customer in Nelson St has requested a supply upgrade to a deterministic N-2 (with break) security level. They have also requested additional capacity to be available for future load increases.

Issues

- There is insufficient capacity in the existing 11kV network to meet the security and long term capacity requirements requested by the customer; and
- Extending or reinforcing the 11kV network does not align with Vector's strategy to phase out the 11kV in the CBD.

Options Considered

- Supply the load from the existing 11kV network and install a new 22kV feeder from Hobson substation to supply the additional load: This option will not meet the N-2 (with break) security of supply requested by the customer;
- Supply the load from the existing 11kV network and extend the existing 22kV network to supply the additional load: This option will not meet customer's requirement for N-2 (with break) security of supply; and
- Install a new 22kV feeder from Hobson substation and extend the existing 22kV network to supply the customer. This option will provide sufficient capacity and N-2 (with break) security of supply required by the customer.

Recommended Solution

Install a new 22kV feeder from Hobson and extend the existing 22kV distribution network in the area to provide N-2 (with break) to supply the customer. This is a customer driven project and therefore subject to the customers' timeframes. At this stage the project is scheduled for 2013.

- **Liverpool – Auckland Medical School**

Background

The Auckland Medical School in Grafton has a demand of 4MVA, supplied by 11kV feeders from Liverpool substation. The Medical School has plans to increase their load to 7MVA by 2015.

Issue

- There is insufficient capacity in the existing 11kV network to supply the additional load.

Options Considered

- Install a new 11kV feeder from Newton substation to the Medical School: Implementing this option will initiate upstream network reinforcement including sub-transmission circuits and transformers at Newton substation to meet the capacity required. This option is costly;

- Install a new 11kV feeder from Liverpool substation to the Medical School: The cost of this option is similar to installing a new 11kV feeder from Newmarket substation. However the Grafton Gully provides a demarcation for the CBD 22kV network and with the long term plan to phase-out 11kV reticulation in the CBD, adding further 11kV load delays this programme; and
- Install a new 11kV feeder from Newmarket substation to the Medical School: Newmarket substation is constrained for space to extend the 11kV switchboard. If the supply is required before Newmarket South substation is established (provisionally 2015) temporary supply arrangements may be needed to avoid extending the Newmarket switchroom. Post 2015, the proposed Newmarket South substation, once constructed, will free up a number of circuit breakers in Newmarket substation. This is a more cost efficient option and the recommended solution.

Recommended Solution

A new 11kV feeder will be installed from Newmarket substation to the Medical School. This is a customer driven project, with the timing subject to customer. Provisional timing is FY15 at this stage.

- **Liverpool – Mayoral Drive 22kV Feeder (FY16)**

Background

A customer in Mayoral Drive has a present demand of 5MVA, supplied by 11kV feeders from Liverpool substation. The customer’s plans include a progressive demand increase up to 10MVA over a 10 year timeframe.

Issues

- There is insufficient capacity in the existing 11kV network to supply the additional load; and
- Extending or reinforcing the 11kV network does not align with Vector’s strategy to upgrade the reticulation voltage to 22kV and phase out the 11kV in the CBD.

Options Considered

- Extend the existing 22kV network to supply the new load. This option will not provide sufficient capacity to meet the long term load growth; and
- Install two new 22kV feeders from Liverpool substation to supply the customer’s load. This option is preferred.

Recommended Solution

Two new 22kV feeders will be installed from Liverpool substation to supply the customer’s forecast load. As it is a customer driven project, the timing is subject to customer’s programme. At this stage the project is scheduled for 2016.

- **Quay - Ports of Auckland Supply (FY17)**

Background

The Ports of Auckland have an existing demand of 4MVA, supplied by 11kV feeders from Quay substation. The 10 year plan of Ports of Auckland indicates a demand increase to 11MVA by 2017, and upwards of 20MVA in the medium-term.

Issues

- o There is insufficient capacity in the existing 11kV network to supply the additional load; and
- o Extending or reinforcing the 11kV network does not align with Vector's strategy to phase out the 11kV in the CBD.

Options Considered

- o Install new 11kV feeders from Quay substation to supply the additional load at the Ports. This option is not in line with Vector's long term plan for the 22kV roll-out and progressive 11kV reticulation retirement within the CBD; and
- o Establish a new 22/11kV zone substation at the Ports of Auckland. The new substation will provide a dedicated supply the private 11kV reticulation network with the Ports. This will provide capacity sufficient to meet the Port of Auckland's long-term plans.

Recommended Solution

It is recommended that a new 22/11kV zone substation be established to meet the projected demand at the Ports. This is a customer project so timing and proposed solution is provisional at this stage.

Projects – Within Five to Ten Years

- **Hobson/Quay - Queens Wharf Supply (FY21)**

A new 22kV distribution feeder is to be installed to supply the Queens Wharf development. Timing is dependent on the customer and is therefore provisional at this stage.

5.6.12 Penrose 33kV

5.6.12.1 Background

Penrose 33kV GXP supplies 12 zone substations, viz. Carbine, Drive, McNab, Mt Wellington, Newmarket, Orakei, Remuera, Rockfield, St Heliers, St Johns, Te Papapa and Sylvia Park. It also supplies a 33kV switching station at St Johns and a 22kV switchboard (at Penrose) supplying Glen Innes, Onehunga and Westfield.

Figure-5-17 below shows the existing 110kV, 33kV and 22kV sub-transmission networks supplied from this GXP.

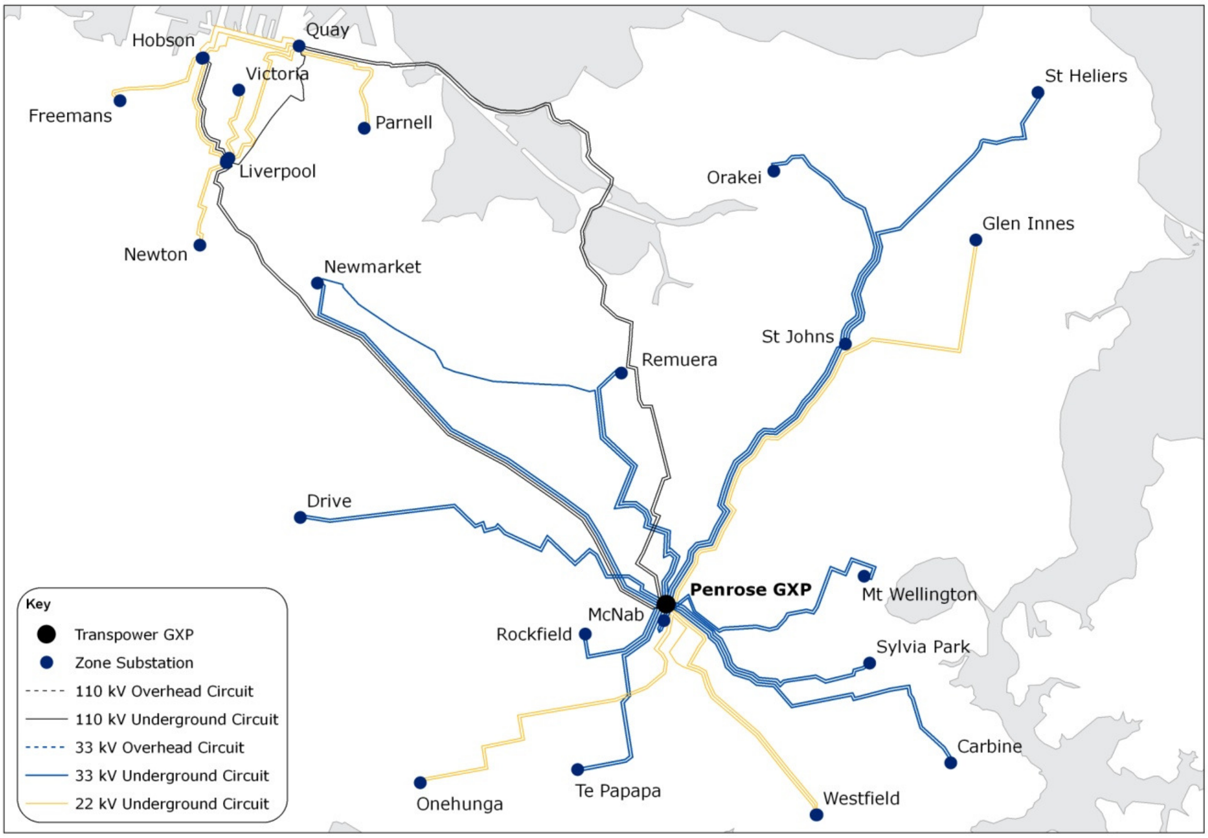

Figure-5-17 : Existing sub-transmission network at Penrose area

Table 5-15 shows the summer and winter load forecasts at the GXP.

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Penrose 33kV (incl 22kV)	259	277	282	287	293	298	304	308	311	313	315
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Penrose 33kV (incl 22kV)	306	319	326	332	339	345	352	358	363	365	368

Table 5-15 : Penrose 33kV summer and winter load projections[58]

The long-term plan is to reduce demand on the Penrose 33kV bus through the establishment of new GXP's at Southdown and Newmarket. It is intended to phase out Penrose 22kV either by transferring load to Penrose 33kV, Southdown or Newmarket GXP's. While a 220kV GXP already exists at Southdown, Vector does not take a supply from it. The impact on Penrose 33kV demand is shown in Table 5-16.

[58] Forecast demand without factoring in the impact of Newmarket and Southdown GXP.

Name	Forecast Demand (MVA) - Summer							
	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26
Newmarket South		47	48	49	49	50	51	60
Southdown			0	10	41	41	41	41
Penrose 33kV	310	266	268	258	229	230	231	223
Name	**Forecast Demand (MVA) - Winter**							
	FY20	**FY21**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**
Newmarket South	48	49	50	51	52	53	53	73
Southdown			15	46	47	47	47	47
Penrose 33kV	313	316	303	274	275	276	278	261

Table 5-16 : Proposed load reduction at Penrose 33kV

The relocation of the Lion Breweries to Ormiston Rd has reduced the demand on Newmarket substation. However the proposed expansion of the Westfield Shopping Centre at 309 Broadway and the redevelopment of the ex-Lion Breweries site is forecast to add significant load. The capacity shortfall will be addressed by the establishment of Newmarket South substation in 2016.

Part of Ellerslie Racecourse has been earmarked for development and this is expected to trigger the construction of Ellerslie zone substation. Industrial load growth in Te Papapa and Westfield area is on-going and is expected to result in a capacity shortfall towards the end of the planning period. A new substation in the vicinity of Southdown is proposed to address this issue.

5.6.12.2 Projects Planned

a. Projects – Within Next Five Years

- **Newmarket South – Land Purchase (FY14)**

It is planned to establish a new substation in the Newmarket South area (refer to Newmarket South substation below) in 2016. Land needs to be secured for this substation.

- **Newmarket - New 11kV Feeders to Supply 309 Broadway (FY13)**

Background

The Westfield Group has planned a commercial redevelopment at 309 Broadway, Newmarket. The customer has requested a 6.5MVA in 2013.

Issues

- There is insufficient capacity in the existing 11kV feeders to supply this new load.

Options Considered

- Install a new 11kV feeder from Newmarket substation to supply the development at 309 Broadway: There is insufficient spare capacity in the backstop feeders to provide N-1 (with break) security; and
- Install two new 11kV feeders from Newmarket substation to supply the development at 309 Broadway. This will provide N-1 (with break) security to the customer for the short to medium term. To accommodate the proposed load increase on Newmarket substation (eg. development of the ex-Newmarket Breweries site) the intention is to

transfer Westfield load to Newmarket South substation once constructed.

Recommended Solution

Two new 11kV feeders will be installed from Newmarket substation to supply the Westfield load. Longer term, the load will be transferred to Newmarket South substation following its commissioning in 2016.

- **Newmarket South – Establish a New Substation (FY16)**

Background

The existing Newmarket substation has three 20MVA transformers, loaded to a maximum of 35MVA in 2012. Load decreased when one of the key customers, Lion Breweries, relocated to Ormiston Road, South Auckland, leaving the existing site with minimal load. Future developers of the vacated site have yet to be confirmed but Newmarket substation is ideally suited to supply this load.

Westfield Group have planned further load increases for its shopping mall at the south end of Newmarket (309 Broadway), which, when combined with the forecast load from the ex-Lion Brewery site re-development, will push the demand above the secure capacity of Newmarket substation. Feeders from adjacent Remuera and Drive substations are heavily loaded and while the option remains to install additional feeders, there is insufficient capacity at these substations to meet the demand.

Issues

- There is insufficient capacity in Newmarket and adjacent substations of Drive and Remuera to maintain network security to the Newmarket commercial centre beyond 2016.

Options Considered

- Establish a new substation (Newmarket South) in the southern precinct of Newmarket with a commissioning date of 2016: The supply to Newmarket South substation will initially utilise Newmarket’s 33kV feeders until capacity constraints trigger an upgrade. Following the establishment of Newmarket South substation and re-development of the ex-Lion Breweries site, Newmarket substation will be located at the load centre. Newmarket South will off-load Remuera and Drive substations and supply the Westfield complex. This option is the most cost effective of the options considered;
- Reinforce Newmarket substation. Newmarket is already a three transformer substation so adding further capacity is not recommended. A building extension is required to accommodate the additional feeder switchgear, but additional transformer capacity cannot be added due to excessive fault levels. Adding further 11kV feeders to the already congested site will cause circuit de-rating and enhance the risks associated with the concentration of Newmarket’s load in one substation. Reinforcing Newmarket substation only briefly defers the need for Newmarket South substation and net present cost (NPC) calculations show this is a costly option compared to the preferred Newmarket South substation; and
- Establish a new substation at Ellerslie to supply the southern precincts of Newmarket. Ellerslie is approximately 5km from the Newmarket commercial centre and the long distribution cabling distances required to supply Newmarket ensure this option is sub-optimal. Furthermore, this cabling only defers Newmarket South substation rather than

displacing it. NPC calculations demonstrate it is more expensive than the preferred option.

Recommended Solution

Construct a new substation (Newmarket South) in the southern precinct of Newmarket in 2016.

- **Rockfield - NZ Technology Park Supply (FY16)**

Background

The New Zealand Technology Park has proposed an increase of 6MVA to their existing demand by 2016.

Issues

- There is insufficient spare capacity on the existing 11kV feeders to meet this additional demand.

Options Considered

- Install two new 11kV feeders from McNab substation to supply the proposed load; and
- Extend two existing spare 11kV feeders at Rockfield to supply the proposed load. The two spare feeders' cables are unused at present after the previous customer's plant closure.

Recommended Solution

Extend two existing spare 11kV feeders at Rockfield to supply the new load The timing of this project is provisional at this stage as it is subject to the customer's development timeframe.

- **Ellerslie – New Zone Substation**

Background

Ellerslie Racecourse is currently supplied by an 11kV feeder from Remuera zone substation. Commercial development is proposed along the southern strip of the Racecourse with an estimated load increase of 8MVA over the next five to ten years. Existing substations supplying the area are Drive, McNab and Remuera and are already heavily loaded.

Issues

- There will be insufficient spare capacity in the local feeders to supply the new load arising from the development at Ellerslie Racecourse; and
- The existing substations supplying the area - McNab, Remuera and Rockfield - are heavily loaded and do not have sufficient spare capacity to meet the forecast load growth.

Options Considered

- Establish a new substation at Ellerslie (Ellerslie substation): Land has been secured in Tecoma St for the new substation.
- Supply to Ellerslie substation will be from Transpower's Penrose GXP: This option will provide sufficient capacity to the development at Ellerslie Racecourse as well as offloading Drive and Remuera substations. This option is the most cost efficient solution of those considered;
- Install additional feeders from McNab substation: McNab substation is already a three transformer substation which supplies the adjacent

industrial area. Adding Ellerslie load will cause McNab to breach its security level; and

- Adding Ellerslie load onto Remuera, Drive or Rockfield substations: These three substations are already heavily loaded. Any load increases will initiate substantial upgrading work including building alterations to accommodate additional switchgear, new higher-rated 11kV switchboards, sub-transmission circuit reinforcement and long distribution cables. These options are costly compared with the Ellerslie substation preference.

Recommended Solution

Construct a new substation (Ellerslie), to be established in 2018.

b. Projects – Within Five to Ten Years

- **Te Papapa - 11kV Reinforcement (FY20)**

Organic growth arising from industrial customers in the Alfred Street area are expected to exceed the capacity of Te Papapa feeder 11 by 2020. Load transfers are impractical as the adjacent feeder, Onehunga 8, is already heavily loaded. The proposed solution is to install a new 11kV feeder from Te Papapa substation in 2020 and re-distribute the load across this and adjacent feeders.

An alternative solution is to connect the feeders to Onehunga substation. This option will create capacity constraints at Onehunga substation, caused by limitations on the sub-transmission cable capacity.

- **Newmarket – Ex-Lion Breweries Site Development Supply (FY21)**

This project is to extend the existing 11kV feeders from Newmarket substation to supply load arising from the re-development at the ex-Lion Breweries site in Newmarket. The timing of this project is subject to the customer's development timeframes.

- **Newmarket – Establish a New 110kV Bulk Supply Substation (FY20)**

  - Newmarket, Newton and Drive zone substations supply the Newmarket commercial centre and fringe area. Load at Newmarket substation is expected to increase in the near to medium term, mainly due to the proposed expansion of Westfield shopping centre around Broadway and redevelopment at ex-Lion Breweries site. A new zone substation is proposed at Newmarket South;
  - The load forecast shows the combined load from these four substations will reach 100MVA around the year 2020. Given the scale of the load and the location of the four substations, Newmarket becomes an ideal location for a bulk supply point. The plan is to establish a bulk supply substation next to Newmarket South substation and install a 110kV circuit, and a 110/33kV 60MVA transformer. The bulk supply substation will initially supply Newmarket and Newmarket South substations;
  - Existing 33kV circuits between Penrose GXP and Newmarket substation will be used initially to back up the single transformer bulk supply substation. Drive and Remuera substations will be connected to Newmarket bulk supply substation when the existing sub-transmission circuits reach end-of-life and new circuits are required; and
  - Connection of Drive and Remuera substations will trigger the installation of the second 60MVA 110kV transformer. This is beyond the planning period.

- **Southdown – Establish a New GXP (>FY23)**

  To relieve the heavily loaded 33kV bus at Penrose GXP, it is proposed to establish a 33kV supply from Transpower's GXP at Southdown. The intention is that as the sub-transmission supplies to Carbine, Onehunga, Te Papapa and Westfield substations are replaced due to age or capacity, they are replaced with 33kV rated equipment and connected to Southdown rather than Penrose. While Southdown GXP exists as a connection point for Mighty River Power's Southdown generating plant it does not have the infrastructure to provide a 33kV supply to Vector at this time.

  Preliminary investigations indicate it is more cost effective to connect Carbine, Onehunga, Te Papapa and Westfield substations to Southdown rather than Penrose, due to shorter sub-transmission cabling distances. Transpower's costs need to be reviewed separately. It is anticipated a new zone substation will also be required at this site.

  Further study will be carried out in conjunction with the asset replacement programme and reinforcement timetable.

5.6.13 Penrose 22kV

5.6.13.1 Background

Penrose 22kV GXP supplies three zone substations, viz. Glen Innes, Onehunga, and Westfield. The firm capacity at the GXP is 90MVA in summer and winter. Table 5-17 shows the summer and winter load forecasts at the GXP.

Name	Actual	Forecast Demand (MVA) - Summer								
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Penrose 22kV	47	49	49	49	50	50	50	50	51	51	51
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Penrose 22kV	51	53	54	54	55	55	56	56	57	57	57

Table 5-17 : Penrose 22kV summer and winter load projections

The long-term plan is to progressively transfer load from the Penrose 22kV bus to the 33kV bus and the proposed Southdown GXP, in conjunction with the 22kV asset replacement programme. Penrose 22kV will be retired.

5.6.13.2 Projects Planned

No expenditure is forecast within this planning period on the Penrose 22kV sub-transmission network.

5.6.14 Roskill 110 kV (Kingsland)

5.6.14.1 Background

Roskill GXP provides a 110kV supply to Kingsland 110/22kV substation and a separate 22kV supply to a number of Vector substations. A single circuit 110kV cable supplies Liverpool substation in the CBD, supporting the existing dual 110kV supplies from Transpower Penrose. The sub-transmission network supplied from Roskill is shown in Figure 5-18.

There are two 110/22kV 60MVA transformers and two 22/11kV 20MVA transformers installed at Kingsland zone substation. The two 22/11kV transformers are supplied from the 22kV switchboard at the substation. Two zone substations, Chevalier and Ponsonby, are remotely supplied from the Kingsland 22kV switchboard via 22kV sub-transmission cables. Table 5-18 shows the summer and winter load forecasts at the substation 22kV switchboard and the sub-transmission network fed from Kingsland is shown in Figure 5-18.

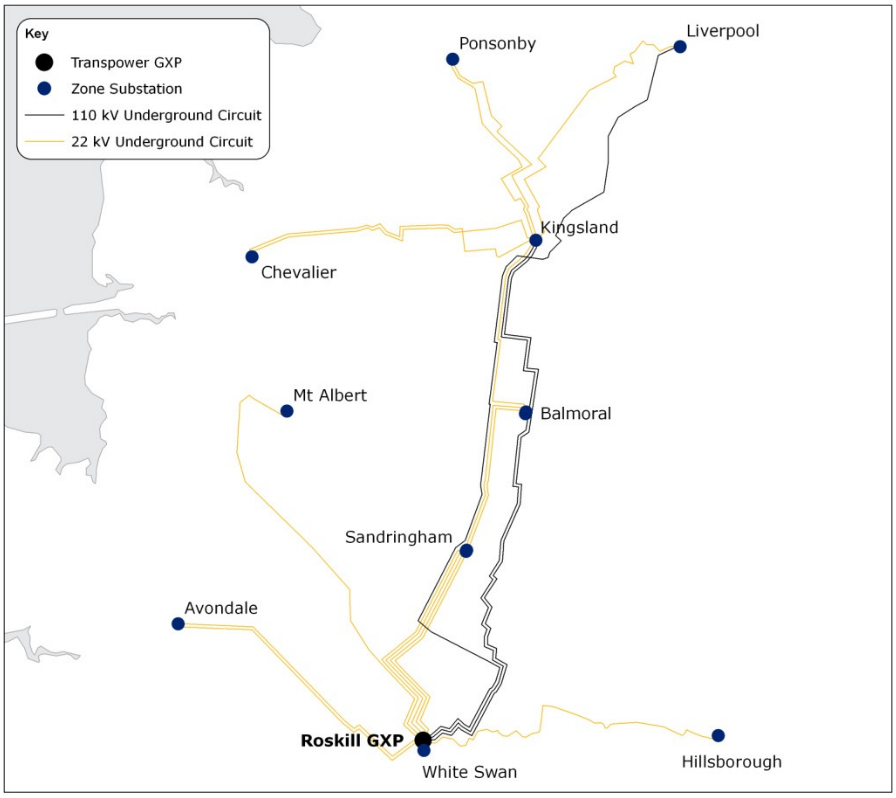

Figure 5-18 : Existing sub-transmission network at Roskill GXP

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Roskill 110kV	37	36	37	37	37	38	38	38	38	38	39
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Roskill 110kV	59	60	60	61	61	61	62	62	63	63	63

Table 5-18 : Roskill 110kV summer and winter load projections

NZTA's Waterview tunnel construction project is expected to add around 19MVA load in total to the 110kV bus at the Roskill GXP (3MVA through Kingsland 22kV and 16MVA through Roskill 22kV) during the construction period from 2013 to 2016. Reinforcement has been carried out to increase the capacity at Chevalier and Avondale substations to meet this demand (refer to individual projects for more details). A permanent supply to the Waterview tunnel of approximately 6MVA is expected to be supplied from the Roskill 22kV bus after 2016.

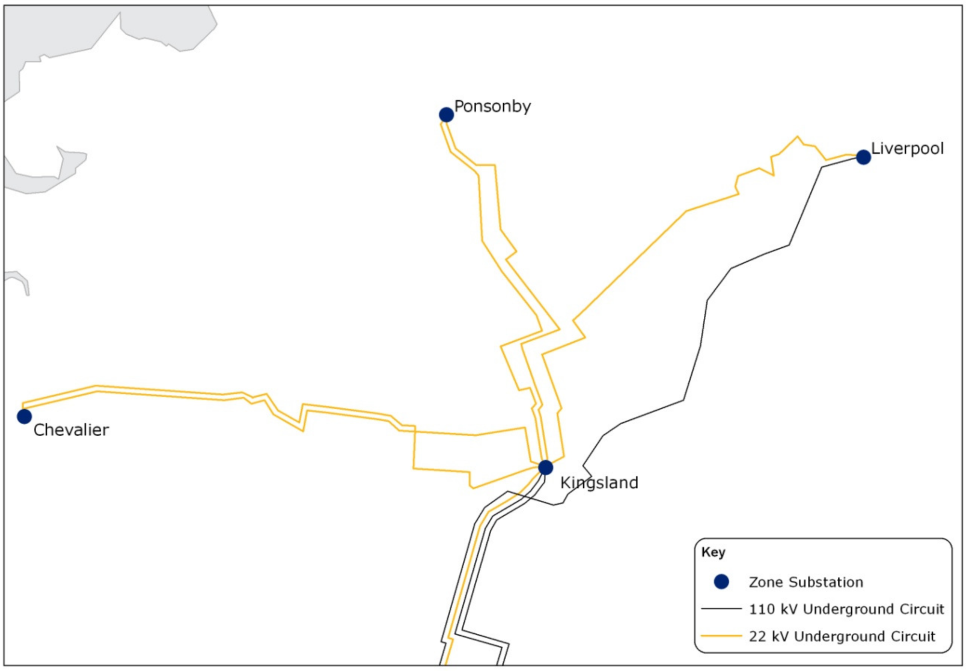

Figure 5-19 : Existing sub-transmission network connecting to Kingsland 110/22kV substation

5.6.14.2 Projects Planned

a. Projects – Within Next Five Years

- **Waterview Tunnel Supply (FY11 - FY15)**

The New Zealand Transport Authority (NZTA) plans to build a road tunnel on SH20 between Waterview and Sandringham. The project comprises two phases, provision of power supplies to construct the tunnel and motorway and the permanent power supply necessary to meet the operational requirements of the tunnel. Table 5-19 summarises the power requirements of each phase.

South Portal Supply	Load	Timeframe	Security of supply	Source GXP
Construction	16.0MVA (combined)	Q3 2013 to 2015/16	N/A	Roskill
Permanent	6.0MVA[59]	2015/16	N-1 with auto switching	Roskill
North Portal Supply	**Load**	**Timeframe**	**Security of supply**	**Source GXP**
Construction	3.0MVA (combined)	Q3 2011 to 2015/16	N/A	Roskill
Permanent	6.0MVA	2015/16	N-1 with auto switching	Henderson

Table 5-19 : Power supplies required for the Waterview tunnel

There is insufficient capacity within the existing network to meet the tunnel demand for both the construction and permanent supplies. A number of options

[59] Total load is expected to be 6MVA split between South Portal and North Portal, but N-1 security requires 6MVA capacity at each portal.

have been investigated to provide the capacity necessary while avoiding asset stranding on completion. The plan is outlined below:

- **Avondale – New 33kV Switchboard (Operated at 22kV) (FY13)**

To meet the electrical demand of the Waterview tunnel boring machine (TBM), a new 33kV cable has been installed (operated at 22kV) from Avondale to the south portal. The project to install a 33kV switchboard at Avondale is underway, which will connect to the Roskill-Avondale sub-transmission circuits and provide supply for the TBM. Forecast demand for the TBM is 16MVA and is required until completion of the tunnel in 2016. 3MVA has been allowed for ancillary services making up the 19MVA expected demand.

Once the construction project is completed, the Avondale circuit will be used to provide a permanent supply to the south portal of the tunnel.

- **Te Atatu – North Portal Permanent Supply (FY16)**

NZTA have requested 100% redundancy for the permanent power supplies to each of the tunnel portals. For security, NZTA have requested each portal be supplied from a different GXP's. The south portal will be supplied from Transpower Roskill while the north portal will be supplied from Transpower Henderson via Te Atatu. A 33/22kV transformer and a new 33kV circuit breaker will be installed at Te Atatu substation, and a new 22kV cable from Te Atatu substation to the north portal is to be laid along SH16 motorway, working in conjunction with the planned causeway widening project.

b. Projects – Within Five to Ten Years

- **Mt Albert – Sub-transmission Cables Replacement (FY20)**

Mt Albert is a single transformer substation. It relies on 11kV feeders from adjacent substations to provide backup capacity. It is estimated that the backup capacity will run out from about 2025. The existing sub-transmission circuit and zone transformer are scheduled for replacement, due to age/condition, around 2020. It is planned to connect the substation to Sandringham 22kV bus when the sub-transmission circuit is replaced.

5.6.15 Roskill 22kV

5.6.15.1 Background

Zone substations supplied from Roskill 22kV are Avondale, Balmoral, Hillsborough, Mt Albert, Sandringham and White Swan. The firm capacity at Roskill 22kV GXP is 141MVA in summer and winter. Table 5-20 shows the summer and winter load forecasts at the GXP.

Name	Actual	Forecast Demand (MVA) - Summer								
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Roskill 22kV	77	98	98	99	99	86	86	87	87	87	88
Name	Actual	Forecast Demand (MVA) - Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Roskill 22kV	116	123	124	124	129	130	131	131	132	133	133

Table 5-20 : Roskill 22kV group summer and winter load projections

The long-term plan is to upgrade Roskill sub-transmission voltage from 22kV to 33kV. Where sub-transmission assets are replaced, or upgraded, 33kV rated assets are installed and operated at the lower 22kV in anticipation of the Roskill upgrade.

NZTA have requested 16MVA to supply to the tunnel boring machine (TBM) during Waterview tunnel construction period from 2013 to 2016. Reinforcement has been carried out at Avondale substation for this purpose.

Westfield Group are planning an expansion of the St Lukes Shopping Mall, requiring extra capacity from Balmoral substation.

5.6.15.2 Projects Planned

a. Projects – Within the Next Five Years

- **Avondale – New 33kV Board (FY13)**

The project to install a 33kV switchboard at Avondale substation has commenced. The switchboard is required to supply the tunnel boring machine during the Waterview tunnel construction period. Refer to the Waterview tunnel project discussion in Section 5.6.14 above for details.

- **Hillsborough – Second Transformer and 33kV Circuit (FY14)**

The project to install a second transformer and 33kV circuit at Hillsborough substation is underway. This is required to address forecast security issues at this substation. The target completion date is April 2014.

- **Balmoral – New 11kV Feeder to St Lukes (FY14)**

A new 11kV feeder is to be installed from Balmoral substation to supply additional load arising from expansion of the St Lukes Shopping Mall. This is a customer driven project with timing set by the customer.

b. Projects – Within Five to Ten Years

- **Mt Albert – Sub-transmission Circuit Replacement (FY20)**

It is planned to supply this substation from Sandringham 22kV bus when the existing sub-transmission circuit between Roskill GXP and Mt Albert are due for replacement. Refer to the Waterview project discussion in Section 5.6.14 above for details.

5.6.16 Pakuranga 33kV

5.6.16.1 Background

Transpower's Pakuranga 33kV bus is supplied by three 220/33kV 120MVA transformers with an N-1 capacity limit of 240/240MVA (winter/summer). The 2012 (F13) winter peak demand was 127MVA.

The summer and winter load forecasts are listed in Table 5-21 and a layout of the sub-transmission arrangement from the GXP is shown in Figure 5-20.

Name	Actual	Forecast Demand (MVA) – Summer								
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Pakuranga 33kV	92	88	89	91	91	92	92	93	93	94	94
Name	Actual	Forecast Demand (MVA) – Winter									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Pakuranga 33kV	127	133	133	134	135	135	136	136	137	138	138

Table 5-21 : Pakuranga 33kV summer and winter load projections

Five zone substations are supplied from Pakuranga - East Tamaki, Greenmount, Howick, Pakuranga and South Howick.

Between 2012 and 2015, the Auckland Manukau Eastern Transport Initiative (AMETI) roading project will improve transport corridors to Pakuranga and Howick. It is possible this may result in a slight growth increase on Howick substation's maximum demand. Due to this uncertainty no provision has been made in the demand forecast at this time.

The Flatbush town centre development project is already underway and it is expected major retail facilities will be taking power by 2015. To meet the supply demand of the town centre and the wider Flatbush area, a new substation is planned.

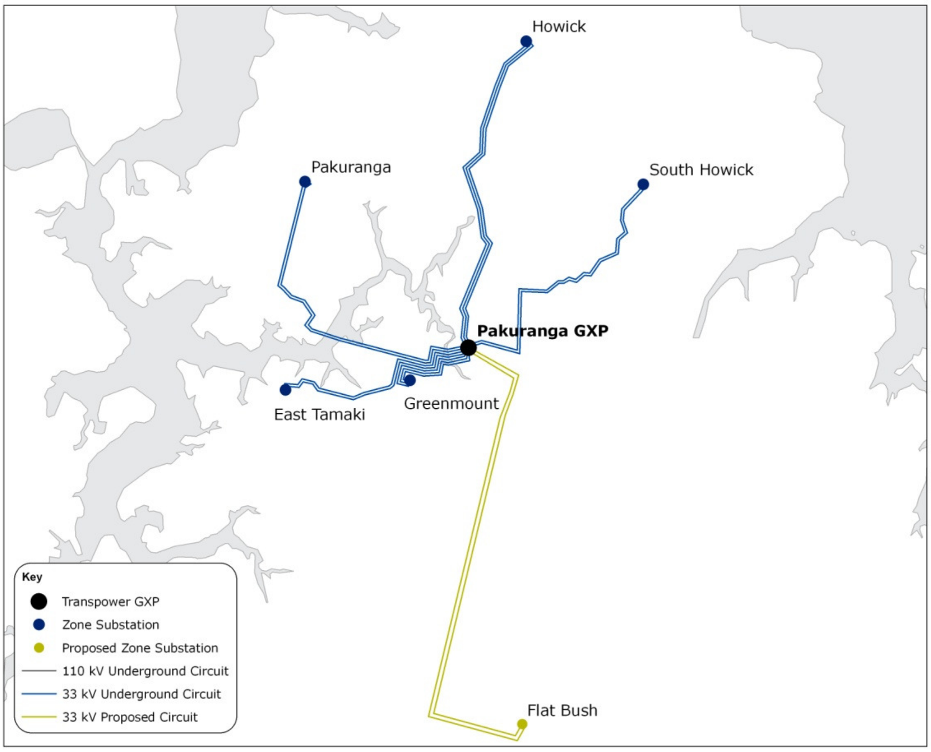

Figure 5-20 : Existing and proposed supply arrangement in the Pakuranga area

5.6.16.2 Projects Planned

a. Projects – Within the Next Five Years

- **Flatbush Zone Substation (FY15)**

Background

The Flatbush area is experiencing moderate load growth and this trend is expected to continue as land is made available for development. It is expected that the Flatbush area will accommodate a population of about 40,000 by 2025. Developments in the area include residential housing, a town centre and multi storey residential apartments. The town centre development is already in progress. Long term demand is estimated to be 30 to 40MVA. To meet the Flat Bush load growth it is proposed to install a new zone substation within the proposed Flatbush town centre by 2015 (FY16). This new substation will be supplied from Pakuranga GXP.

Issues

- Insufficient capacity from the existing feeders to meet the new town centre load; and

- Insufficient capacity from the existing feeders in the area to meet the new residential load growth in the wider Flatbush area.

Options Considered

- New substation at Flatbush supplied from Transpower Pakuranga: Install Flatbush substation at Flatbush town centre and connect to Pakuranga GXP via two 33kV sub-transmission cables, as the least cost substation option. It is anticipated that a second substation will be required to meet the overall demand at Flatbush. This substation will be located at Clover Park. The NPC for both Flatbush and Clover Park substations provides the lowest cost of all the options considered. This is the preferred option;
- New substation at Flatbush supplied from Transpower Otahuhu: Establish Flatbush substation at Flatbush town centre and supply from Otahuhu GXP via two 33kV sub-transmission cables. This option is more expensive than a supply from Pakuranga. Further, adding load to Otahuhu will initiate an early reinforcement of the Transpower Otahuhu transformers;
- New substation at Flatbush supplied from Transpower Wiri: Establish Flatbush substation at Flatbush town centre and supply from Wiri GXP via two 33kV sub-transmission cables. This option is more costly than the supply from Pakuranga. Further, adding load to Transpower Wiri will initiate an early reinforcement of this GXP; and
- Two 11kV feeder cables from Otara substation to Flatbush town centre: Installing two 11kV feeders from Otara will defer the construction of Flatbush substation. However the NPC calculation is well above the cost of the proposed solution.

Recommended Solution

Install a new substation (Flatbush) at Flatbush town centre supplied by two 33kV sub-transmission cables from Pakuranga GXP.

5.6.17 Otahuhu 33kV

5.6.17.1 Background

Vector takes supply from the Otahuhu 22kV bus via two 220/22kV 50MVA transformers. The N-1 firm capacity limits (winter/summer) of this GXP is 59/59MVA. The summer and winter load forecasts are listed in Table 5-22.

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Otahuhu 22kV	47	42	42	43	43	44	44	44	44	44	45
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Otahuhu 22kV	57	54	54	54	55	55	55	56	56	56	56

Table 5-22 : Otahuhu 22kV summer and winter load projections

Two zone substations and a switching station are supplied from the Otahuhu 22kV bus, namely, Bairds, Otara and Highbrook.

The FY13 peak demand at this GXP was 57MVA. The present load projection indicates the demand on this GXP will not exceed its capacity (subject to capacity issues external to the site being addressed) during the planning period. Greenmount landfill generation plant is connected via Otara substation and is currently generating approximately 1.2MW. Taking this into account, the full peak load in the area in 2012 was 58.2MVA. The capacity of the two transformers is 100MVA, but the firm capacity is limited by the 22kV incomer cable ratings and transformer bushings. Transpower have signalled the replacement of the two 220/22kV transformers in their Annual Planning Report[60].

The geo-schematic diagram in Figure 5-21 shows the existing supply arrangement in the Otahuhu area.

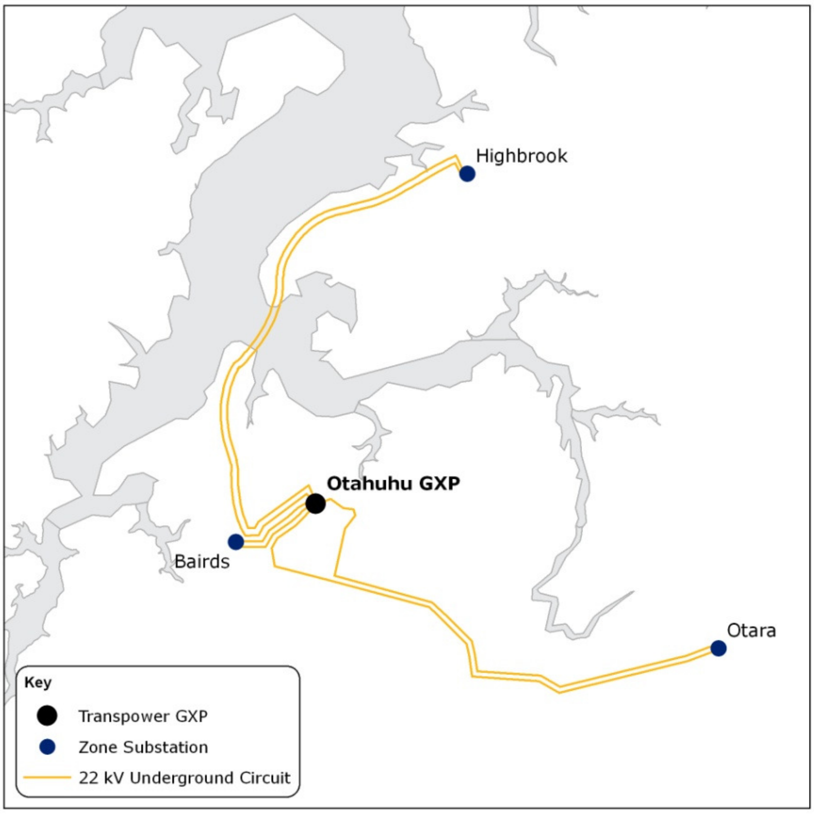

Figure 5-21 : Existing supply arrangement in the Otahuhu area

Otara substation supplies the Flatbush area and is experiencing moderate load growth. Furthermore the growth is expected to continue due to the employment and housing opportunities identified in "The Southern Initiatives" as part of the Auckland Plan. It is proposed to commission a new substation in Flatbush in 2015 at which time approximately 15MVA of capacity will be released from Otara substation. This spare capacity will be used to supply forecast demand expected in north and east of Otara town centre.

Highbrook Business Park was developed as a premium commercial/industrial estate that can accommodate a large range of businesses. Highbrook is unusual as it is the only development within Auckland's distribution area, with the exception of the CBD, where the reticulation voltage is 22kV. A switching station has been established, supplied by two 22kV cables laid from Otahuhu GXP, to provide an N-1 capacity of 23MVA. Current load is about 5.2MVA.

[60] 2012 Annual Planning Report, Transpower New Zealand, Chapter 8, pp120

In April 2011, Goodman Property Trust announced the next development stage of Highbrook Business Park (The Crossing). The Crossing is a 24,700m^2 of commercial and residential development comprising 62 serviced apartments with 17,300m^2 of commercial office space and 4,400m^2 of retail and hospitality-type amenity. This project will be completed in discrete stages.

5.6.17.2 Projects Planned

No new major projects are planned within the next ten years.

5.6.18 Mangere 33kV

5.6.18.1 Background

Vector takes supply from the Mangere 33kV bus via two 110/33kV 120MVA transformers. The N-1 capacity limit (winter/summer) of this GXP is 118/118MVA. The 2012 winter peak demand was 93MVA. The summer and winter load forecasts are listed in Table 5-23.

Name	Actual	Forecast Demand (MVA) - Summer								
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Mangere 33KV	60	59	60	61	63	64	66	67	68	69	72
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Mangere 33KV	93	95	96	98	99	101	103	106	107	109	110

Table 5-23 : Mangere 33kV summer and winter load projections

Vector supplies five zone substations from Mangere 33kV bus, namely, Auckland Airport, Hans, Mangere Central, Mangere East and Mangere West and also a major customer (Pacific Steel) directly from the 110kV bus.

This load is forecast to increase to 111MVA towards the end of the planning period due mainly to the anticipated development of the area surrounding Auckland Airport.

The geo-schematic diagram in Figure 5-22 shows the existing supply arrangement in the Mangere area.

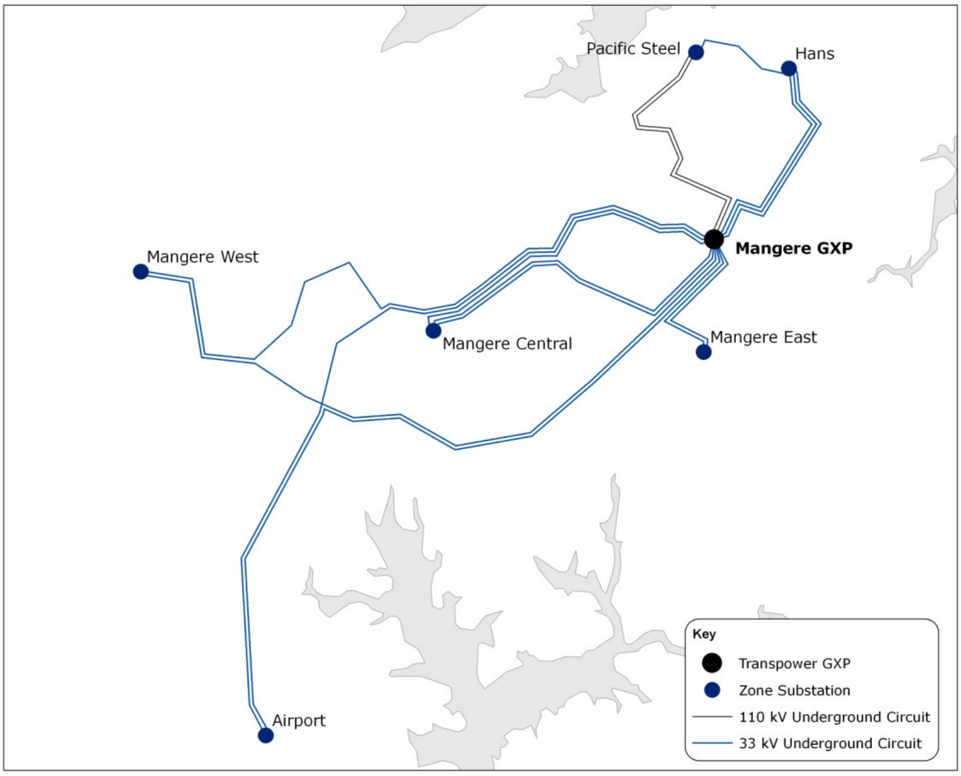

Figure 5-22 : Existing supply arrangement in the Mangere area

Auckland Airport (AIAL) substation is dedicated to supply the Auckland airport demand. Peak demand in 2012 was 16.5MVA. The projected demand towards the end of the planning period is about 33.4MVA. Based on the current load forecast the third transformer may be required in 2018. Once the third transformer has been installed the supply to the site will be constrained to 38MVA by the two incoming 33kV cables. This is a customer operated substation and the projects are initiated in accordance with the customer timeframes. No budgetary provision has been made for upgrade projects in the current AMP.

Middlemore Hospital has indicated a progressive 7MVA demand increase by 2020. A new 11kV feeder cable has been included in the FY13 capital works programme to meet this demand.

Mangere Central substation is expected to exceed its security at the end of the planning period. It is intended to transfer some of the load to Mangere West substation. Forecast developments[61] for the area include re-zoning Paynes Island reserve, corner of Bader Drive and Mascot Avenue and corner Court Town Close and Bader Drive, which will allow for community, retail use and residential use.

If these developments eventuate a third transformer will be required in Mangere Central substation towards the end of the planning period.

5.6.18.2 Projects Planned

a. Projects – Within the Next Five to Ten Years

- **Mangere West – Extend Mangere West #2 Feeder (FY23)**
    - Due to forecast developments in central Mangere, Mangere Central substation may exceed its security in 2022. The proposed solution is to

[61] Auckland Council Plan

extend the Mangere West #2 feeder to transfer about 5MVA load from Mangere Central substation to Mangere West substation in 2022.

- **Mangere East – Rearrange Mangere East #15 and #13 Feeders (FY19)**
  - Mangere East #15 feeder cannot be backstopped successfully using adjacent feeders after winter 2018. Reconfiguring Mangere East #15 feeder and Mangere East #13 feeder will address this problem.
- **Mangere Central - Third Transformer in Mangere Central Substation (FY23)**
  - Mangere Central load is increasing due to new developments around Auckland Airport. To meet the demand it will be necessary to upgrade the existing Mangere Central substation by installing a third transformer around 2022.

5.6.19 Wiri 33kV

5.6.19.1 Background

There are two 110/33kV 50/100MVA transformers installed at Wiri GXP. The N-1 capacity limits (winter/summer) of this GXP are 92/101MVA. The 2012 (F13) winter peak demand was 77MVA.

The summer and winter load forecasts are listed in Table 5-24. The geo-schematic diagram in Figure 5-23 shows the existing supply arrangement in the Wiri area.

Name	Actual	Forecast Demand (MVA) – Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Wiri 33kV	69	69	70	71	71	72	72	73	73	73	74
Name	**Actual**	**Forecast Demand (MVA) – Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Wiri 33kV	77	78	78	79	79	80	81	81	82	82	83

Table 5-24 : Wiri 33kV summer and winter load projections

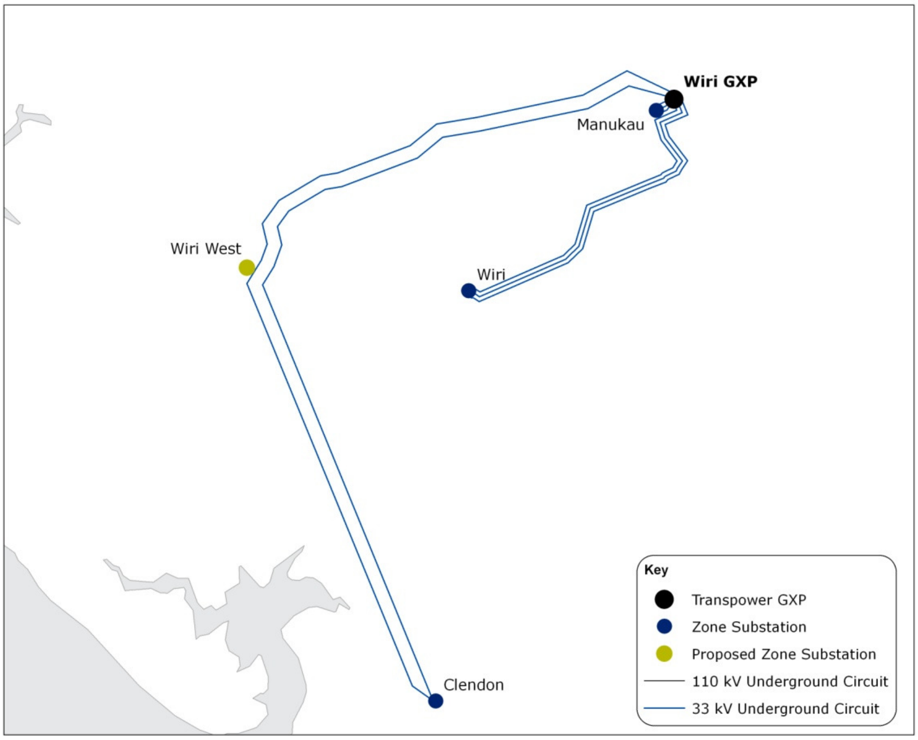

Figure 5-23 : Supply arrangement in the Wiri area

Three zone substations are supplied from this Wiri 33kV bus, namely, Manukau, Wiri and Clendon.

Last year two large capacity connections were made to AMCOR and PMP Print, each requiring 4MVA. Further demand requests have been received from Wiri Correctional Facility and the Manukau Institute of Technology. Growth associated with these developments will determine whether a new substation at Wiri West will be required before the end of the planning period.

Clendon substation has recently been commissioned and comprises two 33/11kV 20MVA transformers. The 33kV cables were designed to accommodate the capacity of a future substation at Wiri West.

5.6.19.2 Projects Planned

a. Projects – Within Next Five to Ten Years

- **Wiri West - Establish a New Substation (FY23)**

The 2012 Auckland Plan identified the areas around Roscommon Road, Puhinui Road and west of Wiri as major business development areas with high growth potential. To meet this demand it is forecast that a new substation (Wiri West) will be required in 2022.

5.6.20 Takanini 33kV

5.6.20.1 Background

Vector takes supply from the Takanini 33kV bus via two 220/33kV 150MVA transformers. The N-1 capacity limit (winter/summer) of this GXP is 126/126MVA.

The 2012 (F13) peak demand was 101MVA. The transformers' capacity is currently limited by protection equipment constraint. Transpower has plans to resolve this issue by 2016.

Table 5-25 shows the summer and winter load forecasts at the GXP.

Name	Actual	Forecast Demand (MVA) - Summer									
	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Takanini 33kV	63	63	65	66	67	67	68	68	69	69	69
Name	**Actual**	**Forecast Demand (MVA) - Winter**									
	FY13	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Takanini 33kV	101	102	103	104	104	105	106	106	107	108	108

Table 5-25 : Takanini 33kV summer and winter load projections

The geo-schematic diagram in Figure 5-24 shows the existing and proposed supply arrangement in the Takanini area.

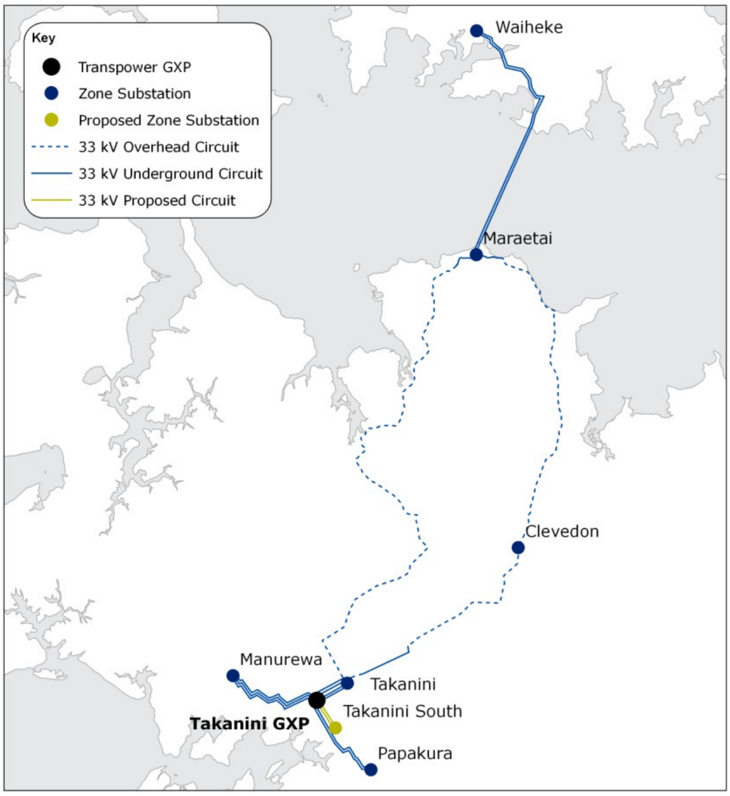

Figure 5-24 : Existing and proposed supply arrangement in the Takanini area

Six zone substations are supplied from Takanini GXP, namely, Takanini, Manurewa, Papakura, Clevedon, Maraetai and Waiheke.

Takanini is expected to experience moderate residential growth with a number of subdivisions under construction or planned. Development of the remainder of Wattle Downs (33ha undeveloped) is expected to continue along with open land surrounding the Super Clinic between Manukau and Manurewa. Growth at Maraetai is dominated by the Beachlands development at Spinnaker Bay where the release of 500 new residential full sections is well underway.

Clevedon substation supplies residential load in the Clevedon area. This substation was established in 2002 to improve the reliability and quality of supply to the area east of Clevedon. The single 33/11kV 5MVA transformer is supplied by a "tee" off the Takanini - Maraetai 33kV circuit. The 2012 winter peak demand was 3.0MVA and is projected to grow to about 3.4MVA towards the end of the planning period. Depending on the long-term load growth, it may be necessary to upgrade the transformer to a 10MVA unit. Proposed district plan changes to Clevedon Village will introduce a number of new residential zones around the village to provide for future growth for up to 600 new homes. This will impact on the available capacity of the Clevedon substation.

Manurewa substation supplies a mixed commercial and residential load in the Manurewa area. There are three 33/11kV 20MVA transformers installed at this substation. The 2012 winter peak demand was 45.3MVA and the projected load by 2022 is about 48.7MVA. The short term capacity for the substation is 54.1MVA, limited by the capacity of the 33kV cables. The summer capacity is also limited to 31.8MVA again, by the capacity of the 33kV cables. The substation load is forecast to approach the limits of its short term capacity towards the end of the planning period, and depending on growth, reinforcement may be required shortly after 2022.

At the beginning of 2011 a new feeder was installed to the Takanini Fonterra site. This feeder transfers about 4.7MVA load from Takanini substation onto Manurewa. It is also expected that 3000 new housing sites will become available over the next 10 years within Manurewa local board area, as part of the Manurewa Local Board Plan.

According to Papakura Local Board Plan, 14,000 more people are expected to be settled in the local board area within the next 20 years. As a result Takanini is expected to experience moderate residential growth with a number of subdivisions under construction or planned, especially near the old horse training track, the Papakura Camp and the extensive farming land west of Takanini.

Depending on load growth Takanini substation may not meet the supply requirements in the latter part of the planning period. It is proposed to establish a new Takanini South substation on a site close to the Addison subdivision in Porchester Road. This substation will provide backstop to Manurewa, Takanini and Papakura substations and cater for the potential load growth on the western side of Porchester Road along Great South Road and the railway line. Timing of this substation is based on the load growth and it is expected that this substation may be required around the end of the planning period.

5.6.20.2 Projects Planned

a. Projects – Within the Next Five Years

- **Maraetai – New 11kV Feeder to Reinforce Maraetai # 9 Feeder (FY14)**

Background

Maraetai #9 feeder cannot be backstopped successfully using adjacent feeders in summer 2013. Installing a new 11kV feeder from Maraetai substation along Whitford-Maraetai Road will provide security to Maraetai #9 feeder. This project is already underway and expected to be complete by December 2013.

Issues

- Insufficient capacity to meet the load growth in the Beachlands area; and
- Security of supply to customers fed from Maraetai #9 feeder.

Options Considered

- Transfer load from Maraetai #9 feeder to South Howick #14 feeder: This project will require the installation of an 11kV feeder cable along Whitford-Maraetai Road to connect the Maraetai #9 feeder to the South

Howick #14 feeder. This is a costly option compared to other options considered; and

- Transfer load from Maraetai #9 feeder to a new feeder: Install a new 11kV feeder cable from the Maraetai substation to offload part of Maraetai #9 load. This is the least cost option (recommended).

Recommended Solution

The proposed solution is to install a new 11kV feeder cable from the Maraetai substation along Whitford-Maraetai Road to offload Maraetai feeder #9 feeder.

b. Projects – Within Next Five to Ten Years

- **Takanini– New Mill Road Feeder (FY20)**

Takanini is expected to experience moderate residential growth with a number of subdivisions under construction or planned. To meet the demand in these areas a new Mill Road 11kV feeder from Takanini zone substation is required. The timing of this feeder is dependent on load growth. At this time it is forecast for reinforcement in 2019.

5.7 Asset Relocation

As outlined in Sections 32, 33 and 35 of the Electricity Act 1992, Sections 33 and 34 of the Gas Act 1992, Section 54 of the Government Roading Powers Act 1989 and Sections 147A and 147B of the Telecommunications Act 2001, it is a requirement for Vector as owner and operator of network assets to relocate assets when requested by requiring authorities. Infrastructure projects can be initiated by other utilities (such as Transpower and Chorus) or roading authorities such as the NZTA and local councils. The process and funding of such relocation work is governed by the relevant Acts.

The timing of relocation projects is driven by the authority concerned and usually provides less advance notice or detailed scope compared with projects initiated from within Vector. Information about projects more than one year in advance is generally not available for all but the large multi-year projects. In this respect expenditure forecasts are based on continuation of the current level of relocation activity.

The relocations forecast is divided into two groups, namely the larger projects as described above and a second group comprising of the smaller projects such as pole relocations, minor network relocations, etc.

Following is a list of known large infrastructure projects greater than $1.0m that require relocation of Vector electricity network assets. Many of these projects also impact on Vector’s gas and communications assets:

- NZTA is constructing a motorway tunnel between Avondale and Waterview and widening the north-western motorway (SH16) from Waterview through to Westgate. Existing 11kV and LV cables that impinge on the work area will need to be relocated;
- Watercare is currently installing a new water main from Redoubt North Reservoir in Manukau to Market Road in Epsom (Hunua 4);
- Transpower, as a result of their NIGUP/NAaN projects, has requested that Vector relocate some if its assets to make way for their works. The NIGUP/NAaN project also requires relocation works to be carried out at three GXP’s. This requires the conversion of 33kV switchgear from outdoor to indoor at Hepburn Road, Penrose and Henderson; and
- Auckland Transport is planning to upgrade the following roads. Their works will require Vector to relocate some of its assets.

- Albany Highway
- AMETI (Auckland Manukau Eastern Transport Initiative):
- Dominion Road;
- Tiverton Road/Wolverton Street; and
- Whangaparaoa Road.

5.8 Customer Connections

Vector spends upwards of $22m per annum on activities that relate to the connection or management of customers connections. The interface with the customer is managed by the Commercial section within Vector. Requests for new connections or changes to existing connections are forwarded to the Commercial group from Vector's field services providers (FSPs), for the small projects, and from developers or consultants for the subdivision and customer substation works. Forecast expenditure is developed for the following categories.

5.8.1 Customer Connections

These are the connection (and disconnection) of smaller customers to Vector's network. This includes minor extensions to the LV mains to allow connection and installation of service pillars. The service main inside the customer's property is the responsibility of the customer. This activity also includes the livening of the service on receipt of a Certificate of Compliance. Expenditure on each service is variable depending on the complexity and scope of the works to be carried out. For the purposes of expenditure forecasting the average cost of connection has been applied to the expected connection numbers for the year.

5.8.2 Capacity Changes

This category includes requests by customers to change their capacity. These changes range from the upgrade of an LV connection through to a distribution substation transformer upgrade. Expenditure forecasting is based on historical average expenditure.

5.8.3 Customer Substations

This category reflects Vector's investment in the equipping and connection to the network of new customer substations. The enclosure or substation room is provided by the customer but the cost of equipping with transformers and switchgear, and connecting into the established electricity network, is funded out of this forecast expenditure. This expenditure forecast is the average of the last five years annual expenditure.

5.8.4 Subdivisions

Subdivision reticulation is managed through the Commercial Group with our FSPs. Expenditure forecasts reflect current economic market conditions with an average of the last three years expenditure as the basis for the estimate.

5.9 LV Reinforcement

LV network design standards are robust enough to have a margin of contingency for load growth. Where growth exceeds the capacity of the LV network, reinforcement is initiated. At this time the response to LV issues is reactive, it requires a customer complaint or a field report to initiate a response. Over the last year Vector has been experimenting with different approaches to gathering LV information in an economical manner (eg. load monitoring in transformers). No recommendation has been made at this time to take these trials to the next stage. Expenditure on LV reinforcement tends to be quite variable. On this basis the expenditure forecast is based on historical expenditure.

5.10 Overhead Improvement Programme (OIP)

Vector, through an agreement with its majority shareholder, the Auckland Energy Consumer Trust (AECT)[62], commenced the Overhead Improvement Programme (OIP) in 2001. Through this it aims to underground or make improvements for amenity purpose to the remaining overhead electricity lines across the urban areas of the former Auckland City, Manukau City and Papakura District.

In accordance with the agreement Vector commenced the programme, investing a minimum of $10 million per annum in this area. The minimum amount of expenditure is inflation-adjusted each year by the producer's price index (PPI). The minimum investment targeted for the FY13 is $13.3million.

UnitedNetworks, when acquired by Vector in 2003, had embarked on an undergrounding programme in the areas of the former Rodney District, North Shore City and Waitakere City. This programme was funded through dividends from shares in UnitedNetworks held through the Waitemata Electricity Trust for Rodney District Council, North Shore City Council and Waitakere City Council. The UnitedNetworks Shareholders Society, as trustees of the Waitemata Electricity Trust, was responsible for administering payment for the undergrounding work.

With the councils divesting their UnitedNetworks shares through the sale of the company to Vector, and then opting to use the proceeds of the sale of shares to fund other council activities, dividend income to the Waitemata Electricity Trust ceased. Vector continued with this programme until the available funds in the Waitemata Electricity Trust, approximately $11 million, had been invested through further undergrounding activity. Vector has not been able to justify further investment in the undergrounding of overhead lines across the areas of the former Rodney District, North Shore City and Waitakere City since funding support ceased in 2005.

5.10.1 Criteria for Selecting the Areas for OIP

Vector sets its priority for OIP expenditure based on the condition and performance of overhead lines. Priority is given to improving areas where large investments would otherwise be needed to rebuild overhead lines.

Secondary drivers include:

- The frequency of faults in the area (pole strikes, etc.);
- The resulting benefit versus undergrounding costs;
- The level of other council or utility works planned for the area; and
- Other synergy opportunities that help to reduce overall costs and provide other benefits.

5.10.2 Projected OIP Expenditure

Vector's targeted OIP investment for the FY13 year is $13.3 million. Projected expenditure for OIP over the next ten years will be targeted at the same (real) level but

[62] This is a requirement of the Trust Deed.

adjusted to reflect movements in PPI. The projected expenditure projection over the planning is shown in Table 5-26 below.

	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Total Budget ($m)	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3

Table 5-26 : OIP improvement budget

5.11 Very Long-Term Demand Projection

As part of the process for preparing the very long-term (50+ years) network development plans for the Northern and Southern regions, an exercise was carried out to predict the very long-term load distribution for the whole of Vector's supply area. The very long-term load distribution assumes the area is developed to its full potential based on the existing designated land use zoning by the city and district councils in their district plans and a continuation of the existing consumption behavioural trend. Based on these assumptions, the total loads in the very long term for the two regions are estimated at:

- Auckland CBD 1000MVA
- Southern region (except the Auckland CBD) 2500MVA
- Northern region 1500MVA

(The above figures represent the upper limit of demand growth in the regions when the land is developed, occupied and utilised to its full potential, if it is ever developed to that extent, based on the existing consumption trend. The impact on demand caused by emerging technologies has not been included in this forecast.)

By comparison, the 2012 coincident demand for the two regions is about 1713MVA. The potential demand increase in the very long term is nearly three times present demand.

5.11.1 Long-Term Demand Position

According to the Auckland Council's Unitary Plan the region is to be developed to accommodate a population of two million (1.87m in Vector's distribution area[63]) by the year 2031. The plan is to accommodate about a quarter of the population in higher density, multi-unit accommodation while the remainder would live in lower density suburbs and rural areas. The strategy allows a coordinated approach to transport, land use and other resources planning.

Based on the very long-term demand distribution study, the technology roadmap study and the ten year load forecast (2010-2020), an indicative long-term demand projection for the next seventy years is presented in Figure 5-25. The straight line projection (instead of an annual growth percentage) reflects the historic growth pattern (see Section 5.3 for a discussion).

The black line represents the demand based on the present consumer behaviour, whereas the green line includes the demand due to the introduction of new technologies and appliances (such as electric vehicles and heat pumps) that are not widely used today. Detailed, more accurate forecast of the first ten years (from 2010 to 2020) of the projection is given in Section 5.4 of this AMP.

[63] Part of Franklin is not in Vector's distribution area.

The Auckland Council has published a draft "Auckland Plan" to guide the development of the city in the next twenty to thirty years to accommodate the anticipated "medium" population growth to two million people by 2031. The "Auckland Plan" will supersede the Regional Growth Strategy when it is formalised. A preliminary assessment of the "Auckland Plan" indicated that it is very similar in approach to the RGS with intense developments within the region's urban limits and concentrated growth along transport corridors. A detailed assessment will be made when the "Auckland Plan" is formalised and the very long-term network development plan modified accordingly.

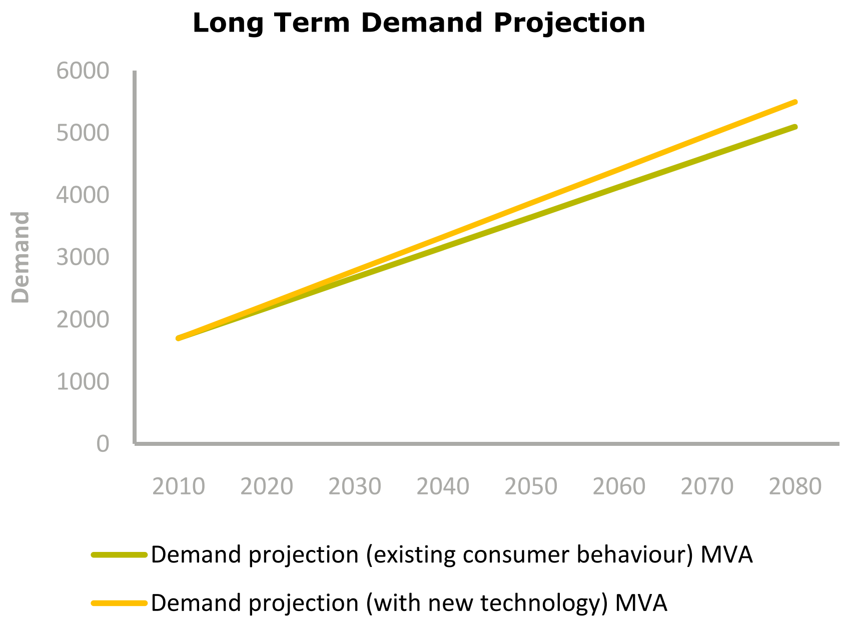

Figure 5-25 : Long-term demand projection[64,65]

5.11.2 Network Architecture

Distribution network architecture can generally be described by two key attributes - voltage levels and network configuration. Reviews of the network architecture for Vector were carried out in 2003/04 (shortly after the merger of Vector and UnitedNetworks Ltd) and in 2007/08. The reviews looked at the appropriate voltage and configuration to be adopted for the development of the Vector electricity network. The following sections summarise the existing and envisaged future network architecture.

5.11.3 Voltage Levels

The reviews concluded two voltage classes should be retained for the Vector network, namely sub-transmission and distribution voltages.

The sub-transmission system conveys bulk electricity around the network, connecting zone substations to each other and to the transmission grid exit points. Selecting the economically optimal sub-transmission voltage level requires a trade-off between capacity and construction cost. Higher voltage circuits can convey more power but are more complex and expensive to create and maintain. The appropriate voltage level, therefore, depends on the size and density of loads.

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[64] This projection assumes that the average load per ICP (long-term) will remain relatively constant, which is in line with Vector's analysis of historical consumption patterns as well as expected future behaviour.

[65] Increased demand with new technology due to impact of electric vehicles.

The electricity distribution network distributes electricity from the zone substations to end-users. Given the extent of these networks, and the large number of connections made to them, distribution voltage levels have to be restricted (the cost of higher voltage assets and of connections to these networks is prohibitive). Again there is a trade-off between capacity and construction cost.

The key findings from the 2007/08 review were:

a. Sub-transmission Voltage

Except for the very large loads (100MVA or above) with load centres at relative long distances (10km or further) from Transpower's GXPs, zone substations should continue to be supplied at 33kV. When used as sub-transmission network, 22kV circuits restrict bulk supply capacity to levels that are inefficiently low in high density areas like Auckland. Converting 22kV to 11kV is not an effective transformation ratio either.

The medium to long-term sub-transmission strategy is, therefore, to freeze further development of the existing 22kV sub-transmission network. When existing 22kV equipment reaches the end of their lives they will be replaced with 33kV rated equipment. Over time the 22kV will be uprated to 33kV.

The 66kV voltage level is comparable to 33kV as a sub-transmission voltage for the metropolitan parts of Auckland and might have been a good voltage choice if Vector had completely rebuilt the sub-transmission network. Not only is this impractical, given the very substantial investment in 33 kV assets, but a significant part of Auckland also still has a relatively low load density (and will remain so for a long time) which does not economically justify building higher-voltage sub-transmission networks. In addition, 66kV is a non-preferred (internationally) standard voltage that is gradually being phased out by electricity distribution businesses around the world.

For areas with large loads in a relatively confined area, or that are far from grid exit points, the preferred sub-transmission level is at 110kV. At present this only applies to the Kingsland, Auckland CBD and the main commercial area of the North Shore. The Auckland load density does not warrant sub-transmission at higher voltage levels.

b. Distribution Voltage

The general distribution voltage level for the Vector network is at 11kV. The load density for most parts of Auckland does not warrant the use of 22kV for distribution, while distribution at lower voltage levels is even less cost-effective. The exceptions are:

- The Auckland CBD, where load density is significantly higher than the rest of the network and also where the area is supplied from the 110kV sub-transmission system. The latter factor makes 22kV distribution a natural choice as this would eliminate the need for an intermediate sub-transmission level; and
- In remote parts of the network where maintaining legal voltage limits is a challenge and uprating to 22kV is a practical and economic solution. Examples are the supply to Piha and Kaukapakapa.

5.11.4 Configuration

The review identified that the sub-transmission configuration is very different for the two regions making up the Vector network. However, the distribution configuration is generally very similar. The difference in configuration will also influence how the two regional networks are electrically protected and operated.

a. Southern Region

The zone substations in the Southern region are typically supplied by two (and in rare occasions three) transformer feeders from GXPs. Typically there is no sub-transmission switchboard at zone substations. The power transformers at zone substations operate in parallel via the 11kV switchboards. From the distribution switchboards, distribution feeders emanate to supply the distribution network. The distribution feeders are configured in radial formation and are interconnected via normally open switches.

This configuration allows the zone substations to operate as separate, "closed" systems with the ability to back-stop each other (take load from adjacent substations) through 11 kV feeders. The level of back-stopping depends on the level of interconnectivity.

For the Southern network, there is a significant emphasis on supply security at the sub-transmission level. In the past the sub-transmission network was developed to provide sufficient redundant capacity to maintain supply under single contingency situations at all times, which is comparable to the practice of most Australian networks of similar size and demand characteristics. As a result of the sub-transmission configuration (no 33kV switchboards at zone substations), there is practically no interconnection between GXPs (nor is it possible). In the unlikely event of the loss of GXPs, load cannot be transferred across networks supplied from different GXPs.

Figure 5-26 below shows a typical network arrangement for the Southern region.

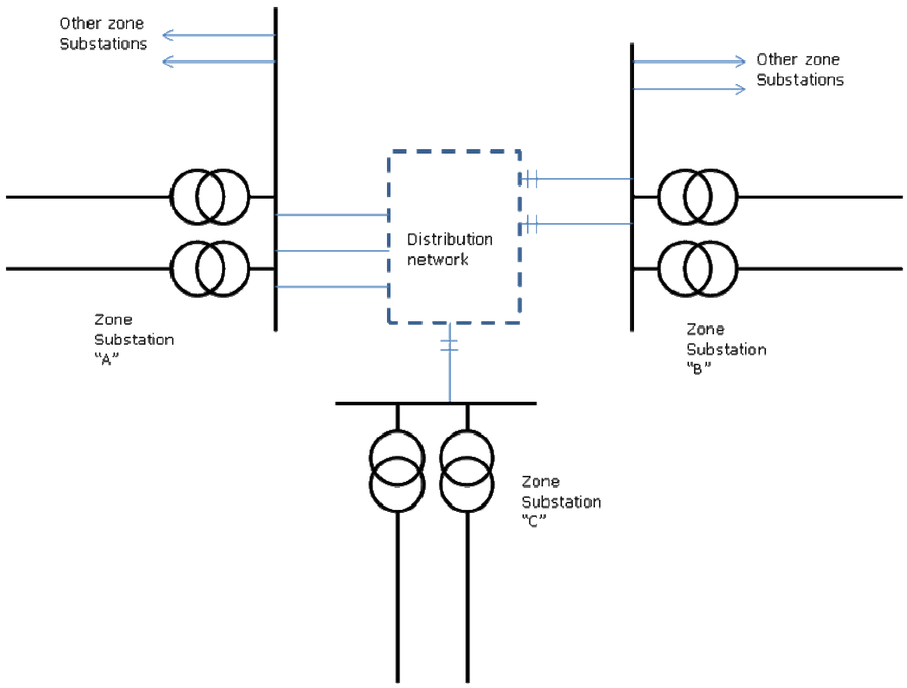


Figure 5-26 : Typical sub-transmission and distribution network arrangement for the Southern region

b. Northern Region

The sub-transmission network in the Northern region is based on a mesh formation. A mesh network can be supplied by up to four circuits depending on the load the mesh is designed to supply and the geography of the area. Typically, only a single transformer is installed at the initial stage of development of zone substations. Supply security for the zone substation is provided by backstop capacity from the mesh sub-transmission network as well as from the neighbouring zone substations via 11kV feeders.

Where it cannot be economically justified to complete the mesh in full, which is often the case during earlier stages of development of an area, zone substations are fed from radial transformer feeders. At the next stage of development other legs of the mesh network are installed. When the mesh is formed, the feeders and power transformers are controlled by sub-transmission switchboards.

Meshed networks are especially suitable for low load density areas where demand for no break supply security is relatively low (for example, residential areas), as additional transformers and substations can be inserted into the mesh as and when the demand growth warrants (instead of having to install sub-transmission feeders from GXPs to zone substations). Also in the rural (long distance and low density) parts of the region, the network is typically constrained by voltage before capacity and security thresholds are reached. In these areas, use of smaller size zone substations and "shorter" feeders will help resolve voltage issues that may arise.

Figure 5-27 below shows a typical network arrangement for the Northern region.

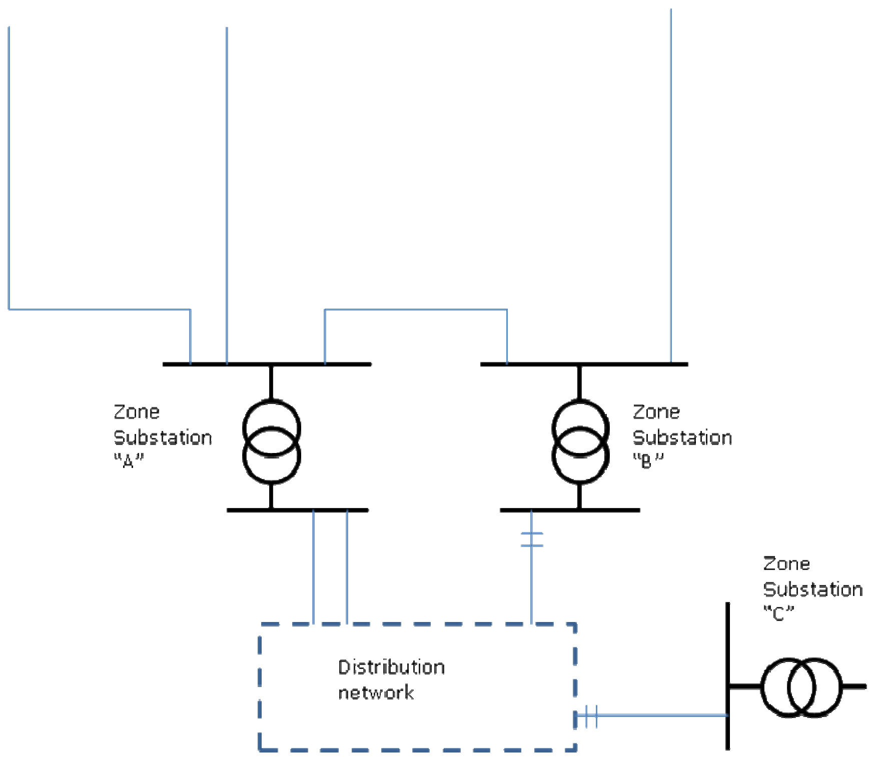


Figure 5-27 : Typical sub-transmission and distribution network arrangement for the Northern region

5.11.5 Radial vs Meshed Configuration

The review identified that meshed sub-transmission networks are more economic if the GXP is off to the side of the supply area, whereas the economics tend to favour radial formations if the GXPs are closer to the centre of the supply area.

5.11.6 Electrical Protection

Protection schemes designed to serve radial systems are different from those designed for mesh systems, with the latter being substantially more complex and requiring a higher degree of fault-discrimination and ability for localised switching. As a result, the protection systems on the Southern network are simpler than those on the Northern and outages resulting from protection events tend to be less widespread, with shorter restoration times.

Vector's gradual upgrade from electro-mechanical relays to digital relays and further developments in the SCADA network (including RTUs) and communications systems, should over time enhance the ability of the Northern network protection systems and result in higher supply security levels.

5.11.7 Effects of Additional Load on Network Architecture

The network architecture reviews carried out in 2003/04 and 2007/08 concluded that the additional demand due to land development in the very long-term does not warrant a change to the existing network architecture (voltage and configuration). The "Network Development Blueprint" projects completed in 2008/09 concluded that the architecture is sufficiently flexible to accommodate additional load to cater for the growth over the next 50 years through a combination of extension (additional substations and feeders) and increased utilisation of existing facilities. The additional load due to new technologies (200~480MVA) is relatively small compared to the long-term growth (~3000MVA) anticipated from additional customers. Change in network architecture is, therefore, not expected to be warranted in the foreseeable future.

5.11.8 Micro Grid

Vector does not consider that the way the regulatory regime is presently being operated provides incentives to improve supply quality above historical levels. There is also little evidence customers are prepared to pay extra for enhanced quality of service. As a result, there is currently little economic or financial justification to develop a full scale system of micro grids covering the whole of the Vector network from the perspective of improving network reliability. These systems also do not currently offer economically viable alternatives to standard grid connections.

It is, therefore, unlikely that there will be significant roll-out of micro-grids in the Vector distribution area in the near to medium-term future. The strategy for micro grid development will, therefore, likely be directed at particular situations where over-voltage or reverse power flow arises from localised applications. These will be dealt with on a case-by-case basis.

5.11.9 Long-Term Asset Investment Strategies

Electricity network asset investment decisions are typically made for assets with very long lives. Traditionally, while consumer and network technology remained relatively stable, investments could be made with a reasonable degree of certainty. However, the electricity market is currently entering a phase of change, with rapidly developing consumer applications and network applications following closely behind.

With the development of the future generation of smart home appliances, fast communications, smart metering and network control systems, increased use of interconnected technologies, customer growth and demand patterns are becoming less certain. Some technologies are expected to increase demand while others will lead to reductions. Changes to consumption patterns (summer or winter peaking, morning or evening peaking) affects how the network is planned, operated and managed.

The new generation of network technology also offers opportunities to enhance asset utilisation and reduce network risks. Initiatives such as network monitoring, remote control and automation are expected to be widely used to enhance the utilisation of the distribution network.

Even in the face of the increased uncertainty about the future, new connections, network capacity augmentation and asset replacement investments remain essential. The following general asset investment guidelines have been adopted:

- The network development strategy is to always aim at deferring investment where this would not breach safety or security standards, and is practicable and economically efficient;

- Non-network solutions should always be considered as part of the mix of technological solutions and where feasible, should be embraced;
- Where network investment proves to be essential, smaller projects are preferred over larger projects (unless synergies of larger projects present a compelling financial advantage); and
- Unless customers desire higher levels of service, or regulatory incentives in this regard are created, the aim is to maintain the existing levels of service.

5.12 Protection, Automation, Communication and Control

As the use and applications for "intelligent" control and information devices on electricity networks increase, the offering of equipment and solutions are increasing apace. This leads to an array of potential devices, standards, solutions and opportunities, some of which provide a high degree of flexibility and compatibility, but many of which rely on proprietary systems, effectively locking in the user.

Vector has decided to adopt, as far as practicable, a standard, internationally-recognised, open communications architecture, that would allow different devices and applications to integrate seamlessly and would allow Vector to choose from a wide range of present and future applications. Adoption of a standards based power system information infrastructure is considered vital to allow the required flexibility to ensure the ongoing, optimal development of control systems. In Figure 5-28 the key standards adopted by Vector for its information and control systems are illustrated.

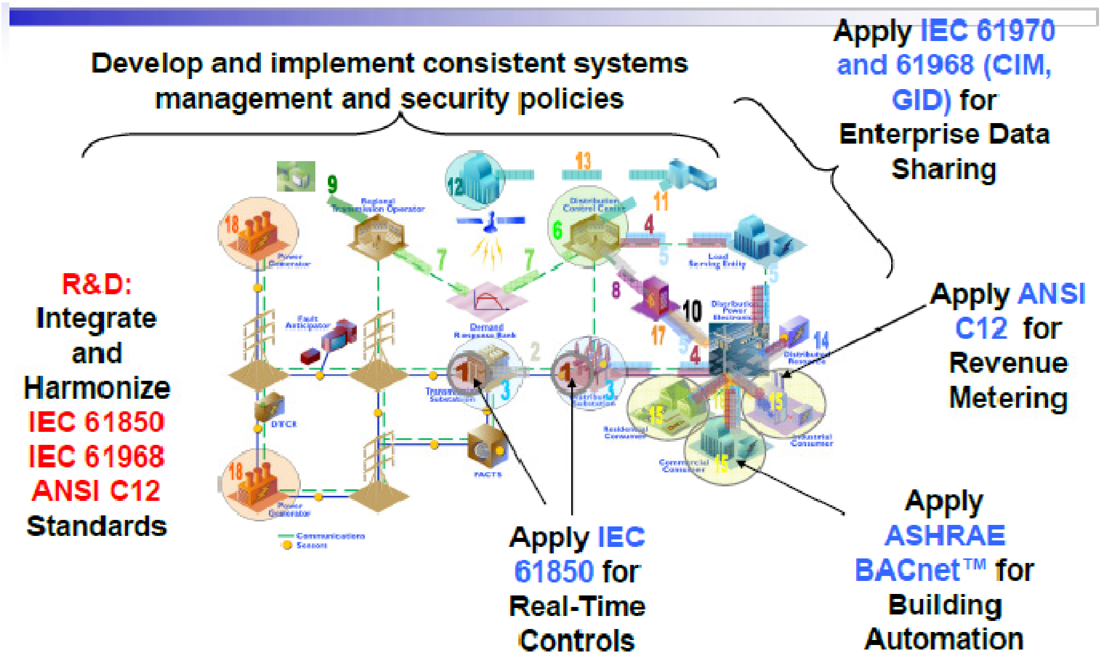


Figure 5-28 : Key standards for information and control systems

An approach that is independent of the architectural technology chosen is necessary to deal with the increased complexity of the power system and to facilitate systems interoperability and reduction in information integration costs.

The International Electrotechnical Commission (www.iec.ch) is the leading global organisation that prepares and publishes international standards for all electrical, electronic and related technologies, primarily for the electric power industry. The IEC is spearheading a global initiative to support the new "smart" electric power network. IEC Technical Committee TC 57 (Power Systems Management and associated information exchange - http://tc57.iec.ch) has developed unique reference architecture for power system protection, automation, communications and control systems. Figure 5-29 shows the Vector targeted reference architecture.

The reference architecture reflects the ultimate objectives for an information infrastructure that can meet all business needs, including network configuration requirements, quality of service requirements, security requirements and data management and exchange requirements. It will enable integration of:

- Abstract modelling;
- Security management;
- Network and system management;
- Data management and exchange; and
- Integration and interoperability.

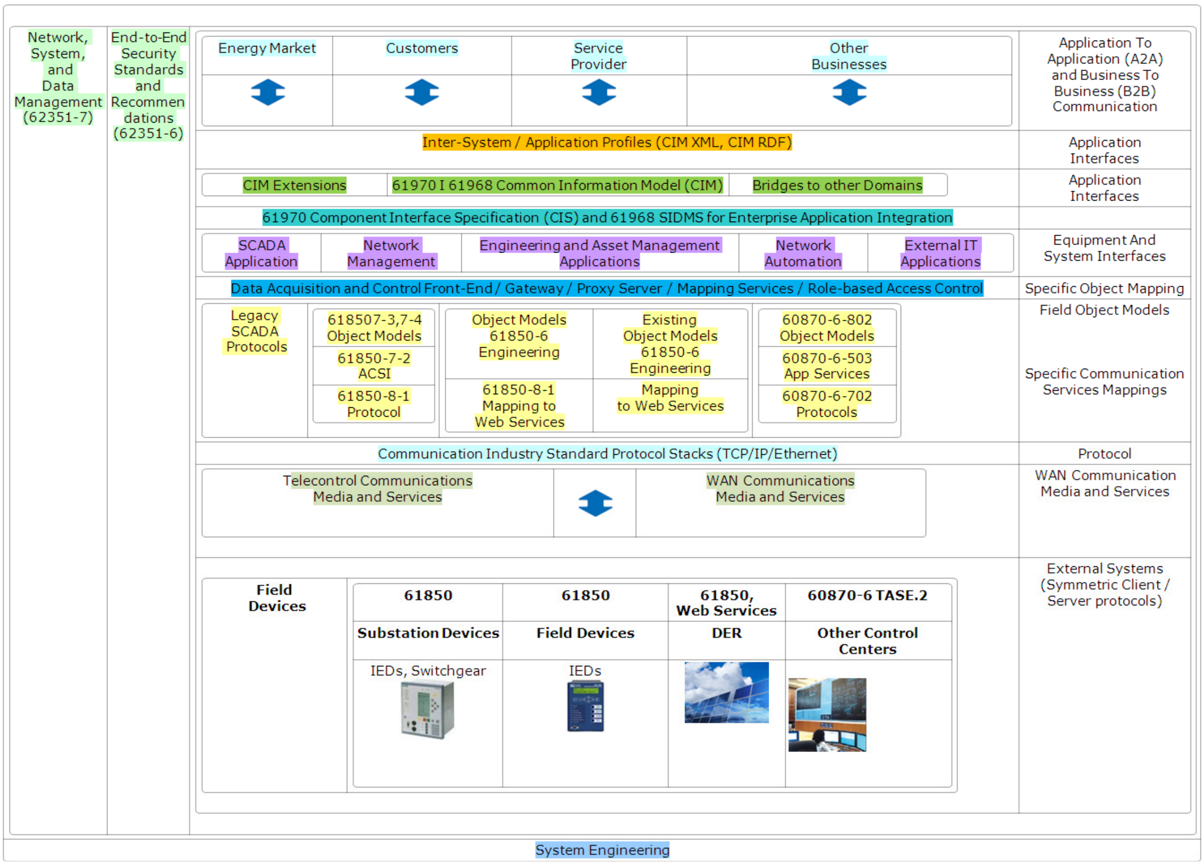


Figure 5-29 : Vector targeted reference architecture

Adopting this reference architecture will facilitate:

- Innovation (enabling advanced applications that will require a ubiquitous infrastructure);
- Cost efficiency;
- Capital savings from standardised components that can be competitively procured;
- Life cycle savings from lower maintenance costs due to standardisation;
- Reduction in stranded assets from systems that can integrate;
- Ability to incrementally build upon first steps and scale up;

- Reduced development costs by building on components of the reference architecture systems engineering;
- Resilience (achieved from structured approaches to systems management); and
- Increased security - consistently and adequately secure the energy industry.

5.12.1 Power System Protection

All of Vector's new and refurbished substations are equipped with multifunctional IEDs. Each IED combines protection, control, metering monitoring and automation functions within a single hardware platform. IED compliance to IEC 61850 is mandatory.

- Vector's older protection system is being phased out over time, with the main drivers for this being:
  - Protection system obsolescence (non-compliance with system requirements);
  - End of technical life or unit failure;
  - Reduced maintenance cost (cost efficiency);
  - Improving safety;
  - Improving reliability;
  - Standardising and simplifying maintenance practice; and
  - Standardising protection installation designs.

At present over 50% of Vector's primary substations are equipped with IEC 61850 compliant IEDs.

5.12.1.1 Network Protection – Design Standards

The main functions of a network protection system are to rapidly detect network faults by monitoring various parameters (current, voltage etc) and selectively initiate fault isolation should an abnormal situation be observed. As a result the protection system minimises damage to the electricity system components (generators, overhead lines, power cables, power transformers, circuit-breakers, etc) and loss of supply to customers.

- Protection systems take into account the following principles:
  - Reliability - the ability of the protection to operate correctly;
  - Speed - minimum operating time to clear a fault;
  - Selectivity - disconnection of minimum network sections in order to isolate the fault; and
  - Cost - maximum value from investments.

a. Maximum Fault Clearing Time

Maximum fault clearing time is defined as the time from fault initiation to the fault breaking device arc extinction. Main protection maximum fault clearing time is stipulated in Table 5-27.

Fault Location	System Voltage			
Primary Equipment	**11kV**	**22kV**	**33kV**	**110kV**
Switchgear and Power Transformer Faults	150ms	150ms	150ms	150ms
Line Faults	600ms	150ms	150ms	150ms

Table 5-27 : Maximum fault clearing time

The fault clearing time of the back-up protection shall not exceed the short-circuit thermal withstand capability of the primary equipment.

b. Protection Schemes

Vector's primary network equipment is protected to minimise damage during any type of faults. All new and refurbished substations are equipped with multifunctional 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 SCADA central computers over the IP based communication network using industry standard communication protocols.

c. Line Protection

Table 5-28 sets out the protection schemes for protecting the various parts of the distribution network.

Line Type	System Voltage	Protection Scheme
Overhead Line	110k	Main - Longitudinal Differential protection (ANSI 87L) Back-up - Distance Protection (ANSI 27) - Breaker Failure (ANSI 50BF)
Overhead Line	33 / 22kV	Main - Longitudinal Differential protection (ANSI 87L) Back-up - Over-current and Earth Fault (50 /51)
Overhead Line	11kV	Main - Over-current and Earth Fault (50 /51) Back-up - Over-current and Earth Fault (50 /51)
Underground Cable	110kV	Main - Longitudinal Differential protection (ANSI 87L) - Thermal overload (ANSI 49) Back-up - Distance Protection (ANSI 27) - Breaker Failure (ANSI 50BF)
Underground Cable	33kV / 22kV	Main - Longitudinal Differential protection (ANSI 87L) - Thermal overload (ANSI 49) Back-up - Over-current and Earth Fault (50 /51-50N/51N)
Underground Cable	11kV	Main - Over-current and Earth Fault (50 /51) Back-up - Over-current and Earth Fault (50 /51)

Table 5-28 : Line protection schemes

Dedicated optical fibres are used for all communication assisted protection schemes eg. longitudinal differential protection scheme.

d. Auto Reclosing

Auto-reclosing is applied to overhead network but not to the underground cable or combined underground cable and overhead lines.

e. Busbar Protection

Table 5-29 sets out the protection schemes for protection busbars at zone substations and bulk supply substations.

System Voltage	Protection Scheme
110kV	Main - Low Impedance differential protection (ANSI 87BB) Back-up - Over-current-time and Earth Fault (ANSI 50/51-50N/51N)
33, 22 and 11kV GIS	Main - Arc detection (50AR) or Low Impedance differential protection (ANSI 87BB) Back-up - Over-current and Earth Fault (ANSI 50/51-50N/51N)
33, 22 and 11kV AIS – Metal-clad	Main - Arc detection (50AR) or Low Impedance differential protection (ANSI 87BB) Back-up - Over-current and Earth Fault (ANSI 50/51-50N/51N)
33, 22 and 11kV AIS	Main - Low Impedance differential protection (ANSI 87BB) Back-up - Over-current and Earth Fault (ANSI 50/51-50N/51N)

Table 5-29 : Busbar protection schemes

5.12.2 Control Centre Applications

5.12.2.1 SCADA Master Station

Siemens Spectrum Power TG master station has been deployed for monitoring and control of the electricity networks.

As with the rest of the Vector information system topology, SCADA solutions based on non-proprietary industry open standards are applied. This is a major driver for flexibility and cost efficiency. Vector has standardised on the Siemens SpectrumPower TG application since 2002. It has been recently upgraded to the latest release.

5.12.2.2 Future SCADA Spectrum Power TG Vision and Development

Siemens is a leader in the implementation of IEC 61850 based solutions, which is the standard adopted by Vector. Siemens has a number of sophisticated SCADA system products and it has laid out its vision and evolutionary path towards a unified platform compliant to the recommended standards (IEC 61850 and IEC61970 CIM), as shown in Figure 5-30, Figure 5-31 and Figure 5-32. This is aligned with Vector's SCADA and information system strategy.

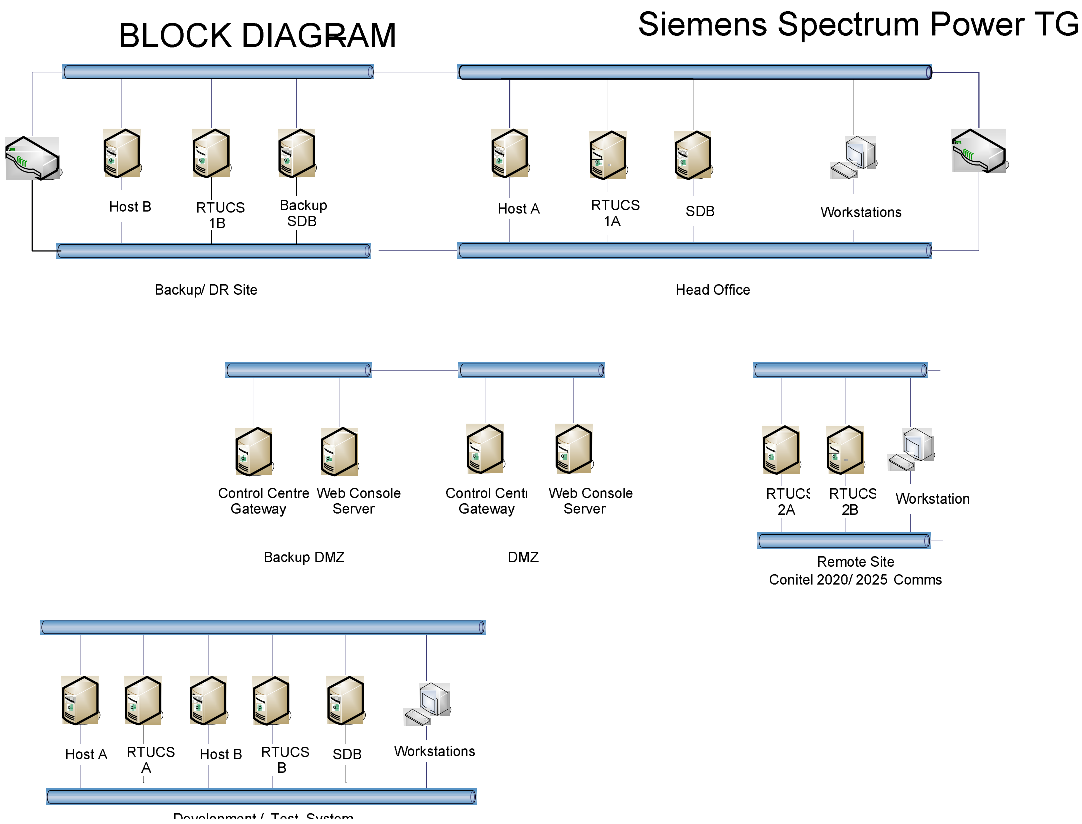


Figure 5-30 : Siemens Spectrum Power TG master station application architecture

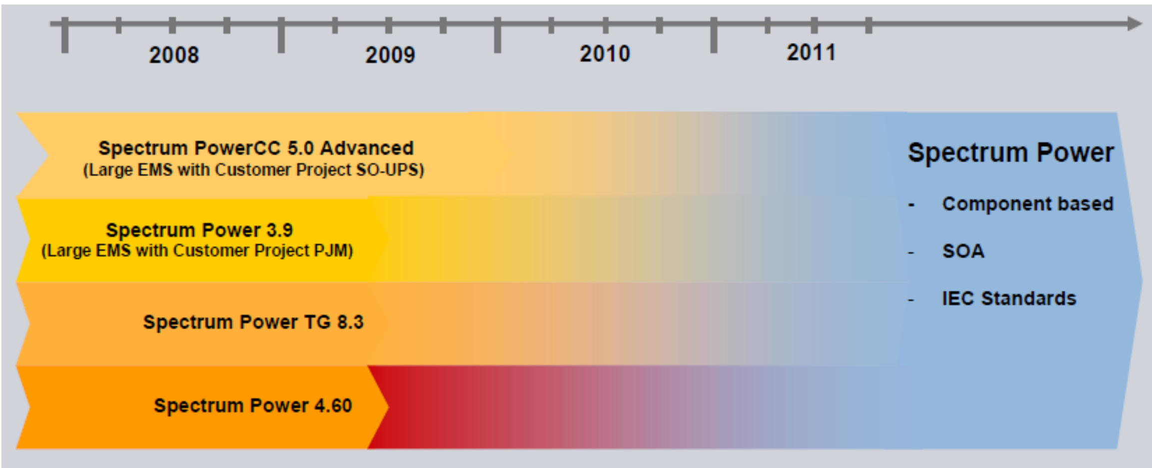


Figure 5-31 : Siemens SCADA control centre applications product portfolio evolution

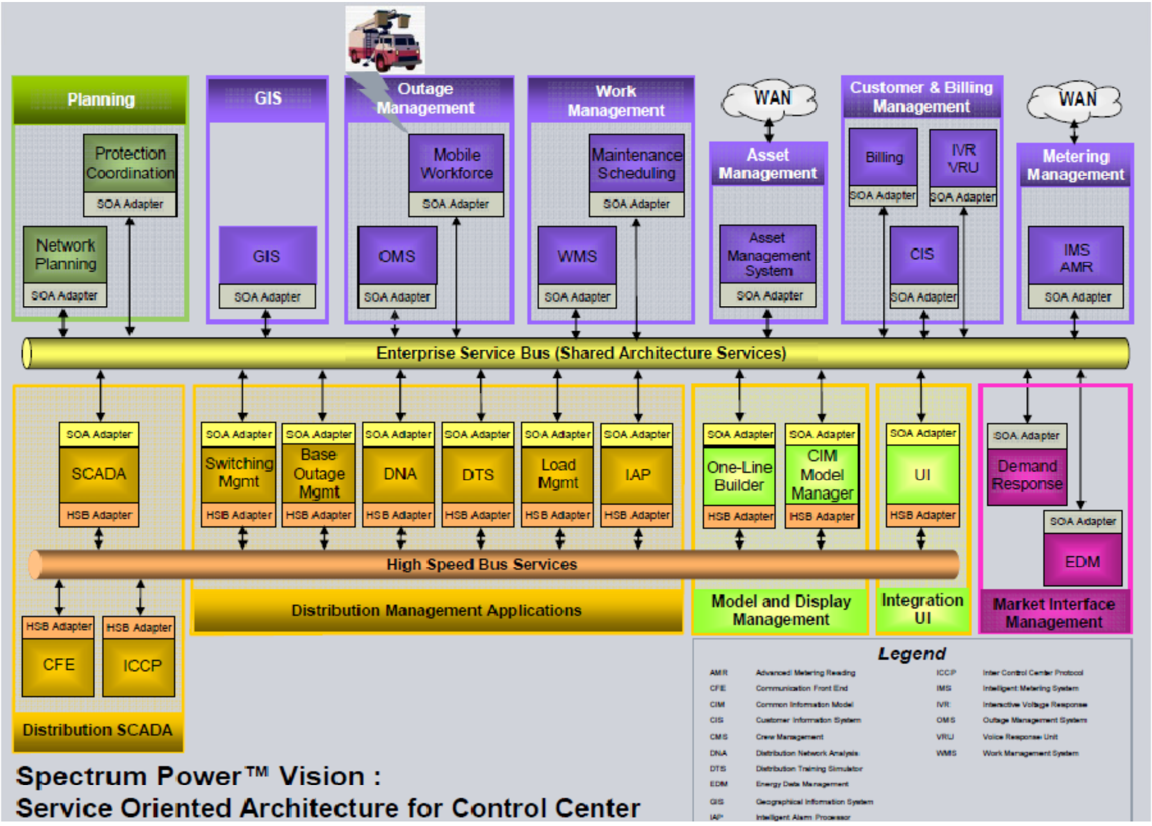


Figure 5-32 : Siemens Spectrum power control centre applications - architecture vision

5.12.2.3 Real-Time Interface to other Control Centres

Vector is planning to implement real-time data exchange with the Transpower SCADA system, via Vector's Siemens Spectrum Power TG Inter-control Centre Communications Protocol solution (ICCP per IEC60870-6 TASE.2 Standard).

Inter-utility real-time data exchange of real-time and historical power system information, including status and control data, measured values, scheduling data, energy accounting data and operator messages is becoming increasingly important and is a vital link in ensuring the maximum benefit from future smart grid operations. The open standard based secure communication links among the utility control centres are identified in Figure 5-36 (IEC 60870-6 TASE.2 Inter-Control Centre Communications (ICCP)).

At present Vector has very limited SCADA information of the Southern network sub-transmission lines connected to Transpower substations eg. no status indication and control capability of Vector's supply lines circuit breakers, circuit loading information, etc. From a network operational excellence perspective this is a significant deficiency.

The Northern region SCADA information of the sub-transmission lines connected to Transpower substations is provided via Vector's "legacy" protocol interface to the Transpower RTU at each site. As a planned part of Transpower's substation automation modernisation programme the support of the "legacy" protocol (Conitel 2020 / 2025) interface will no longer be supported and, if not addressed, would provide a similar deficiency in information about the Northern region interconnections as is experienced in the Southern region.

In addition to these above operational issues, Vector needs to protect its network against potential situations of excessive circulating current condition resulting in outages, should temporarily paralleling of Transpower GXPs occur inside the Vector network. This can be avoided if real-time voltage magnitude and phase angle of

Transpower supply busbars is available for load flow calculation, for which a SCADA interface with Transpower is required.

IEC 60870-6 TASE.2 (ICCP) is a global standard that is very widely used by many utilities for inter-control centre communications between SCADA and/or EMS (energy management system) systems (USA, Europe, Australia etc). It is supported by most vendors of SCADA and EMS systems. Transpower has evaluated a number of options to exchange data with the third parties and has concluded that ICCP is the only solution that:

- Allows fast provisioning of new connections;
- Can be efficiently and effectively secured;
- Is standards-based and in widespread use;
- Allows bi-directional exchange of data and controls;
- Is simple architecture and scalability;
- Provides good native resilience;
- Is based on open standard and has multi-vendor support; and
- Provides low cost integration options.

The intended flow of inter-control information between utilities is illustrated in Figure 5-33.

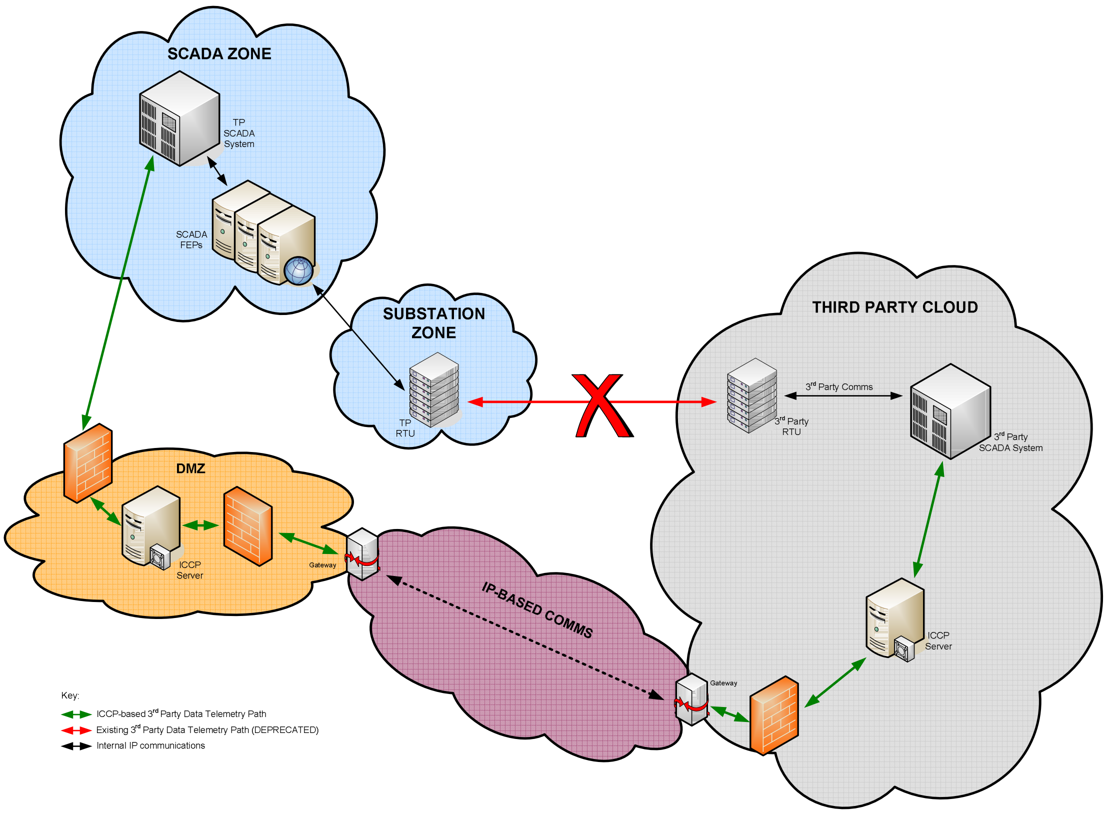


Figure 5-33 : Future Inter-control centre information exchange among NZ utilities

Vector completed a feasibility study to establish an ICCP link with Transpower in 2003.

Vector's Siemens Spectrum Power TG master station supports ICCP, as shown in Figure 5-33 (control centre gateway). The Transpower SCADA master station is capable of secure ICCP information exchange with the third parties. ICCP is Transpower's preferred future proof option for data exchange with the third parties.

ICCP also provides a means of reaching beyond SCADA systems to other utility database systems such as historians (data collection and storage), outage and scheduling systems, to facilitate exchange of data for uses over and above than real-time power system control and supervision. This will provide possible business opportunities and challenges for sharing resources and competing for operating and power system management services.

The immediate benefits for Vector of an ICCP link to Transpower's SCADA master station include:

- Obtaining data originating from Transpower substations would no longer require any Vector equipment at the Transpower substations;
- Existing Vector SCADA communications circuits into Transpower substations would no longer be required;
- Vector's total communications requirements would be simplified;
- Lower lifetime costs for obtaining data from Transpower sites;
- Easier to make changes to data obtained from Transpower sites;
- ICCP is scalable with low incremental cost and expansion only limited by master station capacity and ICCP network bandwidth;
- Higher reliability communications by utilising Transpower's existing redundant network to site;
- Greater data integrity through lower risk of any Transpower site works inadvertently affecting Vector data transfers; and
- Complete flexibility for configuring controls and data acquisition.

5.12.2.4 Penrose to Hobson Tunnel Management System

The tunnel management system is used to monitor:

- Tunnel ventilation;
- Drainage sump level control;
- Status monitoring (temperature, levels);
- Alarm monitoring (fire);
- Visualisation and control (HMI functions); and
- Access control via airlocks.

The system consists of range programmable logical controllers (PLC) made by Siemens S7-200 and S7300 connected in an optical fibre ring. The PLCs are interfaced to a Citect SCADA application, which runs on a stand-alone desktop computer, via ethernet / IP network.

The field installed PLCs are interfaced to Siemens Spectrum PowerTG SCADA master station

5.12.3 Network Automation at Vector

Power system automation schemes are being implemented at Vector to support reduced customer outages, increased network utilisation, cost efficiency and increased system reliability.

Vector's current substation automation system is based on IEC 61850 - *Communication networks and systems for power utility automation standards*. The substation LAN is based on a resilient optical ethernet and the connected IEDs are IEC 61850 standard compliant. Over 80% of Vector's primary substations are equipped with IEC 61850 compliant IEDs.

5.12.3.1 Control Centre Automation - Load Shifting Scheme Based on CIM / IEC 61850 Model

An automation scheme is being developed to transfer network load between adjacent substations under overloading or fault conditions. This is intended to increase asset utilisation and provide an opportunity for substantial cost efficiencies. The scheme, illustrated in Figure 5-34, is based on the information and communication standards adopted by Vector.

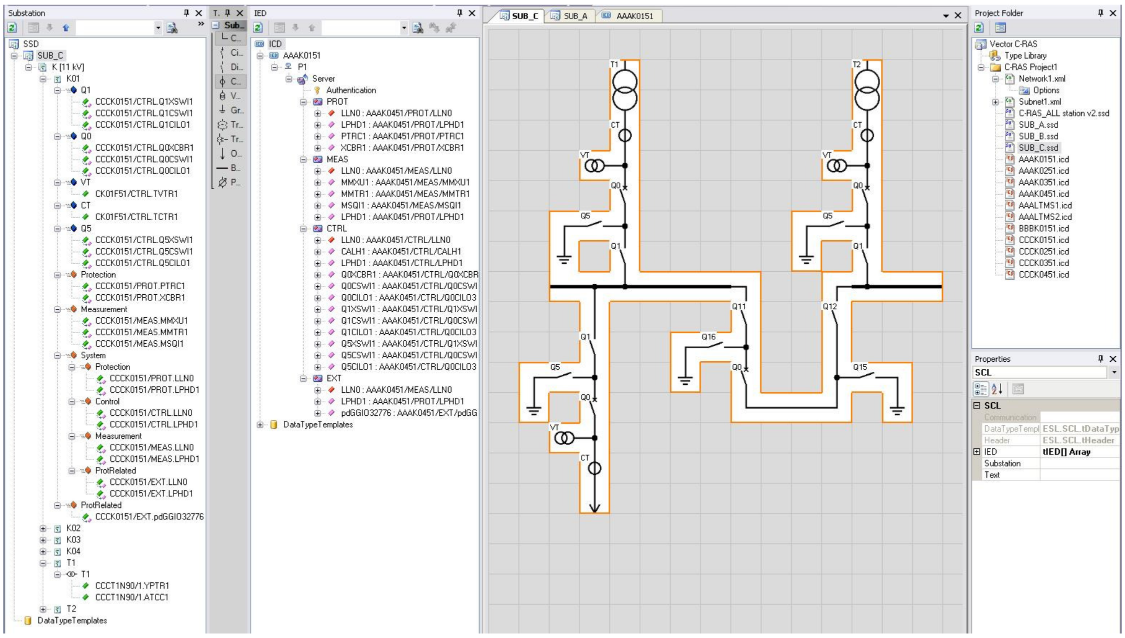


Figure 5-34 : Network automation scheme

5.12.3.2 Substation Automation

Substations constitute the electric power system nodes for all access and information retrieval. Substation automation describes the collection of infrastructure within a substation enabling the coordination of protection, automation, monitoring, metering and control functions, and utilising substation internal communications network infrastructure. Vector's substation automation system is based on resilient optical ethernet local area networks, running IEC 61850 compliant IEDs.

Substation automation is not just the automation of a substation. It is part of a major paradigm shift for all power system operations. It is the first step toward the creation of a highly reliable, self-healing power system that responds rapidly to real-time events with appropriate actions, and supports the planning and asset management necessary for cost-effective operations.

A typical substation automation system, as applied on the Vector network, is illustrated in Figure 5-35.

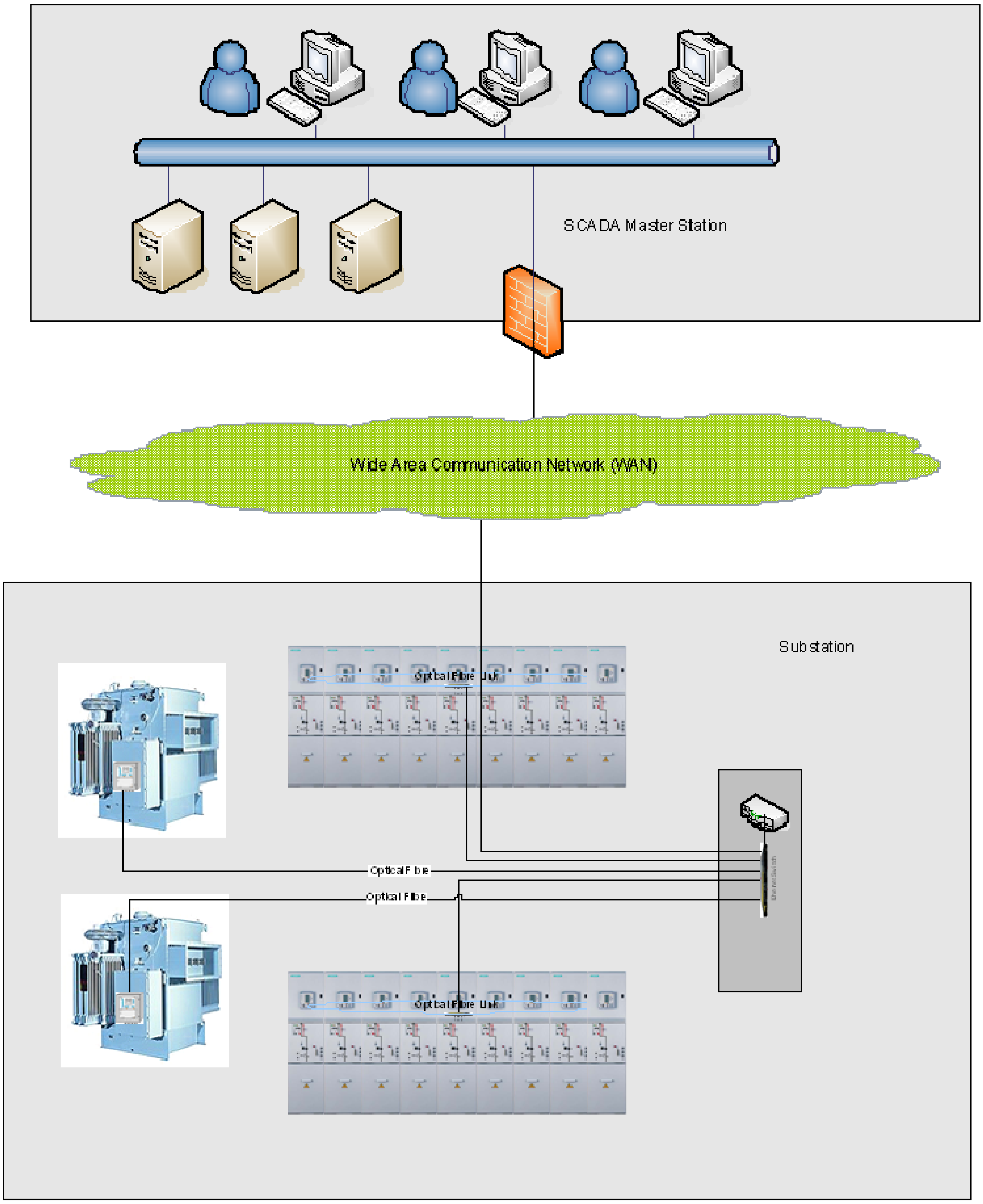


Figure 5-35 : Vector's typical substation automation system

The following automation schemes are being implemented:

- Centralised substation bus load-transfer schemes;
- Centralised substation overloading load shedding scheme; and
- Centralised substation under-frequency load shedding scheme.

The automation schemes are based on the IEC 61850 Standard and peer-to-peer relay communication over the substation LAN. The algorithms for the schemes are centralised in the incoming IEDs. These schemes, illustrated in Figure 5-36, increase reliability, as all incoming IEDs have the same algorithm and execute the programme automation sequence and issue the control command concurrently.

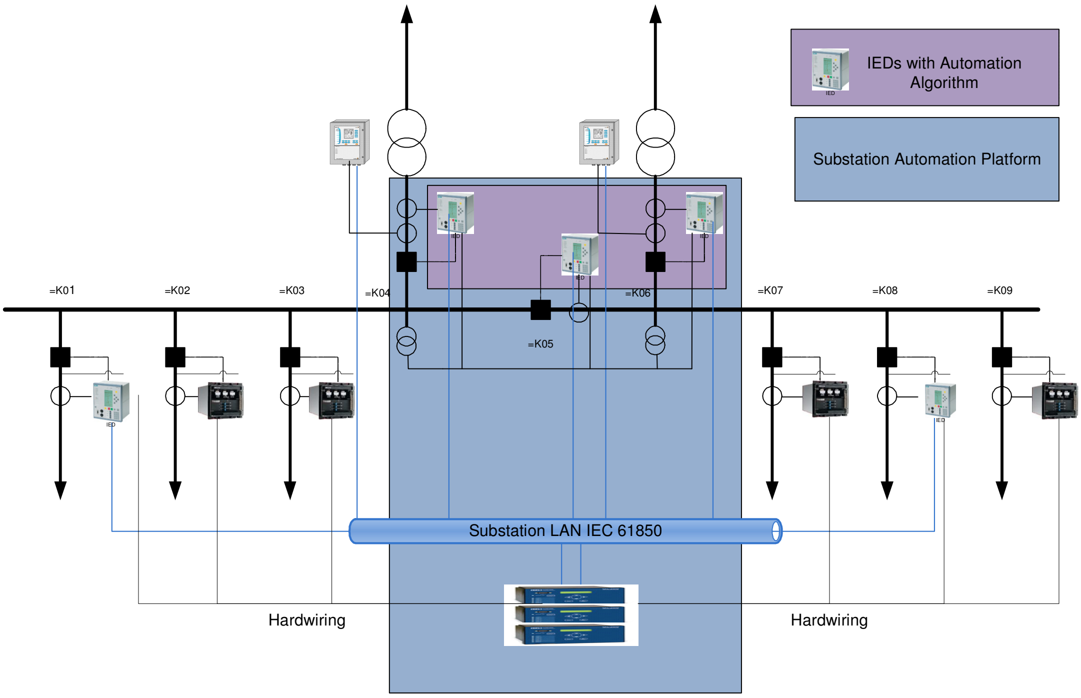


Figure 5-36 : Substation automation scheme

a. Centralised Substation Bus Load-Transfer Schemes

At the substations, a situation arises from time to time where fault current level can exceed the switchgear fault current ratings. This presents safety risks to people and equipment.

To reduce fault levels, and avoid switchgear replacement, the network has been split at substation busbars by opening bus-section circuit breakers. This, however, impacts on network reliability as under incomer fault conditions switching is required to restore supply from the other side of the switchgear bus.

This situation is alleviated by a substation centralised automatic busbar load transfer scheme. The scheme is designed to automatically close the bus section circuit breaker upon loss of one of the incoming feeders.

b. Substation Centralised Overload Load Shedding Scheme

Owing to increased substation loading, a loss of a substation incoming feeder can result in overloading of the primary equipment (eg. power cables, power transformers) associated with the remaining incoming feeder(s). The equipment overloading can lead to accelerated asset ageing, equipment failure or loss of supply to large numbers of customers due to overload tripping.

A substation centralised, automatic feeder, load-shedding scheme has been designed and implemented in order to mitigate these consequences. The basic operation of the load-shedding scheme is to detect when one of the incomers has tripped, to continuously check loading conditions on the remaining incoming feeders and to shed as many outgoing feeder loads as required to prevent tripping of the remaining incomers.

This may result in a loss of some customer load, but the extent of outages will be far less than that which would result from further incomer trips while also protecting the assets.

c. Substation Centralised Automatic Under-Frequency Load Shedding Scheme

The frequency of a power system changes when the load-generation equilibrium is disturbed. If the unbalance is caused by a deficiency in generation capacity, the system frequency decays to a level value at which load-generation equilibrium is re-established. If equilibrium, however, cannot be established system collapse will occur, leading to widespread and possibly prolonged outages.

Vector is required to provide an automatic under frequency load shedding (AUFLS) scheme under the EIPC. The EPIC require electricity distribution utilities to provide 2x16% (of the total load at the time) blocks of customer demand which can be shed automatically via the AUFLS when the grid frequency drops to 47.8Hz and 47.5Hz respectively.

A substation centralised AUFLS scheme is realised through using the incoming feeder IEDs. When under-frequency conditions arise the IEDs initiate load shedding based on the predefined outgoing feeder priorities, by tripping feeders via the substation RTUs via peer-to-peer communication (using the IEC 61850 standard).

5.12.3.3 Distribution Feeder Automation

Feeder automation can be defined as schemes of equipment (automated switches, auto-reclosers etc) capable of acting without human intervention in order to minimise outages, restore supply or carry out other network/asset automation functions eg. substation off-loading. The feeder automation schemes are frequently interfaced to the network control centre for remote indication, control and data acquisition (SCADA functions).

Vector's existing feeder automation schemes enables SCADA functionalities, auto-reclosing, auto-sectionalising, feeder reconfiguration, fault detection and voltage control. Over 300, mostly overhead line pole mounted, switchgear (load-break switches, auto-reclosers and sectionalisers, RMU) have been deployed. GPRS/3G IP (internet protocol) centric third party communication network and DNP3 communication protocol have been used for SCADA master station and engineering applications. The standard Vector deployment is shown in Figure 5-37.

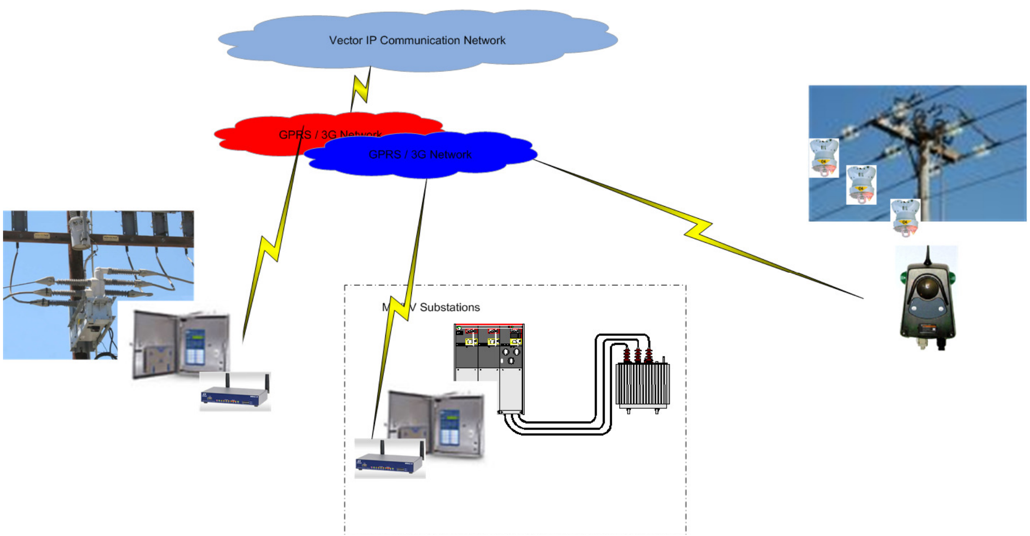


Figure 5-37 : Automation - using GPRS/3G communication system

5.12.3.4 MV/LV Substation - Metering and Monitoring

In order to improve fault location, optimise asset management for the 11kV and LV networks, as well as to improve visibility of the LV network and power quality over the whole of the Vector distribution network, provisionally it is planned to roll-out MV/LV metering and monitoring equipment at selected sites over a 10 year period. (See also the discussion in Section 3.)

Vector has piloted a solution that includes optical current sensors that are interfaced to the control center via IEC 61850 and 3G communication networks. This is illustrated in Figure 5-38.

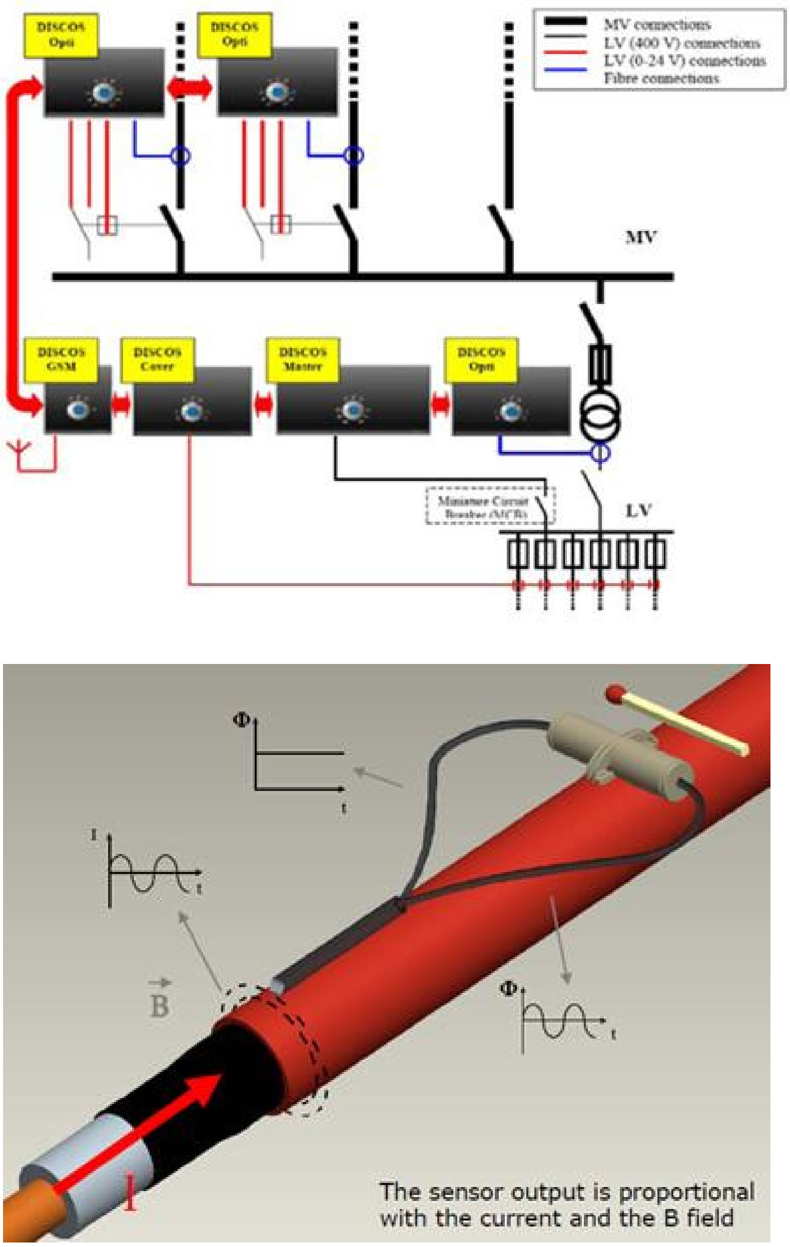


Figure 5-38 : Typical monitoring solution for a single transformer MV/LV distribution substation

5.12.3.5 Remote Terminal Units (RTU) Replacement

The RTUs used on the Vector network are microprocessor controlled electronic devices, which interface objects in the physical world (eg. switchgear, power transformers, etc) to a distributed control system or SCADA system by transmitting telemetry data to the system and/or altering the state of connected objects based on control messages received from the system:

- Over time, a number of different RTUs have been installed in Vector's network many of which are nearing the end of their technical life or are obsolete;
- In the Southern region there are 24 Plessey GPT RTUs and Siemens PCC systems to be replaced; and
- In the Northern region 163 Foxboro C225 RTUs and 3 Foxboro C50 RTUs are planned for replacement.

Vector has standardised on the open industry standards (the IEC defined www.iec.ch) for the distribution and substation automation technologies, the operational communication network (ethernet/TCP/IP) and communication protocols (IEC 61850) from the field to the SCADA master station applications.

Vector has been running an annual RTU replacement programme for a number of years, and is currently replacing approximately 10 RTUs per region per annum. The RTUs are replaced with fully compliant IEC 61850 solutions from SEL.

5.12.4 Technical Application Integration

Increased use of "intelligent" devices utilises ever-increasing volumes of automation and technical analysis applications to optimise planning, design, operations and maintenance activities. Robust and highly integrated communications and distributed computing infrastructures are required for this. This infrastructure needs to be interoperable and easily integrated across vendor equipment and across the network. To achieve the necessary level of interoperability and low cost integration of the complex application requires adoption of a suite of the industry standards.

The reference architecture (Figure 5-39) identified the key standards, IEC 61850 and IEC 61968/IEC61970 (CIM - Common Information Model, GID – Generic Interface Definition) that facilitate interoperability and standardised information exchange.

IEC 61970/61968 standardises:

A shared device information (data) model:

- CIM / XML; and

A shared set of services:

- The Generic Interface Definition (GID).

CIM is an abstract data model that is used to represent the major objects in an electric utility enterprise and facilitate the application integration. Figure 5-39 shows the integration architecture as defined in the IEC 61968-1 Standard.

IEC 61968/IEC61970 (CIM/GID) standard-based solutions are to be used for Vector technical application integrations. The advantages of using CIM/GID based application integration are:

- Vector already has a large population of field installed devices supporting IEC 61850 Standard and harmonisation of the IEC 61850 and the CIM model is under way;

- IEC 62351 Standard is to address cyber security issues for CIM;
- Many of Vector's applications are being developed to be CIM compliant (DIgSILENT Power Factory, Power Factory Station Ware, Siemens Power TG Master Station etc); and
- Lower integration cost.

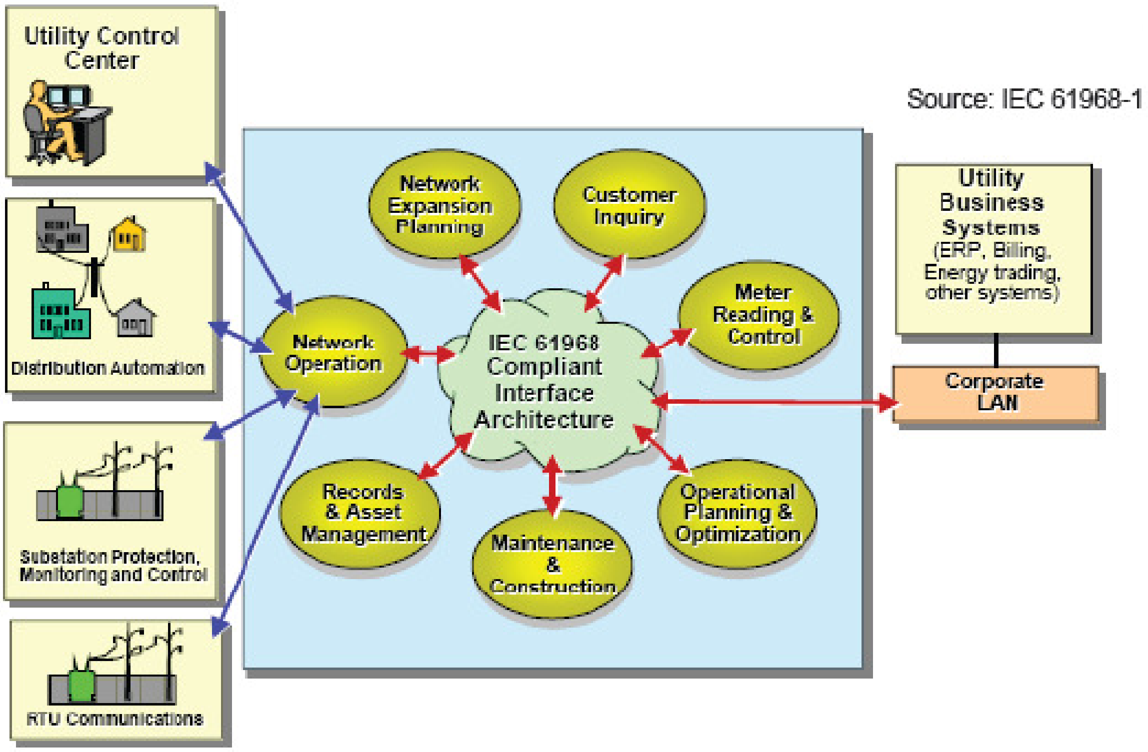


Figure 5-39 : Distribution management system with IEC 61968 compliant architecture

The diagram in Figure 5-40 shows the proposed application and integration of the Vector control systems.

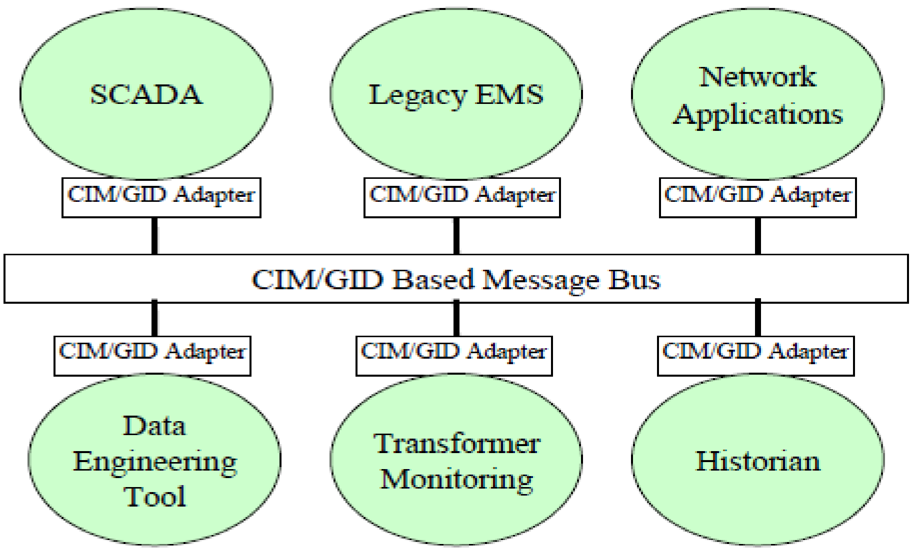
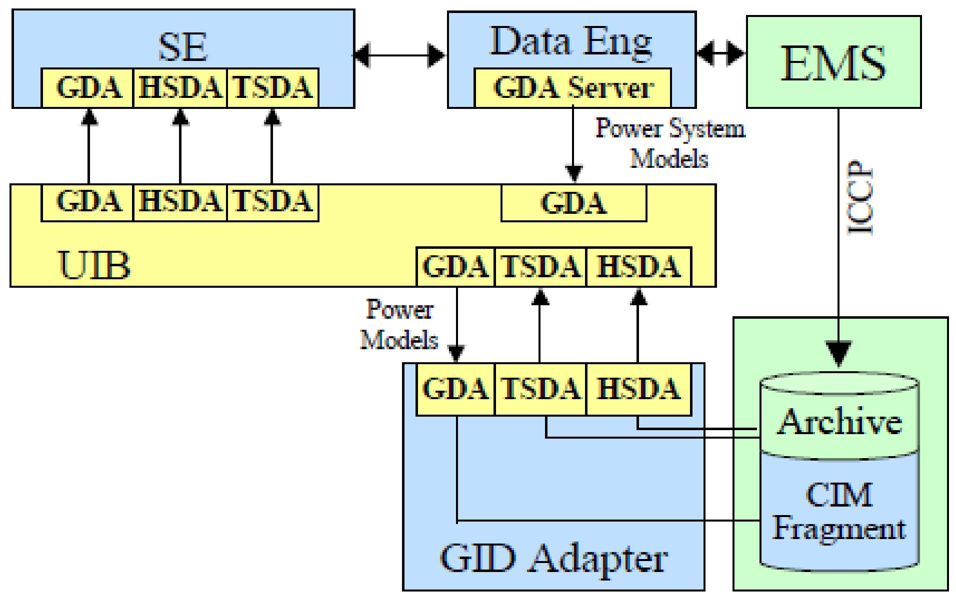


Figure 5-40 : Application integration scenario

5.12.4.1 Utility Integration Bus Topology (UIB)

The Utility Integration Bus (UIB) is a standards-based integration platform designed to significantly reduce the engineering effort required to integrate data in the utility environment. An approach to facilitate incremental upgrading of the Vector's control centre application integration is to use integration solution as shown in Figure 5-41.



API Name	Acronym	Description
Generic Data Access	GDA	Based on the Object Management Group (OMG) Data Access Facility (DAF) specification, GDA is used to access and modify model data in a model server and supports model change notifications.
Generic Eventing and Subscriptions	GES	Based on the OPC Alarm and Events (AE) specification, GES is used to publish and subscribe to XML messages using data in the context of a unified model.
High Speed Data Access	HSDA	Based on the OMG Data Access for Industrial Systems (DAIS) and the OLE for Process Control (OPC) Data Access (DA) specifications, HSDA is used for the exchange of real-time data in the context of a unified model.
Time Series Data Access	TSDA	Based on the OPC Historical Data Access (HDA) specification, TSDA is used to access time-based data from a historian in the context of a unified model.

Figure 5-41 : Specific GID interfaces used for application integration

A project to develop the standards based integration platform is currently underway.

5.12.5 Communication Systems

Deployment of Vector's modern operational wide area communication network (WAN) infrastructure, on the open standard based IP, began in 2002. The WAN consists of the optical fibre infrastructure, digital communication over Vector's copper pilot cables, Vector's owned digital microwave radio links and third party IP network, including wireless GPRS/3G GSM standard based networks. The IP network facilitates cost effective migration and integration of the operational services from obsolete disparate proprietary solutions to the open standard based solution. Over 50% of Vector substations have been connected via IP network. Hundreds of field installed apparatuses (auto-reclosers, load breaker switches, ring main units) are connected via third party GPRS/3G wireless communication networks.

Vector's standard substation LAN and operational WAN is based on ethernet and IP communication technology. The ethernet/IP based operational communication network carries a number of services:

- SCADA (telecontrol and telemetering);
- The telemetry service(s) have QoS assigned, so that performance is not unduly compromised by other traffic sharing the same network;
- Engineering access (remote equipment management, on-line equipment monitoring);
- Digital fault record retrieval;
- Substation telephony – (voice over IP);
- Substation security;
- Video imaging and streaming video over IP is a future application impacting security and health and safety;
- Network management;
- Management of the network devices, routers, switches and, in the future, SNMP management of the IEDs is an essential service; and
- The substation telephone is an essential tool for technicians and engineers working on site.

Choosing the right communications technology is key to creating an intelligent platform that can continually monitor utility assets, operations and consumer demand. The deployment of ethernet and IP based communication systems has become pervasive for a wide range of applications. There has been a rapid development of "networking standards" frequently involving active industry user and supplier organisations.

With current technology it is possible to develop a large, peer, autonomous and scalable network. TCP/IP facilitates a logical, low cost and easy solution to manage systems based on heterogeneous technologies by providing a common communication protocol for disparate communication technologies eg. Vector uses copper (Cu) pilot cables, digital microwave radios, optical fibres, Vodafone GPRS/3G to carry its SCADA communication using TCP/IP protocol. A future network in which all the elements (smart meters, home appliances, home energy management platform, infrastructure devices, plug-in vehicles, etc) support IP will allow utilities and consumers to enjoy the benefits of a competitive and innovative ecosystem built around open standards.

Teleprotection over IP, remote asset management, video surveillance are being planned.

Vector is committed to an open communications architecture based on industry standards. This has resulted in the adoption and deployment of ethernet and IP based communication technologies. TCP/IP facilitates a logical, low cost and easy solution to incorporate and manage heterogeneous technologies by providing a common communication protocol eg. Vector uses copper (Cu) pilot cables, digital microwave radios, optical fibres, Vodafone GPRS/3G to carry its SCADA communication using TCP/IP protocol. Vector's standard substation LAN and operational WAN are based on ethernet and IP communication technology, as illustrated in Figure 5-42 and Figure 5-43.

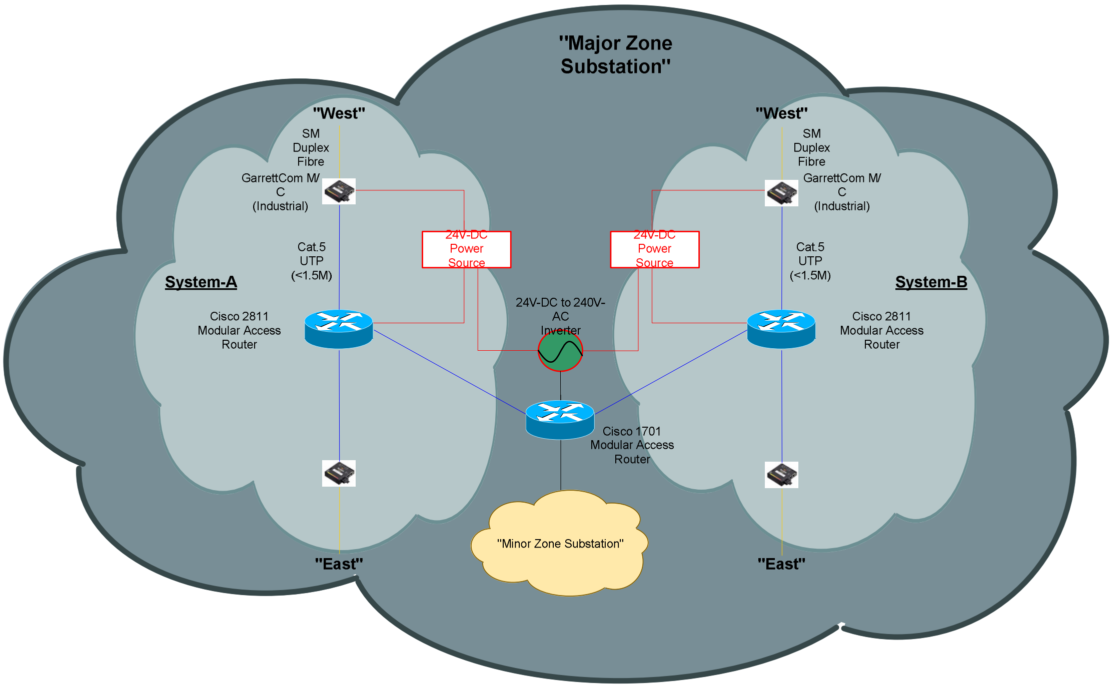


Figure 5-42 : Vector's IP WAN

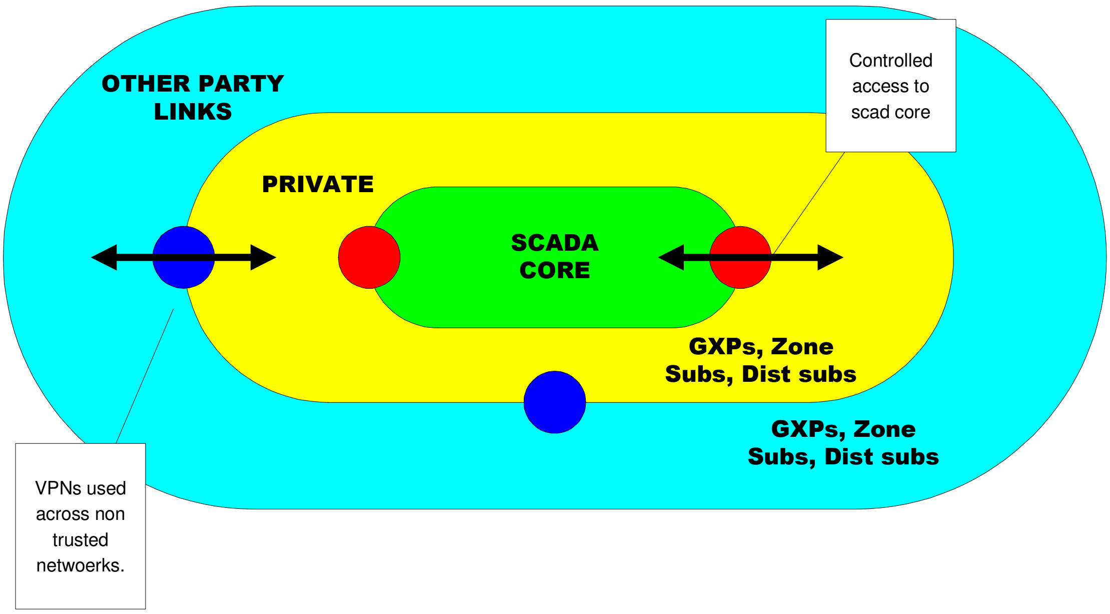


Figure 5-43 : Operation IP communication network - private and public zones boundary

Migration to an IP based network started in 2002. Vector will continue to introduce IP to its substations in conjunction with the network development or protection and control upgrade projects. Within the next five years it is planned that all zone substations will be connected via IP network. The substation communication network is provided by Vector Communication and other third parties, including Telecom, Vodafone and Transpower.

5.12.6 Cyber Security

The public electric power system is now characterised as one of several critical infrastructures, requiring rigorous application of security practices. Cyber security must address not only deliberate attacks, such as from disgruntled employees, industrial espionage and terrorists, but also inadvertent compromises of the information infrastructure due to user errors, equipment failures and natural disasters.

For Vector's real-time information and communications systems the cyber security strategy is focused on prevention, while also defining a response and recovery strategy in the event of a cyber attack. Cyber security risk assessment of Vector's real-time systems is applied to both Vector's power and information infrastructure.

The diagram in Figure 5-44 shows the security requirements, threats, counter-measures and management at Vector.

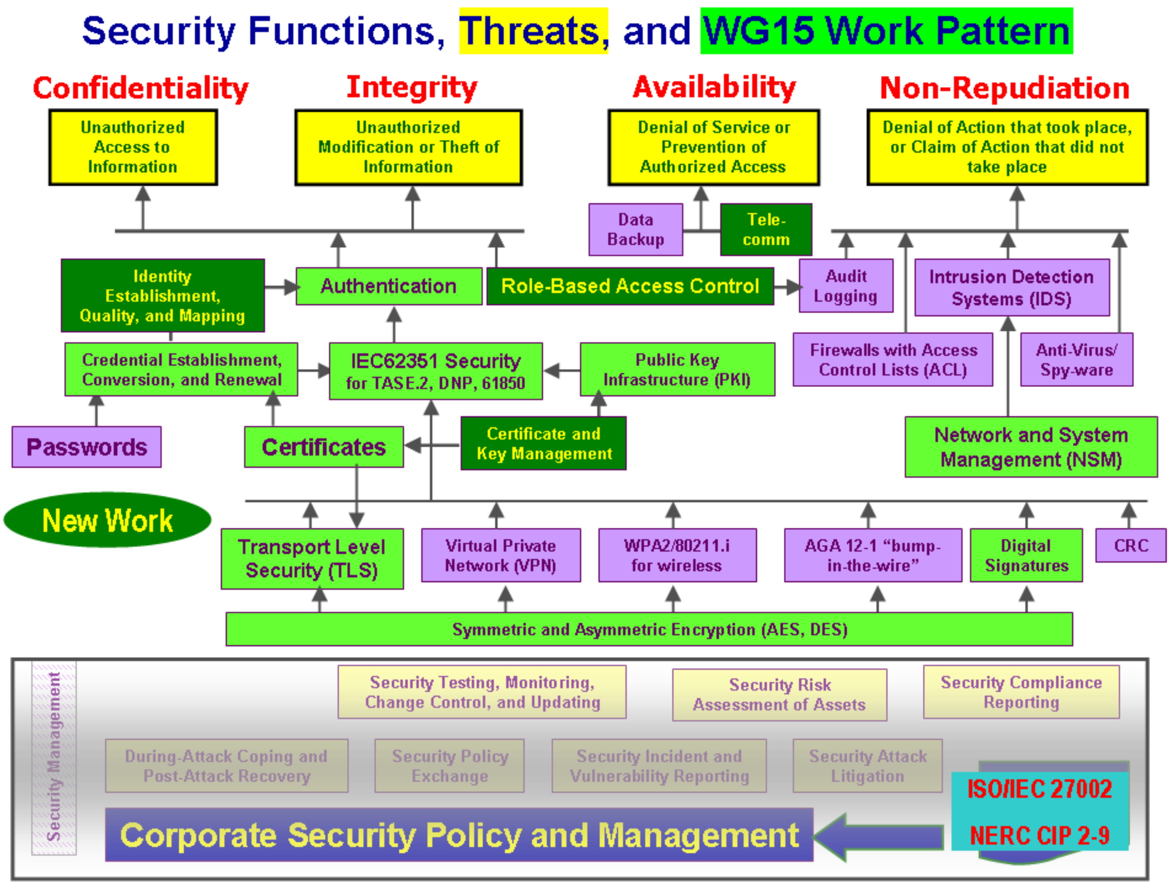


Figure 5-44 : Overall security: security requirements, threats, counter-measures, and management

Communication protocols are one of the most critical parts of power system operations, responsible for retrieving information from field equipment and, vice versa, for sending control commands. Vector is committed to IEC specified communication protocol for its real-time system and application interfaces (Figure 5-48). IEC TC57 has published a set of standards for information security for power system control operations (IEC 62351) to security IEC 60870-5, its derivative DNP, IEC 60870-6 (ICCP), IEC 61850, IEC 61968 and IEC 61970 communication protocols, as illustrated in Figure 5-45.

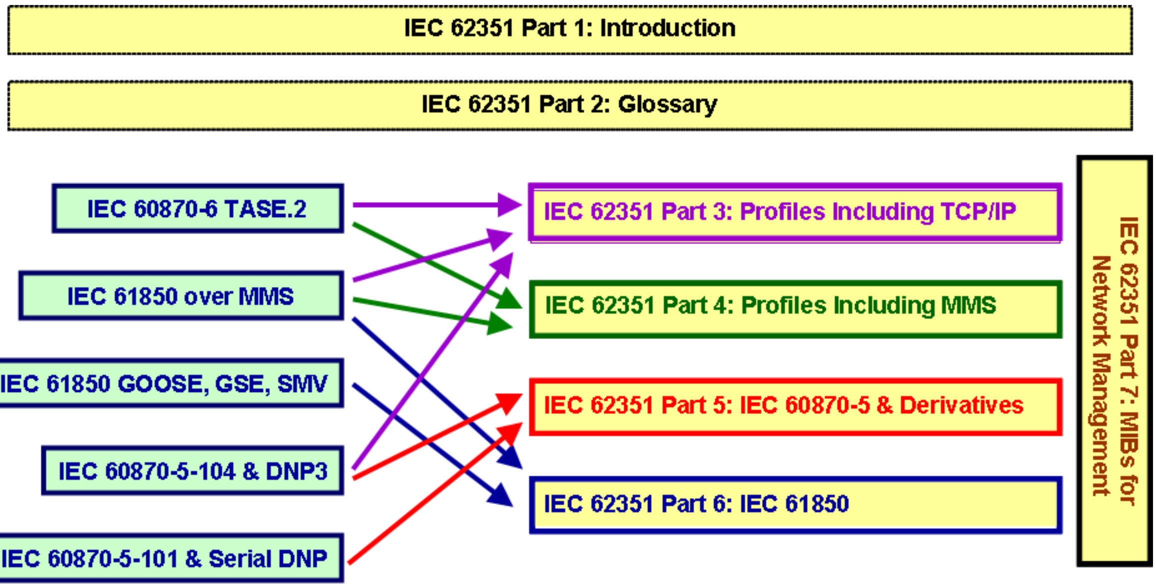


Figure 5-45 : Mapping of TC57 communication standards to IEC 62351 security standards

Vector is in the process of incorporating IEC 62351 Standard protocol security enhancements within the communication protocols it uses for its protection, automation and control systems. New products, when they become available in the products and are practicable to be implemented, will adhere to this standard.

Following a detailed audit in 2009 into the cyber-security standards of Vector's SCADA network, several recommendations for improvement were made. In response, Vector's real-time systems information security policy and management have been enhanced within Vector's overall IT security policy and management. This has been developed in accordance to ISO/IEC 27002 Standard and extended to incorporate real-time system specific requirements as defined by NERC CIP Standards.

Other programmes are also underway to ensure the roles and responsibilities for the SCADA system, which lie across the business, are clearly allocated, and that adequate firewall protection and intrusion detection is provided for all parts of the system.

5.12.7 Substation Information Management

By using object-modelling technology, IEC61850 establishes a standardised self-describing object names structure for substation information. This is discussed below.

5.12.7.1 Digital Fault Recording Retrieval

Vector has implemented the automatic retrieval and archiving of power system digital fault recordings. The application enables timely analysis of substation and network events. It also contributes significantly to the reduction in time of post-fault investigations, problem identification and incident reporting. This is used to facilitate improved network and protection system performance.

5.12.7.2 Setting Management Modelling

Protection system modelling and settings is a vital part of network modelling and scenario simulations. Vector has implemented a protection setting management system (StationWare) from DIgSILENT that has an interface to the DIgSILENT network and protection tool, PowerFactory. Both products are planned to support IEC 61850 and CIM.

5.12.8 Time Synchronisation

Accurate and reliable time synchronisation is critical to ensure automatic control and system protection equipment operates correctly to allow optimal utilisation of network assets. When a system event occurs, it is important for later forensic analysis that all system events and data captured during the event are time stamped accurately so the root cause of the event can be determined. GPS time synchronisation plays a key role in Phasor Measurement Systems – a technique that permits the real-time visualisation of instantaneous power flows.

Time synchronisation of Vector's real-time systems is done using Network Standard Protocol (NTP). Fields installed IEDs are synchronised over an IP based wide area network to 1 ms resolution, using SNMP (Simple Network Time Protocol) according to IEC 61850 Standard.

Edition 2 of IEC 61850 Communication Network and Systems for Power Utility Automation Standards has adopted a precision, sub-microseconds accuracy timing solution based on IEE1588v2 Standard. In future, new equipment will be compliant with this standard.

5.12.9 Energy and Power Quality Metering

Some businesses, such as those in manufacturing and service industries, have a high reliance on disturbance free power supply. One of the objectives of PQ monitoring is to identify disturbances that could adversely impact on customers' equipment with the objective of identifying solutions.

Vector's energy and PQ metering system consists of 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. The meters are web enabled and the latest firmware version of the meters are compliant to the IEC 61850 Standard (Vector's adopted information exchange standard).

The metering system provides Vector with essential information about the quantity, quality and reliability of the power delivered to Vector's customers and is currently used to:

- Improve asset utilisation by managing network peak demands;
- Provide PQ and load data for network management and planning purposes;
- Provide information to assist in the resolution of customer-related PQ issues; and
- Contribute to the power system stability by initiating instantaneous load shedding during under-frequency events.

The following strategies have been implemented to monitor and report PQ problems identified on Vector's network:

- PQ monitoring equipment has been installed at selected GXPs and zone substations;

- An electronic mail system automatically sends a PQ disturbance report in real-time to customers;
- A web-based reporting system that makes real-time and historical PQ information available for diagnosis of customer PQ issues;
- Use of network modelling software and tools to predict the impact of PQ disturbances at customer premises; and
- Using portable PQ instruments to investigate PQ related complaints.

The information in the PQ reports provide details on any event that caused voltage and current transients or voltage sags and swells in the network. By drilling down into each report the daily maximum/average/minimum of voltage, current, frequency, power factor, voltage unbalance, voltage total harmonic distortion (THD) and current THD can be observed. The voltage sags captured by each monitor for the same period can also be viewed as a voltage sag magnitude duration chart.

Other PQ action at Vector includes:

- Installation of PQ monitoring instruments at new zone substations. This is to increase the number of zone substations being monitored and gain increased knowledge of the quality of supply to customers;
- Benchmarking the quality of supply on the network and monitor changes over time;
- Offering support to customers by assisting with solutions to PQ problems; and
- Developing an automated link between network events such as faults and data captured on the PQ instrumentation.

5.13 Network Programme Summary

Table 5-30 summarises the project programme for development of the power network in the two network regions. It shows the current target completion dates for these projects, compared with that in the previous plan. If there is a difference the reasons for the change are described (advanced or delayed) in the following tables. Newly identified and completed projects are also highlighted.

Implementation Date	Substation	Project Description	Implementation Date from Previous AMP	Comments
FY13	Avondale	Avondale zone substation - establish 33kV switchboard	FY13	No change
FY13	Brickworks	First 33/11kV transformer	FY13	No change
FY13	Hillsborough	Substation Designation	FY13	No change
FY13	Hobsonville Point	Zone substation land purchase	FY13	No change
FY13	Hobson	Customer capacity upgrade	FY13	No change
FY13	Newmarket	Customer capacity upgrade	FY13	No change
FY14	Newmarket South	Purchase of land for new zone substation	FY13	Delayed by one year
FY13	Various	Capacitor banks for Northern network	New	Replaces removed capacitor banks
FY13	Waterview	Waterview - South portal sub for 16MW TBM	FY13	No change
FY13	Waterview	Waterview - TP Roskill subtran re-termination	New	New project, customer driven
FY14	Balmoral	Reinforcement of 11kV network for St Lukes supply	FY14	No change
FY14	Birkdale	New 33/11kV transformers	New	Load increase at substation
FY14	Hillsborough	Install second 33kV cable and 33/11kV transformer	FY14	No change
FY14	Hobson	Installation of a 110kV switchboard as part of new GXP	FY14	No change
FY14	Hobson	Install a third 110/22kV transformer	FY14	No change
FY14	Hobsonville	Reinforcement of the Clark Road 11kV feeder	FY14	No change
FY14	Keeling Road	Install second 33/11kV transformer and reinforce 33kV network	FY14	No change
FY14	Matakana	Land Purchase	FY14	No change
FY14	Mangere East	Customer capacity upgrade	FY13	Delayed

Implementation Date	Substation	Project Description	Implementation Date from Previous AMP	Comments
FY14	Maraetai	Reinforce 11kV feeder nine	FY13	Delayed
FY14	Penrose	Enhanced Tunnel fire suppression	FY12	Works partially completed, portion deferred
FY14	Penrose	Reactive power measurement of statcom plant	New	Project in conjunction with TP
FY14	Quay	Replace 22kV CTs in two 22kV interconnectors	New	New project
FY14	Rosedale	Establish a zone substation in Rosedale	FY13	No change
FY14	Ellerslie	Substation Designation	FY13	Deferred due to plan change
FY14	Quay	Reinstate 22kV cable for ripple signal	New	New
FY15	Belmont	New 11kV feeder (Ngataringa Bay)	FY14	Deferred due to reduced load forecast
FY15	Greenhithe	33kV cable extension	FY14	Delayed to align with NZTA works
FY15	Henderson	Replace 33kV switchgear	New	New project in conjunction with TP
FY15	Liverpool	Medical School 11kV reinforcement	FY15	No change
FY15	Orewa	Savoy 11kV feeder reinforcement (spare two extension)	FY15	No change
FY15	Penrose	Reterminate 33kV cables	New	Project in conjunction with TP
FY15	Quay	Extend 22kV switchboard	FY15	No change
FY15	Red Beach	Second 33/11kV transformer	FY14	Postponed
FY15	Takanini	Reterminate 33kV cables	New	Project in conjunction with TP
FY15	Te Atatu	Waterview tunnel supply, north portal	FY15	No change
FY15	Wainui	Zone substation land purchase	FY15	No change
FY15	Warkworth	New 11kV feeder (Matakana)	FY15	No change
FY16	Brickworks	Second 33/11kV transformer	FY13	Deferred due to reduced load forecast
FY14	Hans	Customer capacity upgrade	FY16	Advanced by customer
FY16	Flatbush	Establish a zone substation in Flatbush	FY15	Deferred
FY16	Helensville	Establish new Rodney GXP for future power plant	FY16	No change
FY16	Hepburn	Replace 33kV switchgear	New	New project in conjunction with TP
FY16	Kumeu	Zone substation land purchase	FY16	No change
FY16	Liverpool	Customer capacity upgrade	FY16	No change

Implementation Date	Substation	Project Description	Implementation Date from Previous AMP	Comments
FY16	Newmarket South	Establish Newmarket South zone substation	FY16	No change
FY16	Quay	Install 110kV cable Hobson - Quay and relocate T3A	FY16	No change
FY16	Quay	New 22kV interconnector between Quay and Liverpool	New	New project
FY16	Rockfield	NZ Technology Park supply upgrade	FY16	No change
FY16	Warkworth	Reinforce Whangateau 11kV feeder	FY16	No change
FY16	Westgate	Establish Westgate zone substation	FY16	No change
FY16	Wiri	Reterminate 33kV cables	New	Project in conjunction with TP
FY16	Ngataringa Bay	Rebuild zone substation	New	New project
FY17	Warkworth South	Establish zone substation	FY15	Deferred due to reduced load forecast
FY17	Rosebank	11kV feeder reinforcement	FY16	Delayed to align with NZTA works
FY17	Atkinson Rd	New 11kV feeder (Kaurilands)	FY15	Deferred due to reduced load forecast
FY17	Glenvar	Establish zone substation and reinforce 11kV network	FY17	No change
FY17	Mangere	Reterminate 33kV cables	New	Project in conjunction with TP
FY17	Quay	Ports of Auckland reinforcement	FY17	No change
FY17	Roskill	Reterminate 33kV cables	New	Project in conjunction with TP
FY17	Takanini South	Procurement of land for a zone substation	FY17	No change
FY17	Te Atatu	Upgrade 33/11kV transformers	FY17	No change
FY17	Waiwera	Zone substation land purchase	FY17	No change
FY18	Coatesville	Second 33/11kV transformer	FY18	No change
FY18	Ellerslie	Establish zone substation	FY18	No change
FY18	Greenhithe	Install Second transformer	FY18	No change
FY18	Highbury	Install second 33/11kV transformer	FY18	No change
FY18	Liverpool	Replace 110/22kV T3 transformer	FY14	Deferred
FY18	Oratia	11kV feeder to Piha from Oratia zone substation	FY18	No change
FY18	Sandspit	Establish zone substation	FY18	No change

Implementation Date	Substation	Project Description	Implementation Date from Previous AMP	Comments
FY19	Hobsonville Point	Establish zone substation	FY19	No change
FY19	Kaukapakapa	Establish zone substation	FY17	Deferred due to reduced load forecast
FY19	Mangere East	Rearrange 11kV feeders 13, 15 and 19	FY18	Deferred
FY19	Spur Rd	Second transformer	FY18	Deferred due to revised load forecast
FY19	Takapuna	New 11kV feeder (Taharoto)	FY19	No change
FY19	Takapuna	New 11kV feeder (Clifton)	FY19	No change
FY19	Takapuna	New 11kV feeder (Kitchener)	FY19	No change
FY19	Waimauku	Install 33kV line	FY19	No change
FY20	Takapuna	Install second transformer	FY18	Deferred to take place at the same time as 11kV reinforcement
FY20	Hobson West	Designate site	FY20	No change
FY20	Lincoln	Zone substation land purchase	FY20	No change
FY20	Mt Albert	Sub-transmission reinforcement	FY20	No change
FY20	Takanini	11kV Mill Road feeder from Takanini zone substation	FY17	Deferred
FY20	Te Papapa	11kV reinforcement	FY20	No change
FY21	Newmarket South	Establish Newmarket GXP	FY20	Delayed
FY21	Hobson & Quay	22kV feeders to Queens Wharf	FY21	No change
FY21	Hobson West	Establish zone substation	FY21	No change
FY21	Kumeu	Establish zone substation	FY21	No change
FY21	Woodford	Second 33/11kV transformer + 33kV reinforcement	FY21	No change
FY22	Victoria	Install 22kV switchboard	FY21	Deferred
FY22	Newmarket	11kV supply to ex-Lion Breweries site	FY21	Deferred - customer driven
FY22	Mangere West	Extend 11kV feeder two	FY14	Deferred
FY23	Albany	Establish zone substation	New	Previously deferred
FY23	Wainui	Establish zone substation	FY22	Deferred
FY23	Mangere Central	Mangere Central Install 3rd transformer	FY18	Deferred

Implementation Date	Substation	Project Description	Implementation Date from Previous AMP	Comments
FY23	Wiri West	Establish zone substation	FY20	Deferred
FY23	Manurewa	Feeder reinforcement	New	New project
FY23	Orewa	Install third 33kV circuit	New	New project
On-going	Hobson	Extend 22kV feeders to Tank Farm development	On-going	No change
On-going	Hobson, Liverpool, Quay, Victoria	Auckland CBD 11kV to 22kV load transfer	On-going	No change
On-going	Hobson, Liverpool, Quay, Victoria	Auckland CBD 22kV network extensions	On-going	No change
After FY23	Waitakere	Establish zone substation	FY15	Deferred due to revised load forecast
After FY23	Quay	Install a third 110/22kV Transformer	FY21	No change
After FY23	Southdown	Southdown: establish 33kV cable circuits to GXP to be established by Transpower	FY21	No change

Table 5-30 : Project programme for network development

5.14 Project Expenditure Forecast

The expenditure and timing forecasts for the major projects included in Vector's development programme are listed in Table 5-31.

Current	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Hobson - GXP Construction	$21.9m	$5.1m									
Hillsborough - Install 2nd 22kV Power Transformer & 2nd 22kV Cable	$4.5m	$1.4m									
Rosedale - Zone Substation Construction	$2.8m	$5.4m									
Brickworks - First 33/11kV transformer	$2.1m										
Northern R&D project	$2.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m
Southern R&D project	$2.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m
Avondale - Install 33kV SWBD	$2.0m										
Hobson - Install 3rd 110kV Power Transformer (T5)	$1.7m	$1.4m									
Various - CBD 22kV Rollout	$1.0m	$3.0m	$3.0m	$3.0m	$3.0m	$3.0m	$3.0m	$3.0m	$3.0m	$3.0m	$3.0m
Northern - LV reinforcement	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m
Southern - LV reinforcement	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m
Maraetai - MAR 9 11kV Reinforcement	$1.0m	$0.4m									
Mangere East - Customer capacity upgrade	$0.9m	$1.8m									
Newmarket - 11kV Reinforcement Broadway	$0.6m	$0.7m									
Hobson - 22kV cabling in Halsey St for Waterfront development	$0.5m	$0.5m									
Flatbush - Zone Substation Land Purchase	$0.5m										
Hobsonville Point - Land purchase	$0.5m										
Rosedale - Zone Substation Land Purchase	$0.5m										
Wiri West - Zone Substation Land Purchase	$0.5m										
Waterview - TP Roskill subtran re-termination	$0.5m										
Avondale - 11kV Reinforcement for Waterview	$0.5m										
Hobsonville - Clark Rd 11kV feeder extension	$0.4m	$1.1m									
Rosebank - 11kV Reinforcement	$0.4m	$0.3m	$0.4m	$3.8m	$0.3m						
Highbury - 11kV Reinforcement	$0.3m										

Current	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Chevalier - 11kV Reinforcement for Waterview	$0.3m										
Balmain - 11kV Reinforcement - Additional CB	$0.2m										
Northern - Various 11kV Capacitor Banks	$0.2m										
Waimauku - Install 2nd 33kV Power Transformer	$0.2m										
Warkworth - 11kV Reinforcement - Warkworth South Fdr	$0.2m										
Waterview - New Substation South Portal	$0.2m										
Keeling Rd - Install 2nd 33kV Power Transformer & 33kV Reinforcement	$0.1m	$2.4m									
Newmarket South - New Zone Substation	$0.1m	$0.4m	$5.6m	$5.6m							
Maraetai - 11kV Reinforcement	$0.1m										
Waterview - Zone Substation Construction North Portal permanent	$0.1m	$1.0m	$1.5m	$3.0m	$0.3m						
Various - Ducts: future-proofing ducts - Southern	$0.1m	$0.5m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	
Various - Ducts: future-proofing ducts - Northern	$0.1m	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m
Quay - 110kV cable Hobson - Quay and Relocate T3A	$0.1m		$0.5m	$3.3m							
Avondale - Avondale CB12 metering	$0.1m										
Hobson - 22kV feeder extension for the Tank Farm development	$0.1m										
Flatbush - New Zone Substation		$9.0m	$9.0m	$0.6m							
Birkdale - Substation Reconstruction		$3.3m									
Newmarket - Land purchase		$3.5m									
Te Atatu-Henderson-Westgate duct		$1.0m	$0.5m	$0.5m							
Balmoral - 11kV Reinforcement St Lukes		$1.0m									
Ngataringa Bay - Land Purchase		$1.0m									
Liverpool - Capacity upgrade for University Medical School		$0.9m	$0.9m								
Greenhithe - 33kV cable extension		$0.8m	$0.8m								
Red Beach - Install 2nd 33kV Power Transformer		$0.5m	$1.1m								
Westgate - Zone Substation Construction		$0.5m	$6.4m	$1.5m							
Liverpool - 2nd 22kV tie to Quay		$0.4m	$2.2m	$1.5m							
Various - Minor Fdr Reinforcements: Southern		$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	

Current	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Waterview - South Portal permanent supply			$0.4m								
Flatbush - 11kV Reinforcement		$0.4m	$0.3m	$0.3m	$0.3m						
Liverpool - Fire suppression in Penrose tunnel		$0.4m									
Matakana - Land purchase		$0.4m									
Te Atatu/Waterview - 33kV Reinforcement (ducts)		$0.3m	$0.5m	$0.2m							
Kingsland - Install NER		$0.3m									
Various - Minor Fdr Reinforcements: Northern		$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m
Quay - Reinstate 22kV oil filled cable for ripple signal		$0.3m									
Newmarket South - Designation & consenting		$0.2m									
Ngataringa Bay - Re-establish		$0.1m	$3.0m	$3.5m							
Ellerslie - Substation designation		$0.1m									
Quay - upgrade CTs in 22kV interconnectors 1 and 2		$0.1m									
Warkworth - 11kV Reinforcement - Matakana Fdr		$0.1m	$1.9m								
Henderson Valley - 11kV Indoor SWBD Replace and Switchroom Replacement			$1.2m								
Orewa - 11kV Reinforcement - Savoy Fdr			$0.5m								
Liverpool - 22kV Reinforcement Telecom Mayoral Dr			$0.4m	$0.4m							
Wainui - Zone Substation Land purchase			$0.4m								
Glenvar - New Zone Substation			$0.4m	$1.6m	$4.8m						
Warkworth - 11kV Reinforcement - Whangateau Fdr			$0.1m	$1.2m							
Warkworth South - Zone Substation Construction			$0.1m	$0.9m	$3.6m						
Brickworks - Second 33/11kV transformer				$3.0m							
Quay - Customer capacity upgrade Ports of Auckland				$1.2m	$1.2m						
Waiheke - 11kV Reinforcement				$0.8m							
Rockfield - NZ Technology Park Supply				$0.6m							
Kumeu - Land purchase				$0.5m							
Ellerslie - New Zone Substation				$0.4m	$4.9m	$4.9m					
Liverpool - establish additional 110kV bus				$0.3m	$5.0m						

Current	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Te Atatu - New 33/11kV transformers				$0.2m	$2.0m						
Sandspit - Zone Substation Construction				$0.2m	$1.9m	$4.2m					
Quay - Extend 22kV switchboard				$0.1m	$1.6m						
Atkinson Rd - New 11kV Fdr, redistribute Kaurilands Fdr					$0.8m						
Highbury - Install 2nd 33kV Power Transformer					$0.5m	$3.5m					
Takanini South - Zone Substation Land Purchase					$0.5m						
Waiwera - Zone Substation Land purchase					$0.3m						
Oratia - 11kV Reinforcement					$0.3m	$2.5m					
Liverpool - New 110/22kV transformer					$0.2m	$2.9m					
Kaukapakapa - New Zone Substation					$0.2m	$3.9m	$2.0m				
Hobsonville Point - New Zone Substation					$0.2m	$2.8m	$3.0m				
Greenhithe - Second 33/11kV transformer					$0.1m	$2.1m					
Coatesville - Second 33/11kV transformer					$0.1m	$1.5m					
Hobson - 22kV ducts in Madden St for Waterfront development						$0.3m	$0.3m				
Waimauku - 33kV Reinforcement						$0.3m	$3.7m				
Mt Albert - Subtransmission Reinforcement						$0.1m	$1.9m	$1.9m			
Spur Rd - Install 2nd 33kV Power Transformer						$0.1m	$2.0m				
Takapuna - 11kV Reinforcement - Clifton Fdr						$0.1m	$0.9m				
Takapuna - 11kV Reinforcement - Kitchener Fdr						$0.1m	$0.9m				
Takapuna - 11kV Reinforcement - Taharoto Fdr						$0.1m	$0.9m				
Te Papapa - 11kV Reinforcement						$0.1m	$0.8m	$0.8m			
Newmarket South - Establish new GXP							$0.5m	$4.5m	$9.0m		
Takapuna - Install 2nd 33kV Power Transformer							$0.2m	$6.6m			
Mangere East - 11kV Reinforcement							$0.2m				
Woodford - Install 2nd 33kV Power Transformer & 33kV Reinforcement							$0.2m	$1.9m	$3.2m		
Takanini - 11kV Reinforcement							$0.1m	$1.2m			
Newmarket - ex Lion Breweries site								$0.8m	$0.8m	$0.8m	

Current	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Lincoln - Land purchase								$0.8m			
Hobson - 22kV Reinforcement Queens Wharf								$0.7m	$0.7m	$0.7m	
Hobson - 22kV cabling in Madden St for Waterfront development								$0.5m			
Kumeu - New Zone Substation								$0.5m	$5.6m		
Southdown - Establish 33kV circuits								$0.2m	$2.3m		
Hobson - 3rd 22kV new feeder to supply Waterfront development									$0.8m	$0.8m	
Victoria - Establish 22kV switchboard									$0.2m	$4.1m	
Albany - New Zone Substation									$0.2m	$3.5m	$2.0m
Orewa - Third 33kV circuit										$3.0m	$3.0m
Wainui - Zone Substation Construction										$3.0m	$3.0m
Wiri West - Zone Substation Construction										$1.2m	$7.2m
Mangere West - 11kV Reinforcement										$0.6m	
Manurewa - 11kV Reinforcement										$0.4m	$1.0m
Mangere Central - Third 33/11kV transformer										$0.2m	$1.2m
Te Atatu South - substation construction											$6.0m

Table 5-31 : Timing and estimated cost of major growth projects until 2023

Electricity
Asset Management Plan
2013 – 2023

Asset Maintenance, Renewal and Refurbishment Planning – Section 6

[Disclosure AMP]

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6. Asset Maintenance, Renewal and Refurbishment Planning

6.1 Overview

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.

In this context, Vector's electricity distribution network is designed and built to deliver electricity to the service level set out in the Vector Electricity Network Security Standards[1], as reflected in the connection agreements with its customers[2].

To achieve the required network performance efficiently, the condition of individual assets must be maintained in a serviceable operating state over the period of its useful life.

To deliver on this Vector implements extensive routine and operational preventive activities covering asset inspections, maintenance servicing, and condition testing. These preventive tasks uncover non-compliant or serviceability defects which are then treated as a corrective maintenance action or an asset renewal action depending on the extent and risk with regard to performance and safety.

Vector's long-term asset management strategy is to maintain a safe, efficient and reliable network, adhering to optimum life cycle investment. The optimal life cycle investment considers the balance between asset renewal requiring capital expenditure and the combination of reactive, preventive and corrective operational expenditure.

6.1.1 Vector's Asset Maintenance Approach

Vector has a comprehensive suite of in-house developed maintenance standards that define asset inspections, condition testing and associated maintenance tasks by primary asset category.

In general, Vector's philosophy is to keep its assets in use for as long as they can be operated safely, technically and economically. The maintenance standards support this goal to ensure optimal performance.

Each maintenance standard addresses the purpose, content, frequency, record requirements and associated treatment criteria. The treatment criteria and resulting actions generally direct field staff, to repair, refurbish or replace components, replace entire asset, and for some assets refurbish entire asset off-site or refurbish oil in-situ.

The identification of serviceability or non-compliant defects and the corresponding treatment criteria consider generic performance and safety consequences however treatment timeframes are strongly driven by hazard likelihood. The applied maintenance approach is mature and has developed from a pure condition-based maintenance strategy to incorporate risk elements; however the adoption of a more formal condition-based risk management (CBRM) framework is being implemented[3].

Assets that have low impact on network performance, such as pole fuses supplying individual dwellings, are allowed to run to failure, as the cost of systematically identifying defects to avoid such failures far outweighs the benefits.

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[1] The Electricity Network Security Standards are discussed in more detail in Section 5 of the AMP.

[2] Security levels higher than that described in the standards may be available to consumers, in which case dedicated commercial arrangement will be entered into.

[3] The enhanced condition-based risk management (CBRM) framework is discussed in more detail in Section 6.1.3.

6.1.2 Vector's Asset Renewal Approach

The approach to standalone asset renewal is condition-based. The age of the asset may be reflected through the condition along with other factors, eg. environment, loading, fault duty, maintenance history, etc. Age is not a direct driver of Vector's asset renewal.

In dealing with distribution assets, where Vector has large populations of low cost assets and associated components, the optimal investment options to repair, replace or refurbish are relatively limited and are readily evaluated.

For the more critical distribution and sub-transmission assets where replacement costs are typically high, the optimal investment options to repair, replace or refurbish will require more complex multi-criteria evaluation and business case justification. Factors that may be considered include:

- Maintenance costs over the remaining life of the asset will exceed that of replacement;
- The asset has become obsolete, component fabrication is expensive, the asset may be the last of its kind and inefficient to continue operation and maintain;
- Low cost retrofit replacements are available with enhanced ratings and safety features; and
- Associated risk and asset performance history.

Economic asset refurbishment is generally restricted to sub-transmission transformers and certain size of distribution transformers. This is an efficient way of extending asset life.

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 performance based on historical fault records and reactive maintenance notifications.

At a portfolio level the identified renewal asset is subject to relative ranking via Vector's prioritisation methodology, refer Table 9-1. The applied prioritisation methodology rates the primary driver for the project to the relative importance of the asset, by consequence and likelihood of event.

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.

As previously indicated the field execution and corresponding field data capture relating to asset inspections, condition testing and associated maintenance tasks is essential for accurate assessment and identification of assets that require repair or replacement.

Field data capture and associated system updates and record collection is carried out by Vector's field service providers. In the past field captured data was recorded on paper-based records. 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 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 field service providers. The activities associated with inspections, tests, and preventive and routine maintenance are being captured in a consistent electronic format and provided to Vector. Test measurements are documented in templates.

Analysis of this maintenance/performance data and test measurements enhanced Vector's understanding of asset condition and capability. This, combined with a condition based risk management framework, gives maintenance staff better information to prioritise replacement/renewal investment and trade-off against corrective maintenance programmes.

6.1.3 Enhanced Condition-Based Risk Management Framework

Vector is continually monitoring developments in asset maintenance. Based on Vector's surveys and advice from experts, Vector has identified the substantial benefits that leading international utilities are achieving though adopting a Condition Based Risk Management (CBRM) framework for the renewal and maintenance of their electricity network assets. As part of its ongoing improvement programme, Vector is adopting this approach for future prioritisation of its renewal and maintenance activities.

Elements of a CBRM approach have been in place at Vector for a long time. Recently several steps were taken to introduce a fully fledged CBRM framework. The initial stages of the programme focused on overhead line assets. The purpose of the framework is to:

- Systematically collect and store information about the condition and performance of all major assets on the network and capture this information in an electronic database forming part of Vector's SAP planned maintenance system. Besides information collected during scheduled inspection and maintenance activities, it will also include asset information collected during outages (and subsequent repairs) as well as ad hoc information collected during non-routine field visits;
- Implement a condition-assessment framework that will assign a condition-value to all assets, based on the information collected from the field, test results or other information obtained. In the case of assets for which condition cannot be easily observed (eg. underground assets), condition assessments will be guided by asset performance data collected on the Vector network (failure and reliability data). Known information about similar assets of similar age elsewhere on the network or by other utilities is used as reference for condition assessment along with results from periodic testing and inspections[4]. The condition-based information will increasingly form the basis for assessing the likelihood of the failure of all major network assets; and

[4] When assets are uncovered, whether due to a fault or due to proximity to other assets requiring attention, Vector will use the opportunity to conduct condition inspections or tests.

- Implement a criticality-assessment framework that rates the importance of all assets in terms of the potential impact failure or mal-function of the asset would have on public and operator safety, on network reliability and on operational effectiveness. The criticality assessment takes into account factors such as asset location (geo-spatial analysis), network capacity impacted by failure of the asset and the likely customer impact as a result of the failure of the asset. The criticality information forms the basis for assessing the impact that the failure of an asset will have.

By combining the information about the likelihood and impact of an asset failure, the network-risk associated with the asset can be derived. Vector will eventually maintain this asset risk information for all major assets on its network, using it for enhanced prioritisation of asset replacement and corrective maintenance work.

Collecting asset-related data in the manner described above will also allow Vector to in future accurately assess the health of individual assets on an ongoing basis. By combining the information per asset category or for all assets, the asset-health per category or for the network as a whole, could also be derived. These asset health figures will be continually updated as more or updated information from the field becomes available. By tracking this information over time and assessing this in conjunction with network reliability performance, the effectiveness of Vector's renewal and maintenance investment can be continually assessed and optimised.

Work on developing a CBRM framework for Vector's electricity assets commenced during FY11, focusing on overhead line assets. It is intended to commence with a full implementation of the CBRM framework for all major assets on overhead assets by the end FY13.

6.2 Maintenance Planning Processes, Policies and Criteria

This section presents the planning processes, policies and criteria for managing Vector's network assets. The combination of processes, policies and criteria align with Vector's strategic drivers. The strategic drivers and how they translate into long-term asset management, maintenance and asset renewal approaches are presented as follows:

Operational Excellence

- Continue maintaining the electricity distribution network assets to ensure they 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.

6.2.1 Asset Maintenance Standards and Schedules

As referred to in the previous AMP sections, 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 Investment (AI) asset specialists. The execution and delivery of the standards and the resulting corrective maintenance and asset replacement works are managed by Vector's Service Delivery (SD) group. All field work including inspections, testing, maintenance, replacement work, system updates and data capture are carried out by Vector's field service providers.

Vector has comprehensive standards for each major class of assets, prescribing preventive maintenance requirements and how to treat defects identified either through corrective maintenance or asset renewal processes. The purpose of these standards, in conjunction with the schedules of maintenance work, is to ensure assets operate safely, achieve their design life and deliver the required level of performance.

As part of the asset maintenance standards the frequency of inspection and reporting per asset category has also been defined. This forms the basis of Vector's asset maintenance schedule.

Vector's maintenance standards are kept on Vector's secure websites and are accessible by staff engaged in maintenance activities, as well as to Vector's FSPs. The FSPs must comply with the standards and inspection schedules for each class of assets.

The standards are updated on an "as-you-go basis". Any new findings or updates are incorporated in Vector's standards as soon as they are reviewed by the asset management team and signed off. Vector's FSPs contribute to, and form an integral part of, this continual improvement process.

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. Asset renewal proposals are then reviewed by Vector prior to issuing orders for the work. Maintenance priorities are based on costs, risks and safety criteria. In future, as the CBRM system is progressively rolled out, Vector will increasingly prioritise remedial works in-house.

In making decisions on repairing or replacing the assets, Vector will consider recommendations submitted by the FSPs, as well as the factors discussed above. The long-term plans supported by trend analysis for an asset will also be taken into account when assessing whether it should be maintained or replaced.

Vector also undertakes clustering of the projects where they are part of the replacement programme or growth programme of works. If, for example, during inspection or maintenance work, it is found that a large number of defects occur within a specific geographic area, and within that area a coincident growth or overhead improvement project is planned within the next two years, consideration will be given to resolve proximity defects as a combined project. Likewise, if new assets are planned to be constructed in a specific area, replacement and/or maintenance work may be deferred for up to two years, if deemed safe. In coordinating such projects long-term savings are achieved due to the economy of scale of projects and potential reduction in establishment and re-establishment costs. Moreover, disruptions to customers and the wider public are minimised.

Root cause analysis is normally undertaken as a result of faulty equipment. If this identifies systemic faults or performance issues with a particular type of asset, and if the risk exposure warrants it, a project will be initiated to carry out the appropriate remedial actions on a class of assets. The assets and maintenance standards are also amended to reflect the learning from such root cause analysis.

6.2.2 Maintenance Categories

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 yearly inspections of the overhead sub-transmission network, three-yearly cyclical inspections of the overhead distribution network, 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 all rubbish and 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.

6.2.3 Asset Maintenance and Field Services Provider Management Process

Vector has, through a competitive process, engaged two independent 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.

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

Both service providers are performance managed by Vector's Service Delivery (SD) group. The maintenance contract defines the responsibilities, obligations and Key Performance Indicators (KPIs) to complete scheduled works. Vector's AI group works closely with the SD group to keep abreast of any issues with regard to the contractors' obligations and performance. The maintenance standards form part of the maintenance contract and contractors must comply with them when performing their duties. Figure 6-1 below describes the flow of work and responsibilities in maintaining Vector's assets.

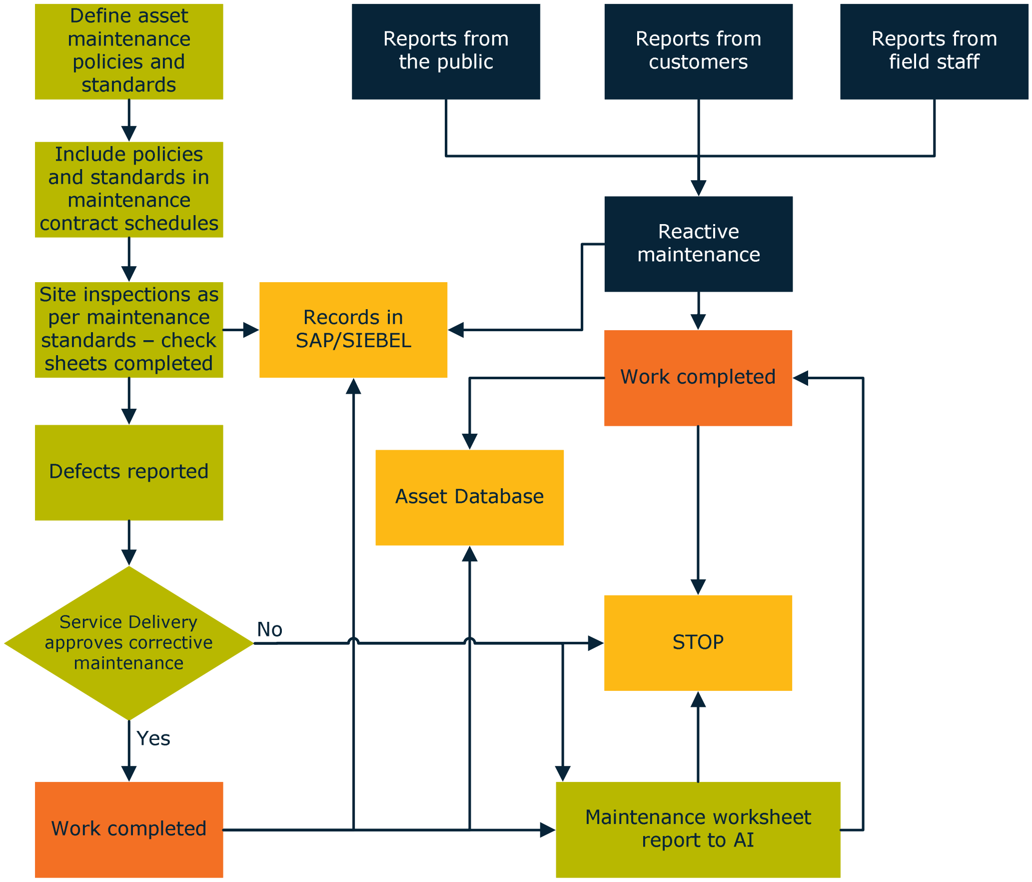

Figure 6-1 : Asset maintenance processes

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 SD, 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.

6.2.4 Forecast Maintenance Expenditures

Vector direct operational expenditure is a combination of the following internal cost elements:

Core Maintenance

- Encapsulates all service provider reactive, planned and corrective maintenance activities, and services associated with the northern and southern network areas. It also includes servicing of the mobile generation units.

Inventory Related Costs

- Management of strategic spares, storage, transformer and switchgear refurbishment and storage.

Vegetation Maintenance

- All reactive, planned and corrective actions associated with distribution assets including substation grounds management, notifications and recovery associated with vegetation management services.

Non-core Maintenance

- Contains maintenance activities relating to exceptional and extreme network events, specialist contractor or extraordinary maintenance activities over and above that provisioned through core maintenance services. This also includes all reactive, planned and corrective work associated with the Penrose-Hobson tunnel and associated services.

Miscellaneous Maintenance

- All reactive, planned and corrective activities and services related to the Lichfield network, check metering support and maintenance, road opening notice fees and building warrant of fitness fees associated with the northern and southern networks.

Maintenance Recoveries

- Cost recovery associated with reactive third party damage activity and capex balancing entry due to the internal capitalisation of assets replaced as the result of faults.

Value Added Maintenance

- Issuing maps and site plans; asset location services, including the marking out of assets, safe work practice site briefings, worksite observer, urgent safety checks, safety disconnections, 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.

For the purpose of information disclosure reporting however, the Electricity Distribution Information Disclosure Determination 2012 has prescribed the reporting of operational expenditure into the following categories:

Asset Replacement and Renewal

- Where the primary driver is the need to maintain network asset integrity so as to maintain current security and/or quality of supply standards and includes expenditure to replace or renew assets incurred as a result of:
  - The progressive physical deterioration of the condition of network assets or their immediate surrounds;
  - The obsolescence of network assets;

- Preventative replacement programmes, consistent with asset life-cycle management policies; and
- The need to ensure the ongoing physical security of the network assets.

Routine and Corrective Maintenance and Inspection

- In relation to expenditure, means operational expenditure where the primary driver is the activities specified in planned or programmed inspection, testing and maintenance work schedules and includes:
- Fault rectification work that is undertaken at a time or date subsequent to any initial fault response and restoration activities;
- Routine inspection;
- Functional and intrusive testing of assets, plant and equipment including critical spares and equipment;
- Helicopter, vehicle and foot patrols, including negotiation of landowner access;
- Asset surveys;
- Environmental response;
- Painting of network assets;
- Outdoor and indoor maintenance of substations, including weed and vegetation clearance, lawn mowing and fencing;
- Maintenance of access tracks, including associated security structures and weed and vegetation clearance;
- Customer-driven maintenance; and
- Notices issued.

Service Interruptions and Emergencies

- In relation to expenditure, means operational expenditure where the primary driver is an unplanned instantaneous event or incident that impairs the normal operation of network assets. This relates to reactive work (either temporary or permanent) undertaken in the immediate or short term in response to an unplanned event. Includes back-up assistance required to restore supply, repair leaks or make safe. It also includes operational support such as mobile generation used during the outage or emergency response. It also includes any necessary response to events arising in the transmission system. It does not include expenditure on activities performed proactively to mitigate the impact such an event would have should it occur; and
- Planned follow-up activities, resulting from an event, which were unable to be permanently repaired in the short term are to be included under routine and corrective maintenance and inspection.

Vegetation Management

- In relation to expenditure, means operational expenditure where the primary driver is the need to physically fell, remove or trim vegetation (including root management) that is in the proximity of overhead lines or cables. It includes expenditure arising from the following activities:
    - Inspection of affected lines and cables where the inspection is substantially or wholly directed to vegetation management (eg. as part

of a vegetation management contract). Includes pre-trim inspections as well as inspections of vegetation cut for the primary purpose of ensuring the work has been undertaken in an appropriate manner;

- Liaison with landowners, including the issue of trim/cut notices and follow up calls on notices; and
- The felling or trimming of vegetation to meet externally imposed requirements or internal policy, including operational support such as any mobile generation used during the activity.

- The following activities and related costs are excluded from this category:
  - General inspection costs of assets subject to vegetation where this is not substantially directed to vegetation management (include in routine and corrective maintenance and inspection);
  - Costs of assessing and reviewing the vegetation management policy (include in network support);
  - Data collection relating to vegetation (include in network support);
  - The cost of managing a vegetation management contract, except as stated above (include in network support); and
  - Emergency work (include in service interruptions and emergencies).

For information disclosure reporting purposes, Vectors' internal cost elements are mapped to the information disclosure (ID) categories as follows:

ID Category - Asset Replacement and Renewal

- Vector Category – Corrective maintenance

ID Category - Routine and Corrective Maintenance and Inspection

- Vector Category - Preventive maintenance
- Vector Category – Third party project coordination
- Vector Category - Lichfield maintenance
- Vector Category - Asset dismantling and removal
- Vector Category - Building warrant of fitness
- Vector Category - CBD tunnel maintenance
- Vector Category - Grounds and buildings vegetation maintenance

ID Category - Service Interruptions and Emergencies

- Vector Category - Exceptional reactive maintenance
- Vector Category - Reactive maintenance
- Vector Category - Capitalised reactive balancing
- Vector Category - External contractor reactive maintenance
- Vector Category - Third party reactive recovery

ID Category - Vegetation Management

- Vector Category - Programmed tree trimming

The direct maintenance expenditure forecasts for the AMP planning period are presented in Table 6-1 below. These forecasts are still subject to ongoing performance measurement and analysis and board approval. All forecasts are expressed in real 2014 dollars. As required by the Electricity Distribution Information Disclosure Determination 2012 the system operations and network support expenditure category contains a mix of both direct and indirect maintenance costs. The direct component of this category of expenditure forecast is included in Table 6-1. The total system operations and network support costs (direct and indirect) are disclosed in Appendix 2 (Schedule 11b) of this AMP.

Budget and Expenditure Forecast (FY)	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Asset Replacement & Renewal	$10.5 m	$11.5 m	$11.5 m	$11.5 m	$11.1 m	$11.2 m	$11.3 m	$11.4 m	$11.5 m	$11.7 m	$11.8 m
Routine & Corrective Maintenance & Inspection	$11.4 m	$12.5 m	$11.6 m	$11.7 m	$11.8 m	$11.9 m	$12.1 m	$12.2 m	$12.4 m	$12.7 m	$12.9 m
Service Interruptions & Emergencies	$6.6 m	$7.1 m	$7.1 m	$7.0 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m
System Operations & Network Support	$10.7 m	$11.1 m	$11.4 m	$11.4 m	$11.4 m	$11.4 m	$11.0 m	$11.0 m	$11.0 m	$11.0 m	$11.0 m
Vegetation Management	$4.2 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m
Direct Operational Expenditure Subtotal	**$43.4 m**	**$46.9 m**	**$46.2 m**	**$46.3 m**	**$46.0 m**	**$46.2 m**	**$46.2 m**	**$46.5 m**	**$46.8 m**	**$47.2 m**	**$47.6 m**

Table 6-1 : Total direct operating expenditure forecast

The direct maintenance forecasts for each expenditure category are further disaggregated by asset category in the Table 6-2 to Table 6-4.

Asset Replacement & Renewal	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Sub-Transmission	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m
Zone Substations	$2.4 m	$2.7 m	$2.7 m	$2.7 m	$2.6 m	$2.6 m	$2.6 m	$2.7 m	$2.7 m	$2.7 m	$2.8 m
Distribution and LV Lines	$1.6 m	$1.8 m	$1.8 m	$1.8 m	$1.7 m	$1.7 m	$1.7 m	$1.7 m	$1.8 m	$1.8 m	$1.8 m
Distribution and LV Cables	$1.1 m	$1.2 m	$1.2 m	$1.2 m	$1.1 m	$1.1 m	$1.1 m	$1.2 m	$1.2 m	$1.2 m	$1.2 m
Distribution Substations and Transformers	$1.8 m	$2.0 m	$2.0 m	$2.0 m	$1.9 m	$2.0 m	$2.0 m	$2.0 m	$2.0 m	$2.0 m	$2.1 m
Distribution Switchgear	$3.4 m	$3.7 m	$3.7 m	$3.7 m	$3.6 m	$3.6 m	$3.6 m	$3.7 m	$3.7 m	$3.8 m	$3.8 m
Other Network Assets	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m
Direct Operational Expenditure Subtotal	**$10.5 m**	**$11.5 m**	**$11.5 m**	**$11.5 m**	**$11.1 m**	**$11.2 m**	**$11.3 m**	**$11.4 m**	**$11.5 m**	**$11.7 m**	**$11.8 m**

Table 6-2 : Asset replacement and renewal operating expenditure by asset category

Routine & Corrective Maintenance & Inspection	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Sub-Transmission	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m
Zone Substations	$1.5 m	$1.6 m	$1.5 m	$1.5 m	$1.5 m	$1.5 m	$1.5 m	$1.6 m	$1.6 m	$1.6 m	$1.7 m
Distribution and LV Lines	$3.9 m	$4.2 m	$3.9 m	$4.0 m	$4.0 m	$4.0 m	$4.1 m	$4.2 m	$4.2 m	$4.3 m	$4.4 m
Distribution and LV Cables	$2.5 m	$2.8 m	$2.6 m	$2.6 m	$2.6 m	$2.6 m	$2.7 m	$2.7 m	$2.7 m	$2.8 m	$2.9 m
Distribution Substations and Transformers	$1.0 m	$1.0 m	$1.0 m	$1.0 m	$1.0 m	$1.0 m	$1.0 m	$1.0 m	$1.0 m	$1.1 m	$1.1 m
Distribution Switchgear	$2.1 m	$2.3 m	$2.1 m	$2.1 m	$2.2 m	$2.2 m	$2.2 m	$2.3 m	$2.3 m	$2.3 m	$2.4 m
Other Network Assets	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m
Direct Operational Expenditure Subtotal	**$11.4 m**	**$12.5 m**	**$11.6 m**	**$11.7 m**	**$11.8 m**	**$11.9 m**	**$12.1 m**	**$12.2 m**	**$12.4 m**	**$12.7 m**	**$12.9 m**

Table 6-3 : Routine and corrective maintenance and inspection operating expenditure by asset category

Service Interruptions & Emergencies	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Sub-Transmission	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m
Zone Substations	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m	$0.1 m
Distribution and LV Lines	$2.6 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m	$2.7 m
Distribution and LV Cables	$2.8 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m	$3.0 m
Distribution Substations and Transformers	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m	$0.3 m
Distribution Switchgear	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m	$0.5 m
Other Network Assets	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m	$0.0 m
Direct Operational Expenditure Subtotal	**$6.6 m**	**$7.1 m**	**$7.1 m**	**$7.0 m**	**$7.1 m**	**$7.1 m**	**$7.1 m**	**$7.1 m**	**$7.1 m**	**$7.1 m**	**$7.1 m**

Table 6-4 : Service interruptions and emergencies operating expenditure by asset category

6.3 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.

6.3.1 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.

Table 6-5 below provides the sub-transmission cable length broken down by network area and operating voltages. Note that the cable lengths provided exclude overhead termination riser lengths.

Cable Length	110kV	33kV	22kV	Total km
Southern	47 km	262 km	129 km	438 km
Northern	0 km	141 km	0 km	141 km
Total	47 km	404 km	129 km	580 km

Table 6-5 : Sub-Transmission cable length

Cable technology has changed over time, and accordingly Vector's adoption and implementation over time reflects this:

- PILC gas filled cable: The conductor core is insulated within oil-impregnated paper; this paper is surrounded by pressurised gas (nitrogen), held inside a lead sheath, by length 1% of system length;
- PILC oil filled cable: The conductor core is insulated within oil-impregnated paper; this paper is bathed in pressurised oil, provided via oil ducts embedded within the paper insulation, held together inside a corrugated aluminium (PICAS) or lead sheath, by length 30% of system length;
- PILC cable: The conductor core is insulated within oil-impregnated paper, held inside a lead sheath, by length 13% of system length; and
- Cross-linked polyethylene (XLPE) cable: The conductor core is insulated with solid cross-linked polyethylene plastic, held inside a polyvinyl chloride (PVC) or high density polyethylene (HDPE) sheath, by length 56% of system length.

The age profiles of different types of sub-transmission cables by network area are given in Figure 6-2 and Figure 6-3 below.

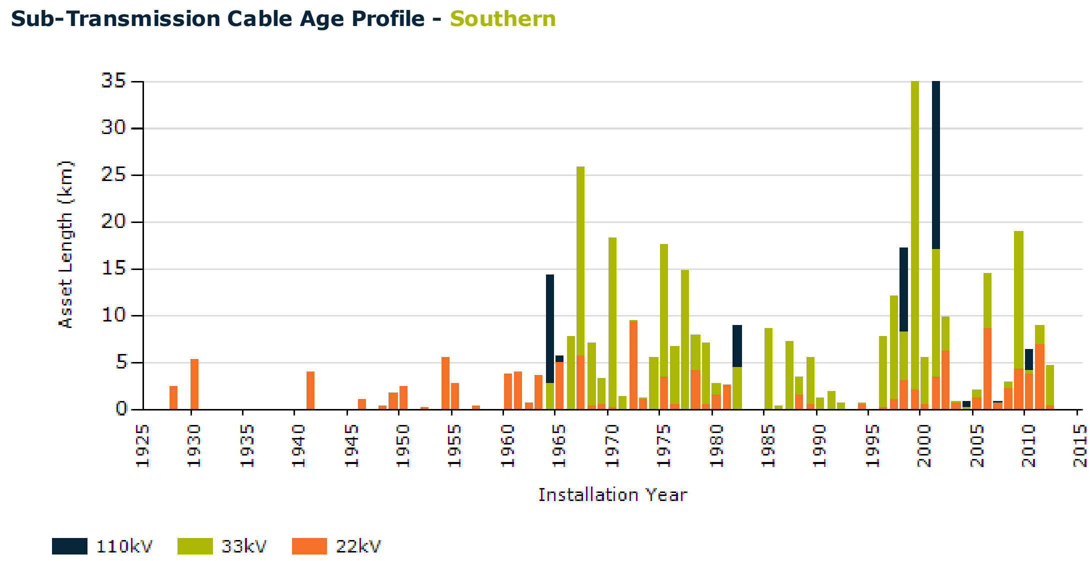

Figure 6-2 : Sub-transmission cable age profile - Southern

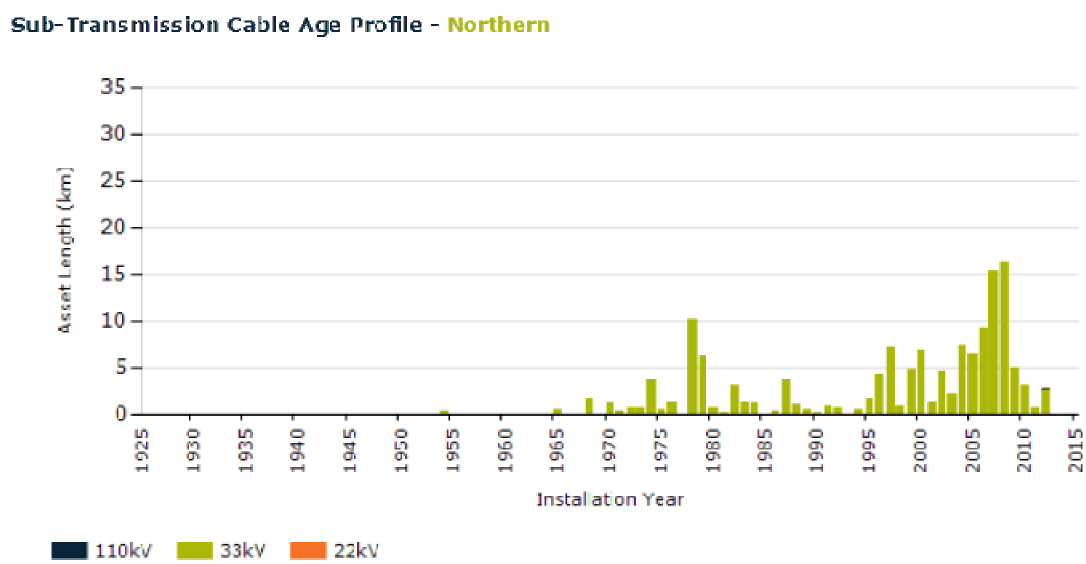

Figure 6-3 : Sub-transmission cable age profile - Northern

6.3.1.1 Routine Asset Inspections, Maintenance and Testing

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.

6.3.1.2 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. These cables are likely to be replaced over the next ten years. Others will be replaced as their failure rate increases or as part of a network redevelopment programme.

Oil Filled PILC Cables

There is approx 170km 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.

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. In particular the 33kV cables between Takanini GXP and Maraetai zone substation have been subjected to a number of faults in the past. These cables are planned to be replaced during FY14-FY15.

Further cable operating (including joints, faults, leaks, etc) information is being compiled for these cables. If for any reason a joint location is being exposed (eg. road realignment), an x-ray test will be performed on the joint 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 6-4 below shows the sub-transmission cable fluid consumption over the past eight years.

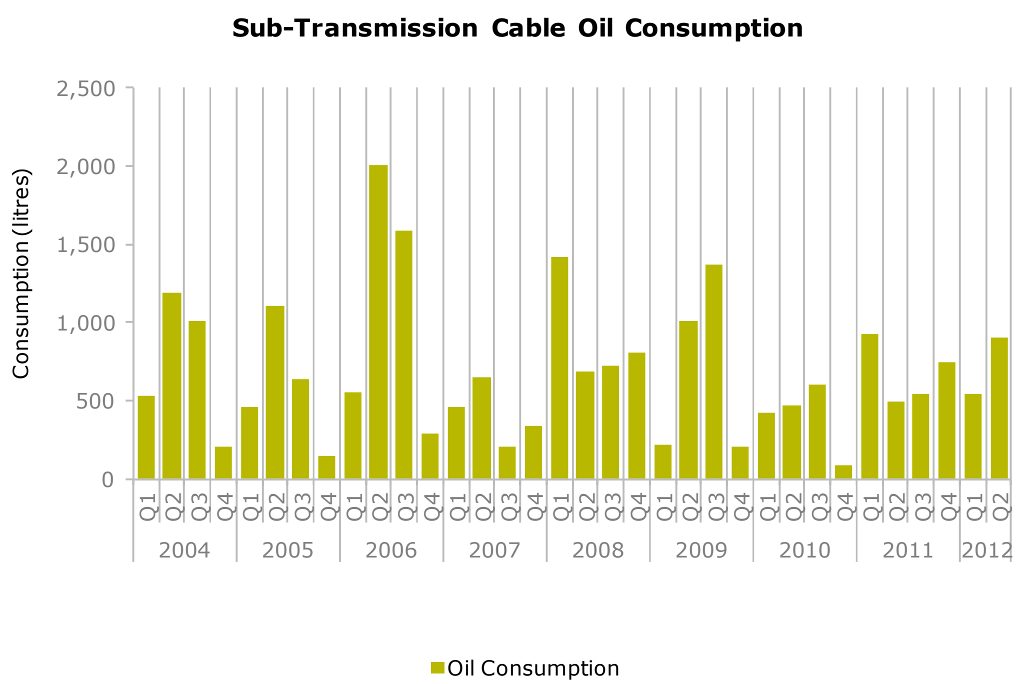

Figure 6-4 : Sub-transmission cable fluid consumption

XLPE Cables

There is approximately 320km 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 are in good condition and will only be replaced when condition deteriorates.

6.3.1.3 Replacement Programme

The following flow charts in Figure 6-5 to Figure 6-7 describe a simplified version of the replacement criteria and process for each type of cable:

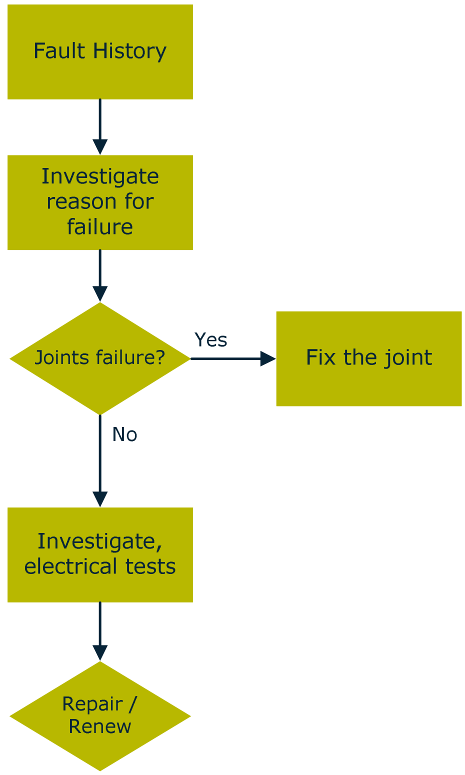

Figure 6-5 : Sub-transmission cables - Paper insulated lead sheathed

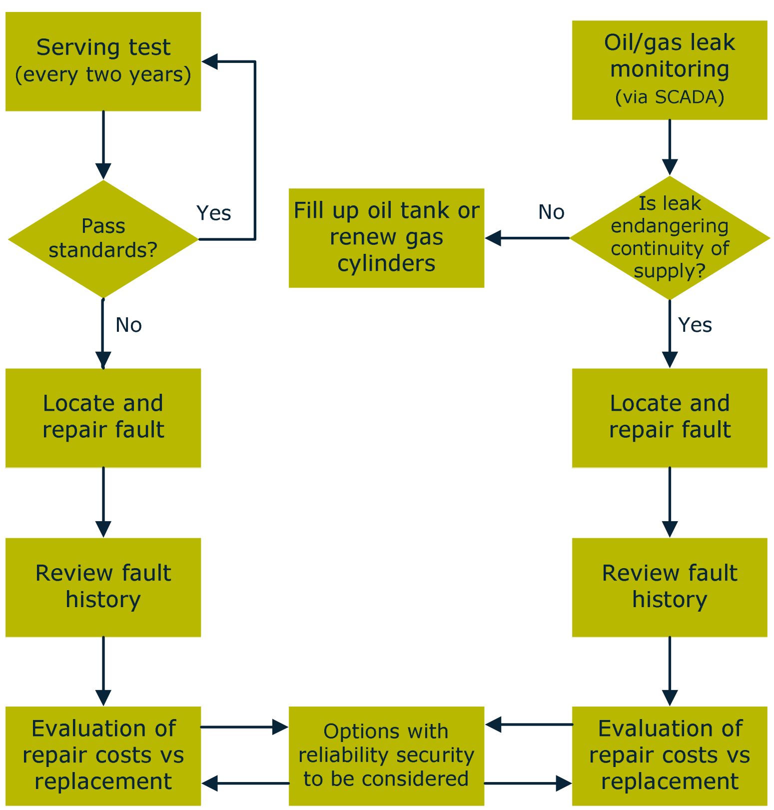

Figure 6-6 : Sub-transmission cables - Oil filled or gas filled

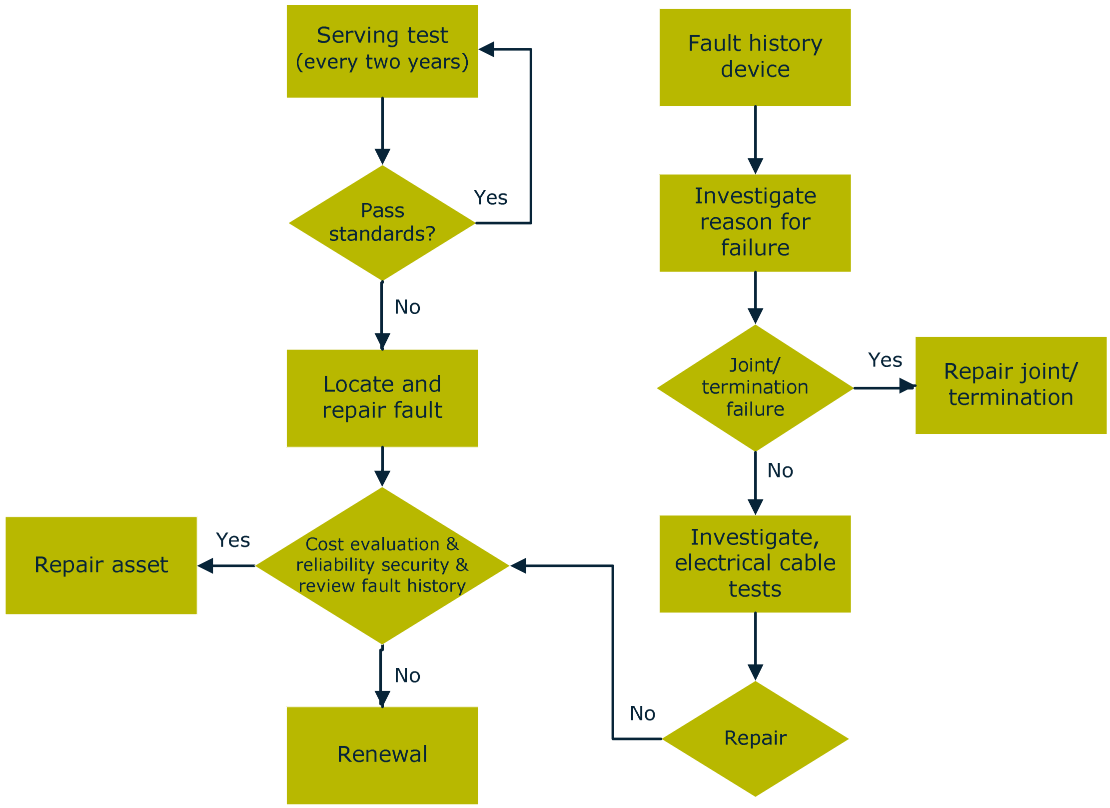

Figure 6-7 : Sub-transmission cables - XLPE

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.

Replacing these circuits represents a significant investment, however keeping them in operation would pose an unacceptable level of risk to the network.[5] The increasing cost of maintenance and operation of keeping these cables is also another factor for replacing them.

A summary of these planned sub-transmission cable replacement projects is presented in Table 6-6 below, with the final timing and priority still subject to ongoing performance measurement and analysis (and approved business cases).

Project Description	Project Unit	Project Year	Project Estimate
Maraetai - 33kV Subt Cable Replace	5.0km	2014/15	$5.9 million
Parnell - 22kV Subt Cable Replace	1.8km	2015/16	$4.0 million
Ponsonby - 22kV Subt Cable Replace	2.5km	2016/17	$5.0 million
Chevalier - 22kV Subt Cable Replace	3.4km	2017/18	$6.0 million

[5] The requirement for replacing the old 22 kV sub-transmission cables was also identified by Siemens GmbH in an assessment carried out in 2009 on the robustness of asset management at Vector.

Project Description	Project Unit	Project Year	Project Estimate
Liverpool - 22kV Subt Cable Replace	2.0km	2018/19	$4.0 million

Table 6-6 : Planned sub-transmission cable replacement projects

An annual provisional allowance of $5.0 million has been made in the 10-year capital expenditure forecast from FY19 onwards in anticipation of replacing older PILC sub-transmission cables, approaching the end of their useful life at that stage. More accurate cost estimates for this replacement work will be prepared closer to the time.

The requirement for replacing each of the sub-transmission cables (as described below) is based on analysis of the condition and fault data currently available. This analysis is further 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.

Maraetai 33kV Sub-transmission Cable Replacement

- This circuit (commissioned in the late 1970's) is the last remaining fluid-filled cable at Takanini. Due to its configuration this cable is subject to the impact of continual faults on the overhead line (such as lightning strikes) to which it is joined. In addition, because of the peat ground it is buried in, the joints are subject to excessive movement which is problematic for a fluid filled cable. This has already resulted in faulted sections of cable being replaced with overhead line and the replacement and reinforcement of many of the joints. Further faults occur on an ongoing basis and the only economically feasible means of addressing this, and to ensure the reliability of supply, is to replace the cable.

Parnell 22kV Sub-transmission Cable Replacement

- Major sections of these old PILC circuits were laid in 1927. Over the years the cables have not performed very well, but sections of the circuits have over time been replaced (due to road realignment requirements, etc) and as a result the failure rate has dropped off. However, the remaining old sections of cable are now well beyond their reasonable life expectancy and, based on historical experience, could fail at any time and would be uneconomic to repair. These cables are also under rated for the proposed new replacement transformers at Parnell zone substation.

Ponsonby 22kV Sub-transmission Cable Replacement

- These circuits consist of one GF (gas filled) 22kV cable installed in 1965 which is one of two remaining gas-filled cables left on the Auckland network. This type of cable technology has gradually been replaced because of the ongoing maintenance issues of leak location and prevention. The other circuit comprises 2x PILC cables installed in 1949-50 and run in parallel. Both cables are under rated for existing capacity at this zone substation.

Chevalier 22kV Sub-transmission Cable Replacement

- This circuit comprises two parallel connected PILC cables installed in 1930. They have been the subject of many failures over the years and are now under rated for the new transformers being installed at this zone substation.

Liverpool 22kV Sub-transmission Cable Replacement

- This project will replace the Liverpool to Quay zone substation gas-filled circuit. Given the ongoing 110kV and 22kV reinforcement programme in the CBD, this cable may be required for the medium term. A final decision will be made closer to the time.

6.3.2 Sub-Transmission 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 sub-transmission voltage 110kV down to medium voltage distribution 11kV.

Vector owns 205 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.

Table 6-7 shows the current number of power transformers on the networks, categorised by supply side operating voltage.

Population	110kV	33kV	22kV	Total
Southern	15	75	37	127
Northern	3	76	0	79
Total	18	151	37	206

Table 6-7 : Sub-transmission transformers - population

The age profile of the sub-transmission transformers is shown in Figure 6-8 and Figure 6-9.

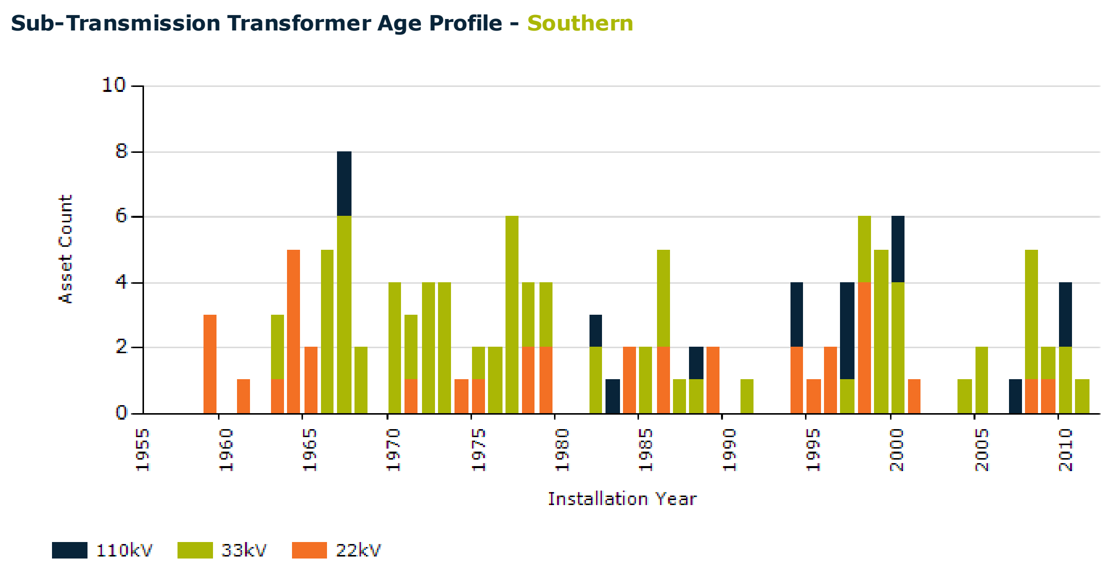

Figure 6-8 : Sub-transmission transformer age profile - Southern

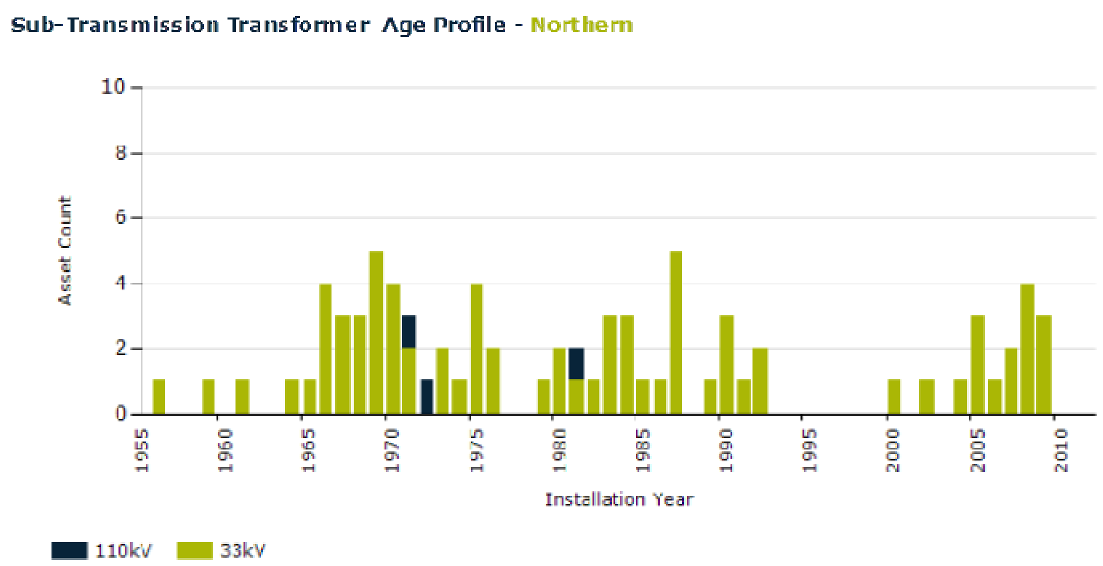

Figure 6-9 : Sub-transmission transformer age profile - Northern

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 ºC
Conductor hot-spot temperature	125 ºC

Metallic part temperature 135 ºC

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.

6.3.2.1 Routine Asset Inspections, Maintenance and Testing

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:

Two-Monthly

- 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.

Yearly

- Transformer oil condition sample, transformer condition assessment (TCA) provided by TJ|H2b Analytical Services[6], 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.

Two-Yearly

- Acoustic partial discharge inspection.

Three-Yearly

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

[6] 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, tapchangers and circuit breakers.

Refurbishment and Renewal Maintenance

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.

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

The flow chart in Figure 6-10 is a simplified version of the condition assessment process.

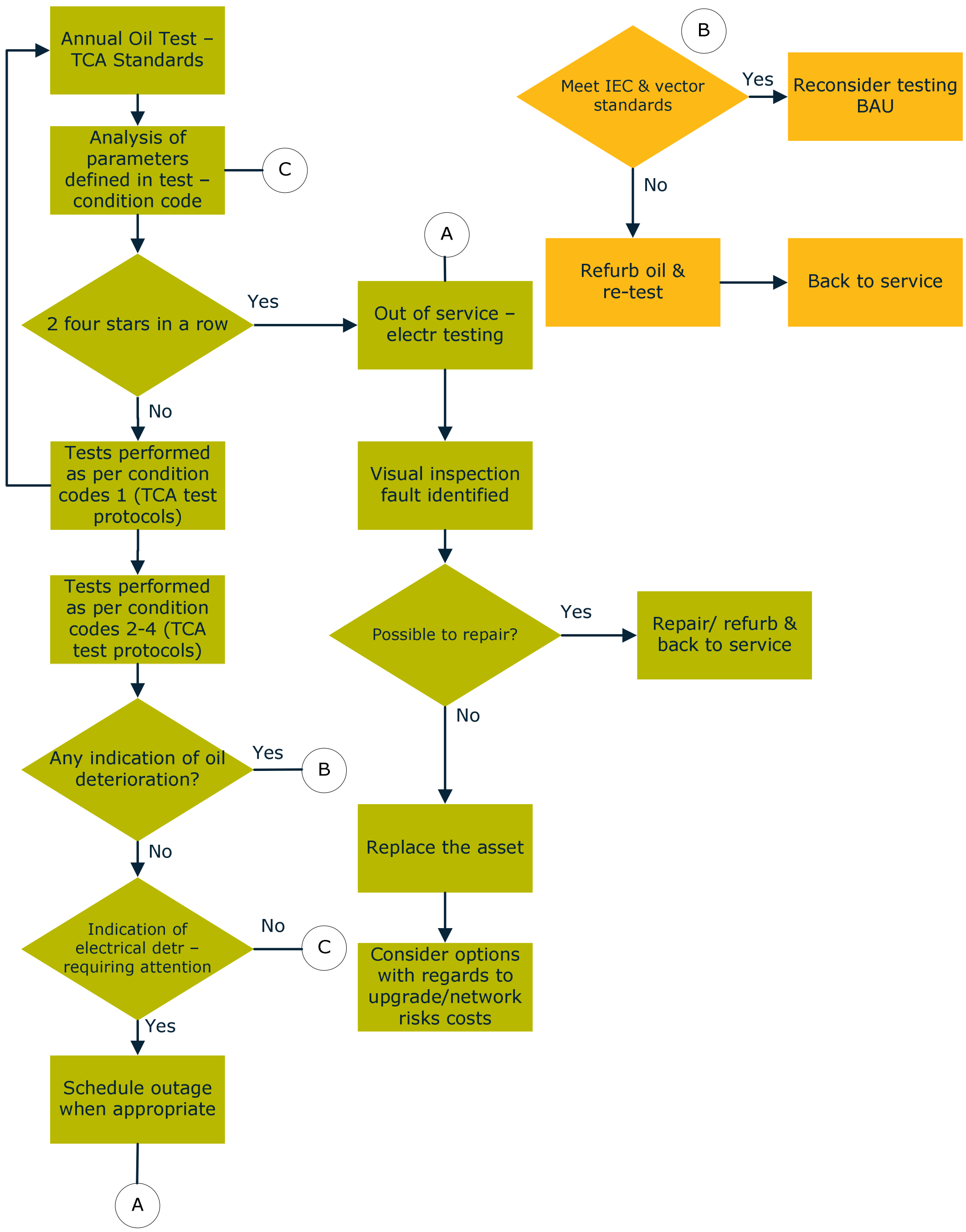

Figure 6-10 : Condition assessment process

6.3.2.2 Refurbishment and Replacement Programme

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.

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.

A summary of the planned sub-transmission transformer replacement projects is presented in Table 6-8. The timing and priority are still subject to ongoing performance measurement, analysis and approved business cases.

Project Description	Project Unit	Project Year	Project Estimate
Balmoral - 22kV Transformer Replace	2 units	2013/14	$4.4m
Onehunga - 22kV Transformer Replace	2 units	2015/16	$4.4m
Mt Albert - 22kV Transformer Replace	1 unit	2016/17	$2.2m
Parnell - 22kV Transformer Replace	2 units	2017/18	$4.4m
Glen Innes - 22kV Transformer Replace	2 units	2018/19	$4.4m
Triangle Rd - 33kV Transformer Replace	2 units	2019/20	$4.0m
Waimauku - 33kV Transformer Replace	1 unit	2020/21	$2.5m

Table 6-8 : Sub-Transmission Transformer Replacement Projects

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.

The degree of polymerisation (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.

Balmoral

- The existing units were manufactured in 1961 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels. These units are only 12MVA and will be replaced with Vector's standard 20MVA units to cope with expected future load growth.

Onehunga

- The existing units were manufactured in 1964 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels.

Mount Albert

- The existing unit was manufactured in 1964 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels.

Parnell

- One of the transformers at this substation failed in 2010 and has an old temporary replacement in its place. The other unit was manufactured in 1964 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels.

Glen Innes

- The existing units were manufactured in 1958 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels. These units are only 12MVA and will be replaced with Vector's standard 20MVA units to cope with expected future load growth. While these units are the oldest in the replacement programme they were fully refurbished in the late 1990's to extend their operational life. As these transformers are supplied from the 22kV bus at Penrose any replacement programme will need to be carefully considered with the network development plan in this area and the future plan for the Penrose 22kV supply.

Triangle Rd

- The existing units were manufactured in 1956 and 1961 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels.

Waimauku

- The existing unit was manufactured in 1959 and recent DP testing indicates the winding insulation is deteriorating to unacceptable levels.

6.3.3 Zone Substation Switchboards and Circuit Breakers

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

Primary class circuit breakers (CBs) and switchboards deployed to operate at these voltage levels are installed inside 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, 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 22kV, 33kV 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. Table 6-9 shows the current number of CBs on the network categorised by operating voltage.

Population	110kV	33kV	22kV	11kV	Total
Southern	11	21	101	852	985
Northern	0	265	0	449	714
Total	11	286	101	1301	1699

Table 6-9 : Zone substation circuit breaker – population

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 SF_6 and vacuum type. Note that CB type as mentioned here refers to the arc quenching technology incorporated and not the insulation medium which can be compound, oil, solid, air or SF_6 gas.

Figure 6-11 and Figure 6-12 show the age profile of CB's and switchboards in the Southern and Northern regions.

Zone Substation Circuit Breakers Age Profile - Southern

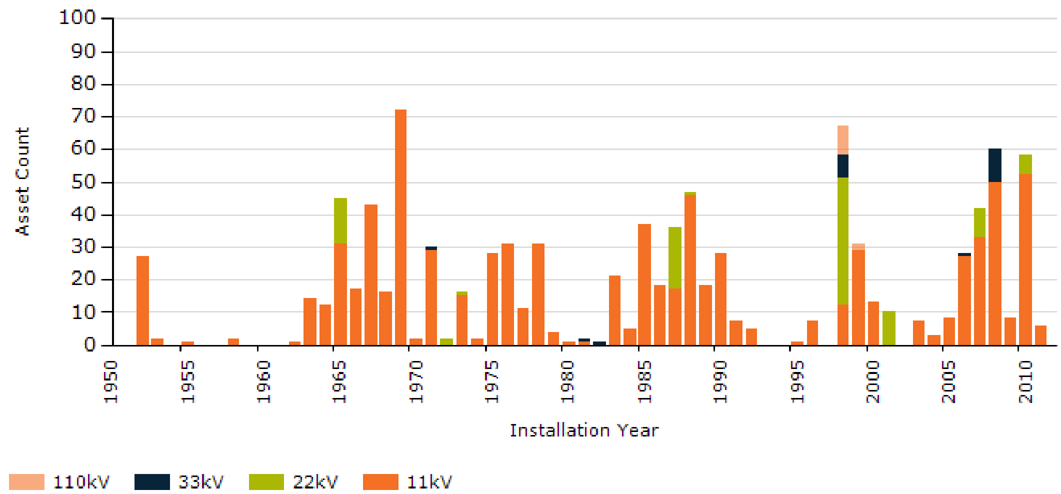

Figure 6-11 : Zone substation circuit breaker age profile – Southern

Zone Substation Circuit Breakers Age Profile - Northern

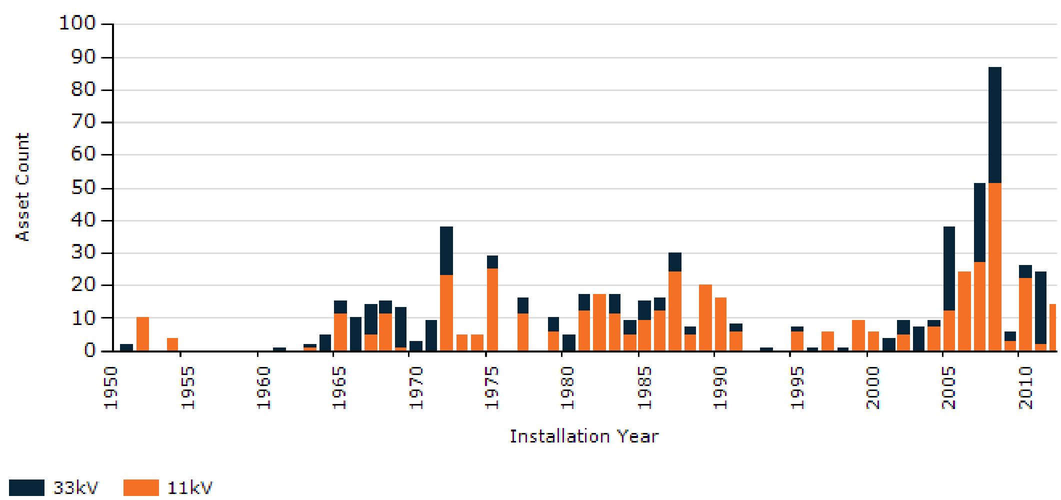

Figure 6-12 : Zone substation circuit breaker age profile – Northern

The number of CBs on the Vector network is increasing due to the establishment of new zone substations and extensions to existing stations to accommodate load growth, as well as reinforcement projects on the sub-transmission system. The vast majority of CBs are configured as indoor switchboards (consisting of multiple CBs connected to a common bus). The remainder are configured as follows:

- 154 outdoor 33 kV rated CBs and associated air break switches (ABS) and outdoor bus works at Vector zone substations;

- 37 outdoor 33kV rated CBs installed at Transpower GXPs (associated ABS and bus works are owned by Transpower);
- Nine bay 110 kV GIS switchboard at Auckland's Liverpool Substation; and
- Two outdoor 110 kV GIS CBs and associated air break switches (ABS) and outdoor bus works at the Lichfield substation (Fonterra cheese factory). Responsibility for maintenance of these two circuit breakers has been assigned to Transpower for the duration of the connection contract.

The oil type circuit breakers are the oldest in the network and constitute 75% of the asset followed by SF_6 at 13% and vacuum at 12%. Circuit breaker technology using vacuum or SF_6 interrupters and SF_6 gas insulated equipment is primarily technology of the last 20 years. Until this time, MOV (minimum oil volume) and bulk oil type circuit breakers dominated the market.

Schedule A of the Commerce Act (Electricity Distribution Services Input Methodology) Determination 2010 specifies standard physical asset lives for indoor switchgear equipment as 45 years, outdoor ABS (air break switch) as 35 years and all outdoor circuit breakers as 40 years regardless of type. This matches reasonably well with Vector's operational experience for this class of equipment.

New equipment purchases must comply with Vector Equipment Standards ENS-0005 for 11kV to 33kV indoor switchboards, ENS-0106 for 33kV outdoor circuit breakers, ENS-0022 for indoor 110kV switchboards and ENS-0165 for outdoor air break switches. These equipment standards specify the latest in low maintenance equipment technology. Depending on the condition of the zone substation building, construction costs to modify existing foundations and buildings can be considerable and need to be evaluated on a station by station basis.

6.3.3.1 Routine Asset Inspections, Maintenance and Testing

The routine inspection, maintenance and testing requirements for Vector's sub-transmission switchboard assets are prescribed in Vector's Network Standard ENS-0049 Maintenance of Substation Circuit Breakers and Switchboards.

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

Two-Monthly

- 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 Renewal Maintenance

- 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.

Fault and Emergency Maintenance

- All identified defects that pose an unsafe condition for public and property, equipment operation, substation security, the environment or safety of personnel require immediate repair, replacement or isolation.

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 and Takaoka circuit breakers have been identified as the next priority replacements.

As noted above, new equipment purchased under Vector specification is maintenance free, fit for life design. Such equipment requires little maintenance activity outside of thermographic survey, PD monitoring and the occasional cleaning of the cabinetry. Existing stations, largely equipped with withdrawable OCB and vacuum circuit breakers (VCBs), will continue to be monitored and maintained on a time and condition basis.

6.3.3.2 Condition of the Assets

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). They are in good condition and pose little risk to the network due to modern manufacturing technologies, higher design specifications and compliance with the latest international equipment standards. Even 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 40 to 50 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, as discussed in Section 6.3.3.3.

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 switchboard installations and outdoor CBs within the last six years are of maintenance free design where end of life is determined by lifetime fault interruption and normal load switching operations and not traditional time-based estimations. IEC Specification 6227-100 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.

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.

6.3.3.3 Refurbishment and Replacement Programme

The timing for replacement or refurbishment decisions is based on assessing asset condition, performance, equipment ratings (actual vs required) and industry related information (eg. known defects). The timing can also be the result of non-electrically related drivers such as site relocation or decommissioning, safety considerations, building code regulations (eg. fire protection requirement, seismic compliance) and condition of the existing building (eg. leaking roofs causing internal faults on the equipment).

To achieve the optimal replacement window requires a balance between risk (reliability and safety) and economic considerations (avoiding unnecessary or early replacement). This requires a fully-fledged switchboard and CB condition based management and replacement strategy, which Vector is continuing to develop and implement.

As noted previously, despite new switchboards being either SF_6 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 recently adopted this approach, particularly where significant extension to the existing switchboards has occurred. One example is that at Otara substation where a seven panel vacuum circuit breaker extension to the existing Reyrolle LMT switchboard is made. All the OCBs will be replaced with new VCBs to remove the risk to the new apparatus as well as extend the life of the existing switchboard. Vector's VCB retrofit programme will continue with Carbine and Belmont substations slated for VCB retrofits this year, followed by Pt Chevalier which is also undergoing switchboard extension to address growth in its supply area.

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.

Due to the age of the existing infrastructure at some substations, the cost of switchboard asset replacement work is estimated to be about $5 million to $7.5 million per annum from now and well into the foreseeable future (estimate includes an allowance for unavoidable but necessary civil and associated (lighting, etc) works). This expenditure will result in the complete replacement (including switchboard, relays, ac/dc supplies, chargers and communications systems) of approximately two to three switchboards per annum.

Figure 6-13 below illustrates the processes involved in evaluating switchboards and circuit breakers for replacement or refurbishment. Other criteria such as the technology, network growth, criticality and related factors are also used to assist in replacement prioritisation.

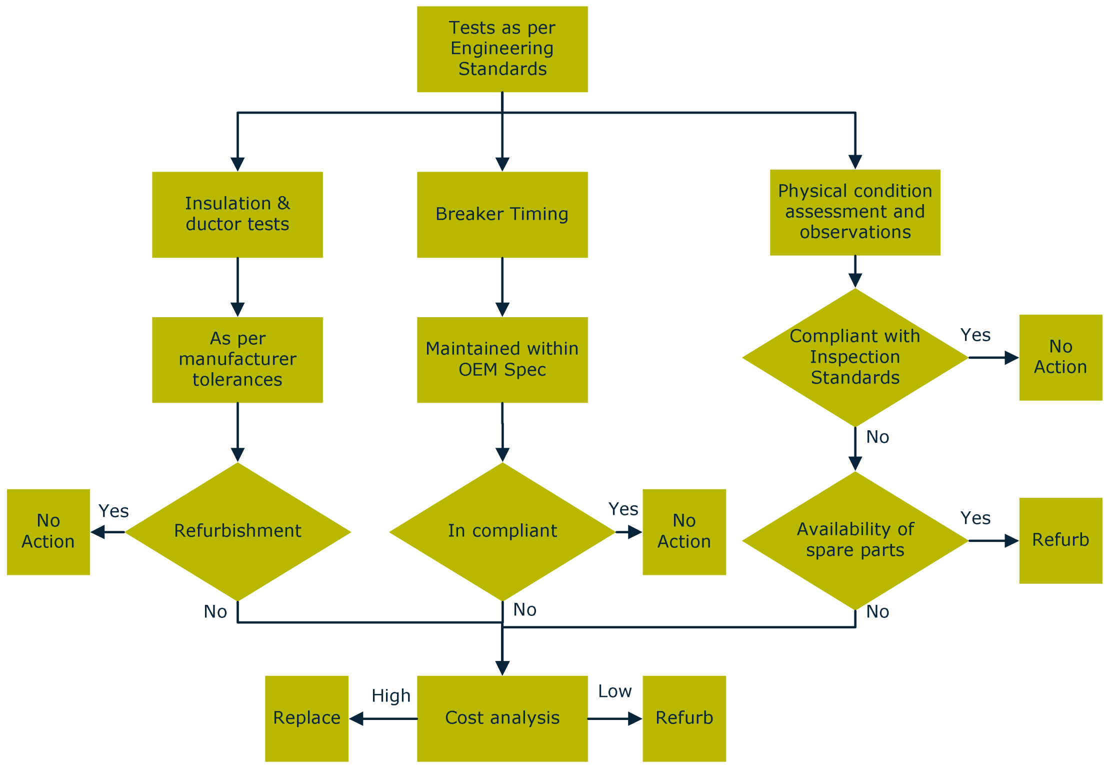

Figure 6-13 : Zone substation circuit breaker replacement decision chart

Through the above process a priority programme of work has been established. Table 6-10 below is a summary of the switchboards and CBs identified for replacement within the next five years.

Project Description	Project Unit	Project Year	Project Estimate
Wairau Valley - 33kV Indoor SWBD Install	32 Panels	2013/14	$1.9m
Riverhead - 11kV Indoor SWBD Replace	12 Panels	2013/14	$1.5m
Sabulite Rd - 11kV Indoor SWBD Replace	11 Panels	2013/14	$1.2m
Balmain - 11kV Indoor SWBD Replace	5 Panels	2013/14	$1.5m
Liverpool - 11kV Indoor SWBD Replace	11 Panels	2013/14	$5.0m
Birkdale - 11kV Indoor SWBD Replace	11 Panels	2013/14	$4.2m
Brickworks - 11kV Indoor SWBD Replace	11 Panels	2013/14	$3.0m
Kingsland - 22kV Indoor SWBD Replace	17 Panels	2013/15	$3.8m
Browns Bay - 11kV Indoor SWBD Replace	10 Panels	2014/15	$1.8m
Balmoral - 11kV Indoor SWBD Replace	12 Panels	2014/15	$1.7m
Onehunga - 11kV Indoor SWBD Replace	12 Panels	2014/15	$1.5m
Hobson - 11kV Indoor SWBD Replace	21 Panels	2015/17	$6.4m

Project Description	Project Unit	Project Year	Project Estimate
New Lynn - 11kV Indoor SWBD Replace	11 Panels	2015/16	$2.3m
Orakei - 11kV Indoor SWBD Replace	16 panels	2015/16	$2.1m
Laingholm - 11kV Indoor SWBD Replace	11 Panels	2016/17	$1.1m
Manurewa - 11kV Indoor SWBD Replace	13 Panels	2016/17	$2.1m

Table 6-10 : Scheduled switchgear replacement

Wairau Valley

- Work to replace the outdoor 33kV switchyard by a new indoor substation has been completed. Due to winter load constraints work will continue to commission the remaining 33kV feeders. The substation was commissioned in FY12. Remaining work at this site is for transferring the remaining feeders to the new switchboard, demolition of the old 33kV yard and site cleanup.

Riverhead

- The replacement of the 11kV Southwales switchboard at this substation is a continuation of the programmed replacements for this type of switchgear on the network. The Southwales switchboards are at the end of their design life and are exhibiting signs of deterioration. Parts availability is limited to those that can be salvaged from previous replacement work.

Sabulite Road

- Work to replace the Southwales Switchboard in a new "Portacom" style building is nearing completion. Remaining work at this site is for final commissioning and site cleanup.

Balmain

- The 11kV Southwales switchboard at this substation is in similar condition to other switchboards of this make and type on the network. This is a continuation of the programmed replacement for this type of equipment which has not been manufactured for many years. Construction work on the building and commissioning of the new switchboard will be completed in FY13/14.

Liverpool

- Stages 2 and 3 of this multi-year project entail switchboard and switchroom construction work and final cable installation and commissioning of the switchboard.

Birkdale

- The switchroom and switchyard require refurbishment. A detailed seismic study has determined that the building is uneconomic to upgrade to current building code requirements. Furthermore there is no space left in the substation for concurrent reinforcement projects requiring new feeders from this site. This project has been rescoped as a complete substation rebuild due to existing constraints and the need for increased capacity for security of supply.

Brickworks

- A detailed seismic study has determined that the building is in a very poor state and cannot be upgraded to comply with the present minimum building code requirements. Furthermore there is no space left in the substation for concurrent reinforcement projects requiring new feeders from this site and increased capacity for future development in the area. This project has been rescoped as a complete substation rebuild due to existing constraints and the need for increased capacity for present and further security of supply.

Kingsland

- The existing double bus configured 22kV AEI type VLP oil switchboard is the last of its type in the Vector network and is at the end of its design life. Major spare parts are no longer available and during its last service, CB tank bushing clamps were found to be broken in almost every circuit breaker due to its long in-service life and metal fatigue. Due to the size of this switchboard, a new building will have to be established on the existing site in order to build a new switchboard while the existing switchboard remains in service. Network constraints will not enable long duration outages of the existing switchboard.

Browns Bay

- The 11kV English Electric switchboard at this substation is the last of its kind on the network. This switchboard is the last to be replaced of a programme of replacement for this type of switchgear. Previous replacement work has provided a variety of used spare parts for emergency use but the overall deteriorated condition requires it to be replaced.

Balmoral

- The replacement of the 11kV Brush switchboard at this substation is a continuation of programmed replacements for this type of switchgear on the network. The Brush switchboards are at the end of their design life and exhibiting signs of deterioration. Parts availability is limited to those that can be obtained from previous replacement work.

Onehunga

- The replacement of the 11kV Southwales switchboard at this substation is a continuation of programmed replacements for this type of switchgear on the network. The Southwales switchboards are at the end of their design life and exhibiting signs of deterioration. Parts availability is limited to those that can be obtained from previous replacement work.

Hobson

- The double bus configured 11kV switchboard at Hobson substation comprises two discrete sections. Panels 1-21 is a Brush type VTD oil switchboard with M14EK3 circuit breakers (ca1968) and panels 22-36 are Reyrolle type LMT oil switchboard (ca 1983). The Brush portion is to be replaced with a new ENS-0005 compliant switchboard. Subsequent asset replacement programmes at this substation will replace the Reyrolle portion with new vacuum circuit breakers. The Brush equipment is at the end of useable life showing sign of rust, compound and oil leaks.

New Lynn

- The existing 11kV Southwales oil type switchboard has past its design life and is showing signs of irreparable deterioration similar to other switchboard of this make and type on the network. A seismic study of the building has also determined that it may be more prudent to establish a new building at the existing site for a new 11kV and future indoor 33kV switchboards. An options analysis will determine the best replacement methodology.

Orakei

- The replacement of the 11kV Brush switchboard at this substation is a continuation of programmed replacements for this type of switchgear on the network. The Brush switchboards are at the end of their design life and exhibiting signs of deterioration. Parts availability is limited to those that can be obtained from previous replacement work.

Laingholm

- The 11kV Southwales switchboard at this substation is in similar condition to other switchboards of this make and type on the network. This is a continuation of the programmed replacement for this type of equipment which has not been under manufacture for many years. Construction work on the building and the new switch is expected to be completed in FY16/17.

Manurewa

- The replacement of the 11kV Brush switchboard at this substation is a continuation of programmed replacements for this type of switchgear on the network. The Brush switchboards are at the end of their design life and exhibiting signs of deterioration. Parts availability is limited to those that can be obtained from previous replacement work.

Beyond this identified programme of works a provisional capital expenditure estimate has been made from FY19 onwards, based on the expectation that other switchgear units on the network will demonstrate similar life-cycle performance to those currently being replaced and units will therefore be reaching the end of their useful lives by then. The actual units to be replaced, and the more accurate cost estimates for this, will be determined closer to the time. This allowance is included in the ten year work programme (Table 6-24).

6.3.4 Zone Substation Buildings

Due to historical reasons, Vector's zone substations are built to two different design philosophies. Due to the predominantly urban environment, substations located in the Southern region were built with the philosophy of containing as much of the primary apparatus as possible in enclosed buildings. The Northern region, initially developed largely in a rural environment, applied a more traditional rural approach, using outdoor switchyards for the sub-transmission apparatus with indoor control rooms and 11kV distribution switchboards.

Due to the different design philosophies, the Northern region substations generally occupy twice the land area compared to a similarly configured urban substation. This in turn requires more maintenance (activities such as weed control, security fences, tree trimming and lawn mowing are more intensive).

For new construction, the trade-off between land, building and equipment needs to be considered, in addition to the visual impact on surrounding land owners and security of the premises. It is more costly to construct enclosed substation buildings although these costs need to be evaluated against reduced land requirements, reduced maintenance of the primary plant equipment and enhanced security of access.

Vector's current network development philosophy for new substations is to enclose all substation apparatus regardless of network region.

Newly constructed substations in the past few years have been of pre-cast concrete tilt slab construction. These stations have been designed for ease of construction, low maintenance, safety of persons and adjoining properties, and compliance with the latest building and seismic requirements. These buildings are also designed to be in keeping with the local environment where they are located. For rural sites the design is less architecturally enhanced due to the reduced need to blend in with the environment facilitating some construction cost reductions.

Vector has also begun a process of evaluating the long-term requirements of the more rural aged substations with a view to converting the outdoor yards to indoor facilities where it is economically viable to do so.

Vector redeveloped the Swanson zone substation in 2010 with a replacement of the outdoor 33kV switchyard with a containerised indoor switchboard. The outdoor equipment had reached the end of it design life and was exhibiting signs of deterioration. The bus work, insulators and outdoor breakers are becoming a safety and security of supply risk. The container solution, albeit industrial in design, is in keeping with the existing substation while at the same time improving the visual impact of the former outdoor apparatus. This project has also improved the security of supply for the area served by this substation, as well as improving personnel and the public safety.

The remainder of Vector substations range from tin-clad wood frame buildings, to block or brick construction, wood frame as well as poured in situ reinforced concrete construction and other variants in various condition relating primarily to the age, materials and construction methodology.

Figure 6-14 : Swanson before redevelopment

Figure 6-15 : Swanson after redevelopment

In all there are 107 in service zone substations and switching stations, with an additional four zone substations currently under construction.

Figure 6-16 and Figure 6-17 show the age profile of zone substation buildings in the Southern and Northern regions respectively.

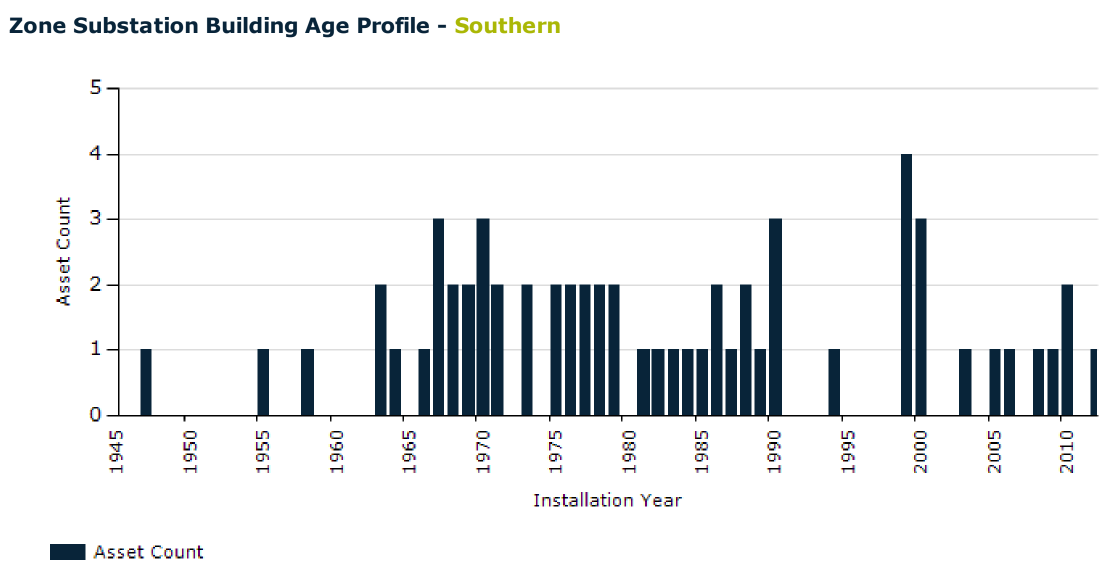

Figure 6-16 : Zone substation buildings age profile - Southern

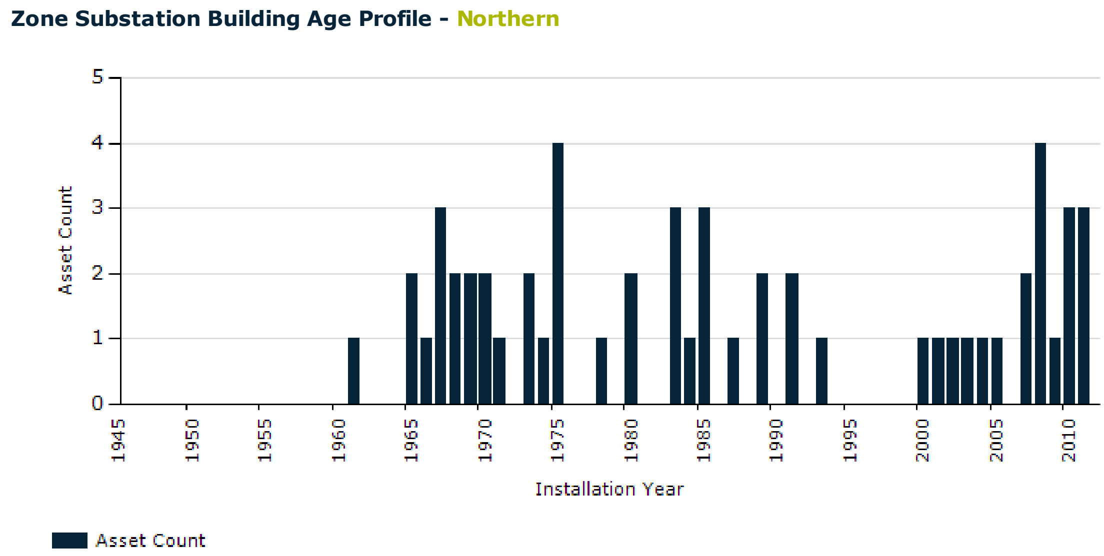

Figure 6-17 : Zone substation buildings age profile - Northern

The substation buildings vary in condition from very good to poor. The poorest, while structurally sound, are in need of upgrades due to deteriorating doors, window frames and roofs. Ongoing refurbishments of these buildings will be required.

6.3.4.1 Routine Asset Inspections, Maintenance and Testing

The substation building maintenance regime covers substation building structures, fire detection and protection, ventilation systems, environmental control fixtures, grounds, driveways, external lighting, fences, security systems, emergency lighting and power supplies.

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

A summary of the standards is given below:

Three-Weekly

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

Monthly

- Building compliance assessment.

Two-Monthly

- Electrical assets visual inspection; and

- Buildings services visual inspection and condition assessment. Ensure telephone and radio are operational, spill kits and first-aid kits are fully stocked, extinguishers compliant, rubbish is removed, structural integrity and cleanliness of internal walls, doors and windows, all drains and plumbing, and sump pumps and alarms are 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, heat pumps and air conditioning systems where fitted, assess filter condition. Ensure all trench covers are secure and trenches and cable ducts are sealed from water ingress. Restock any consumables.

Yearly

- Alarm testing and compliance; ensure correct operation of all fire alarms, intrusion alarms and crisis alarms as required, clean and test all smoke heads; and
- Building warrant of fitness certification.

Refurbishment and Renewal Maintenance

- All defects that are not considered an imminent risk of asset failure or a compromise in site security require repair or replacement before the next inspection is due.

Fault and Emergency Maintenance

- All defects that are considered to pose an imminent risk of asset failure or a compromise in site security require immediate repair or replacement.

6.3.4.2 Seismic Upgrades

The local authority has been empowered to enforce the seismic compliance rules of the Building Act 2004. Section 122 of the Building Act requires assessments be made of certain structures (single story houses, etc are exempt) to verify their performance under earthquake conditions. Section 131 of the Building Act 2004 requires that local authorities develop a policy relating to dangerous and insanitary buildings within their areas of jurisdiction and Auckland Council have developed a policy accordingly.

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 takes into account many factors such as the importance of the building and likely impact of failure of the structure on the public.

There are assessment methods that can be used to rank buildings into likely (to exceed legal requirements) or unlikely (to exceed legal requirements). For example:

- Most buildings designed after 1976 will meet this legal requirement as they would have been designed to NZS4203 which included significant seismic design criteria;
- Similarly, most light weight timber framed buildings, if they are single storey and lightly clad, will meet the legal requirements;
- Conversely, unreinforced masonry buildings and lightly reinforced mass concrete buildings will be unlikely to meet the above legal requirements; and

- The age of the building is important as it indicates not only the length of asset life left but also the likely design code they would have been designed to. Any buildings built earlier than the 1960s are unlikely to have an adequate seismic performance as only nominal attention was paid to earthquake design at that time.

It is reasonable and a simple task to rank buildings into likely or unlikely categories. The age and importance of the substation can be used to help categorise the buildings also.

Vector engaged an experienced seismic and 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.

Of the 71 sites assessed:

- Remediation at Swanson zone station has been completed;
- Two substations (Brickworks and Birkdale) will be rebuilt during 2013/14;
- Seven substations have been assessed in detail resulting in five substations deemed sufficiently strong enough to meet two thirds of the current building code. Spur Rd zone substation requires minor strengthening (which has commenced). The Drive substation requires major refurbishment; and
- Seventeen stations are scheduled for detailed assessment through FY13/14.

The council policy requires compliance with the provisions of the Building Act ten years from when council have made their own determinations.

Vector continues to engage with local authorities on the building and seismic compliance requirements for existing zone substations. An annual expenditure of $1million has been allowed for each of the network regions (Northern and Southern) to accommodate building reinforcement works. However, following the first phase of detailed assessments it is expected that final reinforcements will be completed well within the required 10 years.

6.3.5 Zone Substation DC Supply and Auxiliaries

Substation direct current (DC) auxiliary power systems provide supply to the substations' 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 batteries, a battery charger, a number of dc/dc converters and a battery monitoring system. The major substations are equipped with a redundant dc auxiliary system.

Maintenance for the valve regulated lead acid (VRLA) batteries is based on the recommendations of IEEE–1188 (IEEE Recommended Practice for Maintenance, Testing and Replacement of VRLA Batteries for Stationary Applications). 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 implementing online battery monitoring in its substations. The intention is to in future progressively reduce the requirement for onsite maintenance and inspections.

6.3.6 Power System Protection, Automation and Control Systems

Vector's new and refurbished substations are equipped with multifunctional Intelligent Electronic Devices (IEDs). Each IED combines protection, control, metering monitoring and automation functions within a single hardware platform. The age of installed IEDs is known and, in the absence of accurate performance data, is currently the most reliable indicator to serve as a basis for replacement. As per CIGRE and generally accepted industry practice, the useful life-span for protection relays is generally estimated to be in the following ranges:

- Numerical: 15-20 years;
- Static: 20-25 years; or
- Electromechanical: 32 years.

Vector's protection relay asset consists of 2,826 main protection relays. The age and technology distribution is given in Figure 6-18 and Figure 6-19 below for the Southern and Northern regions respectively.

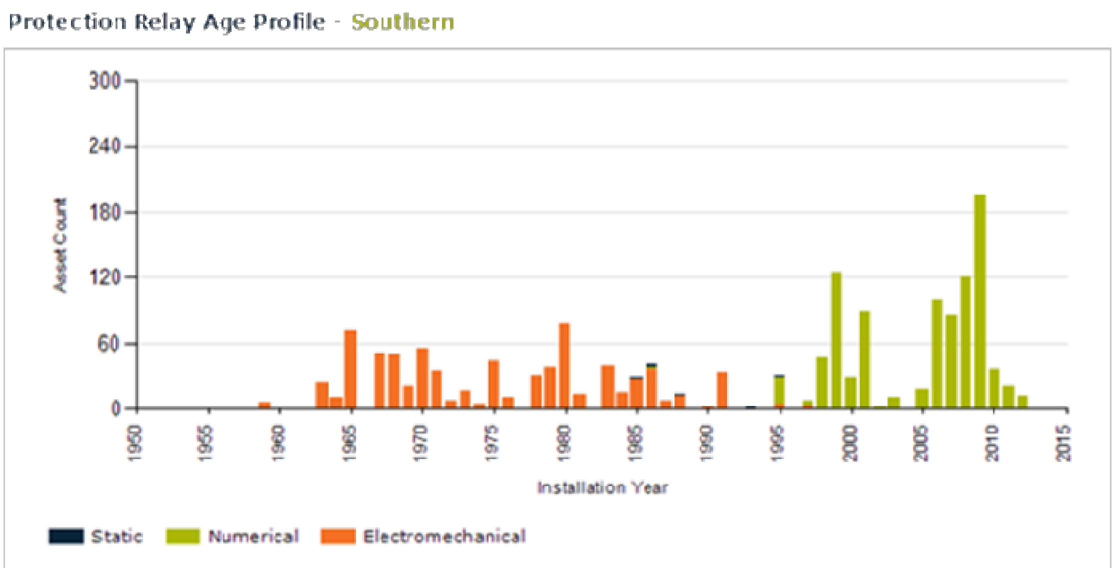

Figure 6-18 : Protection relay age profile - Southern

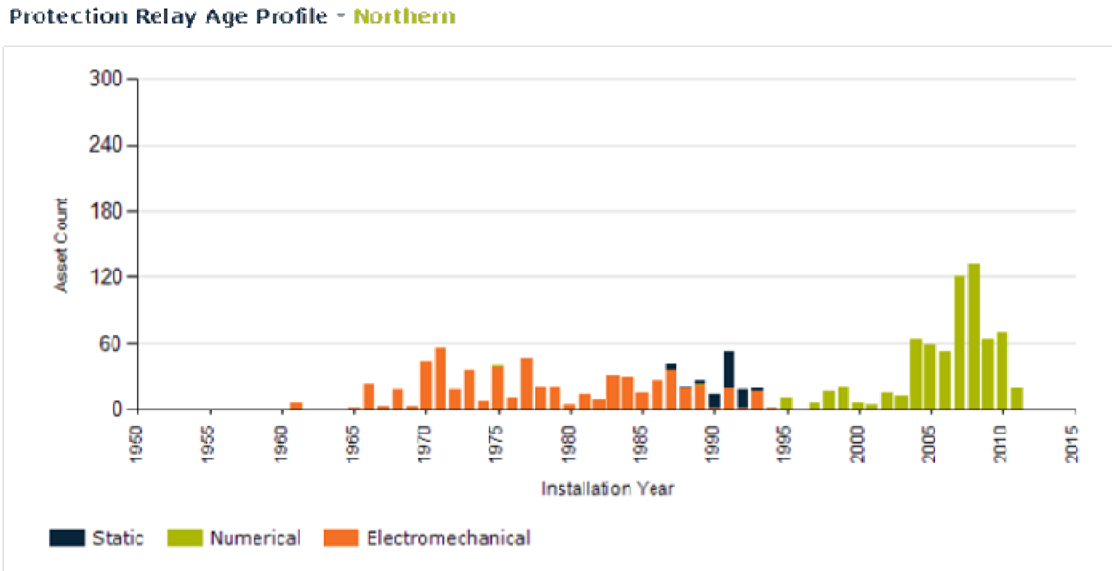

Figure 6-19 : Protection relay age profile - Northern

Vector's financial system (SAP) does not at present explicitly record the value of protection relays. This is included with the value of the switchgear they protect.

Vector is not aware of any systemic problem with its current population of protection relays and the assets are generally in good condition.

6.3.6.1 Maintenance Programme

All protection maintenance is time-based at present. Maintenance frequencies vary depending on the generation of technology. For protection installed at the grid interface, the maintenance frequency is stipulated by the Electricity Industry Participation Code.

Maintenance of numerical relays (self-monitoring) is on an eight-yearly basis. Non self-monitoring relays require four-yearly maintenance. For analogue relays the period is six years, or two years at the grid interface. A summary of Vector's maintenance requirements is given in Table 6-11. If the next (eight-yearly) testing occurs after the relay has been in service for ten years the battery will be replaced.

	Numerical Self Monitoring	Digital Non-Self Monitoring	Analogue (electro-mechanical or non-numerical electronic)	Measuring / Trip Circuit	AUFLS	IED Battery Replace-ment
Grid Interface	10	4	2	4	4	8*
Other Stations	10	4	6	4/6/10**	4	8*
Trf. Mech. Protn.			**			-
Transformer IED			**			8*

	Numerical Self Monitoring	Digital Non-Self Monitoring	Analogue (electro-mechanical or non-numerical electronic)	Measuring / Trip Circuit	AUFLS	IED Battery Replace-ment
Transformer Voltage Regulating Relay, OTI and WTI			**			

	Required by Electricity Industry Participation Code
*	Refer to note 2.
**	Align with associated protection relay (eg. buchholz) maintenance interval.

Notes:

1. Differential protection between the grid and a connected asset to be treated as a single protection function and be tested both ends.
2. Replace 8-yearly. Battery life is estimated to be ten years.
3. Periodic testing of RTU is not required. The RTU's on-board battery shall be replaced when the battery fail alarm is activated.
4. Where CBM test results replace periodic testing, the periodic test interval start date shall be reset to the date of acceptance of CBM results.
5. Calibration and operation of measurement transducers shall be tested when protection tests are carried out. Correct reflection of measured values within specified limits shall be tested locally and remotely (SCADA). Cable pressure alarm transducers and temperature transducers shall be tested 2-yearly.

Table 6-11 : Protection relay maintenance frequencies

6.3.6.2 Replacement Programme

The basic aim of the protection equipment replacement strategy is to ensure the managed replacement of installed protection assets is carried out in order to maximise the overall benefit to Vector and its customers. In order to achieve this the replacement strategy must strike a balance between cost implications and avoiding the risk of asset failures or malfunction. The replacement strategy also needs to consider lifecycle management factors to ensure full protection of Vector's switchgear and transformers are maintained at all times.

The key principle of the strategy is that any protection device which cannot be kept to an overall level of adequacy through routine maintenance should be replaced, given protection is a network-critical function.

For this reason the replacement strategy is pre-emptive in its approach. It is also considered essential for the protection system to be systematically upgraded in order to align with modern practices, allowing substantial benefits offered by modern protection devices to be captured. Finally, the protection system must be sustainable in terms of available skills, spares and support.

The main drivers for protection replacement are:

- Protection system inadequacy (non-compliance with system requirements);
- End of technical life;
- Reduced maintenance cost (cost efficiency);
- Improving safety;
- Improving reliability;

- Standardising and simplifying maintenance practice; and
- Standardising protection installation designs.

The above drivers are balanced against the cost of replacement and practical/operational considerations, and some compromise is therefore necessary.

6.3.7 Supervisory Control and Data Acquisition - SCADA

The Vector SCADA system is made up of the following components:

- SCADA master stations application
- Vector operates a Siemens Spectrum Power TG SCADA system to monitor and control its electricity network.
- Remote telemetry units (RTU)
- Over time a number of different RTUs have been installed in Vector's network, many of which are nearing the end of their technical life or are obsolete. Vector has been running an annual RTU replacement programme for a number of years which is currently replacing approximately ten RTUs per region per annum. RTUs are replaced with a standard interface to both master stations.

6.3.8 Communication Networks and Systems

6.3.8.1 Wide Area Networks

- Vector operates 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.
- 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 wire telephone type pilot cables and third party radio communication systems.

6.3.8.1.1 Digital Microwave Radios (DMR)

- Several digital microwave radio links were installed in 2007 and 2008 to extend Vector's IP operational WAN to zone substations in the Northern region. The equipment was manufactured by Harris Stratex and 4RF. The DMRs are monitored by Vector's communication operational centre.

Conditions

- The DMR has performed reliably even during adverse weather condition. The equipment is expected to last 10 years.

Action

- A redundant IP based non wireless solution is planned to facilitate network availability. It is likely that the solution will be migrated to outsourced IP WAN.

6.3.8.1.2 Open Transport Network - OTN

- The OTN system originally manufactured by Siemens was installed at 12 sites in the Northern region in 2001 for operational services, legacy SCADA communication protocols and tele-protection.

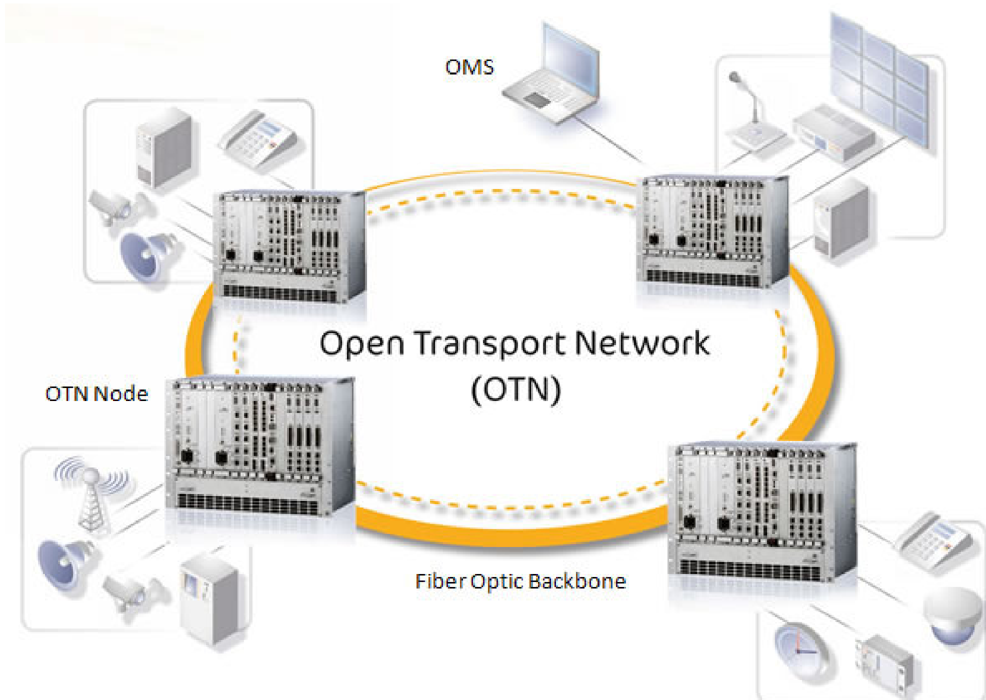

Figure 6-20 : OTN systems

Conditions

- The system is proprietary built and is reaching the end of its technical life. The system is still supported by the new technology owner.

Actions

- The services are being migrated to IP based communication system for operational services and dedicated optical fibres for protection signalling. The OTN system is to be retired in the next five years.

6.3.8.1.3 Nokia PDH (Plesiochronous Digital Hierarchy)

- The Nokia PDH system is a proprietary communication system installed in late 1990 at 10 sites. The system is used for operational communication services, legacy SCADA communication protocols and teleprotection between Maraetai and Waiheke substations.

Conditions

- The system has performed well but is reaching the end of its technical life.

Action

- In conjunction with the renewal project of the secondary systems the system is to be retired in next five years.

6.3.8.1.4 Wireless Cellular 2G/3G Commercial Networks

For communication to distribution substations Vector is using commercial cellular 2G/3G networks. Each distribution substation is equipment with an IP based layer 3 wireless router. The population of the wireless 2G/3G routers is shown in the Figure 6-21 below.

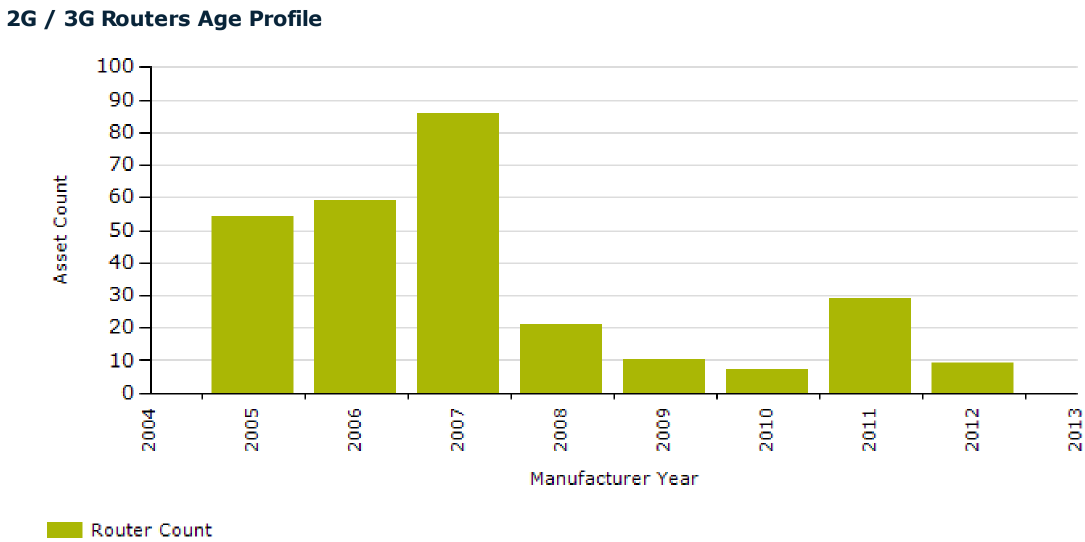

Figure 6-21 : Wireless 2G/3G routers

Conditions

There are no systematic issues with the wireless 2G/3G routers.

Action

Randomly failed routers are to be replaced from the strategic stock. The planned replacement is scheduled at the end of the expected 10 years equipment life.

6.3.8.2 Substation Local Area Networks (LAN)

The substation LAN is based on a resilient optical ethernet architecture compliant to IEC 61850 Standards. The substation ruggedised ethernet switches population per region is shown in the Figure 6-22 and Figure 6-23 below for the Southern and Northern regions respectively.

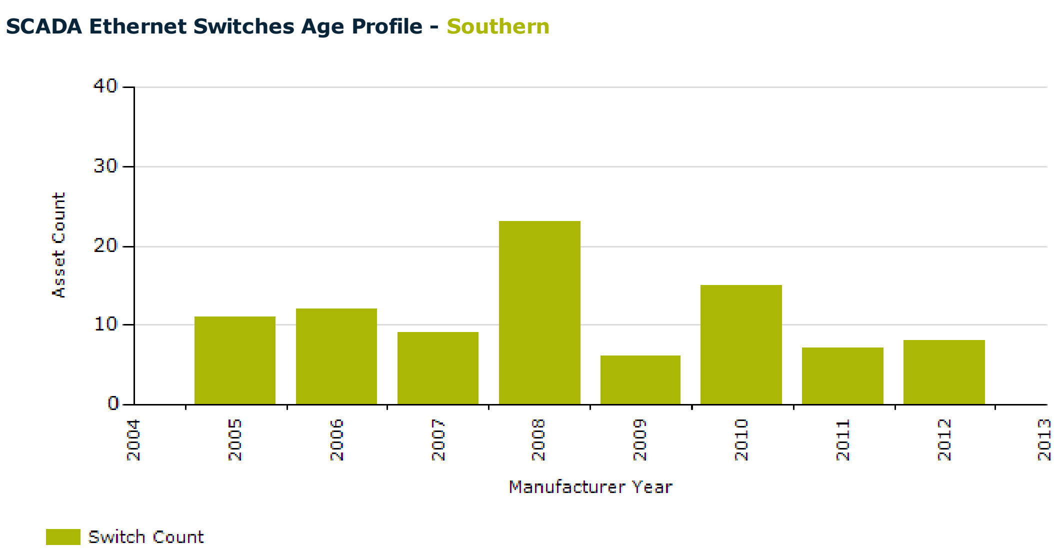

Figure 6-22 : SCADA ethernet switches age profile - Southern

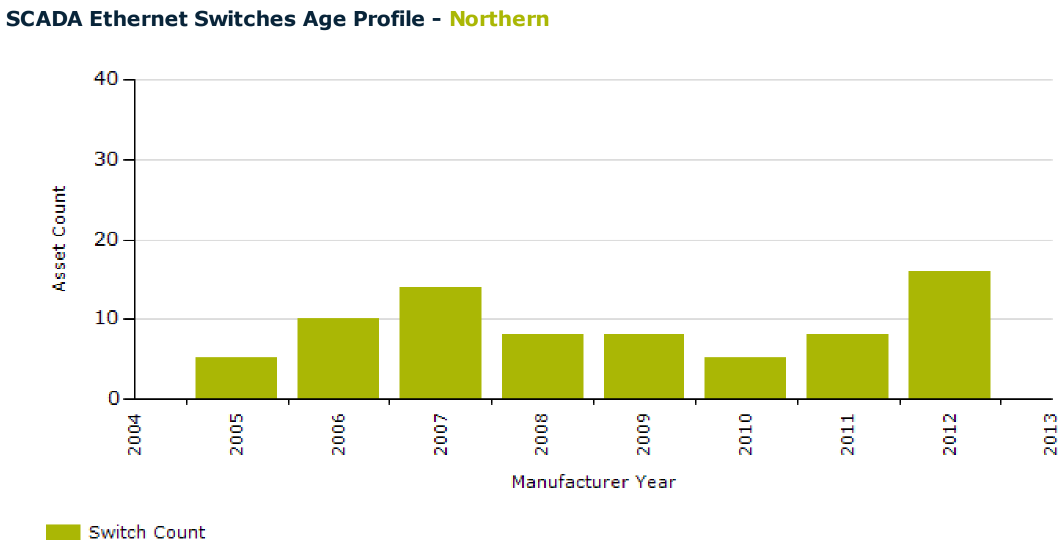

Figure 6-23 : SCADA ethernet switches age profile - Northern

6.3.8.2.1 Wireless Legacy Communication Systems

The Northern region's legacy radio system is based on 6 base stations and one repeater to cover most of the area. It is used for voice, data communication and demand side management applications. The system was installed in the 1990's. The planned migration of the services from the system has started with secondary system renewal and migration of the Northern SCADA system to Vector's Siemens Spectrum Power TG master station application.

In the Southern region, a similar radio network was installed comprising two base stations and three repeaters. One zone substation and five distribution substations are connected to the master station via this radio network. Vector's aim is to migrate those sites to the IP network. This will be achieved by upgrading the equipment on site and installing a 3G router. To enable Vector to become independent of third party mobile connection, Vector is investigating options to change the connection to the zone substation.

Conditions

The system is performing satisfactorily but is obsolete and is to be retired in the next five years.

Actions

As part of the secondary system migration.

6.3.8.2.2 Telephone Type Copper Pilot Communication Cables

Northern Region:

- Around 70% of the pilot cable used for operational communications are installed overhead, and are prone to environmental and lightning caused damage. They are generally in not good condition.
- Two types of pilot cables exist in the Northern region. One type is the pilot cable used for operation communication purposes and the other type is used for load management and street light control.

Conditions

- The overhead pilot cables are generally in unsatisfactory condition and Vector has been migrating operation communication services to optical fibre IP based network since 2006.

Actions

- As part of renewal of the secondary systems and migration to open standards IP communication system, pilot cables used for communication are to be gradually phased out.

Southern Region:

- The pilot cables in the Southern regions are all installed underground. They are used for operational communication services and teleprotection. They have been gradually phased out with migration to optical fibres and IP based communication network.

Conditions

- Most of the pilot cables are still in acceptable condition but there are a number of cables identified with unsatisfactory condition.

Actions

- As part of renewal of the secondary systems and migration to open standards IP communication system, pilot cable use for communication and teleprotection are to be gradually phased out.

6.3.9 Load Control Systems

Vector's load control system comprises audio control frequency ripple control plants, pilot wire system and cycle control plant that can manage or control:

- Residential hot water cylinders and space heating (load shedding);
- Street lighting;
- Meter switch for tariff control;
- Time shift load to improve network asset utilisation; and
- Time shift load to defer reinforcement of network assets.

An overview of Vector's load control systems (pilot and ripple based), with their associated age profiles, is given in Table 6-12 and Table 6-13.

It is recognised emerging technologies, notably smart meters and/or intelligent home energy control devices, are likely to supersede existing load control systems in the near to medium-term future. While Vector's intention is to maintain these to an acceptable standard during the transitional phase, the configuration of the Northern area street lighting and hot water pilot systems is such that a control signal is generated at each zone substation that then operates all lights or hot water loads along the feeders radiating from that substation. A fault in the pilots will affect all connected street lighting or hot water load after that fault. This can result in a very large area of road lighting being inoperable. In conjunction with Auckland Transport it is planned to improve the situation by splitting the road lighting into smaller areas by using photo electric cells that are dedicated to just that area thereby removing the need to rely on a signal that originates from a zone substation. Drawings of the pilot system have not been updated for many years. To reduce hot water load outages it is planned to begin preparing new drawings showing the locations of relays, pilot routes and the areas served by each pilot.

Network Area	Site	Type	Age (Years)	Protocol	Injection Bus (kV)
	Torbay	Pilot Wire	>50	Pilot Wire	11
	Waiake	Pilot Wire	>50	Pilot Wire	11
	James St	Pilot Wire	>50	Pilot Wire	11
	Wairau Valley	Pilot Wire	>50	Pilot Wire	11
	Bush Rd	Pilot Wire	>50	Pilot Wire	11
	Helensville	Pilot Wire	>50	Pilot Wire	11
	Manly	Pilot Wire	>50	Pilot Wire	11
	Belmont	Pilot Wire	>50	Pilot Wire	11
	Ngataringa Bay	Pilot Wire	>50	Pilot Wire	11
	Hauraki	Pilot Wire	>50	Pilot Wire	11
(Albany GXP)	Highbury	Pilot Wire	>50	Pilot Wire	11
	Balmain	Pilot Wire	>50	Pilot Wire	11
	Birkdale	Pilot Wire	>50	Pilot Wire	11
	Northcote	Pilot Wire	>50	Pilot Wire	11
	Hillcrest	Pilot Wire	>50	Pilot Wire	11
	Browns Bay	Pilot Wire	>50	Pilot Wire	11
	Sunset Rd	Pilot Wire	>50	Pilot Wire	11
	East Coast Rd	Pilot Wire	>50	Pilot Wire	11
	Forest Hill	Pilot Wire	>50	Pilot Wire	11
	Milford	Pilot Wire	>50	Pilot Wire	11
	Orewa	Pilot Wire	>50	Pilot Wire	11
	Woodford Ave	Pilot Wire	>50	Pilot Wire	11
	Te Atatu	Pilot Wire	>50	Pilot Wire	11
	Triangle Rd	Pilot Wire	>50	Pilot Wire	11
(Henderson GXP)	Hobsonville	Pilot Wire	>50	Pilot Wire	11
	Swanson	Pilot Wire	>50	Pilot Wire	11
	Riverhead	Pilot Wire	>50	Pilot Wire	11
	Simpson Rd	Pilot Wire	>50	Pilot Wire	11
	Henderson Valley	Pilot Wire	>50	Pilot Wire	11
	McLeod Rd	Pilot Wire	>50	Pilot Wire	11
	Laingholm	Pilot Wire	>50	Pilot Wire	11
(Hepburn GXP)	Brickworks	Pilot Wire	>50	Pilot Wire	11
	Atkinson Rd	Pilot Wire	>50	Pilot Wire	11
	Sabulite Rd	Pilot Wire	>50	Pilot Wire	11
	New Lynn	Pilot Wire	>50	Pilot Wire	11

Table 6-12 : Asset age profile - Northern region – pilot wire system

Network	Type	Year of Manufacture	Population
Northern	Rotary	1961	2
Northern	Rotary	1965	5
Northern	Rotary	1967	1
Northern	Rotary	1976	1

Network	Type	Year of Manufacture	Population
Northern	Cyclo	1983	2
Southern	Static	1990	3
Southern	Static	1992	1
Southern	Static	1993	2
Southern	Static	1994	2
Southern	Static	1995	5
Southern	Static	1996	1
Southern	Static	1997	1
Southern	Static	1999	1
Southern	Static	2002	1
Southern	Static	2005	1
Southern	Static	2006	1
Total (units)			**30**

Table 6-13 : Ripple load control population

6.3.10 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.

Approximately 116,000 poles support the overhead distribution network, of which 7.5% are wood and the remainder concrete. There are also steel towers and telescopic steel poles in the Northern region primarily supporting 110 and 33 kV circuits.

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, 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.[7]

The overhead structure population is summarised in Table 6-14 below by network area and material type.

[7] This is partly as a result of the manner in which assets are categorised under the previous ODV valuation prescribed by the Commerce Commission, where poles are not separately recorded.

Population	Concrete	Wooden	Total
Southern	45,620	5,590	51,210
Northern	62,265	2,693	64,958
Total	107,885	8,283	116,168

Table 6-14 : Overhead structures – population

The age profiles of the wooden and concrete poles on the Vector network are presented in Figure 6-24 and Figure 6-25.

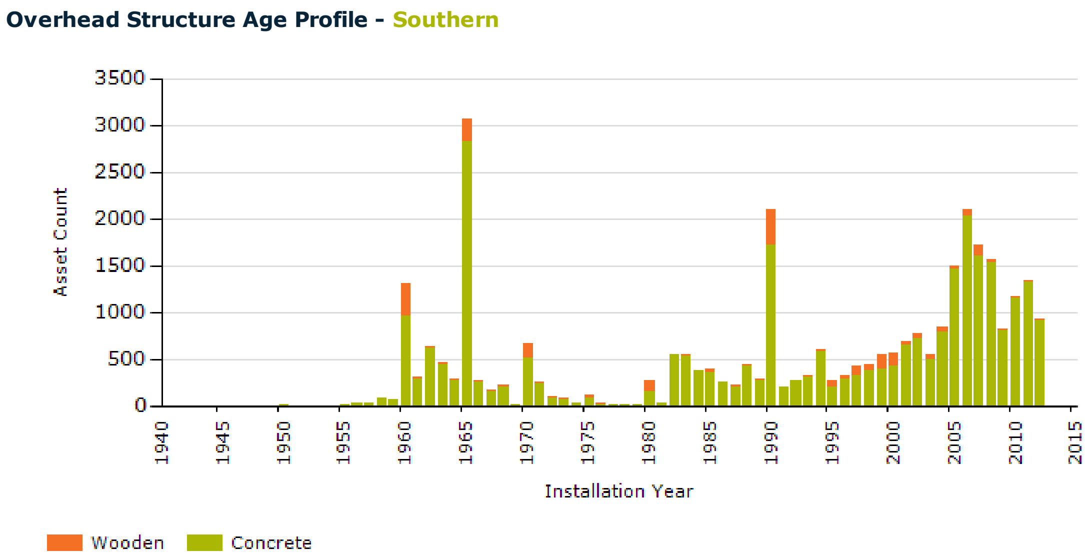

Figure 6-24 : Overhead structures age profile – Southern

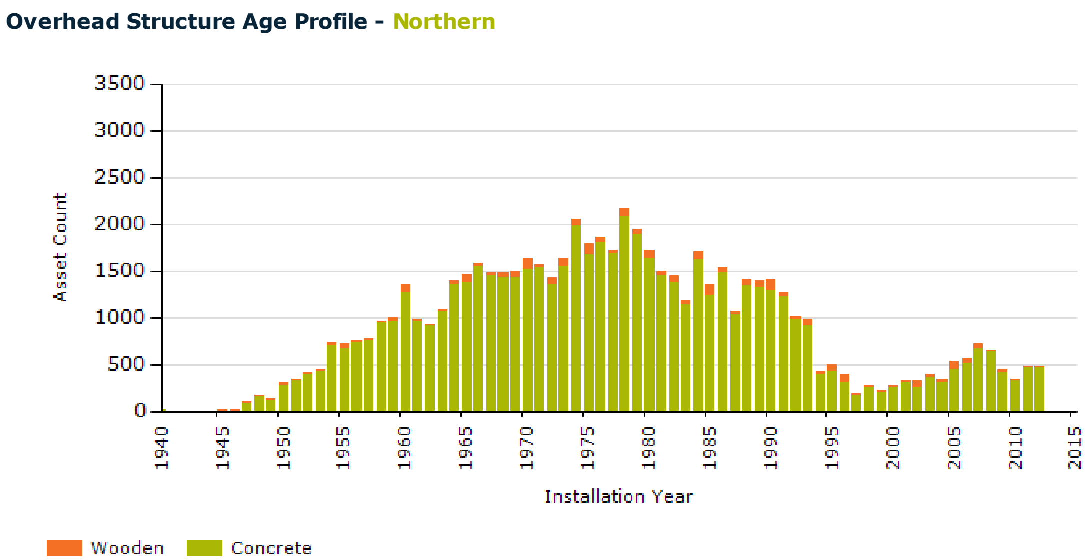

Figure 6-25 : Overhead structures age profile – Northern

There are 103 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 in good condition following extensive reconditioning works over the past few years.

6.3.10.1 Routine Asset Inspections, Maintenance and Testing

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:

Yearly

- 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/NZ 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/NZ 7000 and HB 331-212 is tagged and programmed for repair or replacement.

Refurbishment and Renewal Maintenance

- Any identified defect that renders a potentially unsafe situation to the public or property is repaired, replaced or isolated as soon as practicable, remediation timeframes are based on likelihood of failure creating the unsafe situation.

Fault and Emergency Maintenance

- Any identified defect likely to pose an imminent hazard to public and property is repaired, replaced or isolated immediately.

6.3.10.2 Maintenance and Refurbishment Programmes

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 annual inspection or 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.

6.3.10.3 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.[8]

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.

6.3.11 Overhead Conductors

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.

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[8] Recognising, however, that records for some of the older assets will remain unavailable.

The overhead conductor types and sizes vary across the overhead network and are predominantly copper (Cu), all aluminium conductors (AAC) or aluminium conductor steel reinforced (ACSR) conductors. A smaller quantity of all aluminium alloy conductor (AAAC) are being utilised for new line construction.

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. Table 6-15 below provides a summary of overhead conductor length by network area and operating voltage.

Population	110kV	33kV	22kV	11kV	LV
Southern	0 km	51 km	3 km	957 km	2,045 km
Northern	27 km	387 km	0 km	3,049 km	2,215 km
Total	27 km	438 km	3 km	4,006 km	4,259 km

Table 6-15 : Conductor - Population

Figure 6-26 and Figure 6-27 show the age profiles for all conductor voltages by region.

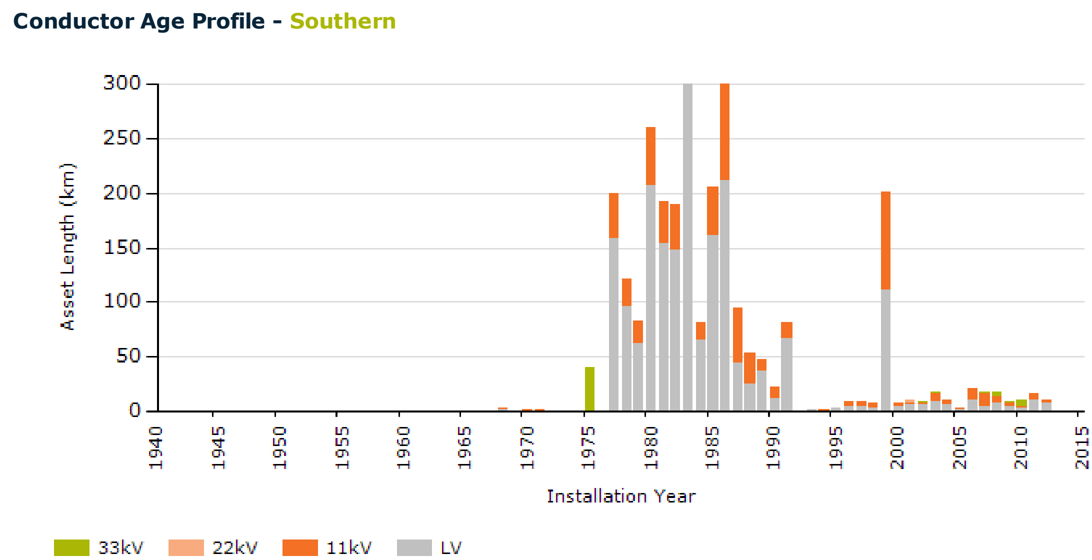

Figure 6-26 : Conductor age profile - Southern

Conductor Age Profile - Northern

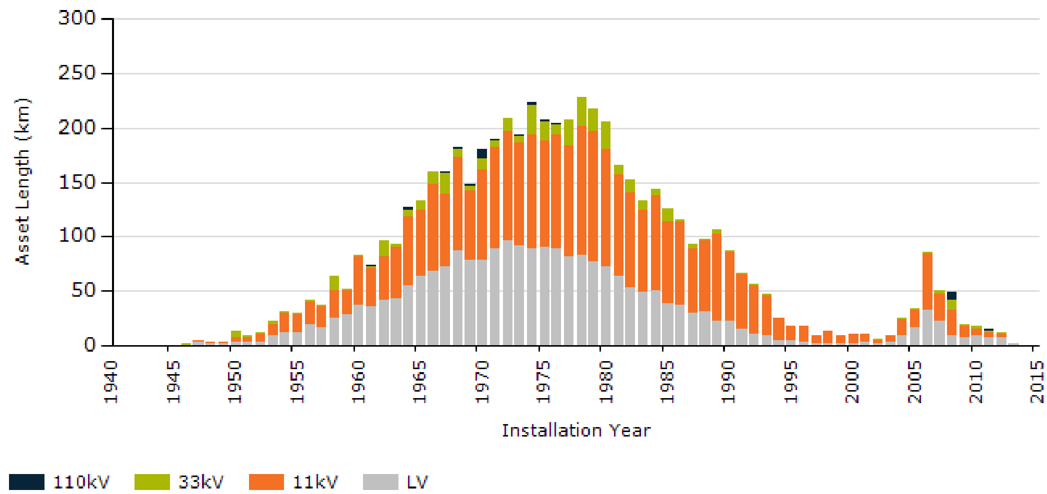

Figure 6-27 : Conductor age profile – Northern

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

6.3.11.1 Routine Asset Inspections, Maintenance and Testing

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:

Yearly

- 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.

Refurbish and Renewal Maintenance

- Any identified defect that renders a potentially unsafe situation to the public or property is repaired, replaced or isolated as soon as practicable. Remediation timeframes are based on likelihood of failure creating the unsafe situation.

Fault and Emergency Maintenance

- Any identified defect likely to pose an imminent hazard to public and property is repaired, replaced or isolated immediately.

6.3.11.2 Maintenance and Refurbishment Programme

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.

6.3.12 Overhead Switchgear

Overhead switches include MV air break switches (ABS), isolating links, SF_6 switches and 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.

In more recent times the installation of new enclosed switches has been triggered by Vector's Standard ENS-0055 which is to replace ABSs with an enclosed switch when the opportunity or condition arises.

Table 6-16 shows the population of overhead switches on the Vector network.

Population	Air Break	Gas Break	Recloser	Sectionaliser
Southern	345	215	27	13
Northern	625	263	101	30
Total	970	478	128	43

Table 6-16 : Overhead switchgear - population

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.

The age profiles in Figure 6-28 and Figure 6-29 below clearly show the transition to enclosed switches in more recent times.

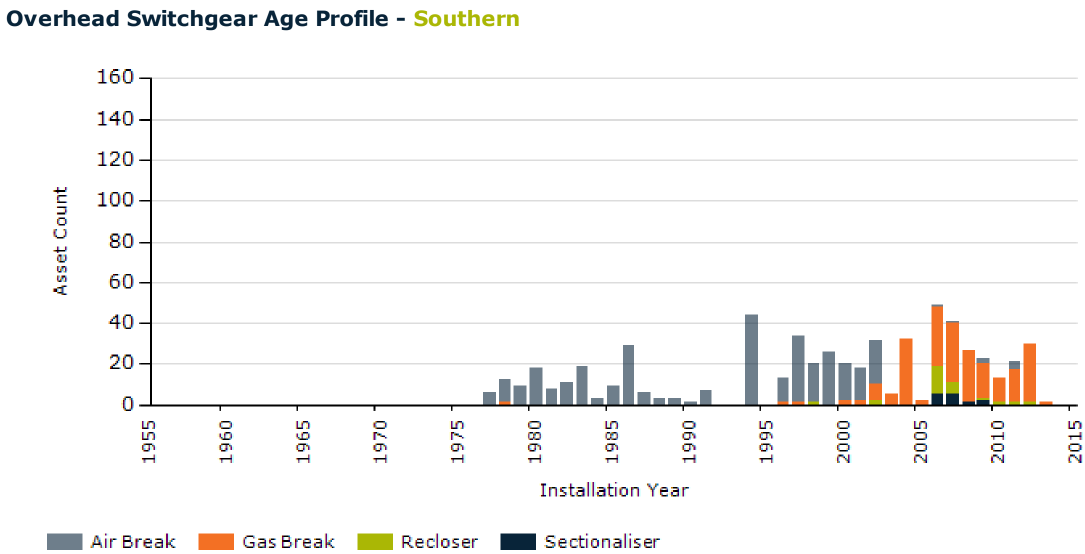

Figure 6-28 : Overhead switchgear age profile – Southern

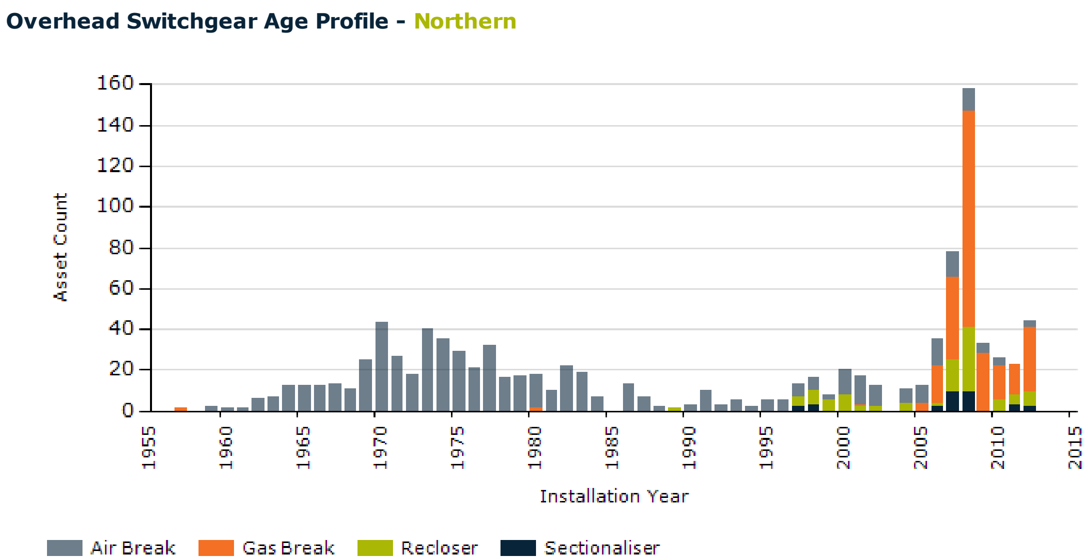

Figure 6-29 : Overhead switchgear age profile - Northern

6.3.12.1 Condition of the Asset

Most of the ABSs are more than 20 years old and are in good to fair condition. The vast majority of the SF_6 switches are less than eight years old and are in excellent condition.

The reclosers are a mixture of older oil-filled units and the newer vacuum or SF_6 insulated equipment. The older oil-filled reclosers are in good condition and the SF_6 and vacuum reclosers and sectionalisers are in excellent condition.

6.3.12.2 Routine Asset Inspections, Maintenance and Testing

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:

Yearly

- 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.

Three-Yearly

- 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.

Five-Yearly

- 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.

Nine-Yearly

- 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 Renewal Maintenance

- Any identified defect that renders a potentially unsafe situation to the public or property is repaired, replaced or isolated as soon as practicable. Remediation timeframes are based on likelihood of failure creating the unsafe situation;
- Non-compliant earthing locations may require additional electrodes, asphalt patching, gradient rings, equipotential grids, fenced or non-conductive enclosures or wider network solutions such as neutral earthing resistors;
- An identified MV ABS defect that meets the operating constraint criteria will require switch replacement if still essential, modern replacement being an enclosed SF_6 switch;
- An identified gas break switch defect that meets the operating constraint criteria, specifically loss of pressure, will require switch removal and return to the manufacturer for repair assessment and acceptance testing;

- Connectors with identified thermal hotspots greater than 15 degrees above surroundings are replaced;
- Switch contacts with identified thermal hotspots greater than 15 degrees above surroundings will require switch replacement if still essential, modern replacement being an enclosed SF_6 switch; and
- Minor mechanical defects such as operating handles require repair.

Fault and Emergency Repair

- All identified defects that pose an unsafe condition for public and property require immediate repair, replacement or isolation.

6.3.12.3 Maintenance, Refurbishment and Replacement Programme

ABSs are maintained when tested. The gas switches are fully enclosed and do not require maintenance. They are expected to have a life of about 40 years.

ABSs are replaced by an enclosed switch if they have to be removed from the pole because of a defect. They are not refurbished. Faulty gas switches are returned to the supplier.

There is no proactive replacement programme for ABSs. However, when coincident overhead replacement and pole replacements occur, any associated ABSs are replaced with gas switches. 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.

While condition data is being collected during routine inspections, as noted above, many ABSs will be replaced before the end of their life. Consequently, 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.

6.3.12.4 Systemic Issues

Vector is not experiencing any systemic operational problems with its overhead switches.

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.

6.3.13 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.

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.

6.3.13.1 Routine Asset Inspections, Maintenance and Testing

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 Renewal Maintenance

- Any identified defect that renders a potentially unsafe situation to the public or property is repaired, replaced or isolated as soon as practicable. Remediation timeframes are based on the likelihood of failure creating an unsafe situation.

Fault and Emergency Maintenance

- Any identified defect likely to pose an imminent hazard to public and property is repaired, replaced or isolated immediately.

6.3.13.2 Maintenance, Refurbishment and Replacement Programme

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.

6.3.13.3 Systemic Issues

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 service. Only durability class 1 crossarms (longer life) are now installed on the network.

Vector has 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 are not separately identified.

6.3.14 Overhead Cable Terminations

Terminations are the connection points between underground cables and the overhead network and include all 11 kV, 22 kV and 33 kV pole terminations. There are different types of these terminations in service.

Table 6-17 below shows the riser cable population breakdown by network area and operating voltage.

Population	33kV	22kV	11kV	Total
Southern	15	4	2,719	2,738
Northern	181	0	5,417	5,598
Total	196	4	8,136	8,336

Table 6-17 : Riser Cable Termination - Population

Figure 6-30 and Figure 6-31 provide the age profiles of riser cable terminations for each network area by appropriate voltage levels.

Riser Cable Terminations Age Profile - Southern

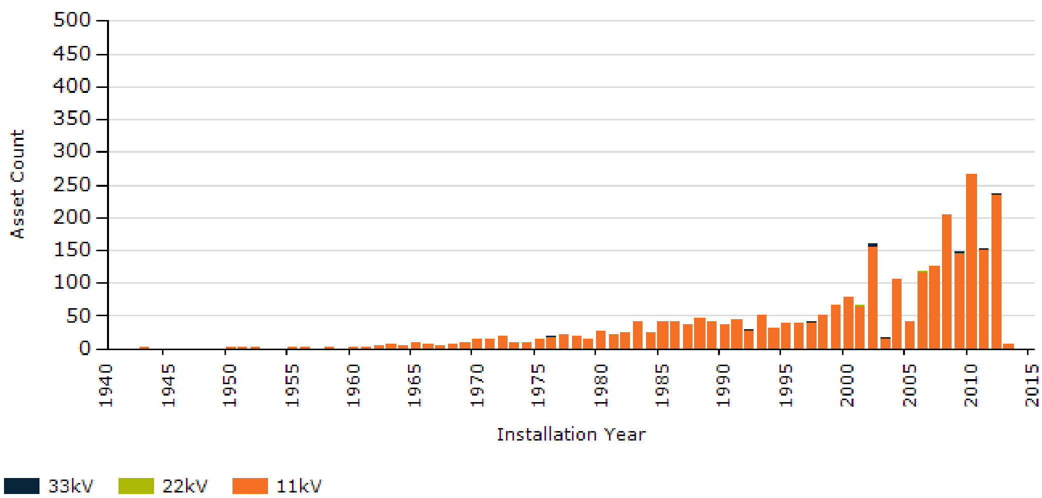

Figure 6-30 : Riser cable termination age profile – Southern

Riser Cable Terminations Age Profile - Northern

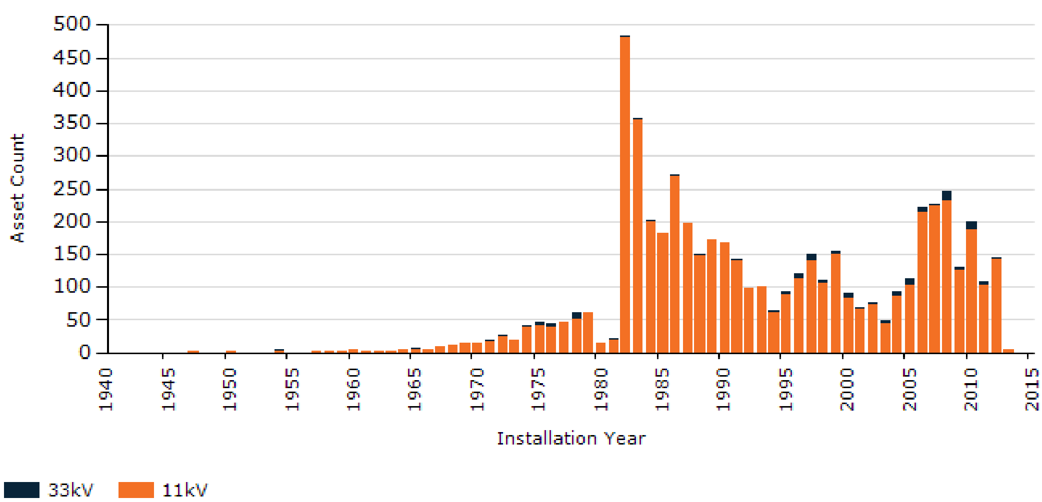

Figure 6-31 : Riser cable termination age profile – Northern

6.3.14.1 Routine Asset Inspections, Maintenance and Testing

The routine inspection, maintenance and testing requirements for Vector's riser cable terminations are prescribed in the Vector Network Standard, ENS-0187 Overhead Network Condition Assessment. There are no routine testing requirements for riser cable terminations.

In summary ENS-0187 defines the following routine actions:

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.

Refurbishment and Renewal Maintenance

- Any identified defect that renders an unsafe situation to the public or property is repaired, replaced or isolated as soon as practicable. Remediation timeframes are based on likelihood of failure creating the unsafe situation.

Fault and Emergency Maintenance

- Any identified defect likely to pose an imminent hazard to public and property is repaired, replaced or isolated immediately.

6.3.14.2 Systemic Issues

For legacy reasons, historical records and the resulting age profiles are not completely accurate.

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.

6.3.15 Overhead Network - General

Various components of the overhead network are separately discussed below. In this section some general issues regarding the overhead network, with assets that do not fit within specific categories, are noted.

All overhead structures and supported equipment are visually inspected every 12 months. Components requiring replacement are identified during the annual overhead inspection or one of the more detailed equipment inspections.

Maintenance of the overhead network is a mix of reactive (based on faults) response and condition monitoring that drive preventative maintenance programmes. With the exception of gas switches and vacuum reclosers, which are returned to the supplier for refurbishment, damaged overhead equipment is not refurbished or salvaged as it is not cost effective to do so.

6.3.15.1 Systemic Issues

Conductor Insulator Ties

- Early preformed conductor ties used a rubber cushioning packer that has a tendency to perish and cause TV interference. These are being replaced as they fail.

Insulators

- Kidney type insulators are prone to failure and are a common source of TV interference. The use of kidney insulators has been superseded by ceramic and glass disc and polymer strain insulators.

Pole Transformer King-Bolts

- 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.
- 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.

110 kV Conductor Corrosion

- The single and double circuit 110 kV lines may require maintenance to replace sections of corroded conductor and further measures to prevent on-going corrosion. Corrosion sites have been detected at the insulator clamps, but the extent of this is still to be determined. Further investigation will be carried out during 2014.

6.3.16 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.

Table 6-18 below shows the breakdown of distribution cables by network area and operating voltage.

Population	22kV	11kV	LV	Total
Southern	48 km	2,084 km	3,141 km	5,273 km
Northern	0 km	1,325 km	1,943 km	3,268 km
Total	48 km	3,409 km	5,084 km	8,541 km

Note: Quantities exclude pole riser lengths of 8m per LV termination, 9m per 11 kV and 22 kV termination, and 10m per 33 kV terminations

Table 6-18 : Distribution Cable - Population

Age profiles for the distribution cables, per category and broken down per network, are given in Figure 6-32 and Figure 6-33.

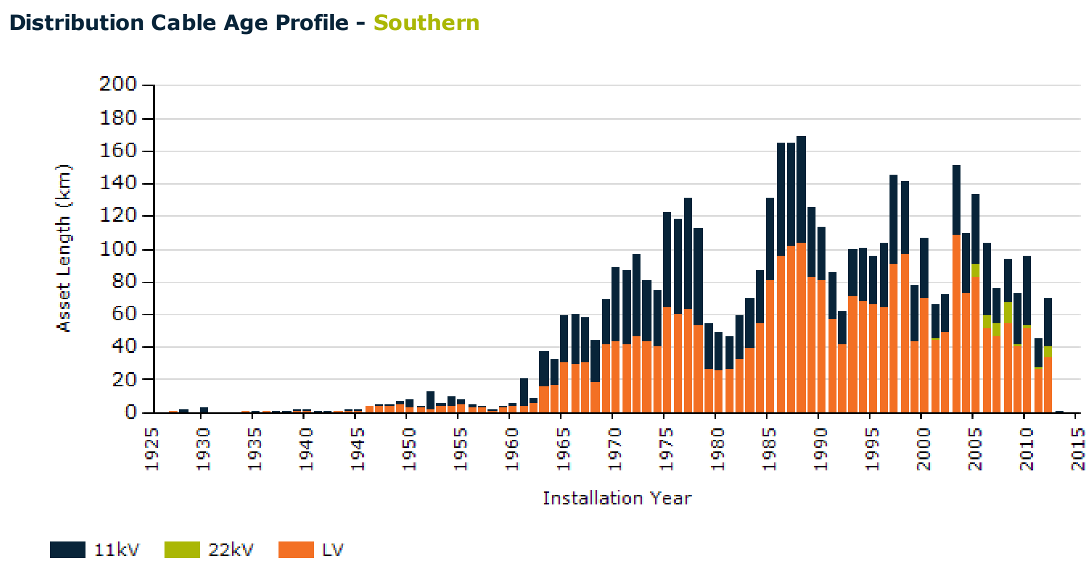

Figure 6-32 : Distribution cable age profile – Southern

Distribution Cable Age Profile - Northern

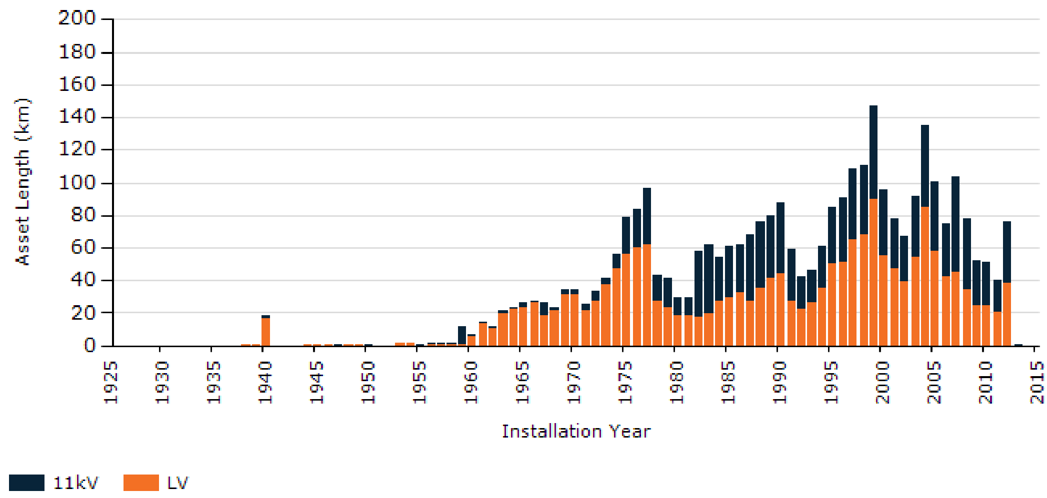

Figure 6-33 : Distribution cable age profile – Northern

6.3.16.1 Routine Asset Inspections, Maintenance and Testing

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.

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.

6.3.16.2 Asset Condition

In the past, some 6.6 kV rated PILC cables were determined to be able to be energised at 11 kV, and in most cases have successfully operated at this voltage for many years.

However, some of these are now becoming more prone to failure. The associated issues are further discussed below.

The 11 kV rated PILC cables are generally operating satisfactorily.

The XLPE insulated cables are in good condition, with the exception of the early natural polyethylene ('poly') cables noted below.

6.3.16.3 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: 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;
- 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.

6.3.17 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.

6.3.17.1 Routine Asset Inspections, Maintenance and Testing

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:

Annual

- 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.

Three-Yearly

- 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.

Five-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 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 Renewal Maintenance

- Non-compliant earthing locations may require additional electrodes, asphalt patching, gradient rings, equipotential grids, fenced or non-conductive enclosures or wider network solutions such as neutral earthing resistors.

Fault and Emergency Maintenance

- All identified defects that pose an unsafe condition for public and property require immediate repair, replacement or isolation.

6.3.17.2 Maintenance, Refurbishment and Replacement Programme

Earthing cables are only maintained if they are visibly unsound, missing, undersized or test results fall outside the limits given in Vector's distribution earthing maintenance standard.

Predicted future expenditure is based on the assumption the replacement/refurbishment rate will continue at the present rate.

6.3.18 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.

The older aluminium pillars are generally adequate for their purpose although many have suffered knocks and minor vehicle impact.

Installation of pits began about ten years ago and comprehensive inspections to date have not shown up any significant maintenance issues.

Table 6-19 provides a summary of the total pillars and pits in use on the Vector network. This includes service and link pillars, service pits (Total Underground Distribution System (TUDS)) and underground network link boxes.

Population	Pillars	Pits	Total
Southern	58,952	24,663	83,615
Northern	24,453	2,282	26,735
Total	83,405	26,945	110,350

Table 6-19 : LV Pit and Pillar - Population

Figure 6-34 and Figure 6-35 show the pillar and pit age profiles for each region.

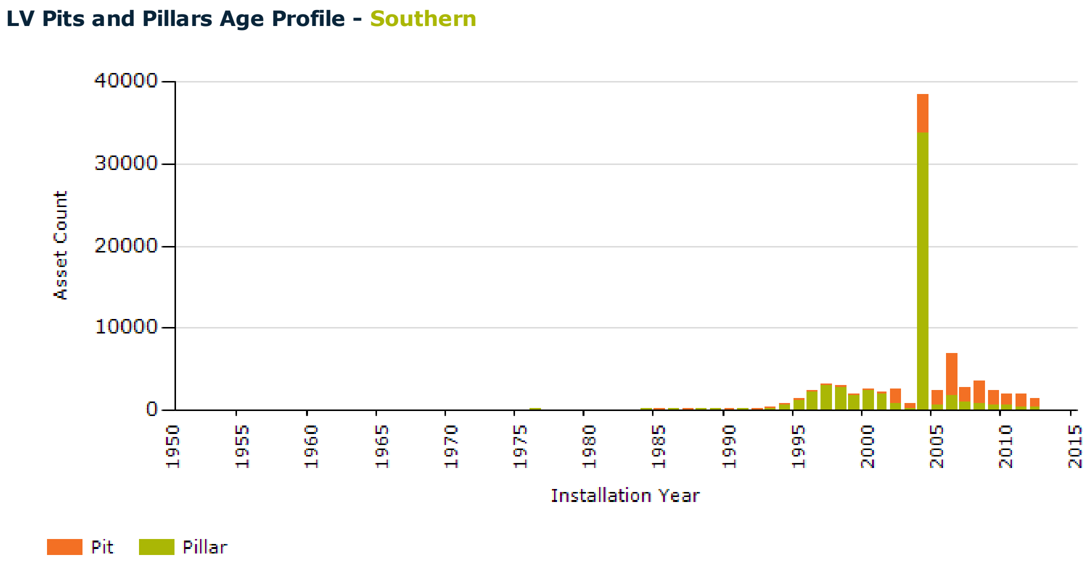

Figure 6-34 : LV pits and pillars age profile – Southern

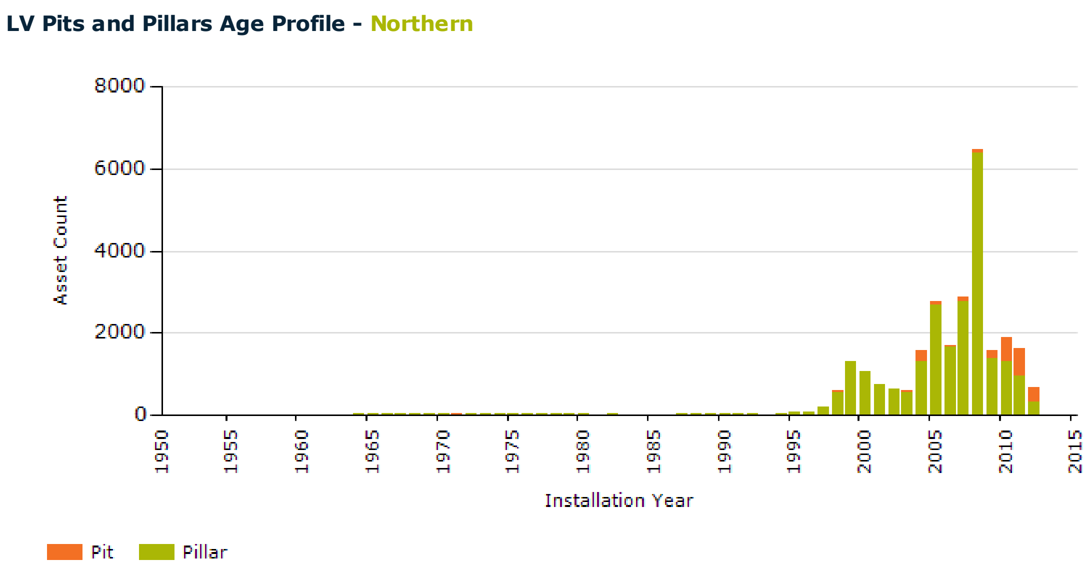

Figure 6-35 : LV pits and pillars age profile - Northern

6.3.18.1 Asset Condition

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 smaller box will be installed.

6.3.18.2 Routine Asset Inspections, Maintenance and Testing

The routine inspection, maintenance and testing requirements for Vector's earthing systems 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.

Refurbish and Renewal Maintenance

- Vegetation that cannot be easily removed or trimmed may require the relocation of the affected pit or pillar;
- Buried or low seated pillars are uncovered and raised. In some cases they may require relocation;
- Assets on private property that exhibit identified defects and require repair or replacement are relocated to the road reserve;
- A pillar due for relocation or replacement will be assessed for suitable pit replacement depending on number of circuits and required capacity for; and
- Minor repairs on site include removal of vegetation, replacement of lid screws, new connectors, corrosion treatments, repainting.

Fault and Emergency Maintenance

- Hazardous defects identified resulting in potential unsafe situations for public or property, are repaired, replaced or isolated immediately.

6.3.18.3 Maintenance, Refurbishment and Renewal Programme

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 remaining mushroom pillars is ongoing, asset surveys have identified the majority of remaining locations; these will be replaced in FY13.

Replacement of underground network boxes has been included as a separate expenditure item. At present there is no history of such replacement and a small provisional sum only is allowed over the next five years.

6.3.18.4 Systemic Issues

For legacy reasons, historical records and the resulting age profiles are not completely accurate.

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.

Progressive removal of mushroom type pillars has been a priority in the Northern network over the last five years; this programme has addressed the removal of mushroom pillars in all clustered areas of the network eg. subdivisions, any remaining ad-hoc mushroom pillars that are found in the Northern region are being replaced with a polyethylene pillar for safety reasons.

6.3.19 Distribution Transformers

Distribution transformers convert distribution voltage levels (typically 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. Vector's distribution transformers are generally 11kV/415V and rated between 15kVA and 1,000kVA. 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.

Transformers are either ground or pole mounted. Ground mounted transformers are either stand-alone, enclosed in metal or fibreglass canopies, installed in open enclosures or installed in a building. They can be further categorised into industrial, cubicle or package types. 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.

All cubicle style transformers that are installed as part of overhead improvement projects are connected to the HV cables by dead-break screened plug-in cable connectors. The connection to the LV cables is through cable lugs and bolted connections to the transformer bushing flag. Ringmain units are installed in the medium voltage compartment of some cubicle style transformers.

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 the development of the 22kV underground distribution networks in the Auckland CBD and Highbrook Business Park, 22kV/415V ground mounted transformers are being installed. Transformers for these two networks 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. The transformers are connected to the HV cables by dead-break screened plug-in cable connectors. The connection to the LV cables is by cable lugs and bolted connections to the transformer bushing flag.

Transformers installed on the network are presently supplied by either ABB or ETEL.

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.

The population and age profiles of Vector's distribution transformers on each network are shown in Table 6-20, Figure 6-36 and Figure 6-37.

Population	Pole Mounted	Ground Mounted	Total
Southern	2,116	6,258	8,374
Northern	5,563	6,862	12,425
TOTAL	7,679	13,120	20,799

Table 6-20 : Distribution transformer - population

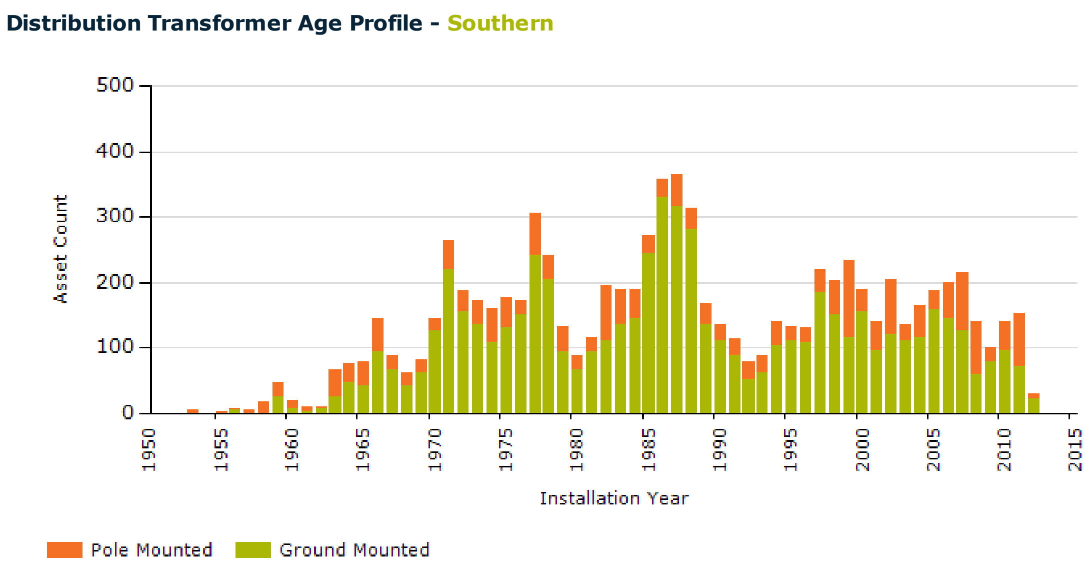

Figure 6-36 : Distribution transformers age profile – Southern

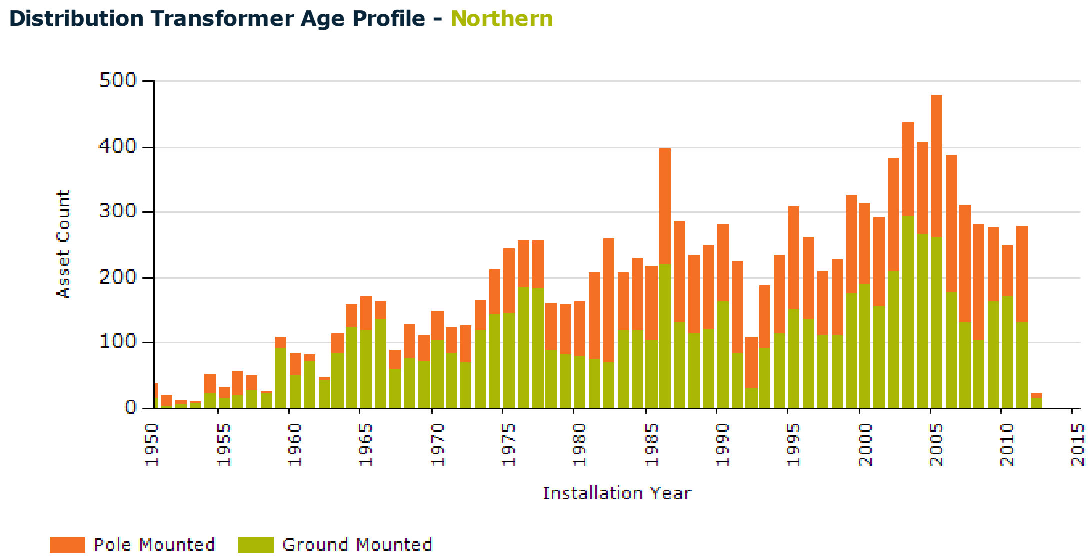

Figure 6-37 : Distribution transformers age profile - Northern

6.3.19.1 Asset Condition

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.

6.3.19.2 Routine Asset Inspections, Maintenance and Testing

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.

6.3.19.3 Maintenance, Refurbishment and Renewal Programme

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.

6.3.19.4 Systemic Issues

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.

6.3.20 Auto and Phase Shifting Transformers

An auto transformer is an electrical transformer with only one winding. A portion of the winding is common to both the primary and secondary circuits. The winding has at least three electrical connection points called taps. The voltage source and the load are each connected to two taps. One tap at the end of the winding is a common connection to both circuits (source and load). Each tap corresponds to a different source or load voltage.

A phase shifting transformer is a transformer that creates an output voltage with an altered phase angle compared to the input voltage, but with the same amplitude.

There are 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.

6.3.20.1 Routine Asset Inspections, Maintenance and Testing

Inspection of the auto transformers and phase shifting transformer is carried out in accordance with Vector Standard ENS-0188. The frequency of inspection is the same as that for ground mounted distribution transformers, currently four-yearly.

Electrical testing is not carried out on the auto transformers and phase shifting transformers, unless there is an issue with a transformer which needs to be investigated and resolved.

Thermal imaging and PD and acoustic discharge testing is presently carried out as part of the inspection programme.

Transformer Condition Analysis (TCA) on oil samples from the 22kV/11kV auto transformer is presently carried out. It is planned that this test for the phase shifting transformer will be added to the activities carried out by the field service provider.

6.3.20.2 Maintenance, Refurbishment and Renewal Programme

Preventative maintenance of the auto transformers and phase shifting transformer is on a time-based inspection regime and is carried out in accordance with Vector Standard ENS-0051. Onsite maintenance is generally minor and includes such items as oil top up, minor rust treatment and paint repairs.

The 11kV/6.6kV auto transformer was refurbished in 2011 prior to being installed at MOTAT. Due to the relatively young age of the 22kV/11kV auto transformer and the phase shifting transformer, their good condition and economic life, there is currently no refurbishment programme for these units.

There is no replacement programme for the auto transformers or the phase shifting transformer.

6.3.21 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. All the voltage regulators installed on the network have been supplied by Siemens, either 165kVA or 220kVA, and with the exception of the Puhoi Regulator which is a three phase unit, all other sites are single phase regulators connected in an open delta arrangement.

The mechanical condition of the regulators on the Southern network is poor as both sites are located very close to the coastline, this results in increasing corrosion on the regulator tanks and controller boxes. The electrical condition however, is good.

As noted, corrosion of the regulator tanks and the controller boxes is occurring on some voltage regulators. Those single phase regulators in poor condition may need to be removed from service and refurbished under corrective maintenance.

6.3.21.1 Routine Asset Inspections, Maintenance and Testing

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.

6.3.21.2 Maintenance, Refurbishment and Renewal Programme

Preventative maintenance of voltage regulators is on a time-based inspection regime and is carried out in accordance with Vector Standard ENS-0061. Onsite maintenance is generally minor and includes such items as oil top up, minor rust treatment and paint repairs.

Presently there is no refurbishment programme for voltage regulators as they are relatively new (1997 being the oldest installation).

Again, as the voltage regulators are quite new, it is expected that the existing installations will be on the network for some time (20 or more years) and as such there are no planned replacement programmes.

6.3.22 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-0090 or 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 11kV with small quantities of 24kV units. 24kV rated SF switchgear is installed on the 22kV distribution networks in the Auckland CBD and Highbrook Business Park.

The predominant distribution switchgear range of manufacturers and types are presented as follows; based on Vector's functional definition of switchgear insulation and arc-quenching mediums.

Oil filled Switchgear – insulation is oil, arc-quenching mediums are oil:

- Andelect - SD, SD2, SD3, SD2TN, SDAF, SDAF3, SDM, SDF, SDF3; 38%
- ABB - SD, SDAF, SDAF3, SD, SD2, SD3; 16%
- Long & Crawford - GF3, ETV2, R4, J2, J4, T4GF3, ALD2P; 39%
- Astec – SD, SDT2N,SD3, SDAF, SDAF3; 1%
- Lucy – FRMU Mk1A; 0.5%
- Southwales – C4X, D4XD; 0.5%

Solid Insulation Switchgear – insulation is resin, arc-quenching medium is air:

- Holec - Magnefix, Hazemeyer; 1%

Sulphur Hexafluoride (SF_6) - insulation is SF_6, arc-quenching medium is SF_6 or vacuum:

- ABB - SafeLink, SafePlus, SafeRing, UniSwitch; 3%
- Schneider – RN2c, RN6c, RM6, FBX-E; 0.5%
- Ormazabal - GAE2K, GA2K1TS-C, GA3K1TS-C; 0.5%

SAP records indicate there are 9,000 distribution switch units on Vector's network. (Note that a unit is defined as a maintainable tank ie. an ETV2, J4 and SDAF are each one tank, as is an SDAF3, GF3 and T4GF3. For solid insulation type switchgear, a cabinet containing multiple cable units and a fuse unit is defined as a maintainable tank.) Table 6-21 summarises the number of switchgear units on the network.

Population	Oil	Solid	SF_6	Total
Southern	6,279	0	497	7,076
Northern	1,728	112	84	1,924
Total	8,307	112	581	9,000

Table 6-21 : Ground mounted distribution switchgear - population

An age profile of Vector's ground mounted distribution switchgear on each network is shown below in Figure 6-38 and Figure 6-39.

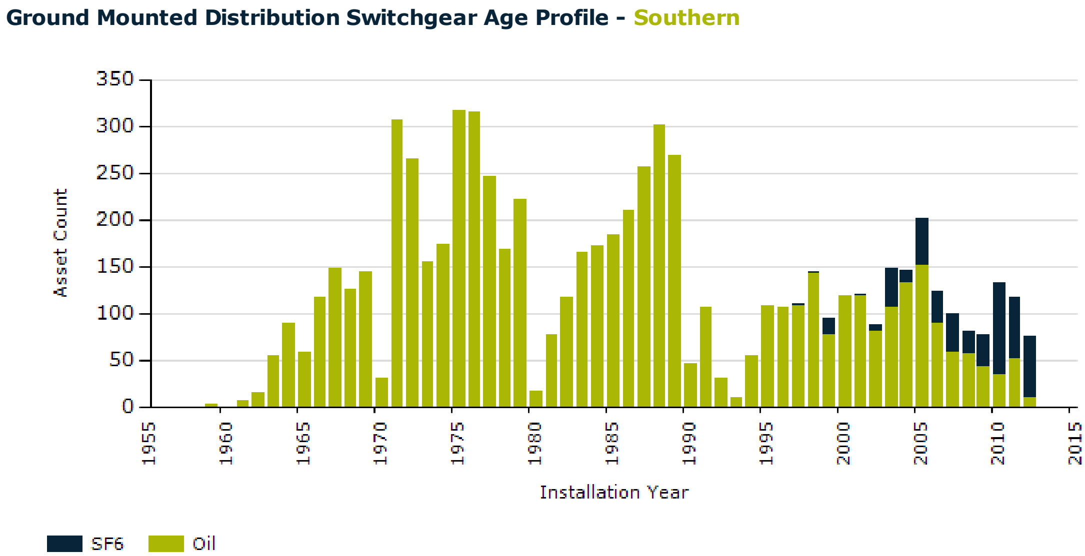

Figure 6-38 : Ground mounted distribution switchgear age profile - Southern

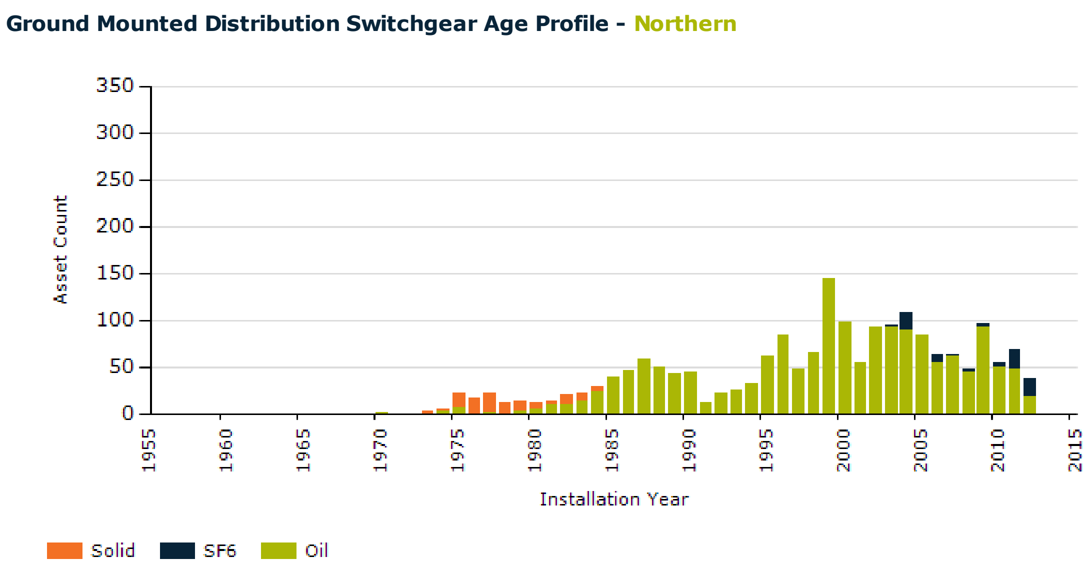

Figure 6-39 : Ground mounted distribution switchgear age profile – Northern

6.3.22.1 Asset Condition

In general the condition of switchgear is good, although there are oil-filled SD 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 SD 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. The risk is identified as AIAE3003 on the Asset Investment Engineering risk register; 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. The risk is identified as AIAE3042 on the Asset Investment Engineering risk register.

6.3.22.2 Routine Asset Inspections, Maintenance and Testing

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.

6.3.22.3 Maintenance, Refurbishment and Renewal Programme

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 was stopped at the end of September 2009 but it is planned to reintroduce it as oil-filled switchgear is required for fault situations during the transition 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.

6.3.22.4 Systemic Issues

For legacy reasons, historical records and the resulting age profiles are not completely accurate.

6.3.23 Ground Mounted Distribution Enclosures

Distribution equipment enclosures are used to accommodate Vector's ground mounted distribution equipment. There are many types of enclosures. They are defined as follows:

- Building - a free-standing concrete or concrete block structure with a roof or room housing Vector's distribution equipment;
- Open enclosure - a rectangular structure, without a roof, made of fibre panels, timber, metal, wire mesh or concrete block housing Vector's distribution equipment; and
- Enclosure - a structure, with a roof, made of metal or fibreglass housing Vector's distribution equipment.

The population breakdown for distribution equipment enclosures is given in Table 6-22. An age profile of Vector's equipment enclosures on each network is shown in Figure 6-40 and Figure 6-41.

Network	Population
Southern	6193
Northern	6990
Total	13183

Table 6-22 : Ground mounted distribution enclosures – population

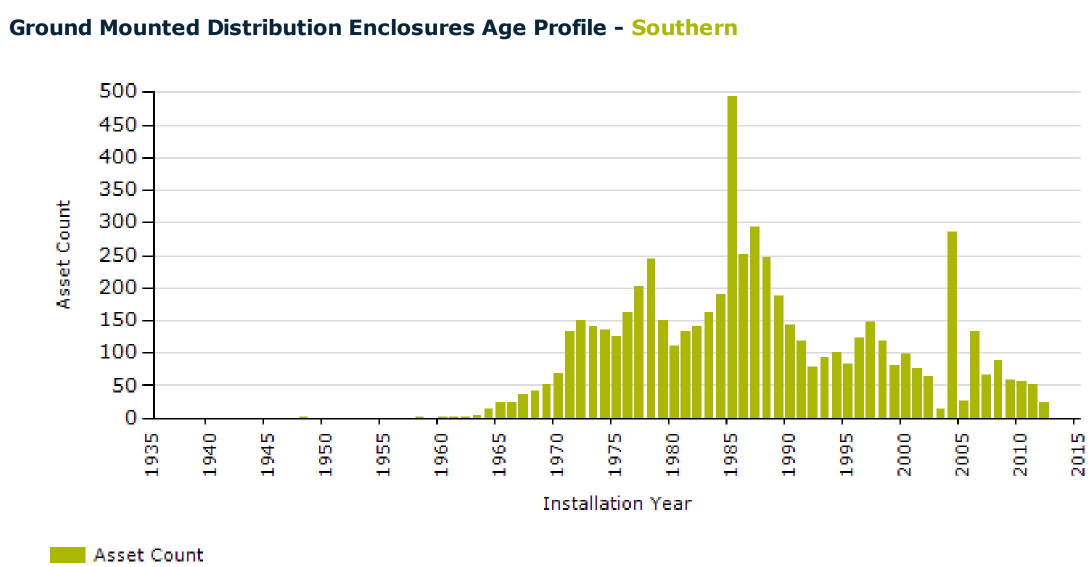

Figure 6-40 : Ground mounted distribution enclosures age profile – Southern

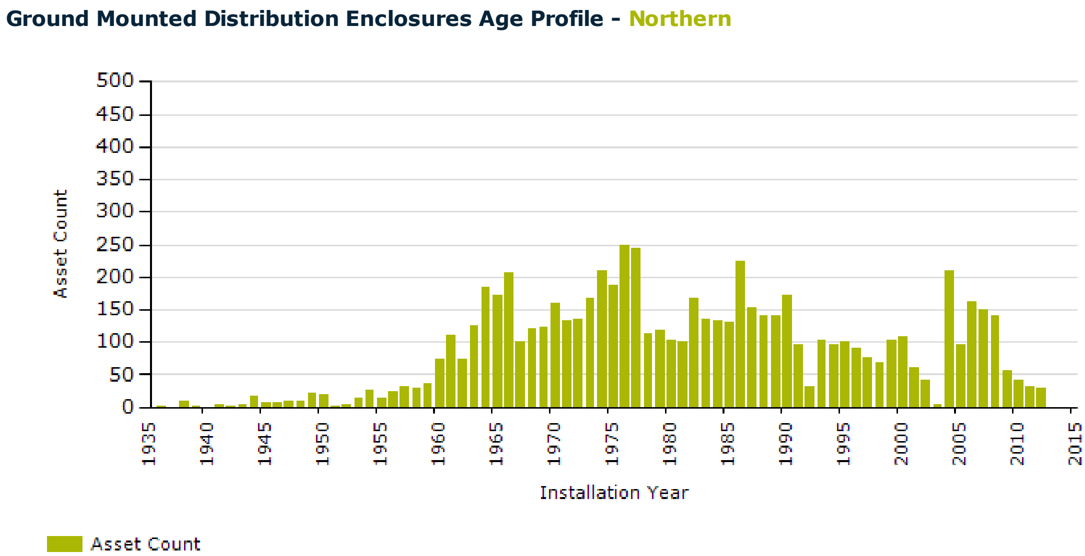

Figure 6-41 : Ground mounted distribution enclosures age profile – Northern

In general the condition of the majority of distribution equipment enclosures is good. There are no systemic issues.

6.3.23.1 Routine Asset Inspections, Maintenance and Testing

The frequency of inspection of distribution equipment enclosures is carried out in accordance with Vector Standard ENS-0188. The frequency of inspection is four-yearly.

There is no test programme for the enclosures.

6.3.23.2 Maintenance, Refurbishment and Renewal Programme

Preventative maintenance of distribution equipment enclosures is on a time-based inspection regime and is carried out in accordance with Vector Standard ENS-0053. Repairs are generally minor.

There is no refurbishment or replacement programme currently under consideration.

6.3.24 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.

LV frames are presently supplied by Reticulation Development Ltd, Hamer Ltd, Jean Muller NZ Ltd and ETEL.

6.3.24.1 Routine Asset Inspections, Maintenance and Testing

LV switchboards and frames are visually inspected as per Vector standards. Thermal imaging is carried out on LV frames every four years.

6.3.24.2 Asset Condition

LV frames of both types are generally in good condition.

6.3.24.3 Systemic Issues

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.

6.3.24.4 Maintenance, Refurbishment and Renewal Programme

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 Section 6.3.23.1 "Asset Condition" above, a frame replacement programme is planned to be carried out over the next ten years.

6.3.25 Power Factor Correction Equipment

In the Southern region there is 153MVAr of capacitor banks installed in 25 zone substations. These capacitor banks are connected to the 11kV switchboards at zone substations and are rated at 3MVAr each. Up to three banks are connected to a zone substation. In the Northern area there are 58 pole mounted 11kV capacitor banks each rated at 750kVAr.

The 11kV capacitors in both regions were installed during 1998/99. About 25% of the original 78 pole mounted banks have been removed because of failure/corrosion/ overhead improvement projects/3rd party incidents etc. The zone substation 11kV capacitors are in good condition, but associated equipment such as enclosures are showing signs of deterioration. The capacitors are housed in weatherproof enclosures. Many of these enclosures are located outdoors, are manufactured from painted mild steel and are rusting. Failures have been caused by water entering the outdoor enclosures. The mounting of the CTs in the enclosures has been causing damage to the potting compound. New CTs and a redesigned mounting system are required. The capacitors at Liverpool have suffered from a reactor fault and require major reconstruction.

6.3.25.1 Inspection and Test Programme

11kV pole mounted capacitors are inspected annually as part of the overhead inspection programme.

11kV and 33kV zone substation capacitors are visually inspected every two months. (Vector Standard ENS-0192).

6.3.25.2 Maintenance, Refurbishment and Renewal Programme

11kV pole mounted capacitors are maintained by cleaning the devices, checking connections and replacing the batteries in the controllers of the switched units at eight yearly intervals. The capacitance of the cans is measured during an eight-yearly maintenance cycle (Vector Standard ENS-0048). Components from removed capacitor banks in good condition are recovered and used to maintain the existing banks. Studies are being carried out to determine whether we need to replace these banks and possibly add more in line with Transpower's new requirement for Vector's network to operate with a high power factor. All installed 11kV zone substation capacitors are inspected every two years, bushings and filters are cleaned and connections checked. The capacitance of the cans is measured, secondary injection performed on the protection relays, the CBs ductored and insulation resistance measured during a four yearly testing cycle (Vector Standard ENS-0192).

6.3.26 11 kV Energy and Power Quality Metering System

6.3.26.1 Asset Description

There are 65 combined energy and PQ meters installed at Transpower grid exit point (GXP) substations and in Vector's distribution network, primarily at zone substation level (refer Table 6-29 below for breakdown). There are four portable PQ meters. The meters communicate via IP network to the metering enterprise applications.

At GXP level, the meters are deployed to provide check metering function to Transpower's revenue metering installations. The meters are connected to check the metering instrument transformers owned by Transpower. The meters also receive pulse streams from Transpower's metering system and provide comparisons between the two systems.

At the control centre ION Enterprise software is deployed for monitoring of real-time power conditions, analyse PQ and reliability, and respond quickly to alarms to avoid critical situations.

The meters are also configured to detect under-frequency events in the network and initiate load shedding.

6.3.26.2 Age Profile

These assets have an expected technical life of 15 years. A breakdown of asset ages is provided in Table 6-23.

Network	Type	Year of Manufacturer	Population
Northern	ION 7650	2010	3
Northern	ION 7650	2007	4
Northern	ION 7650	2008	1
Northern	ION 7650	2007	4
Northern	ION 765000	2011	2
Southern	ION 7330	2003	3
Southern	ION 7330	2009	4
Southern	ION 7500	2002	9
Southern	ION 7550	2007	1
Southern	ION 7600	2002	10

Network	Type	Year of Manufacturer	Population
Southern	ION 7650	2006	3
Southern	ION 7650	2007	1
Southern	ION 7650	2008	1
Southern	ION 7650	2010	2
Southern	ION 7650	2011	3
Southern	ION 7700	1999	5
Southern	ION 7700	2001	3
Southern	ION 7700	2002	2
Southern	ION 7700	2003	2
Southern	ION 7700	2006	1
Southern	VIP	2002	1
Total (units)			**65**

Table 6-23 : Combined energy and power quality meters

6.3.26.3 Condition of the Asset

The metering assets are in good condition.

6.3.26.4 Replacement/Refurbishment/Expansion Programme

Vector keeps spare meters in case of meter failures. Based on the performance and failure rate Vector will consider planned replacement of the older generation of the meters from 2015.

Over the next five years it is currently planned to installed 41 new PQ meters at zone substation level and complete installation of PQ meters at GXP Albany, Henderson, Hepburn, Wellsford and future 110 kV Wairau GXP.

Vector's ION Enterprise Energy Management system is currently planned to be upgraded to version 6.0 and additional capabilities in analysing databases of PQ and energy measurements are also currently planned to be implemented over the next three years.

6.3.27 Other Diverse Assets

6.3.27.1 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 6-42.

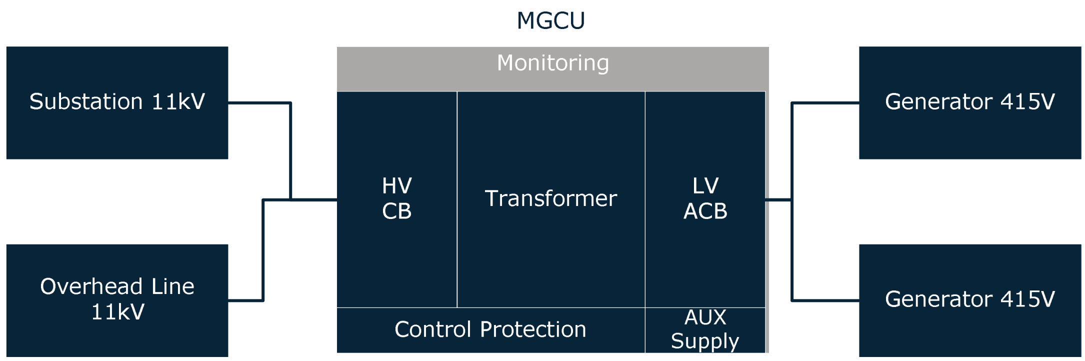

Figure 6-42 : Mobile generator connection diagram

The units are stored at, and maintained by, NZ Generator Hire.

6.3.27.2 Tunnels

Vector has a number of cable tunnels in its Southern network.

The most significant of which being the Penrose CBD Tunnel constructed during 2000/01 to enable the installation of electricity cables between Penrose and the Auckland CBD. The CBD tunnel itself is approximately 9200m long and 3m in diameter and extends from the Penrose shaft in the Transpower switchyard to the Vector Hobson substation yard.

There are three main vertical shafts at Penrose, Newmarket and Hobson with three smaller vertical shafts at Liverpool where cables from Penrose and Hobson exit the tunnel into the Liverpool substation. At Gillies Avenue there is also a smaller lined shaft allowing two cables to exit the tunnel to supply the substation at Newmarket.

The CBD tunnel is primarily a conduit for Vector's 110kV cables, and also supports sections of 22 kV and 33 kV cable. The equipment found in the tunnel itself includes:

- Cantilevered cable brackets fixed to both walls carrying two of Vector's 110kV cables;
- A radio communication system allowing RT to RT communication, RT to access controller at the surface communication, and RT broadcast communication;
- A standard water sprinkler operated fire suppression system;
- A 750mm gauge railway; and
- A drainage system comprising drainage sumps and submersible pumps.

During the construction of the tunnel a railway was installed to enable the transport of staff and materials from the tunnel entry/exit portals to the various work sites. Since the completion of the cable installation the railway has been used by staff conducting maintenance of the tunnel and the cables. This is a registered railway under NZTA and as such Vector is required to submit a Rail Safety Case to NZTA and is responsible for licensing drivers under this Rail Safety Case.

In June 2010 Vector and Transpower signed an agreement which allows Transpower to install additional cables and ancillary equipment in the tunnel. Installation works are currently underway.

The tunnel has been designed with the capacity to accommodate more circuits than presently installed. All work and maintenance within the tunnel is governed by Vector Standard EOS-018.

The other major tunnels are:

- Swanson Street Tunnel - approximately 350 metre in length from the Hobson substation east up Swanson Street;
- Victoria Street;
- North Western Motorway crossing Kingsland; and
- May Road to South Western Motorway crossing.

6.3.28 Cable Ducts

Cables can be directly buried or installed in ducts. When cables are directly buried they have to be installed in a safe manner which allows heat to be dissipated to the surrounding soil as well as buried deep enough to minimise the risk of accidental excavation damage and the effect of solar gain on the ground causing temperature rise and de-rating.

Cable ducts offer the benefit of providing added protection to cables, allowing more flexibility around installation and also simplifying future replacement. Ducts are also installed for future-proofing purposes; making use of construction opportunities and synergies as they arise[9].

However, cable ducts act as insulation to the cable which de-rates them. Often it has also been found that spare ducts have been crushed and are not usable.

Historically, Vector only installed ducts at road crossings, across bridge abutments, railway crossings or when new roads were laid (where a moratorium on later excavation is imposed). As time went on, ducts started to be installed as standard practice when opportunities arose, largely due to the low incremental cost of the materials.

A recent review of the cost of duct installation indicates they may not be as cost effective as they used to be. A review of the spare ducts policy (including the circumstances when spare ducts are to be installed and how these ducts are managed) will be carried out in the next 12 months.

6.4 Spares Policy and Procurement Strategy

Vector's Strategic Spares Guideline EEA-0034 outlines the strategy and policy for the handling and purchase of strategic spares for the purposes of maintaining the electricity supply in the event of a major equipment failure or contingency event. Specifically, strategic spares refer to equipment and or parts that need to be held in store for ready deployment and cannot be obtained in reasonable time due to long delivery periods or obsolescence.

Vector's asset specialists 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.

In practice it is impossible to carry spares for all network equipment. In addition, parts for some aged apparatus are no longer available as the OEM manufacturer no longer exists. Where possible, critical parts are recovered from other assets as reinforcement and replacement projects are undertaken.

In some instances, other market manufacturers have been approached to remanufacture critical parts, for example contacts on early model tap changers.

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[9] For example, working alongside other utility providers when they construct new footpaths or roads.

Lack of spares for key equipment could present a risk to the business, which is especially the case on older, discontinued equipment. This is taken into account in prioritising the asset replacement programmes.

6.5 Adopting New Technologies

Vector has a team of asset specialists that approve and review all network fittings and apparatus to be used on the networks. An important function of this work is to look to the market and evaluate new, improved and emerging technologies. Important examples of how this has occurred in practice are discussed below. The adoption of new technologies related to the secondary network is described in Section 3 of this AMP.

6.5.1 Sub-Transmission Systems

6.5.1.1 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 Standard 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.

6.5.1.2 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.

6.5.1.3 Distribution Cables

The sub-transmission system of Vector's networks comprises of a mixture of cable technologies. These technologies consist of fluid-filled, PILC, gas pressurised and XLPE cable technologies. Cable construction is also wide ranging from single phase, three phase, steel wire armoured (SWA), submarine and others.

XLPE cables are the preferred construction type worldwide and Vector has taken up this technology as its standard. Vector's current standard is for the installation of XLPE cable at all distribution voltage levels and sub-transmission voltages.

Changes in joint and termination technologies have advanced over the past 20 years and Vector has adopted some of these available technologies. After product evaluation, Vector has adopted mechanical sheer bolt fault-rated connector technology as well as 'cable plug' connecting systems for all of its MV switchgear apparatus complying with Vector Standard ENS-0005.

6.5.1.4 Protection and Control

Vector has adopted the IEC 61850 protocol. This protocol provides guidance on the series of standards applying to substation automation equipment and systems with an explanation of their structural elements, configurations and basic functions. Vector has selected protection relays, SCADA and control systems complying with this standard. Vector makes extensive use of the functionality offered by new relay systems to not only enhance network protection schemes, but also for monitoring and metering purposes.

Further, Vector is gradually converting its copper pilot wire system to fibre optics, enabling greater functionality between stations and taking full advantage of the protection and control systems.

6.5.2 Distribution Systems

6.5.2.1 Transformers

Technology in distribution transformers has been unchanged over the past ten years. However, developments in insulating materials have progressed to address environmental concerns around oil-filled apparatus. Vector has explored the technology available for use in environmentally sensitive locations where the effects of fire, smoke and possible run-off into watercourses is an issue.

For these situations, Vector has adopted a synthetic ester (MIDEL 7131) instead of mineral oil as the insulating fluid. MIDEL 7131 is environmentally friendly, fully biodegradable and non-toxic.

6.5.2.2 Oil-Filled Switchgear

Vector has decided to terminate the installation of oil-filled switchgear. Vector now procures switchgear that has a primary insulation medium of SF_6 and an arc-quenching medium of SF_6 or vacuum, in line with Vector's specification for MV switchgear for use on its sub-transmission networks.

6.5.2.3 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.

6.6 Renewal Programme and Expenditure Forecasts

All asset replacement projects and programmed replacement works have been identified for the review period as outlined in the preceding sections.

To ensure a consistent ranking of project priorities, a prioritisation matrix has been developed that is applied to each identified project. (This applies to the whole capital programme, not just the network integrity-related works). The matrix, in as far as it applies to renewal works, is described in Table 9-1.

6.6.1 Projects Previously Planned for Completion

Table 6-24 below shows the progress of projects planned in the previous AMP for completion in FY12/13.

Project Description	Target completion	Comments
Avondale - 11kV Indoor SWBD Retrofit - 13 Panels	FY12/13	Project deferred until FY15 to coordinate with system growth projects
Balmain - 11kV Indoor SWBD Replace - 5 Panels	FY12/13	Project 50% complete, on track to finish during FY12/13
Belmont - 11KV Indoor Retrofit - 9 Panels	FY11/12	Completed
Belmont - Protection System Upgrade	FY12/13	Completed
Carbine - 11KV Indoor SWBD Retrofit - 22 Panels	FY11/13	Completed
Chevalier - 11kV Indoor SWBD Retrofit - 11 Panels	FY12/13	Completed
Highbury - 11kV Indoor SWBD Retrofit - 5 Panels	FY12/13	Project deferred to FY13 and incorporated into system growth project
Liverpool - 110KV Switchboard Refurbishment		Urgent works resulting from condition monitoring (project scope complete during FY13)
Liverpool - 11kV Indoor SWBD Replace - Stage II	FY12/13	Project completed
Milford - 11kV Indoor SWBD Replace - 5 Panels	FY12/13	Project deferred to FY13/14 to coordinate with Highbury reinforcement project
Otara - 11kV Indoor SWBD Retrofit - 13 Panels	FY12/13	Completed
Sabulite Rd - 11kV indoor SWBD Replace - 11 Panels	FY12/13	Project delayed due to additional site work, rescheduled to complete in FY12/13
Spur Rd - Seismic Rebuild	FY12/13	Project deferred to FY13/14 to accommodate additional work due to seismic assessment
Swanson - Seismic Strengthening	FY12/13	Completed
Wairau Valley - 33kV Capacitor Reactor Replacement		Project completed, urgent works resulting from condition monitoring.
Wairau Valley - 33kV Capacitor Bank Replacement		Project completed, coordinated work associated with the 33kV switchboard installation
Wairau Valley - 33kV Indoor SWBD Install	FY11/13	Project 80% complete, on track to finish during FY12/13

Table 6-24 : Progress of projects for completion in FY12/13

6.6.2 Assumptions used in Maintenance and Renewal Planning

Vector relies on the accuracy and completeness of its asset data to determine its asset maintenance and replacement requirements. The following gives an account of the assumptions used in the preparation of this section of the AMP:

- The quantity of assets installed on the Vector electricity distribution network as recorded in Vector's asset management systems (including GIS and FAR) has been used to formulate the maintenance and replacement plans;
- Ownership of equipment held by Vector is determined by a combination of the records it holds and policy (on asset ownership) updated to take into account any relevant information uncovered and changes in legislation and regulations from time to time. There is a relatively small number of poles (about 500) where ownership cannot be determined with absolute certainty. This could have a small impact on maintenance opex;

- Vector uses asset condition as the main driver for asset replacement. Asset condition is determined by a combination of test information and observation from field staff conducting the maintenance and inspection programme;
- Vector relies on oil consumption to determine the seriousness of leakage in sub-transmission cables. Leakage is one of the main drivers for asset health assessment;
- Age, date of manufacture and installation could be important attributes for some classes of assets (particularly the high value assets such as power transformers, high voltage switchboards and sub-transmission cables). Vector relies on records kept in its asset management systems for their accuracy and completeness. Distribution assets records (eg. asset age) are less complete or accurate. This, to some extent, affects how Vector determines some modes of failure;
- Costs estimates for replacement and other works programmes are prepared based on a number of assumptions (such as trenching through rock or soil area). The impact of assumptions on cost estimates can be very significant. Cost estimation tends to be less accurate for projects or work programmes further into the future;
- The cost estimates given in this section of the AMP are presented in real (2014 disclosure year) NZ dollars (refer to Clause 3.16 of Attachment A of the Electricity Distribution Information Disclosure Determination 2012, and are applicable for the whole disclosure period;
- Cost estimates for distribution projects and work programmes are based on the unit rates and relevant rate adjustments agreed between Vector and its field services providers through the Multi Utility Services Agreement (MUSA);
- Risk levels are generally based on qualitative assessments. Vector does not use quantitative assessment tools (such as value of loss load) to evaluate risks; and
- Vector’s maintenance and inspection programme are based on its technical standards which are based on past practice, experience and performance of assets and international standards.

6.6.3 Renewal Expenditure Forecast

Based on the renewal requirements described in this section of the AMP, and after applying the prioritisation criteria, the proposed network integrity (asset renewal or replacement) capex programme for the next ten years is presented in Table 6-25.

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Various - OH Structure Replace	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m	$6.7m
Various - OH Structure Replace	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m	$5.4m
Balmoral - 22kV Power Transformer Replace	$4.2m	$0.2m									
Brickworks - 11kV Indoor SWBD Replace and Switchroom Replacement	$3.0m										
Various - Distribution Asset Reactive Replace	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m	$2.7m
Various - Distribution Asset Reactive Replace	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m
Various - UG Cable Replace	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m	$2.6m
Birkdale - 11kV Indoor SWBD Replace - 11 Panels	$2.2m	$2.0m									
Various - Third Party Event Reactive Replace	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m
Various - Third Party Event Reactive Replace	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m
Wairau Valley - 33kV Indoor SWBD Install	$1.7m	$0.2m									
Various - UG Cable Replace	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m	$1.6m
Various - Power System Protection Replacement / Upgrade	$1.5m										
Balmain - 11kV Indoor SWBD Replace - 5 Panels	$1.5m										
Various - GM Transformer Replace	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m
Sabulite Rd - 11kV Indoor SWBD Replace - 11 Panels	$1.2m										
Maraetai - PAC Systems Renewal	$1.2m	$0.2m					$0.5m	$0.7m			
Various - Sub-transmission Cable Reactive Replace	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m
Various - GM Switchgear Replace	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m	$1.1m
Liverpool - 11kV Indoor SWBD Replace	$1.0m	$4.0m									
Various - GM Switchgear Replace	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m	$1.0m
Various - GM Pillar and Pit Replace	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m	$0.9m
Maraetai - 11kV Indoor SWBD Replace - 11 Panels	$0.9m	$0.1m									
Balmoral - 22kV Subt Cable Replace	$0.8m										
Liverpool - PAC System Renewal	$0.7m								$0.1m	$1.5m	$2.0m
Various - OH Transformer Replace	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m	$0.7m
Otara - PAC Systems Renewal	$0.6m										

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Various - GM Transformer Replace	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m
Various - Telecom Initiated Reactive Replace	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m
Various - OH Conductor Replace	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m
Various - OH Transformer Replace	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m	$0.6m
Carbine - PAC system renewal	$0.5m										
Wairau Valley - PAC Systems Renewal	$0.5m										
Chevalier - PAC system renewal	$0.4m										
Various - OH Conductor Replace	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m
Various - OH Riser Replace	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m
Various - OH Switchgear Replace	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m
Various - Earthing Upgrades	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m
Various - GM Pillar and Pit Replace	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m
Various - OH Switchgear Replace	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m	$0.4m
Various - Earthing Upgrades	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m
Warkworth - Substation Fence Rebuild & Land Stabilisation	$0.3m										
Kingsland - 22kV Indoor SWBD Replace & Switchroom	$0.3m	$2.5m	$1.0m								
Birkdale - PAC System renewal	$0.3m	$0.2m	$0.2m								
Various - Exceptional Event Reactive Replace	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m	$0.3m
Various - DC Auxiliary System Replacement	$0.3m										
Various - Exceptional Event Reactive Replace	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m
Various - Telecom Initiated Reactive Replace	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m
Avondale - PAC System Renewal	$0.2m		$0.7m								
Various - Communication System	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m
Various - Control Centre Applications	$0.2m	$0.2m	$0.2m	$0.2m	$3.0m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m
Various - Strategic Spares	$0.2m	$0.2m	$0.2m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m
Riverhead - 11kV Indoor SWBD Replace - 12 Panels	$0.2m	$1.3m									
Bairds - PAC System Renewal	$0.1m							$0.5m	$0.8m		

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Takanini - Maraetai 33kV Cct1 Cable Replace	$0.1m	$2.8m	$3.0m								
Various - OH Riser Replace	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m
Otara - 11kV Indoor SWBD Retrofit - 13 Panels	$0.1m										
Various - Strategic Spares	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m	$0.1m
Wellsford - 33kV Outdoor CB Replace - 2 CBs	$0.1m	$0.4m									
Liverpool - Protection System Upgrade / Replace		$0.5m									$0.1m
Quay - PAC Systems Renewal		$0.5m	$0.4m			$0.5m	$0.4m				
Milford - 11kV Indoor SWBD Replace - 5 Panels		$0.5m									
Riverhead - PAC Systems Renewal		$0.5m									
Milford - PAC System Replacement		$0.4m									
Sabulite Rd - PAC Systems Renewal		$0.4m									
Kingsland -PAC System Renewal		$0.3m									
Brickworks - PAC System Renewal		$0.3m									
Various - Upgrade of Nu-Lec devices		$0.3m									
Onehunga - 11kV Indoor SWBD Replace - 12 Panels		$0.2m	$1.3m								
Various - Communication System		$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m	$0.2m
Various - Replacing Tail End RTU's		$0.2m	$0.1m								
Greenmount - PAC System Renewal		$0.2m	$0.1m					$0.1m	$0.6m		
Hobson - PAC System Renewal		$0.2m						$0.1m	$1.7m		
Parnell - 22kV Subt Cable Replace		$0.2m	$3.9m								
Balmoral - 11kV Indoor SWBD Replace - 12 Panels		$0.1m	$1.6m								
Hans - 11kV Indoor SWBD Retrofit - 10 Panels		$0.1m	$0.4m								
Maraetai - Protection System - Line Protection Upgrade- 33kV Takanini - Maraetai		$0.1m						$0.4m			
Onehunga - 22kV Power Transformer Replace		$0.1m	$4.4m								
Pakuranga - PAC Systems Renewal		$0.1m					$0.5m	$0.2m			
AUFLS Instantaneous Dump		$0.1m	$0.1m								
AUFLS Instantaneous Dump		$0.1m	$0.1m								

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Browns Bay - 11kV Indoor SWBD Replace - 10 Panels		$0.1m	$1.7m								
Greenmount - 11kV Indoor SWBD Retrofit - 2 Panels		$0.1m	$0.1m								
Hans - PAC System Renewal		$0.1m	$0.7m								
Onehunga - PAC System Renewal		$0.1m	$0.6m								
Henderson Valley - 33kV Outdoor CB Replace and Switchroom Build			$1.0m								
Henderson Valley - PAC System Renewal			$0.8m								
Avondale - 11kV Indoor SWBD Retrofit - 13 Panels			$0.6m								
Belmont - 33kV Outdoor CB Replace - 1 CBs			$0.5m								
Hobson - 22kV Indoor SWBD - 21 Panels			$0.4m	$3.0m	$3.0m						
Browns Bay - PAC System Renewal			$0.4m								
Ponsonby - 22kV Subt Cable Replace			$0.4m	$4.6m							
Glen Innes - PAC System Renewal			$0.2m			$0.1m					
Liverpool - Protection System - Line Differential Protection Upgrade - 110kV Liverpool Penrose			$0.2m								
Mt Albert - 22kV Power Transformer Replace - T1			$0.2m	$2.0m							
Orakei - 11kV Indoor SWBD Replace - 16 Panels			$0.2m	$1.9m							
New Lynn - 11kV Indoor SWBD Replace and Switchroom Replacement			$0.1m	$2.2m							
New Lynn - 33kV Outdoor CB Replace and Switchroom Build			$0.1m	$1.0m							
Mt Albert - 11kV Indoor SWBD Retrofit - 5 Panels			$0.1m	$0.2m							
Mt Albert - PAC System Renewal			$0.1m	$0.7m							
Orakei - PAC System Renewal			$0.1m	$0.2m							
Helensville - 33kV Outdoor CB Replace - 2 CBs			$0.1m	$0.5m							
Helensville - PAC System Renewal			$0.1m	$0.1m							
Hillcrest - 11kV Indoor SWBD Retrofit - 12 Panels			$0.1m	$0.6m							
Hillcrest - PAC System Renewal			$0.1m	$0.5m							
New Lynn - PAC System Renewal			$0.1m	$0.4m							
Chevalier - 22kV Subt Cable Replace				$0.5m	$5.6m						

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Parnell - 22kV Power Transformer Replace - T1 & T2				$0.3m	$4.1m						
Hobson - Power System Protection - 22kV Switchgear Busbar Protection				$0.3m							
Manurewa - 11kV Indoor SWBD Replace - 13 Panels				$0.2m	$1.9m						
Wairau Valley - 11kV Indoor SWBD Replace - 11 Panels				$0.1m	$1.1m						
Laingholm - 11kV Indoor SWBD Replace - 11 Panels				$0.1m	$1.0m						
Manurewa - PAC System Renewal				$0.1m	$0.5m						
Howick - 11kV Indoor SWBD Retrofit - 13 Panels				$0.1m	$0.6m						
Howick - PAC System Renewal				$0.1m	$1.1m						
Manurewa - 11kV Indoor SWBD Retrofit - 7 Panels				$0.1m	$0.4m						
East Coast Rd - 11kV Indoor SWBD Retrofit - 7 Panels				$0.1m	$0.3m						
Waiake - 33kV Outdoor CB Replace - 1 CB				$0.1m	$0.2m						
Waiake - PAC Systems Renewal				$0.1m	$0.4m						
East Coast Rd - PAC System Renewal					$0.7m						
Glen Innes - 22kV Power Transformer Replace					$0.3m	$4.1m					
Liverpool - 22kV Subt Cable Replace					$0.3m	$3.7m					
Triangle Rd - 33kV Power Transformer Replace					$0.3m	$3.7m					
Drive - 11kV Indoor SWBD Replace - 13 Panels					$0.1m	$1.4m					
Freemans Bay - 11kV indoor SWBD Replace - 13 Panels					$0.1m	$1.4m					
Orewa - 11kV Indoor SWBD Replace - 5 Panels					$0.1m	$0.9m					
Waikaukau Rd- 33kV Outdoor CB Replace - 3 CBs					$0.1m	$0.7m					
Drive - PAC System Renewal					$0.1m	$0.2m					
Freemans Bay - PAC System Renewal					$0.1m	$0.2m					
Manukau - 11kV Indoor SWBD Retrofit - 13 Panels					$0.1m	$0.6m					
Manukau - PAC System Renewal					$0.1m	$0.8m					
Quay - 11kV Indoor SWBD Retrofit - 9 Panels					$0.1m	$0.4m					
Waiheke - Protection System - Protection Relay Replace					$0.1m	$0.6m					

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Various - Subt Cable Replace						$0.4m	$5.0m	$5.0m	$5.0m	$5.0m	$5.0m
Airport - PAC System Renewal						$0.2m	$0.4m				
Waimauku - 33kV Power Transformer Replace						$0.2m	$2.3m				
Various - CB & SWBD Replace						$0.2m	$2.0m	$2.0m	$2.0m	$2.0m	$2.0m
Various - Power Transformer Replace						$0.2m	$1.9m	$2.5m	$4.0m	$5.0m	$6.0m
Various - CB & SWBD Replace						$0.2m	$1.5m	$1.5m	$1.5m	$1.5m	$1.5m
Mangere Central - 11kV Indoor SWBD Replace - 15 Panels						$0.1m	$1.6m				
Pakuranga - 11kV Indoor SWBD Replace - 13 Panels						$0.1m	$1.6m				
Hobsonville - 11kV Indoor SWBD Replace - 11 Panels						$0.1m	$0.9m				
Hobson - 11kV Indoor SWBD Retrofit - 15 Panels						$0.1m	$0.7m				
Mangere Central - PAC System Renewal						$0.1m	$0.5m				
Rockfield - 11kV Indoor SWBD Retrofit - 12 Panels						$0.1m	$0.6m				
Rockfield - PAC System Renewal						$0.1m	$1.0m				
St Heliers - 11kV Indoor SWBD Retrofit - 13 Panels						$0.1m	$0.6m				
Browns Bay - 33kV Outdoor CB Replace - 2 CBs						$0.1m	$0.5m				
Hobsonville - PAC System Renewal						$0.1m	$0.5m				
Northcote - 11kV Indoor SWBD Retrofit - 5 Panels						$0.1m	$0.2m				
Northcote - PAC System Renewal						$0.1m	$0.3m				
Orewa - PAC System Renewal						$0.1m	$0.2m				
St Heliers - PAC Systems Renewal							$0.5m	$0.8m			
Takanini - PAC Systems Renewal							$0.5m	$0.9m			
Woodford Ave - 11kV Indoor SWBD Retrofit - 6 Panels							$0.3m				
Sandringham - 11kV Indoor SWBD Replace - 18 Panels							$0.2m	$1.9m			
Swanson - 11kV Indoor SWBD Replace - 10 Panels							$0.1m	$1.1m			
Torbay - 11kV Indoor SWBD Replace - 5 Panels							$0.1m	$0.9m			
South Howick - 11kV Indoor SWBD Retrofit - 12 Panels							$0.1m	$0.6m			

Project	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
South Howick - PAC Systems Renewal							$0.1m	$0.9m			
Takanini - 11kV Indoor SWBD Retrofit - 10 Panels							$0.1m	$0.6m			
Swanson - PAC System Renewal							$0.1m	$0.4m			
Torbay - PAC System Renewal							$0.1m	$0.4m			
Sandringham - PAC Systems Renewal								$0.1m	$1.0m		
Te Papapa - 11kV Indoor SWBD Retrofit - 13 Panels								$0.1m	$0.6m		
Wiri - 11kV Indoor SWBD Retrofit - 15 Panels								$0.1m	$0.7m		

Table 6-25 : 10 year programme of renewal works

Electricity
Asset Management Plan
2013 – 2023

Systems and Data – Section 7

[Disclosure AMP]

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7. Systems, Processes and Data

7.1 Asset Information Management Background

This section describes the information systems and associated business processes Vector maintains and operates to manage its asset data.

Vector’s day-to-day operation involves specialists and teams within the organisation and its Field Service Providers (FSPs) undertaking a wide variety of business functions such as financial forecasting, network planning, project management, asset valuation, maintenance management, asset inspection and condition monitoring.

These business functions are supported by data, systems and business processes. The following diagram (Figure 7-1) illustrates the relationships between business teams, functions, information systems and data: many functions are dependent on the same systems or indeed the same source data.

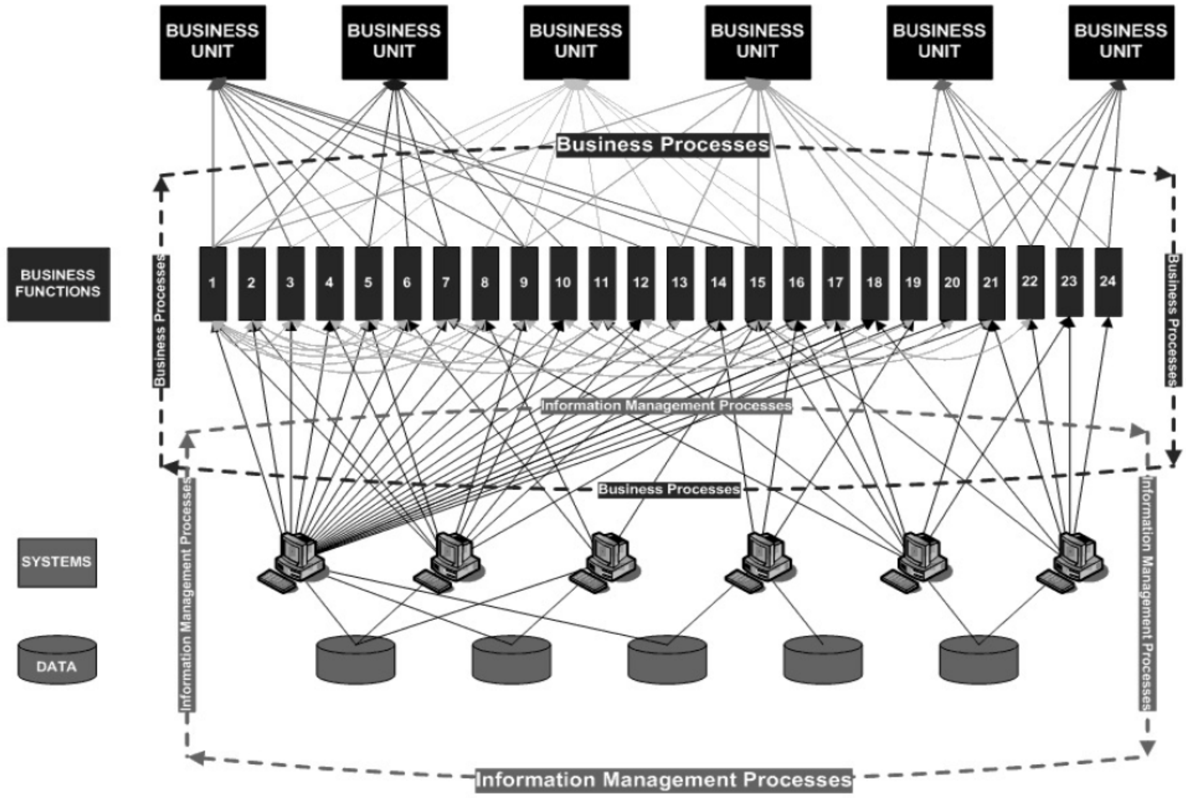


Figure 7-1 : Information Management Framework

To establish effective management of data and Information Systems (IS), Vector has created a Corporate Data Catalogue (CDC), which holds a reference definition of data sets managed by Vector and held in its corporate systems, including those required to support asset management. For each data set, the master system and owner is identified. In addition, the CDC provides an assessment at the enterprise level of each data set in terms of quality, security, sensitivity and criticality and the basis for identifying fitness for purpose of data.

Recently, Vector has supplemented the CDC by applying a Data Source Verification (DSV) methodology to those data sets that support external reporting purposes, such as compliance statements and information disclosures. DSV is a detailed field-by-field analysis to determine the quality and completeness of each data field in terms of its acceptance as a source for reporting requirements.

In many cases data flow diagrams are developed in conjunction with DSV analysis to provide a systems perspective on the verification of source to output. For auditability reasons, Vector uses the UML 2.0 standard for data flow diagrams. The outputs of the DSV analyses provide a basis for prioritising actions where necessary to address specific issues of data quality or completeness.

Vector's FSPs employ their own IS to manage activities related to their core functions such as works management, resource scheduling and mobile data capture. These form critical links in the upstream information supply chain. The data sets held in the FSPs' systems are managed by Vector's FSPs on Vector's behalf in accordance to Vector's asset information policies and standards and the wider provisions of the contractual arrangements between Vector and the FSPs. As asset information process framework is being developed that defines, for each step in the end-to-end asset management process (as described in Section 1.11) a set of controls for asset information from source to output including:

- Asset information policies;
- Asset information business process maps;
- Business rules/work instructions for asset information;
- Asset information standards;
- "Owners" and "responsible persons" for the execution of each asset information process;
- Operational level asset information systems; and
- Asset management reporting methodology (described in Section 7.3).

The framework will be maintained and updated in line with the requirements of Vector's asset management practices, including emerging external reporting obligations.

7.2 Asset Information Systems

Vector's asset data is held by a dozen or more primary or enterprise systems which are described in Section 7.3, built around Vector's corporate Enterprise Resource Planning (ERP) system. By establishing an Asset Information Lifecycle System (ALIS) in its ERP System, Vector has adopted an Enterprise Asset Management (EAM) approach, in which electricity assets are managed by its ERP system through their entire lifecycles, in common with other network fixed assets, notably those of Vector's gas distribution and gas transmission businesses.

The enterprise systems are supplemented by a number of standalone databases, typically PC-based tools with no programmatic data feeds to or from enterprise systems. In addition, Vector manages a highly developed real-time data system (SCADA), the design, operation and future direction of which is described in depth in Sections 5 and 6.

Each asset information system has a specific purpose, and is the master repository, providing the ultimate, sole source of truth for a specific data set, as summarised in Table 7-1.

ERP	Event Mgt	Geospatial	Billing	Other Enterprise System	Real-Time System	Standalone System	FSPs' Systems

Asset Management Systems	Financial information	Technical attributes	Transactional history	Location	Connectivity	Customer service
Fixed Asset Register (FAR)	★	✓				
Asset Valuation Register	★	✓				
Asset Lifecycle Information System (ALIS)	★	★	★	✓		✓
Materials Management System (MMS)	★	✓	★			
Project Management Information Systems (PMIS)	★		★	✓		✓
Geographic Information System (GIS)		✓		★	★	✓
Landbase				★		
Engineering Drawing System (EDS)		★		✓	✓	
Power Systems Model (PSM)		★			✓	
Protection Settings Database (PSD)		★				
Cable Capacity Calculator (CCC)		★				
Real-Time Data Historian			★		✓	
Customer Management System (CMS)			★	✓		★
Outage Records			★	✓	✓	
Billing System	★		★		✓	★
SCADA					★	★
Asset Management Reporting Systems (AMR)	✓	✓	✓	✓	✓	✓

Master (source data) repository	★
Secondary reference	✓

Table 7-1 : Vector's asset information systems

Figure 7-2 illustrates the current organisation of Vector's asset information systems. Overlapping blocks indicate where systems are integrated, notably within the ERP system as a whole and between the ALIS and Geographic Information System (GIS). In addition, the real-time data historian is interfaced to SCADA. A number of one and two-way data exchanges also exist between several of the enterprise systems and between the ALIS and the FSPs' works management systems.

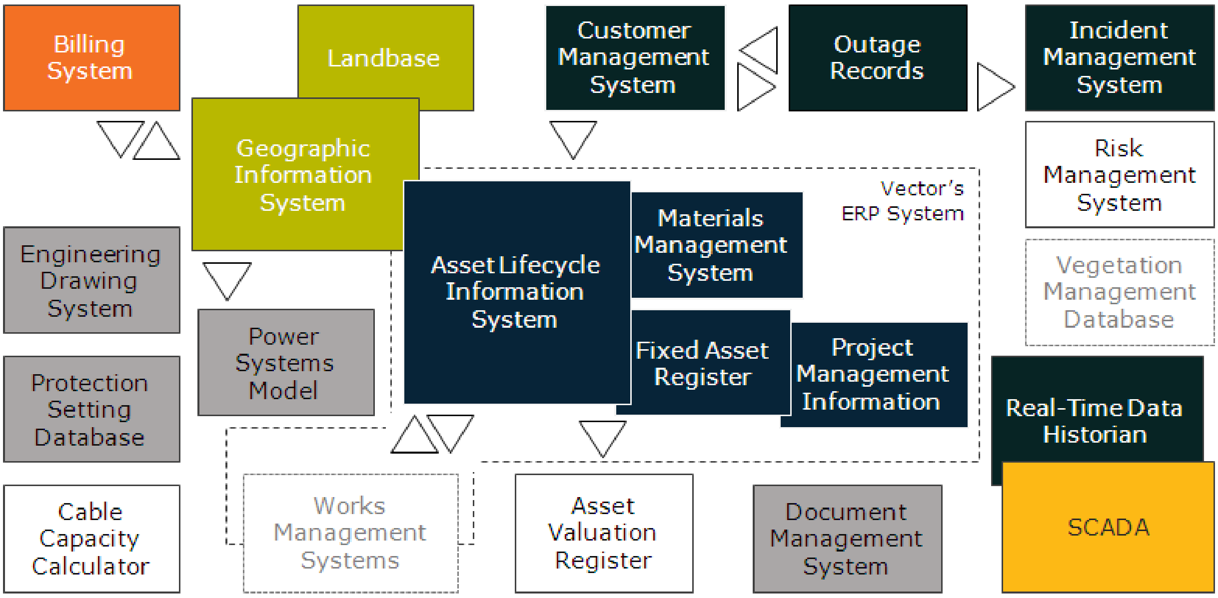


Figure 7-2 : Vector's asset information systems landscape: current state

The following sections describe the functionality of each system. Section 7.2.7 describes the linkages within Vector's ERP system and related systems.

7.2.1 Asset Lifecycle Information System (ALIS)

The primary purpose of the ALIS is to maintain, in the Technical Asset Master (TAM) register, a complete inventory of all network physical assets, including strategic spares, as the master record of all static information (attributes or characteristics) about Vector's network physical assets, with the exception of geospatial information and connectivity.

As a core operational application, the ALIS is continually updated by asset data specialists within Vector's FSPs through an as-building process in which attribute data is captured and partially transferred to GIS and geospatial data is captured in GIS and transferred back to ALIS. These activities are controlled by asset data standards, business rules, work instructions and the relevant provisions of the contractual agreement between Vector and the FSPs.

In line with the objective of optimising Vector's lifecycle asset management capability, the ALIS has been designed to hold the planned maintenance regime for each asset, according to the relevant engineering standard.

The secondary purpose of the ALIS is to capture, from Vector's FSPs, the transactional history of each asset record, in terms of inspection and maintenance activities and defects. Data is provided continually from the FSPs' works management systems via a file upload facility; master data is also downloadable from the ALIS.

As described below, the ALIS is also linked with Vector's Materials Management System (MMS) and Project Management Information System (PMIS).

7.2.2 Fixed Asset Register (FAR)

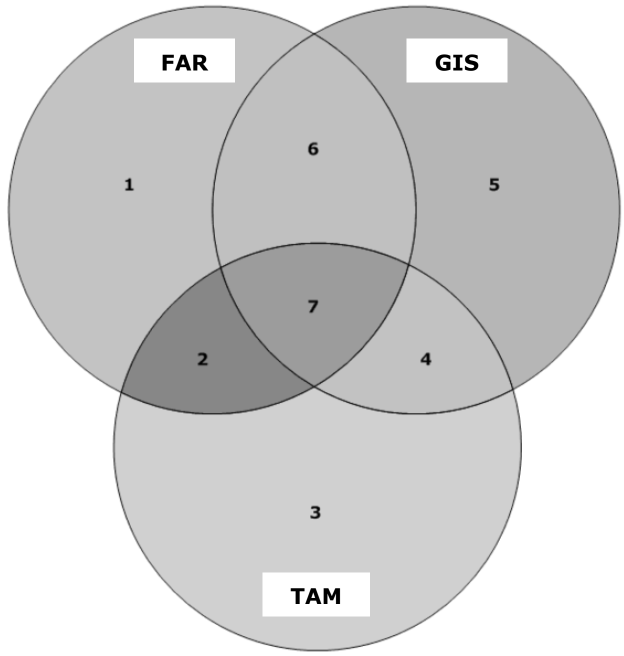
The FAR holds the master register of financial fixed assets, providing the basis for depreciation, taxation, valuation and financial reporting, and is linked with the TAM, being continuously updated by the TAM as assets are commissioned, refurbished and decommissioned.

7.2.3 Geographic Information System (GIS)

A geospatial model of Vector's electricity network between the Transpower GXPs and the customer connection interfaces is maintained in a proprietary database. The model is continually updated by Vector's FSPs via the ALIS, and by direct input, as described above. GIS acts as the master register for asset geospatial information and default network connectivity.

The base data in Vector's GIS is made accessible to third parties as a reference for underground service locations and for other purposes, including the coordination of works within Vector and externally.

Most electricity network fixed assets are recorded in all three of the TAM, FAR and GIS registers, as defined by category seven in Figure 7-3. However, as shown in the diagram, the GIS excludes certain asset types and in some special cases assets are not recorded in the TAM. The GIS also holds information about non-Vector assets. The category definitions are unambiguous and governed by asset data policies standards and business rules.



KEY	Category Definition	*Examples*
1	Non-network assets and network assets with no maintenance requirement	*Land, easements, corporate IT systems*
2	Non-geospatial network assets with a maintenance requirement	*SCADA / comms, auxiliary equipment*
3	Non-geospatial network equipment with a maintenance requirement that is not individually capitalised	*LV connectors and other overhead line components*
4	Geospatial network equipment with a maintenance requirement that is not individually capitalised	*Cable terminations, Telecom poles*
5	Non-Vector owned objects with no (Vector) maintenance requirement	*Streetlights*
6	Capitalised geospatial assets with no maintenance requirement	*None*
7	Capitalised network assets with a maintenance requirement	*Most assets are in this category*

Figure 7-3 : Categorisation of asset data in the TAM, FAR and GIS registers

7.2.4 Materials Management System (MMS)

Vector's MMS is used to manage the supply chain for network equipment. The ERP system link between the MMS and the TAM register enables seamless tracking of serialised equipment along the supply chain, through procurement, to inventory, to network asset, through refurbishment cycles and finally through to disposal.

7.2.5 Project Management Information System (PMIS)

Vector uses a project management module in its ERP system to capture capital and operational project costs and also a separate enterprise system for programme/project management of its capital works programme generally. Settlement of capital costs from project accounts through to financial asset records is readily facilitated and tracked through the ERP system link to the FAR.

7.2.6 Customer Management System (CMS)

Vector's CMS is a core operational application in which a full record of network faults and other customer information is captured by Vector's FSPs. This includes certain asset-related technical information as well as the operational and customer information more conventionally associated with a CMS. In order to enable reporting and analysis of this information from an asset management perspective, whenever a specific asset is associated with a network fault event, the service request (SR) number from CMS is cross-referenced against the technical object record in the ALIS.

7.2.7 Overview of ERP and Related System Links

The organisation within Vector's ERP system and the interfaces between the ALIS and the GIS, the CMS and Vector's FSPs' works management systems are shown in more detail in Figure 7-4. This arrangement, together with the supporting business processes, offers a number of advantages in terms of asset lifecycle information management, as described below:

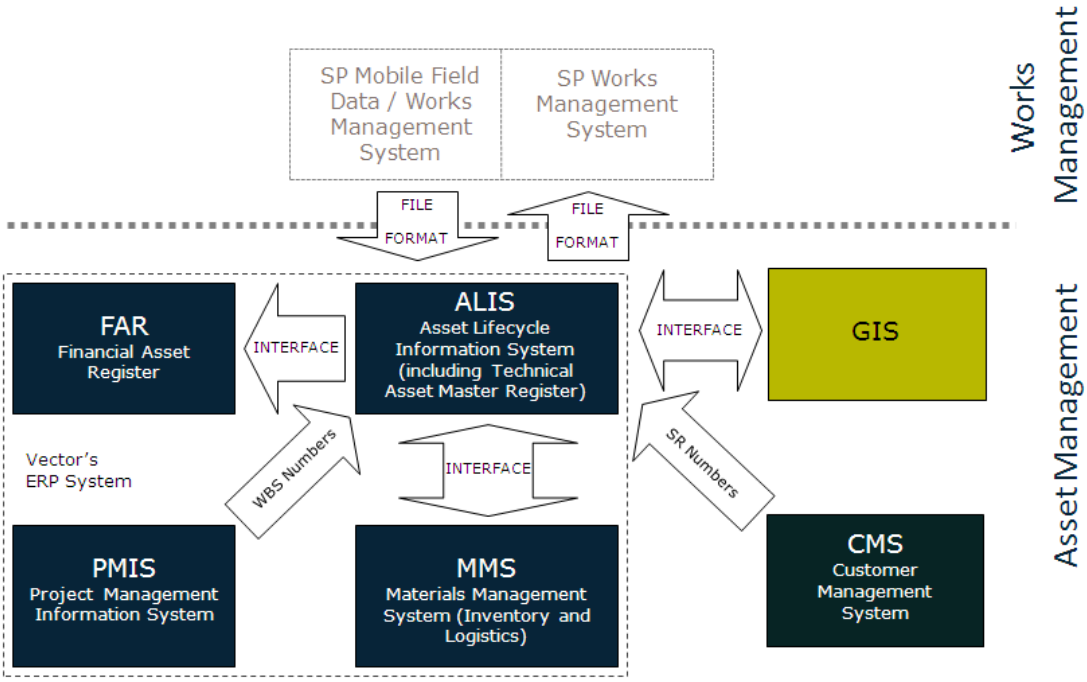


Figure 7-4 : Asset management / works management: organisation of information systems

- By linking the TAM register (within the ALIS) and the FAR, via an inherent ERP system interface, Vector's technical and financial registers are able to be maintained in synch. Geospatial asset information in the GIS is maintained in synch with the ALIS, and hence also with the FAR. In this way, regulatory, statutory and other audit compliance is supported;
- The link from the MMS to the ALIS also enables equipment records in the TAM to be pre-populated efficiently and accurately from material master data in the MMS. As noted above, the link also enables efficient asset creation, installation, refurbishment and disposal;
- Settlement of capital costs from project WIP accounts through to financial asset records is facilitated by the link from the PMIS to the FAR;
- Faults information is captured in the CMS; by cross-referencing the service request (SR) numbers from the CMS into the ALIS, a complete transactional history of

maintenance information is available at the asset (or network segment) level. This supports investment decisions related to network upgrading, asset replacement/ refurbishment and the optimisation of operational/capital expenditure; and

- Finally, by providing a relatively loose form of integration with the FSPs' works management systems, via a specified set of file formats for up-loading and down-loading to and from the ALIS, the minimum possible degree of constraint is imposed on the FSPs' choice of mobile data capture technology. The link itself provides for improved oversight of works management.

7.2.8 Landbase

Vector has a long-term contract with an external organisation for the provision of a comprehensive, managed national land and property information database. This "landbase" is derived in turn from over 100 different sources and enables Vector to have confidence that the information in the GIS is accurately mapped and to leverage relevant up-to-date contextual information.

7.2.9 Asset Valuation Register

Vector's regulatory asset valuation register is derived from the data maintained in the FAR, TAM and GIS, in accordance with the guidelines set down by the Commerce Commission. The register is maintained in a standalone PC-based database.

7.2.10 Engineering Document System (EDS)

Vector maintains engineering drawings and certain other related rich content documents in an engineering drawing system (EDS) which supports workflow management, version control and web access for Vector's FSPs and design consultants.

More generally, Vector also operates a corporate electronic document management system as a secure, centralised repository for key documents such as contracts and certificates.

7.2.11 Power Systems Model (PSM)

Vector employs a specialised power systems model (PSM) application for the purposes of analysing the network from an electrical power systems perspective. The PSM is programmatically updated via importing from GIS on a periodic basis and covers the entire high voltage and medium voltage networks and selected parts of the low voltage network.

The PSM enables Vector to undertake a wide range of power systems studies on the network in its present state and to model the potential impact of changes to the network configuration or to the network load. The model is built in line with the principles outlined in IEC 61850 (as described in Section 5) and Vector's technical requirements for protection and control, in order to support enhanced reliability and security analysis.

7.2.12 Protection Settings Database (PSD)

Vector also maintains a PSD supplied by the same vendor as the PSM, which holds the master register for the settings of the network protection relays and other intelligent electronics devices (IEDs) located in zone substations and other key points around the electricity network. The PSD is also used to download the protection settings and other configurations to the IEDs.

7.2.13 Cable Capacity Calculator (CCC)

The CCC simulates the thermal behaviour of power cable installations by performing capacity and temperature rise calculations. The calculator is used to determine the maximum current power cables can sustain without deterioration of their electrical properties and underpins decisions related to the design of the network.

7.2.14 Real-Time Data Historian

A very large archive database of historical time-series data is maintained in an OPC (object linking and embedding for process control) formatted repository, which captures data transmitted across the SCADA system from the IEDs. This information is used to provide asset utilisation information and support decision-making in network planning and operational control.

In line with the policy to adopt good practice industry standards, Vector has adopted a standardised convention for a topological data model in accordance with the electric power system Common Information Model (CIM) defined by IEC61970-301. This allows easy alignment with the IEC61850 Standard for the exchange of time-series and real-time data between IEDs and systems, including SCADA and the Historian.

The historian application can be used to perform advanced calculations practically in real-time and to create notifications, either directly, or via the ALIS. In due course, by combining time-series data with the TAM data, Vector's ability to execute condition-based/risk-based asset maintenance strategies will be enhanced.

7.2.15 Outage Records

A replica of Vector's high voltage and medium voltage network structure is maintained in a bespoke system, HVEvents, to manage the recording of interruption events and to prioritise network reconfiguration and restoration after an event.

The number of customers affected and the duration of interruptions to be identified against each event by event type and location is enabled by logging events at the individual distribution transformer level.

Reporting of network reliability and calculation of asset performance statistics is derived from the data captured in this system.

Network performance is monitored through ongoing review of the data captured in HVEvents by the network performance team, comprising representatives from Asset Investment, Customer Services and Network Operations. Significant equipment-related incidents are cross-checked with the relevant asset engineer in order to identify root causes of incidents and put in place immediate and permanent corrective actions as appropriate. Results are currently logged in a stand-alone faulted-equipment database.

7.2.16 Billing System

Vector's billing system records all metered revenue data, and includes a database of all Installation Control Points (ICPs). The database is reconciled monthly to the electricity registry. ICP addresses entered into Vector's billing system are passed to Vector's CMS via an electronic link and to Vector's GIS via a geo-coding application. The ICP hierarchy in the billing system is, in turn, updated electronically from the network connectivity information held in the GIS.

7.2.17 SCADA

Vector's electricity network is monitored and controlled in real time using the SCADA system, which is described in detail in Sections 5 and 6.

7.3 Asset Management Reporting

Whilst Vector's corporate Business Intelligence (BI) toolset includes a range of professional reporting applications for the reporting, visualisation and analysis of asset data, traditionally Vector's approach to BI in the asset management context has been one of ad-hoc extraction of data directly out of a single operational system, such as the ERP or CMS, into a standalone PC-based database or spreadsheet.

In some cases, notably for the analysis and thematic mapping of geospatial information, specialised BI tools have been employed.

In order to maximise the value available from Vector's asset information systems, an asset management reporting strategy is being implemented using BI tools in a framework based on the asset management lifecycle, as illustrated in Figure 1-12 in Section 1.11. Reporting requirements for decision making and other purposes are identified across the asset management lifecycle, drawing on data from several operational systems. In addition to the operational sources shown, a significant amount of relevant data is also sourced from outside of the organisation, including for example geospatial, meteorological and other contextual data, so that intelligence is gained from a blend of internal and external data sets.

Following this approach, at the "condition and performance reporting" stage of the framework, BI tools have been used to develop a suite of network reliability reports, based on data from Vector's outage records and CMS.

The objective is to make information accessible by hosting/posting data (for example, via Vector's intranet) rather than by sharing or sending large amounts of data around the organisation. The approach involves an iterative and collaborative engagement with users to identify requirements which are often not fully understood at the outset and builds the data into a seamless (rather than monolithic) repository of asset data. A key objective is to eliminate dependence on "human data warehouses."

In this way, by exploiting the functionality of all BI tools to export to spreadsheets, Vector is encouraging self-service of data by asset management specialists and teams thereby enabling rapid data extraction, visualisation and analysis to support better, faster decision-making.

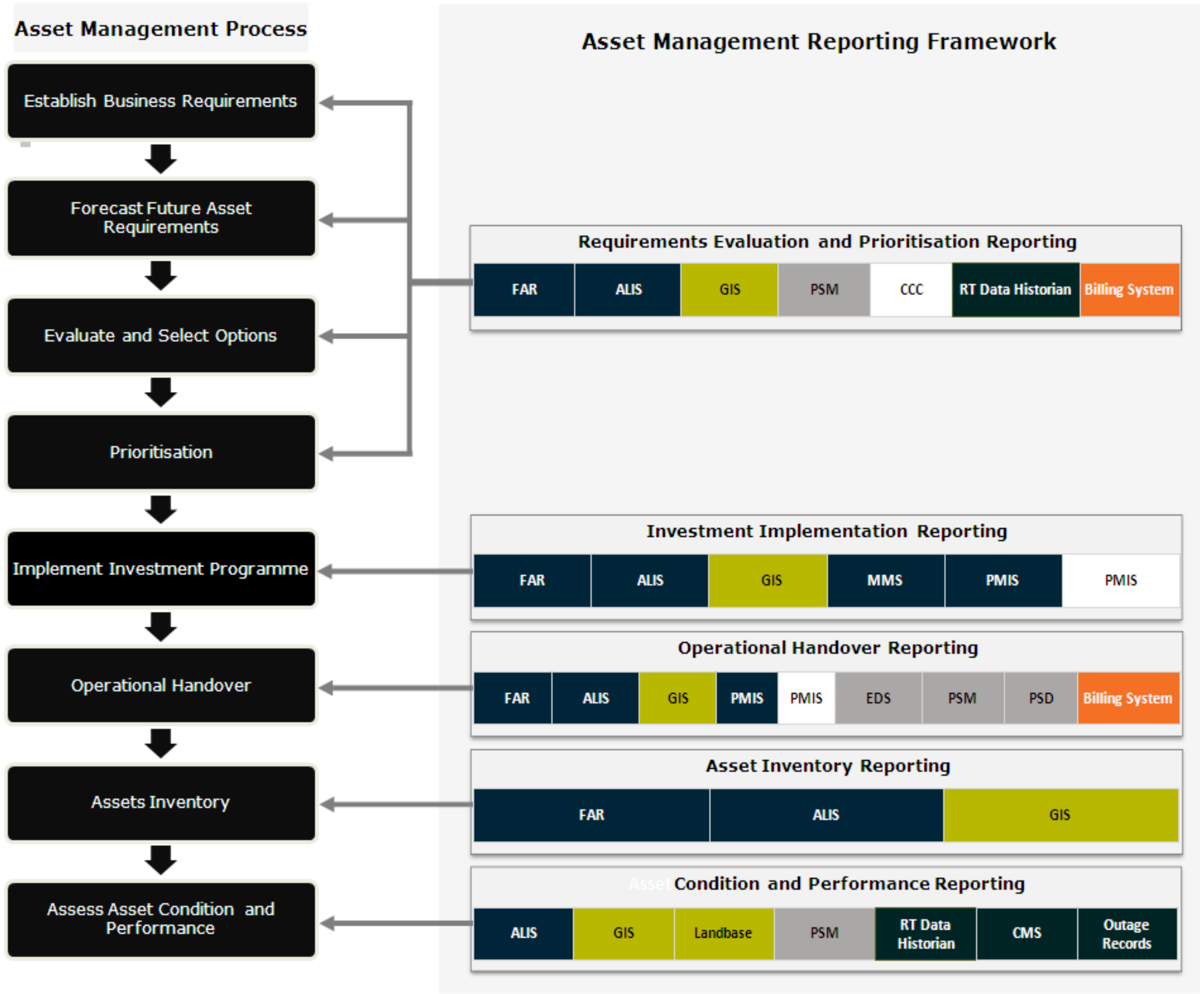


Figure 7-5 : Asset management reporting framework

7.4 Improvement Initiatives

Vector, in common with other providers of integrated infrastructure solutions, is by its nature complex and has, over time, acquired additional layers of complexity in the way its systems, processes and data are structured and managed. In order to address the challenges this presents, and in line with Vector's group goals of operational excellence, cost efficiency and customer and regulatory outcomes (Section 1.3), Vector is adopting a more holistic approach to managing asset information.

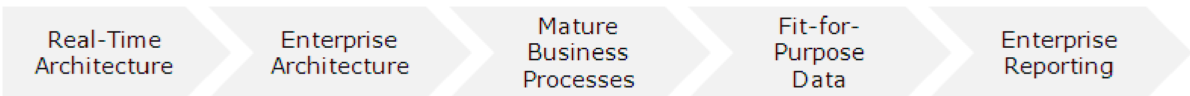


Figure 7-6 : Vector's holistic approach to asset information

This approach has led to the development of a programme of initiatives with the objectives summarised in Table 7-2.

Focus	Objectives
Asset information	• Retiring or consolidating disparate datasets, particularly those in stand-alone systems • Ensuring, through the CDC (and where appropriate, through the application of DSV methodology) that all data is fit-for-purpose in terms of its ownership, definition, quality, completeness, accuracy, security and sourcing • Improving and simplifying how data is transformed into information • Continuing to cleanse data through a prioritised programme of improvement initiatives • Achieving full connectivity (allowing tracing from customer to supply)
Business processes	• Developing a framework of mature and consistent policies, business processes, work instructions and standards with the objective of simplifying the end-to-end management of asset information • Ensuring ownership and quality assurance along the information supply chain by closing the "information loop" • Addressing communication within and between business units to avoid duplication of effort
Information systems	• Extracting the maximum value from information systems • Consolidating information systems • Delivering integrated solutions, and developing simple user interfaces • Marking targeted improvements to address "band-aids" and "work-arounds" • Enhanced approach to reporting

Table 7-2 : Asset information objectives

In order to deliver the programme, a 10-year asset information systems roadmap has been developed that addresses these areas of focus and covers three core IS environments supporting the electricity network business: the Asset Lifecycle Information System (ALIS) environment, Geospatial/Network Information (GNI) systems environment, and Real-Time/Operational (RTO) systems environment. Vector's holistic approach, as illustrated in Figure 7-7 below, is to develop integrated solutions at all levels, rather than simply at the application level.

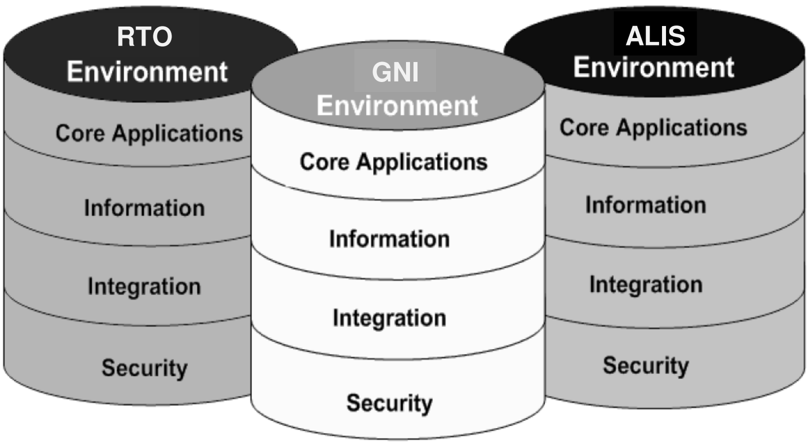


Figure 7-7: Core IS environments

For the ALIS, GNI and RTO environments, this approach is designed to enable a number of specific improvements, as summarised in the Table 7-3.

Environment	Planned Improvements
ALIS	• Extend the capability of the ALIS and related enterprise systems • Exploit market developments in ERP system functionality • Improve the usability of ALIS for infrequent users, for example by simplifying the user interface • Develop capability in equipment performance analysis • Streamline the interface with the GIS • Exploit the Real-Time Historian to develop asset management functionality (for example by triggering notifications in ALIS based on data changes in the Real-Time Historian) • Develop core ALIS functionality (extend its static and transactional data models) • Implement a link between ALIS and EDS • Deploy data cleansing / improvement / QA tools
GNI	• Eliminate excessive customisation in GIS order to simplify maintenance and reduce the cost and complexity of upgrades • Upgrade / simplify the core GIS system and geospatial data model • Streamline the interface between GIS and ALIS • Exploiting the full functionality of the GIS, for example use of GIS for design work (rather than importing and re-drawing from computer aided drawing systems) • Mitigating GIS data extraction issues (such as connectivity) • Supporting closer alignment between GIS and real-time systems • Develop geospatial processes / functionality, particularly on-line mapping, spatial analysis (of data sets including those held by GIS) and web interaction • Implement a link between GIS and EDS • Deploy data cleansing / improvement / QA tools (for spatial data and connectivity) • Develop outage management capability: implement electronic switching schedules, planned outage management, electronic fault reporting / management and dispatching. • Develop power systems modelling capability: upgrade PSM, consolidate Vector's CCC into PSM, develop capability to exploit smart network data • Investigate and implement new initiatives: spatial visualisation, 3D data model development and visualisation, advanced outage management.
RTO	• System consolidation (as described in Section 5) • Define the relationships between SCADA / GIS / ALIS / PSM • Further development of the operational representation of connectivity • Support the implementation of outage management / DMS functionality • Integrate with Transpower SCADA system • Extend SCADA core system (functional SCADA tiles) • Investigate and implement new initiatives: DMS functionality, real-time power analysis, smart network support

Table 7-3 : Proposed developments in Vector's core IS environments

Supporting these initiatives, Vector's approach to developing its overall enterprise environment is focussed on: systems integration, facilitating the electronic provision of data to/from Vector's FSPs, developing a corporate approach to reporting based on the enterprise BI toolset, and upgrading Vector's CMS and Billing Systems.

Table 7-4 summarises how these developments are projected to be scheduled over the next ten years, building on the foundational work done over the last five years, notably in extending Vector's ERP system functionality.

Asset Management Systems	2008-2012 New / upgrade	2008-2012 Consolidation / integration	2008-2012 Functional development	2008-2012 Data improvement	2013-2017 New / upgrade	2013-2017 Consolidation / integration	2013-2017 Functional development	2013-2017 Data improvement	2018-2022 New / upgrade	2018-2022 Consolidation / integration	2018-2022 Functional development	2018-2022 Data improvement
Fixed Asset Register (FAR)		✓	✓	✓				❖				
Asset Valuation Register				✓								
Asset Lifecycle Information System (ALIS)	✓	✓	✓	✓			◆	❖			◆	
Materials Management System (MMS)		✓	✓	✓			•	❖			•	
Project Management Information Systems (PMIS)		✓	✓				•				•	
Geographic Information System (GIS)		✓	✓	✓	◆		◆	❖	◆		◆	❖
Landbase	✓	✓	✓	✓							•	
3D Data Model					◆		◆	❖	◆	◆	◆	
Engineering Drawing System (EDS)				✓		•	•	❖			•	
Power Systems Model (PSM)		✓	✓	✓	•	•	•	❖	•	•	•	❖
Protection Settings Database (PSD)			✓	✓			•		•	•	•	
Cable Capacity Calculator (CCC)				✓	•	•		❖				
Real-Time Data Historian	✓	✓	✓		•	•	•			•	•	
Customer Management System (CMS)			✓		◆		◆	❖				❖
Outage Records	✓	✓	✓	✓	◆	◆	◆				•	
Distribution Management System (DMS)					◆	◆	◆		◆	◆	◆	
Billing System				✓				❖	◆		◆	
Real-Time Operational Systems (inc SCADA)		✓	✓			◆	◆				◆	
Asset Management Reporting systems (AMR)	✓	✓	✓	✓	◆	◆	◆	❖	◆	◆	◆	❖

Significant developments over the last 5 years	✓
Projected major capex investment	◆
Projected minor capex investment	•
Projected opex	❖

Table 7-4 : Mapping recent and projected developments in Vector's core IS environments and asset data quality to individual systems

These developments will result in the gradual deployment of a much more integrated structure for Vector's asset information systems as shown in Figure 7-7. The initiatives follow from the strategic direction for Vector's asset information systems described in Figure 7-8.

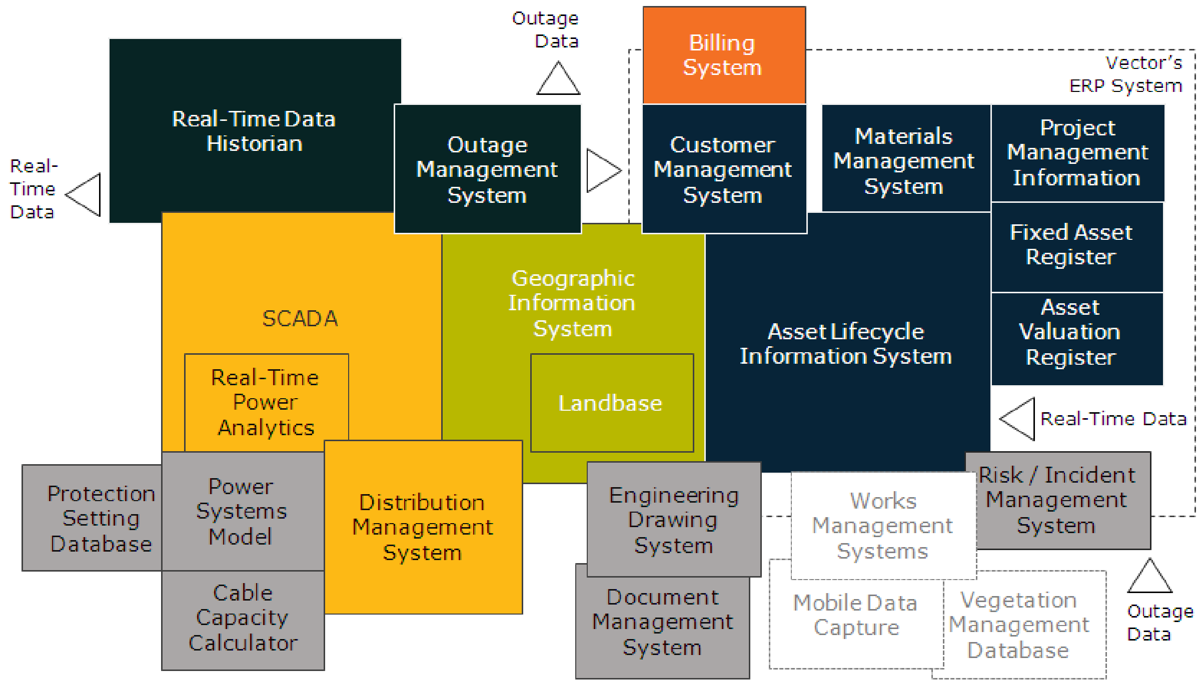


Figure 7-7 : Proposed integrated structure for Vector's asset information systems

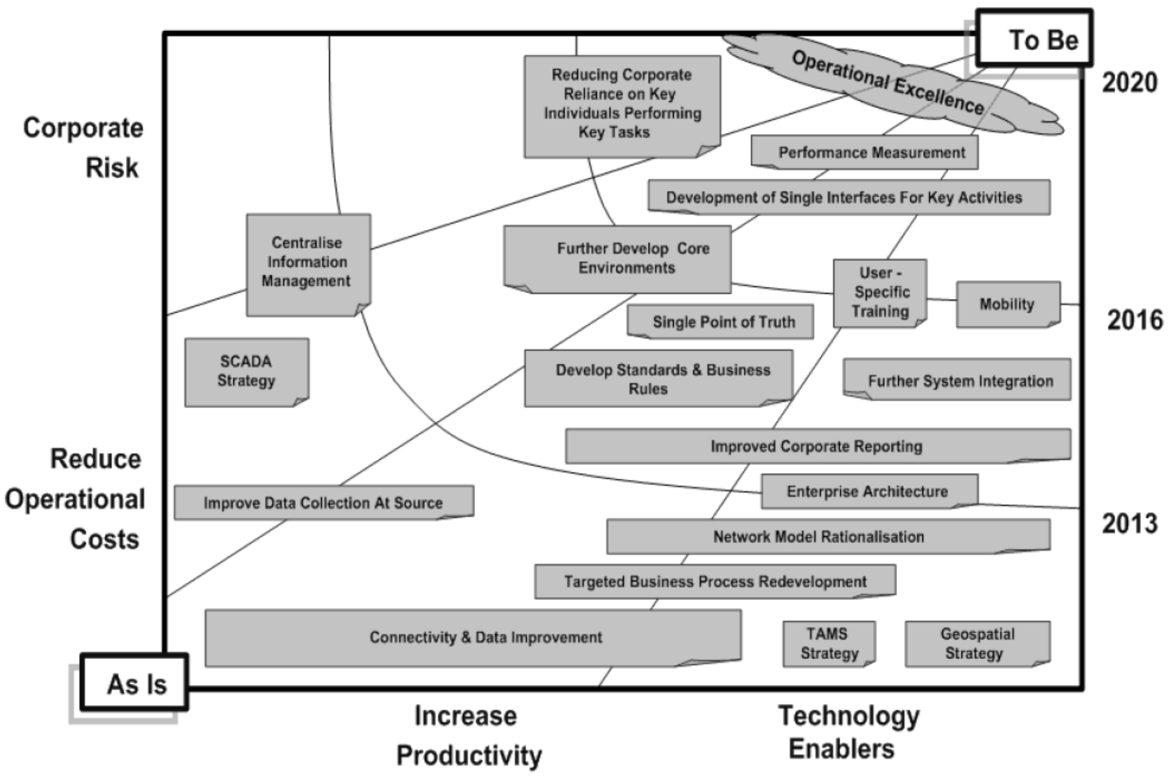


Figure 7-8 : Indicative strategic direction for Vector's asset information systems

7.5 Asset Data Quality

Alongside investments in asset information systems, Vector continues to improve asset information. Where limitations have been identified at the data set level (described in the CDC, see Section 7.1), initiatives are put in place to address the root causes and remediate data. These initiatives are managed by an asset information improvement plan, which includes the following initiatives related to the electricity network.

Initiative	Legacy data	System level data	Process or standard	Resource	Target date
Develop a robust process for managing distributed generation sites in GIS			✓	Medium	2013
Simplify the process for settlement of capitalisable project costs to fixed assets in FAR	✓			Medium	2013
Rectify connectivity issues associated with LV open points in GIS; align with SCADA	✓		✓	Medium	2013
Extend ALIS data model to incorporate ancillary equipment and provide enhanced controls	✓	✓	✓	Low	2013
Clean up ICP data set in GIS and Billing System	✓		✓	High	2013
Electronically manage switching schedules		✓	✓	Medium	2013
Electronically capture unplanned outage information		✓	✓	Medium	2013
Formalise process for managing updates to CDC including DSV methodology where required			✓	Low	2013
Exploit distribution monitoring data in RT Historian to improve asset lifecycle management		✓	✓	Medium	2014
Substantially rectify incomplete or inaccurate distribution equipment asset attribute data in ALIS	✓			High	2014
Correct or populate inaccurate and missing spatial location data in GIS	✓			Medium	2014
Further develop MMS capability to deliver efficiencies in asset creation		✓	✓	Medium	2014
Further develop PSM functionality		✓		Medium	2014
Refine ALIS data model to enable tracking of high-maintenance equipment classes at a lower level		✓	✓	Medium	2015
Provide access to all major asset lifecycle data sets from Vector's AMR systems	✓	✓	✓	Medium	2015
Simplify the management of linear assets in ALIS		✓	✓	High	2016
Exploit smart network data to improve asset lifecycle management		✓	✓	High	2016
Audit and update as necessary zone substation engineering drawings in EDS and on-site	✓		✓	High	2017

Table 7-5 : Asset Information Improvement Plan

7.6 10-year Forecast for Non-Network Assets

Table 7-6 summarises Vector's projected capital and operational expenditure in the asset management IT component of Non-Network Assets (figures are June 2013 real values).

Asset Management Expenditure Forecasts ($'000)	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Geospatial Systems	2,350	200	550	300	300	300	1,300	1,300	300	300	300
Outage Management	400	250	200	200	1,000	1,000	0	0	0	0	0
Power Systems Modelling	50	250	250	250	0	0	0	0	0	0	0
New Initiatives	0	250	750	500	500	500	500	500	1,500	1,500	1,500
ALIS	750	500	750	500	500	500	500	500	500	500	500
Systems Integration (electricity business)	1,000	1,000	500	500	500	500	500	500	500	500	500
Reporting (electricity business)	350	350	350	350	350	350	350	350	350	350	350
Capital Expenditure	**4,900**	**2,800**	**3,350**	**2,600**	**3,150**	**3,150**	**3,150**	**3,150**	**3,150**	**3,150**	**3,150**
Reference information maintenance	195	195	195	195	195	195	195	195	195	195	195
Improvements to legacy asset information	200	300	300	300	300	300	300	300	300	300	300
Operational Expenditure	**395**	**495**	**495**	**495**	**495**	**495**	**495**	**495**	**495**	**495**	**495**

Table 7-6 : 10-year forecast for Asset Management component of Non-Network Assets

Electricity
Asset Management Plan
2012 – 2022

Risk Management – Section 8

[Disclosure AMP]

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8. Risk Management

8.1 Risk Management Policies

Risk management is integral to Vector's asset management process. Vector's risk management policy sets out the company's intentions and directions with respect to risk management including its objectives and rationale. 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.

Vector's core operational capabilities, such as asset, operational and investment management, are supported by robust risk management decision-making, processes and culture. Risk and assurance management also underpin Vector's ability to meet its compliance obligations. By the nature of the electricity distribution business there are many inherent risks and safety management is one of Vector's top priorities in the day to day operations of the network. Vector takes this responsibility seriously and has stringent risk management processes in place covering hazard identification, risk assessment and the monitoring and review of hazards. The primary principle in managing asset and infrastructure risk is to reduce the risks to as low as reasonably practical (ALARP).

The risk management capability is built on a risk management process which requires risks to be identified and analysed, assessed and managed. This means understanding both the nature of a risk and its level. This includes identifying the cause and effect of a risk, the potential likelihood of a risk occurring and the potential impact(s) of a risk. Following this, the overall risk exposure is agreed which involves identifying and evaluating any controls in place to manage the risk. A 'control' is any policy, practice or device which is in place to modify (reduce) a risk. The risk exposure is determined from an evaluation against Vector's risk management framework and a decision made as to whether the level of risk is acceptable. If it is not acceptable a 'treatment' is developed and prioritised against others. In terms of asset management these often become security of supply or asset integrity capital projects, or become the basis for work practice decisions. The effectiveness of the controls and the delivery of these projects are subject to ongoing monitoring. The consequences and likelihood of failure or non-performance of assets, the current controls to manage these, and required actions to mitigate risks, are all documented, understood and evaluated by Vector as part of the asset management process.

The acceptable level of asset-risk will differ depending on the impact, should an asset fail, on the electricity supply or its potential for harm. This in turn is influenced by the different categories of customers, communities' willingness to accept risk and the circumstances and environment in which the risk would occur. Risk analysis covers a range of risks from those that could occur at a relatively high frequency but with low impact, such as tree interference, through to low probability events with high impact, such as the total loss of a zone substation for an extended period.

Risks associated with assets are primarily managed by a combination of:

- Reducing the probability of failure through the capital and maintenance work programme and enhanced work practices; and
- Reducing the impact of failure through the application of appropriate network security standards, robust network design supported by contingency and emergency plans.

8.2 Risk Accountability and Authority

8.2.1 Vector Risk Structure

Figure 8-1 shows Vector's risk management structure and reporting lines.

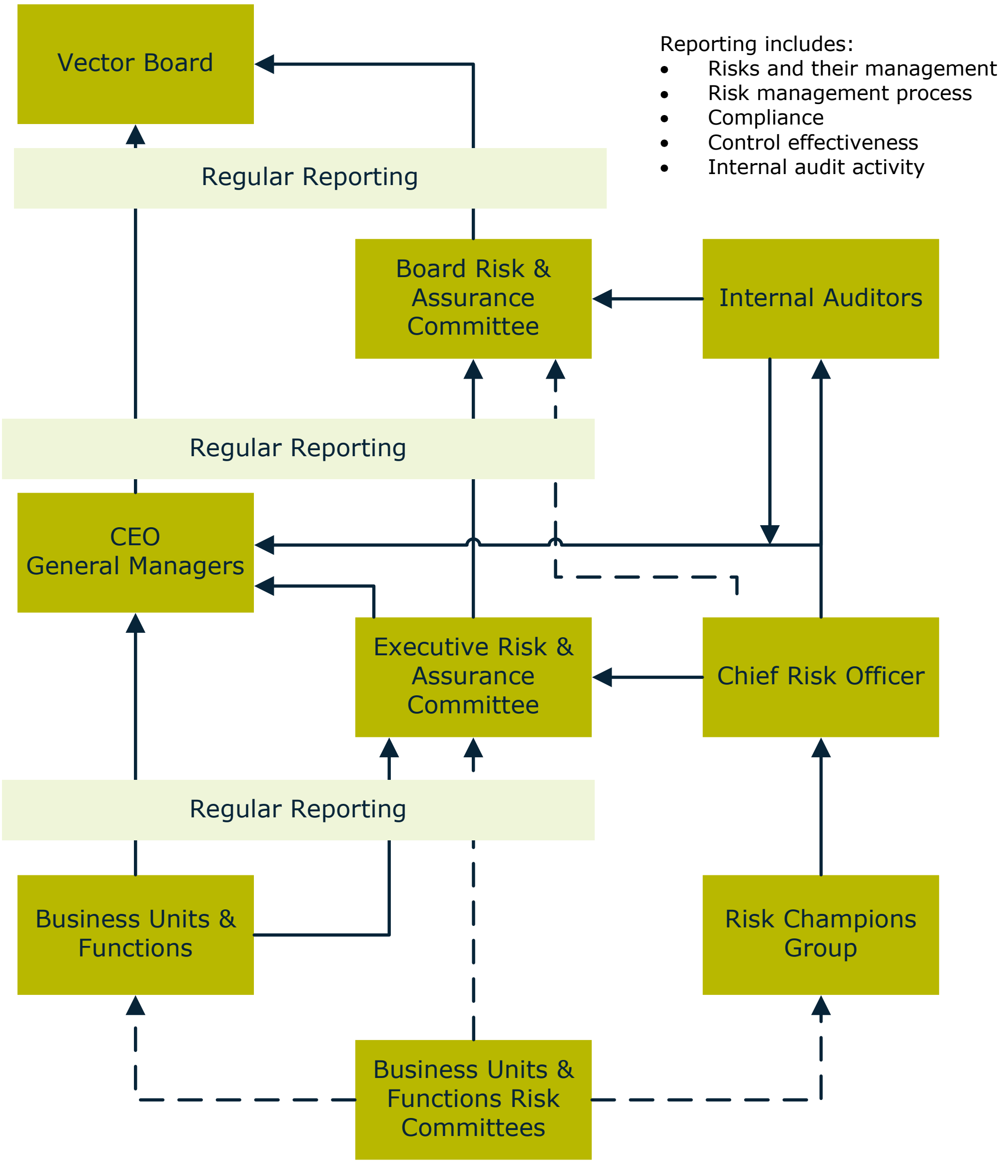

Figure 8-1 : Vector's risk management structure

The following paragraphs describe the accountabilities and authorities of the committees within the risk management structure.

8.2.2 Board Risk and Assurance Committee

Vector’s board has overall accountability for risk management. This responsibility (excluding security of supply risks which remain a full board responsibility) has been delegated to the Board Risk and Assurance Committee (BRAC) which provides oversight of Vector’s risk and assurance framework and performance.

The BRAC meets four times a year to review the group’s risk context, key risks and key controls, which include the internal audit and insurance programmes.

8.2.3 Executive Risk and Assurance Committee

The Vector executive has established an Executive Risk and Assurance Committee (ERAC) to provide specific focus and leadership on risk management. The committee has the overarching responsibility of ensuring risk management and assurance in Vector is appropriate in terms of scope and strategy, as well as implementation and delivery.

Vector has also established a business continuity management steering committee made up of a mixture of executive and management with specific related responsibility to focus on the development and management of Business Continuity Management (BCM) throughout the company including the operation of electricity networks.

8.2.4 Management and Business Areas

The group general managers and their direct reports have responsibility for ensuring that sustainable risk management and assurance practices are developed and effectively implemented within each of Vector’s business groups.

Asset related risks and their control and mitigation measures are largely the responsibility of the Asset Investment (AI) and Service Delivery (SD) groups. The AI group oversees network asset management strategy and performance and includes the development of standards for the electricity network and its component assets.

The SD group manages the operational delivery of the strategy. This includes delivery in the field of the requisite levels of maintenance and capital expenditure (capex) so the network meets the stated reliability, safety, environmental and performance standards. The SD group also manages the safe and reliable operation of the network to predefined levels.

8.2.5 Risk Champions

Risk champions have the responsibility of facilitating risk management practices in their business groups by:

- Ensuring, in conjunction with the risk-owners, that their risk registers are accurate and up to date;
- Completing general risk management reporting requirements within their business groups;
- Ensuring effective risk management meetings are conducted in their areas (and cross-functionally as appropriate); and
- Ensuring appropriate risk communication and induction is undertaken in their business groups.

8.2.6 Chief Risk Officer

Vector appointed a Chief Risk Officer, reporting to the CEO, in July 2012. The Vector Chief Risk Officer is part of the Vector executive leadership and is responsible for the development of the Enterprise Risk Management (ERM) framework, including all supporting business systems, policies and processes. The risk management framework is approved by the BRAC.

The role includes, amongst other things, the monitoring and reporting of progress against the ERM plan and overall delivery of risk management and assurance, as well as communicating on risk management and assurance issues across Vector.

8.2.7 Staff

Each staff member is responsible for ensuring they understand the risk management practice in Vector and how it applies to them. This includes being actively engaged in the identification of new risks and ensuring these are appropriately acknowledged.

Individual staff may have specific responsibilities for the ownership and management of a specific risk, control or treatment depending on their roles.

8.3 Risk Management Process and Analysis

8.3.1 Risk Management Process

The Vector ERM framework is aligned to and based upon AS/NZS ISO31000:2009. The current risk management process adopted by Vector is shown in Figure 8-2 below. The Chief Risk Officer is currently undertaking a review of the Vector ERM framework and it is anticipated that changes focused on continuous improvement of the framework will occur over the next 12 months.

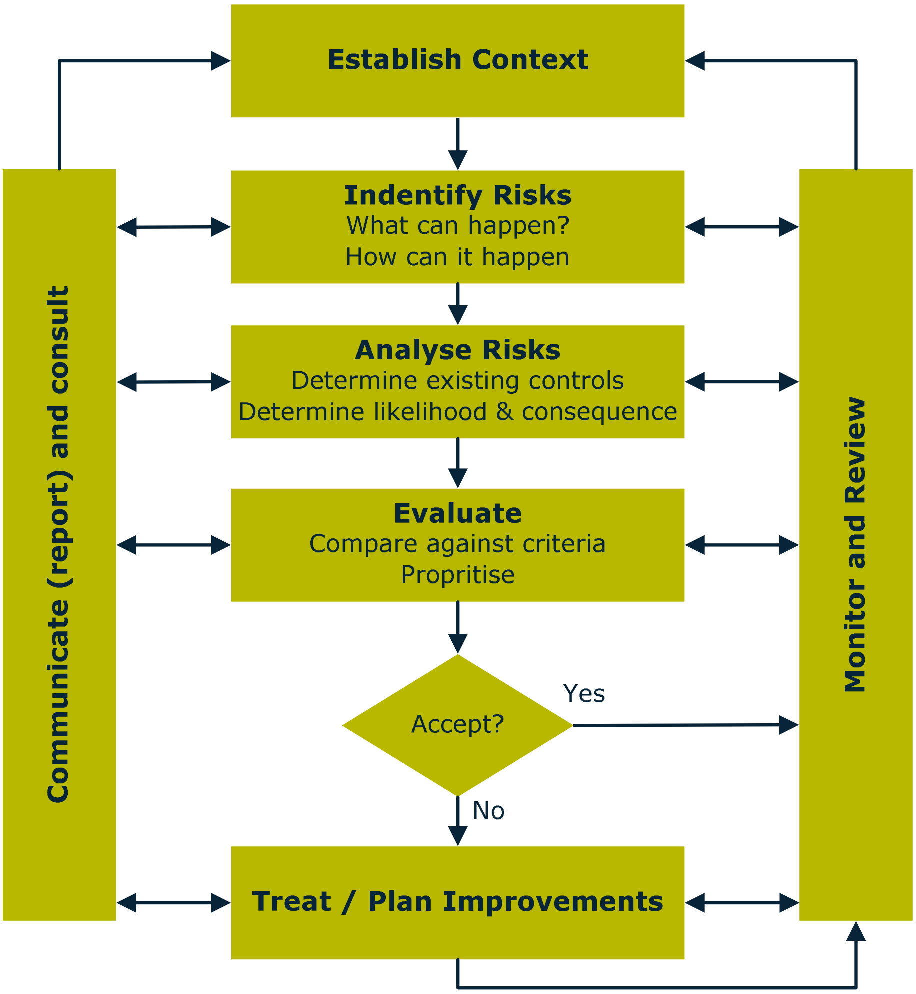

Figure 8-2 : Vector's risk management process (based on ISO31000: 2009)

The level of a risk is determined by considering the combination of the "likelihood" and "consequences" of the risk occurring given current controls. This is then compared to Vector's risk assessment matrix shown in Figure 8-3 below. The overall risk exposure is used as a key factor in determining whether the risk is acceptable and driving the need and priority of any subsequent action.

Risks which have "catastrophic" or "major" risk consequences include those which could lead to loss of life, cause serious damage to the environment, create a major loss of electricity supply, lead to major financial loss or have a significant impact on Vector's reputation.

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 controls, including organisation-wide 'risk management' and BCM governance. The Internal Audit programme is overseen by the BRAC.

Risk Assessment

	Minor	Moderate	Serious	Major	Catastrophic
Frequent	H	H	VH	E	E
Likely	M	H	VH	VH	E
Possible	L	M	H	VH	VH
Unlikely	L	M	M	H	VH
Rare	L	L	L	M	H

Risk Assessment Using Consequence And Likelihood

L = Low
M = Moderate
H = High
VH = Very High
E = Extreme

Red = Board Attention
Orange = Executive Attention
Green = Management Attention

Figure 8-3 : Vector's risk assessment matrix

The asset management process is also specifically reviewed by an independent third party as a requirement of the AECT Trust Deed which governs key aspects of how the company must operate. The results from this review are reported through to the full board.

8.3.2 Network and Asset Risk Management

The management of the electricity network assets is underpinned by the risk management principles described above. The AI group which oversees network asset management and performance uses these principles in the development of standards for the electricity network and its component assets.

The SD group manages the operational delivery of the strategy. This includes delivery in the field of the requisite levels of maintenance and capital development so the network meets the stated risk rated reliability, safety, environmental and performance standards. The SD group also manages the safe and reliable operation of the network to predefined levels.

The AI and SD groups both have an integrated approach to risk management and their respective responsibilities in relation to it, which encompasses:

- Identifying and assessing risks;
- Managing and maintaining controls;

- Developing and implementing treatments proportionate to the risk involved;
- Monitoring risks, the effectiveness of controls and progress of treatments;
- Maintaining up to date risk registers which clearly identify risks, the ownership of the risks, possible outcomes and mitigation measures; and
- Reporting these risks, controls and treatments to the ERAC and BRAC as appropriate.

Regular risk meetings are held at all levels of Vector, and within the AI and SD groups, at which the existing risk registers are reviewed, potential risk scenarios discussed, and new risks, including those that have a low probability of occurrence but a high level of impact, identified for inclusion in the risk registers (along with the appropriate mitigation measures).

Apart from the regular risk meetings, risks are also identified during the annual planning and routine operational processes. The network development and asset replacement processes identify situations where network security in parts of the network may be vulnerable to high impact low probability events. Procedures are in place to record incidents occurring on the network during the course of daily operation. Mitigating action plans are then developed to reduce the impact of such events. These incidents are then recorded in the Risk and Incidents Management System (RIMS) along with the appropriate mitigation measures. Section 8.4 documents Vector's business continuity approach to mitigate the effect of high impact events on the business.

8.3.2.1 Risk Registers

Vector's risk registers identify risks and capture their management at different levels of detail and at different levels of responsibility, taking a tiered approach. These are routinely reviewed and reported on.

The risk registers report absolute risk classification (ie. excluding any organisational controls) and the risk classification with controls and treatments in place. The treatments are initiatives which are undertaken primarily to reduce the risk. These risks are managed at various levels, as appropriate, within Vector. The findings are reflected in Vector's asset planning outcomes. The most significant risks have visibility through to the ERAC and to the BRAC. Table 8-1 below shows the key information requirements for risks in Vector's risk registers.

Heading		Description
Unique ID number		Unique code for each risk
Risk Description	Short name	Short name for the risk to ease communication
	Full name and consequence	Full name defines the event or circumstance and the consequences which emanate from this risk
Categorisation	Strategic impact	One of 5 predefined categories
	Strategic objective	One of 18 predefined categories
Risk tier		Categorises risk in to one of three groupings in terms of breadth verses detail
Product type	Product type #1	What product in the group the risk is associated with, such as electricity, gas etc
	Product type #2	What - sub product of the above the product risk is associated with, such as for gas - wholesale gas
Risk Ownership	Function / Business Unit	Reporting unit

Heading		Description
	Sub function	Reporting sub-unit within reporting unit
	Owner	Name of owner of risk
Absolute	Consequence	Absolute - Consequence. Likely impact with no controls in place
	Probability / Likelihood	Absolute - Probability. Likelihood of risk occurring if no controls were in place
	Risk Assessment	Absolute - Risk Assessment. Assessment of risk as a combination of likelihood and consequence with no controls in place
Controlled	Consequence	Controlled - Consequence. Impact with (effective) controls in place
	Probability / Likelihood	Controlled - Probability. Likelihood of risk occurring with (effective) controls in place
	Risk Assessment	Controlled - Risk Assessment. Assessment of risk as a combination of likelihood and consequence with (effective) controls in place
Treated / 'As Low As Reasonably Practicable' (ALARP)	Consequence	Treated - Consequence. Impact when treatments are completed
	Probability / Likelihood	Treated - Probability. Likelihood of risk occurring when treatments are completed
	Risk Assessment	Treated - Risk Assessment. Assessment of risk as a combination of likelihood and consequence when treatments are completed
Assurance process	Key Controls	A brief description of controls
	Status	An evaluation of the quality of the control
	Process	How Vector gets assurance of the control
	Control review date	When the control gets reviewed
	Control owner	Who manages the control
Treatments	Treatment name	A brief description of treatment
	% Complete	% of project complete
	Completion date	Date when treatment is scheduled to be complete
	Treatment owner	Owner of treatment
Admin	Risk origin	To track risk origin in terms of any past register / or to note as "new"
	Date listed	Date when risk was added to register
	Reviewer	Name of person who reviewed the risk
	Last updated	Date when risk has last been reviewed

Table 8-1 : Risk register headings

8.3.2.2 Key Operational Risks

Table 8-2 below outlines the most significant high level (non specific) electricity risks Vector has identified in its asset management risk register. While control and mitigation measures are in place to address these, work is ongoing to improve the controls and to ensure they remain effective.

Risk ID	Risk description	Risk Assessment Classification		
		Absolute	Controlled	Treated
AIAE5001	External events such as natural disasters or man-made related disasters disrupt the operations, or damage or destroy Vector assets potentially leading to lost revenue, cost/losses, liability, reputation damage, customer dissatisfaction and/or potential regulatory consequences.	Very High	High	High
AIAE4031	Breach of Electricity Industry Participation Code (Load Shedding Scheme)	Very High	High	Moderate
AIAE1038	Power quality performance below compliance levels. The risk is that Vector is unable to deliver power quality to acceptable standards, which has the potential to lead to a loss of reputation and regulatory consequences.	Very High	High	Moderate
AIPI0003	Inability to identify network operational issues due to poor / corrupted field data.	Very High	High	Moderate
AIPI0011	Failure to meet quality standard set as under Part 4 of the Commerce Act 1986 and/or failure to deliver compliant information disclosures	Very High	High	High

Table 8-2 : Most significant high level risks identified in the Vector electricity asset risk register

8.3.2.3 Integrated Risk Management – Our Aspiration

Vector continues to look to enhance the integration of the risk management process into its core planning and prioritisation activities. It is recognised many of the risk control or mitigation measures require capital investments and capital investment 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 years capital works programme (capital expenditure forecasts). These projects are identified by the risk identification number (from the risk register).

Other residual risks are controlled / mitigated through maintenance programme of works. These projects are part of the corrective or reactive maintenance programme.

Table 8-3 gives a summary of the key asset related risks identified in the risk register (cross reference to the risk ID) and the expenditure programme to control / mitigate these asset risks.

Risk ID	Risk Description – Short	Expenditure Programme
AIAE3003	Possible harm resulting from explosion of leaning fused switches in SD oil filled distribution switchgear	Routine and preventive opex Refurbishment and renewal opex Capital expenditure projects
AIAE3014	Cast metal cable pothead failure causing possible harm	Fault and emergency opex Capital expenditure projects
AIAE3015	Unidentified loose neutral connections causing possible harm	Fault and emergency opex Capital expenditure projects

Risk ID	Risk Description – Short	Expenditure Programme
AIAE3016	Marine cable failure	Fault and emergency opex
AIAE3017	Risk of tower failure due to corrosion	Fault and emergency opex Refurbishment and renewal opex
AIAE3018	Uninsulated stay wires leading to risk of public injury	Refurbishment and renewal opex
AIAE3021	Uncontrolled oil spillage at zone substations with inadequate protection leading to environmental damage	Fault and emergency opex Refurbishment and renewal opex Capital expenditure projects
AIAE3026	Electricity distribution critical spares, tools and equipment	System management and operations opex
AIAE3046	Building Code compliance – seismic risk to substations	Routine and preventive opex Capital expenditure projects
AIAE3031	Possible harm caused by asset failure with uncertain ownership or POS location (including abandoned Telecom poles)	Routine and preventive opex
AIAE3040	King-bolt corrosion on overhead distribution transformer bearer arms	Fault and emergency opex Refurbishment and renewal opex
AIAE3042	Leaking Series 1 SD distribution switch gear	Routine and preventive opex Refurbishment and renewal opex Capital expenditure projects
AIAE3045	Possibility of harm or significant property damage associated with equipment failure at a distribution substation	Routine and preventive opex Refurbishment and renewal opex
AIAE3047	Uncontrolled discharge of oil from oil cables	Fault and emergency opex Refurbishment and renewal opex Capital expenditure projects
AIAE3048	Uncontrolled oil loss from distribution assets	Fault and emergency opex Refurbishment and renewal opex
AIAE3049	Possible fatality or serious harm resulting from a failure of a "letter-box pillar" (meter)	Fault and emergency opex Refurbishment and renewal opex Capital expenditure projects
AIAE 3050	Increase in fault level due to Vector's work resulting in potential damage to customers' properties	Routine and preventive opex
AIAE3052	Aluminium suspension clamps. Accelerated corrosion of conductor at the suspension clamp interface	Capital expenditure projects

Table 8-3 : Summary of the key asset risks identified in the risk register

Vector is looking to improve the standardisation of risk descriptions, assessments, evaluations and the prioritisation of treatments and is investigating enhanced computer-based platforms to aid in their overall analysis and management.

Vector is also intending to develop an overall risk-performance measurement structure which will be used to measure, track and report over time the effectiveness of the management of individual risks and the overall risk-management process itself (and specifically asset-related risk management).

Components of this integrated risk-management suite are currently being investigated or tested and it is anticipated to have the full system in place by 2013.

8.3.2.4 Incident Management and Reporting

Vector recognises that the accurate, effective and efficient reporting and management of incidents is an important input into the risk analysis and management. This process is a significant source of information on the nature and level of risks and the effectiveness of controls. Incident reporting and management is a key component of Vector's health and safety management system, and as a result Vector has developed and implemented a centralised incident and risk management database called RIMS (Risk and Incident Management System).

Incident reporting provides a key mechanism to gain insight into the root causes of incidents and provides a valuable opportunity to trend, learn, improve, and avoid similar events in future. In managing incidents, Vector's priorities are to:

- Stabilise and manage the immediate situation. Depending on the event this includes ensuring the safety of its employees, contractors and members of the public; limiting damage to assets; limiting environmental harm, and preserving operations;
- Notify the appropriate internal staff and external authorities, agencies and organisations (where required) of the incident;
- As appropriate, (in accordance with HSEMS 9) investigate the incident and prepare an incident report that considers all of the contributing factors, identifies the root cause(s) and recommends corrective actions as appropriate;
- Carry out any corrective actions; and
- Close out the incident.

Vector also provides a weekly report to the executive team and senior managers, showing all incidents rated with the potential significance rating of "serious or above" This report is reviewed as the first agenda item on the weekly executive meeting every Monday.

The Corporate HSE team is now focusing on understanding the HSE Culture across Vector.

8.4 Business Continuity Management

8.4.1 Business Continuity Policies

Vector requires an appropriate level of BCM capability in order to meet:

- Its obligations as the owner of "lifeline" utility businesses; such that it is able to function to the fullest possible extent (even though this may be at a reduced level during and after an emergency);
- Customer expectations that service disruptions will be minimised; and
- Shareholders' expectations in terms of protecting value if a disruptive event occurs.

To deliver this Vector has developed a BCM policy which requires that following a range of possible events, emergencies and crises Vector can:

- Minimise their impact on people, operations, assets and reputation;
- Maintain services to the fullest possible extent; and
- Recover to a business as usual position as quickly as reasonably practicable.

To deliver this Vector has established, and maintains, a robust BCM capability. Critical components are live tested on a regular basis to assess the ability to accommodate physical, business and personnel changes. Sufficient personnel are trained to manage serious situations and cope if key people are unavailable.

Vector extends the requirement to maintain a robust and workable BCM capability to its key external service providers that are relied upon by Vector to support its operations.

8.4.2 BCM Responsibilities

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 a BCM steering committee. Additional oversight is provided by the BRAC and 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.

8.4.3 Business Continuity Capability

To deliver on its BCM policy Vector, as a whole and within its individual functional and business units, as appropriate:

- Undertakes Business Impact Analysis (BIA) and reviews of key disruptive events and recovery timeframes to determine BCM capability requirements;
- Ensures it has in place the appropriate level of BCM capability to be able to respond when a disruptive event occurs. This capability consists of:
  - People;
  - Plans; and
  - Infrastructure;
- Reviews and updates this capability annually (or as required if material external or internal changes have occurred) and has a full review scheduled on an appropriate timescale;
- Ensures the BCM capability extends to third parties where they are key agents in the delivery of an activity for Vector;
- Requires a BCM associated programme of testing to be planned and delivered; and
- Ensures it has appropriate:
  - BCM communication/awareness processes in place;
  - Levels of BCM training; and
  - Monitoring and reporting.

8.4.4 Business Continuity Plans

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.

With respect to governance each BCP:

- Has an owner. The owner has responsibility for the plan and all aspects of the capability around this plan;
- Is developed by those who are associated with the activity and who are named in the Plan;

- Is reviewed annually and fully reviewed within a timeframe appropriate to the associated activity, or when required if significant external or internal changes occur;
- Has a programme for testing the combination of:
    - People;
    - Plan;
    - Infrastructure; and
    - Has an appropriate associated training and communication plan;

With respect to components, each BCP:

- Identifies which individuals/groups are notified of an event, including naming appropriate alternates, and having an appropriate escalation process defined;
- Identifies third parties that are required to support a given activity and identifies planning around their disruption;
- Outlines key activities to be undertaken;
- Provides key information required to make the implementation of the Plan achievable; such as:
    - Contact lists (internal and external);
    - Maps/plans/drawings/instructions/flow charts;
    - Criticality information;
    - List of required associated equipment; and
    - Appropriate check lists; and
- Has appropriate metadata:
    - Owner;
    - Versions; and
    - Date last reviewed and by whom.

8.4.5 Civil Defence and Emergency Management

Vector is classed as a "lifeline utility" under the Civil Defence and Emergency Management Act 2002 (CDEM) and 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.

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 has in place individual emergency response plans for major events and a National Civil Defence Emergency Management Plan that sits above these plans for use in the event of a declared civil defence emergency.

Vector is a member of the Auckland Engineering Lifelines Group (AELG). Membership in the AELG 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 its electricity distribution assets.

A key area of focus for the company is to better utilise information from the AELG and from other Lifelines groups around the country into its asset management process.

Vector is also a member of the National Engineering Lifelines Committee and keeps abreast of national issues and initiatives through this forum.

8.4.6 BCP and Emergency Response Plans

Vector has a number of plans to cover emergency situations. These plans are reviewed and updated regularly to ensure they are current. Examples of the plans are:

- Crisis management plan;
- Emergency response plan;
- Switching Plans;
- Electricity operations centre emergency evacuation plan;
- Emergency load shedding plan;
- Participant Outage Plan;
- Vector Group crisis communications plan;
- Vector Group pandemic health plan;
- Transpower contingency plans;
- Call Centre BCP; and
- Spill Response Protocol for transformers, switchgear and fluid-filled cables.

These plans are further described below.

8.4.6.1 Crisis Management Team Plan

The crisis management team plan 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.

While the crisis management team plan procedures have been developed to cover a broad set of circumstances, Vector is mindful that every crisis has its own unique set of circumstances, which will require good judgement from Vector employees to be managed effectively.

The crisis management team plan is not intended to cover operational emergency response requirements, as these are covered by the relevant emergency response plans. The plan is designed to support those 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.

8.4.6.2 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 whose role it is to oversee the management of potential loss, and restoration, of supply following a significant event. The team is very experienced and undertakes exercises periodically at least annually.

This plan will be reviewed annually to ensure continuous improvement and a standardised approach to all operational incidents across the group.

8.4.6.3 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 and instructing field staff to manually operate field switches.

The control room also 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" or "extreme" classification within the risk matrix (see Figure 8-3), which corresponds with the loss of a zone substation or critical sub-transmission feeder. These contingency plans are reviewed once a year.

8.4.6.4 Electricity Operations Centre Emergency Evacuation Plan

The purpose of this 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 located at Vector's head office at 101 Carlton Gore Road, Newmarket, Auckland.

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 located at Massey, in west Auckland. Regular evacuation exercises are held to ensure evacuation of the control centre can proceed smoothly and at any time.

8.4.6.5 Emergency Load Shedding Strategy

The purpose of this document is to provide procedures for emergency load shedding when required, as requested by Transpower during a grid emergency, or during planned load shedding for energy shortfall. The document does not cover water heating load shedding for reducing peak loads either for network constraints or reducing transmission (peak demand) charges.

Vector is required, under the Electricity Industry Participation Code (2010), to provide automatic under frequency load shedding (AUFLS) capabilities in two blocks, each of 16% of the total load at all times to maintain grid security. Load shedding will occur automatically under specified system frequency excursion situations. The load groups are reviewed regularly to ensure the required capability is maintained and the priorities are appropriate.

From time to time, Vector is requested by Transpower, acting in the capacity of Transmission Grid System Operator, to shed load to avoid cascade tripping of the grid under emergency situations. Vector has assigned load groups to cover such contingencies.

8.4.6.6 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.

8.4.6.7 Vector Group Crisis Communications Plan

The Vector Group crisis communications plan has been written to ensure 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; and
- When the situation is expected to be (or is) resolved.

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.

8.4.6.8 Vector Group Pandemic Health Plan

As a lifeline utility the Civil Defence and Emergency Management Act (2002) requires Vector to be able to function to the fullest possible extent during and after an emergency.

The objective of this plan is to manage the impact of a pandemic on Vector’s employees and its business to ensure continuation of network operations through two main strategies including the containment of disease by reducing spread within Vector’s offices and facilities, and maintenance of essential services if containment is not possible.

8.4.6.9 Transpower Contingency Plans

The purpose of these plans is to assess the consequences of loss or reduction of supply from Transpower’s Grid Exit Points (GXP), and planning around the restoration or partial restoration of supply following a catastrophic failure.

The contingency plans have been prepared by Transpower for loss of supply at each GXP. Depending upon the GXP lost, other Transpower substations may also be affected. For example, loss of the Otahuhu GXP would affect all of Vector’s network north of Otahuhu. Some Transpower GXPs have more than one busbar so supply lost could be to a single busbar or to a whole substation.

8.4.6.10 Call Centre Business Continuity Plan

The core business of Telnet Services, Vector's call centre provider, 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/DR 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 around handling of safety critical and emergency calls.

8.4.6.11 Spill Response Protocol for Transformers, Switchgear and Fluid-filled Cables

The purpose of this protocol is to document Vector's expectations in the management of liquid spills from all transformers, switchgear and fluid filled cables (FF cables). The document forms part of Vector's overall environmental management response, but places emphasis on the immediate and specific risk of environmental impact from spills from existing facilities.

8.4.6.12 Critical Spares

A stock of spares is maintained for critical components of the network so that fault repair is not hindered by the lack of availability of required parts. Whenever new equipment is introduced to the network an evaluation is made of the necessary spares required to be retained to support the repair of any equipment failures. Refer to Section 6.4 for further details.

8.5 Insurance

The Treasury function manages the placement of insurance for Vector.

Vector's approach to its insurance programme has been to balance risk and cost and has involved regular review of the financial risk appetite of the group. This translates into a programme whereby Vector seeks cover for low probability major or catastrophic events, and carries as an operational expense the cost of other events which have a lesser financial impact. With respect to the latter category, risk mitigation activity is undertaken to reduce the likelihood of these events through proactive maintenance programmes and thorough management processes.

8.6 Health and Safety

8.6.1 Health and Safety Policy

Vector's health and safety policy states the company's overarching commitments and requirements for health and safety. Vector conducts its business activities in such a way as to protect the health and safety of employees, contractors, members of the public and visitors in and within the vicinity of Vector's work environment and those people in the vicinity of its assets. The company is committed to continual and progressive improvement in its health and safety performance and ensures it has sufficient, competent resources and effective systems at all levels of the organisation to fulfil this commitment.

Any work conducted on and around Vector's assets by external parties, including its service providers, is also required to be conducted in line with the Vector health and safety policy and the Vector HSE Management system.

Vector's health and safety policy objectives are to:

- Provide a safe and healthy work place for all staff, contractors, the public and visitors;
- Ensure health and safety considerations are part of all business decisions;
- Monitor and continuously improve health and safety performance;
- Communicate with staff, contractors, customers, and stakeholders on health and safety matters;
- Operate in a manner that minimises health and safety hazards; and
- Encourage safe and healthy lifestyles, both at work and at home.

To achieve this Vector:

- As a minimum, meets all relevant legislation, standards and codes of practice for the management of health and safety;
- Identifies, assesses and controls workplace hazards;
- Accurately reports, records and learns from all incidents and near misses;
- Has established health and safety goals at all levels within Vector, and regularly monitors and reviews the effectiveness of Vector's Health and Safety Management System;
- Consults, supports and encourages participation from its people on issues that have the potential to affect their health and safety;
- Promotes its leaders', employees' and contractors' understanding of the health and safety responsibilities relevant to their roles;
- Provides information and advice on the safe and responsible use of Vector's products and services;
- Suspends activities if safety would be compromised; and
- Takes all practicable steps to ensure Vector's contractors work in line with this policy.

8.6.2 Health and Safety Practices

All Vector employees and contractors working for Vector are responsible for ensuring their own safety and the safety of others by adhering to safe work practices, making appropriate use of plant and equipment (including using protective clothing and equipment) and promptly reporting incidents, near misses and hazards to Vector.

Vector's Health and Safety Management System (HSEMS) defines the high level essentials necessary to maintain an incident free environment. This is documented in a set of 11 HSE Standards. Beneath these standards are more detailed "key requirement" documents that provide more specific detail on specialised activities such as confined space entry, working at heights etc.

These standards and key requirement documents allow each business unit to develop their own safe work method statements or procedures.

This approach is necessary for Vector and its Field Service Providers (FSPs) to have the flexibility to manage their business units in a manner that identifies and eliminates incidents.

Key elements of Vector's health and safety practices, as they relate to assets and asset management, include the following:

- Wherever practicable Vector will eliminate, isolate or minimise hazards or control risks to As Low As Reasonably Practicable (ALARP), so as to ensure the safety and health of personnel, the public, the environment;
- The identification of safety and health hazards and the assessment of their associated risks to ensure they are managed to an acceptable level during their operation or associated activities ;
- Vector practices preventative maintenance strategies to all critical plant and equipment to ensure continued safe, environmentally sound, economic and effective operation. In addition, Vector ensures the reliability of critical safety backup equipment, protective devices and key operating equipment is maintained;
- Safety considerations are incorporated into Vector's design standards and asset selection criteria;
- Appropriate safety equipment is installed, inspected and maintained and staff are competent to identify items in need of repair or replacement;
- All FSPs working for the company are required, as a minimum, to comply with Vector's safe work practices whilst carrying out any work on the network. FSPs are also required to report all employee and third party incidents related to work on the Vector network, together with their investigations and corrective and preventive actions;
- Vector monitors electricity related public safety and employee/contractor safety incidents. These incidents are reviewed monthly to ensure lessons are captured and shared with its FSPs; and
- Ongoing public safety awareness communications programmes on electricity are undertaken. These include:
    - Vector's "Stay safe around electricity" schools programme, which was started in 2005. Since conception, more than half of Auckland's primary schools have been visited and over 60,000 children have been through the programme, which is designed to raise children's awareness of the hazards of electricity;
    - An annual "Switch on to safety" campaign which targets people who undertake Do It Yourself (DIY) activities around their homes. The campaign encourages people to 'think first' before working or playing near Vector's networks and their service lines. This includes high risk activities such as gardening (digging), fencing, tree trimming, painting, water blasting and boating (boat masts and lines hazards and submarine cables). The campaign is run over the spring/summer months when these activities are most prevalent. A variety of integrated and targeted media is used -including newspaper (the NZ Herald), internet, email and radio – to deliver the key messages;
    - Promoting safe work practices extensively to external contractors whose work brings them in close proximity to Vector's networks ie. council and water service contractors, arborists. As well as protecting the contractors themselves, the programme aims to protect the community from hazards and ensure an ongoing safe and reliable power supply to Vector's customers. Vector provides free services and resources to help contractors work safely around Vector's networks, including free network maps, on-site mark outs and supervision, safety guides and presentations. To ensure it is easy to get in touch with us Vector has dedicated freephone numbers; and

- Vector is also a founding member of the “before-u-dig service” (www.beforeudig.co.nz). “Before-u-dig” enables contactors to obtain plans from a number of asset owners like Vector, simply by making one enquiry, rather than calling each asset owner individually.

A full review is currently being undertaken of Vector’s health and safety framework in order to identify potential improvement opportunities. Vector continually strives for excellence in safety performance and recognises the importance of a robust, well structured safety framework to assist in delivering an incident and injury free workplace.

8.6.3 Safety Management System for Public Safety

The passing of the Electricity Amendment Act 2006 and Gas Amendment Act 2006 required companies in New Zealand engaged in the generation, transmission and distribution of electricity or gas to develop, implement and maintain a safety management system that will ensure their generation and distribution systems will not pose a significant risk of serious harm to members of the public or of significant damage to public property.

This amendment to the legislation was followed by the production of the New Zealand Standard (NZS7901) that sets out the detail. Vector has been audited to, and passed, the NZS7901 requirements and has made the statutory declaration to the Secretary of MED that Vector has an accredited safety management system.

8.7 Environmental Management

8.7.1 Environmental Policy

Vector’s environmental policy confirms its commitment to managing the environmental impact of its businesses, and ensuring as a minimum, compliance with legislation, standards and any resource consents held by the company. The company conducts its operations in such a way as to respect and protect the natural environment, and sensitive sites and is committed to continual and progressive improvement in its environmental performance. Sufficient competent resources and effective systems are provided at all levels of the organisation to fulfil this commitment. Vector also requires all employees and service providers working for Vector to proactively manage their employees and work for Vector in line with this policy.

Vector’s environmental policy is to:

- Ensure environmental considerations are part of all business decisions;
- Meet or exceed all relevant environmental legislation, regulations or codes;
- Participate and work with government and other organisations to create responsible laws, regulations, standards and codes of practice to protect the environment;
- Monitor and continuously improve Vector’s environmental performance;
- Operate in a manner that minimises environmental and social impacts;
- Take appropriate action where there is a negative impact on the environment and a material breach of the Resource Management Act 1991; and
- Communicate with employees, contractors, customers and other relevant stakeholders on environmental matters.

To achieve this Vector:

- Has plans in place to avoid, remedy or mitigate any adverse environmental effects of its operations; and

- Focuses on responsible energy management and will practice energy efficiency throughout all of its premises, plant and equipment, where possible.

The long-term operational objectives of Vector are to:

- Utilise fuel as efficiently as practicable;
- Mitigate, where economically feasible, fugitive emissions and in particular greenhouse gas emissions;
- Wherever practicable use ambient and renewable energy; and
- Work with its customers to maximise energy efficiency.

8.7.2 Environmental Practices

Vector also puts significant emphasis on environmental management and continues improving its environmental management in partnership with Vector's FSPs. Vector's key practices in this regard include the following:

- Vector continually explores opportunities for minimising waste generation and, when identified, pursues economically viable opportunities consistent with business priorities and community expectations. All wastes generated from operations are effectively managed and disposed of in a cost effective manner in compliance with statutory requirements;
- When addressing environmental issues, consideration is given to both long-term impacts of waste disposal and to potential long-term issues;
- One of Vector's key performance indicators (KPIs) is to avoid any activity that would cause Vector to be in breach of the Resource Management Act 1991;
- Vector's health and safety management system (HSEMS 11) includes minimum acceptable standards on environmental management and a focus on eliminating damage; and
- Environmental incidents are accurately reported, recorded and investigated with any learnings and improvements shared across Vector's FSPs at the safety leadership forum.

Electricity
Asset Management Plan
2013 – 2023

Summary of Expenditure Forecast – Section 9

[Disclosure AMP]

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9. Expenditure Forecast and Reconciliation

This section summarises how the capital, operating and maintenance forecast expenditures are compiled, including prioritisation of expenditures.

As Vector operates to a June financial year all its budgeting, financial and management reporting activities align with the June year. However, the Electricity Distribution Information Disclosure Determination 2012 requires Vector to disclose its expenditure and expenditure forecast information on a March disclosure year basis, as presented in information disclosure schedules contained in the appendices of this AMP. There are, therefore, time shift differences in the expenditure forecast disclosed in the appendices of this AMP compared to the budget and forecasts Vector operates to and figures that may be reported in Vector's financial statements or elsewhere.

As indicated in Section 1.3 of this AMP, while this AMP also satisfies regulatory requirements, its main purpose is as a working guideline for the management of Vector's electricity distribution network assets. The forecasts contained in Sections 5, 6, 7 and 9 of this AMP are therefore presented on a real June 2013[1] New Zealand dollars basis, for Vector financial (July – June) years – which is the input required into Vector's budgeting and financial forecasting processes.

However, since the Electricity Distribution Information Disclosure Determination 2012 requires Vector to disclose the financial information in real 2013 dollars and in regulatory years (ending 31 March). These figures are presented in the Report on Forecast Capital Expenditure (Information Disclosure Schedule 11a, Appendix 1 of this AMP) and the Report on Forecast Operational Expenditure (Information Disclosure Schedule 11b, Appendix 2 of this AMP). These two reports also contain the expenditure forecasts expressed in nominal dollars as required by the Information Disclosure Determination.

The price inflation factors used to convert the constant price forecasts to nominal forecasts are explained in Section 9.6. Given the many variants in reporting financial information, the reader is cautioned when comparing the expenditure information in this AMP and the associated appendices.

Due to the difference between the regulatory calendar and Vector's corporate planning cycle the Board has not yet approved the 2013/14 budgets and expenditure forecasts. The 2013/14 budget and expenditure forecasts are, therefore, still subject to change to reflect changing operating, commercial or regulatory environments. In addition, while the expenditure forecasts for later years presented in this AMP are the best estimates available at the time of preparing this plan they will be subject to change in future as circumstances change and projects are reviewed.

It is possible Vector will need to apply to the Commerce Commission for a "customised price-quality path", which takes into account future capital expenditure (capex) and operating expenditure (opex) requirements. Vector would then be locked into a five year capex forecast which would underpin line revenue. While the forecasts in this AMP have been prepared according to good industry practice, Vector would need to review its expenditure plans to ensure they provide a suitable basis for such a fixed price path.

9.1 Capital Expenditure

9.1.1 Refinements to Vector's Capital Expenditure Forecasting Methodology

Over the last two years, Vector's actual capital expenditure on electricity projects was less than the forecast expenditure, in spite of the fact that the original proposed

[1] FY2014 is the first year of the planning period of the disclosure AMP, commencing on 1 July 2013.

programmes were substantially delivered as envisaged. Further analysis indicates that this divergence was primarily caused by the following factors:

- In accordance with good engineering practice, Vector includes a contingency amount in its forecast expenditure on each project. This is to allow for expenditure during the construction phase of a project that could not reasonably have been foreseen and included at the planning and design stage, thus avoiding the need for frequent budget increase requests. The contingency amount allowed is based on actual historical experience on similar project categories. Due to the nature of project delivery, the actual contingency amounts spent on projects vary considerably, mostly not requiring the full allowance. When viewed at a project portfolio level, where the budget is built up as the sum of individual project budgets each including a normal contingency allowance, the net result is that the full contingency allowance is likely to be under-spent.

- In Vector's capital expenditure budget, allowance is made for third-party initiated projects, such as new customer connections and asset relocations. This forecast expenditure is based on requirements and work-programmes submitted by the external parties and represent the best information available at the time of preparing budgets and forecasts. However, very often these third-party works do not proceed according to the originally submitted timescales, or in some cases does not proceed at all. As a result, we find that actual expenditure on this type of work can be less than originally envisaged – a situation that appears to have become more so over the last three years.

A decision has now been made to reflect the above factors in our future capital works 10-year forecasts, and accordingly the future figures have been reduced from previous levels – including that submitted in earlier asset management plans. The cost reductions are made at a project portfolio level, not at individual project level. For each individual project, there is still a significant likelihood that the full forecast amount may be required. As a result, the total future expenditure forecast is now less than the forecast built up from the sum of the various projects planned for each year.

This refined approach holds a degree of risk, as it is possible that one or more of the high-level factors may change in a particular year (for example, all third-party projects envisaged at the planning stage may proceed, or exceptional factors may require full project contingency amounts on the majority of projects) and the capital budget may then prove insufficient to allow planned delivery.

9.1.2 Capital Expenditure Forecast

Vector's electricity distribution capex forecast for the next ten financial years (ending 30th June) is presented in Table 9-1. This is based on the revised forecasting methodology described above.

Budget and Expenditure Forecast (FY) (Portfolio forecasting approach)	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Customer connection	$24.6 m	$24.1 m	$24.1 m	$24.1 m	$24.0 m	$24.0 m	$23.5 m	$23.5 m	$23.4 m	$23.3 m	$23.3 m
System growth	$60.2 m	$48.0 m	$41.7 m	$38.8 m	$33.9 m	$34.8 m	$24.1 m	$26.0 m	$28.3 m	$24.0 m	$28.2 m
Asset replacement and renewal	$67.4 m	$56.9 m	$61.9 m	$56.3 m	$61.4 m	$57.9 m	$61.6 m	$57.7 m	$54.7 m	$52.0 m	$53.5 m
Asset relocations	$24.2 m	$21.3 m	$22.6 m	$19.7 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m	$18.3 m
Reliability, safety & environmental	$7.6 m	$6.5 m	$5.6 m	$5.8 m	$5.0 m	$4.9 m	$5.8 m	$4.5 m	$3.6 m	$3.6 m	$3.6 m
Non-system fixed assets (Asset IT)	$0.0 m	$2.8 m	$3.4 m	$2.6 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m	$3.2 m
Asset Capital Expenditure total	**$184.0 m**	**$159.6 m**	**$159.3 m**	**$147.4 m**	**$145.9 m**	**$143.1 m**	**$136.4 m**	**$133.2 m**	**$131.5 m**	**$124.5 m**	**$130.1 m**

	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Components of system growth										
Network reinforcement	$42.4 m	$37.8 m	$34.4 m	$32.0 m	$33.7 m	$22.9 m	$23.8 m	$25.9 m	$21.4 m	$27.3 m
Large customer connections	$5.6 m	$3.8 m	$4.4 m	$1.9 m	$1.2 m	$1.2 m	$2.2 m	$2.4 m	$2.7 m	$1.0 m
Asset replacement and renewal										
Large asset replacement projects	$14.5 m	$19.2 m	$16.0 m	$18.0 m	$17.0 m	$18.5 m	$14.8 m	$12.7 m	$12.4 m	$13.3 m
Mass asset replacement projects	$37.8 m	$37.8 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m	$37.7 m
Protection & control assets	$4.7 m	$5.0 m	$2.6 m	$5.7 m	$3.2 m	$5.5 m	$5.2 m	$4.3 m	$1.9 m	$2.5 m
Components of reliability, safety & environmental										
Quality	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m	$1.3 m
Legislative and regulatory	$3.6 m	$2.7 m	$3.0 m	$2.3 m	$2.2 m	$3.1 m	$1.8 m	$0.9 m	$0.9 m	$0.9 m
Other reliability, safety & environmental	$1.7 m	$1.7 m	$1.5 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m	$1.4 m
Components of asset relocation										
Overhead to underground	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m	$13.3 m
Other asset relocation	$8.0 m	$9.3 m	$6.4 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m	$5.0 m

* Figures are in 2014 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

Table 9-1 : Capital expenditure forecast - revised (portfolio) forecasting methodology (Vector financial years)

9.1.3 Capital Expenditure Categories

The expenditure categories contained in the forecasts are based on the Electricity Distribution Information Disclosure Determination 2012 as follows:

9.1.3.1 Customer Connection

Customer connection is the gross capital expenditure for the establishment of a new customer connection point or alterations to an existing customer connection point. This expenditure category includes gross capital expenditure relating to:

- Connection assets and/or parts of the network for which the expenditure is recoverable in total, or in part, by a contribution from the customer requesting the new or altered connection point; and
- Electricity injection and off-take points of connection.

Capital contributions for this type of work are accounted for separately. Expenditures under this category are discussed in more detail in Section 5 of this AMP.

9.1.3.2 Network Growth

Network growth is the gross capital expenditure to provide additional capacity on a part of the network to meet a change in demand or embedded generation, or additional investment to maintain current security and/or quality of supply standards due to the increased demand or generation. This expenditure category includes gross capital expenditure associated with SCADA and telecommunications assets.

Forecast expenditure on large customer connections (those that require additions to the Vector sub-transmission network or material reinforcement of the distribution network) is also included in this expenditure category.

Expenditures under this category are discussed in more detail in Section 5 of this AMP.

9.1.3.3 Asset Replacement and Renewal

Asset replacement and renewal refers to the gross capital expenditure required to maintain network asset integrity so as to maintain the current security and/or quality of supply standards and includes expenditure as a result of:

- The progressive physical deterioration of the condition of network assets or their immediate surrounds;
- The obsolescence of network assets;
- Preventative replacement programmes, consistent with asset life-cycle management policies; or
- The need to ensure the ongoing physical security of the network assets.

Vector generally divides asset renewal expenditure in three broad categories:

- Renewal of large assets, individually identified in advance of the financial year;
- Renewal of bulk (smaller) assets, generally identified during the course of a financial year; and
- Protection and control assets.

Expenditures under this category are discussed in more detail in Section 6 of this AMP.

9.1.3.4 Asset Relocation

Asset relocation refers to the gross capital expenditure required to relocate assets due to third party requests, such as for the purpose of allowing road widening or similar needs. This expenditure category includes gross capital expenditure relating to the undergrounding of previously aboveground assets (such as overhead improvement programmes) at the request of a third party. Capital contributions for this type of work are accounted for separately.

Expenditures under this category are discussed in more detail in Section 5 of this AMP.

9.1.3.5 Reliability, Safety and Environmental

Safety, reliability and the environmental impact of installations are key considerations in the design or maintenance of Vector' assets and, as such, form primary inputs into our asset management processes. However, in particular instances the need may arise in specific parts of the network to enhance safety, reliability or to mitigate against a (potential) negative environmental impact. Expenditure on such works is covered under this category:

Quality of Supply

The primary purpose of this expenditure is to maintain the security and/or quality of supply performance of the network. This may include expenditure to, in specific parts of the network where intervention is required, to reduce the:

- Interruption/fault rate;
- Average time that customers are affected by planned and/or unplanned interruptions; or

  Number of consumers affected by planned and/or unplanned interruptions.

Legislative and Regulatory

The primary purpose of this expenditure is to create or modify network assets as a result of a new regulatory or legal requirement.

Other Reliability, Safety and Environmental

The primary purpose of this expenditure is to maintain network reliability or safety or to mitigate the environmental impacts of the network, but is not included in either of the quality of supply or legislative and regulatory categories.

Expenditures under this category, if any, are discussed in Sections 5 and 6 of the AMP.

9.1.3.6 Non-network Capex

Non-network asset expenditure relates to the expenditure required to provide electricity lines services but is not directly related to any network asset, and includes expenditure on or in relation to:

- Information and technology systems;
- Asset management systems;
- Office buildings, depots and workshops;
- Office furniture and equipment;
- Motor vehicles;
- Tools, plant and machinery; or

- Any other items treated as non-network assets under Generally Accepted Accounting Practice (GAAP).

For the purpose of this Asset Management Plan, only expenditures on asset management systems, information and technologies are included. These expenditures are discussed in more detail in Section 7 of this AMP. Other expenditures such as corporate IT, office furniture, etc are excluded from this AMP. It should be noted that the forecasts provided under Schedule 11a of the Information Disclosure (Appendix 1 of this AMP) include **all** non-network asset expenditures (on an allocation basis) and not just the asset management systems, information and technologies discussed in Section 7 of this AMP.

9.2 Maintenance and Operations Expenditure

Vector's electricity distribution maintenance budget for the financial year ending 30th June 2013 and the maintenance expenditure forecast for the disclosure years ending 30th June from 2014 to 2023 are set out in Table 9-2. The expenditure forecasts are presented in June 2013 real New Zealand dollars and relate to the direct maintenance, inspection and field operation of assets to maintain network and asset integrity and their capability to deliver the level of service in accordance with Vector's asset management strategies. These expenditures do not include categories that are of an indirect/business support nature.

The expenditure forecasts presented in this table has been reclassified (compared to the forecast contained in the previous AMP) based on the expenditure categories defined in the Electricity Distribution Information Disclosure Determination 2012. The forecast under the System Operations and Network Support category contains direct expenditure only (indirect/corporate component of this category is not included) and therefore remains compatible with the previous forecast. The forecast for this category presented in the Information Disclosure schedule 11b however contains both direct and indirect expenditures and is therefore different from the figures in this section of the AMP.

9.2.1 Operating Expenditure Categories

Vector's direct operating expenditure is grouped under the following categories as defined in the Electricity Distribution Information Disclosure Determination 2012.

9.2.1.1 Service Interruption and Emergency

This expenditure is provided for attending to any unplanned instantaneous event or incident that impairs the normal operation of network assets. This includes reactive work (either temporary or permanent) undertaken in the immediate or short term in response to an unplanned event. It includes back-up assistance required to restore supply, repair leaks or make safe, operational support such as mobile generation used during the outage or emergency response and any necessary response to events arising in the upstream transmission system. It does not include expenditure on activities performed proactively to mitigate the impact such an event would have should it occur.

Planned follow-up activities resulting from an event which were unable to be permanently repaired in the short term are to be included under routine and corrective maintenance and inspection category.

9.2.1.2 Vegetation Management

This category of expenditure is provided to physically fell, remove or trim vegetation (including root management) that is in the proximity of overhead lines or cables. It includes expenditure arising from the following activities:

- Inspection of affected lines and cables where the inspection is substantially or wholly directed to vegetation management (e.g., as part of a vegetation management contract) including pre-trim inspections as well as well as inspections of vegetation cut for the primary purpose of ensuring the work has been undertaken in an appropriate manner;
- Liaison with landowners including the issue of trim/cut notices, and follow up calls on notices; and
- Felling or trimming of vegetation to meet externally imposed requirements or internal policy, including operational support such as any mobile generation used during the activity.

Budget and Expenditure Forecast (FY)	2013 AMP	Forecast									
	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Asset Replacement & Renewal	$10.5 m	$11.5 m	$11.5 m	$11.5 m	$11.1 m	$11.2 m	$11.3 m	$11.4 m	$11.5 m	$11.7 m	$11.8 m
Routine & Corrective Maintenance & Inspection	$11.4 m	$12.5 m	$11.6 m	$11.7 m	$11.8 m	$11.9 m	$12.1 m	$12.2 m	$12.4 m	$12.7 m	$12.9 m
Service Interruptions & Emergencies	$6.6 m	$7.1 m	$7.1 m	$7.0 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m	$7.1 m
System Operations & Network Support	$10.7 m	$11.1 m	$11.4 m	$11.4 m	$11.4 m	$11.4 m	$11.0 m	$11.0 m	$11.0 m	$11.0 m	$11.0 m
Vegetation Management	$4.2 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m	$4.8 m
Direct Operational Expenditure Subtotal	**$43.4 m**	**$46.9 m**	**$46.2 m**	**$46.3 m**	**$46.0 m**	**$46.2 m**	**$46.2 m**	**$46.5 m**	**$46.8 m**	**$47.2 m**	**$47.6 m**

* Figures are in 2014 real New Zealand dollars (million);

** The year reference indicates the end date of the Vector financial year

Table 9-2 : Direct Operational Expenditure Forecast (Vector financial years)

The following activities and related costs are excluded from this category:

- General inspection costs of assets subject to vegetation where this is not substantially directed to vegetation management (include in routine and corrective maintenance and inspection);
- Costs of assessing and reviewing the vegetation management policy (include in network support);
- Data collection relating to vegetation (include in network support);
- The cost of managing a vegetation management contract, except as stated above (include in network support); and
- Emergency work (include in service interruptions and emergencies).

9.2.1.3 Routine and Corrective Maintenance and Inspection

This category of expenditure is for activities specified in planned or programmed inspection, testing and maintenance work schedules including:

- Fault rectification work that is undertaken at a time or date subsequent to any initial fault response and restoration activities;
- Routine inspection;
- Functional and intrusive testing of assets, plant and equipment including critical spares and equipment;
- Helicopter, vehicle and foot patrols, including negotiation of landowner access;
- Asset surveys;
- Environmental response;
- Painting of network assets;
- Outdoor and indoor maintenance of substations, including weed and vegetation clearance, lawn mowing and fencing;
- Maintenance of access tracks, including associated security structures and weed and vegetation clearance;
- Customer-driven maintenance; and
- Notices issued.

It should be noted that historically, including in previous Asset Management Plans, Vector classified these expenditure items under the "Planned maintenance" category.

9.2.1.4 Asset Replacement and Renewal

Asset replacement and renewal opex refers to the expenditure required to maintain network asset integrity so as to maintain the current security and/or quality of supply standards and includes expenditure as a result of:

- The progressive physical deterioration of the condition of network assets or their immediate surrounds;
- The obsolescence of network assets;
- Preventative replacement programmes, consistent with asset life-cycle management policies; or
- The need to ensure the ongoing physical security of the network assets.

It should be noted that historically, including in previous Asset Management Plans, Vector classified these expenditure items under the "Corrective maintenance" category.

Expenditures under the above four categories are discussed in more detail in Section 6 of this AMP.

9.2.2 Support Costs

In addition to the above four direct expenditure categories, the Electricity Distribution Information Disclosure Determination 2012 also defines two categories of operational expenditures that are related to the management of the electricity distribution business but are not directly related to the maintenance and inspection of network assets. A description of these two expenditure categories is included in the following two sections. These two categories are a combination of internal/staff costs and external costs and are disclosed separately under Schedule 11b of the Information Disclosure regime, and do not form part of the AMP direct Opex forecasts.

9.2.2.1 Business Support

Business support costs include operational expenditure associated with the following corporate activities:

- HR and training (other than operational training);
- Finance and regulation including compliance activities, valuations and auditing;
- CEO and director costs;
- Legal services;
- Consulting services (excluding engineering/technical consulting);
- Property management;
- Corporate communications;
- Corporate IT;
- Industry liaison and participation;
- Commercial activities including pricing, billing, revenue collection and marketing; and
- Liaison with Transpower, customers and electricity retailers.

9.2.2.2 System Operations and Network Support

System operations and network support costs include indirect operational expenditures for the management of the network and include expenditure relating to control centre and office-based system operations, including:

- Asset management planning including preparation of the AMP, load forecasting, network modeling;
- Network and engineering design (excluding capitalized design costs for capital projects);
- Network policy development (including the development of environmental, technical and engineering policies);
- Standards and manuals for network management;
- Network record keeping and asset management databases including GIS;
- Outage recording;
- Connection and customer records/customer management databases (including embedded generators);

- Customer queries and call centre (not associated with direct billing);
- Operational training for network management and field staff;
- Operational vehicles and transport;
- IT & telecoms for network management (including IT support for asset management systems);
- Day to day customer management including responding to queries on new connections, disconnections and reconnections, embedded generators;
- Engineering and technical consulting;
- Network planning and system studies;
- Logistics (procurement) and stores; and
- Network asset site expenses and leases.

9.3 Assumptions for Preparing Expenditure Forecasts

9.3.1 Operating Uncertainty

While the 10 year expenditure forecasts have been prepared based on the best information at Vector's disposal, it should be noted electricity distribution businesses in New Zealand are still experiencing a period of significant economic volatility. Factors that may materially influence investments levels going forward include:

- Economic cycles and the impact of these on electricity demand. GDP figures published by Statistics NZ over the past four years ending March 2012 show three recent years of very low to negative growth (1.7%, 1.5% and -0.4% for the years ending March 2012, 2011 and 2010). Other economic indicators such as consumer and business confidence, unemployment rate and housing construction are also pointing towards a cautious recovery. During the same period, electricity delivered through the Vector network recorded growth rates[2] of 1.1%, 0.0% and, 0.1% respectively. Overseas, various economies are facing uncertainties caused by state debt burden, the fading effect of economic stimulus packages and low consumer confidence leading to low rates of job creation and economy activities. The protracted downturn in Europe and the USA is affecting the economic growth in China and Australia, New Zealand's top trading partners. The impact of this on New Zealand's export earnings and therefore the state of its economy is still uncertain;
- Analysis of energy consumption patterns on the Vector network over the last 8 years indicates that the average energy consumption of consumers across all categories is declining. The overall energy consumption trend has been flat. This trend does not appear to be replicated to the same extent in individual energy peak demand usage, and overall peak demand is still growing. Peak demand, rather than energy volumes conveyed through the network, is a key factor for investment decisions;
- The rebuilding of Christchurch and the Government's infrastructure programme (such as the Ultra Fast Broadband project) is likely to put significant pressure on construction resources both in terms of availability of the required skills and costs of construction;
- We continue to see relatively rapid change in electricity distribution and consumer technologies (see discussions in Section 3). New applications, associated with more intelligent networks, could have a substantial impact on how networks

[2] Refer to Vector Information Disclosure table AM1.

develop in the medium to longer term future, and hence also on the associated expenditure patterns;

- As a large 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. Part 4 was introduced in 2008 with objectives including the promotion of regulatory certainty and incentives for regulated businesses to invest, following concerns that previous regulatory settings were insufficient to promote investment in essential infrastructure;
    - The Commerce Commission, with input from stakeholders including Vector, is currently in the process of implementing Part 4. As part of this process it determined Input Methodologies for electricity distribution businesses in December 2010. Vector does not believe that the current Input Methodologies provide an adequate level of certainty or investment incentives. In particular, the cost of capital input methodology would not permit commercially realistic returns on investment (e.g. they provide a lower rate of return than the comparable Australian regulatory regime). Further, the asset valuation input methodology does not allow for a new and robust asset valuation to be developed at the start of the new regulatory regime and is based on prior valuations that are not fit for purpose. The Commission's decisions on the input methodologies and the regulatory processes in which they were developed have been subject to a series of legal challenges, including from Vector;
    - More certainty on incentives (or disincentives) for investment should be evident once the legal challenges are decided. However, these may not be settled until late 2013 and final prices may not be determined until 2014. As the next regulatory price reset is scheduled for 2015, it is likely that considerable regulatory uncertainty will remain a feature of the investment environment until 1 April 2015. There is a risk that a legally required review of input methodologies in 2017 could further exacerbate the uncertainty with the regulatory settings;
    - Should Vector be unsuccessful in its challenge to the allowed return on investment, it is likely that the investment plan set out in the AMP will be reduced. Vector does not believe that the current allowed regulated rate of return adequately compensates shareholders for the risk associated with investing in electricity distribution businesses and, should the existing situation persist, it is therefore likely to reduce its network investments to minimum safe levels.
- It is also not clear whether the regulatory regime and/or customer expectations will support investment in reliability improvements or energy efficiency. The quality requirements for electricity distribution businesses focus only on maintaining the current level of quality of supply (i.e. the principle of "no material deterioration"), not on improving it. The Commerce Act (Section 54Q) requires the Commission to promote investment by electricity distribution businesses in energy efficiency. However, the Commission has yet to implement this requirement. In the absence of quality or efficiency incentives, investment may only maintain, not improve, energy efficiency or quality of supply on regulated networks such as Vector's; and

In addition to those discussed above, Vector has also observed other factors that have historically caused major variations between forecast and actual expenditure:

- While long term customer connection numbers have been relatively stable, annual figures can vary significantly. This is driven by factors outside Vector's control;
- Electricity demand, which is a prime driver for network investment, is closely linked to customer connection numbers;

- The timing of large customer and relocation projects is very uncertain, and Vector often experiences significant discrepancies between previously requested timelines, which drives the AMP cost estimates, and actual construction periods; and
- Vector is continually improving the manner in which we collect, store and analyse asset information data. As better and more information become available, this sometimes identifies a need for accelerated (or decelerated) renewal.

9.3.2 Range of Expenditure Forecasts

To accommodate the level of uncertainty discussed above in a ten year investment programme presents challenges. To reflect this, Vector has prepared a range of forecasts bound by an upper and a lower expenditure level as shown in Figure 9-1. The criteria used to prepare these forecasts are described below. The boundary lines reflect the impact that regulatory settings could have on expenditure – this is the biggest uncertainty factor we face. Expenditure variances caused by other uncertain factors can lead to actual expenditure lying anywhere within the indicated range.

As noted before, Vector does not believe that the current allowed regulated rate of return adequately compensates shareholders for the risk associated with investing in electricity distribution businesses and, should the existing situation persist, it is therefore likely to reduce its network investments.

The lower line represents the minimum expenditure Vector would have to commit in order to deal with known health, safety and environmental issues, comply with its legal obligations, and provide sufficient network capacity to just meet peak demands under normal conditions, but without necessarily maintaining security of supply under fault conditions.[3]

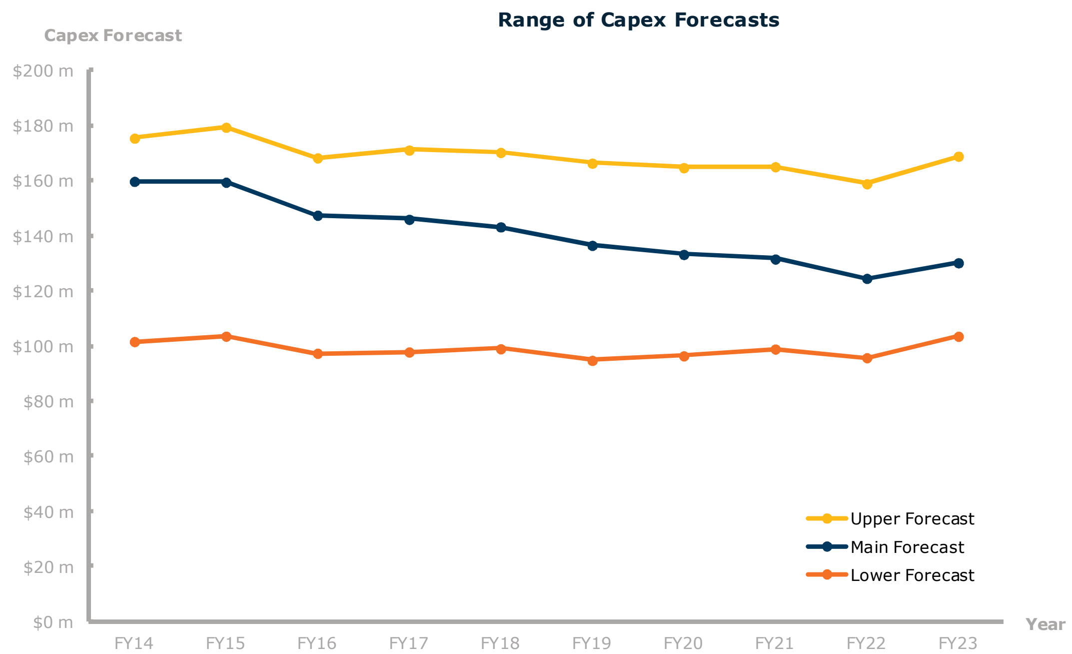

Figure 9-1 : Forecast capital expenditure range

It includes the minimum essential expenditure on planned asset replacement, network performance improvement, customer growth (only where Vector is obliged to supply,

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[3] It does not refer to a lower demand growth scenario, to which a response would be tailored as details become available and which would not lead to under-investment on the network.

which would generally exclude subdivisions and large customer projects), relocation projects (where Vector is obliged) and security of supply based projects.

This expenditure profile would eventually result in increasing asset failure rates and breaching of Vector's security of supply criteria, increasing the likelihood of a breach of the regulatory quality levels two years out of three. This would result in a reduction in customer service levels (reduced reliability and extended outages) and sharply increasing operational expenditure on fault response and customer complaints. Overall, adopting this profile would have a severe impact on our customers, far outweighing the value of the cost savings resulting from regulatory settings. Vector would, therefore, be very reluctant to embark on this profile and would only do so if forced to by excessive regulatory uncertainty and an inability to achieve commercially realistic returns.

The upper line represents expenditure levels that would allow Vector to achieve a substantial step improvement in network performance (as opposed to current forecast expenditure levels, which are targeted at maintaining current performance levels). This higher expenditure would enable Vector to:

- Effect major, rapid improvements in the quality of service (reliability) provided by the network;
- Accelerate asset replacement rates to improve age profiles of selected asset categories, where warranted by condition or reliability impact;
- Make investments to specifically target reduced electricity losses and improved network efficiency;
- Underground more selected parts of the network where external interference is currently impacting on reliability[4];
- Substantially reduce maintenance expenditure over time;
- Invest in a more wide-spread roll-out of smart network technologies to expand on the substantial investments made in the past decade; and
- Significantly enhance network security of supply performance.

This expenditure profile, which would improve the quality of service delivered to customers[5] is currently not viable as under the present regulatory regime Vector cannot recover the higher expenditure to provide the higher level of service and efficiency.

Vector's proposed capex forecast is based on the portfolio of projects selected using the Asset Investment Prioritisation Matrix as shown in Table 9-3 below. The projects selected for the proposed investment portfolio are based on the latest available information on growth, asset condition, regulatory requirements and risks to deliver the target level of service in a sustainable manner.

If the upper or lower capex scenarios discussed previously are adopted this would have a direct impact on the maintenance expenditure resulting in lower and upper range operational expenditure as reflected in Figure 9-2.

Adopting the lower capex range, in which the general asset base would be allowed to age and no major network improvements would be implemented, would cause escalating fault and maintenance expenditure (the higher opex range).

Should the high capex scenario be adopted, the average network age would decrease (higher proportion of new assets) and there will be substantially increased levels of network automation (as measured against the current provisional capex programme).

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[4] Vector has an ongoing under-grounding program, but the scope of this is based on meeting the AECT Trust Deed obligations. For more discretionary under-grounding, the focus would rather be to reduce external network interference (such as car versus pole incidents) on parts of the network where this occurs frequently.

[5] It will be ensured that such improvements are well aligned with customers' actual requirements and willingness to pay for the improved quality.

The net effect of this is that the fault frequency should reduce (especially in the first three years), as would the maintenance costs. There would also be a reduced requirement for renewal maintenance (resulting in the lower opex range).

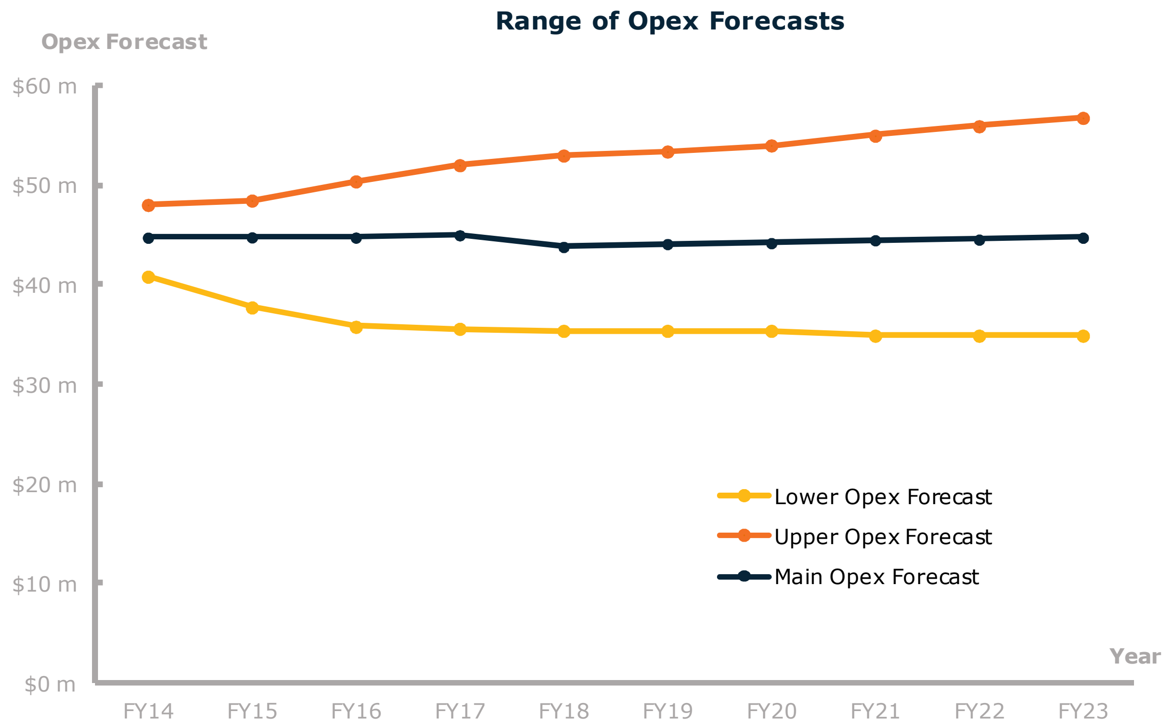


Figure 9-2 : Forecast opex range

The proposed opex forecast was developed to maintain the service potential of the network to deliver the target level of service in a sustainable manner.

9.4 Prioritisation of Expenditure

Section 1 of this AMP explains the relationship between Vector's goals and strategies, its asset management and investment strategies and policies and how these are used to guide the capital and maintenance works programme.

Section 5 of this AMP details the planning policies and standards, industry information, grid and grid exit point information, load growth assumptions, asset capacities, network operations information and network data required for the preparation of a ten year network development plan. A ten year expenditure projection on customer and growth works programme has been prepared, based on the network development plan. Similarly a programme for overhead improvement in the Southern region has been prepared in accordance with the requirement set out in the AECT Trust Deed. An asset relocation programme is also identified based on information available from roading and local authorities.

Section 6 of this AMP details the asset inspection, maintenance, replacement and refurbishment policies and standards. A replacement and refurbishment programme has been prepared for each asset category, based on these policies and standards and taking into account the information on asset age and condition and unit rates (material and labour). Following from this works programme, a ten year capital and operating expenditure projection on maintenance and replacement has been prepared.

An expenditure prioritisation process has been developed in line with Vector's strategies and goals to ensure those projects of the highest importance and with the highest cost-benefit are implemented. A four band prioritisation matrix has been developed to rank all projects identified in Section 5 and Section 6, as illustrated in Table 9-3 below. The four priority bands are:

1. Vital investments;
2. Critical investments;
3. Essential investments; and
4. Beneficial investments.

The prioritisation process involves assigning a priority band to each of the value drivers for each project based on an understanding of the purpose, value and risk of the project. The value drivers[6] as illustrated in Table 9-3 are:

- Health, safety and environmental;
- Security and capacity;
- Customer connections;
- Network reliability and asset performance;
- Brand and reputation;
- Legal compliance;
- Financial performance; and
- Operational performance improvement.

The highest priority band will be chosen as the score for the project. The projects are then ranked according to the scores, with a ranking of one being the highest priority. Projects and programmes with a ranking of 1 to 3 are selected as the main expenditure forecast (refer to Table 9-3).

[6] The value drivers are not listed in any order of priority.

Rank	Security & Capacity	Customer Connections	Network Reliability & Asset Performance	Brand & Reputation	Legal Compliance	Health, Safety & Environment	Financial Performance	Operational Performance Improvement
1. Vital investments	Mitigate capacity breach leading to asset damage. Mitigate capacity breach to widespread or critical areas.	Mitigate capacity breach to critical customer.	Reactive replacement of critical assets.	Avoid potentially serious reputation damage.	Avoid serious breach of technical regulations. Avoid serious breach of HSE or environmental legislation.	Mitigate imminent serious HSE or environmental threats.	Mitigate extreme and very high risks	Mitigate critical cyber security breach.
2. Critical investments	Mitigate security breach to widespread or critical areas. Mitigate capacity breach.	Satisfy contractual obligations (critical customers). New connections and capacity increase (critical customers).	Replacement of severely deteriorated assets with high risk and high consequence of failure. Reactive replacement of assets required for network operation.	Avoid potential reputation damage.	Regulatory compliance (including Industry Participation Code, environmental, HSE, etc). Asset relocation as required by statute.	Mitigate anticipated serious environmental or HSE threats.	Mitigate high impact direct risks.	Overhead improvement programmes (AECT obligation). Mitigate serious cyber security breach.
3. Essential investments	Mitigate security breach in the general network areas (except for remote rural areas).	Customer capacity and security requests. Customer funded projects.	Replacement of rapidly deteriorating assets or assets at the end of technical life with increased risk of failure. High consequence of failure. Medium term mitigation against natural disasters.		Regulatory improvement. Mitigate breach of technical regulations (voltage, etc) in localised areas. DG connections.	Medium term safety & environmental improvement.	Assets costing more to maintain and operate than to replace.	Technology trials. Enhance operational efficiency. Asset relocation required by requiring authorities.

Rank	Security & Capacity	Customer Connections	Network Reliability & Asset Performance	Brand & Reputation	Legal Compliance	Health, Safety & Environment	Financial Performance	Operational Performance Improvement
			Reliability improvements (to widespread or critical areas).					
4. Beneficial investments	Mitigate security of supply breach in remote rural areas.		Asset condition deteriorating gradually with increased risk of failure. Steady state asset replacement programmes. Reliability improvements.			Long term safety & environmental improvement.	Safeguard future options. Discretionary initiatives that are NPV>0.	Asset relocation requested by consumers and land owners. Enhance supply quality. Improve asset management and operational practices.

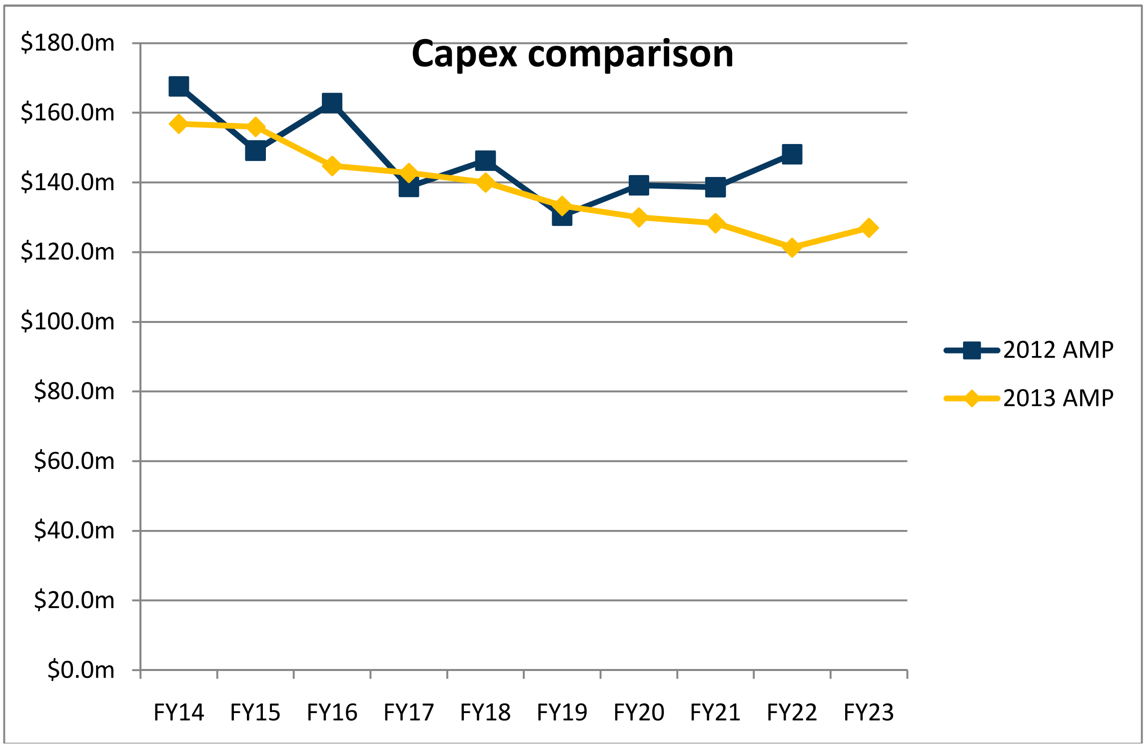
Table 9-3 : Asset investment Prioritisation matrix

9.5 Comparison of Expenditure Forecasts with that in the previous AMP

9.5.1 Capital Expenditure

In Figure 9-3 a comparison is presented between the 10-year capital expenditure forecast included in Vector's 2012 Asset Management Plan, and the updated 10-year forecast included in this (2013) plan. To make the comparison useful, the following modifications were made to ensure consistency between the current and previous Asset Management Plan figures:

- The 2012 AMP figures were escalated to current year values
- The new category for non-system fixed assets have been excluded from the 2013 AMP figures



Note: The figure is based on Vector financial years, not regulatory years

Figure 9-3 : Comparison of capital expenditure profile between this AMP and the previous forecast

The latest 10-year capital investment plan for the electricity network has remained broadly similar to that planned in 2012, as reflected in the projects planned (described in sections 5 and 6) and the relative consistency of the forecast expenditure levels between years. Some project shifts between years is always anticipated, as the investment plans are updated on an annual basis to reflect actual and new forecast electricity demand levels, new customer demands, and the actual performance of assets and associated renewal plans.

Overall the forecast capital expenditure is lower than that forecast in the previous AMP[7], largely as a result of the modified forecasting approach, as described in section 9.1.1.

9.5.2 Direct Operating Expenditure

In Figure 9-4 a comparison is provided of the latest 10-year direct operating expenditure forecast with that included in the 2012 Asset Management Plan.

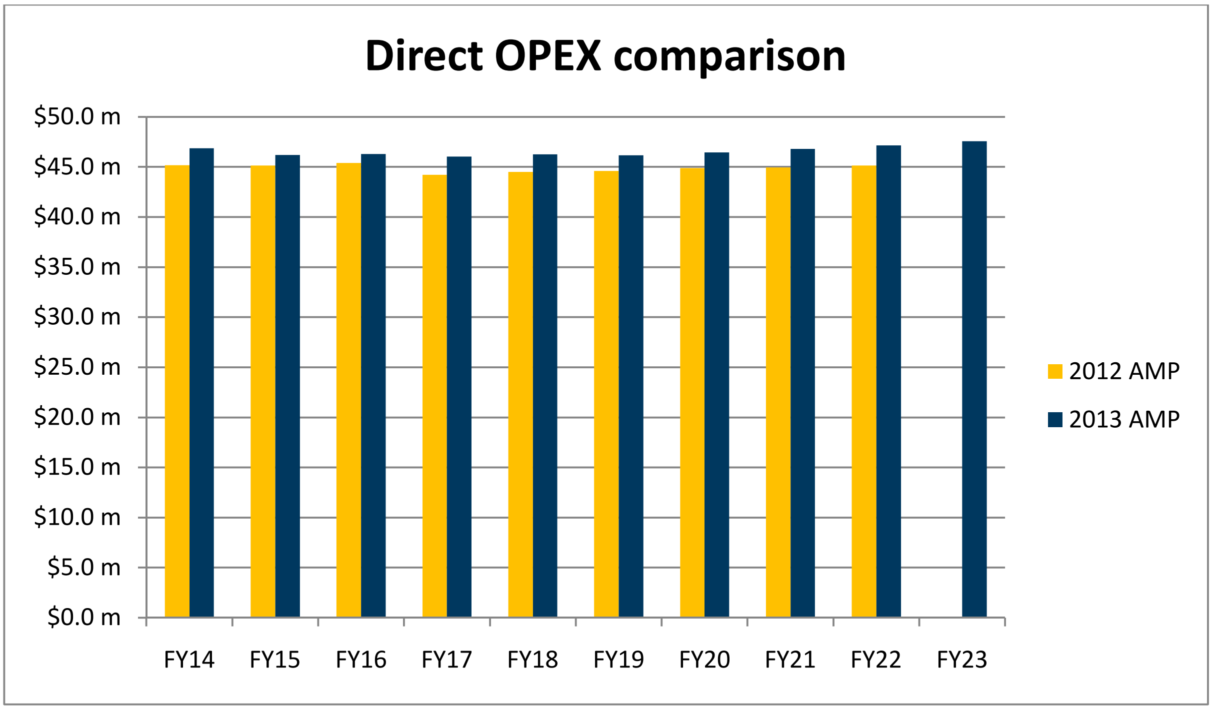


Figure 9-4 : Comparison of direct operating expenditure profile between this AMP and the previous forecast

The increase in the forecast operating expenditure reflects provisions that are now made for the following:

- **Additional compliance reporting requirements:** Changes to the information Disclosure Regime, as well as anticipated changes to introduce a higher compliance burden for field data accuracy, is expected to increase inspection and data collection cost for Vector's service providers.
- **Future network monitoring requirements:** Vector is currently conducting several pilot programmes in smart network technology, and introducing new technology on its network. Depending on the outcome of the trials and the extent to which Vector will decide to adopt more data-intensive network applications, the volume of network monitoring, data collection and data-processing may be increased from current levels (but which will likely over time be offset by reductions in investments in conventional network assets).
- **Service provider performance payments:** In terms of Vector's contracts with its field service providers, performance bonuses are payable if certain key performance measures are achieved. The current direct operating expenditure forecasts include an allowance for such payments at historical run-rates. However, as part of continual improvement, we anticipate that the performance of the

[7] Based on the 9-years overlapping capital expenditure forecast, the total difference is $67.6M (June 2013 real), or 5.1% of the escalated 2012 total.

service providers should further improve in future, in which case additional performance payments will be made.

- **Maintenance after extreme network events:** In terms of Vector's contracts with its field service providers, provision is made for normal reactive maintenance on assets damaged during the normally anticipated operation of the network (including storm and third-party damage). However, should an exceptional event occur, the service providers are entitled to additional payment to reflect the abnormal extent of repair and maintenance work this would involve. Based on analysis of actual such payments over the last ten years, an allowance is included in the direct opex forecast.

9.6 Price Escalation Factors

Vector is required under Clause 2.6 of the Electricity Distribution Information Disclosure Determination 2012 to disclose its Forecast Capital and Operational Expenditure as set out in Schedules 11a and 11b. Schedules 11a and 11b require the expenditure forecasts to be presented in both constant price and nominal terms.

Clause 3.8.5 of the Attachment A of the Electricity Distribution Information Disclosure Determination 2012 requires the assumptions used in the price inflator to be recorded in the AMP. The following price inflation table has been used to convert constant price forecasts to nominal forecasts.

Jun-13	Jun-14	Jun-15	Jun-16	Jun-17	Jun-18	Jun-19	Jun-20	Jun-21	Jun-22	Jun-23	Jun-24
1.5%	1.8%	1.8%	2.4%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%

9.7 Reconciliation of Actual Expenditure against previous AMP Budget

Table 9-4 summarises the actual 2012 regulatory year expenditure against the forecast for the year for all capital and operating expenditure categories[8].

Variance between Actual Expenditure and Previous Year's Forecast	Actual Mar-12	2012 AMP Forecast Mar-12	Variance	Variance %
Customer connection	$22.1 m	$21.6 m	$0.5 m	2.4%
System growth	$34.4 m	$55.5 m	-$21.1 m	-38.1%
Asset replacement and renewal	$54.5 m	$55.9 m	-$1.4 m	-2.6%
Reliability, safety & environmental	$1.9 m	$3.4 m	-$1.5 m	-45.0%
Asset relocation (including undergrounding)	$11.8 m	$25.8 m	-$14.0 m	-54.2%
Capital Expenditure Subtotal	$124.6 m	$162.2 m	-$37.6 m	-23.3%
Routine & preventive maintenance	$20.0 m	$19.6 m	$1.5 m	1.9%
Refurbishment & renewal	$10.9 m	$11.6 m	-$1.5 m	-6.0%
Fault and emergency	$8.5 m	$13.0 m	-$1.8 m	-34.4%
O & M Subtotal	$39.4 m	$44.2 m	-$4.8 m	-10.9%
Total Direct Expenditure	$164.0 m	$206.4 m	-$42.4 m	-20.5%

Table 9-4 : Asset management plan expenditure reconciliation

[8] Refer to table AM1 of Information Disclosure 2012.

An explanation for variances over 10% is provided below:

System Growth

Actual expenditure for supply to large customers was $6.6m compared to a budget of $16.4m. This difference is due to the cancellation of a major upgrade ($5.1m) by the customer and other smaller projects amounting to another $2m. A further reduction of $3.2m was the result of budgeted projects deferred and delayed by customers.

A reforecast of the Hobson GXP project resulted in the transfer of $3.7m of budget expenditure from year 12 to year 13. The delay in the start of Waimauku substation upgrade project has caused critical work components being deferred until after the peak winter period. This resulted in a $1.3m deferment into year 13. Delays in the settlement of substation land purchases caused an under spend of $0.6m against budget.

The provisional budget for ducts was under spent by $1.7m. The CBD 22kV rollout and conversion expenditure was below budget by $2m due to delays in the nominated projects while cancelled projects accounted for a further $0.9m unspent budget.

Reliability, Safety and Environment

The apparent under-spending in the reliability, safety and environment capex category was mainly due to $1.3m transferred to fund the 22kV Liverpool switchboard replacement (partly to improve reliability of supply to the CBD) and $0.4m to fund the distribution earth switch padlocks replacement project (grouped under protection under the Vector accounting system).

Asset Relocation (including OIP)

Relocations expenditure was $8.6m against a budget of $11.7m. The key differences were an under spend of $4.7m on transport-related projects due to project timing changes by the requiring authorities, and additional expenditure associated with the relocation of the sub-transmission circuits at Wairau Rd substation (-$1.2m).

Expenditure on the overhead to underground conversion programme was $10.9m below budget due to the environment created by the Government Ultra-Fast Broadband (UFB) initiative. In particular, the initiative diminished incentives for investing in copper telecommunications networks, thus reducing opportunities to coordinate with Vector, which is necessary to achieve successful undergrounding outcomes.

Faults and Emergency Maintenance

An allowance of $6.0m was made in the 2012 faults and emergency maintenance budget to be capitalised to reflect the capital nature of the repair works and in accordance with Vector’s accounting policy. The actual amount of repairs and emergency maintenance work being capitalised in the year was $10.5m which result in an apparent under spend in the faults and emergency category.

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Appendices

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Appendix 1

APPENDIX 1

Company Name **Vector Limited**
AMP Planning Period **1 April 2013 – 31 March 2023**

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

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	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
9	**11a(i): Expenditure on Assets Forecast**	**$000 (in nominal dollars)**										
10	Consumer connection	24,838	23,383	23,957	24,497	25,034	25,637	25,810	26,299	26,925	27,447	28,086
11	System growth	55,338	47,179	42,611	39,849	36,305	36,643	28,996	28,405	31,589	29,309	32,598
12	Asset replacement and renewal	65,694	57,112	60,700	58,969	63,057	63,122	66,845	66,213	64,140	62,487	64,605
13	Asset relocations	24,820	20,757	22,206	20,831	19,489	19,604	20,289	20,862	21,383	21,918	22,466
14	Reliability, safety and environment:											
15	Quality of supply	6,909	1,124	1,267	1,296	1,328	1,362	1,396	1,430	1,466	1,503	1,540
16	Legislative and regulatory	-	2,953	2,863	2,984	2,585	2,388	3,136	2,365	1,304	1,084	1,111
17	Other reliability, safety and environment	-	1,731	1,643	1,532	1,463	1,480	1,517	1,555	1,594	1,634	1,675
18	**Total reliability, safety and environment**	6,909	5,808	5,774	5,812	5,376	5,230	6,049	5,350	4,364	4,220	4,326
19	**Expenditure on network assets**	177,599	154,239	155,249	149,958	149,261	150,237	147,988	147,128	148,401	145,381	152,080
20	Non-network assets	12,810	12,064	12,152	12,352	12,460	9,787	9,313	9,047	9,678	9,561	9,614
21	**Expenditure on assets**	190,409	166,303	167,401	162,310	161,721	160,023	157,301	156,176	158,079	154,942	161,694
22												
23	*plus* Cost of financing	1,631	3,265	3,220	3,105	3,036	3,032	2,893	2,873	2,946	2,877	3,026
24	*less* Value of capital contributions	25,122	26,623	29,412	27,863	26,223	26,394	27,172	27,768	28,446	29,003	29,677
25	*plus* Value of vested assets	-	-	-	-	-	-	-	-	-	-	-
26												
27	**Capital expenditure forecast**	166,918	142,946	141,209	137,552	138,534	136,661	133,022	131,280	132,579	128,816	135,043
28												
29	Value of commissioned assets	166,918	154,029	144,545	150,683	154,988	143,676	137,392	132,575	136,828	125,991	142,014

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
	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
32		**$000 (in constant prices)**										
33	Consumer connection	24,838	23,075	23,224	23,220	23,156	23,134	22,725	22,589	22,562	22,439	22,401
34	System growth	55,338	46,570	41,327	37,784	33,601	33,063	25,575	24,389	26,461	23,980	25,981
35	Asset replacement and renewal	65,694	56,378	58,825	55,920	58,301	56,977	58,832	56,888	53,760	51,097	51,521
36	Asset relocations	24,820	20,484	21,522	19,758	18,033	17,691	17,861	17,918	17,918	17,918	17,918
37	Reliability, safety and environment:											
38	Quality of supply	6,909	1,107	1,229	1,229	1,229	1,229	1,229	1,229	1,229	1,229	1,229
39	Legislative and regulatory	-	2,907	2,779	2,827	2,395	2,156	2,757	2,037	1,096	886	886
40	Other reliability, safety and environment	-	1,710	1,593	1,453	1,353	1,336	1,336	1,336	1,336	1,336	1,336
41	**Total reliability, safety and environment**	6,909	5,725	5,600	5,508	4,976	4,720	5,321	4,601	3,660	3,450	3,450
42	**Expenditure on network assets**	177,599	152,232	150,497	142,191	138,068	135,585	130,315	126,385	124,361	118,883	121,271
43	Non-network assets	12,810	11,910	11,779	11,709	11,526	8,848	8,197	7,774	8,107	7,819	7,668
44	**Expenditure on assets**	190,409	164,142	162,276	153,900	149,593	144,432	138,512	134,159	132,468	126,703	128,939
45												

APPENDIX 1

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

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)

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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*
	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
46	**Subcomponents of expenditure on assets (where known)**											
47	Energy efficiency and demand side management, reduction of energy losses	-	-	-	-	-	-	-	-	-	-	-
48	Overhead to underground conversion	13,727	12,841	12,841	12,841	12,841	12,841	12,841	12,841	12,841	12,841	12,841
49	Research and development	1,792	2,388	1,911	1,911	1,911	1,911	1,911	1,911	1,911	1,911	1,911

		Current Year CY	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
57												
58	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
59	**Difference between nominal and constant price forecasts**	**$000**										
60	Consumer connection	-	309	734	1,277	1,878	2,502	3,085	3,711	4,363	5,008	5,685
61	System growth	-	610	1,284	2,065	2,703	3,581	3,421	4,016	5,129	5,330	6,617
62	Asset replacement and renewal	-	733	1,875	3,049	4,755	6,145	8,012	9,325	10,380	11,391	13,084
63	Asset relocations	-	273	684	1,073	1,456	1,914	2,428	2,943	3,465	4,000	4,547
64	Reliability, safety and environment:											
65	Quality of supply	-	16	39	68	100	133	167	202	238	274	312
66	Legislative and regulatory	-	46	85	157	191	233	379	328	207	198	225
67	Other reliability, safety and environment	-	21	50	79	109	144	181	219	258	298	339
68	**Total reliability, safety and environment**	-	83	174	304	400	510	727	749	703	770	876
69	**Expenditure on network assets**	-	2,008	4,751	7,767	11,193	14,652	17,674	20,744	24,039	26,498	30,809
70	Non-network assets	-	154	373	643	934	939	1,115	1,273	1,571	1,742	1,946
71	**Expenditure on assets**	-	2,162	5,124	8,410	12,127	15,591	18,789	22,017	25,611	28,240	32,755
72												

		Current Year CY	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
73	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
74	**11a(ii): Consumer Connection**						
75	*Consumer types defined by EDB**	**$000 (in constant prices)**					
76	Service connection		8,959	9,116	9,116	9,044	9,020
77	Substations (business customers)		6,071	6,040	6,040	6,040	6,040
78	Business subdiovisions		1,253	1,329	1,329	1,333	1,334
79	Residential subdivisions		4,421	4,273	4,270	4,272	4,273
	Capacity change business customers		2,028	2,068	2,068	2,068	2,068
	2013 total connection	24,838					
80	Easements business customers		344	398	398	399	399
81	**include additional rows if needed*						
82	**Consumer connection expenditure**	24,838	23,075	23,224	23,220	23,156	23,134
83	*less* Capital contributions funding consumer connection	17,961	17,750	17,913	17,911	17,845	17,823
84	**Consumer connection less capital contributions**	6,877	5,325	5,311	5,309	5,311	5,312

APPENDIX 1

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

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)
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This information is not part of audited disclosure information.

sch ref

		Current Year CY	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
85	**11a(iii): System Growth**						
86	Subtransmission		7,105	13,469	10,446	3,653	2,444
87	Zone substations		20,944	15,809	14,580	17,962	17,299
88	Distribution and LV lines		583	528	519	517	324
89	Distribution and LV cables		15,356	8,837	9,358	8,358	8,838
90	Distribution substations and transformers		744	771	814	719	692
91	Distribution switchgear		1,502	1,606	1,648	2,115	3,262
	2013 total system growth	55,338					
92	Other network assets		336	307	419	277	204
93	**System growth expenditure**	55,338	46,570	41,327	37,784	33,601	33,063
94	*less* Capital contributions funding system growth	1,002	-	-	-	-	-
95	**System growth less capital contributions**	54,336	46,570	41,327	37,784	33,601	33,063

		Current Year CY	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
103							
104	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
105	**11a(iv): Asset Replacement and Renewal**	**$000 (in constant prices)**					
106	Subtransmission		4,022	7,026	6,269	6,285	5,222
107	Zone substations		17,008	16,934	14,849	15,347	16,357
108	Distribution and LV lines		16,912	16,733	16,777	16,738	16,758
109	Distribution and LV cables		8,295	8,197	8,219	8,200	8,210
110	Distribution substations and transformers		3,948	3,906	3,916	3,907	3,912
111	Distribution switchgear		5,400	5,217	5,171	5,160	5,166
	2013 total asset replacement	65,694					
112	Other network assets		794	811	719	2,664	1,352
113	**Asset replacement and renewal expenditure**	65,694	56,378	58,825	55,920	58,301	56,977
114	*less* Capital contributions funding asset replacement and renewal	157	-	-	-	-	-
115	**Asset replacement and renewal less capital contributions**	65,537	56,378	58,825	55,920	58,301	56,977
116	**11a(v):Asset Relocations**						
117	*Project or programme**						
118	Major project 1		566	591	622	622	155
119	Major project 2		93	1,150	373	-	-
120	Major project 3		949	1,244	311	-	-
121	Major project 4		-	-	-	47	1,135
	2013 total asset relocation	24,820					
122	Overhead improvement programme		12,841	12,841	12,841	12,841	12,841
123	**include additional rows if needed*						
124	All other asset relocations projects or programmes		6,035	5,696	5,612	4,523	3,560
125	**Asset relocations expenditure**	24,820	20,484	21,522	19,758	18,033	17,691
126	*less* Capital contributions funding asset relocations	6,001	8,409	10,471	8,344	6,263	5,850
127	**Asset relocations less capital contributions**	18,818	12,075	11,051	11,415	11,770	11,841

APPENDIX 1

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

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

sch ref			*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
128		for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**

129 11a(vi):Quality of Supply

sch ref		Item	Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
130		*Project or programme**						
131		Northern - Distribution Substation Automation		329	439	439	439	439
132		Southern - Distribution Substation Automation		420	439	439	439	439
133		Northern - Power Quality Monitoring		179	176	176	176	176
134		Southern - Power Quality Monitoring		179	176	176	176	176
135		2013 total reliability	6,909					
136		**include additional rows if needed*						
137		All other quality of supply projects or programmes	-	-	-	-	-	-
138		**Quality of supply expenditure**	6,909	1,107	1,229	1,229	1,229	1,229
139	*less*	Capital contributions funding quality of supply	-	-	-	-	-	-
140		**Quality of supply less capital contributions**	6,909	1,107	1,229	1,229	1,229	1,229
141								

142 11a(vii): Legislative and Regulatory

sch ref		Item	Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
143		*Project or programme**						
144		Major project 1		332	443	443	443	443
145		Major project 2		332	443	443	443	443
146		Major project 3		714	238	-	-	-
147		Major project 4		-	664	221	-	-
148								
149		**include additional rows if needed*						
150		All other legislative and regulatory projects or programmes		1,529	990	1,720	1,509	1,270
151		**Legislative and regulatory expenditure**	-	2,907	2,779	2,827	2,395	2,156
152	*less*	Capital contributions funding legislative and regulatory	-	-	-	-	-	-
153		**Legislative and regulatory less capital contributions**	-	2,907	2,779	2,827	2,395	2,156
161								

sch ref			*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
162		for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**

163 11a(viii): Other Reliability, Safety and Environm

sch ref		Item	Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
164		*Project or programme**	**$000 (in constant prices)**					
165		Northern - Reliability Improvements		602	646	646	646	646
166		Southern - Reliability Improvements		704	689	689	689	689
167								
168								
169								
170		**include additional rows if needed*						
171		All other reliability, safety and environment projects or programmes		404	258	117	18	-
172		**Other reliability, safety and environment expenditure**	-	1,710	1,593	1,453	1,353	1,336
173	*less*	Capital contributions funding other reliability, safety and environment	-	-	-	-	-	-
174		**Other reliability, safety and environment less capital contributions**	-	1,710	1,593	1,453	1,353	1,336
175								

APPENDIX 1

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

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*
	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
178	**11a(ix): Non-Network Assets**						
179	**Routine expenditure**						
180	*Project or programme**						
181	Systems Integration	1,206	973	608	486	486	486
182	Reporting		340	340	340	340	340
183	ALIS		547	669	547	486	486
184	Others	10,273	8,675	8,654	8,998	8,595	5,784
185							
186	**include additional rows if needed*						
187	All other routine expenditure projects or programmes	101	-	-	-	-	-
188	**Routine expenditure**	11,579	10,536	10,271	10,372	9,909	7,097
189	**Atypical expenditure**						
190	*Project or programme**						
191	Geospatial Systems	909	717	450	353	292	292
192	Outage Management		280	207	195	778	973
193	Power Systems Modelling		195	243	243	61	-
194							
195							
196	**include additional rows if needed*						
197	All other atypical projects or programmes	322	182	608	547	486	486
198	**Atypical expenditure**	1,231	1,374	1,508	1,338	1,617	1,751
199							
200	**Non-network assets expenditure**	12,810	11,910	11,779	11,709	11,526	8,848

Company Name Vector Limited

For Year Ended 31st March 2014

Schedule 14a Mandatory Explanatory Notes on Forecast Information

1. This Schedule provides for 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 2.7.1. 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 (Schedule11a)

3. In the box below, comment on the difference between nominal and constant price capital expenditure for the disclosure year, as disclosed in Schedule 11a.

Box 1: Commentary on difference between nominal and constant price capital expenditure forecasts

Vector has used the Reserve Bank of New Zealand December 2012 Monetary Policy Statement to develop the CPI forecast from 2013 to 2015. Thereafter we have assumed a long-term inflation rate of 2.5%. The CY13 is based on 2013 inflation and the nominal dollars is inflated by RBNZ CPI forecast between 2013 and 2015. Thereafter it is inflated by 2.5%. These figures are used to convert constant price forecasts to nominal forecasts.

The CY13 figures in Schedules 11a are based on the figures disclosed in the 2012 information disclosure.

Electricity
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Appendix 2

APPENDIX 2

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

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												
7		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
8	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
9	**Operational Expenditure Forecast**	**$000 (in nominal dollars)**										
10	Service interruptions and emergencies	11,555	6,915	7,149	7,307	7,507	7,696	7,885	8,076	8,276	8,479	8,689
11	Vegetation management	4,630	4,587	4,815	4,924	5,046	5,172	5,301	5,434	5,570	5,709	5,852
12	Routine and corrective maintenance and inspection	9,865	12,167	11,951	12,055	12,468	12,920	13,411	13,946	14,528	15,161	15,849
13	Asset replacement and renewal	10,637	11,179	11,631	11,895	11,869	12,138	12,557	13,004	13,479	13,985	14,524
14	**Network Opex**	36,687	34,848	35,546	36,181	36,890	37,926	39,155	40,460	41,852	43,333	44,914
15	System operations and network support	36,971	42,716	43,781	44,838	45,949	47,098	47,989	49,093	50,321	51,579	52,868
16	Business support	29,868	29,462	29,994	30,674	31,434	32,220	33,026	33,851	34,698	35,565	36,454
17	**Non-network opex**	66,839	72,178	73,774	75,511	77,384	79,318	81,015	82,945	85,018	87,144	89,322
18	**Operational expenditure**	103,526	107,025	109,320	111,692	114,274	117,244	120,170	123,404	126,871	130,477	134,236
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	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
21		**$000 (in constant prices)**										
22	Service interruptions and emergencies	11,555	6,823	6,930	6,926	6,943	6,945	6,942	6,936	6,935	6,932	6,931
23	Vegetation management	4,630	4,525	4,667	4,667	4,667	4,667	4,667	4,667	4,667	4,667	4,667
24	Routine and corrective maintenance and inspection	9,865	12,004	11,588	11,427	11,532	11,658	11,806	11,978	12,173	12,393	12,640
25	Asset replacement and renewal	10,637	11,029	11,275	11,275	10,980	10,952	11,055	11,169	11,294	11,432	11,583
26	**Network Opex**	36,687	34,381	34,460	34,295	34,123	34,223	34,470	34,750	35,069	35,424	35,821
27	System operations and network support	36,971	42,154	42,439	42,501	42,501	42,501	42,250	42,167	42,167	42,167	42,167
28	Business support	29,868	29,075	29,075	29,075	29,075	29,075	29,075	29,075	29,075	29,075	29,075
29	**Non-network opex**	66,839	71,229	71,515	71,576	71,576	71,576	71,325	71,242	71,242	71,242	71,242
30	**Operational expenditure**	103,526	105,610	105,975	105,871	105,699	105,799	105,796	105,992	106,311	106,666	107,063
31	**Subcomponents of operational expenditure (where known)**											
32	Energy efficiency and demand side management, reduction of											
33	energy losses	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
34	Direct billing*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
35	Research and Development	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Insurance	3,347	3,774	4,219	4,673	4,907	4,907	4,907	4,907	4,907	4,907	4,907
37	** Direct billing expenditure by suppliers that direct bill the majority of their consumers*											

APPENDIX 2

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

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

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	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
41	**Difference between nominal and real forecasts**	**$000**										
42	Service interruptions and emergencies	-	92	219	381	564	751	943	1,139	1,341	1,547	1,759
43	Vegetation management	-	62	147	257	379	505	634	767	903	1,042	1,185
44	Routine and corrective maintenance and inspection	-	163	363	629	936	1,262	1,605	1,968	2,355	2,768	3,209
45	Asset replacement and renewal	-	150	356	620	889	1,185	1,503	1,835	2,185	2,553	2,941
46	**Network Opex**	-	467	1,085	1,886	2,767	3,703	4,685	5,710	6,783	7,909	9,093
47	System operations and network support	-	562	1,341	2,337	3,448	4,597	5,739	6,927	8,154	9,412	10,701
48	Business support	-	386	918	1,599	2,359	3,145	3,950	4,776	5,622	6,490	7,379
49	**Non-network opex**	-	948	2,260	3,935	5,808	7,742	9,689	11,703	13,776	15,902	18,080
50	**Operational expenditure**	-	1,415	3,345	5,821	8,575	11,445	14,374	17,413	20,560	23,811	27,174

Company Name Vector Limited

For Year Ended 31st March 2014

Schedule 14a Mandatory Explanatory Notes on Forecast Information

1. This Schedule provides for 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 2.7.1. 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 operational expenditure forecasts (Schedule 11b)

3. In the box below, comment on the difference between nominal and constant price operational expenditure for the disclosure year, as disclosed in Schedule 11b.

Box 2 Commentary on difference between nominal and constant price operational expenditure forecasts

Vector has used the Reserve Bank of New Zealand December 2012 Monetary Policy Statement to develop the CPI forecast from 2013 to 2015. Thereafter we have assumed a long-term inflation rate of 2.5%. The CY13 is based on 2013 inflation and the nominal dollars is inflated by RBNZ CPI forecast between 2013 and 2015. Thereafter it is inflated by 2.5%. These figures are used to convert constant price forecasts to nominal forecasts.

The CY13 figures in Schedules 11b are based on the figures disclosed in the 2012 information disclosure.

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Appendix 3

APPENDIX 3

Company Name **Vector Limited**
AMP Planning Period **1 April 2013 – 31 March 2023**

SCHEDULE 12a: REPORT ON ASSET CONDITION

This schedule requires a breakdown of asset condition by asset class as at the start of the forecast year. The data accuracy assessment relates to the percentage values disclosed in the asset condition columns. Also required is a forecast of the percentage of units to be replaced in the next 5 years. All information should be consistent with the information provided in the AMP and the expenditure on assets forecast in Schedule 11a. All units relating to cable and line assets, that are expressed in km, refer to circuit lengths.

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.	0.3%	0.0%	43.7%	56.0%		3	5.6%
11	All	Overhead Line	Wood poles	No.	0.9%	0.0%	56.8%	42.3%		2	1.0%
12	All	Overhead Line	Other pole types	No.				100.0%		4	-
13	HV	Subtransmission Line	Subtransmission OH up to 66kV conductor	km			82.2%	17.8%		4	-
14	HV	Subtransmission Line	Subtransmission OH 110kV+ conductor	km			96.8%	3.2%		4	-
15	HV	Subtransmission Cable	Subtransmission UG up to 66kV (XLPE)	km		0.1%	11.4%	88.5%		4	5.4%
16	HV	Subtransmission Cable	Subtransmission UG up to 66kV (Oil pressurised)	km		3.4%	96.2%	0.4%		4	3.3%
17	HV	Subtransmission Cable	Subtransmission UG up to 66kV (Gas pressurised)	km		44.5%	55.5%			4	100.0%
18	HV	Subtransmission Cable	Subtransmission UG up to 66kV (PILC)	km		5.5%	88.4%	6.2%		3	16.7%
19	HV	Subtransmission Cable	Subtransmission UG 110kV+ (XLPE)	km				100.0%		4	-
20	HV	Subtransmission Cable	Subtransmission UG 110kV+ (Oil pressurised)	km			99.8%	0.2%		4	27.9%
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			97.8%	2.2%		4	-
24	HV	Zone substation Buildings	Zone substations up to 66kV	No.		3.7%	71.6%	24.6%		2	4.5%
25	HV	Zone substation Buildings	Zone substations 110kV+	No.			100.0%			3	-
26	HV	Zone substation switchgear	22/33kV CB (Indoor)	No.				100.0%		4	-
27	HV	Zone substation switchgear	22/33kV CB (Outdoor)	No.				100.0%		4	-
28	HV	Zone substation switchgear	33kV Switch (Ground Mounted)	No.						N/A	-
29	HV	Zone substation switchgear	33kV Switch (Pole Mounted)	No.			82.7%	17.3%		4	-
30	HV	Zone substation switchgear	33kV RMU	No.				100.0%		4	-
31	HV	Zone substation switchgear	50/66/110kV CB (Indoor)	No.		10.8%	12.7%	76.4%		4	10.8%
32	HV	Zone substation switchgear	50/66/110kV CB (Outdoor)	No.		12.1%	86.3%	1.6%		4	12.1%
33	HV	Zone substation switchgear	3.3/6.6/11/22kV CB (ground mounted)	No.		11.6%	37.7%	50.7%		4	20.7%
34	HV	Zone substation switchgear	3.3/6.6/11/22kV CB (pole mounted)	No.						N/A	-

APPENDIX 3

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

SCHEDULE 12a: REPORT ON ASSET CONDITION

This schedule requires a breakdown of asset condition by asset class as at the start of the forecast year. The data accuracy assessment relates to the percentage values disclosed in the asset condition columns. Also required is a forecast of the percentage of units to be replaced in the next 5 years. All information should be consistent with the information provided in the AMP and the expenditure on assets forecast in Schedule 11a. All units relating to cable and line assets, that are expressed in km, refer to circuit lengths.

sch ref

42					**Asset condition at start of planning period (percentage of units by grade)**						
43											
44	**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**
45	HV	Zone Substation Transformer	Zone Substation Transformers	No.	1.0%	2.4%	49.5%	47.1%		4	4.4%
46	HV	Distribution Line	Distribution OH Open Wire Conductor	km		0.0%	88.6%	11.4%		4	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%	7.3%	92.6%		4	4.7%
50	HV	Distribution Cable	Distribution UG PILC	km	0.0%	0.3%	62.0%	37.8%		4	2.3%
51	HV	Distribution Cable	Distribution Submarine Cable	km			100.0%			4	-
52	HV	Distribution switchgear	3.3/6.6/11/22kV CB (pole mounted) - reclosers and sectionalisers	No.	1.2%			98.8%		4	10.2%
53	HV	Distribution switchgear	3.3/6.6/11/22kV CB (Indoor)	No.			19.2%	80.8%		4	-
54	HV	Distribution switchgear	3.3/6.6/11/22kV Switches and fuses (pole mounted)	No.	2.1%	4.1%	14.0%	79.8%		4	10.3%
55	HV	Distribution switchgear	3.3/6.6/11/22kV Switch (ground mounted) - except RMU	No.			22.7%	77.3%		4	6.6%
56	HV	Distribution switchgear	3.3/6.6/11/22kV RMU	No.			13.2%	86.8%		4	4.7%
57	HV	Distribution Transformer	Pole Mounted Transformer	No.	0.3%	0.0%	14.2%	85.5%		4	10.6%
58	HV	Distribution Transformer	Ground Mounted Transformer	No.	1.0%	0.3%	17.1%	81.6%		4	5.1%
59	HV	Distribution Transformer	Voltage regulators	No.			14.3%	85.7%		3	-
60	HV	Distribution Substations	Ground Mounted Substation Housing	No.	0.9%	1.8%	21.7%	75.6%		4	3.0%
61	LV	LV Line	LV OH Conductor	km			92.5%	7.5%		4	0.2%
62	LV	LV Cable	LV UG Cable	km		0.0%	47.1%	52.9%		4	0.1%
63	LV	LV Streetlighting	LV OH/UG Streetlight circuit	km					100.00%	3	0.1%
64	LV	Connections	OH/UG consumer service connections	No.					100.00%	4	-
65	All	Protection	Protection relays (electromechanical, solid state and numeric)	No.	3.6%	11.5%	45.6%	39.4%		4	16.5%
66	All	SCADA and communications	SCADA and communications equipment operating as a single system	Lot		12.6%		87.4%		4	13.0%
67	All	Capacitor Banks	Capacitors including controls	No.			96.2%	3.8%		4	-
68	All	Load Control	Centralised plant	Lot			100.0%			2	-
69	All	Load Control	Relays	No.						N/A	-
70	All	Civils	Cable Tunnels	km			8.7%	91.3%		4	-

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Appendix 4

APPENDIX 4

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

SCHEDULE 12b: REPORT ON FORECAST CAPACITY

This schedule requires a breakdown of current and forecast capacity and utilisation for each zone substation and current distribution transformer capacity. The data provided should be consistent with the information provided in the AMP. Information provided in this table should relate to the operation of the network in its normal steady state configuration.

sch ref

7 **12b(i): System Growth - Zone Substations**

sch ref	*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
8										
9	Atkinson Road	19	20	N-1	20	95%	20	98%	No constraint within +5 years	Meets Vector security criteria
	Auckland Airport	18	25	N-1	-	71%	25	107%	Transformer	Meets Customer security criteria, any upgrade is initiated by customer
	Avondale	30	20	N-1 switched	24	149%	20	156%	No constraint within +5 years	Meets Vector security criteria
	Bairds	27	20	N-1 switched	26	133%	20	137%	No constraint within +5 years	Meets Vector security criteria
	Balmain	9	-	N	13	-	-	-	No constraint within +5 years	Meets Vector security criteria
	Balmoral	18	12	N-1 switched	13	149%	20	92%	No constraint within +5 years	Meets Vector security criteria
	Belmont	14	13	N-1 switched	11	109%	13	113%	No constraint within +5 years	Meets Vector security criteria
	Birkdale	23	16	N-1 switched	17	144%	20	119%	No constraint within +5 years	Meets Vector security criteria - Transformer upgrade planned within 5 years
	Brickworks	8	-	N	8	-	15	58%	No constraint within +5 years	Meets Vector security criteria - Second transformer installation planned within 5 years
	Browns Bay	17	13	N-1 switched	18	135%	13	143%	No constraint within +5 years	Meets Vector security criteria
	Bush Road	26	24	N-1 switched	13	109%	24	112%	No constraint within +5 years	Meets Vector security criteria
	Carbine	18	20	N-1	19	92%	20	98%	No constraint within +5 years	Meets Vector security criteria
	Chevalier	20	20	N-1	16	98%	20	101%	No constraint within +5 years	Meets Vector security criteria
	Clendon	19	20	N-1	19	93%	20	95%	No constraint within +5 years	Meets Vector security criteria
	Clevedon	3	-	N	4	-	-	-	No constraint within +5 years	Meets Vector security criteria
	Coatesville	10	-	N	10	-	20	54%	No constraint within +5 years	Meets Vector security criteria - Second transformer installation planned within 5 years
	Drive	28	20	N-1 switched	27	141%	20	151%	No constraint within +5 years	Meets Vector security criteria
	East Coast Road	17	-	N	13	-	-	-	No constraint within +5 years	Meets Vector security criteria - Planned Rosedale substation will reduce the load at East Coast Rd
	East Tamaki	17	20	N-1	8	84%	20	84%	No constraint within +5 years	Meets Vector security criteria
	Forrest Hill	19	20	N-1	17	93%	20	96%	No constraint within +5 years	Meets Vector security criteria
	Freemans Bay	20	18	N-1 switched	19	113%	18	126%	No constraint within +5 years	Meets Vector security criteria
	Glen Innes	10	12	N-1	12	87%	20	55%	No constraint within +5 years	Meets Vector security criteria, transformer change as part of asset replacement programme
	Greenhithe	14	-	N	10	-	20	79%	No constraint within +5 years	Meets Vector security criteria - Second transformer installation planned within 5 years
	Greenmount	39	40	N-1	29	97%	40	98%	No constraint within +5 years	Meets Vector security criteria
	Gulf Harbour	8	-	N	13	-	-	-	No constraint within +5 years	Meets Vector security criteria
	Hans	25	20	N-1 switched	11	124%	20	129%	No constraint within +5 years	Meets Vector security criteria
	Hauraki	9	-	N	10	-	-	-	No constraint within +5 years	Meets Vector security criteria
	Helensville	13	8	N-1 switched	10	176%	8	191%	No constraint within +5 years	Meets Vector security criteria
	Henderson Valley	18	16	N-1 switched	19	112%	16	118%	No constraint within +5 years	Meets Vector security criteria
	Highbrook	5	-	N	-	-	-	-	No constraint within +5 years	Switching Station
	Highbury	14	-	N	10	-	15	96%	No constraint within +5 years	Meets Vector security criteria - Second transformer installation planned within 5 years
	Hillcrest	24	24	N-1	23	98%	24	105%	No constraint within +5 years	Meets Vector security criteria
	Hillsborough	15	-	N	18	-	20	80%	No constraint within +5 years	Meets Vector security criteria - Second transformer currently being installed
	Hobson 110/11kV	22	25	N-1	15	87%	25	91%	No constraint within +5 years	Meets Vector security criteria
	Hobson 22/11kV	20	15	N-1 switched	16	134%	15	143%	No constraint within +5 years	Meets Vector security criteria

APPENDIX 4

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

SCHEDULE 12b: REPORT ON FORECAST CAPACITY

This schedule requires a breakdown of current and forecast capacity and utilisation for each zone substation and current distribution transformer capacity. The data provided should be consistent with the information provided in the AMP. Information provided in this table should relate to the operation of the network in its normal steady state configuration.

sch ref

Hobson 22kV	72	40	N-1 switched	37	181%	80	102%	No constraint within +5 years	Meets Vector security criteria - third transformer installation planned within 5 years
Hobsonville	22	16	N-1 switched	12	135%	16	145%	No constraint within +5 years	Meets Vector security criteria , Hobsonbille Point and Westgate substations planned to reduce Hobsonville load
Hospital	6	-	N	7	-	-	-	No constraint within +5 years	This substation is dedicated to supply the customer. Capacity upgrades will be driven by the customer.
Howick	41	40	N-1 switched	15	102%	40	105%	No constraint within +5 years	Meets Vector security criteria
James Street	20	16	N-1 switched	19	126%	16	131%	No constraint within +5 years	Meets Vector security criteria
Keeling Road	15	-	N	18	-	20	78%	No constraint within +5 years	Meets Vector security criteria - Second transformer installation planned within 5 years
Kingsland	22	20	N-1 switched	23	110%	20	118%	No constraint within +5 years	Meets Vector security criteria
Laingholm	9	8	N-1 switched	10	126%	8	130%	No constraint within +5 years	Meets Vector security criteria
Liverpool	45	40	N-1 switched	28	111%	40	117%	No constraint within +5 years	Meets Vector security criteria
Liverpool 22kV	87	135	N-1	65	65%	135	71%	No constraint within +5 years	Meets Vector security criteria
Mangere Central	26	20	N-1 switched	14	128%	20	132%	No constraint within +5 years	Meets Vector security criteria
Mangere East	26	20	N-1 switched	26	130%	20	141%	No constraint within +5 years	Meets Vector security criteria
Mangere West	17	30	N-1	3	56%	30	57%	No constraint within +5 years	Meets Vector security criteria
Manly	19	16	N-1 switched	15	120%	16	125%	No constraint within +5 years	Meets Vector security criteria
Manukau	29	40	N-1	27	72%	40	76%	No constraint within +5 years	Meets Vector security criteria
Manurewa	46	40	N-1 switched	28	115%	40	119%	No constraint within +5 years	Meets Vector security criteria
Maraetai	6	15	N-1	2	40%	15	44%	No constraint within +5 years	Meets Vector security criteria
McKinnon	24	20	N-1 switched	11	119%	20	136%	No constraint within +5 years	Meets Vector security criteria
Mcleod Road	13	-	N	13	-	-	-	No constraint within +5 years	Meets Vector security criteria
McNab	47	40	N-1 switched	29	118%	40	128%	No constraint within +5 years	Meets Vector security criteria
Milford	8	-	N	9	-	-	-	No constraint within +5 years	Meets Vector security criteria
Mt Albert	8	-	N	9	-	-	-	No constraint within +5 years	Meets Vector security criteria
Mt Wellington	20	20	N-1 switched	22	101%	20	107%	No constraint within +5 years	Meets Vector security criteria
New Lynn	14	13	N-1 switched	14	116%	13	123%	No constraint within +5 years	Meets Vector security criteria
Newmarket	42	40	N-1 switched	32	105%	40	119%	No constraint within +5 years	Meets Vector security criteria
Newton	19	16	N-1 switched	21	118%	16	127%	No constraint within +5 years	Meets Vector security criteria
Ngataringa Bay	8	-	N	10	-	-	-	No constraint within +5 years	Meets Vector security criteria
Northcote	7	-	N	8	-	-	-	No constraint within +5 years	Meets Vector security criteria
Onehunga	15	15	N-1 switched	14	102%	20	81%	No constraint within +5 years	Meets Vector security criteria, transformer change as part of asset replacement programme
Orakei	22	18	N-1 switched	15	124%	18	134%	No constraint within +5 years	Meets Vector security criteria
Oratia	6	-	N	6	-	-	-	No constraint within +5 years	Meets Vector security criteria
Orewa	16	20	N-1	10	81%	20	108%	No constraint within +5 years	Meets Vector security criteria
Otara	32	30	N-1 switched	25	105%	30	170%	No constraint within +5 years	Meets Vector security criteria - Planned Flat Bush substation will reduce the load at Otara within 5 years
Pacific Steel	56	40	-	15	140%	40	140%	No constraint within +5 years	Meets Vector security criteria
Pakuranga	24	20	N-1 switched	10	119%	20	129%	No constraint within +5 years	Meets Vector security criteria
Papakura	26	20	N-1 switched	10	130%	20	133%	No constraint within +5 years	Meets Vector security criteria
Parnell	10	12	N-1	16	87%	20	62%	No constraint within +5 years	Meets Vector security criteria, transformer change as part of asset replacement programme
Ponsonby	16	12	N-1 switched	11	131%	12	135%	No constraint within +5 years	Meets Vector security criteria
Quay	23	20	N-1 switched	27	115%	20	140%	No constraint within +5 years	Meets Vector security criteria
Quay 22kV	34	60	N-1	33	56%	60	69%	No constraint within +5 years	Meets Vector security criteria
Ranui	11	-	N	12	-	-	-	No constraint within +5 years	Meets Vector security criteria

APPENDIX 4

Company Name **Vector Limited**
AMP Planning Period **1 April 2013 – 31 March 2023**

SCHEDULE 12b: REPORT ON FORECAST CAPACITY

This schedule requires a breakdown of current and forecast capacity and utilisation for each zone substation and current distribution transformer capacity. The data provided should be consistent with the information provided in the AMP. Information provided in this table should relate to the operation of the network in its normal steady state configuration.

sch ref

	Red Beach	16	-	N	17	-	20	104%	No constraint within +5 years	Meets Vector security criteria - Second transformer installation planned within 5 years
	Remuera	28	20	N-1 switched	22	138%	20	170%	No constraint within +5 years	Meets Vector security criteria
	Riverhead	9	8	N-1 switched	13	120%	8	134%	No constraint within +5 years	Meets Vector security criteria
	Rockfield	21	20	N-1 switched	31	104%	20	130%	No constraint within +5 years	Meets Vector security criteria
	Rosebank	21	22	N-1	17	96%	22	99%	No constraint within +5 years	Meets Vector security criteria
	Sabulite Road	20	13	N-1 switched	20	156%	13	166%	No constraint within +5 years	Meets Vector security criteria
	Sandringham	21	20	N-1 switched	49	104%	20	107%	No constraint within +5 years	Meets Vector security criteria
	Simpson Road	5	-	N	6	-	-	-	No constraint within +5 years	Meets Vector security criteria
	Snells Beach	6	-	N	6	-	-	-	No constraint within +5 years	Meets Vector security criteria - Planned Sandspit substation will reduce the load at Snells Beach and increase transfer capacity at this substation
	South Howick	30	20	N-1 switched	16	149%	20	152%	No constraint within +5 years	Meets Vector security criteria
	Spur Road	10	-	N	16	-	-	-	No constraint within +5 years	Meets Vector security criteria
	St Heliers	22	18	N-1 switched	18	126%	18	130%	No constraint within +5 years	Meets Vector security criteria
	St Johns	18	20	N-1	28	91%	20	132%	No constraint within +5 years	Meets Vector security criteria
	Sunset Road	18	13	N-1 switched	17	142%	13	146%	No constraint within +5 years	Meets Vector security criteria
	Swanson	11	-	N	12	-	-	-	No constraint within +5 years	Meets Vector security criteria
10	Sylvia Park	18	20	N-1	14	88%	20	110%	No constraint within +5 years	Meets Vector security criteria
11	Takanini	14	15	N-1	12	91%	15	96%	No constraint within +5 years	Meets Vector security criteria
12	Takapuna	9	-	N	10	-	-	-	No constraint within +5 years	Meets Vector security criteria
13	Te Atatu	22	13	N-1 switched	11	173%	20	116%	No constraint within +5 years	Meets Vector security criteria - Transformer upgrade planned within 5 years
14	Te Papapa	24	20	N-1 switched	11	121%	20	125%	No constraint within +5 years	Meets Vector security criteria
15	Torbay	9	-	N	8	-	-	-	No constraint within +5 years	Meets Vector security criteria - Planned Glenvar substation will reduce the load at Torbay and increase transfer capacity at this substation
16	Triangle Road	17	10	N-1 switched	19	167%	10	180%	No constraint within +5 years	Meets Vector security criteria - Transformer upgrade planned within 5 years
17	Victoria	27	20	N-1 switched	24	134%	20	140%	No constraint within +5 years	Meets Vector security criteria
18	Waiake	10	-	N	9	-	-	-	No constraint within +5 years	Meets Vector security criteria - Planned Glenvar substation will reduce the load at Waiake and increase transfer capacity at this substation
19	Waiheke	11	13	N-1	3	88%	13	94%	No constraint within +5 years	Meets Vector security criteria
20	Waikaukau	7	-	N	9	-	-	-	No constraint within +5 years	Meets Vector security criteria
21	Waimauku	9	-	N	5	-	10	100%	No constraint within +5 years	completed
22	Wairau	16	16	N-1 switched	18	100%	16	105%	No constraint within +5 years	Meets Vector security criteria
23	Warkworth	17	15	N-1 switched	20	116%	15	125%	No constraint within +5 years	Meets Vector security criteria
24	Wellsford	8	8	N-1 switched	6	105%	8	113%	No constraint within +5 years	Meets Vector security criteria
25	Westfield	30	20	N-1 switched	17	152%	20	159%	No constraint within +5 years	Meets Vector security criteria
26	White Swan	31	30	N-1 switched	20	103%	30	106%	No constraint within +5 years	Meets Vector security criteria
27	Wiri	38	40	N-1	24	96%	40	100%	No constraint within +5 years	Meets Vector security criteria
28	Woodford	10	-	N	20	-	-	-	No constraint within +5 years	Meets Vector security criteria

29 [1] *Extend forecast capacity table as necessary to disclose all capacity by each zone substation*

APPENDIX 4

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**

SCHEDULE 12b: REPORT ON FORECAST CAPACITY

This schedule requires a breakdown of current and forecast capacity and utilisation for each zone substation and current distribution transformer capacity. The data provided should be consistent with the information provided in the AMP. Information provided in this table should relate to the operation of the network in its normal steady state configuration.

sch ref

30	**12b(ii): Transformer Capacity**	
31		**(MVA)**
32	Distribution transformer capacity (EDB owned)	3,960
33	Distribution transformer capacity (Non-EDB owned)	499
34	**Total distribution transformer capacity**	4,460
35		
36	**Zone substation transformer capacity**	4,006

Company Name Vector Limited

For Year Ended 31st March 2014

Schedule 15 Voluntary Explanatory Notes

1. This Schedule enable EDBs to provide, should they wish to-

   1.1 additional explanatory comment to reports prepared in accordance with clauses 2.3.1, 2.4.21, 2.4.22, 2.5.1, 2.5.2 and 2.6.5;

   1.2 information on any substantial changes to information disclosed in relation to a prior disclosure year, as a result of final wash-ups.

2. Information in this Schedule is not part of the audited disclosure information, and so is not subject to the assurance requirements specified in Section 2.8.

3. Provide additional explanatory comments in the box below.

Box 1: Voluntary explanatory comments on disclosed information

The following voluntary notes relate to the information disclosure under Schedule 12b:

Vectors security standard allows substation demand to exceed an N-1 security level for 5% of the time in a year for residential substations and 2% of the time in a year for industrial substations, thus ensuring a higher utilisation than that can be achieved with a strictly deterministic N-1 security criterion.

Vector uses cyclic equipment rating when assessing the substation capacity rather than the name-plate (continuous) rating provided in the "Installed Firm Capacity (MVA)".

The total capacity of power transformers of 4006MVA includes the capacity of 110kV transformers at bulk supply substations.

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Appendix 5

APPENDIX 5

Company Name	**Vector Limited**
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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

sch ref			Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
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		for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
11	*Consumer types defined by EDB**							
12	Residential & Small Medium Enterprise (SME)		3,633	4,858	4,858	4,858	4,833	4,833
13	Industrial & Commercial (I & C)		108	120	120	120	120	120
14								
15								
16								
17	**Connections total**		3,742	4,978	4,978	4,978	4,953	4,953
18	**include additional rows if needed*							
19	**Distributed generation**							
20	Number of connections		78	83	80	80	80	80
21	Installed connection capacity of distributed generation (MVA)		0	11	5	5	5	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)**	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
25	GXP demand		1,698	1,744	1,766	1,789	1,815	1,836
26	*plus* Distributed generation output at HV and above		13	13	13	13	13	13
27	**Maximum coincident system demand**		1,711	1,757	1,780	1,802	1,828	1,849
28	*less* Net transfers to (from) other EDBs at HV and above		-	-	-	-	-	-
29	**Demand on system for supply to consumers' connection points**		1,711	1,757	1,780	1,802	1,828	1,849
30	**Electricity volumes carried (GWh)**							
31	Electricity supplied from GXPs		8,656	8,659	8,661	8,661	8,659	8,655
32	*less* Electricity exports to GXPs		-	-	-	-	-	-
33	*plus* Electricity supplied from distributed generation		112	112	112	112	112	112
34	*less* Net electricity supplied to (from) other EDBs		-	-	-	-	-	-
35	**Electricity entering system for supply to ICPs**		8,768	8,771	8,773	8,773	8,771	8,767
36	*less* Total energy delivered to ICPs		8,413	8,416	8,417	8,417	8,415	8,412
37	**Losses**		355	355	356	356	356	356
38								
39	**Load factor**		59%	57%	56%	56%	55%	54%
40	**Loss ratio**		4.1%	4.1%	4.1%	4.1%	4.1%	4.1%

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Appendix 6

APPENDIX 6

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**
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		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
9	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
10	**SAIDI**						
11	Class B (planned interruptions on the network)	19.5	18.9	18.9	18.9	18.9	18.9
12	Class C (unplanned interruptions on the network)	75.8	95.1	95.1	88.3	88.3	88.3
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.14	0.11	0.11	0.08	0.08	0.08
15	Class C (unplanned interruptions on the network)	0.87	1.55	1.55	1.16	1.16	1.16

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Appendix 7

APPENDIX 7

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**
Network / Sub-network Name	**Vector (Southern region)**

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		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
9	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
10	**SAIDI**						
11	Class B (planned interruptions on the network)	5.6	5.5	5.5	4.9	4.9	4.9
12	Class C (unplanned interruptions on the network)	49.2	62.3	62.3	53.7	53.7	53.7
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.09	0.08	0.08	0.04	0.04	0.04
15	Class C (unplanned interruptions on the network)	0.62	1.12	1.12	0.75	0.75	0.75

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Appendix 8

APPENDIX 8

Company Name	**Vector Limited**
AMP Planning Period	**1 April 2013 – 31 March 2023**
Network / Sub-network Name	**Vector (Northern region)**

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*
9	for year ended	**31 Mar 13**	**31 Mar 14**	**31 Mar 15**	**31 Mar 16**	**31 Mar 17**	**31 Mar 18**
10	**SAIDI**						
11	Class B (planned interruptions on the network)	40.9	39.4	39.4	40.4	40.4	40.4
12	Class C (unplanned interruptions on the network)	116.7	145.5	145.5	141.3	141.3	141.3
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.21	0.17	0.17	0.13	0.13	0.13
15	Class C (unplanned interruptions on the network)	1.26	2.21	2.21	1.78	1.78	1.78

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Appendix 9

APPENDIX 9

Company Name: **Vector Limited**
AMP Planning Period: **1 April 2013 – 31 March 2023**
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).

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
3	Asset management policy	To what extent has an asset management policy been documented, authorised and communicated?	The organisation does not have a documented asset management policy.	The organisation has an asset management policy, but it has not been authorised by top management, or it is not influencing the management of the assets.	The organisation has an asset management policy, which has been authorised by top management, but it has had limited circulation. It may be in use to influence development of strategy and planning but its effect is limited.	The asset management policy is authorised by top management, is widely and effectively communicated to all relevant employees and stakeholders, and used to make these persons aware of their asset related obligations.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to ensure that its asset management strategy is appropriately aligned with the organisation's other organisational policies and strategies or with stakeholder requirements. OR The organisation does not have an asset management strategy.	The need to align the asset management strategy with other organisational policies and strategies as well as stakeholder requirements is understood and work has started to identify the linkages or to incorporate them in the drafting of asset management strategy.	Some of the linkages between the long term asset management strategy and other organisational policies, strategies and stakeholder requirements are defined but the work is fairly well advanced but still incomplete.	All linkages are in place and evidence is available to demonstrate that, where appropriate, the organisation's asset management strategy is consistent with its other organisational policies and strategies. The organisation has also identified and considered the requirements of relevant stakeholders.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to ensure that its asset management strategy is produced with due regard to the lifecycle of the assets, asset types or asset systems that it manages. OR The organisation does not have an asset management strategy.	The need is understood, and the organisation is drafting its asset management strategy to address the lifecycle of its assets, asset types and asset systems.	The long-term asset management strategy takes account of the lifecycle of some, but not all, of its assets, asset types and asset systems.	The asset management strategy takes account of the lifecycle of all of its assets, asset types and asset systems.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation does not have an identifiable asset management plan(s) covering asset systems and critical assets.	The organisation has asset management plan(s) but they are not aligned with the asset management strategy and objectives and do not take into consideration the full asset life cycle (including asset creation, acquisition, enhancement, utilisation, maintenance decommissioning and disposal).	The organisation is in the process of putting in place comprehensive, documented asset management plan(s) that cover all life cycle activities, clearly aligned to asset management objectives and the asset management strategy.	Asset management plan(s) are established, documented, implemented and maintained for asset systems and critical assets to achieve the asset management strategy and asset management objectives across all life cycle phases.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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
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	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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?	The organisation does not have plan(s) or their distribution is limited to the authors.	The plan(s) are communicated to some of those responsible for delivery of the plan(s). OR Communicated to those responsible for delivery is either irregular or ad-hoc.	The plan(s) are communicated to most of those responsible for delivery but there are weaknesses in identifying relevant parties resulting in incomplete or inappropriate communication. The organisation recognises improvement is needed as is working towards resolution.	The plan(s) are communicated to all relevant employees, stakeholders and contracted service providers to a level of detail appropriate to their participation or business interests in the delivery of the plan(s) and there is confirmation that they are being used effectively.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
29	Asset management plan(s)	How are designated responsibilities for delivery of asset plan actions documented?	The organisation has not documented responsibilities for delivery of asset plan actions.	Asset management plan(s) inconsistently document responsibilities for delivery of plan actions and activities and/or responsibilities and authorities for implementation inadequate and/or delegation level inadequate to ensure effective delivery and/or contain misalignments with organisational accountability.	Asset management plan(s) consistently document responsibilities for the delivery of actions but responsibility/authority levels are inappropriate/ inadequate, and/or there are misalignments within the organisation.	Asset management plan(s) consistently document responsibilities for the delivery actions and there is adequate detail to enable delivery of actions. Designated responsibility and authority for achievement of asset plan actions is appropriate.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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)	The organisation has not considered the arrangements needed for the effective implementation of plan(s).	The organisation recognises the need to ensure appropriate arrangements are in place for implementation of asset management plan(s) and is in the process of determining an appropriate approach for achieving this.	The organisation has arrangements in place for the implementation of asset management plan(s) but the arrangements are not yet adequately efficient and/or effective. The organisation is working to resolve existing weaknesses.	The organisation's arrangements fully cover all the requirements for the efficient and cost effective implementation of asset management plan(s) and realistically address the resources and timescales required, and any changes needed to functional policies, standards, processes and the asset management information system.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to establish plan(s) and procedure(s) to identify and respond to incidents and emergency situations.	The organisation has some ad-hoc arrangements to deal with incidents and emergency situations, but these have been developed on a reactive basis in response to specific events that have occurred in the past.	Most credible incidents and emergency situations are identified. Either appropriate plan(s) and procedure(s) are incomplete for critical activities or they are inadequate. Training/ external alignment may be incomplete.	Appropriate emergency plan(s) and procedure(s) are in place to respond to credible incidents and manage continuity of critical asset management activities consistent with policies and asset management objectives. Training and external agency alignment is in place.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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)?	Top management has not considered the need to appoint a person or persons to ensure that the organisation's assets deliver the requirements of the asset management strategy, objectives and plan(s).	Top management understands the need to appoint a person or persons to ensure that the organisation's assets deliver the requirements of the asset management strategy, objectives and plan(s).	Top management has appointed an appropriate people to ensure the assets deliver the requirements of the asset management strategy, objectives and plan(s) but their areas of responsibility are not fully defined and/or they have insufficient delegated authority to fully execute their responsibilities.	The appointed person or persons have full responsibility for ensuring that the organisation's assets deliver the requirements of the asset management strategy, objectives and plan(s). They have been given the necessary authority to achieve this.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
40	Structure, authority and responsibilities	What evidence can the organisation's top management provide to demonstrate that sufficient resources are available for asset management?	The organisation's top management has not considered the resources required to deliver asset management.	The organisations top management understands the need for sufficient resources but there are no effective mechanisms in place to ensure this is the case.	A process exists for determining what resources are required for its asset management activities and in most cases these are available but in some instances resources remain insufficient.	An effective process exists for determining the resources needed for asset management and sufficient resources are available. It can be demonstrated that resources are matched to asset management requirements.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
42	Structure, authority and responsibilities	To what degree does the organisation's top management communicate the importance of meeting its asset management requirements?	The organisation's top management has not considered the need to communicate the importance of meeting asset management requirements.	The organisations top management understands the need to communicate the importance of meeting its asset management requirements but does not do so.	Top management communicates the importance of meeting its asset management requirements but only to parts of the organisation.	Top management communicates the importance of meeting its asset management requirements to all relevant parts of the organisation.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to put controls in place.	The organisation controls its outsourced activities on an ad-hoc basis, with little regard for ensuring for the compliant delivery of the organisational strategic plan and/or its asset management policy and strategy.	Controls systematically considered but currently only provide for the compliant delivery of some, but not all, aspects of the organisational strategic plan and/or its asset management policy and strategy. Gaps exist.	Evidence exists to demonstrate that outsourced activities are appropriately controlled to provide for the compliant delivery of the organisational strategic plan, asset management policy and strategy, and that these controls are integrated into the asset management system	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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.

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Question No.	Function	Question	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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)?	The organisation has not recognised the need for assessing human resources requirements to develop and implement its asset management system.	The organisation has recognised the need to assess its human resources requirements and to develop a plan(s). There is limited recognition of the need to align these with the development and implementation of its asset management system.	The organisation has developed a strategic approach to aligning competencies and human resources to the asset management system including the asset management plan but the work is incomplete or has not been consistently implemented.	The organisation can demonstrate that plan(s) are in place and effective in matching competencies and capabilities to the asset management system including the plan for both internal and contracted activities. Plans are reviewed integral to asset management system process(es).	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation does not have any means in place to identify competency requirements.	The organisation has recognised the need to identify competency requirements and then plan, provide and record the training necessary to achieve the competencies.	The organisation is the process of identifying competency requirements aligned to the asset management plan(s) and then plan, provide and record appropriate training. It is incomplete or inconsistently applied.	Competency requirements are in place and aligned with asset management plan(s). Plans are in place and effective in providing the training necessary to achieve the competencies. A structured means of recording the competencies achieved is in place.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
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.

Question No.	Function	Question	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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?	The organization has not recognised the need to assess the competence of person(s) undertaking asset management related activities.	Competency of staff undertaking asset management related activities is not managed or assessed in a structured way, other than formal requirements for legal compliance and safety management.	The organization is in the process of putting in place a means for assessing the competence of person(s) involved in asset management activities including contractors. There are gaps and inconsistencies.	Competency requirements are identified and assessed for all persons carrying out asset management related activities - internal and contracted. Requirements are reviewed and staff reassessed at appropriate intervals aligned to asset management requirements.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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?	2			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?	2			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	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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?	The organisation has not recognised the need to formally communicate any asset management information.	There is evidence that the pertinent asset management information to be shared along with those to share it with is being determined.	The organisation has determined pertinent information and relevant parties. Some effective two way communication is in place but as yet not all relevant parties are clear on their roles and responsibilities with respect to asset management information.	Two way communication is in place between all relevant parties, ensuring that information is effectively communicated to match the requirements of asset management strategy, plan(s) and process(es). Pertinent asset information requirements are regularly reviewed.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not established documentation that describes the main elements of the asset management system.	The organisation is aware of the need to put documentation in place and is in the process of determining how to document the main elements of its asset management system.	The organisation in the process of documenting its asset management system and has documentation in place that describes some, but not all, of the main elements of its asset management system and their interaction.	The organisation has established documentation that comprehensively describes all the main elements of its asset management system and the interactions between them. The documentation is kept up to date.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered what asset management information is required.	The organisation is aware of the need to determine in a structured manner what its asset information system should contain in order to support its asset management system and is in the process of deciding how to do this.	The organisation has developed a structured process to determine what its asset information system should contain in order to support its asset management system and has commenced implementation of the process.	The organisation has determined what its asset information system should contain in order to support its asset management system. The requirements relate to the whole life cycle and cover information originating from both internal and external sources.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	There are no formal controls in place or controls are extremely limited in scope and/or effectiveness.	The organisation is aware of the need for effective controls and is in the process of developing an appropriate control process(es).	The organisation has developed a controls that will ensure the data held is of the requisite quality and accuracy and is consistent and is in the process of implementing them.	The organisation has effective controls in place that ensure the data held is of the requisite quality and accuracy and is consistent. The controls are regularly reviewed and improved where necessary.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
64	Information management	How has the organisation's ensured its asset management information system is relevant to its needs?	The organisation has not considered the need to determine the relevance of its management information system. At present there are major gaps between what the information system provides and the organisations needs.	The organisation understands the need to ensure its asset management information system is relevant to its needs and is determining an appropriate means by which it will achieve this. At present there are significant gaps between what the information system provides and the organisations needs.	The organisation has developed and is implementing a process to ensure its asset management information system is relevant to its needs. Gaps between what the information system provides and the organisations needs have been identified and action is being taken to close them.	The organisation's asset management information system aligns with its asset management requirements. Users can confirm that it is relevant to their needs.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
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

Question No.	Function	Question	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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?	The organisation has not considered the need to document process(es) and/or procedure(s) for the identification and assessment of asset and asset management related risks throughout the asset life cycle.	The organisation is aware of the need to document the management of asset related risk across the asset lifecycle. The organisation has plan(s) to formally document all relevant process(es) and procedure(s) or has already commenced this activity.	The organisation is in the process of documenting the identification and assessment of asset related risk across the asset lifecycle but it is incomplete or there are inconsistencies between approaches and a lack of integration.	Identification and assessment of asset related risk across the asset lifecycle is fully documented. The organisation can demonstrate that appropriate documented mechanisms are integrated across life cycle phases and are being consistently applied.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to conduct risk assessments.	The organisation is aware of the need to consider the results of risk assessments and effects of risk control measures to provide input into reviews of resources, training and competency needs. Current input is typically ad-hoc and reactive.	The organisation is in the process ensuring that outputs of risk assessment are included in developing requirements for resources and training. The implementation is incomplete and there are gaps and inconsistencies.	Outputs from risk assessments are consistently and systematically used as inputs to develop resources, training and competency requirements. Examples and evidence is available.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to identify its legal, regulatory, statutory and other asset management requirements.	The organisation identifies some its legal, regulatory, statutory and other asset management requirements, but this is done in an ad-hoc manner in the absence of a procedure.	The organisation has procedure(s) to identify its legal, regulatory, statutory and other asset management requirements, but the information is not kept up to date, inadequate or inconsistently managed.	Evidence exists to demonstrate that the organisation's legal, regulatory, statutory and other asset management requirements are identified and kept up to date. Systematic mechanisms for identifying relevant legal and statutory requirements.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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?	2			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	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4
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?	The organisation does not have process(es) in place to manage and control the implementation of asset management plan(s) during activities related to asset creation including design, modification, procurement, construction and commissioning.	The organisation is aware of the need to have process(es) and procedure(s) in place to manage and control the implementation of asset management plan(s) during activities related to asset creation including design, modification, procurement, construction and commissioning but currently do not have these in place (note: procedure(s) may exist but they are inconsistent/incomplete).	The organisation is in the process of putting in place process(es) and procedure(s) to manage and control the implementation of asset management plan(s) during activities related to asset creation including design, modification, procurement, construction and commissioning. Gaps and inconsistencies are being addressed.	Effective process(es) and procedure(s) are in place to manage and control the implementation of asset management plan(s) during activities related to asset creation including design, modification, procurement, construction and commissioning.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation does not have process(es)/procedure(s) in place to control or manage the implementation of asset management plan(s) during this life cycle phase.	The organisation is aware of the need to have process(es) and procedure(s) in place to manage and control the implementation of asset management plan(s) during this life cycle phase but currently do not have these in place and/or there is no mechanism for confirming they are effective and where needed modifying them.	The organisation is in the process of putting in place process(es) and procedure(s) to manage and control the implementation of asset management plan(s) during this life cycle phase. They include a process for confirming the process(es)/procedure(s) are effective and if necessary carrying out modifications.	The organisation has in place process(es) and procedure(s) to manage and control the implementation of asset management plan(s) during this life cycle phase. They include a process, which is itself regularly reviewed to ensure it is effective, for confirming the process(es)/ procedure(s) are effective and if necessary carrying out modifications.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
95	Performance and condition monitoring	How does the organisation measure the performance and condition of its assets?	The organisation has not considered how to monitor the performance and condition of its assets.	The organisation recognises the need for monitoring asset performance but has not developed a coherent approach. Measures are incomplete, predominantly reactive and lagging. There is no linkage to asset management objectives.	The organisation is developing coherent asset performance monitoring linked to asset management objectives. Reactive and proactive measures are in place. Use is being made of leading indicators and analysis. Gaps and inconsistencies remain.	Consistent asset performance monitoring linked to asset management objectives is in place and universally used including reactive and proactive measures. Data quality management and review process are appropriate. Evidence of leading indicators and analysis.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation has not considered the need to define the appropriate responsibilities and the authorities.	The organisation understands the requirements and is in the process of determining how to define them.	The organisation are in the process of defining the responsibilities and authorities with evidence. Alternatively there are some gaps or inconsistencies in the identified responsibilities/authorities.	The organisation have defined the appropriate responsibilities and authorities and evidence is available to show that these are applied across the business and kept up to date.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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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

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4

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.

105	Audit	What has the organisation done to establish procedure(s) for the audit of its asset management system (process(es))?	The organisation has not recognised the need to establish procedure(s) for the audit of its asset management system.	The organisation understands the need for audit procedure(s) and is determining the appropriate scope, frequency and methodology(s).	The organisation is establishing its audit procedure(s) but they do not yet cover all the appropriate asset-related activities.	The organisation can demonstrate that its audit procedure(s) cover all the appropriate asset-related activities and the associated reporting of audit results. Audits are to an appropriate level of detail and consistently managed.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation does not recognise the need to have systematic approaches to instigating corrective or preventive actions.	The organisation recognises the need to have systematic approaches to instigating corrective or preventive actions. There is ad-hoc implementation for corrective actions to address failures of assets but not the asset management system.	The need is recognized for systematic instigation of preventive and corrective actions to address root causes of non compliance or incidents identified by investigations, compliance evaluation or audit. It is only partially or inconsistently in place.	Mechanisms are consistently in place and effective for the systematic instigation of preventive and corrective actions to address root causes of non compliance or incidents identified by investigations, compliance evaluation or audit.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.
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?	The organisation does not consider continual improvement of these factors to be a requirement, or has not considered the issue.	A Continual Improvement ethos is recognised as beneficial, however it has just been started, and or covers partially the asset drivers.	Continuous improvement process(es) are set out and include consideration of cost risk, performance and condition for assets managed across the whole life cycle but it is not yet being systematically applied.	There is evidence to show that continuous improvement process(es) which include consideration of cost risk, performance and condition for assets managed across the whole life cycle are being systematically applied.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

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.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

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?	The organisation makes no attempt to seek knowledge about new asset management related technology or practices.	The organisation is inward looking, however it recognises that asset management is not sector specific and other sectors have developed good practice and new ideas that could apply. Ad-hoc approach.	The organisation has initiated asset management communication within sector to share and, or identify 'new' to sector asset management practices and seeks to evaluate them.	The organisation actively engages internally and externally with other asset management practitioners, professional bodies and relevant conferences. Actively investigates and evaluates new practices and evolves its asset management activities using appropriate developments.	The organisation's process(es) surpass the standard required to comply with requirements set out in a recognised standard. The assessor is advised to note in the Evidence section why this is the case and the evidence seen.

Schedule 17 Certification for Year-beginning Disclosures

Clause 2.9.1 of section 2.9

We, Peter Bird and

Hugh Fletcher, 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 2.4.1, 2.6.1 and sub-clauses 2.6.3(4) and 2.6.5(3) 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

13 March 2013

Date