# 2006
# ASSET MANAGEMENT PLAN

This Asset Management Plan is based on the assumption that Vector is able to reach a satisfactory outcome with the Commerce Commission in respect of the Notice of Intention to Declare Control issued by the Commerce Commission on the 9 August 2006.

# ASSET MANAGEMENT SUMMARY

This plan is prepared to meet the disclosure requirements of Regulation 24 of the Commerce Commission Electricity Information Disclosure Requirements 2004 and subsequent amendments.

## THE VECTOR NETWORK


The Vector network supplies more than one third of New Zealand's electricity peak demand.  The distribution business involves the operation and maintenance of electricity networks in the greater Auckland and Wellington areas.

## NETWORK SUMMARY

| | |
|---|---|
| Peak Demand | 2,088MW |
| Area Covered | 5,200km$^2$ |
| Customer Connections | 660,347 |
| Supply Points from Transpower | 22 |
| Zone Substations | 123 |
| Distribution Substations | 24,616 |
| Subtransmission Cables | 691km |
| Subtransmission Lines | 518km |
| HV Distribution Cables | 4,057km |
| HV Distribution Lines | 4,509km |

# PURPOSE OF THE ASSET MANAGEMENT PLAN

The purpose of this 2006 Asset Management Plan (AMP) is to describe how Vector will manage its network assets and investment to achieve its performance targets, strategic goals and commercial objectives.

Vector's AMP is provided to enable customer's and stakeholders to identify Vector's performance targets, its areas of business focus, forecast levels of maintenance expenditure and capital investment planned to manage this asset base.

The plan identifies Vector's approach to network risk management and contingency planning. The AMP is an important part of Vector's engagement with consumers.

Vector's approach to asset management is one which seeks to strike a balance between the needs and expectations of our customer's, and the funds required to provide the network service. This incorporates the risk and consequences of asset failure.

Vector's asset management approach is to:

- Ensure that targeted standard service levels are met, including reliability of supply to customers.
- Provide a safe environment for operating personnel and the general public
- Proactively manage environmental issues
- Manage network assets to ensure they meet their required functionality, performance and value to ensure long term viability of the electricity network business

This AMP gives an overview to Vector's approach to maintenance, development, asset renewal and replacement within a highly regulated framework.

# DATE AND PLANNING PERIOD

The AMP has been developed as part of the requirements of Regulation 24 of the Commerce Commission Electricity Information Disclosure Requirements 2004 (consolidating all amendments to 1 April 2006) and covers a period of ten years from 1 July 2006 until 30 June 2016.

The plan is a view going forward and does not commit Vector to any of the individual projects or initiatives set out in the plan. These may be modified to reflect changing operational, regulatory or customer requirements and must be approved through normal internal governance procedures.

The AMP is an evolving document, the review of which is an ongoing process within Vector as improved knowledge is gained of our customer's expectations, asset capabilities and condition.

## APPROVED BY DIRECTORS

This plan was approved by the Directors of Vector Limited on the 31st of August 2006 and is subject to Vector reaching a satisfactory outcome with the Commerce Commission in respect of the Notice of Intention to Declare Control issued by the Commerce Commission on the 9 August 2006.

## ASSET MANAGEMENT SYSTEMS AND INFORMATION

Information systems are central to Vector's goals of providing superior customer service. Decisions on asset performance, maintenance, and replacement, contractor responsiveness and optimisation of expenditure require timely and accurate information. Areas of focus for Vector continue to be centred on improving the accuracy and completeness of asset information.

To ensure international best practices are applied to asset management, Vector has staff members actively involved in international technical working groups such as CIGRE and ESAA.

## NETWORK AND ASSET DESCRIPTION

Vector's network can be viewed as three networks:

1. 110kV transmission network, which connects from the Transpower network to Vector bulk supply substations

2. 33kV and 22kV subtransmission networks, which connect between Transpower grid exit points (GXP) and Vector's geographically distributed zone substations.

3. 11kV and 6.6kV, and 400/230V distribution network linking customers to Vector's zone substations.

Each part of the network is designed, operated and maintained to achieve the levels of reliability set out in this AMP.

## SERVICE LEVEL OBJECTIVES

Service for Vector is to understand what our customers' value and meeting these requirements in a timely and commercially-effective manner.

Vector offers differing service standards depending on customer segment against which our performance is measured.

The standards are set based on Vector’s understanding of customer preferences and network capabilities associated with the delivery of these standards.

These service standards vary between regions reflecting differences in network design, security standards, and consumer’s’ standards. Work will continue to align these standards where practical

Common to all network areas is the continuation of health and safety as an area of focus for the business. Vector's policy is to:

> *“Create and maintain a safe and injury free working environment for our employees, our service providers, our suppliers and the public we serve.”*

Our safety goal remains:

> *“No lost time injuries to any person working on our network.”*

## ASSET DEVELOPMENT AND MAINTENANCE PLANS

Ensuring the network meets the future demands of customer, load growth, statutory requirements, environmental and safety issues, ensures that Vector needs to continually improve its asset management.

Vector’s approach is to optimise the use of existing assets through automation, load management or other non-asset development solutions to defer major capital expenditure, whilst ensuring reliability targets are not compromised.

Value based asset maintenance, refurbishment and replacement programmes are critical to Vector. Asset maintenance plans are developed taking into account customer expectations, environmental considerations, operational performance, equipment condition and cost. Generic maintenance plans are developed for each asset type, but are applied based on performance requirements and criticality.

The underlying objective of the asset replacement programme is to identify where value can be gained through equipment replacement rather than incurring ongoing remedial and preventative maintenance costs.

Vector’s continued focus on improved asset condition and network performance information will result in improved replacement/refurbishment decision making.

## RISK ASSESSMENT

Risk is managed in Vector by a combination of:

- Reducing the likelihood of failure, through the capital and maintenance work programmes and enhanced working practices

- Reducing the impact of failure, through contingency and emergency management plans. These plans have been developed under the framework of risk reduction, readiness, response and recovery.
- The identification and management of risk is undertaken by all levels within Vector including the Board and Executive Risk Committees

## EVALUATION OF PERFORMANCE

Measurement and communication of performance measures is an integral part of Vector's management process. Physical performance is tracked through the measures of:

- Reliability
- Safety
- Power Quality
- Customer satisfaction
- Environmental impact

All employees and service providers are accountable for achieving the performance targets. Vector’s service providers are offered incentives through their contracts to achieve targets whilst Vector employees have the performance measures embedded in their performance KPI’s.

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# GLOSSARY OF TERMS

| | |
|---|---|
| AAC | All Aluminium Conductor |
| AAAC | All Aluminium Alloy Conductor |
| ABC | Aerial Bundled Conductor |
| ABS | Air Break Switch |
| AMP | Asset Management Plan |
| ARC | Auckland Regional Council |
| BRC | Board Risk Committee |
| CAIDI | Customer Average Interruption Duration Index |
| CBD | Central Business District |
| CDEM | Civil Defence Emergency Management |
| CIGRE | Conference Internationale des Grands Reseaux Electriques (International Council for Large Electric Systems) |
| CCT | Covered Conductor Thick |
| Cu | Copper |
| DC | Direct Current |
| DFA | Delegated Financial Authority |
| DGA | Dissolved Gas Analysis |
| DMS | Distribution Management System |
| DNP3 | Distributed Network Protocol |
| DTS | Distributed Temperature Sensing |
| EBL | Electricity Business Line |
| ERC | Executive Risk Committee |
| ESAA | Electricity Supply Association of Australia |
| FPI | Fault Passage Indicators |
| GWh | Gigawatt hour |
| GIS | Geographical Information System |
| GIS | Gas Insulated Switchgear |
| GPD | Group Peak Demand |
| GPS | Global Positioning System |
| HRC | High Rupturing Capacity fuse |
| HV | High Voltage |
| Hz | Hertz |
| ICP | Installation Control Point |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronic Engineers |
| IED | Intelligent Electronic Data |
| IP | Internet Protocol |
| IPC | Insulation Piercing Connector |
| km | Kilometre |
| kV | Kilovolt |
| kVA | Kilovolt Ampere |
| kW | Kilowatt |
| LTI | Lost Time Injuries |
| LTIFR | Lost Time Injury Frequency Rate |

| | |
|---|---|
| LV | Low Voltage |
| MEN | Multiple Earthed Neutral |
| MW | Megawatt |
| MVA | Mega Volt Ampere |
| n-1 | Security Standard |
| NICAD | Nickel Cadmium battery |
| Nilstat ITP | Protection Relay |
| ODV | Optimised Deprival Value/Valuation |
| OSH | Occupational Safety and Health |
| PCLL | Post Contingency Load Limit |
| PDC | Polarisation Depolarisation Current |
| PI | Historical Storage Software Package |
| PIAS | Paper Insulated Aluminium Sheath Cable |
| PILC | Paper Insulated Lead Cable |
| PVC | Polyvinyl Chloride |
| RMU | Ring Main Unit |
| RTU | Remote Terminal Unit |
| SAIDI | System Average Interruption Duration Index |
| SAIFI | System Average Interruption Frequency Index |
| SAP | Systems Applications and Processes |
| SCADA | Supervisory Control and Data Acquisition System |
| $SF_6$ | Sulphur hexafluoride |
| SREI | Safety Rules Electricity Industry |
| TASA | Tap Changer Activity Signature Analysis |
| TCA | Tap Changer Condition Assessment |
| TCP/IP | Transmission and Control Protocol/Internet Protocol |
| TLA | Territorial Local Authority |
| TLS | Transformer Load Simulator |
| TMS | Transformer Management System |
| TRIFR | Total Recorded Injury Frequency Rate |
| V | Volt |
| VRLA | Valve Regulated Lead Acid battery |
| VT | Voltage Transformer |
| XLPE | Cross Linked Polyethylene Cable |
| ZAIDI | Zonal Average Interruption Duration Index |

# 1. INTRODUCTION

## 1.1. VECTOR ASSET MANAGEMENT OVERVIEW

Vector continues to maintain a customer focused approach to effective asset management for its 660,000 electricity customer's in the Auckland and Wellington regions.

Vector strives to provide an appropriate level of quality as defined in terms of safety, customer satisfaction, reliability and power quality.

To do this, Vector has developed and implemented business systems and practices such as:

- Regular customer surveys to measure Vector's performance against customer expectations and capture the results as company wide performance targets

- Contracts with field service providers that are structured to reflect Vector's own customer drivers, particularly in the area of network performance. These targets are also company wide performance targets ensuring all Vector employees have the same focus

- Ensuring world class health and safety and environmental processes are in place by providing training to all staff; having zero tolerance for work place accidents and employing a world leader in safe work practices (Shaw Energy Delivery Service) to annually audit Vector's practices; ensuring a company wide focus on safety through assessing staff and service provider performance with respect to specific Key Performance Indicators (KPIs) related to safety

- A business information unit utilising industry leading technology to gather, integrate and present information from a number of systems in a way that facilitates better understanding of Vector's quality performance, which enhances Vector's ability to better plan and manage its network

- Benchmarking Vector's capital delivery model against international practices and methods. Dellwind Pty Ltd, Melbourne has reviewed the capital delivery process against overseas best practice to ensure Vector is abreast of international best practice trends.

The objective of the Asset Management Plan (AMP) is to describe how Vector will manage its network assets and investment in order to achieve its performance targets and strategic goals.

Managing these objectives in the current environment brings its own set of challenges.

- The current regulatory environment creates price quality tension. The dichotomy is to improve network performance, addressing the issues associated with aging assets while building for disparate organic growth within the network.
    - Expenditure on growth requires discrete investments, the cost generally increasing with the capacity required and invariably made with a long term view. Slow uptake of the capacity by customer's coupled with the long term view causes positive returns on investment to be some years away.
    - Customer loads have a short planning horizon. Accommodating sizeable loads such as shopping malls, etc can require investment at short notice. This affects cash flows and long term plans.
    - Uncertainty around the outcome and the consequences of regulatory processes has an impact on long term network investment profiles

- New Zealand's currency continues to weaken against our overseas trading partners. This adversely impacts on Vector as a significant proportion of distribution equipment is sourced overseas. Much of the overseas sourced equipment contains metal which is commanding high overseas prices. Materials, such as copper, aluminium and steel are sought after by recent entrant countries such as China and India pushing up world prices.

- Rising construction costs have contributed to increased pressure on constrained budgets. Civil costs have been increasing particularly as oil prices have increased sharply in recent times.

- The lack of adequate numbers of skilled field resources continues to create challenges in executing of projects in a timely manner. While our field contractors have been actively recruiting overseas and engaging trainees to supplement their staff, there is still a shortage of some specific skill sets. Vector's training company, Utilitech, has been making a significant contribution by ensuring staff working on the electricity network meet required competency standards. They have played a pivotal role in training contractors staff working on the electricity networks

- Compliance costs continue to rise as our field activities come under increasing scrutiny from the Territorial Local Authoritys' (TLA). While our practices are not the issue we are finding that an increasing array of network distribution assets are being targeted for consent conditions. Increasingly restrictive operating constraints such as hours of work are applied by the TLA's, translating into increased costs and feeding back through contractors to Vector. Meeting increasingly stringent traffic management requirements has again adversely impacted on contractors with the corresponding flow-on impact to Vector

- Vector is only one part of the overall electricity supply chain to the end use customer and we are clearly dependent on the generators and Transpower to deliver. Security of supply into Auckland and Wellington are areas of concern to us. While shortcomings of the supply in Wellington are being addressed, solutions surrounding capacity shortfall into Auckland are far from resolved. The customer does not differentiate between Transpower's or Vector's network when they do not have electricity at their premises. The successful delivery of power to the customer is dependent on the robustness of both Transpower and Vector networks.

- Construction timeframes can be long on some of the larger projects and accuracy of forecasting is crucial to ensure projects are delivered on time. The consequences of delivering a key infrastructure reinforcement project late can result in customers without electricity.

- The introduction of the Trees Regulations, while bringing clarity round vegetation ownership responsibility, has resulted in an increased vegetation management spend by Vector

- In all forecasting there needs to be robustness around assumptions, particularly with respect to seasonal and annual variability. Continual efforts are made to refine forecasts by factoring in any parameters that may improve the accuracy. Repeat years of mild weather tend to obscure underlying load that becomes evident during adverse weather conditions.

- Extreme events such as storms test the robustness of the network. While faults result in loss of power to customer's they are not all the result of maintenance practices. Trees falling across lines can result in serious outages even though sound maintenance practices have been adhered to.

However to maintain the network to a level where it is unaffected by extreme events is not only impractical but would also come with an unacceptably high cost to the customer.

To mitigate the impacts of extreme events Vector has implemented contingency plans, both internally and with its service providers, to manage responses to these extreme events. Vector has a Storm Response plan that maps out the processes to be followed before, during and after the event. A more generic Emergency Response Plan maps out the processes for emergencies other than for storms

This AMP provides a view of Vector's approach to maintenance, development, asset renewal and replacement. This may change over time as Vector seeks to continually prioritise work given the availability of resources.

Retailer contracts, developed by previous network owner's, have resulted in differing management and customer service relationships across the three regions. The Auckland network operates a conveyance contractual model ensuring a direct relationship with its 302,000 customer's. The Northern and Wellington networks operate an interposed model where Vector provides line services to Energy Retailers who have the relationship with the customer.

Asset management at Vector is based around understanding the limitations of network assets, particularly aging assets. The objective is to enhance network capacity or replace aged assets in a timely manner so that a near continuous supply of electricity is available to the customer.

This is achieved by having sound information on which to base decisions. Vector has invested heavily in a number of technology solutions that enhance the decision making process so that sound decisions can be made that factor in risk, timely and appropriate investment in the network, shareholders and customer's expectations.

The decision making systems that support the asset management processes include but are not limited to customer management systems, GIS, SAP financial system and SCADA.

The asset planning process prioritises the programmes for maintenance and development to balance risk, cost, customer service and operational efficiency.

The AMP describes Vector's asset management approach and outcomes. From this document, customers and stakeholders can identify and understand the rationale behind Vector's performance targets, areas of business focus, forecast levels of maintenance expenditure and capital investment. The plan also includes Vector's approach to the management of network risks and contingency planning.

## 1.2. NETWORK SUMMARY

The Vector network supplies more than one third of New Zealand's electricity peak demand. The distribution business involves the operation and maintenance of a regional supply network that covers greater Auckland and greater Wellington - an area of approximately 5,200km$^2$.

| | |
|---|---|
| Peak Demand | 2,088MW |
| Area Covered | 5,200km$^2$ |
| Customer Connections | 660,347 |
| Supply Points from Transpower | 22 |
| Zone Substations | 123 |
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| Subtransmission Cables | 691km |
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| HV Distribution Lines | 4,509km |

## 1.3. ASSET MANAGEMENT PHILOSOPHY

Vectors objective is to achieve sustainable long-term value creation through operational excellence in network management. Vector sees growth as the key, by way of incremental organic growth, horizontal growth into management services and new revenue. These can only be achieved through Operational Excellence.

In the context of asset management these can be captured under the headings of cost management, operational efficiency, risk management and customer service.

Value creation is generated through asset ownership and management, leveraging off innovative data management, and supply chain performance based contracts.

Vector's approach to asset management is designed to ensure a balance between the expectations of our customer's, business objectives, regulatory framework and minimising the life time costs of maintenance and replacement. This is managed within an acceptable financial and technical risk envelope.

Vector will not compromise on safety or environmental compliance. Other aspects of asset management are prioritised on the basis of risk. With restrictions on available funds there is always tension between expenditure on customer growth, network reinforcement and asset replacement. Vector endeavours to optimise its expenditure whilst meeting customer needs. It will not invest, however, at any cost, as illustrated by the number of embedded networks, reticulated by other network companies, within its traditional network boundaries.

Vector will achieve these objectives by:

- Ensuring that the required service levels are met
- Provision of a safe environment for operating personnel and the general public
- Proactively managing environmental issues
- Managing the assets to achieve the required functionality, performance and value to enable the continuation of a viable long term network business
- Ensuring the network is managed to world class safety levels

Assets must be operated and maintained to continue to meet performance standards cost-effectively. Functionality and performance requirements are continually reviewed and revised to reflect the changing operational and customer requirements on the network.

In line with Vector's approach to customer driven service provision, the asset management plans are continually refined from analysis of customer requirements, assessment of asset condition, and the risk and consequences of asset failure.

A flow chart of the process is shown in Figure 1.1.

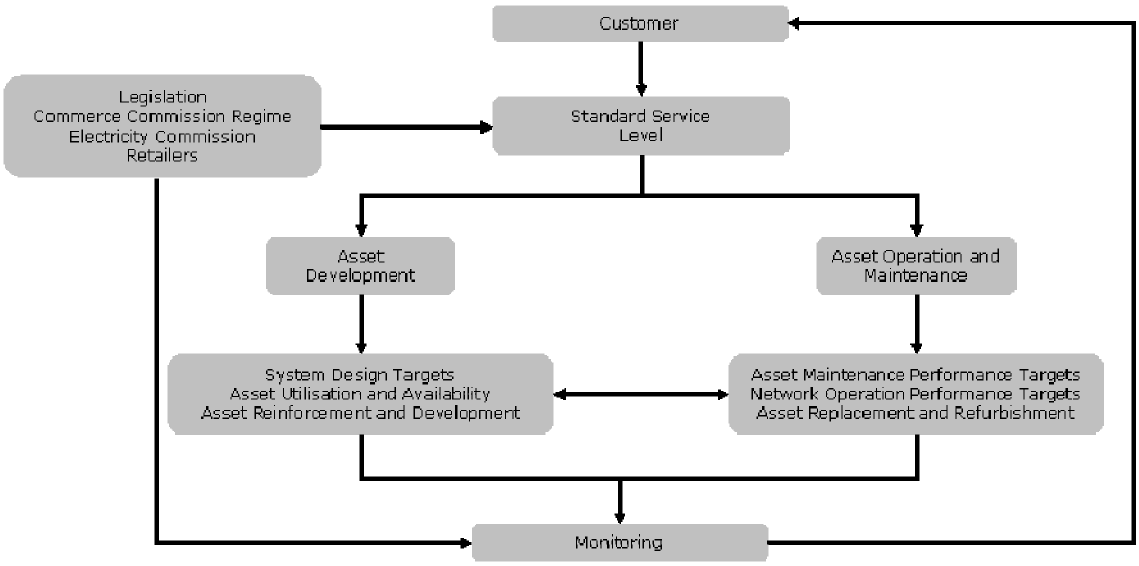



*Figure 1.1 Asset Management Philosophy*

## 1.4. ASSET MANAGEMENT PROCESS

Vector's asset management process is shown in Figure 1.2.

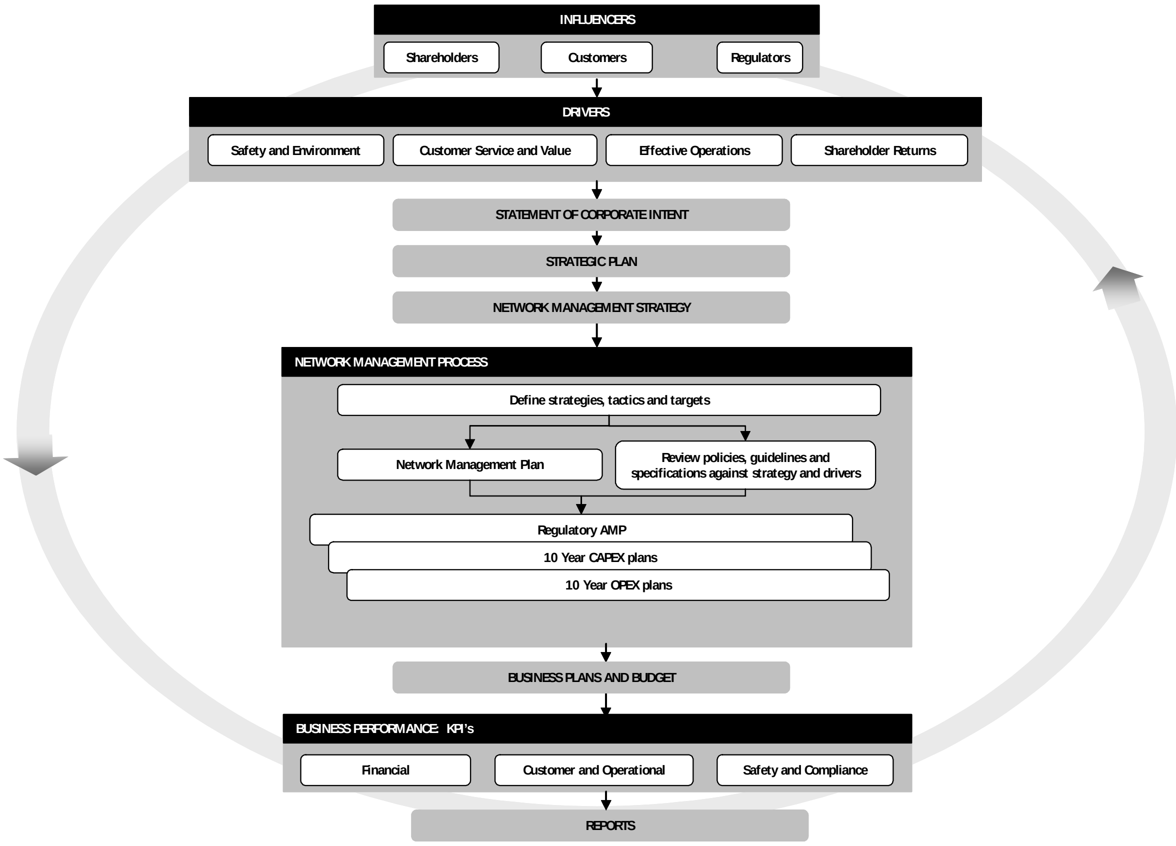



*Figure 1.2 Vector's Asset Management Process*

### 1.4.1. INFLUENCERS

- ***Shareholders***

  Vector is a publicly listed company with Auckland Energy Consumer Trust retaining a 75.1% ownership and the remaining 24.9% owned by institutional and individual shareholders.

  The provisions of the Companies Act and the New Zealand Stock Exchange Listing Rules require Vector to act in the interests of all shareholders and to treat all shareholders equally as a publicly listed company. Good asset management practices are an integral part of maintaining and enhancing the value of an infrastructure business to its shareholders, hence the AMP defines the technical approach to achieve these objectives. Areas of potential conflict between shareholder interests and asset management practices are addressed during the development of the AMP in order to maintain sustainable business performance.

- ***Customer's***

  Vector manages the electricity network to meet the needs of its customer's and works with energy retailers on all three networks to manage customer issues.

- ***Regulations***

  Statutory requirements impact on how Vector operates to meet its service delivery standards. The following statutes and all subsequent amendments are of particular relevance to this AMP:

  *Commerce Act 1986*
  *Electricity Information Disclosure Requirements 2004*
  *Electricity (Hazards from Trees) Regulations 2003*
  *The Electricity Act 1992 and Electricity Amendment Act 2001*
  *Electricity Regulations 1997*
  *Electrical Codes of Practice 1993*
  *New Zealand Standard NZS3000 1999*
  *Australian/New Zealand Standard ANZS3000 2000*
  *Health and Safety in Employment Act 1992*
  *Resource Management Act 1991*
  *Civil Defence Emergency Management Act 2002*
  *Electricity and Gas Industries Act 2004*
  *Electricity Governance Rules and Regulations*
  *Local council district plans*

  Other statutes apply to the business as a whole, but are peripheral to the asset management philosophy.

### 1.4.2. ASSET MANAGEMENT DRIVERS

- ***Shareholder Returns***

  Vector's objective is to manage its assets to meet the shareholders' requirements for a return on investment, preservation and enhancement of the value of the company, and community obligations.

- ***Customer Service and Value***

  Vector's objective is to deliver improved customer value by matching the performance of both its assets and service providers to the performance its customer's expect and are willing to pay for.

- ***Effective Operation***

  Vector's objective is to manage the operation of its assets in such a way as to deliver the required performance at the lowest overall cost.

- ***Health and Safety and Environmental Responsibility***
  Vector will at all times ensure its employees, service providers and customer's safety is not put at risk by the management of its assets. Vector will manage the network and act in an environmentally responsible manner.

## 1.5. RELATIONSHIP WITH BUSINESS PROCESSES

The Asset Management Plan is directly influenced by a number of other policy documents and processes:

- ***Strategic and Business Plans***
  Vector has developed a strategic intent and a set of supporting organisational values. Its strategic intent is to enhance its core business and to pursue significant growth opportunities in selected market spaces.

  It has a documented business plan which details the strategic intent, budget and initiatives that will be undertaken by all functions and business lines during the forthcoming year.

- ***Network Management Strategy***
  This defines the approach and direction for network management in terms of network value, performance, revenue and customer expectations for service and quality.

- ***Performance Targets***
  Performance targets are established for the company as part of the long-term and annual planning rounds. These include customer service, network performance and financial targets. These are cascaded down to individual business units and service providers.

### 1.5.1. PLAN IMPLEMENTATION

The outputs from the asset planning process, which incorporates continual review of asset functionality requirements and customer feedback, are the operational, maintenance and capital work programmes.

- ***Asset Maintenance Plans/Schedules***
  For each customer area, asset or asset group, specific maintenance programmes are established annually, taking into account long-term strategic positioning.

- ***Asset Development***
  For each customer area, capital works programmes are developed to ensure timely delivery of the projects necessary to meet network capacity and security criteria.

- ***Equipment and Design Standards***
  Equipment and design specifications, based on the required functionality of the assets, are included in the Network Standards Manuals, policies and guidelines. These documents are continually reviewed to ensure the standards are based on current performance and functionality requirements, and to take advantage of new working practices and technology, to ensure minimum asset lifecycle costs.

## 1.6. PLANNING PERIOD

This AMP covers a period of ten years from 1 July 2006 until 30 June 2016. The plan is a view going forward. It does not commit Vector to any of the individual projects or initiatives set out in the plan. These may be modified to reflect changing operational, regulatory or customer requirements and must be approved through normal internal governance procedures.

The AMP is an evolving document, the review of which is an ongoing process within Vector. Vector encourages and welcomes stakeholder comment on the plan.

## 1.7. RESPONSIBILITIES AND ACCOUNTABILITIES FOR ASSET MANAGEMENT

Vector is the largest multi-network infrastructure and associated services company in New Zealand. Its business includes the ownership and management of:

- electricity networks in Auckland and Wellington,
- gas transmission network
- gas distribution network company
- gas energy wholesaling and sales business
- gas processing and treatment plant in Taranaki
- LPG sales business
- electricity and gas metering business
- broadband communications business
- industry training business (Utilitech)

The company is structured into business units to focus on managing its core businesses. These business units are supported by shared centres of excellence providing the necessary supporting services to enable them to operate the respective core business effectively and efficiently. The electricity and gas businesses are each headed by a Divisional CEO. The metering business and the telecommunications business are each headed by a General Manager. Supporting these three business units are five service functions, viz, finance, regulatory performance and strategy, information services, organisation services, and legal services. Each of these functions is headed by a Group General Manager. Figure 1.3 outlines the executive structure of the company.

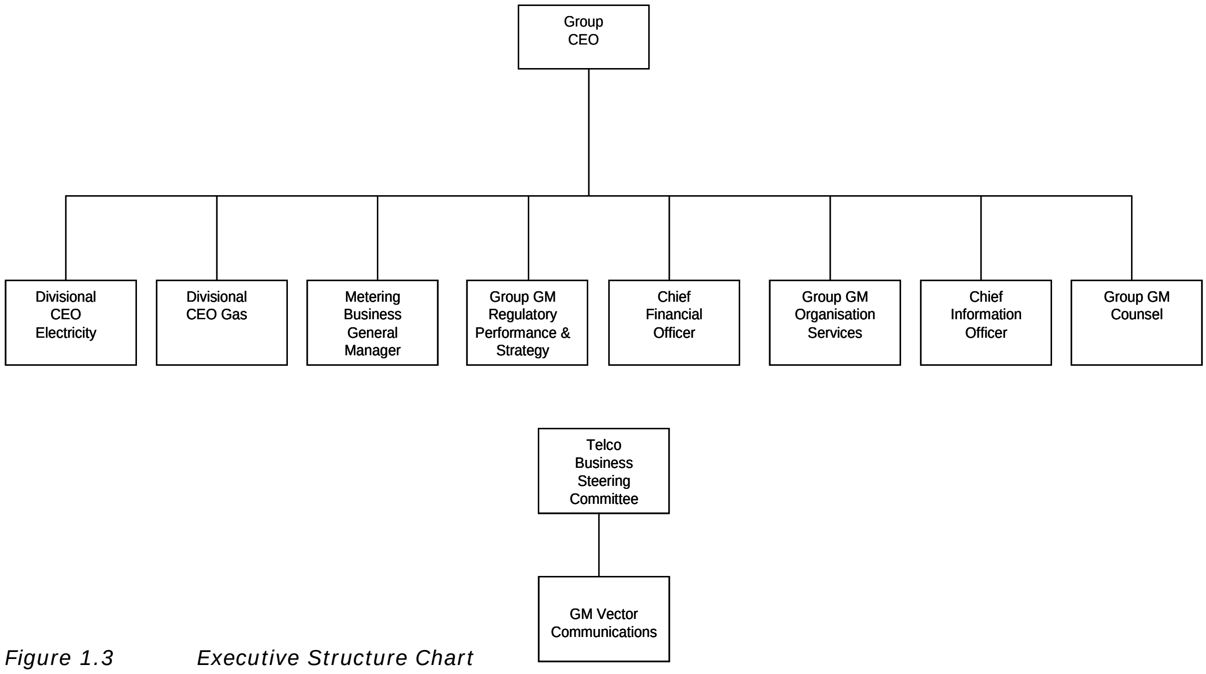



*Figure 1.3 Executive Structure Chart*

The management of the electricity assets is the responsibility of the Divisional CEO Electricity. The following chart highlights the structure of the Electricity Business. Reporting to the Divisional CEO Electricity are seven Divisional Managers. A brief description of the responsibilities of these Divisional Managers is given in the chart.

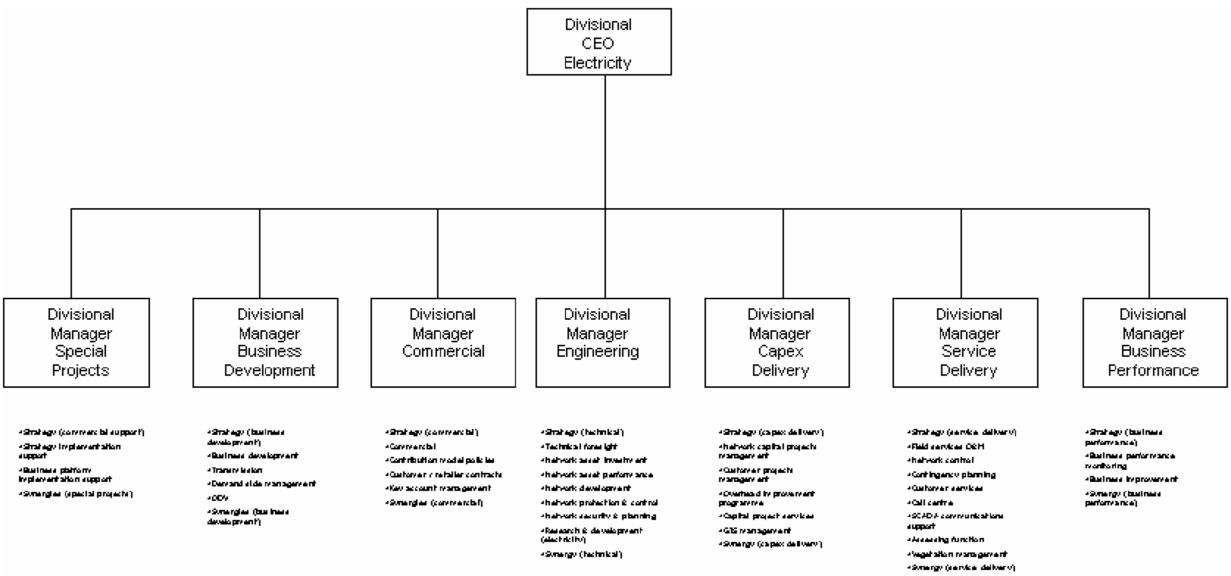



*Figure 1.4 Asset Management Structure Chart*

The responsibility for identifying the planned work required on the network resides with the Divisional Manager Engineering. His team contains the personnel responsible for initiating long term capacity reinforcement projects, asset replacement and asset performance programmes. Annual budgets are approved by the Board with the underlying projects individually approved in accordance with assigned delegated financial authorities (DFA's). Management and Executive have pre-assigned expenditure commitment ranges for individual projects, with the Board approving expenditure above these levels.

Reinforcement and customer initiated projects are managed by the Divisional Manager – Capex Delivery, while replacement projects are managed through the Divisional Manager – Service Delivery. The Divisional Manager – Service Delivery is also responsible for managing the remedial and faults budgets, network operations and customer services.

All capex and remedial work is contracted to independent contractors. For the purposes of maintenance, managing faults and remedial works, three contractors (procured through competitive processes) are assigned geographic areas in which to operate. Siemens Energy Services Ltd manages the Northern and Wellington networks, Energex (NZ) Ltd, the Auckland CBD while Northpower Ltd manages South Auckland. These contractors and several others compete for capex work across the regions.

Risks are captured by all staff into the risk register and assigned a classification in accordance with the "consequences" and "likelihood" of the event occurring. Senior management are assigned the responsibility to analyse the risk, identify solutions to eliminate, mitigate, or monitor and ensure these solutions are implemented. Regular reviews of the risk register are carried out separately by the Electricity Business Line Risk Committee, the Executive Risk Committee and the Board Risk Committee to ensure the risks are being adequately and appropriately addressed.

The risk processes are described in greater detail in Section 6

## 1.8. ASSET MANAGEMENT INFORMATION SYSTEMS

### 1.8.1. OVERVIEW

Decisions on asset performance, asset maintenance, asset replacement, customer responsiveness and optimisation of expenditure require current and accurate information. Enhancing the level of information Vector holds on its assets and network, together with implementation of tools to support the effective use of this information, continues to be a high area of focus.

The Geographical Information System (GIS) is one of the two physical asset registers. The other is the SAP Financial System which maintains a register of project costs against asset classes. While integration between the GIS and SAP registers exists, a single point of entry for asset information is being investigated. The GIS remains the central focus for asset information collected within Vector and information flows between the GIS and other corporate systems. Our service providers are accountable for the provision of accurate, timely asset maintenance and fault data into the GIS, and are contractually incentivised to do so.

Collection and validation of asset information using field computers is a key feature of Vector's information strategy.

### 1.8.2. GIS SYSTEM

The GIS system is the cornerstone of Vector's asset management information systems. The system is used for the following business requirements:

- Performance monitoring of assets for customer management
- Analysis of asset performance
- Data for calculation of the network ODV
- Exported data files for import into network analysis applications
- Geographic based analysis of customer data
- Asset preventative maintenance and test recording
- Base data for asset maintenance scheduling
- Reference for asset location
- Network model for import into SCADA/DMS
- Vector's asset physical register link to SAP financial register

The following developments to the system have been completed over the past 12 months.

***Extension of the System to Support Requirements for SCADA/DMS in the Auckland Region***

The GIS system provides the foundation data for the SCADA/DMS system. To allow this, data must be accurate and timely. It is no longer sufficient for this to be a pictorial representation of the asset. It also requires the underlying logic to enable the network connectivity to be represented. This has been achieved for the Auckland network and its roll-out to the other two networks is being considered.

In addition, the new version of GE Smallworld will allow Vector to implement "proposed" networks on the GIS which will transition to "As Builts" during the project lifecycle. Work is underway to develop the processes to achieve this.

With the new version of GIS software, a schematic can be displayed on the screen as a substitute for the current integrated schematic view of the HV and sub-transmission network.

***Common Landbase for all Networks***

The northern network GIS has been converted to the Terraview landbase and the project to convert Wellington to Terraview will shortly be completed.

***Aerial photography for all networks***

Orthophotography is now available on the GIS for all networks.

***Network Drawings***

All the Vector network drawings have been merged into Projectwise (Bentley). This has replaced the old Vector drawing register (Access Database) and the United Networks previous version of Projectwise.

***Field Data Collection and Verification***

A GIS based field application has been developed and implemented to allow recording of inspections, tests and defects as part of Vector's preventative maintenance programmes. This system is currently being significantly upgraded with enhanced capability for both PDA and laptop users in the field, as well as improved functionality to allow Vector to gather accurate information in real time.

Functionality is also being improved to allow errors in the GIS data, noticed during field inspections, to be corrected in the field.

### 1.8.3. SCADA/DMS (SUPERVISORY CONTROL AND DATA ACQUISITION/DISTRIBUTION MANAGEMENT SYSTEM)

Vector has implemented its "real-time" network management system across the Auckland network. This involves tight integration between the GE Smallworld GIS, the SPL WorldGroup Pty Ltd DMS system, the Siebel Customer Management system and the Siemens PowerTG SCADA system. The extension of this integrated environment across the other two networks in Wellington and Northern (both of which already use a common GE Smallworld GIS) is being considered.

***SCADA/DMS system.***

The solution provides base SCADA functionality, integrated with advanced distribution management system (DMS) functions including outage management, switching management, real-time load flow analysis and dynamic asset rating.

The system is integrated, both with Vector's GIS system (for network data in both GEO and schematic form) and with its Customer Management System (for customer call taking and for provision of information on outages to customer's).

The system provides Vector with advanced tools, which improve customer service (through more accurate and up to date information on faults), reduce restoration times, improve asset utilisation and reduce the potential for human error.

### 1.8.4. NETWORK ANALYSIS TOOLS

***DIgSILENT Powerfactory***

Vector uses a specialised electricity network simulation software package, DIgSILENT Powerfactory, for all power system related modeling and analysis. This system is currently being upgraded to a more flexible server version and tighter integration with the GIS is being reviewed.

The complete subtransmission and high voltage distribution network is modeled for all three regions, from the Transpower grid exit points to the low voltage terminals of Vector's distribution transformers.

These network models are being used for investment decisions and enhancement to customer service based on load flow, short circuit, network reliability assessment, protection device coordination, motor starting, network loss assessment and power quality analysis.

***CYMCAP***

CYMCAP continues to be used for calculation of ratings for underground cables.

***PI***

PI continues to be used for evaluating network and feeder loadings, on an on-line basis. The new generation of protection relays has the ability to collect a multitude of information, such as current, voltage, power factor, power quality, etc. A selected list of these measurements will be recorded in the PI system for reference by network planning and operation.

### 1.8.5. PROTECTION SETTING MANAGEMENT SYSTEM

The importance, complexity and number of protection relays are increasing with the growth of the power system, the addition of new substations and replacement of old equipment.

Modern microprocessor relay availability has been tremendously enhanced by relay hardware and software self-supervision functionality. However, with the complexity of modern relays comes the risk of incorrect relay settings which can cause mal-operation of the protection system. This negative effect on the overall power system performance will be investigated and addressed.

Vector is implementing a web-enabled Protection Setting Management System (PowerWare) from DigSILENT. PowerWare, being a single effective protection setting management tool, is expected to facilitate increased protection system reliability and hence power system reliability. It will enable:

- Simplification and cost reduction of the protection setting process by providing seamless integration with DigSILENT Power Factory power system analysis and protection setting / coordination software;
- Import the manufacturer's specific protection relay setting files enabling increased data integrity for verification of the applied settings, protection system auditing as well as investigation of protection system operation;
- Formalising setting procedures (from initial setting preparation to final approval and setting application) with in-built controlled workflow and protection system documentation management, which will ensure that the applied protection settings are adequately managed, documented and accurately applied;

PowerWare also provides an industry standard interface (XML based) for data exchange with other applications and will be able to disseminate the protection data to other Vector IT applications.

### 1.8.6. PROTECTION SYSTEM - AUTOMATIC DIGITAL FAULT RECORD RETRIEVAL AND PRESENTATION

After a power system fault, a fast and comprehensive analysis of the cause of the disturbance is a decisive factor in quickly restoring the system, and keeping the outage time to a minimum.

In order to facilitate it, an automated centralised digital fault record retrieval system with a web-based user interface has been implemented as part of Vector's substation IT system.

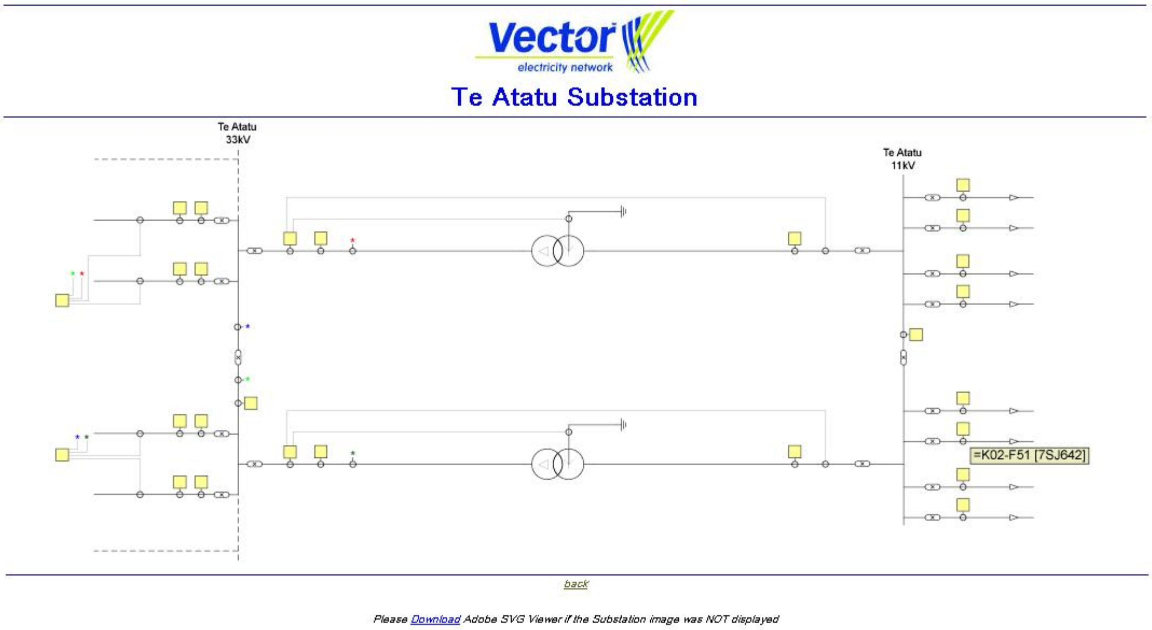



*Figure 1.5 Te Atatu Substation SLD*


*Figure 1.6 Relay Access*

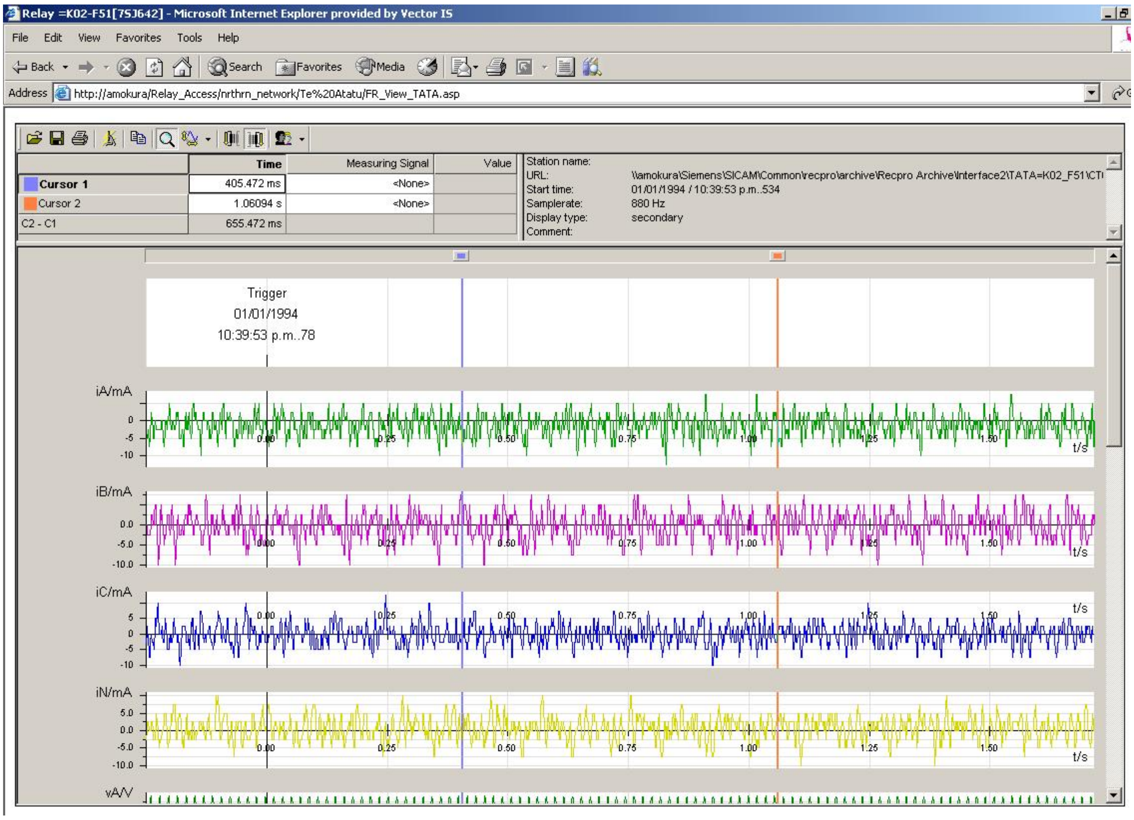


*Figure 1.7 Fault Recordings*

# 1.9. NETWORK PERFORMANCE REPORTING AND ANALYSIS

## 1.9.1. CURRENT SYSTEMS

Over the past 12 months, Vector has developed a comprehensive suite of reporting and analysis tools to help track and understand the performance of the network.

All reporting is automatically updated each morning so staff have accurate and current information. Access is company wide, through Vector's intranet. The following tools are in place:

***Automated Daily Fault Reports***

Each morning a summary of HV faults from the past 24 hours is automatically sent to key staff across Vector and its zone based contractors.

## HV Event Report from midnight yesterday to present

**25 Apr 06 09:05 a.m.**

Business Information Intranet Site
Click Here for SAIDI/SAIFI/CAIDI Current Month
Click Here for SAIDI/SAIFI/CAIDI Current Financial Year
Click Here for a Geographical Map showing Outages over the Last 7 days.
Click Here for LV Events

| KEY: | Cust Affec | Vector SAIDI | Max Time Off (mins) | Recent Trend vs SLA |
|---|---|---|---|---|
| | 0 | 0 | 0 | |
| | 1-200 | 0-0.1 | 0-120 | OK |
| | 201-500 | 0.1-0.5 | 120-150 | < SLA |
| | 201-1000 | 0.5-1 | 150-180 | = SLA |
| | 1001+ | >1.0 | 180+ | > SLA |

Click on the blue hyperlinks to go into further detail regarding an individual outage.

### Unplanned Events since midnight yesterday

| Event ID | Date & Time | Region | System Level | Location | Substation | Main Reason | Sub Reason | Cust Affec | Vector SAIDI | Max Time Off | Faults Last 12mths |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 188646 | 24 Apr 22:42 | Auckland | Feeder | TAKA 12 | Takanini | NO FAULT FOUND | PATROLLED | 427 | 0.028 | 47 | 12 |
| 188645 | 24 Apr 20:16 | Auckland | Feeder | MARA 7 | Maraetai | NO FAULT FOUND | PATROLLED | 79 | 0.010 | 80 | 10 |

### Planned Events since midnight yesterday

| Event ID | Date & Time | Region | System Level | Location | Substation | Cust Affec | Vector SAIDI | Max Time Off (mins) |
|---|---|---|---|---|---|---|---|---|
| 188643 | 24 Apr 11:00 | Northern | Feeder | 38LIME | Warkworth | 1 | 0.000 | 125 |
| 188644 | 24 Apr 09:52 | Northern | Feeder | 13KAUK | Helensville | 54 | 0.021 | 256 |

### Auto Reclosers Events since midnight yesterday

| Event ID | Date & Time | Region | Location | Substation | Reclose Events last 1mth |
|---|---|---|---|---|---|
| 188649 | 25 Apr 06:47 | Auckland | WAIH 5 | Waiheke | 1 |
| 188642 | 24 Apr 07:03 | Northern | 39PORT | Wellsford | 2 |

### Top Customers likely to have lost power since midnight yesterday

| Event ID | Event Type | Customer Name | REGION | Feeder | KAM |
|---|---|---|---|---|---|
| 188646 | Unplanned | TELECOM NEW ZEALAND LTD (ALL) | Auckland | TAKA 12 | Ulhas Rao |

*Figure 1.8 Automated Daily Fault Report – Summary Report*

The information in the email provides awareness of the faults that have happened. Links to further details on each are provided from within the email.

# UNPLANNED HV EVENT DETAILS

| | | |
|---|---|---|
| **Event ID** | 188498 | Old EventNr: |
| **Date** | 02/04/2006 16:11 p.m. | |
| **Region** | Auckland | |
| **System Level** | Feeder | |
| **Substation** | Balmoral | |
| **Location Code** | BALM 1 | |
| **Location Name** | SPRINGWOOD PLACE VIA LOCAL | |
| **Main Reason** | ANIMAL | |
| **Sub Reason** | BIRD | |

## Operational Details

| | |
|---|---|
| **Contractor** | Energex |
| **Operations Engineer** | Russell Downey |
| **Field Person** | Joe Clarke |
| **Comments** | Bird strike caused 2 HV lines to break mid span. |
| **Service Request Nr** | 1-60609099 |
| **Defect Number** | |

## Location Details

| | |
|---|---|
| **Street Address** | MATIPO STREET |
| **Suburb** | MT EDEN SOUTH |
| **Closest Asset 1** | 21949 |
| **Closest Asset 2** | |

## Fault Trip Details

| | |
|---|---|
| **Fault Trips** | 1 |
| **Trip Device** | Scada CB |
| **Device Nr** | CB1 at BALM |
| **Protection Operation** | OK |
| **Function** | Over Current |
| **Protection Comments** | O/C & E/F |
| **FPI Operation** | Not Applicable |
| **FPI Comments** | |

| Performance Measure for Event | | | |
|---|---|---|---|
| **Customer Mins** | 73,654 | **Vector Saidi** | 0.1115 |
| **Customers Affec** | 913 | **Vector Saifi** | 0.0014 |
| **Max Time Off for some customers** | 139 | **Customers over Restoration SLA** | 0 |

| Outage Detail by Feeder | | | | | |
|---|---|---|---|---|---|
| **Feeder** | **Service Level** | **Total Cust Affec** | **Max Time Off for some customers** | **Customers over Restoration SLA** | **Caused by Adjacent Circuit** |
| BALM 1 | Residential | 913 | 139 | 0 | No |

| Outage Restoration Detail by Feeder | | | |
|---|---|---|---|
| **Feeder** | **Outage Time** | **Customers out at this time** | **Comments** |
| BALM 1 | 02/04/06 16:11 p.m. | 913 | Whole feeder. |
| | 02/04/06 16:53 p.m. | 364 | Rocklands Ave, Matipo St, Kensington Ave, Kingsford Rd. |
| | 02/04/06 18:30 p.m. | 0 | All on |

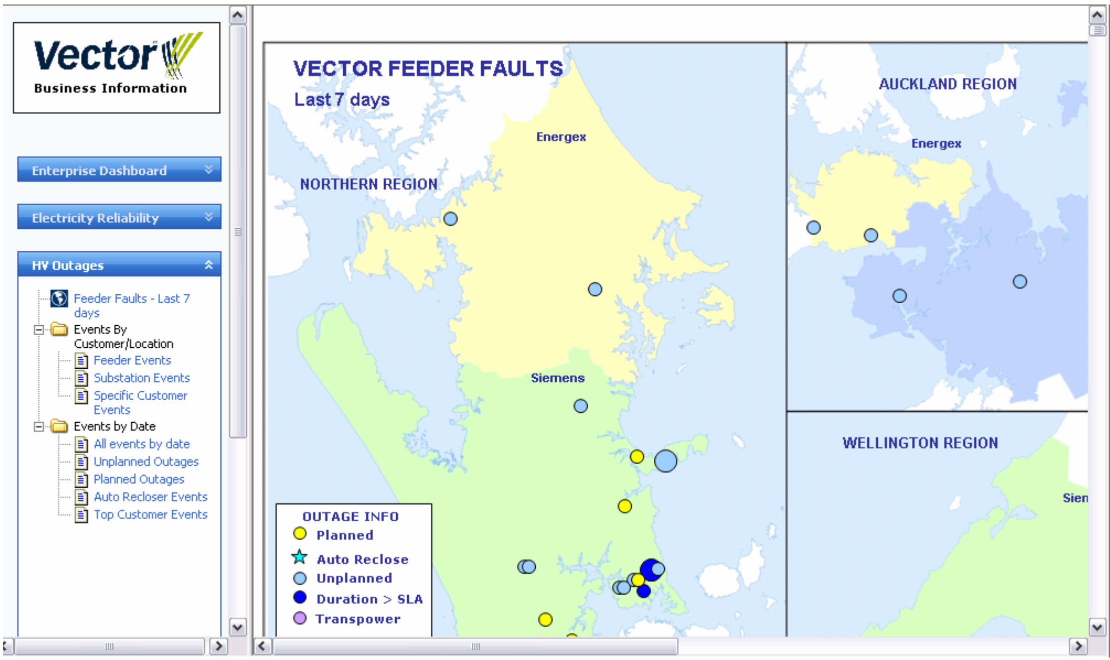
| Top Customers possibly affected | | |
|---|---|---|
| **Customer Name** | **KAM** | **Customer Contact** |
| THE WAREHOUSE LTD (BALMORAL) | Kay Trott | Wayne Inger |

*Figure 1.9 Automated Daily Fault Report – Summary Report for Specific Fault*

## ***HV Outages Reporting***

A range of reports has been developed to provide access to information to support decision making on network performance improvement initiatives.

The reports allow access to 7 years history of HV fault events, analysed in a variety of ways. The reports allow users to easily change parameters to meet their particular information requirements. Figure 1.10 illustrates how fault information may be represented graphically




**HV Events at - CARBINE**

From 28/04/2003 To 28/04/2006

Click on the blue hyperlinks to go into further detail regarding an individual outage.

| Feeder | Event Type | Event Reason Major | Cust Affec | Vector SAIDI | Event ID |
|---|---|---|---|---|---|
| ⊞ CARB 10 | | | 1 | 0.000 | |
| ⊞ CARB 11 | | | 100 | 0.001 | |
| ⊟ CARB 13 | | | 774 | 0.025 | |
| 07/07/04 | Planned | OTHER PLANNED | 8 | 0.002 | 184338 |
| 20/05/04 | Unplanned | THIRD PARTY INCIDENT | 187 | 0.014 | 183817 |
| 30/12/03 | Unplanned | EQUIPMENT - UG | 579 | 0.008 | 165146 |
| ⊞ CARB 14 | | | 6 | 0.000 | |
| ⊞ CARB 15 | | | 727 | 0.044 | |
| ⊞ CARB 17 | | | 184 | 0.005 | |
| ⊞ CARB 18 | | | 124 | 0.004 | |
| ⊞ CARB 19 | | | 334 | 0.025 | |
| ⊞ CARB 22 | | | 937 | 0.055 | |
| | | | **3,187** | **0.160** | |

*Figure 1.10 HV Outages Reporting*

## Reliability Reporting

In addition to information on individual events, overall monitoring against performance targets is also reported.

These reports track performance against a variety of measures including SAIDI, SAIFI, CAIDI and Service Level objectives. Figure 1.11 is an example of innovative ways of presenting reliability results

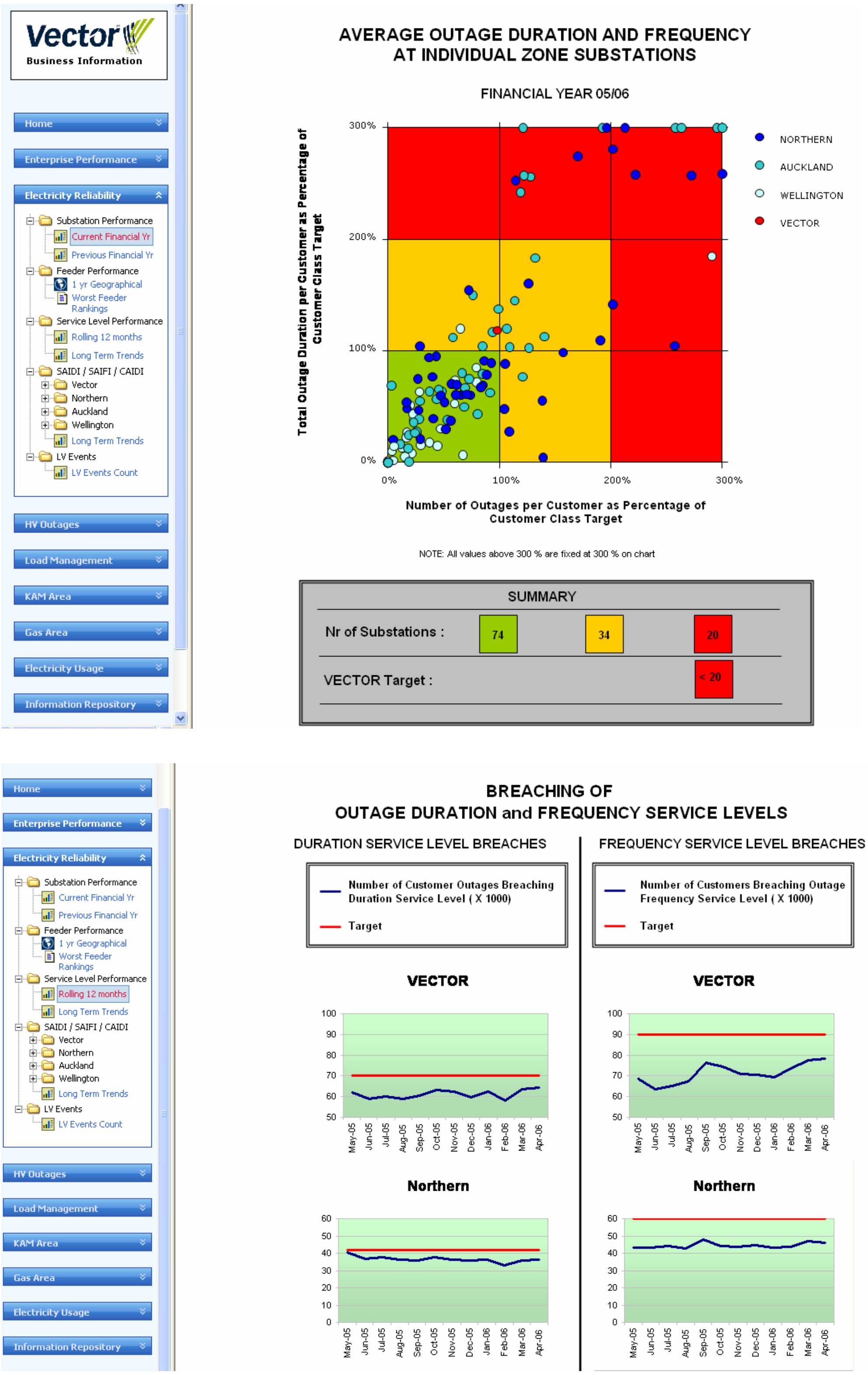



*Figure 1.11 Reliability Reporting*

## ***Focused Analytical Reports***

Interactive reports have been implemented which allow staff to discover underlying trends and patterns.

Figure 1.12 provides an example of how each feeder can be analysed across a variety of performance measures. The user is able to select a particular measure to sort by. Colour is used to indicate relative ranking for each measure.

**WORST 15 FEEDER RANKINGS**

**Based on performance for the year up to 28/04/2006**

RANKED BY SAIDI

| REGION | ZBC | SLA TYPE | SUBSTATION | FEEDER | SAIDI | SAIFI | CAIDI | Frequency SLA | Duration SLA |
|---|---|---|---|---|---|---|---|---|---|
| Northern | Siemens | RESIDENTIAL | Orewa | 26WAIW | 1 | 2 | 211 | 1 | 2 |
| Auckland | Northpower | RURAL | South Howick | SHOW 3 | 2 | 1 | 340 | 22 | 170 |
| Northern | Energex | RURAL | Warkworth | 38MATA | 3 | 4 | 241 | 147 | 269 |
| Northern | Siemens | RURAL | Helensville | 13KAUK | 4 | 24 | 109 | 159 | 3 |
| Northern | Siemens | RURAL | Swanson | 31BETH | 5 | 3 | 288 | 67 | 14 |
| Northern | Siemens | RURAL | Henderson Valley | 15PIHA | 6 | 9 | 202 | 186 | 32 |
| Auckland | Northpower | RESIDENTIAL | Mangere East | MEAS 17 | 7 | 5 | 293 | 15 | 534 |
| Auckland | Northpower | RESIDENTIAL | Manukau | MKAU 19 | 8 | 8 | 235 | 34 | 53 |
| Northern | Siemens | RURAL | Swanson | 31BIRD | 9 | 10 | 225 | 127 | 8 |
| Northern | Siemens | RESIDENTIAL | Northcote | 25HARB | 10 | 21 | 197 | 16 | 10 |
| Auckland | Northpower | RESIDENTIAL | Waiheke | WAIH 3 | 11 | 25 | 176 | 40 | 43 |
| Northern | Siemens | RURAL | Laingholm | 18MACK | 12 | 22 | 203 | 157 | 37 |
| Auckland | Northpower | RESIDENTIAL | Mangere East | MEAS 19 | 13 | 26 | 182 | 70 | 47 |
| Northern | Siemens | RURAL | Waimauku | 40MURI | 14 | 15 | 247 | 158 | 111 |
| Auckland | Northpower | RURAL | Otara | OTAR 16 | 15 | 12 | 286 | 71 | 125 |
| Northern | Siemens | RURAL | Helensville | 13SOUT | 16 | 14 | 253 | 116 | 29 |
| Auckland | Energex | INDUSTRIAL | Onehunga | ONEH 7 | 19 | 56 | 110 | 106 | 12 |
| Northern | Siemens | RURAL | Helensville | 13WAIT | 20 | 6 | 364 | 10 | 165 |
| Auckland | Northpower | RESIDENTIAL | Manurewa | MANU 8 | 23 | 44 | 164 | 46 | 15 |
| Auckland | Energex | RESIDENTIAL | Chevalier | CHEV 7 | 24 | 86 | 93 | 83 | 7 |
| Auckland | Northpower | INDUSTRIAL | Mcnab | MNAB 12 | 25 | 71 | 112 | 106 | 1 |
| Northern | Siemens | INDUSTRIAL | Henderson Valley | 15PARR | 29 | 33 | 246 | 3 | 11 |
| Wellington | Siemens | RESIDENTIAL | Ngauranga | NGA4 | 31 | 7 | 394 | 5 | 254 |
| Auckland | Northpower | RESIDENTIAL | Waiheke | WAIH 5 | 32 | 11 | 367 | 11 | 115 |
| Northern | Siemens | RESIDENTIAL | Keeling Road | 55UTIL | 34 | 57 | 156 | 30 | 4 |
| Auckland | Northpower | RESIDENTIAL | Mangere East | MEAS 12 | 38 | 76 | 136 | 13 | 45 |
| Northern | Siemens | RESIDENTIAL | Manly | 20ARMY | 39 | 13 | 371 | 17 | 93 |
| Auckland | Northpower | RESIDENTIAL | Waiheke | WAIH 6 | 45 | 40 | 262 | 4 | 128 |
| Auckland | Energex | RESIDENTIAL | Chevalier | CHEV 5 | 49 | 173 | 59 | 131 | 5 |
| Northern | Siemens | RESIDENTIAL | Orewa | 26MAIR | 53 | 174 | 68 | 173 | 6 |
| Northern | Siemens | RESIDENTIAL | Northcote | 25EXMO | 55 | 134 | 98 | 87 | 13 |
| Auckland | Northpower | INDUSTRIAL | Wiri | WIRI 2 | 97 | 222 | 81 | 12 | 23 |

*Figure 1.12 Focused Analytical Reports*

The visualisation in Figure 1.13 was developed to assist with understanding of the relationship between wind speed and fault frequency.

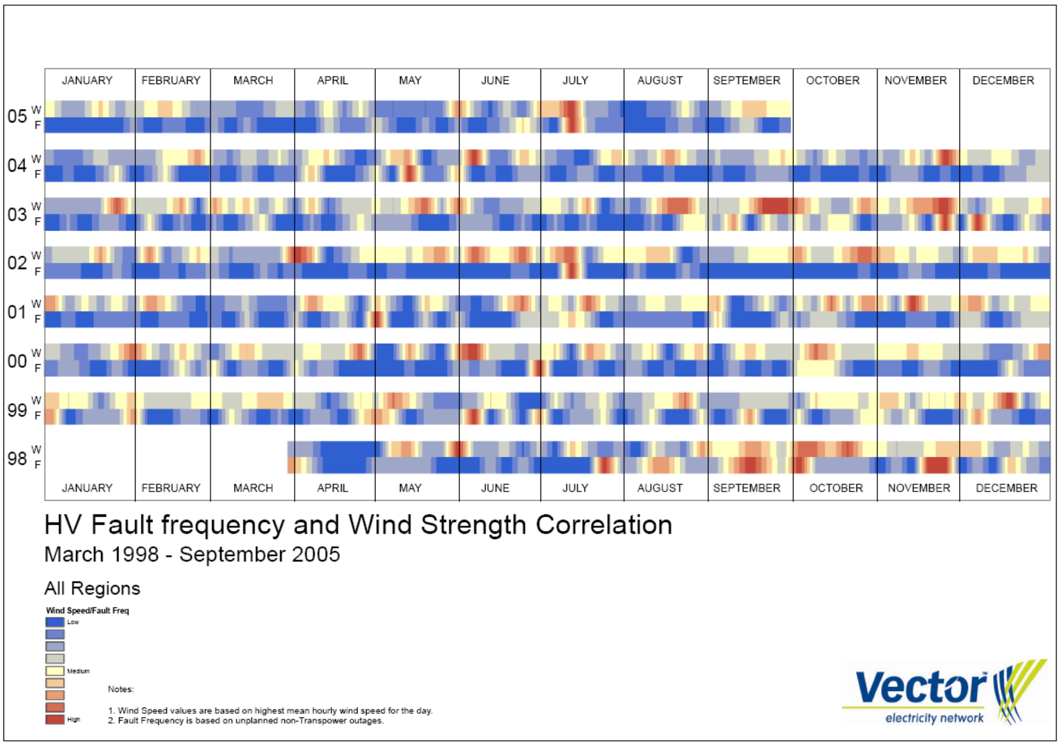



*Figure 1.13 Focused Analytical Reports*

## ***GIS Maps***

A large number of sophisticated maps are produced to assist with asset management decision making.

Below, a series of grids was overlaid on the network at a set scale and all defective assets were weighted and summed within each grid. Clustered blocks with the highest defect weightings were chosen as priority areas for maintenance.

The analysis in Figure 1.14 was carried out to assist with understanding the relationship between of customer satisfaction and network reliability.

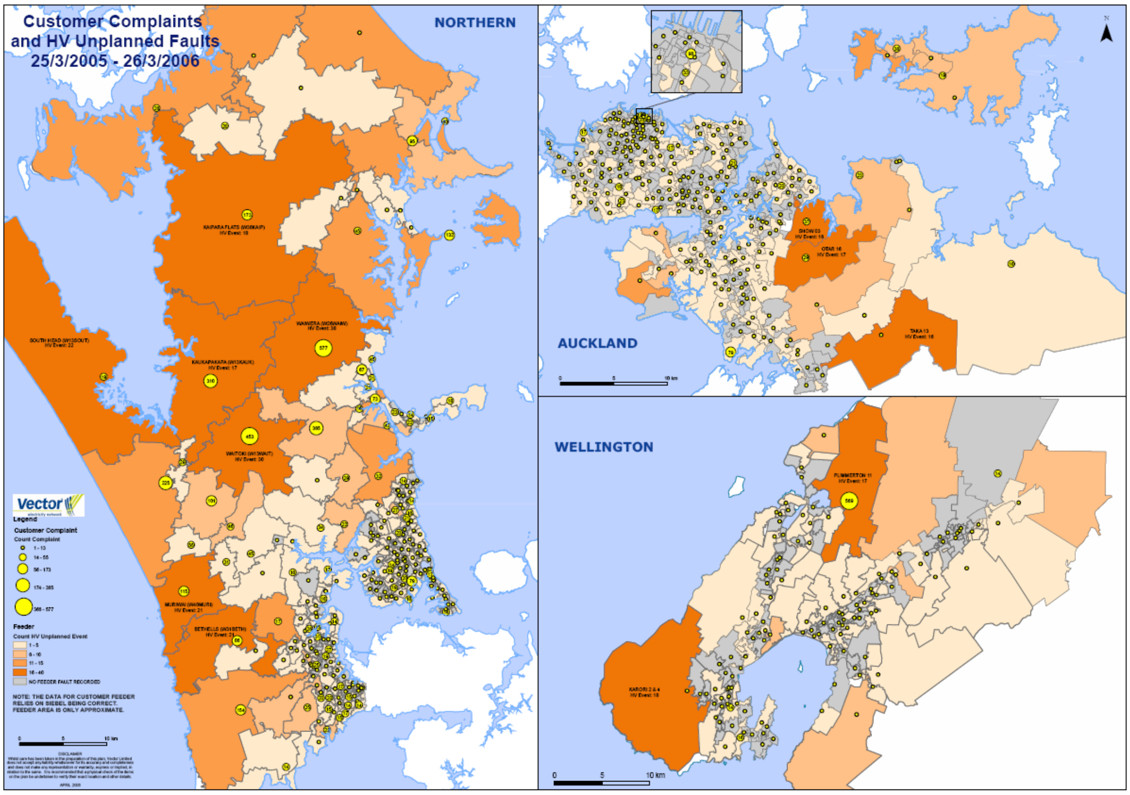



*Figure 1.14 Focused Analytical Reports*

The analysis in Figure 1.15 was undertaken to assist the Auckland Regional Council meet their tree trimming obligations on their land. A similar analysis was undertaken for Wellington City Council.

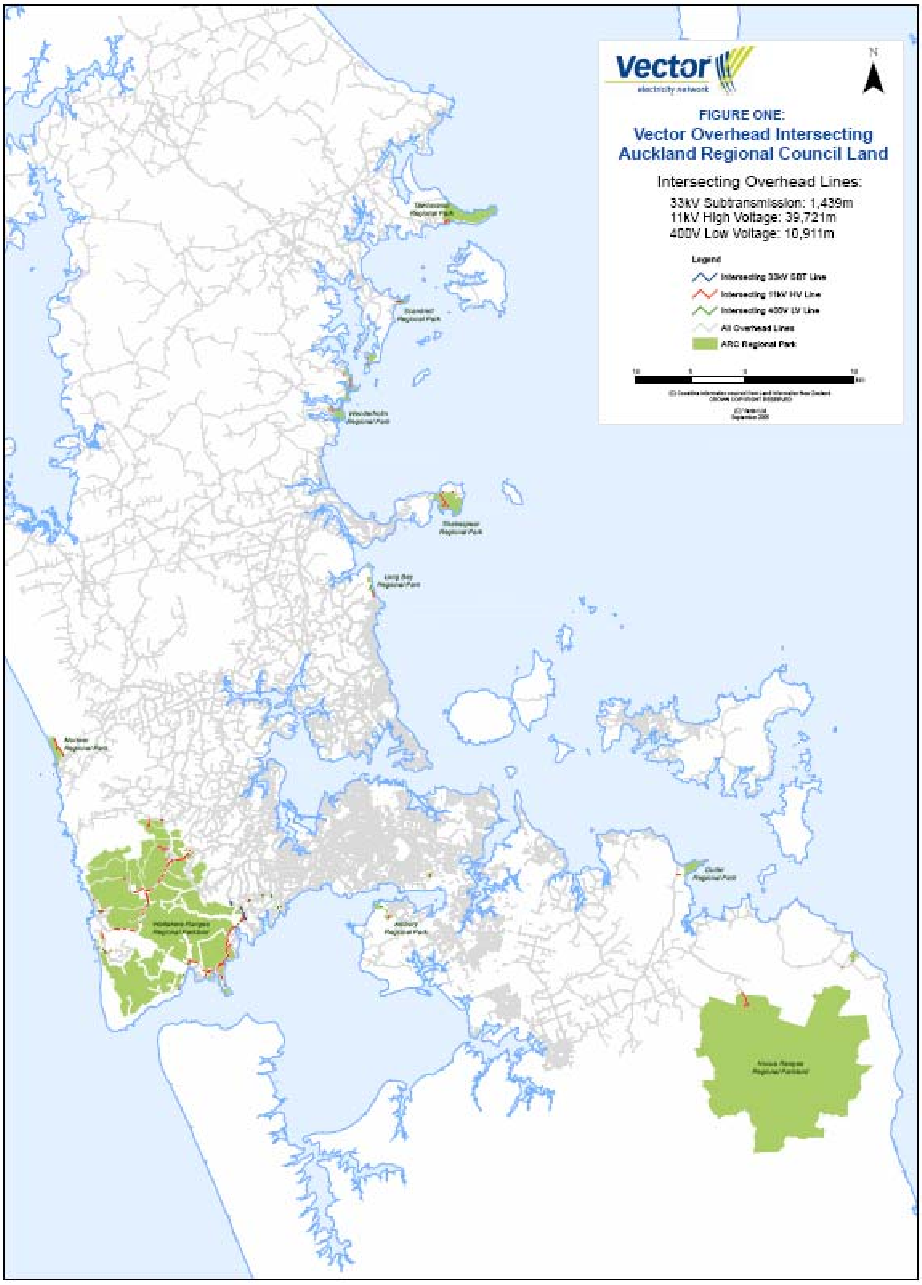



*Figure 1.15     GIS Maps*

# 2. NETWORK ASSETS

## 2.1. NETWORK OVERVIEW

The overall architecture of the network is shown in Figure 2.1.

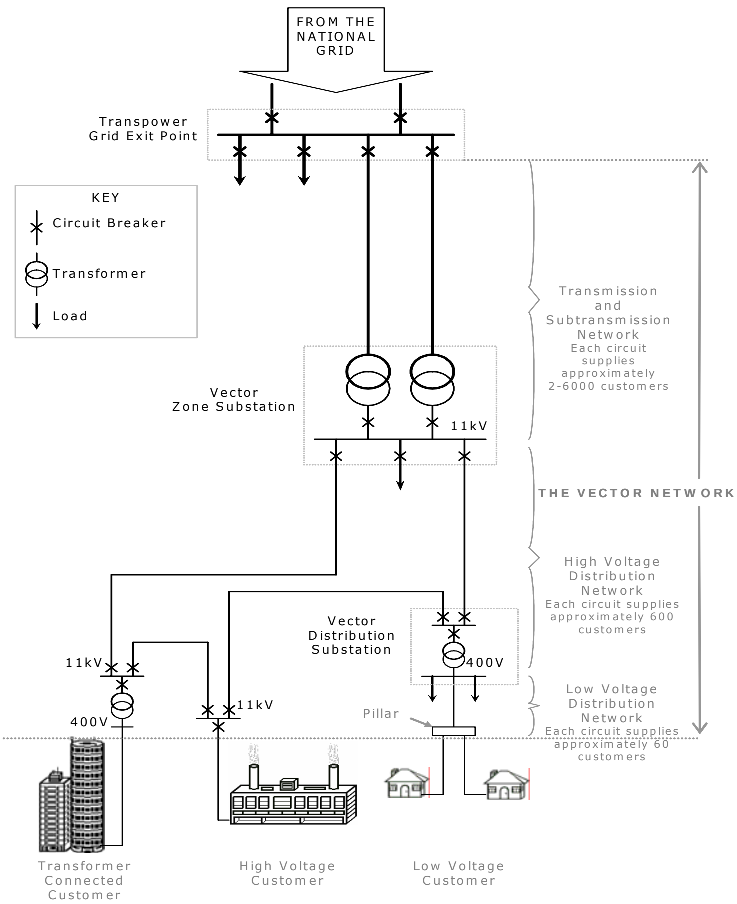



*Figure 2.1 Schematic of Vector's Network*

The network is made up of three component networks – transmission, sub-transmission and distribution. The 110kV transmission network connects the Transpower network to the Vector's bulk supply substations for Vector supply, but also supports security on the Transpower transmission system.

The sub-transmission network connects the Transpower network at the grid exit points to zone substations, at 33kV or 22kV. Each substation serves a particular geographic area, with known asset and customer characteristics.

At the zone substations the voltages are further stepped down to 11kV or 6.6kV. The distribution network then carries the electricity to distribution transformers, or for some commercial customer's, directly to their premises. At the distribution transformers, electricity is stepped down to 400/230V for final delivery to customers.

In 2003, a decision was made to develop a 22kV distribution network in the Auckland CBD to replace the existing 11kV distribution network. The first phase of the programme to establish a 22kV distribution backbone network is completed. Plans are in hand to transfer load from the existing 11kV network onto the newly established 22kV network.

## 2.2. TRANSMISSION AND SUBTRANSMISSION NETWORK

The higher voltage transmission and sub-transmission network is designed to transfer large amounts of electricity efficiently. The network transfers electricity from Transpower's network via 22 grid exit points (GXPs), to 123 zone substations.

The grid exit points, their installed capacity and the 2005 peak demand are listed in Table 2.1.

| Network | Grid Exit Point | Installed Capacity (MVA) | Firm Capacity (MVA) | 2005 Peak Demand (MVA) |
|---|---|---|---|---|
| | | | | |
| **Auckland** | Mangere 110kV | | | 140 |
| | Mangere 33kV | 2*120 | 108 | 91 |
| | Otahuhu 22kV | 2*50 | 60 | 51 |
| | Pakuranga 33kV | 2*120 | 136 | 118 |
| | Penrose 110kV | | | 71 |
| | Penrose 33kV[1] | 2*160, 1*200 | 427 | 337 |
| | Penrose 22kV | 3*45 | 90 | 66 |
| | Roskill 110kV | | | 166 |
| | Roskill 22kV | 2*70, 1*50 | 141 | 100 |
| | Takanini 33kV | 2*150 | 123 | 102 |
| | Wiri 33kV | 1*100, 1*50 | 107 | 73 |
| | | | | |
| **Northern** | Albany 110kV | | | 174 |
| | Albany 33kV | 2*120 | 125 | 121 |
| | Henderson 33kV | 2*120 | 135 | 93 |
| | Hepburn 33kV | 1*85, 1*100 | 133 | 132 |
| | Silverdale 33kV | 1*100 | | 62 |
| | Wellsford 33kV | 2*30 | 31 | 29 |
| | | | | |
| **Wellington** | Central Park 33kV | 2*100, 1*120 | 228 | 126 |
| | Gracefield 33kV | 2*100 | 89 | 56 |
| | Haywards 33kV | 1*27.5 | | 12 |
| | Melling 33kV | 2*50 | 52 | 40 |
| | Pauatahanui 33kV | 2*20 | 24 | 18 |
| | Takapu Rd 33kV | 2*100 | 123 | 78 |
| | Upper Hutt 33kV | 2*40 | 37 | 30 |
| | Wilton 33kV | 2*100 | 106 | 72 |
| | Kaiwharawhara 11kV | 2*40 | 41 | 36 |
| | Haywards 11kV | 1*20 | | 16 |
| | Melling 11kV | 2*25 | 27 | 20 |
| | Central Park 11kV[2] | 2*25 | 36 | 17 |
| | | | | |
| **Lichfield** | Lichfield | | | 9 |

*Table 2.1 Transpower GXPs*

[1] includes 22kV load

[2] 2*25MVA 33/11kV transformers commissioned after winter peak 2005 (replacing 2*30MVA 110/11kV units)

A zone substation typically supplies between 2,000 and 6,000 customers. The subtransmission network consists of a combination of overhead lines and underground cables.

At the zone substations, the subtransmission voltages are stepped down to 11kV (or 6.6kV) to supply the distribution network. The zone substations are all remotely controlled via the SCADA system, which allows remote operation to be carried out from the Control Room and returns load and equipment operation information.

## 2.3. TRANSMISSION AND SUBTRANSMISSION DESIGN

The transmission network has been developed essentially as a radial network.

The sub-transmission networks in Auckland and Wellington have been designed as radial feeders, with one, two or three transformers at each zone substation. There are no ties between zone substations at sub-transmission level (other than in the CBD). The sub-transmission network in the Northern region is a combination of radial feeders and meshed networks.

The future development of the sub-transmission system will be driven by the reliability, design standards and customer service levels.

***Auckland Network***

Generally the load on a zone substation should not exceed 30MVA in the Auckland network, in order to keep the number and size of 11kV feeders within practical bounds. In some cases where the load is relatively concentrated, the design maximum load can rise to 50MVA (e.g., in the CBD, where land for new zone substations is expensive and difficult to obtain, or in heavily industrial areas).

If there is to be no loss of supply for a single sub-transmission circuit fault, the allowable load on the station is limited to the sum of the short-term ratings of the remaining healthy circuits.

Vector’s design philosophy permits the station load to be increased beyond this limit by accepting a small probability that in the event of a fault, load will have to be shed immediately while load transfers are carried out, with the proviso that all supply is restored within three hours. For the sub-transmission security targets see Section 3.

***Wellington Network***

In the case of Wellington, each zone substation has dual transformers feeders at subtransmission level, allowing an n-1 security standard to be achieved. The size of transformers in Wellington varies between 10MVA to 30MVA depending on the load density of the area the zone substation supplies. The design for zone substations in the Hutt and Porirua areas are similar to that for Wellington, i.e., to maintain a single contingency security.

The Wellington CBD operates a closed ring 11kV network offering high security. Outside this area the network is operated as open radial 11kV feeders which are generally supported by strong interties between feeders. Rural feeders and those on the extremities of the network (e.g. new subdivisions) are the only 11kV feeders that cannot be interconnected with n-1 security

It should also be noted that due to fault level constraints, the transformers at eleven of the Wellington network zone substations can not be operated in parallel.

***Northern Network***

The sub-transmission network in the Northern Region is generally configured in a mesh formation. Security of the network is dependent on the power flow in the network under different contingency conditions. Except for the rural zone substations, a well interconnected 11kV network helps to provide mutual backup for zone substations. The load forecasts in Section 4 indicate a number of zone substations operating close to their load limit. An outage of one transformer would, in theory, overload the second transformer were it not for the ability to transfer load onto adjacent substations via the 11kV network. The transformers at six of the Northern network substations can not be operated in parallel due to fault level constraints.

## 2.4. DISTRIBUTION NETWORK

The function of the distribution network is to deliver electricity from the zone substations to customers. It includes a system of cables and overhead lines operating mainly at 11kV, with some 6.6kV, which distribute electricity from the zone substations to distribution substations. Typically 600 customers are supplied at the high voltage distribution level.

At the distribution substations, the electricity is stepped down to 400V and delivered to customers either directly, or through a reticulation network of overhead lines and cables. Approximately 30 to 150 customers are supplied from each distribution substation, via the low voltage distribution network.

For larger loads, electricity can also be delivered at 6.6kV, 11kV or (for very large loads) 33kV. Four main categories of customer connection are available and the final network connection type is determined through consultation with the customer. The connection types are:

- Single phase low voltage:
    - o Typical of low capacity customers such as residential or small commercial. Supplied generally from a shared distribution substations

- Three phase low voltage
    - o Typical of large residential, commercial or small industrial. Supplied generally from a shared distribution substation

- Transformer connection
    - o Typically a large commercial or industrial customer. Load is sufficient to warrant a dedicated transformer but supply is provided at 400V

- High voltage connection
    - o Generally associated with larger industrial customers or customers with a number of distributed transformers on their premises. The electricity is supplied at a high voltage e.g. 33kV or 11kV

## 2.5. DISTRIBUTION DESIGN

The distribution system in Auckland, Northern and Wellington areas (with the exception of the CBD) consists of interconnected radial circuits originating from zone substations. The design is based on the concept of availability of feeder backstopping capacity, according to the security standards.

A distribution feeder fault may result in an outage, but in urban substations supply should largely be able to be restored within two to three hours by switching operations on the distribution network. This system provides a very reliable means of electricity supply.

In the case of Wellington CBD, the backbone 11kV network is constructed in the form of closed rings fitted with unit protection. In this type of network, no supply loss will be experienced by customers under single contingency situations. From the backbone closed ring networks, radial feeders have also been developed to supply the marginal demand. These radial feeders are interconnected to allow backup under emergency conditions.

The distribution circuits are controlled by automatic circuit breakers at the zone substations. Switches are installed at strategic locations on the circuits to provide operational flexibility. A key focus is on automation of these switches in the network where applicable to improve service levels. For details, see Section 7.2.2. For the distribution security targets see Section 3.

There are a number of large customers in the Auckland network connected to the network at high voltage. The ownership of the substations serving these customer's varies from site to site, but generally Vector owns the incoming switchgear and any protection equipment associated with it.

The customer usually owns the transformer(s), any outgoing switchgear and associated protection, and the building. Similar arrangements exist on the Northern areas. With the exception of three customers', Vector owns all the distribution transformers in Wellington.

## 2.6. SCADA

The role of SCADA systems is being extended from a network management tool to a knowledge management tool that serves a wider range of users.

Vector's SCADA system consists of a number of SCADA subsystems. These subsystems have been installed over time and some of them are based on technology that has become obsolete or does not integrate well with the other business applications. These subsystems are progressively being replaced.

An integration and replacement strategy for the SCADA system components is described below:

### 2.6.1. INTEGRATION STRATEGY

The integration strategy enables Vector to implement technologies across the whole network, using standard communication protocols with the ability to easily migrate to a future overall SCADA system.

### 2.6.2. SCADA MASTER STATIONS

A Siemens Telegyr (PowerTG) master station has recently been deployed for monitoring and control of the Auckland electricity network. This system is currently undergoing a software and hardware upgrade (more powerful processors and improved testing and staging).

A LN2068 SCADA master station, from Leads and Northrop, with Foxboro workstations is used on the Northern and Wellington electricity networks.

### 2.6.3. REMOTE TERMINAL UNITS (RTU)

A number of different RTUs have been installed in Vector's network.

A large proportion of the RTU's have reached the end of their technical life and become obsolete. Vector has embarked on a planned replacement programme of the RTUs. The implemented SCADA integration strategy enables Vector to deploy a standard RTU as the replacement across the whole network.

#### 2.6.4. COMMUNICATION PROTOCOLS

A variety of SCADA communication protocols are presently used to communicate between the various SCADA systems and different type of Intelligent Electronic Devices (IEDs) installed in the network.

Adoption of an industry standard communication protocols benefits Vector in reduced purchasing, implementation and maintenance costs.

## 2.7. COMMUNICATION SYSTEM

Vector's communications network consists of different architectures and technologies of which some are based on proprietary solutions. The physical network infrastructure consists of optical fibre, copper wire telephone type pilot cables and third party radio communication systems.

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

Vector is committed to an open communication architecture and to industry standards. This has resulted in the adoption and deployment of Ethernet and Internet Protocol base communication technology.

IP based technology is cost effective and offers future proofing against early obsolescence for communication within and outside electricity substations.

## 2.8. POWER SYSTEM PROTECTION

The main role of protection relays is to detect network faults by monitoring various parameters and initiating the opening of relevant circuit breakers should an abnormal situation be observed. This minimises damage to the equipment, hazards to people 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
Cost: maximum protection at lowest cost

All new and refurbished substations are equipped with multifunctional Intelligent Electronic Devices (IED's). 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 Internet Protocol (IP) based communication network using the industry standard communication protocols.

## 2.9. ENERGY AND PQ METERING

Vector's supply point energy and power quality metering system consists of a number of intelligent web-enabled revenue class energy and power quality meters. The meters communicate to the metering central software over an Ethernet based IP routed communication network.

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

- Improve operational efficiency by controlling peak demands at the bulk supply points, which ultimately reflects in reduced line charges to Vector's customers
- Provide comprehensive power quality and reliability information that will enable the verification of the quality of power delivered to our customer's against the published Vector service levels, and faster resolutions of power quality issues
- Increase the power system stability by initiating instantaneous load shedding during under frequency events.

## 2.10. LOAD CONTROL SYSTEM

Vector's load control system consists of a number of audio control frequency ripple control plants, pilot wire and DC bias systems, as well as a small number of CylcoControl plants. These assets together with Vector's metering system offer the ability to:

- Control residential hot water cylinders and space heating (load shedding)
- Control street lighting
- Meter switch for tariff control

Vector is investigating the feasibility of lowering the existing audio control frequencies in areas where absorption of existing control frequency signals is excessive.

Different technologies are also being investigated for load management functions. The outcome of the evaluation will determine the future load control system to be developed.

## 2.11. IMPROVEMENTS TO NETWORK DESIGN

The current network design is periodically reviewed to ensure it is aligned with feedback from customers. This feedback is captured in Vector's service level standards and implemented across all three networks.

This approach allows an optimised network architecture based on customer needs, return on investment, reliability and risk. Network simulation software is one tool that can be used to select the optimum solution.

Performance parameters will be established to measure the success of any project and Vector will continuously strive to improve performance through feedback and optimisation. Technological developments and innovation in areas such as distribution network automation and distributed generation technology will be considered in the process.

# 3. ■ SERVICE STANDARDS

Service for Vector means understanding what our customers' value, and delivering to those requirements within the limitations of budgetary constraints. Essential asset management objectives are to provide a safe, environmentally responsible, high quality, reliable supply of electricity, in compliance with all statutory and regulatory requirements to meet the changing needs of stakeholders.

The Commerce Commission's regulatory price-quality regime for electricity lines businesses is a major influence when considering these objectives. The stipulation of price and quality thresholds is an indirect control mechanism. Therefore investment and service standard decisions must be considered in the context of compliance with the thresholds.

Vector regularly engages its customers in all network areas to obtain feedback on what is important to them and how we can improve service. Our research has shown a diverse range of customer expectations across each network; however it continues to highlight reliability and quality of supply as priority values.

The following sections relating asset management objectives to service standards are as follows;

- Reliability.
- Standard Service Levels.
- Security
- Quality.

## 3.1. RELIABILITY

Service reliability from the perspective of "keeping the lights on", is the outcome of how often electricity supply gets interrupted, and how long it takes to restore supply once interrupted. The key performance measures used to target, monitor, report and analyse network reliability are SAIDI and SAIFI.

SAIDI short for System Average Interruption Duration Index measures the average minutes without supply, prescribed as follows:

$$\text{SAIDI} = \frac{\text{Sum of the customer minutes lost}}{\text{Total number of customers}}$$

SAIFI short for System Average Interruption Frequency Index measures the average number of supply interruptions, prescribed as follows:

$$\text{SAIFI} = \frac{\text{Sum of the number of customers interrupted}}{\text{Total number of customers}}$$

SAIDI and SAIFI as stated above are high level network performance output measures. Standard service levels, which are discussed greater detail in the following section, are customer performance output measures.

**Reliability Targets**

Vector has aligned its SAIDI and SAIFI targets to match those introduced by the regulatory price-quality regime, and customer expectations expressing general comfort with the level of service being provided and an understanding of price-quality ramifications.

The threshold targets are defined below. They are set in place until 1 April 2009, and are expected to be achieved with the exception of extreme weather events.

The reliability thresholds were defined in the Commerce Act Electricity Distribution Thresholds Notice 2004, clause 6, which came into force on the 1 April 2004.

The SAIDI and SAIFI Threshold targets apply to Vector as follows:

a) Interruption Duration

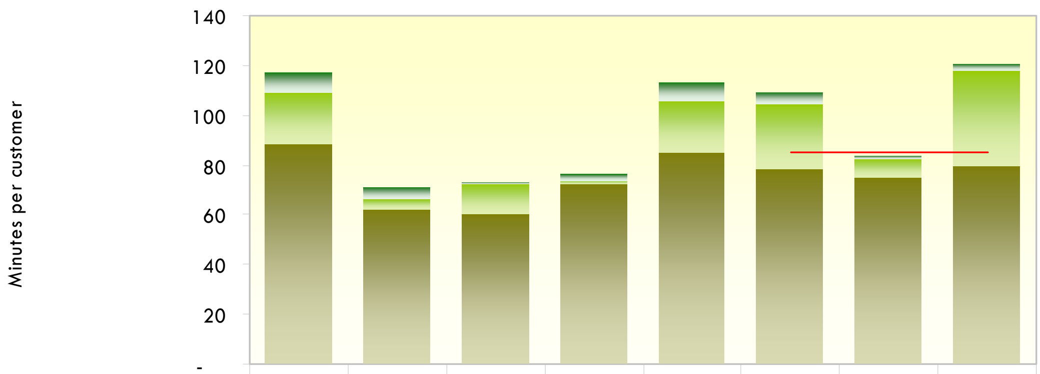
$$SAIDI_{Threshold} \le \left( \frac{SAIDI_{98/99} + SAIDI_{99/00} + SAIDI_{00/01} + SAIDI_{01/02} + SAIDI_{02/03}}{5} \right) \le 85 \text{mins}$$

b) Interruption Frequency

$$SAIFI_{Threshold} \le \left( \frac{SAIFI_{98/99} + SAIFI_{99/00} + SAIFI_{00/01} + SAIFI_{01/02} + SAIFI0_{02/03}}{5} \right) \le 1.31 \text{ints}$$

## Reliability Results

As an electricity distribution business, Vector has a duty to demonstrate that no material deterioration in annual SAIDI or SAIFI has occurred, compared against the respective threshold measures. Annual SAIDI performance for the last eight disclosure years is presented in Figure 3.1. The SAIDI presented does include the impact of Transpower outages to better represent the customer's' experience, along with the impact of extreme weather events.




| | 98/99 | 99/00 | 00/01 | 01/02 | 02/03 | 03/04 | 04/05 | 05/06 |
|---|---|---|---|---|---|---|---|---|
| Transpower | 8 | 5 | 1 | 3 | 8 | 5 | 1 | 3 |
| Extreme Weather | 21 | 4 | 12 | 1 | 21 | 26 | 7 | 38 |
| Vector | 89 | 63 | 60 | 73 | 85 | 78 | 75 | 80 |
| Target Threshold | | | | | | 85 | 85 | 85 |

*Figure 3.1 SAIDI Actuals (including Transpower outages)*

Due to the impact of extreme weather events, Vector's most recent year end 05/06 SAIDI performance finished at an overall 118 minutes. The regulatory assessment SAIDI threshold of 85 minutes has been exceeded. However, excluding extreme weather events the normalised year end result would be 80 minutes, which is below the assessment threshold value of 85 minutes.

In explanation to the Commerce Commission, Vector has identified the following extreme weather events considered to be outside of Vector's reasonable control, affecting the Auckland Area on the 18th September 2005, 8th October 2005, 26th November 2005 and the 24th January 2006. For the Northern Area, the 12th July 2005, 18th and 19th September 2005, 8th October 2005, 26th November 2005, 24 January 2006 and the 26th March 2006. For the Wellington Area, the 2nd and 4th of January 2006.

In order to define "extreme weather events", Vector employs a methodology which combines meteorological data (peak average wind speed >50kph), with excessive HV fault frequency (8-times or greater than the daily average)[3], to identify extreme

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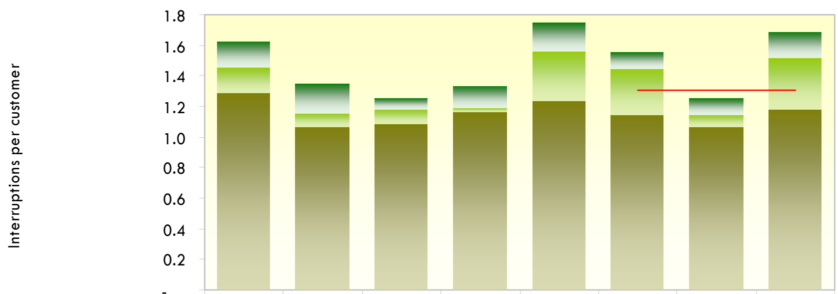
[3] OFGEM, the UK regulator, defines a Category 1 (medium event) as "Non-lightning events ≥8 and <13 times daily mean faults at higher voltage and <35% of exposed customers affected"

event days. The extreme event days are then examined by each event causal factor to define a list of exclusion events outside reasonable control. The occurrence of extreme weather events such as lightning strikes, storms/cyclones, and flooding has a major impact on SAIDI performance. In the case of Vector's (overhead) networks it is the high wind/heavy rain events that have the most impact.

The rationale for the number of interruptions as the trigger rather than SAIDI is that the sheer volume of faults causes response times to extend beyond typical repair times. Available field resources are unable to clear the faults faster than they are being reported. Restoration times lengthen, compounded by the difficulty in reaching some fault locations, and delays in repair work caused by unsafe working conditions. Invariably during storm conditions, the contractor can only focus on ensuring the network is safe for the public (e.g. no live conductors on the ground) and it is only post storm that restoration work can commence in earnest.

SAIDI is driven by a combination of factors: the number of faults on the network, the number of customers affected by each fault, and the time taken to restore supply either by switching affected customers to an alternate supply after an interruption, or by repairing the fault. These in turn are affected by the network design and construction standards, equipment standards, management and performance of field staff, vegetation management, and condition of the network assets, in conjunction with external environmental factors (of which a number are outside the control of Vector, such as 3rd party damage and extreme weather).

Annual SAIFI performance is presented on the same basis in Figure 3.2. Vector's most recent year 05/06 SAIFI performance finished at an overall 1.52 interruptions. Again, due to the impact of extreme weather events, the year end result has exceeded the assessment SAIFI threshold of 1.31 interruptions.




| | 98/99 | 99/00 | 00/01 | 01/02 | 02/03 | 03/04 | 04/05 | 05/06 |
|---|---|---|---|---|---|---|---|---|
| Transpower | 0.16 | 0.19 | 0.07 | 0.14 | 0.18 | 0.11 | 0.11 | 0.17 |
| Extreme Weather | 0.17 | 0.09 | 0.09 | 0.02 | 0.33 | 0.30 | 0.08 | 0.33 |
| Vector | 1.29 | 1.07 | 1.09 | 1.16 | 1.23 | 1.15 | 1.07 | 1.19 |
| Target Threshold | | | | | | 1.31 | 1.31 | 1.31 |

*Figure 3.2 SAIFI Actuals (including Transpower outages)*

Excluding the impact of extreme weather events from the 05/06 SAIFI performance figures, the year end result would be 1.19 interruptions, below the assessment threshold value of 1.31 interruptions.

As highlighted in Figure 3.3, weather (39%) has the most significant impact on network performance, followed by equipment failures (33%), third party incidents, (15%), and vegetation, (9%).

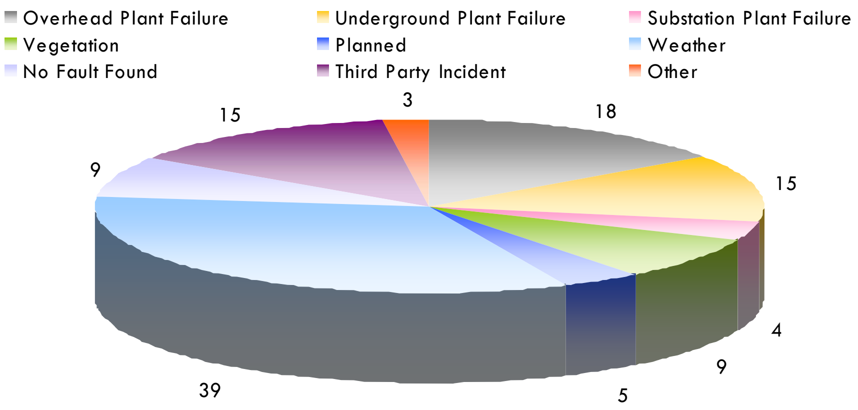



*Figure 3.3 Breakdown of 05/06 Incident Cause (by SAIDI minutes)*

While extreme weather is beyond Vector's reasonable control, cost effective initiatives to improve SAIDI and SAIFI will continue to focus on:

- Reducing the number of unplanned events - Enhancement of procurement, installation, operation, maintenance and replacement techniques and practices to improve plant reliability and minimise external causal factors e.g. vegetation and third party incidents.
- Reducing the number of customers exposed to an unplanned event - At the distribution level continue installing additional protection devices, such as fusing, circuit breakers, autoreclosers, and additional feeders. Major initiatives commenced during the 05/06 year include the planning and installation of 80 autoreclosers throughout the network. At sub-transmission level security enhancements such as additional zone substations, and additional supply redundancy, can make a significant difference.
- Reducing the time customers are exposed to an unplanned event - Further improvements can be achieved through network automation, sectionalisers, fault indicators, additional response staff, and repair practices, such as temporary by-pass or alternative local generation. Significant projects proposed or completed during the 05/06 year were the installation of 45 sectionalisers, 100 network automated switches and the addition of 500 fault indicators to aid in front line fault response.

## 3.2. STANDARD SERVICE LEVELS

Our research shows a diverse range of customer expectations across each network, especially the impact and importance of reliability in terms of outage frequency and associated duration. To deliver against these diverse requirements Vector has aligned and translated the overall network reliability targets into standard service levels.

The standard service levels are based on two criteria, the time taken to restore power and the number of interruptions that may be experienced. As presented in Table 3.1 the standard service levels consider the network area, the customer type and service area. The standard service levels are indicative of what customer's can expect for the price they pay. Customer's are able to contract for higher levels of reliability and quality where required.

| VECTOR STANDARD SERVICE LEVELS | | | | |
|---|---|---|---|---|
| Network Area | Consumer Type | Service Area | Fault restoration time (hours) | Potential number of outages per year |
| Auckland | Commercial & Industrial | CBD | 0-2 | 0-3 |
| | | Industrial | 0-2 | 0-4 |
| | | Urban | 0-2.5 | 0-4 |
| | | Rural | 0-3 | 0-14 |
| | Business | Urban | 0-2.5 | 0-4 |
| | | Rural | 0-3 | 0-14 |
| | Residential | Urban | 0-2.5 | 0-4 |
| | | Rural | 0-3 | 0-14 |
| Wellington and Northern | Commercial & Industrial | CBD | 0-3 | - |
| | | Industrial | 0-3 | - |
| | | Urban | 0-3 | - |
| | | Rural | 0-6 | - |
| | Business | Urban | 0-3 | - |
| | | Rural | 0-6 | - |
| | Residential | Urban | 0-3 | - |
| | | Rural | 0-6 | - |

*Table 3.1 Standard Service Levels: Reliability*

The difference in service levels between Auckland and Wellington/Northern are due to legacy clauses contained within the respective Use of Network Agreements with Retailers.

For network and asset management purposes, overall network reliability is translated into SAIDI, SAIFI and CAIDI targets for the following:

- Zonal Performance
- Feeder Performance
- Standard Service Level Performance.

The SAIFI, fault frequency results are reviewed to understand if there is a particular asset or group of assets causing high fault frequencies, or a particular fault cause in an area. The results of the analysis can then be used to initiate revised preventative maintenance, asset refurbishment or replacement programmes, or other solutions if the fault cause is external, such as car versus pole or directional drilling.

The CAIDI fault duration results are reviewed to understand what is causing the high duration outages and what the potential solutions could be. The solutions could range from restructuring of the fault crew response, automation, or installation of fault passage indicators, to assist efficient fault location.

Internal reporting monitors service levels against targets to ensure that effort is directed to proactively highlight poorly performing areas and specific corrective actions taken to enhance reliability.

Our service providers are incentivised under the performance nature of the contract to manage the operation and maintenance of the network to achieve the network reliability targets and standard service levels.

The annual maintenance plans are developed as a result of the review and analysis of SAIFI and CAIDI performance, and the optimum management plan to achieve the standard service level for that network is established.

## 3.3. SYSTEM DESIGN SECURITY

### 3.3.1. NETWORK SECURITY

Vector's approach to asset management and network planning has historically been driven by the following principles:

- Investment strategies and service offering improved value to customer's and improved return to shareholders
- Customer needs, which vary by customer segment and are reflected by service level standards, are trending towards higher reliability and improved power quality

- Capacity and network reinforcements are investments and Vector strives for least cost solutions (optimum asset utilisation) and the deferring of capital expenditure

- Risk management strategies are aligned with the planning philosophy

- Continuously strive for innovation and optimisation in network design and introducing leading edge technology like sophisticated scheduling and remote switching technology to improve utilisation

- Encourage non network and demand side solutions where practical

In support of these principles, Vector is progressively moving away from a deterministic (n-1) planning approach to a probabilistic approach, which recognises that our product has variable reliability and quality and that the customer's' needs and business strategy should drive investment in the network.

The success of reliability based planning depends on the data and model used. Vector has selected DigSilent Power Factory as the analysis tool for this purpose. A combination of industry long-term averages and Vector data are used in this model. The short-term goals for this model are:

- Comparing the network reliability with customer specified reliability requirements and costs

- Overlaying recorded service level standards indices with predicted values and identify areas to focus on to get the maximum improvement

- Refining service level standards to determine service levels that are consistent with the network

- Improving asset utilisation and determining the optimum capital expenditure and network reinforcement window

- Demonstrating the relative improvement in reliability for different planning options

The long-term goals include assessment of the impact of ageing assets on the performance of the network. The reliability targets in Table 3.1 will continue to apply until the reliability based planning model is able to provide more customer and network specific service levels.

The security criteria for the subtransmission network and the distribution network is described in Tables 3-2 and 3-3.

### 3.3.2. NETWORK TRANSMISSION, SUBTRANSMISSION AND DISTRIBUTION RELIABILITY

| | Type of load | Security Criteria<br>Single contingency only[4] |
|---|---|---|
| 1 | Predominantly residential substations | Full backup available at all times. No interruption of supply for 95% of the time in a year. For Auckland, any supply loss will be restored within 2.5 hrs in urban areas and 3 hours in rural areas. For Northern and Wellington, any supply loss will be restored within 3 hours in urban areas and 6 hours in rural areas. |
| 2 | Mixed commercial / industrial / residential substations | Full backup available at all times. No interruption of supply for 98% of the time in a year. For Auckland, any supply loss will be restored within 2 hrs. For Northern and Wellington, any supply loss will be restored within 3 hours. |
| 3 | CBD or predominantly industrial | Full backup available at all times. No interruption of supply[5] for 99.5% of the time in a year. For Auckland, any supply loss will be restored within 2 hrs. For Northern and Wellington, any supply loss will be restored within 3 hours. |

*Table 3.2 Subtransmission Network*

| | Type of load | Security Criteria[6][7]<br>Single contingency only |
|---|---|---|
| 1 | Overhead spurs supplying up to 1MVA urban area | No back stop. Total loss of supply upon failure. Supply restoration upon repair time |
| 2 | Overhead spurs supplying up to 2.5MVA rural area | No back stop. Total loss of supply upon failure. Supply restoration upon repair time |
| 3 | Underground spurs supplying up to 400kVA | No back stop. Total loss of supply upon failure. Supply restoration upon repair time |
| 4 | Predominantly residential feeders | Full backup available 95% of the time in a year. Supply might be lost for 5% of the time in a year. |
| 5 | Mixed commercial / industrial / residential feeders | Full backup available 98% of the time in a year. Supply might be lost for 2% of the time in a year. |
| 6 | CBD or high density industrial | Full backup available 99.5% of the time in a year. Supply might be lost for 0.5% of the time in a year. |

*Table 3.3 Distribution Network*

4 Full backup can be provided via the sub-transmission or distribution network, or other means such as mobile generation

5 Brief interruption acceptable if for no more than 1 minute

6 Restoration of supply, in the event that there is an interruption, shall be targeted as per Table 3-3.

7 There will be a supply interruption for every feeder fault, but supply will be restored through backup (except in the case of spurs)

The variation between different categories of customer's is for two reasons:

1. Reliability requirements of CBD, industrial and commercial customer's are higher than residential.

2. Load profiles for different customer categories vary, residential areas have peaks of typically less than three hours, so an outage which leads to an inability to supply all customers in a peak time is basically self-correcting, but commercial and industrial areas have much longer peaks.

This approach is to differentiate service levels among different categories of customer's, such that Vector can focus on providing for their needs.

## 3.4. POWER QUALITY

Selected businesses, such as those in manufacturing and service industries, have a high reliance on disturbance free power supply. One of the objectives of power quality monitoring is to identify disturbances that adversely impact on customer's equipment with the objective of identifying solutions.

The following strategies have been implemented to monitor and report power quality problems identified on Vector's network.

- Power quality monitoring equipment has been installed at selected grid exit points and zone substations

- An electronic mail system that automatically sends a power quality disturbance report in real-time to customer's

- A web-based reporting system that makes real-time and historical power quality information available for diagnosis of customer's power quality issues. Figure 3.4 illustrates a typical report that is available to help resolve power quality issues that may be experienced at customer's premises

- Use of network modelling software and tools to predict the impact of power quality disturbances at customer's premises.

- The availability of portable power quality instruments to investigate power quality related complaints

Examples of the manner in which power quality data can be presented are shown in Figures 3.4, 3.5 and 3.6

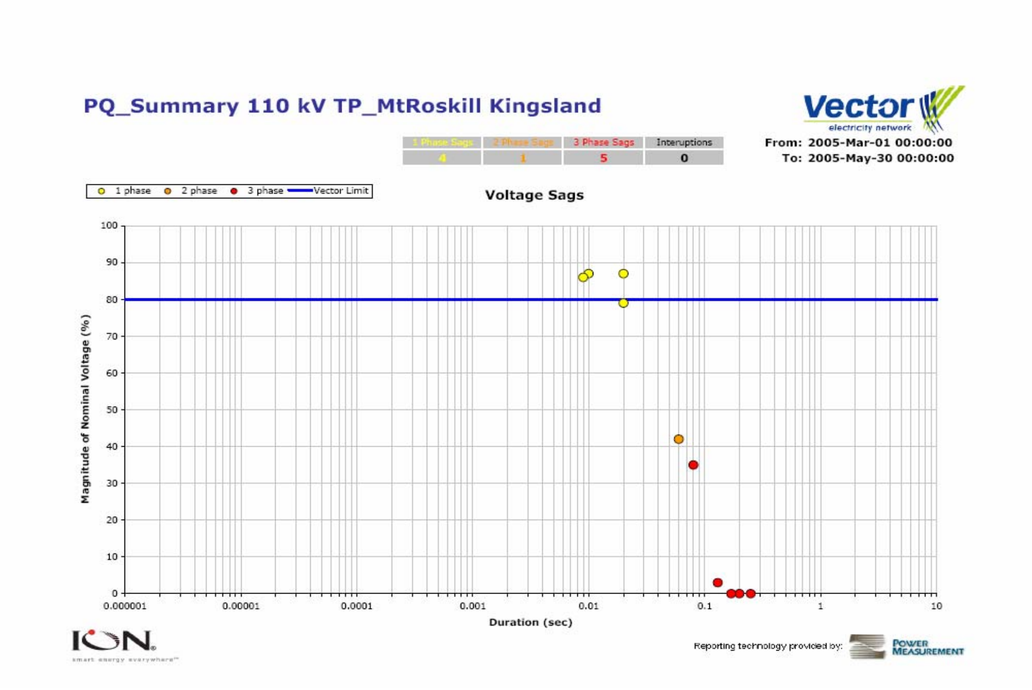
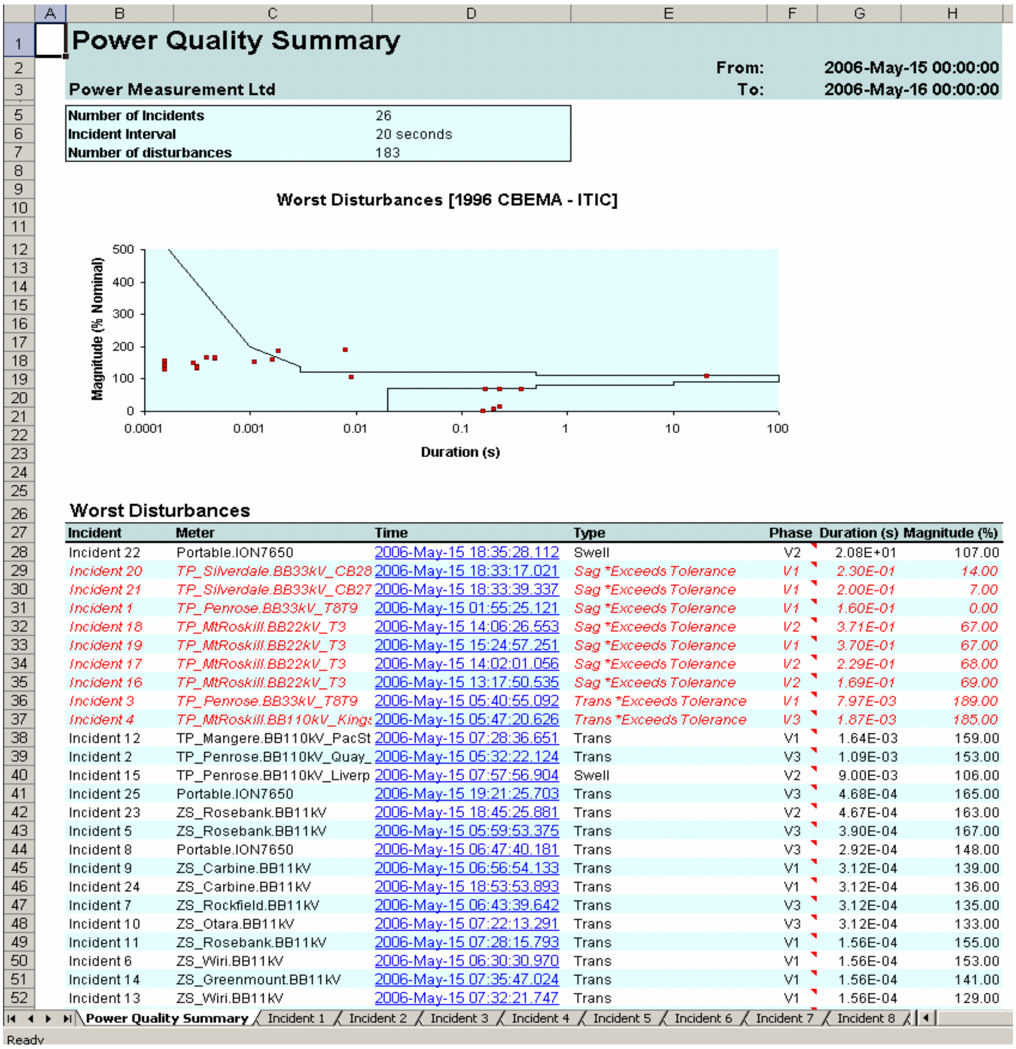



*Figure 3.4 Example of a Voltage Sag Report*




| Incident | Meter | Time | Type | Phase | Duration (s) | Magnitude (%) |
|---|---|---|---|---|---|---|
| Incident 22 | Portable.ION7650 | 2006-May-15 18:35:28.112 | Swell | V2 | 2.08E+01 | 107.00 |
| Incident 20 | TP_Silverdale.BB33kV_CB28 | 2006-May-15 18:33:17.021 | Sag *Exceeds Tolerance | V1 | 2.30E-01 | 14.00 |
| Incident 21 | TP_Silverdale.BB33kV_CB27 | 2006-May-15 18:33:39.337 | Sag *Exceeds Tolerance | V1 | 2.00E-01 | 7.00 |
| Incident 1 | TP_Penrose.BB33kV_T8T9 | 2006-May-15 01:55:25.121 | Sag *Exceeds Tolerance | V1 | 1.60E-01 | 0.00 |
| Incident 18 | TP_MtRoskill.BB22kV_T3 | 2006-May-15 14:06:26.553 | Sag *Exceeds Tolerance | V2 | 3.71E-01 | 67.00 |
| Incident 19 | TP_MtRoskill.BB22kV_T3 | 2006-May-15 15:24:57.251 | Sag *Exceeds Tolerance | V1 | 3.70E-01 | 67.00 |
| Incident 17 | TP_MtRoskill.BB22kV_T3 | 2006-May-15 14:02:01.056 | Sag *Exceeds Tolerance | V2 | 2.29E-01 | 68.00 |
| Incident 16 | TP_MtRoskill.BB22kV_T3 | 2006-May-15 13:17:50.535 | Sag *Exceeds Tolerance | V2 | 1.69E-01 | 69.00 |
| Incident 3 | TP_Penrose.BB33kV_T8T9 | 2006-May-15 05:40:55.092 | Trans *Exceeds Tolerance | V1 | 7.97E-03 | 189.00 |
| Incident 4 | TP_MtRoskill.BB110kV_Kings | 2006-May-15 05:47:20.626 | Trans *Exceeds Tolerance | V3 | 1.87E-03 | 185.00 |
| Incident 12 | TP_Mangere.BB110kV_PacSt | 2006-May-15 07:28:36.651 | Trans | V1 | 1.64E-03 | 159.00 |
| Incident 2 | TP_Penrose.BB110kV_Quay_ | 2006-May-15 05:32:22.124 | Trans | V3 | 1.09E-03 | 153.00 |
| Incident 15 | TP_Penrose.BB110kV_Liverp | 2006-May-15 07:57:56.904 | Swell | V2 | 9.00E-03 | 106.00 |
| Incident 25 | Portable.ION7650 | 2006-May-15 19:21:25.703 | Trans | V3 | 4.68E-04 | 165.00 |
| Incident 23 | ZS_Rosebank.BB11kV | 2006-May-15 18:45:25.881 | Trans | V2 | 4.67E-04 | 163.00 |
| Incident 5 | ZS_Rosebank.BB11kV | 2006-May-15 05:59:53.375 | Trans | V3 | 3.90E-04 | 167.00 |
| Incident 8 | Portable.ION7650 | 2006-May-15 06:47:40.181 | Trans | V3 | 2.92E-04 | 148.00 |
| Incident 9 | ZS_Carbine.BB11kV | 2006-May-15 06:56:54.133 | Trans | V1 | 3.12E-04 | 139.00 |
| Incident 24 | ZS_Carbine.BB11kV | 2006-May-15 18:53:53.893 | Trans | V1 | 3.12E-04 | 136.00 |
| Incident 7 | ZS_Rockfield.BB11kV | 2006-May-15 06:43:39.642 | Trans | V3 | 3.12E-04 | 135.00 |
| Incident 10 | ZS_Otara.BB11kV | 2006-May-15 07:22:13.291 | Trans | V3 | 3.12E-04 | 133.00 |
| Incident 11 | ZS_Rosebank.BB11kV | 2006-May-15 07:28:15.793 | Trans | V1 | 1.56E-04 | 155.00 |
| Incident 6 | ZS_Wiri.BB11kV | 2006-May-15 06:30:30.970 | Trans | V1 | 1.56E-04 | 153.00 |
| Incident 14 | ZS_Greenmount.BB11kV | 2006-May-15 07:35:47.024 | Trans | V1 | 1.56E-04 | 141.00 |
| Incident 13 | ZS_Wiri.BB11kV | 2006-May-15 07:32:21.747 | Trans | V1 | 1.56E-04 | 129.00 |

*Figure 3.5 Automated Daily Power Quality Summary Report.*

The information in this report provides details on any event that caused voltage and current transients or voltage sags and swells in the network.

## Power Quality Summary Reports

Information about all metering reports can be found HERE.

To access Power Quality Summary reports, select below

**Auckland**

| | | |
|---|---|---|
| Hepburn | 33 kV | TP_Hepburn Rd Rosebank |
| | 11kV | ZS_Rosebank |
| Mt Roskill | 110 kV | TP_MtRoskill Liverpool |
| | 110 kV | TP_MtRoskill Kingsland |
| | 22 kV | TP_MtRoskill T2T4 |
| | 22 kV | TP_MtRoskill T3 |
| | 11 kV | ZS_Victoria |
| Penrose | 110 kV | TP_Penrose Quay_SS |
| | 110 kV | TP_Penrose Liverpool_SS |
| | 33 kV | TP_Penrose T8T9 |
| | 33 kV | TP_Penrose T11 |
| | 11 kV | ZS_Quay |
| | 11 kV | ZS_Rockfield |
| | 11 kV | ZS_Carbine |
| | 11 kV | ZS_McNab |
| Mangere | 110 kV | TP_Mangere PacSteel_1 |
| | 110 kV | TP_Mangere PacSteel_2 |
| | 33 kV | TP_Mangere T1T2 |
| Takanini | 33 kV | TP_Takanini T5T8 |
| | 11 kV | ZS_Takanini |
| | 11 kV | ZS_Manurewa |
| Otahuhu | 22 kV | TP_Otahuhu T11T12 |
| | 11 kV | ZS_Bairds |
| | 11 kV | ZS_Otara |
| Pakuranga | 33 kV | TP_Pakuranga T5T6 |
| | 11 kV | ZS_Greenmount |
| | 11 kV | ZS_Howick |
| Wiri | 33 kV | TP_Wiri T1T2 |
| | 11 kV | ZS_Wiri |
| Lichfield | 11 kV | Lichfield T1T2 |

*Figure 3.6 Top Layer of Weekly Power Quality Summary Report.*

By drilling down into each monitor, the daily Max/Ave/Min of voltage, current, frequency, power factor, voltage unbalance, voltage total harmonic distortion (THD), 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. An example of this is shown in Figure 3.7.

***Long Term Data Analysis and reports.***

The analysis of voltage sag magnitudes and duration has been recently performed for the data captured by power quality monitors installed at 11 kV zone substations.

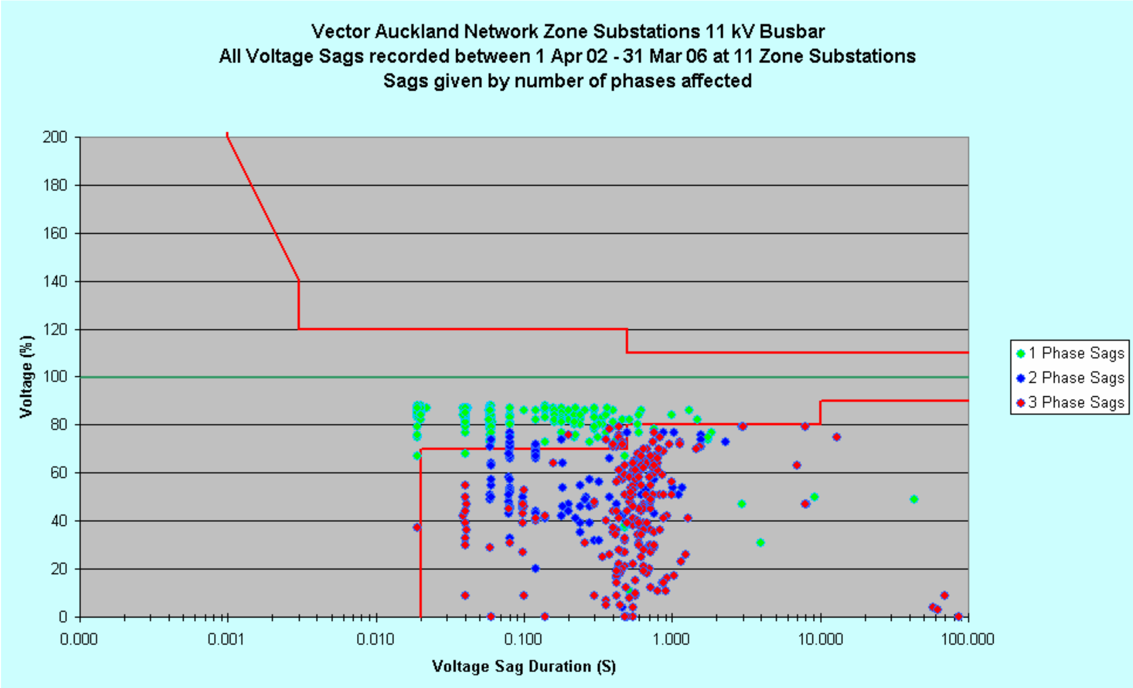



*Figure 3.7 11 kV Voltage Sag Magnitude – Duration Chart.*

### 3.4.1. FUTURE PLANS

***Power Quality Monitors.***

Future plans include:

- Installation of additional numbers of PQ monitoring instruments in the field. This is to gain increased knowledge of the quality of supply to customer's
- Developing an automated link between network events such as faults and data captured on the PQ instrumentation

# 4. ■ NETWORK DEVELOPMENT

Network development's role is to find cost effective solutions to load related problems within an acceptable company risk profile. This profile is captured in network security standards which are used as the criteria for identifying and initiating solutions to specific overloading problems. Not all solutions result in network reinforcement

The electricity network must efficiently deliver power to customers in a manner that meets their needs for reliability, capacity and quality. This is achieved within the statutory framework by anticipating these needs through forecasting techniques that allows potential load related network problems to be addressed in a timely and cost effective manner.

Vector's approach is to consider options that maximise the utilisation of existing assets through automation, demand-side management or other non-network asset investment solution. Invariably these solutions are cheaper to implement and can defer major capital investment.

Network capital expenditure is generally driven by growth and new connections, but regulatory compliance, safety and environmental issues, and the replacement of aging assets all contribute significantly to the capital spend

This section gives an overview of the major development projects planned for the network.

## 4.1. FORECAST GROWTH

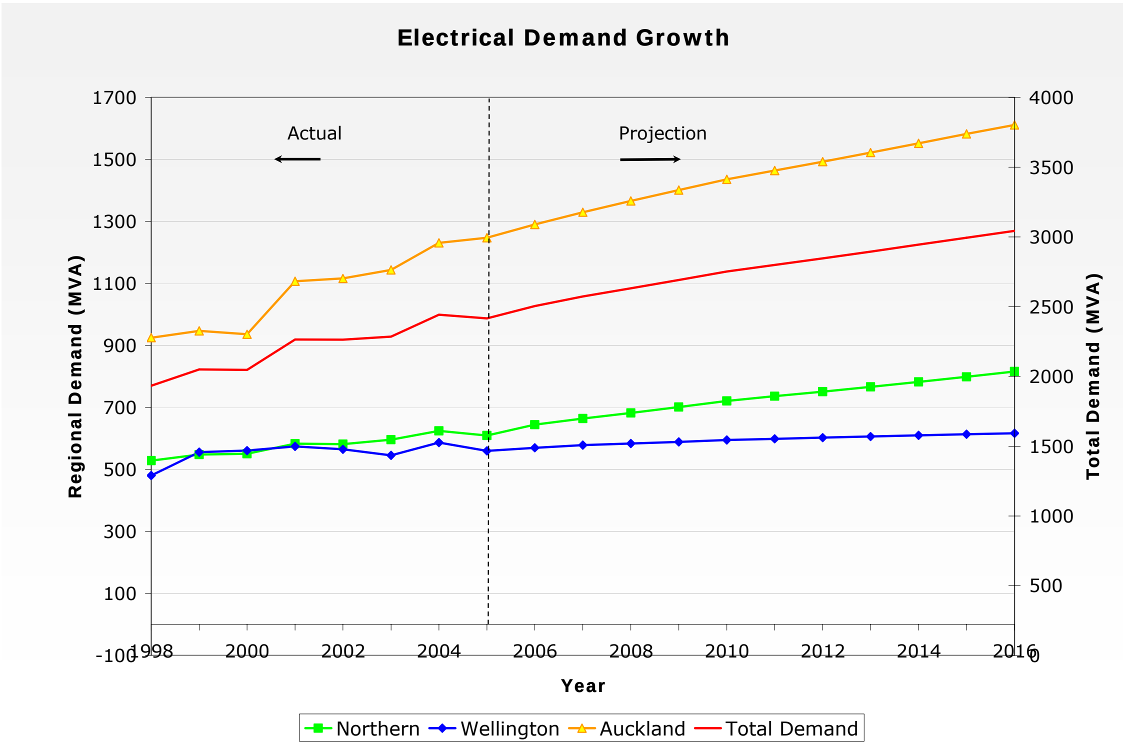



*Figure 4.1 Forecast Maximum Demand across the Network*

Figure 4.1 shows the forecast electricity demand growth across the network both at a regional level and an aggregated company level. The long-term forecast for Vector's total network shows an average demand growth rate across all three networks of 1.4% per annum.

The forecasting technique used by Vector relies on historical zone substation and 11/6.6kV feeder load data captured via SCADA and stored in PI historical storage. Individual growth factors (at feeder level) reflecting population growth demographics, customer type, economic growth, land usage and district plan changes are applied to the load data to generate a demand projection over the planning period. Individual commercial developments and subdivisions are also factored in. The growth factor is calculated at both feeder and zone substation level.

The load forecast model takes into account embedded generation and network capacitors by removing them from the base year demand record prior to applying the growth factor. This allows the growth factor to be calculated without these distortions. Once the demand profile has been produced, embedded generation and network capacitors are added back to the forecast.

The output from this granular level load forecast can be used to determine a regional growth figure. To verify the bottom up approach, a top-down model compares the extrapolated macro trend-line derived from historical regional loads overlaid over the bottom-up trend line.

Growth trends are reviewed annually. Historical zone substation and feeder load information gathered over the previous five years is used to determine the starting load for the forecast. This approach removes short term weather distortions, as the objective is to capture the underlying long term growth rates. Seasonal variations are captured through the interconnection of distribution feeders between zone substations and the ability to adjust feeder load by moving "open points".

Short-term maximum demand on Vector's network is primarily influenced by climate, particularly the severity of winter. Medium-term growth is driven mainly by population increases and commercial developments.

Vector's network comprises predominantly of compact urban load or CBD load with small rural communities scattered around periphery of the network.

A measure of load diversity is achieved with residential customer's 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.

Figures 4.2 – 4.5 show the typical load characteristics for different categories of customer's.

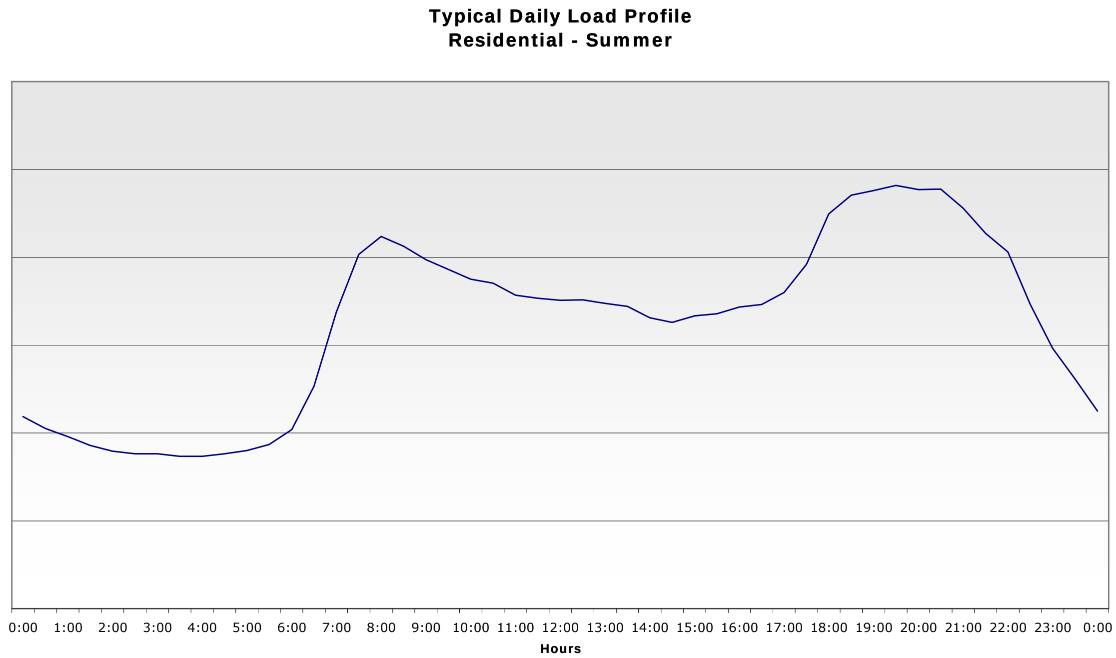



*Figure 4.2 Typical summer load profile for residential customer's*

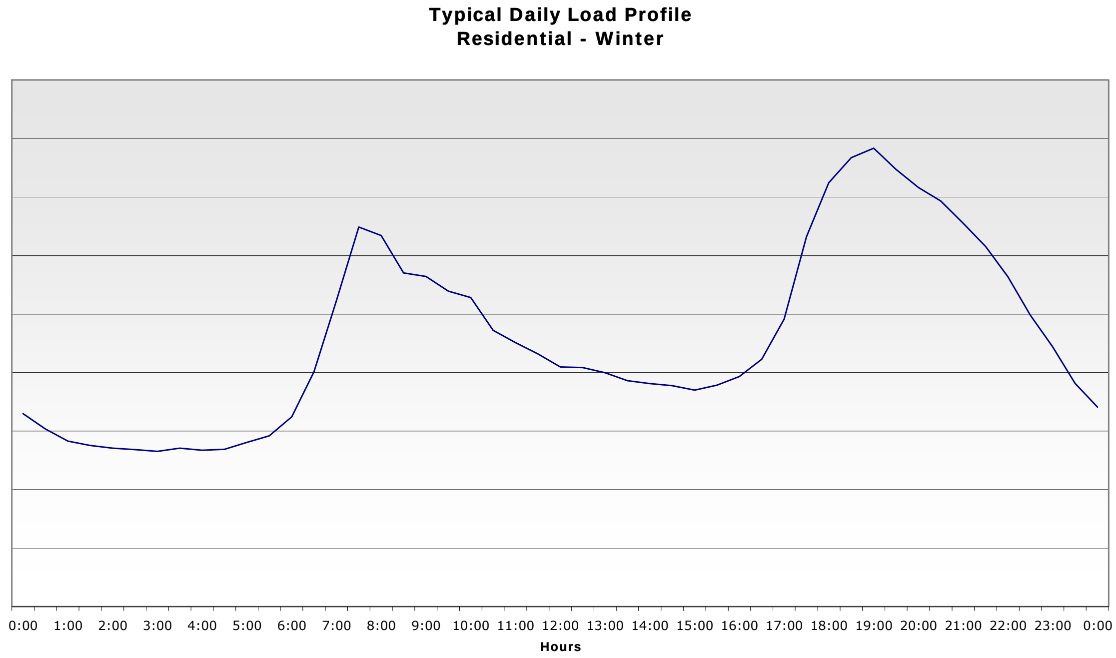



*Figure 4.3 Typical winter load profile for residential customer's*

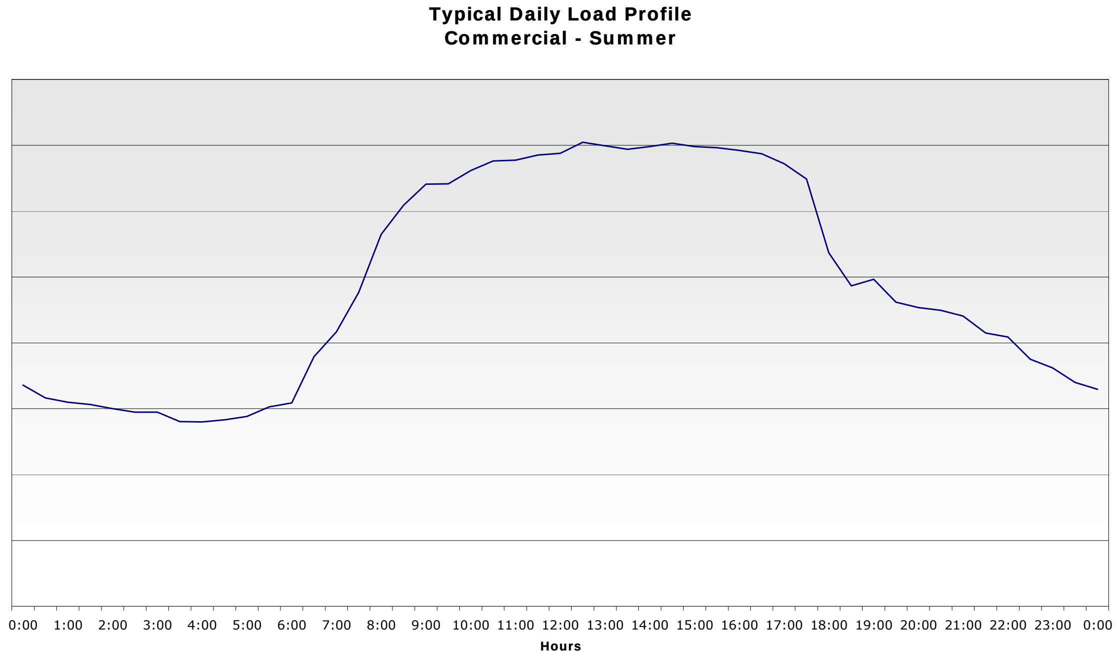



*Figure 4.4 Typical summer load profile for commercial customer's*

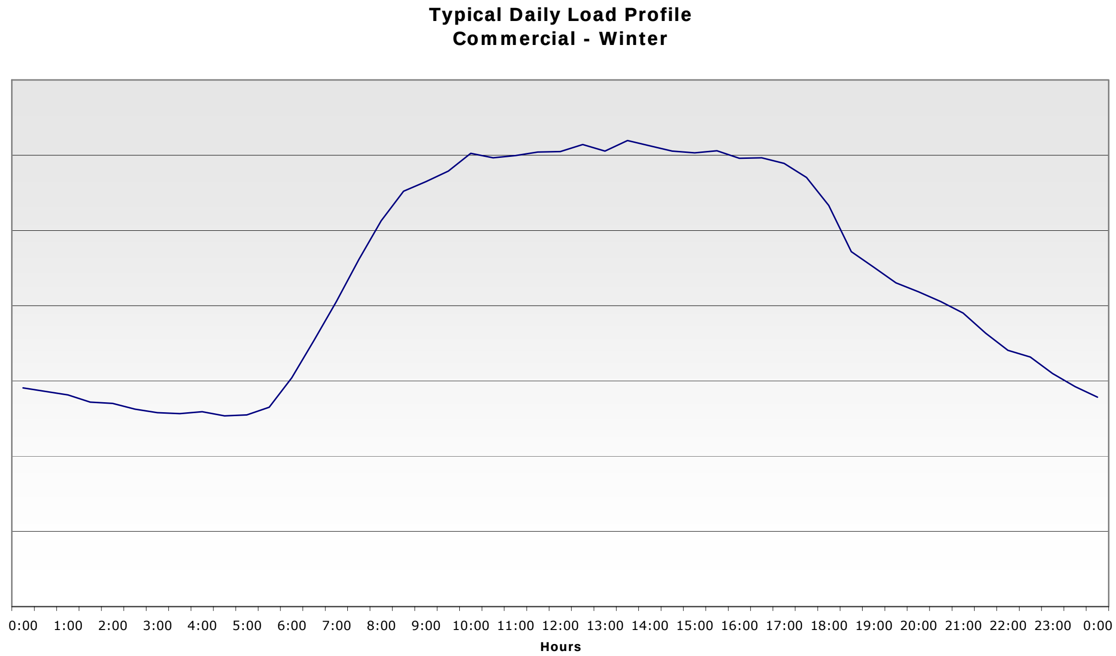



*Figure 4.5 Typical winter load profile for commercial customer's*

Growing demand for residential air conditioning in summer, especially for residential use, is increasing overall electricity consumption and an area that is receiving close attention. Not only is this load unavailable for demand-side management through traditional load management systems, but residential air conditioning systems are relatively cheap to the customer and easy to install.

This load is creating summer peaks on a network that traditionally encountered winter peak. A close watch is being kept on summer loads and these are an integral part of the load forecasts. Reinforcement projects are planned and solutions implemented to ensure forecast loads do not exceed the system design security criteria outlined in Section 3.

### 4.1.1 DEMAND FORECASTS

The demand forecasts for zone substations on Vector's network in Northern, Auckland and Wellington, are tabulated are detailed below.

Tables 4.2, 4.3, and 4.4 indicate the normal and cyclic ratings of the zone substation transformers and the associated maximum demand on each zone substation. All loads and transformer capacities are in MVA. Although a number of substations fail to meet "n-1" security at a subtransmission level (see column "meets "n-1" security in 2006"), these substations may be supported at a distribution level.

The figures in the "Distribution Backstop Shortfall" column represent the load that cannot be transferred to adjacent distribution feeders in the event of a major fault (e.g. zone transformer failure) which is coincident with the zone substation maximum demand. To restore supply to customers under these circumstances load must be shed through load control, voluntary load reduction or the installation of generators.

Network constraints can occur when the forecast load exceeds the equipment ratings. Where constraints are identified, projects are initiated and are listed in Sections 4.4 to 4.6. The load forecasts do not include load transfers arising from new projects. The peak demand and total energy delivered to each of the Vector networks during the 2005/06 year, are listed in Table 4.1

| **Network Area** | **Peak Demand (MVA)** | **Total Energy Delivered (GWh)** |
|---|---|---|
| Auckland | 1247 | 5510 |
| Northern | 609 | 2418 |
| Wellington | 574 | 2361 |
| Vector* | 2088 | 10289 |

*coincident demand

*Table 4.1 Network Demand and Energy*

| Substation | Transformer ONAN Capacity | Voltage | Transformer ONAF/ODAF /OFAF Rating | Cyclic Rating | 2005 Actual | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Meets "n-1" security in 2006 | Distribution Backstop Shortfall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Atkinson Road** | 2*10 | 33kV | | 24 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | N | |
| **Balmain** | 1*12.5 | 33kV | | 12 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | N | |
| **Belmont** | 2*12.5 | 33kV | | 28 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | Y | |
| **Birkdale** | 2*12.5 | 33kV | | 30 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | N | |
| **Brickworks** | 1*12.5 | 33kV | | 13 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | N | |
| **Browns Bay** | 2*12.5 | 33kV | | 28 | 18 | 20 | 21 | 22 | 22 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | N | |
| **Bush Road** | 2*12 | 33kV | 2*24 | 42 | 29 | 31 | 33 | 35 | 37 | 39 | 40 | 41 | 43 | 44 | 45 | 47 | N | |
| **Coatsville** | 1*11.5 | 33kV | | 12 | 8 | 8 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | N | 3 |
| **East Coast Road** | 1*12.0 | 33kV | | 24 | 14 | 15 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 19 | N | 6 |
| **Forrest Hill** | 1*12.5 | 33kV | | 15 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 15 | N | |
| **Hauraki** | 1*12.5 | 33kV | | 13 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | N | |
| **Helensville** | 2*7.5 | 33kV | | 18 | 12 | 12 | 13 | 13 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 16 | N | |
| **Henderson Valley** | 2*12.5 | 33kV | 2*14 | 28 | 19 | 25 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 31 | 32 | 33 | N | |
| **Highbury** | 1*12.5 | 33kV | | 15 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | Y | |
| **Hillcrest** | 2*12 | 33kV | | 48 | 15 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 16 | 17 | N | |
| **Hobsonville** | 2*12.5 | 33kV | | 32 | 21 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | N | |
| **James Street** | 2*12.5 | 33kV | | 32 | 23 | 23 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 26 | 26 | 27 | N | |
| **Keeling Road** | 1*15 | 33kV | 1*24 | 24 | 8 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | N | |
| **Laingholm** | 2*7.5 | 33kV | | 17 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 13 | 13 | 13 | 14 | N | |
| **Manly** | 2*12.5 | 33kV | | 30 | 25 | 26 | 28 | 29 | 31 | 33 | 34 | 35 | 36 | 38 | 39 | 40 | N | 4 |
| **McKinnon** | 1*15 | 33kV | 1*19 | 24 | 10 | 11 | 12 | 13 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 23 | N | |
| **Mcleod Road** | 1*12.5 | 33kV | | 16 | 13 | 12 | 13 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | N | |
| **Milford** | 1*12.5 | 33kV | 1*14 | 14 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | N | 3 |
| **New Lynn** | 2*12.5 | 33kV | | 30 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 17 | N | |
| **Ngataringa Bay** | 1*12.5 | 33kV | | 14 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | N | |
| **Northcote** | 1*12.5 | 33kV | 1*16 | 15 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | N | |
| **Orewa** | 2*20 | 33kV | | 30 | 18 | 22 | 23 | 25 | 27 | 30 | 31 | 33 | 35 | 37 | 39 | 42 | N | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Riverhead** | 2*7.5 | 33kV | | 18 | 11 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | N | |
| **Sabulite Road** | 2*12.5 | 33kV | | 26 | 18 | 20 | 20 | 21 | 21 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | N | |
| **Spur Road** | 1*12.5 | 33kV | | 14 | 14 | 15 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | N | |
| **Simpson Road** | 1*7.5 | 33kV | | 9 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | N | |
| **Snells Beach** | 1*7.5 | 33kV | | 9 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | N | 3 |
| **Sunset Road** | 2*12.5 | 33kV | | 30 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 19 | 20 | 20 | 20 | N | |
| **Swanson** | 1*12.5 | 33kV | | 15 | 13 | 13 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | N | 1 |
| **Takapuna** | 1*24 | 33kV | | 24 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | N | |
| **Te Atatu** | 2*12.5 | 33kV | | 28 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | 21 | N | |
| **Torbay** | 1*12.5 | 33kV | | 13 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 12 | N | |
| **Triangle Road** | 2*10 | 33kV | | 24 | 19 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 24 | 25 | 26 | 26 | N | |
| **Waiake** | 1*12.5 | 33kV | | 15 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | N | |
| **Waikaukau** | 1*7.5 | 33kV | | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | N | |
| **Waimauku** | 1*7.5 | 33kV | | 8 | 6 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | N | 3 |
| **Wairau** | 2*12.5 | 33kV | 1*16+1*12.5 | 32 | 23 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 25 | 26 | 26 | N | |
| **Warkworth** | 2*7.5 | 33kV | | 18 | 15 | 14 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 16 | N | |
| **Wellsford** | 2*7.5 | 33kV | | 18 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | N | |
| **Woodford** | 1*12.5 | 33kV | 1*16 | 15 | 11 | 13 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 16 | N | |

*Table 4.2 Northern Network Load Forecast*

| Substation | Transformer ONAN Rating | Voltage | Transformer ONAF/ODAF /OFAF Rating | Cyclic Rating | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Meets "n-1" security in 2006 | Distribution Backstop Shortfall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Auckland Airport** | 2*20 | 33kV | 2*25 | 59 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | Y | |
| **Avondale** | 2*15 | 22kV | 2*20 | 48 | 25 | 25 | 26 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | N | |
| **Balmoral** | 2*12 | 22kV | | 24 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | N | |
| **Bairds** | 2*20 | 22kV | 2*20 | 48 | 24 | 23 | 23 | 24 | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 27 | N | |
| **Carbine** | 2*15 | 33kV | 2*20 | 42 | 24 | 23 | 23 | 23 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | N | |
| **Chevalier** | 2*18 | 22kV | | 31 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 20 | 20 | Y | |
| **Clevedon** | 1*5 | 33kV | | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Y | |
| **Drive** | 2*15 | 33kV | 2*20 | 48 | 30 | 30 | 31 | 31 | 32 | 32 | 32 | 33 | 33 | 33 | 34 | 34 | N | |
| **East Tamaki** | 2*15 | 33kV | 2*20 | 48 | 15 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | Y | |
| **Freemans Bay** | 1*15 + 1*18 | 22kV | 1*20 + 1*18 | 31 | 19 | 21 | 22 | 22 | 23 | 24 | 24 | 24 | 25 | 25 | 26 | 26 | N | |
| **Glen Innes** | 2*12 | 22kV | | 24 | 15 | 16 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 20 | N | |
| **Greenmount** | 2*20+1*12 | 33kV | 3*20 | 71 | 43 | 45 | 46 | 47 | 48 | 49 | 51 | 52 | 53 | 54 | 56 | 57 | N | |
| **Hans** | 2*15 | 33kV | 2*20 | 43 | 25 | 27 | 28 | 29 | 30 | 30 | 31 | 31 | 32 | 32 | 33 | 33 | N | |
| **Hobson 110/11kV** | 2*25 | 110kV | | 60 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 39 | N | |
| **Hobson 22/11kV** | 1*10+1*12 | 22kV | 2*15 | 33 | 14 | 14 | 15 | 15 | 16 | 16 | 17 | 17 | 18 | 18 | 19 | 19 | Y | |
| **Howick** | 3*20 | 33kV | | 62 | 40 | 40 | 40 | 41 | 41 | 41 | 41 | 42 | 42 | 42 | 42 | 42 | N | |
| **Kingsland** | 2*15 | 22kV | 2*20 | 48 | 23 | 24 | 24 | 24 | 25 | 25 | 25 | 26 | 26 | 26 | 27 | 27 | N | |
| **Liverpool** | 3*15 | 22kV | 3*20 | 72 | 48 | 51 | 53 | 54 | 56 | 57 | 59 | 60 | 62 | 63 | 65 | 66 | N | |
| **McNab** | 3*20 | 33kV | | 57 | 43 | 45 | 47 | 48 | 49 | 50 | 50 | 51 | 52 | 53 | 53 | 54 | N | |
| **Mangere Central** | 2*16.5 | 33kV | 2*20 | 57 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 32 | N | |
| **Mangere East** | 2*15 | 33kV | 2*20 | 46 | 23 | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | N | |
| **Mangere West** | 2*30 | 33kV | | 71 | 18 | 18 | 19 | 19 | 20 | 21 | 21 | 22 | 22 | 23 | 23 | 24 | Y | |
| **Manukau** | 2*15+1*16.5 | 33kV | 3*20 | 56 | 30 | 32 | 32 | 33 | 35 | 36 | 37 | 38 | 39 | 40 | 42 | 43 | Y | |
| **Manurewa** | 3*16 | 33kV | 3*20 | 71 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 56 | 57 | 58 | 59 | 60 | N | |
| **Maraetai** | 2*15 | 33kV | | 24 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | Y | |
| **Mt Albert** | 1*12 | 22kV | | 14 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | N | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mt Wellington** | 2*15 | 33kV | 2*20 | 48 | 21 | 21 | 22 | 23 | 24 | 25 | 25 | 25 | 26 | 26 | 27 | 27 | N | |
| **Newmarket** | 3*15 | 33kV | 3*20 | 70 | 44 | 55 | 64 | 68 | 71 | 73 | 74 | 76 | 77 | 79 | 80 | 82 | N | |
| **Newton** | 2*12 | 22kV | 2*16 | 38 | 16 | 16 | 16 | 17 | 17 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | N | |
| **Onehunga** | 2*11 | 22kV | 2*15 | 26 | 23 | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | N | |
| **Orakei** | 2*14.5 | 33kV | 2*18 | 43 | 32 | 32 | 33 | 33 | 34 | 35 | 35 | 36 | 37 | 37 | 38 | 39 | N | |
| **Otara** | 2*15 | 22kV | | 35 | 17 | 19 | 20 | 21 | 21 | 23 | 23 | 25 | 26 | 27 | 28 | 29 | N | |
| **Pacific Steel** | 2*25 | 110kV | 2*40 | 80 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | N | |
| **Pakuranga** | 2*16.5 | 33kV | 2*20 | 48 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 23 | N | |
| **Papakura** | 2*15 | 33kV | 2*20 | 44 | 20 | 25 | 25 | 26 | 27 | 28 | 28 | 28 | 28 | 29 | 29 | 29 | N | |
| **Parnell** | 2*12 | 22kV | | 26 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | Y | |
| **Ponsonby** | 2*9 | 22kV | 2*12 | 27 | 16 | 16 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | N | |
| **Quay** | 2*15 | 22kV | 2*20 | 48 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | N | |
| **Remuera** | 2*15 | 33kV | 2*20 | 48 | 33 | 34 | 34 | 35 | 35 | 36 | 36 | 36 | 37 | 37 | 37 | 38 | N | |
| **Rockfield** | 2*15 | 33kV | 2*20 | 48 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | N | |
| **Rosebank** | 2*16 | 33kV | 2*21.5 | 52 | 26 | 26 | 27 | 27 | 27 | 27 | 28 | 28 | 28 | 28 | 29 | 29 | N | |
| **Sandringham** | 2*16 | 22kV | 2*20 | 47 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 23 | 24 | N | |
| **South Howick** | 2*15 | 33kV | 2*20 | 47 | 25 | 25 | 26 | 26 | 26 | 27 | 27 | 28 | 28 | 28 | 29 | 29 | N | |
| **St Heliers** | 2*15 | 33kV | 2*17.5 | 42 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 23 | N | |
| **Takanini** | 2*15 | 33kV | | 36 | 20 | 16 | 16 | 17 | 18 | 19 | 19 | 20 | 20 | 21 | 21 | 22 | N | |
| **Te Papapa** | 2*15 | 33kV | 2*20 | 46 | 21 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 24 | 25 | N | |
| **Victoria** | 2*20 | 22kV | 2*20 | 40 | 24 | 25 | 25 | 26 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 32 | N | |
| **Waiheke** | 2*12.5 | 33kV | | 30 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | Y | |
| **Westfield** | 3*15 | 22kV | | 52 | 31 | 33 | 33 | 34 | 34 | 34 | 35 | 35 | 35 | 36 | 36 | 37 | N | |
| **White Swan** | 3*15 | 22kV | | 39 | 32 | 32 | 32 | 33 | 33 | 34 | 34 | 34 | 35 | 35 | 34 | 34 | N | |
| **Wiri** | 3*20 | 33kV | | 70 | 40 | 42 | 43 | 45 | 47 | 48 | 50 | 52 | 54 | 55 | 57 | 59 | N | |
| **Lichfield** | 2*20 | 110kV | | | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | Y | |

*Table 4.3 Auckland Network Load Forecast*

| Substation | Transformer ONAN Capacity | Voltage | | Cyclic Rating | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Meets "n-1" security in 2006 | Distribution Backstop Shortfall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **8 Ira St** | 2*16 | 33kV | 2*20 | 19 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | Y | |
| **Brown Owl** | 2*11.5 | 33kV | 2*23 | 19 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 16 | 16 | Y | |
| **Evans Bay** | 2*20 | 33kV | | 36 | 16 | 17 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 19 | 19 | Y | |
| **Frederick St** | 2*18 | 33kV | 2*30 | 50 | 35 | 37 | 38 | 38 | 39 | 39 | 40 | 40 | 41 | 41 | 42 | 42 | N | |
| **Gracefield 11kV** | 2*11.5 | 33kV | | 19 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | N | |
| **Hataitai** | 2*11.5 | 33kV | 2*23 | 19 | 18 | 18 | 18 | 18 | 18 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | Y | |
| **Haywards 11kV** | 1*20 | 33kV | | 20 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 16 | N | 4 |
| **Johnsonville** | 2*11.5 | 33kV | 2*23 | 19 | 22 | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 23 | 23 | 23 | 23 | Y | |
| **Kaiwharawhara** | 2*40 | 33kV | | 80 | 36 | 38 | 38 | 39 | 39 | 39 | 40 | 40 | 40 | 41 | 41 | 41 | Y | |
| **Karori** | 2*20 | 33kV | | 38 | 19 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | Y | |
| **Kenepuru** | 2*11.5 | 33kV | 2*23 | 23 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | Y | |
| **Korokoro** | 2*11.5 | 33kV | 2*23 | 25 | 13 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | Y | |
| **Maidstone** | 2*11 | 33kV | 2*22 | 35 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 17 | 17 | 17 | 17 | Y | |
| **Mana-Plimmerton** | 2*10 | 33kV | 2*16 | 32 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | N | |
| **Melling 11kV** | 2*25 | 33kV | | 50 | 20 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 22 | Y | |
| **Moore St** | 2*30 | 33kV | | 46 | 22 | 24 | 26 | 27 | 28 | 31 | 31 | 32 | 33 | 34 | 34 | 35 | Y | |
| **Naenae** | 2*11.5 | 33kV | 2*23 | 19 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | Y | |
| **Nairn St** | 2*25 | 33kV | | 60 | 17 | 18 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 22 | Y | |
| **Ngauranga** | 2*10 | 33kV | | 26 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | Y | |
| **Palm Grove** | 2*20 | 33kV | | 23 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 28 | 28 | 28 | N | 2 |
| **Petone** | 2*10 | 33kV | 2*20 | 20 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | Y | |
| **Porirua** | 2*10 | 33kV | 2*20 | 20 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | Y | |
| **Seaview** | 2*11 | 33kV | 2*22 | 30 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 17 | 17 | 17 | 17 | Y | |
| **Tawa** | 2*10 | 33kV | 2*16 | 32 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | Y | |
| **Terrace** | 2*30 | 33kV | | 46 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 30 | 31 | 31 | 31 | 32 | Y | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trentham** | 2*11.5 | 33kV | 2*23 | 20 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | Y | |
| **University** | 2*20 | 33kV | | 44 | 24 | 25 | 25 | 26 | 26 | 26 | 26 | 26 | 27 | 27 | 27 | 27 | N | |
| **Waikowhai St** | 2*16 | 33kV | | 31 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | N | |
| **Wainuiomata** | 2*11.5 | 33kV | 2*23 | 36 | 17 | 17 | 17 | 17 | 17 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | Y | |
| **Waitangirua** | 2*10 | 33kV | 2*16 | 32 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 14 | 14 | Y | |
| **Waterloo** | 2*11.5 | 33kV | 2*23 | 21 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | Y | |

*Table 4.4 Wellington Network Load Forecast*

## 4.2. NETWORK INVESTMENT

Vector invests in its network to:

- Provide additional capacity for growth.
- Replace assets which have come to the end of their economic lives.
- Ensure the assets comply with health, safety and environmental statutory requirements.
- Maintain and improve the service provided by the network.

To ensure Vector is making sound investments projects are evaluated against a range of drivers important to the company. Typical examples may be risk, safety, and return on investment. These drivers are weighted so that projects selected closely aligned to the parameters most important to Vector. In a financially constrained environment this process provides an unbiased selection tool for projects.

A new solution may incorporate the use of (but is not limited to):

- Demand side management
- Embedded or distributed generation (interconnected or behind-the-load)
- Non-traditional technologies

Most alternative solutions, such as automation and load management, provide incremental increases in capacity at a fraction of the cost of traditional, capital intensive solutions.

These solutions are an efficient way of deferring traditional investment and reduce the risk of large traditional investments being stranded, especially in low load growth areas.

### 4.2.1. NETWORK CONSTRAINT MANAGEMENT

As load grows the capacity of existing assets is consumed. Eventually network constraints arise where the load on existing assets compromises Vector's service standards. Network constraints are geographically constrained, time-of-day dependent and are relieved as soon as further capacity is provided through investment.

Constraints occur at all parts of the network, from transmission, and subtransmission to the distribution network.

Management of these constraints is either through capital investment or by:

- Reconfiguring the network to reduce the load in the constrained area. This process is used frequently and is achieved by moving feeder "open points" to equalise the load across feeders. Ultimately as load increases, opportunities to move "open points" diminish resulting in equipment overload or feeder outages if reinforcement is not implemented.

- Encouraging customer's to shed load at peak times. This option is being developed on Vectors network although it is noted it has been implemented on other networks.

- Load control. This is used extensively to manage feeder loads against equipment overload, particularly during network faults or during winter or summer peaks.

- Local generation. There is no robust mechanism for initiating generation on a widespread scale as a means of reducing feeder peak loads. While we have agreements with selected customers e.g. Wellington Hospital, to supply generation capacity, there is no formal process in place to coordinate wholesale generation. Vector has however acquired two mobile generator connection units that can be deployed to cover large outage areas when required.

- Automated switching. This is generally installed to initiate rapid restoration following a fault rather than load transfer or investment avoidance. For example, the scheme installed in the Onehunga area.

A list of proposed projects to alleviate capacity and security constraints are outlined in Section 4.4

#### 4.2.2. NON-TRADITIONAL INVESTMENT SOLUTIONS

Non-traditional investment solutions fall into the following areas:

**Increasing the utilisation of existing assets**
- Improved control of network assets (remote controlled and automated switches)
- Real-time monitoring and rating of assets
- Targeted maintenance programmes

**Demand-side response**
- Embedded generation (both new generation and use of existing generation – e.g. CBD buildings with emergency generators)
- Customer load management; real-time access to sheddable loads in peaks
- Customer demand reduction; through price signals, demand reduction programmes; run by Vector or third parties
- Energy storage devices

- Demand Exchange; evolving market mechanism developed to enable load to be traded
- Peak demand pricing

**Customer investment**

- Investment in site equipment (power factor correction, voltage conditioners etc)
- Insurance to cover risks
- Determining specific service levels

New technologies are emerging in all of the above areas.

### 4.2.3. DISTRIBUTED GENERATION

Distributed generation refers to energy production embedded within the distribution network. It includes production from power plants, customer back up generators and smaller generation technologies such as solar panels and fuel cells.

Vector has prepared and published guides on its web site, detailing the application and approval process for customer's who wish to install embedded generation on the distribution network.
Vector employs distributed generation as a non-traditional investment solution that is considered and applied where appropriate. A current initiative is to actively purchase on the Vector Demand-side Exchange website (www.demandexchange.co.nz), back-up diesel generation capacity and non-essential interruptible load for load management during peak load times on the Vector network.

### 4.2.4. EMBEDDED GENERATION

The following embedded generation (greater than 1MW) sites are connected to the Vector network

- Wellington Hospital
- Auckland Hospital
- Greenmount Landfill Power Station
- Rosedale Landfill Power Station
- Redvale Landfill Power Station
- Whitford Landfill Power Station
- Silverstream Landfill Power Station

### 4.2.5. THIRD PARTY SERVICE PROVISION

Vector recognises that third parties can provide some of the above investment solutions. Vector encourages third party service provision through the communication of:

- The required outcome the solution must provide
- The area the solution is required in
- The timeframe in which the solution is required

Vector's policy is to compensate third parties for the provision of services, including distributed generation, so long as:

- The risk of the non-provision of the service can be managed so that it does not breach Vector's service standards
- The provision of the service complies with Vector's technical codes and does not interfere with other Vector customers
- Payments to service providers are linked directly to the provision of the service which gives the correct commercial outcomes
- Commercial agreements are reached on connection, including use of network costs

Compensation is based upon the actual benefit received by Vector. To ensure Vector receives the maximum value from these investments it seeks to:

- Encourage the number of possible solutions and participants
- Set prices through a competitive process
- Ensure timeframes are short to enable other solutions to emerge over time

#### 4.2.6. LARGE CUSTOMERS

Vector has a number of large customer sites at various locations in its network. The following are those customer sites with demand 5MVA or above:

- Fonterra Cheese Factory at Lichfield
- Auckland International Airport
- Mangere Waste Water Treatment Plant
- AHI Glass
- Fisher & Paykel Appliance Factory at East Tamaki
- Pacific Steel

#### 4.2.7. NETWORK OPTIMISATION

In Vector's 2004 ODV of electricity networks, optimisation was conducted in accordance with the ODV Handbook's specifications and guidelines. The optimisation process involved determining if individual items could be eliminated or reduced to a lower value or lower capacity item that still provided the required service levels. The planning horizons specified in the ODV Handbook have been used to determine forecast loadings on assets when conducting optimisation determinations.

Optimisations were determined to apply to some assets within the following asset classes:

- Zone Substation (Power) Transformers
- Subtransmission cables and overhead lines
- HV Distribution substations
- HV Distribution switchgear
- HV Distribution transformers
- HV Distribution cables and overhead lines
- LV Distribution cables and lines (including streetlighting circuits)

For the 2004 ODV, Vector recorded $76.7m of optimisation.

## 4.3. ASSET DEVELOPMENT

A number of areas within the Vector network are at risk of having their supply security criteria breached. Prior to capital investment the following options are considered:

- Increased asset utilisation, through advanced automation, or dynamic equipment ratings
- Load management including demand-side management
- Level of acceptable risk
- Asset performance improvement
- Customer requirements and customer based solutions
- Capital investment meeting commercial objectives

Projects are prioritised in accordance with the following criteria:

- Safety, regulatory or environmental issues
- Risk and consequences of not carrying out the project?
- What is the impact on customers?
- Can the project be deferred?
- Is rate of return on investment acceptable?
- Is the project required as part of a larger project?
- What is the impact on the performance and operation of the network?
- Are funds available?

This results in a revised asset development programme in terms of the:

- Solution adopted to address the issue or constraint
- Timing of the solution
- Cost of the solution

Within the Network Investment Assessment Process, two drivers were specifically included to value the improvement in service level (SAIDI) and probability of interruptions (ALPI). These drivers look at the existing service and reliability levels and value the improvements that can be achieved by implementing the project against the respective targets.

For projects that require capital investment, a list of the more significant ones is contained in the next section. They have been summarised according to broad cost bands (i.e. between $1 and $5 million, and > $5 million). Projects costing less than $1 million and minor 11kV reinforcement projects have not been individually listed.

"Committed" projects are those with an approved budget. Those projects with a "Proposed" status do not have an approved budget and are still considered to be in the planning stage.

The timing of projects is indicative only and is always subject to the commercial objectives detailed earlier.

# 4.4. AUCKLAND CUSTOMER AREA

## 4.4.1. GROWTH IN THE AUCKLAND AREA

This area covers Auckland City, Manukau City and parts of Papakura District.

Residential demand is expected to increase in central Auckland with the development of new apartments and refurbishment of offices into apartments. Residential growth in the Manukau City and Takanini/Alfriston areas is also high because of a high number of planned subdivisions. Residential growth elsewhere in the Auckland network is expected to be low, with infill housing being the major form of development.

Industrial and commercial development is expected to continue to be focused in the Avondale area and around East Tamaki, with large retail development in Mt Wellington. Industrial and commercial load growth is also expected to continue in the Wiri and Manukau areas, and in the vicinity of Auckland airport.

## 4.4.2. ISSUES AND OPTIONS IN THE AUCKLAND AREA

Projects currently under way or planned to start in the next twelve months

**A1: Manukau Area**

| | |
|---|---|
| *Project* | *Third transformer at Manukau zone substation* |
| *Driver* | *Growth* |

*Timescale* *2006*
*Status* *In Progress* *Estimated capital $1-5 million*

There are two 33/11kV 20MVA transformers installed at this substation. The 2005 peak demand is 29MVA. The projected load towards the end of the planning period is about 43MVA. The PCLL for the substation is 30MVA.

The load at Manukau is increasing with developments around the city centre and nearby shopping complexes, apartment blocks, office blocks, and the construction of a new stadium and recreation park.

A project to install a third 20MVA transformer (relocated from Mangere Central) and an 11kV board extension is in progress and is on schedule for completion before the end of 2006. With the additional transformer, the PCLL will increase to 52MVA.

Two new 11kV feeder projects from Manukau zone substation are in progress, to be commissioned after the substation upgrade. This will reinforce the 11kV distribution network and resolve several feeder backstopping capacity shortfalls.

In the medium term, new 11kV feeders will be extended southwards along Great South Road. Ducts will be installed when undergrounding along Great South Road and when the highway extension gets underway. An extension of the 11kV network along Lambie Drive to Wiri Station Road will improve feeder interconnection.

### A2: Roscommon Area

*Project* *Establish Wiri West zone substation*
*Driver* *Growth*
*Timescale* *2010*
*Status* *Proposed* *Estimated capital >$5 million*

The load on the existing Manurewa substation is reaching capacity. To maintain security to the area west of Manurewa substation and to supply the new subdivision developments west of Wiri substation, an option is to establish a zone substation near Roscommon Road. Another alternative is to establish a substation on an existing site Vector owns at Clendon Park. These options will be analysed before a final decision is made.

### A3: East Tamaki (Highbrook Area)

*Project* *Highbrook Industrial subdivision*
*Driver* *Growth*
*Timescale* *2006*
*Status* *In Progress* *Estimated capital >$5 million*

This is a new greenfield industrial site development where the subdivision is being reticulated at 22kV. The subdivision coincides with major roading changes at the intersection of the Southern motorway.

Demand is expected to reach 25MVA. Load on two 11kV feeders from Bairds has been transferred to East Tamaki and the lines upgraded to 22kV to provide the initial supply to the development. These two lines are connected to the 22kV switchboard at Transpower Otahuhu grid exit point.

When the motorway bridge is completed, a 22kV switchboard will be established at Highbrook. This switchboard will be supplied by two new 22kV cables laid from Transpower Otahuhu grid exit point.

### A4: Manukau - Flat Bush Area

| | | |
|---|---|---|
| *Project* | *Establishment of a new Zone substation at Flat Bush* | |
| *Driver* | *Growth* | |
| *Timescale* | *2010* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

The emerging Flat Bush township with city centre and high density multi-storey residential has a planned population of 45,000. The demand is conservatively estimated in excess of 30MVA and will, in the medium term require a new zone substation (Flat Bush zone substation).

Three new 11kV feeders are to be installed to offload existing 11kV feeders supplying Flat Bush. Two of these feeders are from Otara and one from Manukau and will be commissioned before the end of 2006. The third feeder from Greenmount is proposed for completion by end 2007.

For the short term three options are under consideration to provide the required network reinforcement pending the establishment of Flat Bush Zone substation.

1. Establish a new zone substation to the South West of Flat Bush on an already designated site owned by Vector.
2. Establish Flat Bush Zone substation close to the emerging load centre.
3. Reinforce Otara Zone substation.

Option 1 is a sub optimal solution as it is as distant from the emerging Flat Bush load centre as is the existing Otara zone substation. Option 2 acknowledges the establishment of Flat Bush zone substation at the emerging load centre and is the best long term solution as it will not only lead to considerable savings in 11kV distribution reinforcement but will also increase reliability due to shorter feeders.

Option 3 provides a means of deferring the large Flat Bush substation start up costs and also allows the new Flat Bush CBD roading to be completed before establishing the zone substation. The 11kV capacity created at Otara will, in the long term, be used to supply undeveloped industrial sites and to pick up the demand when Greenmount Power Station gas reserves decrease. Distribution feeder reinforcement from Otara to Flat Bush can be used to backup Flat Bush zone substation and vice versa.

### A5: Hans Area (Mangere Station)

| | | |
|---|---|---|
| *Project* | *Install a 3rd 20MVA transformer* | |
| *Driver* | *Growth* | |
| *Timescale* | *2014* | |
| *Status* | *Proposed* | *Estimated capital $1- 5 million* |

There are two 33/11kV 20MVA transformers installed at this substation. The 2005 peak demand is 24MVA. The projected load towards the end of the planning period is about 33MVA. Load forecast shows that Hans zone substation has reached its PCLL limit.

Short term relief can be achieved by transferring load onto Mangere East and Bairds zone substation. Further investigation will be carried out to determine the optimum network solution for the area and this project may need to be brought forward depending on the actual load.

### A6: Auckland CBD

| | | |
|---|---|---|
| *Project* | *22kV distribution backbone stage 3 & 4* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1-5 million* |

The load growth in Auckland CBD requires more capacity in distribution network to supply new loads and provide adequate security of supply. Instead of reinforcing the 11kV network, the most cost effective solution is to install 22kV distribution network and gradually transfer load from 11kV to 22kV.

The 22kV backbone distribution network stage 1 & 2 project has been completed in 2005 to supply new load (Vector Arena, etc) as well as connecting load transferred from the existing 11kV network. Stage 3 & 4 is under construction and due to be completed in mid 2006. The completion of this project is expected to meet the load growth and maintain the supply capacity and security in the Auckland CBD.

### A7: Auckland CBD

| | |
|---|---|
| *Project* | *Auckland 11kV to 22kV load transfer* |
| *Driver* | *Growth* |
| *Timescale* | *on-going* |

*Status* *Committed* *Estimated capital $1-5 million*

Following the completion of the 22kV backbone distribution network, load will be transferred from the existing 11kV network to the new 22kV network. This project will relieve the heavily loaded 11kV network and maintain the supply capacity and security in the Auckland CBD.

**A8: Newmarket Area**

| | | |
|---|---|---|
| *Project* | *Newmarket 11kV reinforcement* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1 - 5 million* |

This project is to install new cables, switchgear and rearrange the 11kV network in Newmarket area. The completion of the project is expected to relieve some heavily loaded feeders.

**A9: Remuera Area**

| | | |
|---|---|---|
| *Project* | *Remuera 11kV reinforcement* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1 - 5 million* |

This is project is to install two new 11kV feeders to reinforce existing network in Remuera. The completion of the project will relieve heavily loaded feeders from Remuera and enhance supply security.

**A10: Auckland CBD**

| | | |
|---|---|---|
| *Project* | *Fanshawe Street 22kV distribution network* | |
| *Driver* | *Growth* | |
| *Timescale* | *2007* | |
| *Status* | *Proposed* | *Estimated capital $1 - 5 million* |

This project is required to meet the long term development at Auckland city's north-western area around Fanshawe Street and the Tank Farm. It is proposed to install two 22kV new feeders from Hobson zone substation along Fanshawe Street to the Air NZ building. While an 11kV option was considered, the proposed redevelopment of the Tank Farm makes this a short term solution and costly.

**A11: Te Papa Area**

| | |
|---|---|
| *Project* | *Te Papa area 11kV reinforcement* |
| *Driver* | *Growth* |

| | | |
|---|---|---|
| *Timescale* | *2007* | |
| *Status* | *Proposed* | *Estimated capital $1- 5 million* |

Investigations indicate a security shortfall in this area. This project proposes a new 11kV cable and switchgear connecting up to the existing network. An alternative generator option is not feasible due to the size of the backstop shortfall and the cost of interconnection arrangements for the network.

**Projects planned for years 2008-2011**

**A12: Otahuhu Area**

| | | |
|---|---|---|
| *Project* | *Third Transformer at Hans substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

Additional capacity will be required to supply the Savill Drive industrial subdivision. Options for reinforcement include a third 33/11kV transformer at Hans substation or a new substation closer to the load centre. Further investigation will be carried out to determine the optimum network solution for the area.

**A13: Auckland CBD**

| | | |
|---|---|---|
| *Project* | *New 110kV switchgear and transformer at Hobson Substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

Additional 22kV capacity is required at Hobson by 2008 to supply load at Hobson. Freemans Bay substation is to be supplied from Hobson and with the retirement of the Penrose Quay cables, Quay substation load will also be supplied from this substation. A third 110/22kV transformer will be installed together with a new 110kV switchboard.

Alternatives include a third 110kV cable from Liverpool but this would require additions to the 110kV board at Liverpool. The optimal solution is the staged approach as proposed.

Establishing an 110kV switchboard at Hobson also mitigates the existing risk of a catastrophic failure at Liverpool, which is currently a potential single point of failure for the CBD supply.

**A14: Ponsonby and Chevalier Areas**

| | | |
|---|---|---|
| *Project* | *Uprating Ponsonby and Chevalier substations to 11kV* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

Ponsonby and Chevalier are the last remaining substations operating at 6.6kV. Backstopping from adjacent 11kV substations is not feasible while interconnecting transformers is not warranted as the intention is to convert this network to 11kV.

New 22/11kV transformers are required for Chevalier while existing Ponsonby transformers were replaced in 2001 with dual ratio units so are adequate for future needs. Load growth indicates that the new transformers will be required prior to 2008.

The alternative option of reinforcing 6.6kV network is considered to be a short term solution, therefore is not preferred.

### A15: Hillsborough Area

| | | |
|---|---|---|
| *Project* | *Establish Hillsborough zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

Steady load growth in the Hillsborough area over the last eight years has been accommodated by reinforcement projects on the distribution network. These reinforcements only redistribute existing network capacity without generating new capacity. The next stage is to either upgrade Onehunga substation and reinforce 11kV network in surrounding area or establish a new zone substation at Hillsborough. The Hillsborough zone substation offers the most economic long term option. This substation is to be commissioned by the end of 2008.

### A16: Greenlane Area

| | | |
|---|---|---|
| *Project* | *Establish Greenlane zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2009* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

Commercial development on Ellerslie Racecourse land coupled with general load growth in the Greenlane area, has identified the need for increased network capacity. A new zone substation is proposed for this area.

The alternative option of 11kV network reinforcement from the adjoining substation is not a cost effective solution.

### A17: St Johns Area

| | | |
|---|---|---|
| *Project* | *Establish St John zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2009* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

St Johns substation is a sub-transmission switching station. Development of the Mt Wellington Quarry and growth surrounding the Auckland University Glen Innes campus has identified a need to increase network capacity in this area.

Options considered include reinforcement of 11kV network or establishment of a new zone substation in the area. The former is not preferred due to the capacity constraints at surrounding zone substations. The establishment of St Johns zone substation is a cost effective solution which will provide the capacity and security to meet the long term growth.

### A18: Newmarket Area

| | | |
|---|---|---|
| *Project* | *Establish Mahuru substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2010* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

To meet projected growth arising from forthcoming commercial developments in Newmarket, it will be necessary to establish a new zone substation. An optimal site has been identified at Mahuru St.

Expansion of the existing Newmarket zone substation is not a preferred option. Newmarket is already a three transformer substation and further expansion not only affects fault levels but also concentrate considerable load on one site. Further investigation work is to be carried out.

### A 19: Freemans Bay Area

| | | |
|---|---|---|
| *Project* | *Extend 22kV distribution network to Freemans Bay* | |
| *Driver* | *Growth* | |
| *Timescale* | *2010* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

As part of the 11/22kV upgrade in the Auckland CBD it is proposed to extend this conversion towards Freemans Bay. The project involves installation 22kV cables and switchgear, and transferring load from the 11kV to 22kV network. The 22kV upgrade will increase the network capacity and provides a sound footing for long term growth in this area.

The alternative option of reinforcing the 11kV network is not a cost effective solution therefore is not preferred.

### A20: Auckland CBD

| | | |
|---|---|---|
| *Project* | *22kV switchboard at Victoria substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2011* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

A 22kV switchboard is to be established at Victoria substation to enable interconnection of 22kV circuits as part of the rollout of the 22kV network in the Auckland CBD. The switchboard will serve as a marshalling point for the 22kV distribution network in the area.

The alternative option is to install cables and switchgear at various locations to improve the connectivity in CBD 22kV distribution network. However, this option is not preferred due to the higher cost and difficulty in securing suitable sites in the CBD.

### Projects planned for years 2012-2016

| No | Project Description | Year | Cost |
|---|---|---|---|
| | | | |
| A21 | Hobson West switching station | 2012 | $1-5m |
| A22 | 33kV reinforcement to Hillsborough substation | 2012 | >$5m |
| A23 | Third transformer for South Howick substation | 2013 | $1-5m |
| A24 | Third transformer for Bairds substation | 2014 | $1-5m |
| A25 | 33kV reinforcement to St Johns substation | 2014 | >$5m |
| A26 | 33kV reinforcement to Onehunga substation | 2015 | >$5m |

*Table 4.5 Auckland projects planned for years 2012-2016*

## 4.5. NORTHERN CUSTOMER AREA

### 4.5.1. GROWTH IN THE NORTHERN AREA

This area covers the North Shore City, Waitakere City, and Rodney District and includes residential (both rural and suburban), commercial and industrial developments.

Most of the commercial and industrial developments are centred around the Albany Basin, Takapuna, Glenfield, Henderson and Te Atatu areas. Areas north of the Whangaparaoa Peninsula and west of Henderson are predominantly rural residential.

Overall the load growth in the region is relatively high at around 2% per annum. The highest load growth in this region is expected to occur in the Albany Basin with the development of industrial and retail businesses. With the motorway from North Shore to Orewa (which is being extended to Puhoi), it is expected that significant residential developments will take place in areas north of Silverdale. Demand in established areas is expected to remain relatively static.

### 4.5.2. ISSUES AND OPTIONS IN THE NORTHERN AREA

Projects currently underway or expected to start in the next 12 months.

#### N1: Albany Basin Area

| | | |
|---|---|---|
| *Project* | *Establish a 33kV bus at Bush Road substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital >$5 million* |

The two transformers at Bush Road are fed from the Albany grid exit point via a radial circuit and teed off from the Albany-Sunset Road circuit. Security will be enhanced by installing a new 33kV feeder from Albany to Bush Road substation and on to Sunset Road substation. The installation of a 33kV switchboard will allow better utilisation of the feeder capacity and improve operational flexibility of the network. This project is expected to be commissioned by June 2006.

#### N2: Warkworth Area

| | | |
|---|---|---|
| *Project* | *Install ex-Coatesville transformer at Warkworth* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1-5 million* |

To address capacity constraints at Warkworth substation, it is proposed to install the spare transformer from Orewa transformer in Warkworth. Warkworth substation will then have 3x7.5MVA transformers to supply a load of around 15MVA. This project will include provision for additional 33kV circuits on the 33kV bus to allow for future load growth.

#### N3: Henderson Area

| | | |
|---|---|---|
| *Project* | *Reconfigure the Henderson area 33kV network* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1-5 million* |

The presence of a number of tee off and spur line arrangements on the 33kV network in the area has resulted in performance and loading issues. It is proposed to address these issues by reconfiguring the 33kV network at Waikaukau substation and replacing the protection relays. This is an intermediate solution to improve some of the loading constraints and allows time for future 33kV reinforcements to be investigated fully.

### N4: Silverdale Area

| | | |
|---|---|---|
| *Project* | *Establish Red Beach zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital >$5 million* |

Demand is expected to grow with the extension of the Northern motorway towards the Silverdale/Orewa. A new zone substation at Red Beach is under construction. Both Spur Rd and Manly substations are very heavily loaded and require offloading. The Red Beach substation will enable Manly and Spur Rd substations to be offloaded and reinforce supply to the Red Beach area. It also allows capacity to supply the initial stages of the Silverdale North development until a new substation is constructed for this development in about 5-7 years time.

This project was delayed due to issues around the designation for the site.

### N5: Gulf Harbour Area

| | | |
|---|---|---|
| *Project* | *Lay 33kV cable to Gulf Harbour* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1-5 million* |

Load growth at Gulf Harbour has necessitated reinforcement of the network from Manly substation to maintain adequate supply security.

Load forecasts indicate that the area will require a zone substation to supply the load and a proposal is included in this AMP. A 33kV cable will be installed to the future substation site and will be operated at 11kV until the zone substation is constructed. This cable is expected to be commissioned by June 2006. Gulf Harbour substation is included in the long term plans for supplying the area.

### N6: Glen Eden Area

| | | |
|---|---|---|
| *Project* | *Establish a new zone substation at Oratia* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital >$5 million* |

Steady load increases on Waikaukau substation has flagged the need for additional network capacity in the region. Waikaukau substation has a single 7.5MVA transformer which is fully loaded. A new substation is to be established at Oratia allowing Waikaukau to be offloaded, providing backstop support to surrounding substations (Henderson Valley and Laingholm) and capacity provision for future load growth. It also makes provision for a new 11kV feeder to supply the area to the west of the substation e.g. Piha.

**N7: Albany Basin**

| | | |
|---|---|---|
| *Project* | *Additional 11kV switchgear and transformer at Mckinnon zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

Development in the Albany Basin requires additional 11kV feeder support from McKinnon substation. Additional switchgear and another 33/11kV transformer are required at McKinnon substation. The switchgear project is expected to be completed in late 2006 and the commissioning of the new transformer should be completed before May 2007.

The area surrounding McKinnon substation is largely vacant and has potential for significant load growth. Several projects are underway, such as a new Westfield shopping centre, making this reinforcement important to be able to supply the new loads.

**N8: Coatesville Area**

| | | |
|---|---|---|
| *Project* | *Coatesville 33kV Switchgear* | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

The 33kV supply to Coatesville substation is from Albany GXP. Load projections show that the 33kV cable from Albany will overload under certain contingency conditions. To remove this constraint from the network, it is proposed to install new 33kV switchgear at Coatesville substation and re-arrange the 33kV network. This will enhance the security of the 33kV network in this area.

It also makes provision for backstopping new load coming on stream around the Westgate shopping centre. There are large areas of vacant land which will be developed over the next 5-10 years and require new zone substations to be constructed to supply this load.

### N9: Albany Basin Area

| | | |
|---|---|---|
| *Project* | *33kV cables to McKinnon substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2007* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

As the load on McKinnon substation continues to grow, reinforcement of the Browns Bay 33kV ring network is required to maintain supply security. Options considered include:

- Installation of a 33kV cable from the Albany grid exit point to McKinnon substation
- Installation of a 33kV cable from the Albany grid exit point to Browns Bay substation

Load flow analysis shows that a higher level of security will result from installing two 33kV cables to McKinnon substation. As the existing 33kV cable has insufficient capacity for the projected loads due to derating from adjacent cables, this project has been brought forward to 2007. This project is being undertaken concurrently with the project described in N7 above.

### N10: Westgate Area

| | | |
|---|---|---|
| *Project* | *Massey North zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2007* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

Load growth north of Triangle Rd substation and to the north and east of the Westgate shopping centre has signalled the need for additional capacity in this area. Triangle Rd substation is fully loaded and the site is not large enough to redevelop and continue to supply the area. A new zone substation in the Westgate area allows Triangle Rd substation to be offloaded and will cater for the forecast load growth. Refer also to the project described in N8.

### N11: Takapuna Area

| | |
|---|---|
| *Project* | *Lay additional 33kV cables to Takapuna substation* |
| *Driver* | *Growth* |
| *Timescale* | *2007* |

| | | |
|---|---|---|
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

The load on the Takapuna 33kV ring continues to increase. To maintain supply security to the network in this area, 33kV reinforcement is required. The backstopping for this substation is from the Belmont 33kV circuits which are overhead lines. Because of load sharing, the loss of the one of the Belmont circuits causes the Takapuna circuit to overload.

### N12: Rosedale Rd Area

| | | |
|---|---|---|
| *Project* | *Rosedale zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2007* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

Significant development is taking place in new industrial subdivisions located in the Rosedale area. A new zone substation in the vicinity of Old Rosedale Rd is proposed to share the load increase in the Albany basin that would otherwise be fed from McKinnon substation and enhance the network capacity in the Rosedale area. The new substation also allows a higher level of backstopping to local feeders

Options considered included:

- Installation of a second transformer at East Coast Road substation
- Establishment of a new substation in Rosedale Rd

Economic analysis has shown that the establishment of a new zone substation in Rosedale Road is the preferred long term option.

### N13: Warkworth Area

| | | |
|---|---|---|
| *Project* | *Warkworth 33kV Reinforcement* | |
| *Driver* | *Growth* | |
| *Timescale* | *2007* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

Load on the existing two 33kV lines supplying Warkworth are approaching their capacity limit and reinforcement is required.

Options considered include:

- Reinforcing the existing 33kV lines
- Establishing a new 33kV line

The preferred option is to upgrade an existing 11kV line so it can operate at 33kV. This will provide three 33kV lines to reinforce Warkworth and also allow for future substations at Tomarata, Omaha, Sandspit and Warkworth Central.

The Warkworth area continues to grow with several major subdivisions being proposed in various parts of the network. To supply this load growth, additional zone substations will be required. Timing is dependent on when the developments occur. However, because of the time required to implement this project, it needs to proceed as soon as possible.

### Projects planned for years 2008-2011

#### N14: Glenfield / Birkdale Area

| | | |
|---|---|---|
| *Project* | *33kV cable reinforcement* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

The 33kV network is running out of capacity under contingency conditions. This reinforcement is required to maintain security of supply to the network. Options investigated include installing an additional 33kV circuit from Wairau or making minor alterations to the existing 33kV network and making provision for additional 11kV backstopping to the area.

#### N15: North Shore Area

| | | |
|---|---|---|
| *Project* | *33kV cable to Forest Hill substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

The load on the Wairau 33kV supply point is operating at its N-1 capacity. It is possible to reinforce the supply to this substation by constructing a new 110kV circuit from Albany. However, this reinforcement will not be required if the substation is reinforced at220kV. The installation of a 33kV cable from Sunset Road to Forest Hill and reconfiguration of the 33kV network will allow load to be transferred from Wairau 110/33kV substation to Albany 220/33kV substation and defer the 110kV reinforcement. This plan will need to be implemented if the 220kV reinforcement of Wairau substation is unavailable in time. (ref Transpower Annual Plan 2006)

#### N16: New Lynn Area

| | | |
|---|---|---|
| *Project* | *Reinforce 33kV capacity at New Lynn substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

New Lynn substation is supplied at 33kV from Hepburn Rd Substation and also from Sabulite substation. Network reinforcement of the New Lynn area is necessary to maintain supply security. Although a number of 11kV options were considered the preferred option is to reinforce the 33kV ring by adding an extra 33kV cable between Sabulite and New Lynn zone substations. There are some constraints on this solution such as very limited space for installing additional 33kV switchgear at both these substations. A final solution will require resolving these constraints.

The 11kV options were discarded because they involved complicated switching operations and only provided a short-term solution.

### N17: Kaukapakapa Area

| | | |
|---|---|---|
| *Project* | *Establish a new zone substation at Kaukapakapa* | |
| *Driver* | *Growth* | |
| *Timescale* | *2009* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

The load on the Helensville 11kV feeder to Kaukapakapa continues to show steady increase and is approaching its full load capacity. The 11kV feeder is very long and has poor reliability. This project is to resolve the loading on this long rural feeder by establishing a new zone substation at Kaukapakapa. The substation will provide capacity to offset the load increases, allow offloading of Helensville substation, partition the 11kV feeder to improve its performance statistics and backstop the adjacent zone substations.

### N18: Greenhithe Area

| | | |
|---|---|---|
| *Project* | *Establish a new zone substation at Greenhithe* | |
| *Driver* | *Growth* | |
| *Timescale* | *2009* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

The Greenhithe area is largely rural but this is rapidly changing as new motorways are developed through the area. This area is supplied by long 11kV feeders from remote zone substations which are very heavily loaded and require reinforcement. Extending the 11kV network does not provide sufficient security of supply or an economic solution to the issue. It is proposed to establish a new zone substation on an existing site to the supply the load to this developing area.

### N19: Whangaparaoa Area

| | | |
|---|---|---|
| *Project* | *Establish a new zone substation at Gulf Harbour* | |
| *Driver* | *Growth* | |
| *Timescale* | *2009* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

Demand on the Whangaparaoa Peninsula has been growing steadily and due to its geographic layout, backup supplies are limited. Over recent years, incremental capacity enhancements such as the dual rating of zone substation transformers have been implemented to defer major reinforcement.

Additional 33kV and 11kV capacity is now required to maintain the level of security. A new zone substation is to be established at Gulf Harbour, utilising the 33kV cable recently laid from Manly zone substation to the Gulf Harbour zone substation site (refer N5).

**N20: Swanson Area**

| | | |
|---|---|---|
| *Project* | *Establish a new zone substation at Waitakere* | |
| *Driver* | *Growth* | |
| *Timescale* | *2010* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

The Swanson area continues to develop and the Swanson zone substation is approaching full capacity. This substation has several very long rural feeders which have poor reliability. Rather than reinforce this substation with an additional transformer, it has been decided to construct a new zone substation at Waitakere. This substation will offload Swanson substation and allow for ongoing growth in this area. The new substation will allow some of the long 11kV feeders to be shortened, improving network performance.

Once completed, it is planned to extend the 33kV line from this substation to Waimauku, providing sub-transmission security to both substations.

**N21: Henderson Area**

| | | |
|---|---|---|
| *Project* | *Install second transformer at Keeling Rd zone substation* | |
| *Driver* | *Growth* | |
| *Timescale* | *2010* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

The load on Keeling Rd substation continues to increase with commercial development in the Henderson area. This substation was commissioned in 2003 with one transformer but with provision for a second transformer once the load grew. The load will be monitored each year to determine the exact timing of this reinforcement.

**N22: Greenhithe / Hobsonville Area**

| | |
|---|---|
| *Project* | *Install 33kV line between Greenhithe and Hobsonville* |
| *Driver* | *Growth* |

*Timescale* *2010*
*Status* *Proposed* *Estimated capital $1-5 million*

The area between the proposed Greenhithe substation and Hobsonville substation is growing and is expected to develop considerably over the next few years. This is a result of the new motorway construction and land being made available for development. It is planned to install a new 33kV circuit between Greenhithe substation and Hobsonville substation. This circuit will provide a 33kV backstop to the new Greenhithe substation described in N18 above. It will provide interconnection between the Albany and Henderson GXPs and provide more flexibility in supplying the network.

### N23: Snells Beach Area

*Project* *Sandspit Rd zone substation*
*Driver* *Growth*
*Timescale* *2010*
*Status* *Proposed* *Estimated capital $1-5 million*

Snells Beach load continues to grow as land is made available for subdivision. Snells Beach is supplied by a single 33kV line from Warkworth substation (see N13 above). Due to its remoteness, backstopping Snells Beach substation at 11kV is limited. It is proposed to install another substation in the Sandspit area. The two substations will then provide mutual backstopping.

### N24: Henderson Area

*Project* *Keeling Road substation to Woodford substation 33kV tie*
*Driver* *Growth*
*Timescale* *2010*
*Status* *Proposed* *Estimated capital $1-5 million*

The Henderson area is supplied at 33kV from the Henderson and Hepburn Rd GXPs. This area is continuing to grow and the existing 33kV network is becoming constrained. To improve the network security, a 33kV tie line between the Woodford and Keeling Road substations is proposed. Currently these substations are supplied by single circuit 33kV radial lines. The tie line will enhance the security of both substations. Options for reinforcement are constrained by the existing GXP locations.

**Projects planned for years 2012-2016**

| No | Project Description | Year | Cost |
|---|---|---|---|
| | | | |
| N25 | South Titirangi zone substation | 2011 | >$5m |
| N26 | Tomarata zone substation | 2011 | $1-5m |
| N27 | 33kV reinforcement to Manly substation | 2011 | >$5m |
| N28 | 33kV reinforcement to Orewa substation | 2012 | >$5m |
| N29 | Wainui zone substation | 2012 | >$5m |
| N30 | 33kV reinforcement to Northcote substation | 2013 | $1-5m |
| N31 | Simpson zone substation second transformer | 2013 | $1-5m |
| N32 | Hobsonville East zone substation | 2014 | >$5m |
| N33 | Waiwera zone substation | 2014 | >$5m |
| N34 | 110kV reinforcement to Wairau substation | 2014 | >$5m |
| N35 | Glenvar zone substation (Long Bay) | 2015 | >$5m |

*Table 4.6 Northern projects planned for years 2012-2016*

## 4.6. WELLINGTON CUSTOMER AREA

### 4.6.1. GROWTH IN THE WELLINGTON AREA

The Wellington area covers the cities of Wellington, Porirua, Lower Hutt and Upper Hutt.

Wellington City is one of the major metropolitan centres in the country with high density commercial developments. It is also the seat of Government and contains a number of Government departments.

The Wellington CBD is business and retail centre for the region although there are significant retail centres in Lower Hutt, Porirua, and Upper Hutt.
Apart from the city CBD's there is widespread residential load distributed throughout the area. These are interspaced with pockets of commercial and light industrial customers.

Overall demand growth in the region is expected to be low with most of the growth expected to take place around the Wellington CBD area. Residential load is increasing in Churton Park, Woodridge subdivision, Whitby and the Aotea Block, Porirua.

#### 4.6.2. ISSUES AND OPTIONS IN THE WELLINGTON AREA

Projects currently underway or expected to start in the next 12 months

**W1: Wellington CBD**

| | | |
|---|---|---|
| *Project* | University 33kV Cable reinforcement | |
| *Driver* | *Growth* | |
| *Timescale* | *2006* | |
| *Status* | *Committed* | *Estimated capital $1-5 million* |

The capacity of the University Zone substation is limited by sections of 33kV gas filled cable. These are being replaced with higher capacity XLPE cable. Non network options were considered, but were not able to provide a satisfactory solution.

**Projects planned for years 2008-2011**

**W2: Wellington CBD**

| | | |
|---|---|---|
| *Project* | *Frederick Zone Substation (Te Aro) 11kV network reinforcement* | |
| *Driver* | *Growth* | |
| *Timescale* | *2007-2008* | |
| *Status* | *Proposed* | *Estimated capital $1-5 million* |

Due to the load growth of Te Aro, reinforcement of the 11kV network supplying this area is required to maintain security. Two new 11kV feeders will be installed in Nairn St substation and the network configured to transfer 12MVA of Frederick St substation load. This will defer the 33kV upgrade to Frederick St substation. This strategy will also defer Bond Zone substation. Non network options were considered, but were not able to provide a satisfactory solution.

**W3: Wellington CBD**

| | | |
|---|---|---|
| *Project* | *Reinforcement of the 33kV capacity to Terrace & Moore Zone substations* | |
| *Driver* | *Growth* | |
| *Timescale* | *2008-2010* | |
| *Status* | *Proposed* | *Estimated capital >$5 million* |

The ratings of existing 33kV cables to Terrace and Moore St substations are less that the zone substation transformer capacity. To gain full capacity from the transformers the two existing 33kV cables to each zone substation will be run in parallel and a new 33kV XLPE cable of rating comparable to the transformer added. This will increase the capacity (utilisation) of the zone substations and mitigate the consequential risk of simultaneous multiple failures of the aging 33kV gas cables.

Non network options were considered, but were not able to provide a satisfactory solution.

The new 33kV feeders to Terrace and Moore zone substations will be supplied from Central Park GXP instead of Wilton GXP. This solution will mitigate some of the earthquake risk as the existing Moore and Terrace 33kV cables cross the earthquake fault line. It adds benefits by providing diversity of supply to these key Wellington CBD substations.

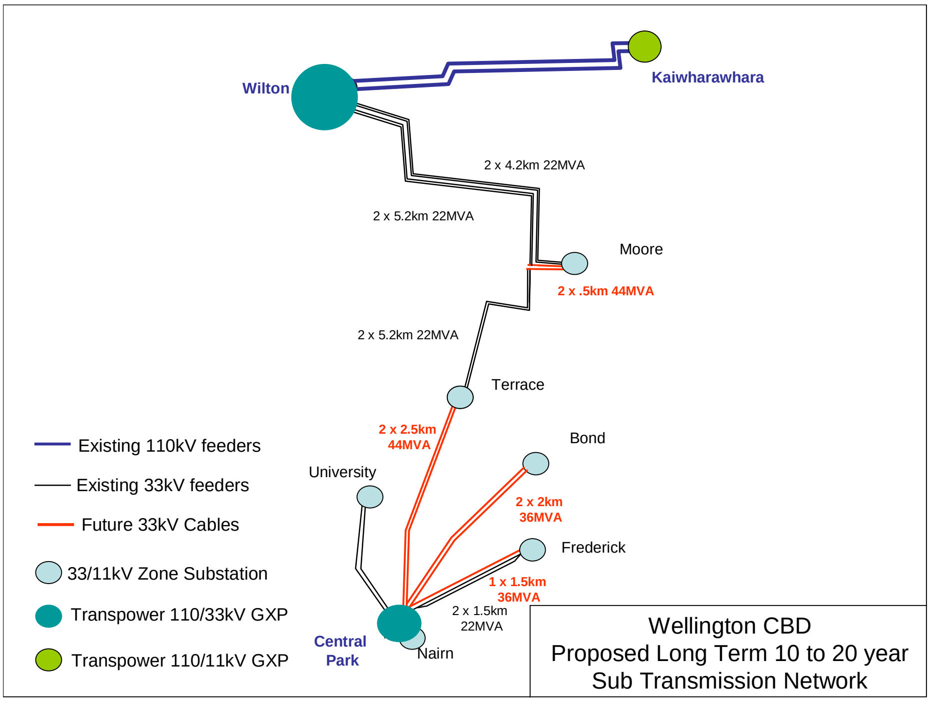



*Figure 4.6 Reinforcement of Terrace and Moore Zone Substations*

## W4: Wellington CBD

*Project* *Reinforcement of the Terrace and Moore 11kV networks*
*Driver* *Growth*
*Timescale* *2009-2011*
*Status* *Proposed* *Estimated capital $1-5 million*

Reinforcement of the 11kV network in the Wellington CBD in line with demand growth forecasts in order to maintain supply security.

### Projects planned for years 2012-2016

| No | Project Description | Year | Cost |
|---|---|---|---|
| | | | |
| W5 | 33kV reinforcement to Palm Grove substation | 2013 | $1-5m |
| W6 | Bond Street zone substation | 2014 | >$5m |

*Table 4.7 Wellington projects planned for years 2012-2016*

# 4.7. CHANGES FROM PREVIOUS PLAN

## 4.7.1. AUCKLAND AREA

***Greenlane Substation***

The project previously identified as a new substation in the Penrose area has been named Greenlane substation.

## 4.7.2. NORTHERN AREA

The 33kV reinforcement projects previously grouped as one project, have been split out and separately identified.

***Triangle Rd substation***

The project previously identified to install larger transformers at Triangle Rd substation, has been deleted and replaced with a new zone substation at Massey North (Westgate). This better reflects the growth patterns in this area.

***Whenuapai Substation***

The project previously called Whenuapai substation has been replaced with a new zone substation at Hobsonville East.

***North Titirangi substation***

The project previously identified to replace the transformers at Atkinson Rd substation with larger units has been replaced with a new zone substation at South Titirangi. This provides a better long term solution.

***Warkworth 33kV Line and Tomarata substation***

These are new projects which were not in the previous plan and are required because of continued load growth in the Wellsford and Warkworth areas. The Tomarata substation will be supplied from the new Warkworth 33kV line.

***Waitakere substation***

This is a new project which replaces the project to install a second transformer at Swanson substation. This provides a better long term solution.

***Waiwera and Glenvar substations***

These two new substations were not in the previous plan. Extension of the motorway past Puhoi is expected to increase residential growth in the Waiwera area. Land made available for development in the Long Bay area mean will also require additional network capacity

***33kV line extensions***

Two new sub-transmission projects have been included in the plan. One links Hobsonville and Greenhithe substations while the other links Keeling Rd and Woodford substations. Both are to maintain adequate supply security.

### 4.7.3. WELLINGTON AREA

***Ripple injection plant at Melling***

The project to install a ripple plant at Melling has been removed. Options for this project are still being evaluated.

***Trentham – Haywards distribution network***

The previous solution was to reconnect one of the two 33kV Haywards-Trentham circuit to form an 11kV interconnection between the Haywards 11kV and Trentham 11kV switchboards.

This solution has been overtaken by a proposal to install a 33/11lV transformer at Haywards (by Transpower) to improve the security of supply in the area.

## 4.8. TRANSFORMER REDEPLOYMENT

To ensure optimum utilisation of existing assets, transformers removed from substations are relocated to other substations if performance and condition criteria are met and it is economic to do so. These are evaluated on a project by project basis.

## 4.9. TRANSPOWER SUPPLY POINTS

Transpower supplies the Vector network through 22 grid exit points. Transpower and Vector liaise on works programmes to ensure priority and critical issues are addressed.

### 4.9.1 ISSUES AND OPTIONS AT THE GRID EXIT POINTS

**Central Park Grid Exit Point**

Transpowers upgrade project completed.

**Hepburn Grid Exit Point**

| | |
|---|---|
| *Driver* | *Security of supply* |
| *Timescale* | *2006* |
| *Status* | *Committed* |

The existing transformer capacity at Hepburn is insufficient to meet the Transpower security standard despite having ample back up capacity from within the 33kV and 11kV networks.

A proposal to install a new 110/33kV 120MVA transformer at Hepburn has been agreed. A second new 110/33kV 120MVA transformer is also planned to be installed to replace an existing aging unit.

**Albany Grid Exit Point**

| | |
|---|---|
| *Driver* | *Security of supply* |
| *Timescale* | *2006* |
| *Status* | *Committed* |

The existing transformer capacity at Albany is insufficient to meet the Transpower's security standard despite having ample backup capacity from within the 33kV and 11kV networks. A proposal to install a third 220/33kV 120MVA transformer at Albany has been agreed with Transpower.

**Penrose Grid Exit Point**

| | |
|---|---|
| *Driver* | *Security of supply* |
| *Timescale* | *> 2006* |
| *Status* | *Proposed* |

There are current concerns over the security of the 220kV supply into Penrose. Options to address this issue are currently being investigated by Transpower.

**Silverdale Grid Exit Point**

| | |
|---|---|
| *Driver* | *Security of supply* |
| *Timescale* | *2007* |
| *Status* | *Committed* |

Silverdale GXP was commissioned in 2003. A single 220/33kV 100MVA transformer was installed. Load flow analysis shows that the 33kV backup capacity will be exceeded in 2007. It is proposed to install a second 220/33kV 120MVA transformer to improve the security of supply.

**Haywards Grid Exit point**

| | |
|---|---|
| *Driver* | *Security of supply* |
| *Timescale* | *2008* |
| *Status* | *Proposed* |

The existing single 110/33kV transformer and the single 110/11kV transformer do not meet Vector's security criteria. It is proposed to install a 33/11kV transformer to improve the security of supply to both the 33kV and 11kV buses.

Further details of Transpower's plans can be found in their Annual Planning Report.

## 4.10. COMMUNICATION NETWORK

Vector's communication network provides a communication path for various applications and operational services such as:

Protection signalling
Automation
SCADA
Metering and load control
Remote equipment monitoring and maintenance
Operational Telephony
Substation Security
Transfer of large amount of power system data available within modern microprocessor based IEDs

The communication network physical layers are mainly based on the copper wire telephony type pilot and optical fibre cables. Third parties communication networks (UHF/VHF, GSM/GPRS, digital microwave, Ethernet/IP) are used to extend the network coverage.

Vector is moving its operational services to an IP based communication network. Digital communication over the pilot cable has been successfully implemented using g.shdsl communication technology.

New substations built are interconnected to the communication network via optical fibres. The existing pilot cables that have reach end of their technical life are being replaced with optical fibre cables.

## 4.11. CUSTOMER INITIATED NETWORK DEVELOPMENTS

Customer initiated capital expenditure is driven primarily through the growth of the city, and with North Shore and South Auckland areas being some of the fastest growing areas in New Zealand, Vector experiences a significant level of customer initiated projects.

- New subdivisions account for around 40% of customer activity, including reticulation and streetlighting for commercial and residential developments
- New service connections in areas where reticulation already exists or only requires moderate extension account for a further 20% of expenditure
- Customer substations are installed for commercial customer's with loads unable to be supplied from the low voltage reticulation
- Major customer developments (such as Highbrook) and upgrades (such as Pacific Steel, etc)

The remainder of the expenditure is divided between:

- Cable relocations; mainly driven by road widening projects
- Capacity changes; where transformer connected customer's require an upgrade or downgrade in capacity
- Low voltage reinforcements; where a change in customer capacity requires an upsizing of the low voltage network

The demands from the customer led initiatives are included in the load forecasts and influence the timing and priority of capital works in the Vector network.

Forthcoming projects identified but have yet to be fully committed to a formal plan are listed as follows:

- Silverdale North development. This is an extensive housing development and business park expected to accommodate in excess of 40,000 people by 2021.
- Albany Basin: An ongoing development in the Albany Basin which will eventually comprise of 6000 residents and 15,000 employees
- Flat Bush: Manukau City Council have indicated an extensive residential and commercial development in the Flat Bush area eventually accommodating 40,000 people by 2020
- Newmarket: Ongoing development involving the Westfield Plaza
- Mt Wellington Quarry: Residential development associated with the disused Mt Wellington quarry

## 4.12. EXPENDITURE FORECAST

The capital expenditure plan that corresponds to the asset replacement, refurbishment and development projects is given in Table 4.8. These forecasts are based on known and current solutions only. Extensive analysis of alternate approaches, including load management, increased asset utilisation through advanced technology etc is expected to enable the forecast expenditure to be reduced.

Network projects include:

- Compliance projects where the main drivers are regulatory, environmental, health and safety etc

- Growth projects where the main drivers relate to growth in demand

- Performance projects where the main driver is replacement of assets in order to improve network reliability and/or reduce maintenance costs.

- Replacement projects where the main driver is replacement of assets that are at the end of their useful life, or where the whole of life maintenance and remedial costs are higher than the replacement costs. Risk analysis is another key driver in this category

- Overhead Improvement Programme relates to undergrounding projects in the Auckland distribution area initiated in accordance with the Auckland Electricity Consumer's Trust Deed

Table 4.8 and Figure 4.8 show the proposed network expenditure over the next ten years.

| Expenditure Category ($ millions) | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Growth | $41 | $71 | $72 | $63 | $68 | $63 | $61 | $61 | $64 | $56 |
| Replacement | $66 | $51 | $50 | $63 | $61 | $76 | $72 | $84 | $74 | $76 |
| Customer | $39 | $38 | $40 | $39 | $39 | $39 | $39 | $39 | $39 | $39 |
| Compliance | $8 | $7 | $7 | $2 | $2 | $2 | $2 | $2 | $2 | $2 |
| Performance | $4 | $2 | $2 | $1 | $1 | $1 | $1 | $1 | $1 | $1 |
| Overhead Improvement Programme | $11 | $11 | $11 | $11 | $11 | $11 | $11 | $11 | $11 | $11 |
| **GRAND TOTAL** | **$169** | **$180** | **$181** | **$180** | **$183** | **$193** | **$186** | **$198** | **$191** | **$185** |

*Table 4.8 Forecast Capital Expenditure Budget*

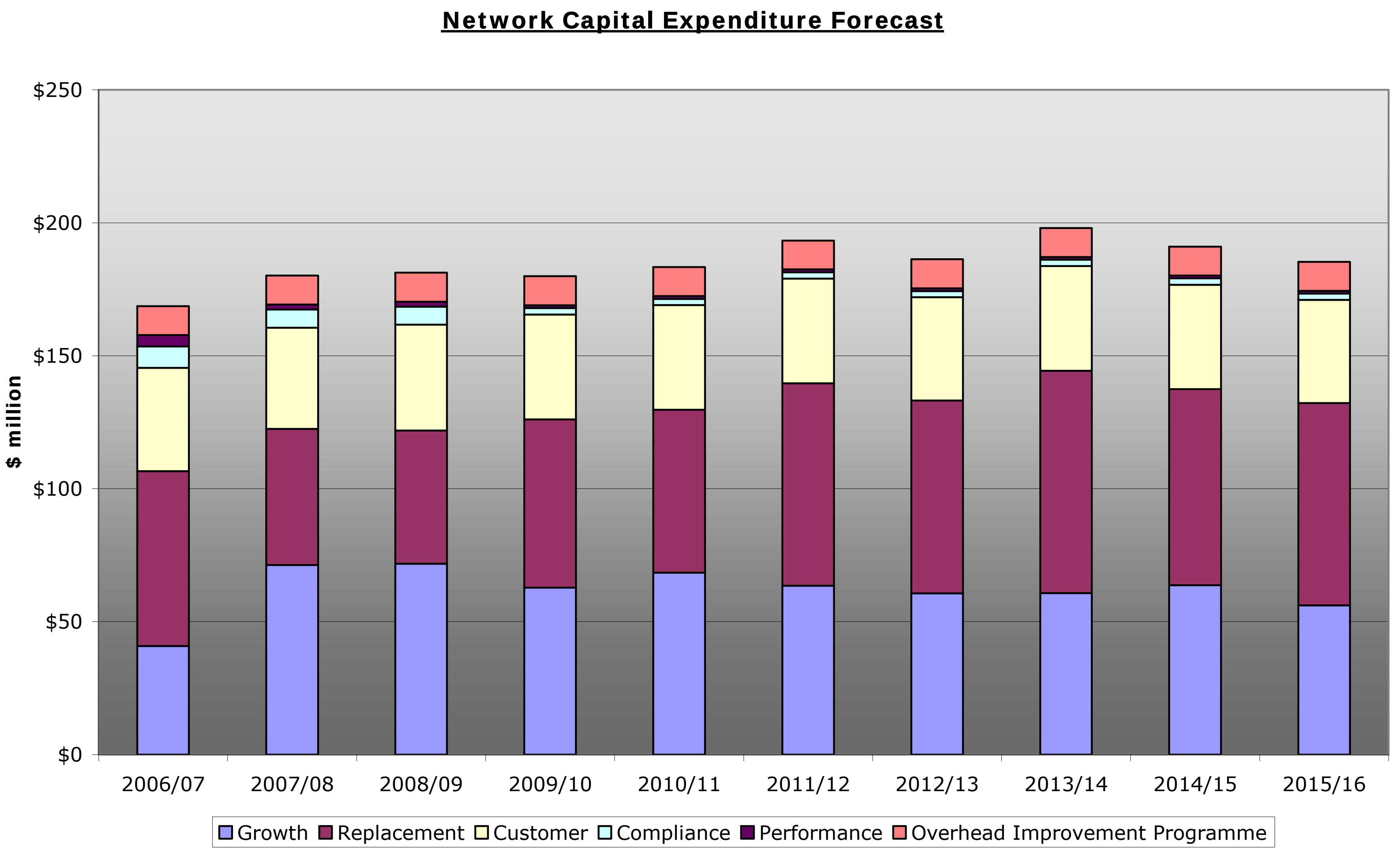



*Figure 4.7 Forecast Capital Expenditure Chart*

# 5. LIFE CYCLE ASSET MANAGEMENT

## 5.1. ASSET MAINTENANCE AND RENEWAL STRATEGY

Vector operates and manages a wide range of assets from 110kV power transformers to 230V service connections. Each asset is managed in terms of risk and criticality with the optimum maintenance, refurbishment and replacement strategies defined.

The foundation of the asset maintenance plan is the customer service targets, based on customer type and service expectations. The resulting maintenance refurbishment and replacement strategies for each asset ultimately address the impact on customer service targets, power quality, health and safety implications, reliability management and cost.

This section gives an overview to Vector's approach to maintenance, asset refurbishment and replacement.

In general, across all network areas, preventative maintenance on Vector's network consists of the following:

- Routine asset inspections, condition assessments, servicing and testing of assets
- Evaluation of the results in terms of meeting customer service levels, performance expectations, risks etc
- Repair, refurbishment or replacement of assets when required

Detailed maintenance criteria for each asset are documented in Vector's maintenance instructions and standards together with the Contractors documentation. These include the inspection, testing and condition assessment requirements for each asset, together with decision guides on the appropriate countermeasures.

The maintenance criterion receives constant attention and review to ensure that Vector's practice and policy reflect the optimal needs of individual assets or areas. Assets that are considered to have a greater risk of failure or the consequence of failure are deemed too great have enhanced preventative and condition based maintenance schedules.

As a general philosophy, the timing of any individual asset or area replacement is based on the following condition and performance assessments:

- As the asset approaches the end of its useful life and is no longer suitable for its application, in terms of asset functionality or customer requirements

- When the asset presents an unacceptable risk regarding its function, environment, or to the safety of public or operating and maintenance personnel

- For economic reasons the whole of life maintenance or remedial costs are higher than the expected replacement costs

When the requirement arises for an individual asset or area to undergo replacement, the opportunity is taken to consider an upgrade and/or capacity increase to meet future supply requirements.

## 5.2. OVERHEAD NETWORK

### 5.2.1. ASSET DESCRIPTION

*Overhead Lines*

The overhead system consists of 28km of 110kV line, 488km of 33kV line, 3km of 22kV (link with Counties Network), 4,483km of 11kV line and 7,996km of 400V line. There is still 26 km of 6.6kV in Auckland and this is being progressively uprated to 11kV. Over 155,000 poles support the overhead distribution network, of which 22% are wood and 78% concrete. There are also 120 steel towers in the northern network.

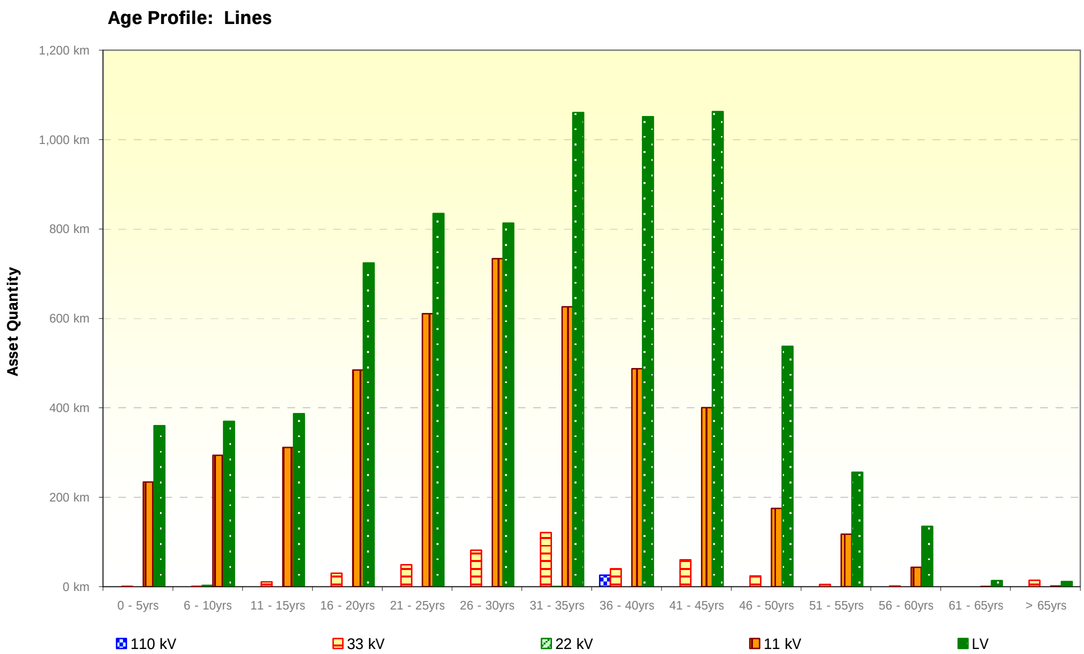



*Figure 5.1* Overhead lines age profile

The poles have an average age of 29 years; however there are a large number of poles older than 40 years of age. The expected life of a wood pole is 40 years and 60 years for concrete. Relatively few new wood poles have been installed since the early 1960's. In the 1980's Vector's Auckland network installed pole nails on wood poles as a way of extending the life of the poles. This was very successful and some of these poles are still in service today. In general poles in the Wellington network are in poor/good condition, with a large number of wood poles being replaced recently. Poles in the Auckland network are in fair/good condition, and poles in the Northern network are in good condition.

The circuits supported by the steel towers range in voltage from 110kV to 400V with most having been in service for more than 70 years. A recent inspection of the towers revealed that the majority show severe corrosion of the hot dip galvanised braces and bolts together with ground-line corrosion of some main members. While there have been no unassisted tower failures, structural modelling has shown that their mechanical integrity has been severely compromised with the result that they pose an unacceptable security of supply and a safety risk.

Conductors vary across the overhead network, but are predominantly Copper (Cu), All Aluminium Conductor (AAC) and Aluminium Conductor Steel Reinforced (ACSR) conductors. New line reconstruction utilises All Aluminium Alloy Conductor (AAAC). Low Voltage Aerial Bundle Conductor (LVABC) and Covered Conductor Thick (CCT) for 11kv lines are used in areas susceptible to tree damage, where the trees can not be cut or removed due to council restrictions. There is a small section of High Voltage Aerial Bundle Conductor (HVABC) which was installed 12 years ago.

Although the material proved to be effective for improving reliability, it was not continued with because of high installation costs. Conductors in all networks are generally in good condition.

The crossarms on the networks are mostly hardwood (99%), with the remaining few being steel. The crossarms on the Wellington and Auckland networks are in fair condition and the crossarms on the Northern network are in poor condition.

Fault passage indicators, both remote and local have been installed at most major tee offs on the overhead lines. All pole mounted fault passage indicators are in poor condition and are being replaced with conductor mounted units.

*Overhead Switches*

There are 1763 Air Break Switches (ABS) and 70 $SF_6$ fill switches for breaking the overhead network into sections. Most of the ABS's are more than 20 years old and are not cost effective to refurbish. ABS's on all networks are in fair to poor condition. The vast majority of the $SF_6$ switches are less than 5 years old and all are in excellent condition.

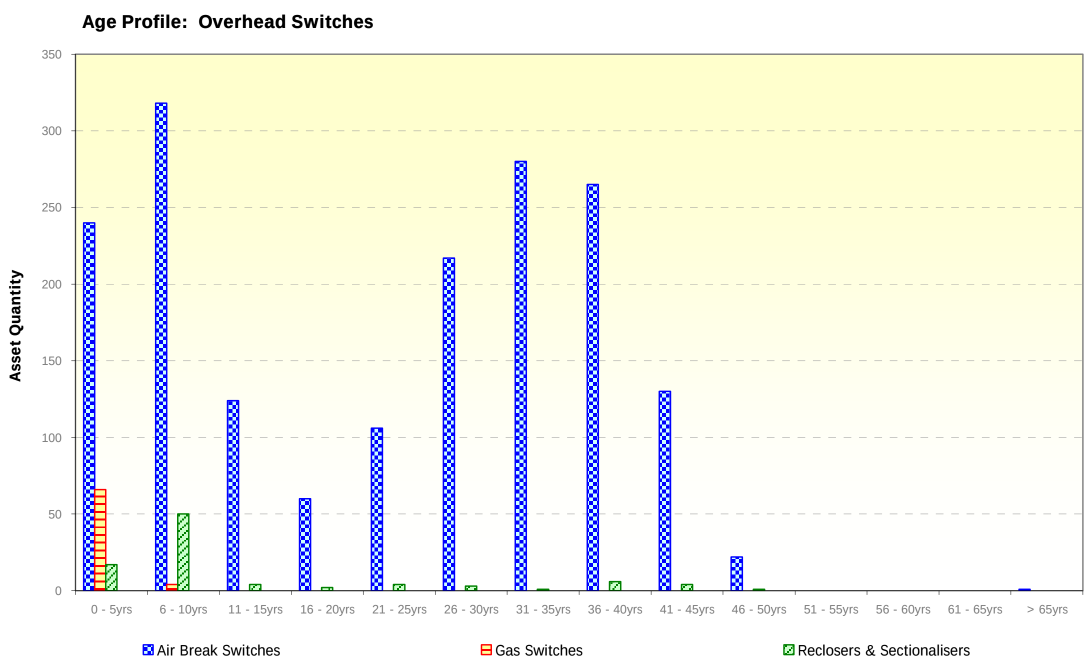



*Figure 5.2* Overhead switches age profile

There are 92 oil filled, $SF_6$ and vacuum reclosers and sectionalisers on the network. The oil filled reclosers are in poor condition and generally found on the Auckland and Northern networks. All other reclosers are less than 10 years old and in excellent condition.

### 5.2.2. ASSET MAINTENANCE

Maintenance of the overhead network is a mix of reactive (based on faults) and condition monitoring to drive the preventative maintenance programs.

Planned maintenance includes;

- Annual visual line patrol of poles and hardware checking for safety issues and hardware about to fail, including clearance checking to meet the Electrical Code of Practice.

- Five yearly condition assessments of wood poles using ultrasonic methodology. This includes considering the top load applied to poles, to determine if the pole is serviceable.

- Five yearly detailed visual inspection of all poles, towers and hardware. For all heavily loaded concrete poles a serviceability check considering the loads applied to poles is also completed.

- Proactive vegetation management and local council vegetation management agreements in line with the tree regulations.

- Five yearly measurements of earth sites.

- Three yearly ABS visual inspection and manual operation is carried out. A thermovision camera is used to check the contact and connections under load.

- Nine yearly visual inspections of $SF_6$ switches, includes operation, gas pressure checks.

- Five yearly inspections and testing of reclosers and sectionalisers.

- Five yearly inspections and testing of fault passage indicators, including battery replacement.

- Corona camera inspections are being trialled on a sample of 110kV, 33kV insulators and on some 11kV feeder with unknown faults. This is ongoing and the results are currently being analysed.

A problem has been identified with some types of 11kV Expulsion Drop Out (EDO) fuses that are overheating and have the potential to catch fire. This appears to be caused by different metals used at the pivot point on the fuse holder, which are seizing and stopping the fuse holder from falling. This is being monitored and if warranted a replacement program will be put in place.

One brand of 400V service fuses has been overheating and failing. This problem has also been found in Australia. The exact cause is yet to be determined, but it is believed that it is starting with the connections overheating, because of water in the jumper leads. These are no longer used and are being replaced when found.

A safety risk has been identified with old connectors and a replacement program has been implemented. Many connectors 11kV and 400V are now over 40 years old. A number of sample tests were carried out on low voltage connectors. Many were found to be at the end of their life. A programme is now in place to replace all low voltage connectors over the next six years.

### 5.2.3. ASSET RENEWAL AND REFURBISHMENT

There is a mix of replacement strategies due to the diverse range of assets on the overhead network and of differing critically.

*Bulk Asset Replacement*

Areas for a bulk replacement of overhead assets are determined by mapping equipment defects found during asset condition surveys, equipment failures, and considering the age profile of the equipment. The number of customer's on feeders also assists with prioritising areas. Equipment in these areas with less than ten years of expected life is replaced.

*Steel Towers*

Over the next 2 years all steel towers will be refurbished with corrosion abrasive blasting and any severely damaged members replaced. The entire structure will then be painted with the paint that has been adopted by Transpower for their tower refurbishment work. The paint is expected to provide a period of 20 years with low maintenance. At the end of this period maintenance will consist of cleaning and repainting.

*Poles*

Poles are tested for their serviceability as set out in HB C(b)1:2006 and AS/NZS 4676:2000. Wood poles are also tested using ultrasound method. Any pole not meeting serviceability requirements are programmed for replacement.

An accelerated pole testing program has been implemented in Wellington resulting in over 3000 pole (both wood and concrete) changes scheduled to be completed over the next two to three years.

*Crossarms and Hardware*

Crossarms are identified for replacement from the detailed line inspections. Crossarms installed before 1990, were of class 2 and tended to have a life of up to 40 years. Class 3 crossarms installed in the 1990's are found to be in need of replacement after 20 years. Only class 1 or 2 are now installed on the network. Crossarm replacements are a particular focus in the northern network

Pin type insulators are no longer used for 33kV and 11kV insulators. All replacements are of the solid core post type as they provide a higher level of reliability in pollution environments and lightning prone areas.

*Conductors*

Conductors are programmed for replacement based on condition assessments and analysis of fault history. Numbers of joints per span or signs of damage are used to determine the need for replacement. 11kV spur lines of 16mm2 copper are being replaced with AAAC conductors and fused where possible.

*Air Break Switches*

Air Break Switches (ABS) are replaced based on condition assessments. Before replacement units are installed an evaluation is undertaken to determine if the switch is needed at all and if so it is in the optimum position. All replacements are with $SF_6$ switches. The old ABS's are not refurbished.

*Reclosers*

A number of the older oil filled reclosers are now at the end of their useful life. Some of the units are now being serviced every two years and are no longer economic. These are being replaced with vacuum reclosers.

*Programs of work*

Refurbishment and replacement of assets on the overhead network is an ongoing program with budget allocated for each year. Work packages are developed by each of Vector's contracting partners based on results from the condition inspections network performance.

## 5.3. SUBTRANSMISSION CABLES

### 5.3.1. ASSET DESCRIPTION

The subtransmission network consists of 685km of cables and lines rated at 110kV, 33kV and 22kV as detailed below.

| Cable Type | 110kV | 33kV | 22kV | Total Length (km) |
|---|---|---|---|---|
| Underground PILC | 0 | 33 | 68 | 101 |
| Underground XLPE | 28 | 206 | 24 | 258 |
| Underground Fluid Filled | 26 | 175 | 19 | 220 |
| Underground Gas Pressurised | 20 | 74 | 12 | 106 |
| Total by Voltage | 74 | 488 | 123 | 685 |

*Table 5.1 Subtransmission cables by lengths and voltage*

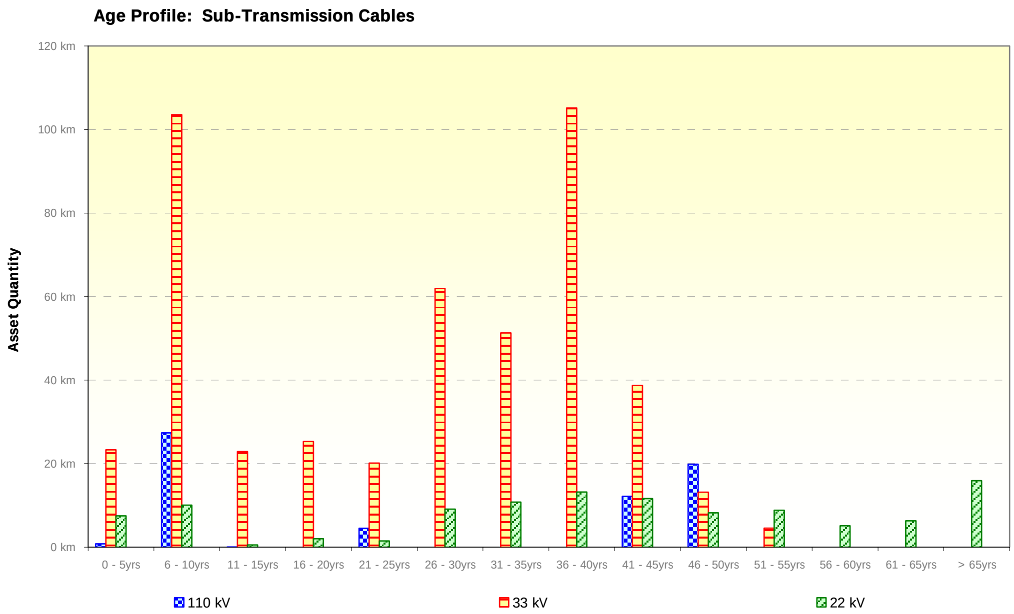



*Figure 5.3* Subtransmission cable age profiles

On average the subtransmission cables are 27 years old and generally they are in good to very good condition. However, there are some of the older gas filled cables that are starting to exhibit signs of ageing with increasing frequencies of gas leakage. This is closely monitored and a number of these cables have been flagged for replacement within the planning period.

### 5.3.2. ASSET MAINTENANCE

Due to the criticality of these cables to the overall system security and reliability of the network, there are regular inspection and condition monitoring activities undertaken, such as;

- Regular route patrols, with enhanced frequency in parts of the CBD, to identify any potential problems in the Auckland network
- Proactive work with external service providers to prevent third party damage
- Annual cable termination inspections and thermographics
- All gauges and transducers associated with pressure cables are checked at 6 monthly intervals
- Serving tests are conducted every 2 years to prove the integrity of the cables outer sheaths.
- On-line and off-line Partial discharge testing is being trialled on cables where previous fault history indicates potential problems.

Over and above routine maintenance all fluid filled and pressurised gas cables are continuously monitored via the centralised SCADA system, to provide early warning alarms of falling pressure, and associated leaks can be rectified before a failure has the chance to occur.

The main maintenance related issues with these cables are gas leaks and serving faults. These are repaired as and when is necessary with the fault history being used as an input into the replacement decision making process.

### 5.3.3. ASSET RENEWAL AND REFURBISHMENT

Subtransmission cable replacement is determined by a combination of condition and performance assessments relating to the risk of loss in functionality, analysis of failure and defect rates, associated costs of repair, failures and condition tests.

The anticipated subtransmission cable replacement program over the next ten years is detailed below, however this program is subject to change as improved condition information becomes available, performance expectations are changed and or changes to the network design and configuration.

Year 2006/07 projects

- Upgrade the Distributed Temperature Sensing system on the Auckland network.

Years 2007/08 – 2010/11 projects

- Install Distributed Temperature Sensing on the Wellington network.
- Replace both Balmoral, Auckland 22kV solid cables.
- Replace one Evans Bay, Wellington 33kV gas cable.
- Replace both Sandringham, Auckland 22kV solid cables
- Replace both Parnell, Auckland 22kV solid cables.
- Replace both Ponsonby, Auckland 22kV gas/solid cables.
- Replace both Chevalier, Auckland 22kV oil/solid cables.
- Replace the Palm Grove, Wellington 33kV gas cable.

Years 2011/12 – 2015/16 projects

- Replace both Maidstone, Wellington 33kV gas cables.
- Replace both Hataitai, Wellington 33kV gas cables.
- Replace the Liverpool to Quay, Auckland 22kV gas cable.
- Replace both Ira Street, Wellington 33kV gas cables.
- Replace the Takanini to Maraetai, Auckland 33kV oil cables.
- Replace both Karori, Wellington 33kV gas cables.
- Replace three McNab Street, Auckland 33kV solid cables.
- Replace both Onehunga, Auckland 33kV solid cables.
- Replace both Petone, Wellington 33kV gas cables.

## 5.4. DISTRIBUTION CABLES

### 5.4.1. ASSET DESCRIPTION

*Distribution cables*

The underground distribution network is via 5km of 22kV, 4,048km of 11kV, 9km of 6.6kV and 10,153km of 400V cables.

The 6.6kV and the older 11kV cables are PILC or PIAS construction while the more recent 11kV and the 22kV cables are XLPE insulated. The PILC cables are in good condition although some early 1950s cable has been failing. There a concern that the PIAS cable may be subject to corrosion of the extruded aluminium sheath and while a section has been replaced in the past 12 months there is no evidence yet that this is likely to become a major problem. The XLPE insulated cables are in good condition with the exception of the early natural polyethylene cables which are prone to develop water trees and fail.

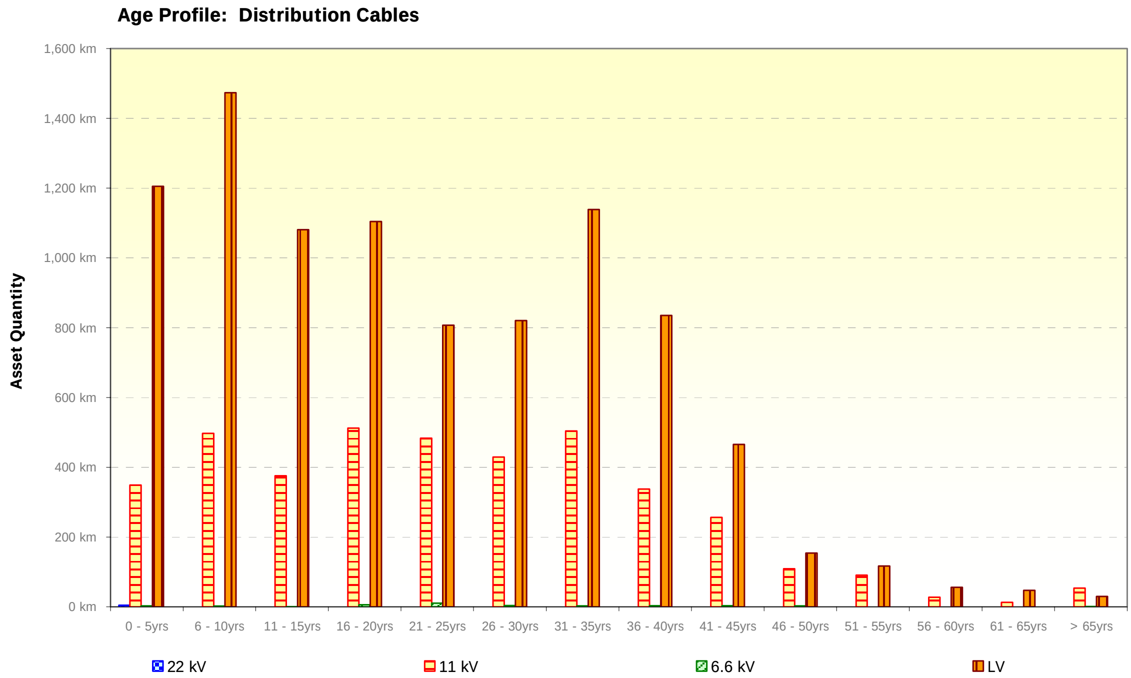



*Figure 5.4* Distribution cables age profile

Old 400V cables are PILC construction while newer cables utilise either PVC or XLPE insulation. In general the PILC and XLPE cables are in good condition. Some of the single core PVC cables have failed and this may become an issue in the future.

*Pillars and pits*

Pillars and pits provide the point for a service cable to connect to Vector's reticulation. They contain the fuses necessary to isolate the service cable from the network distribution cable and to prevent major damage to the service cable following a fault in the installation.

For loads up to 100 amps 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 pillars which have mild steel components are showing signs of age and in many cases the steel portion is suffering from severe corrosion with replacement of individual pillars being a common event.

The older polyethylene pillars are generally adequate for their purpose although many have suffered knocks and minor vehicle impact.

Installation of pits began about 3 years ago and comprehensive inspections to date have not shown up any potential maintenance issues.

### 5.4.2. ASSET MAINTENANCE

*Distribution cables*

Maintenance of the underground cable network is limited to visual inspections of cable terminations, undertaken in conjunction with the overhead inspections. The cables are operated to failure and then repaired or sections replaced as necessary.

On the northern network during the early 1970s considerable quantities of natural polyethylene insulated 11kV cable were installed. This type of cable has a high fault history and the current policy is to repair the cable when it faults to restore supply to the area as soon as possible, then take steps to replace the cable as soon as can be managed.

*Pillars and pits*

Pillars and pits are visually inspected at 3 yearly intervals. The pillar inspection includes a loop impedance test to check the condition of the connections from the fuses to the source.

Where practical, damaged pillars are repaired, otherwise a new pillar or a pit is installed depending upon the circumstances.

### 5.4.3. ASSET RENEWAL AND REFURBISHMENT

*Distribution cables*

Cable replacements are determined based on a combination of fault history and frequency together with tests completed as part of fault repairs. This coming year it is intended to target some areas that have suffered higher than typical cable fault rates and carry out some trials to establish a means of determining the condition of the cables.

*Cable terminations*

Cable termination replacement is driven by visual inspection and analysis of fault rates. The exception to this are 11kV cast metal terminations, where analysis of fault rates together with a risk assessment has resulted in a decision to replace them with modern equivalent heatshrink terminations.

*Pillars and pits*

Pillars are generally replaced following faults or reports of damage. Pillars with a high likelihood of future repeat damage by vehicles are replaced with pits. Older pillars are being targeted for planned replacement as particular types of pillar begin to show signs of reaching a point where repair is impractical and uneconomic.

The anticipated distribution cable and pillar replacement projects over the next ten years are detailed below.

Year 2006/07 projects

- Replace five PIAS 11kV cables in White Swan Rd Auckland that have a high fault history.
- Replace Haywards – Ferguson Drive A, Wellington, 11 kV cable. Examination of a section of cable has revealed that it has been subject to excessive discharge in the insulating papers and must be replaced.
- Continued program replacement of cast iron cable terminations.
- Replace natural polythene 11 kV cables that have faulted during the year.
- Test selected cables to determine whether condition assessment is practical.
- First year of a planned program for the replacement of breadbox and mushroom pillars in the northern network.

Years 2007/08 – 2010/11 projects

- Continued replacement of natural polythene cables.
- Targeted replacement of cables that have been displaying a high fault rate.
- Continued program replacement of cast iron cable terminations.
- Complete breadbox and mushroom pillar replacement project.
- Replace concrete pipe pillars.

Years 2011/12 – 2015/16 projects

- With the reduction in the remaining population of natural polythene insulated cable the number of faults of this type will be falling, however it is anticipated that there will still be cables of this type in service requiring replacement.
- Continue targeted replacement of cables that are showing high fault rates.
- Continued program replacement of cast iron cable terminations.
- Replace metal pillars that were fitted with mild steel components.

## 5.5. SUBTRANSMISSION TRANSFORMERS

### 5.5.1. ASSET DESCRIPTION

Vector owns 248 transformers, including two at Lichfield, which lies outside of Vector's main supply networks. There are 16 transformers with a primary voltage of 110kV, 47 at 33kV and 185 at 22kV ranging in rating from 5MVA to 65MVA. The age profile of the subtransmission transformers is shown below.

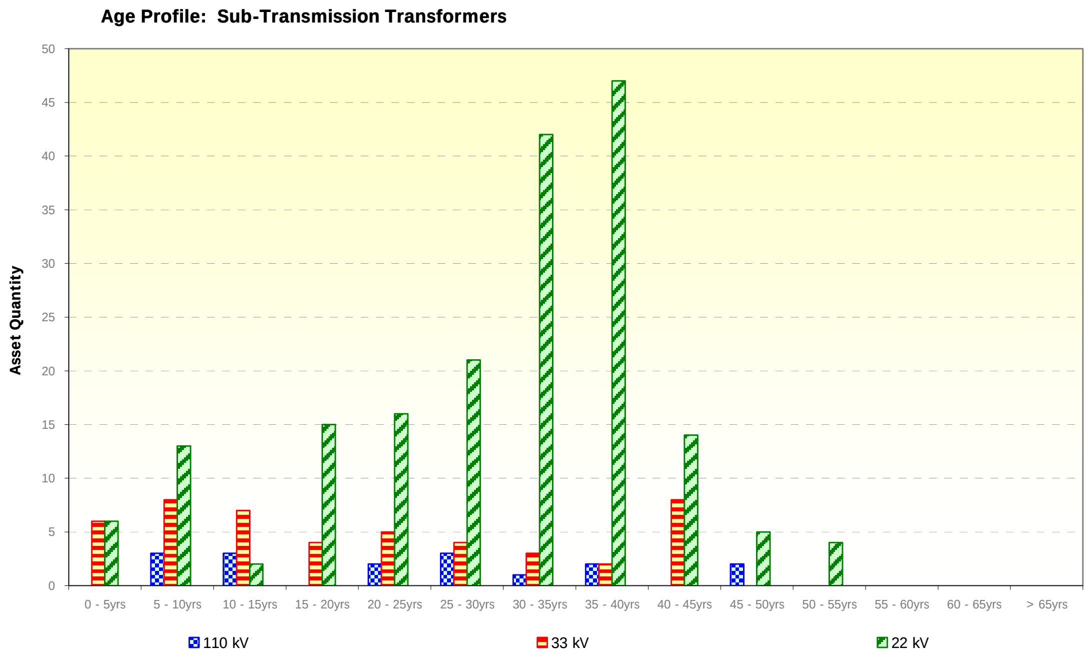



*Figure 5.5* Subtransmission transformers

The transformer population is in good condition overall however there are a small number that indicate they are coming to the end of their useful life and these are monitored closely. The design life of a transformer is 45 years, but if the transformer is not subject to abnormal operating conditions and is well maintained, the design life can be extended.

### 5.5.2. ASSET MAINTENANCE

Routine inspection and condition monitoring include;

- Annual dissolved gas analysis
- Monthly visual checks for moisture, oil levels and leaks, and fan operation
- Annual Thermal Imaging of terminations and connections
- Annual Tap Changer Activity Signature Analysis (TASA) condition assessment
- As required Transformer Condition Assessment (TCA) condition assessment as an alternative to dissolved gas analysis

The timing for the transformer refurbishment is scheduled based on DGA and other condition assessment results. Transformers scheduled for movement to another site are refurbished as part of the move where their condition and assessed remaining useful life makes this an economic option. To improve the decision accuracy associated with major refurbishment, the PDC method, a non-invasive test to determine the moisture content of the winding insulation is being trailed.

### 5.5.3. ASSET RENEWAL AND REFURBISHMENT

Transformer asset replacement is based on a combination of non-invasive and invasive condition assessment; components that have deteriorated beyond acceptable parameters are taken out of service for a detailed inspection. Tests are then conducted on the oil and winding insulation. The investigation gives an indication of life expectancy of the transformer and a decision is made on refurbishment or replacement based on the functionality and performance requirements of the asset.

Year 2006/07 projects

- There are four transformers programmed for major refurbishments being two 110kV transformers from the Wairau substation and two 33kV transformers from the Hans and Coatesville substations.
- There are no planned transformer replacements in this period.

Years 2007/08 – 2010/11 projects

- Budgetary provision has been made to replace one transformer in 2010/11.

Years 2011/12 – 2015/16 projects

Budgetary provision has been made to replace three transformers during this period.

## 5.6. CIRCUIT BREAKERS

### 5.6.1. ASSET DESCRIPTION

There are 2,420 Circuit Breakers (CBs) in Vector's combined regional networks. Thirty five 33kV CBs are installed at Transpower Grid Exit Points in the northern network with the remaining installed at Vector Zone Substations and at secondary distribution substations in the Wellington network. Vector also owns two 110kV CBs and associated isolators at Lichfield.

Both zone and secondary substations contain CBs in either an indoor switchboard configuration (consisting of multiple CBs connected to a common bus) or individually connected in outdoor switchyards.

The CBs range from new to over 50 years of age. Further, the CB's consist of a mix of technologies which also corresponds to the relative age of the equipment. 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%.

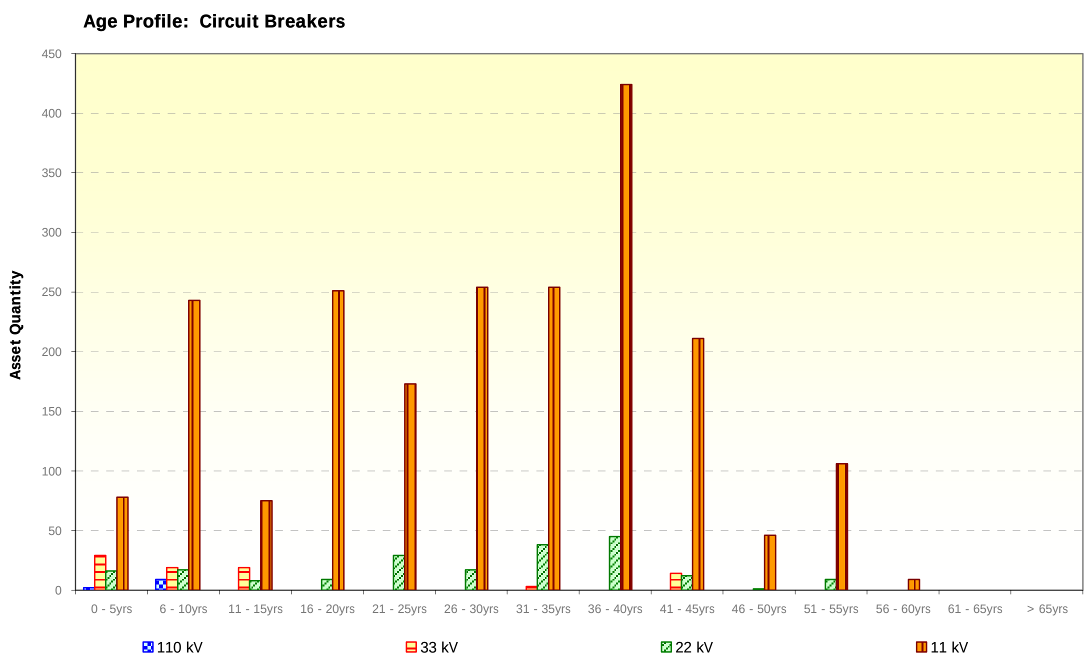



*Figure 5.6* Circuit breaker age profile

The data indicates that the majority of CB's are less than 40 years of age. The bulk of installations occurred in two waves; in the 1965-70 eras and to a lesser extent in the 1980s.

The SF6 and Vacuum CB's are the newest in the networks. They are in very good condition and pose little risk to the network due to modern manufacturing technologies, higher specifications and compliance with the latest international equipment standards.

The oil type CBs are approaching the end of their useful design life and underrating, failures, mal operations, lack of spare parts and the like are and will continue to be of concern for this aged equipment.

#### 5.6.2. ASSET MAINTENANCE

Asset maintenance criteria including inspection, testing and condition assessment is a requirement due to the criticality of this asset to the network.

In general, preventative maintenance on Vector's switchgear consists of the following

- All switchgear is visually inspected monthly/quarterly for leaks and general condition depending on history and type (i.e. some circuit breakers require more frequent inspection than others)

- Thermographic examination is undertaken on all switchboards annually

- Kelman profile testing and non-invasive partial discharge location and monitoring is carried out on a two year cycle

- Major maintenance on the switchgear including inspection and testing of circuit breakers on an eight year cycle and testing of protection relays and systems on a two and four year cycle

- Condition assessments (either on a scheduled basis or as a result of routine inspection or equipment fault operation).

Through this process assets that have been identified for replacement are the Reyrolle type 'C' CB's (due to age and on going operational concerns) English Electric type OLX switchboards, 33 kV ORT2 CBs and possibly Motorpol supplied 36PV25 (Crompton & Grieve) CB's which recent tests have shown a possible design weakness which is presently under further investigation.

#### 5.6.3. ASSET RENEWAL AND REFURBISHMENT

The timing for the replacement circuit breakers is based on condition, performance, ratings and industry related information but can also be the result of non-electrically related drivers such as site relocation or decommissioning, safety considerations and Building code regulations (e.g. fire protection requirements). A

risk matrix has been developed that identifies priority Circuit Breakers for replacement.
Programmed replacements are:

Year 2006/07 projects

- 11kV English Electric type OLX switchboard at Triangle Rd substation - 10 CBs.
- 11kV Ferguson Pailin switchboard at McNab substation – 26 CBs.
- 11kV Reyrolle type C7T switchboard at The Terrace substation – 15 CBs.
- 33kV Reyrolle type ORT2 outdoor CBs in the Northern network Wellsford (CBs P132 & P136) and Warkworth (CBs P106, P280, P130) – 5 CBs
- Reyrolle type C switchboards in Wellington at Victoria, Tory and Adelaide St secondary substations.

Years 2007/08 – 2010/11 projects

- Continue replacement of Reyrolle Type "C" switchboards in Wellington
- Continued replacement of the 11kV English Electric type OLX, South Wales and GEC/Brush oil type switchboards in the Northern Region. (Browns Bay, Atkinson Road, Balmain, Helensville, New Lynn, Hauraki, Laingholm and Sabulite Rd to be considered)
- Replacement of 11kV South Wales, AEI and Brush/GEC switchboards in the Auckland region. (Maraetai, Westfield, Onehunga, Orakei, Manurewa and Pakuranga substations to be considered).
- Replacement of Zone substation switchgear as identified by condition and risk ratings

Years 2011/12 – 2015/16 projects

- Continued replacement of oil type circuit breakers across the networks based on condition and risk assessment.

## 5.7. ZONE SUBSTATION BUILDINGS

### 5.7.1. ASSET DESCRIPTION

There are 128 buildings located at zone substations in the Vector network. These buildings are generally stand alone and house switchgear, protection equipment, ancillary supplies, plus in some instances transformers and ripple injection equipment.

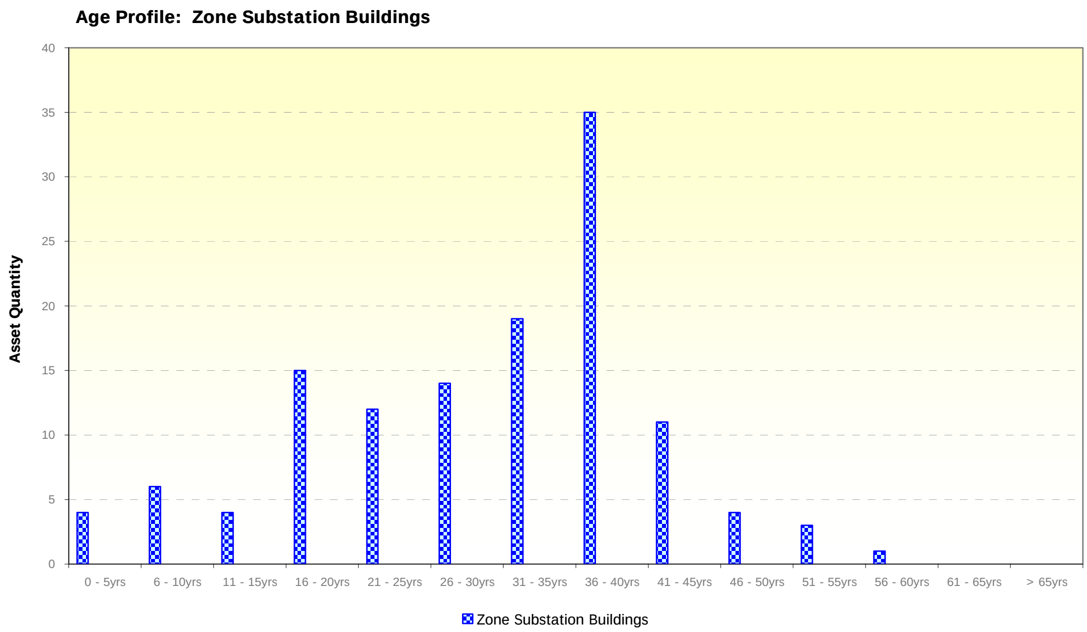



*Figure 5.7 Zone substation building age profile*

The average age of the buildings is 30 years and they are generally in a good condition.

### 5.7.2. ASSET MAINTENANCE

The routine monthly and quarterly zone substation inspections include the building and other assets such as lighting, fire systems, security systems, fans, heaters and safety equipment. The grounds and ripple injection spaces are also maintained with regard to access security, condition and safety.

Where appropriate annual building warrants of fitness inspections are carried out and any defects rectified.

### 5.7.3. ASSET RENEWAL AND REFURBISHMENT

The zone substation building refurbishment program includes, as necessary, such tasks as roofing replacement, exterior and interior painting, upgrading of security and fencing to maintain the assets in good condition.

This work is done as part of an ongoing seven year program.

# 5.8. POWER SYSTEM PROTECTION

## 5.8.1. ASSET DESCRIPTION

Vector operates over 5,300 protection relays of which 75% are electromechanical, 17% solid state and 8% of digital or numerical type.

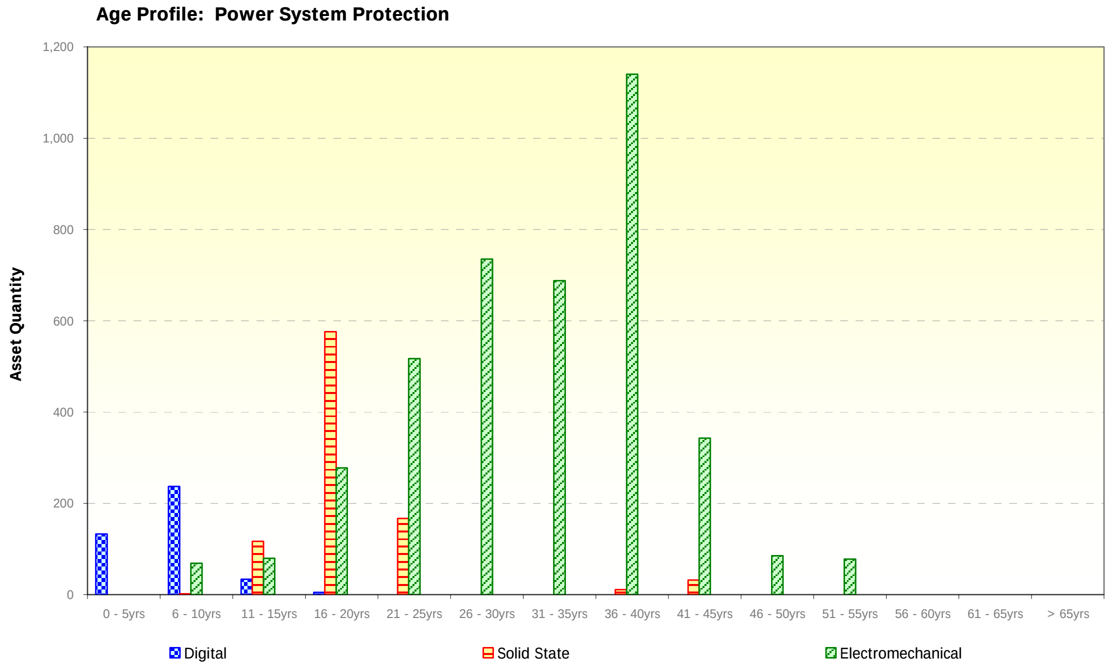



*Figure 5.8* Protection relays age profile

Apart from the Nilstat ITP relays they are generally in good condition.

## 5.8.2. ASSET MAINTENANCE

Electromechanical relays are tested on a four year basis.

Solid state relays of the Nilstat ITP type are tested on an annual basis, to monitor the condition prior to replacement.

Numerical relays are equipped with self-diagnostic functions, but international experience has shown that not all protection relay faults can be detected by the self-monitoring functions; therefore Vector has adopted the recommendations on testing numerical protection relays from the CIGRE Study Committee B5 Protection and automation. The testing schedule is shown in Table 5.2.

| Test | Test Description | Interval |
|---|---|---|
| Function check of the protection (without test equipment) | The function check is to include:<br>Comparison of the quantities "current" and "voltage" with the displays<br>Tripping test by initiating a Trip command<br>Reading-out and analysis of the event memory<br>Check of the protection local and remote fault indications | Two Years |
| Protection Test (with test equipment) | The Protection Test is to include:<br>Check of one measuring point of the input quantities "current" and voltage" both for each phase, neutral and for each measuring range by comparison with the display<br>Check of the function of all binary inputs and outputs<br>Interface test consisting of:<br>Reading out and analysis of the indication and fault recording memory using PC interface<br>Reading-out of all setting parameters and comparison with the initially set parameters<br>Check of the protection local and remote fault indications | Four Years |
| Parts Replacement | Back-up battery replacement | Ten Years |

*Table 5.2 Protection Relay Test Schedule*

### 5.8.3. ASSET RENEWAL AND REPLACEMENT

Replacement programmes are generally based on relay condition and or failure. At the time of replacement the opportunity is taken to upgrade the protection schemes to meet the current standards.

The planned protection relay replacement program over the next ten years is detailed below.

*Year 2006/07 projects*

- Ongoing replacement of Nilstat relays.
- Parnell Substation. Overall cable transformer differential protection replacement of the incoming feeders.
- Quay 110kV substation. Transformer and cable differential protection replacement.
- Remuera substation. Protection and control replacement / upgrade.
- Quay 11kV substation. Protection and control replacement / upgrade.
- Wiri Substation. Protection and control replacement / upgrade.

*Years 2007/08 – 2010/11 projects*

Auckland network

- Ongoing replacement of Nilstat relays.
- Victoria substation. Protection and control replacement / upgrade.
- Hans substation. Protection and control replacement / upgrade.
- Papakura substation. Protection and control replacement / upgrade.
- Quay 22kV substation. Protection and control replacement / upgrade.
- Manukau substation. Protection and control replacement / upgrade.

Northern network

- Zone substation and network supplied from GXP Hepburn. Protection and control replacement / upgrade.
- Zone substation and network supplied from GXP Henderson. Protection and control replacement / upgrade.
- Zone substation and network supplied from GXP Wellsford. Protection and control replacement / upgrade.

Wellington network

- Zone substation and network supplied from GXP Takapu Rd. Protection and control replacement / upgrade.
- Zone substation and network supplied from GXP Haywards. Protection and control replacement / upgrade.
- Zone substation and network supplied from GXP Gracefield. Protection and control replacement / upgrade.
- Zone substation and network supplied from GXP Wilton. Protection and control replacement / upgrade.

*Years 2011/12 – 2015/16 projects*

- Ongoing protection and control replacements / upgrades across all networks as identified by asset condition monitoring

## 5.9. SUBSTATION DC AUXILLIARY SUPPLY

### 5.9.1. ASSET DESCRIPTION

There are 92 DC auxiliary systems, with an average age of 29 years that provide power supply to the substation protection, control, metering, monitoring, automation and communication systems, as well as power to the circuit breaker tripping and closing coils. These systems are in good condition.

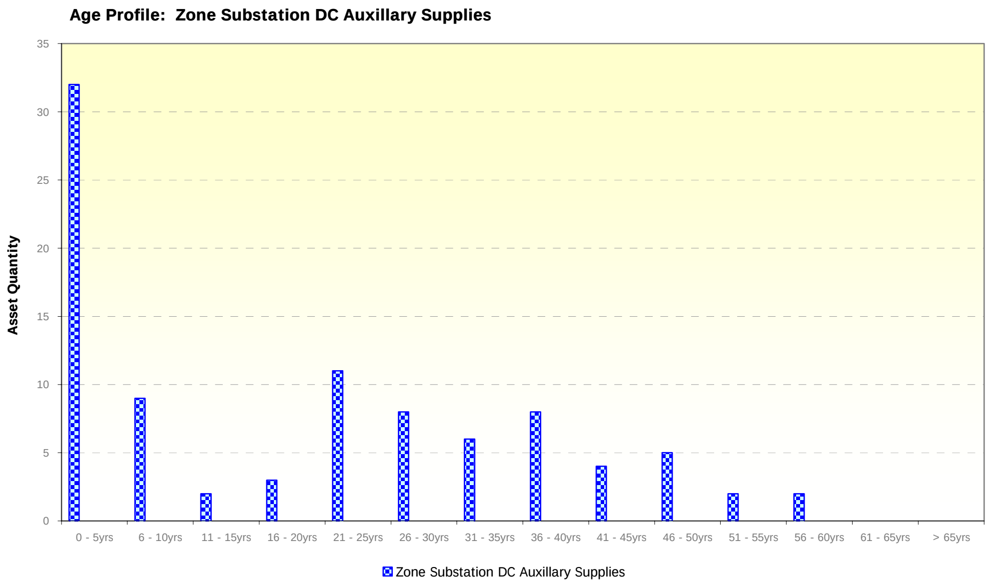



*Figure 5.9* DC auxiliary supplies age profile

Vector's standard DC auxiliary systems consist of a string of batteries, battery charger, number of DC/DC converters and battery monitoring system.

The major substations are equipped with a redundant DC auxiliary system.

### 5.9.2. ASSET MAINTENANCE

Maintenance for the VRLA batteries is based on the recommendations of IEEE–1188 (IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve Regulated Lead Acid Batteries for Stationary Applications).

### 5.9.3. ASSET RENEWAL AND REFURBISHMENT

In all networks batteries are replaced, using VRLA batteries, as they fail or based on condition assessment results.

## 5.10. SCADA

### 5.10.1. ASSET DESCRIPTION

The existing SCADA system consists of three sub-systems, the main SCADA system, the ripple control and metering system, Remote Terminal Units (RTUs) at the grid exit points and RTUs at zone substations for operational control and indication of network status. The control systems for all network areas are based in Auckland. Due to their age the RTUs are generally in a fair condition.

#### 5.10.2. ASSET MAINTENANCE

The main SCADA system is self-diagnostic in terms of failure being immediately apparent in the Control Room. The existing SCADA RTU's do not have full back up and maintenance is based on failure.

A large proportion of the RTUs have reached or exceeded there design life and are technically obsolete.

#### 5.10.3. ASSET RENEWAL AND REFURBISHMENT

Vector has embarked on a planned replacement programme of the RTUs. 10 RTUs are replaced annually per region. The implemented SCADA integration strategy enables Vector to deploy the selected modern type of RTUs (e.g. from Foxboro or Serce) as the replacements across the whole network.

### 5.11. ENERGY AND PQ METERS

#### 5.11.1. ASSET DESCRIPTION

Vector's bulk metering systems consists of 35 intelligent web-enabled revenue class energy and power quality meters communicating within the metering central server over an Ethernet based IP routed communication network. These meters are less than four years old

The system provides Vector with essential information to control cost, quality and reliability of the power delivered to Vector's customers. It is currently used to:

- Improve operational efficiency by controlling peak demands at the grid exit points, which ultimately reflects in reduced line charges to Vector's customers.

- Provide comprehensive power quality and reliability information that will enable the verification of quality of power delivered to our customer's against the published Vector service levels, and faster resolutions of power quality issues

- Increase the power supply stability by initiating instantaneous load shedding during grid under frequency events

These meters have been installed since 1999 are still relatively new and in very good condition.

### 5.11.2. ASSET MAINTENANCE

Planned maintenance is based on a four yearly inspection cycle carried out in conjunction with the protection relays. As these devices are intelligent any malfunction is notified promptly to the master station enabling remedial actions to be undertaken as necessary.

### 5.11.3. ASSET RENEWAL AND REFURBISHMENT

These assets have an expected life of 15 to 20 years. They will be scheduled for replacement based on service history, reliable operation and age.

Year 2006/07 projects

- There are no planned replacements in this period.

Years 2007/08 – 2010/11 projects

- There are no planned replacements in this period.

Years 2011/12 – 2015/16 projects

- Replacement will be considered from 2014 depending on performance.

## 5.12. DC SYSTEM

### 5.12.1. ASSET DESCRIPTION

In central Wellington, as part of 15 distribution substations there are DC assets used to supply the trolley bus network. These comprise of 15 converter transformers, 19 mercury arc rectifiers, 2 solid state rectifiers and 53 DC circuit breakers. To provide backup supply, in case of faults, there is approximately 53 km of DC underground cables linking various substations.

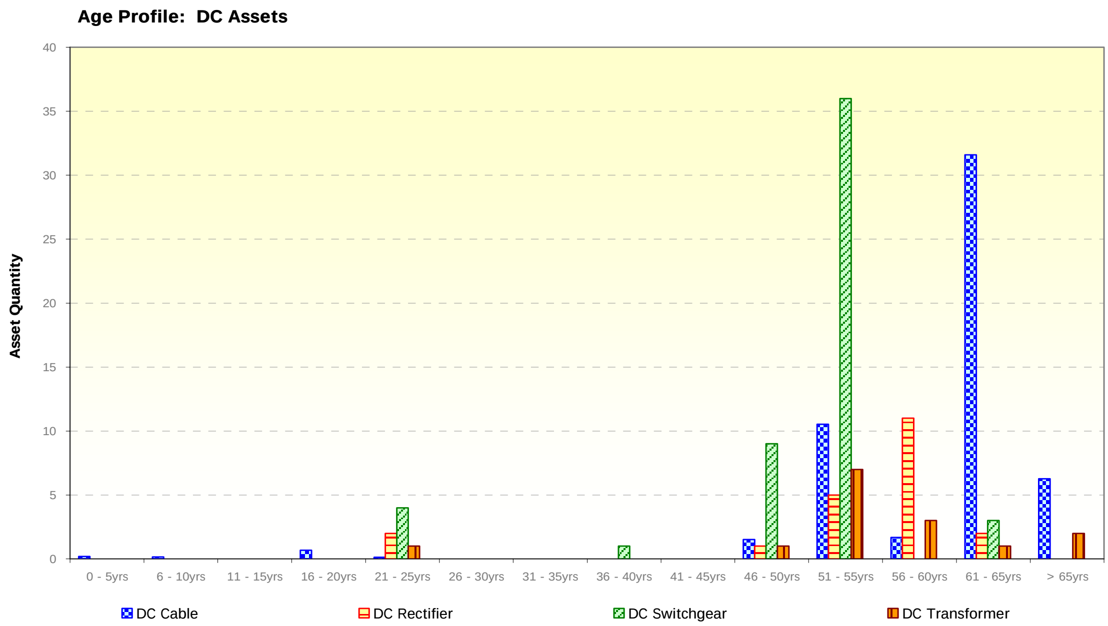



*Figure 5.10* DC equipment age profiles

On average these assets are 54 years old, have exceeded their design life and they are in a fair to poor condition. These assets are used to supply a single customer and Vector is currently in negotiations to reach agreement on the continued use of the DC system together with the level of service required. Such an agreement is necessary to ensure the ongoing operation, maintenance and refurbishment of the asset. Without such an agreement, the asset may need to be decommissioned over time.

### 5.12.2. ASSET MAINTENANCE

Over the last ten years Vector has encouraged the customer to refurbish the facility to ensure ongoing reliable operation. However, as historically these assets have been reasonably reliable, the customer has instructed Vector to minimise maintenance levels. Consequently, very little maintenance other than visual inspections has been completed. Over the last three years the fault rate has increased. In late 2005 – early 2006 Vector undertook an extensive review of these assets. As a result, an upgrade and maintenance plan has been developed for the next 10 years. The implementation of this plan, however, requires the customer to commit to funding.

Vector has implemented a detailed inspection and condition monitoring program to assess remaining life and identify any potential issues. This includes;

- Thermal imaging on all assets;
- Transformer oil dissolved gas analysis;
- Ductor tests and trip testing on the DC circuit breakers;

- Arc drop tests and tank to cathode voltage tests on the mercury arc rectifiers;
- Insulation tests on a sample of underground cable.

These tests are undertaken on an annual basis.

The transformer tests all show high levels of contamination of the oil with six of the 15 having signs of overheating and partial discharge indicating possible thermal faults.

The mercury arc rectifiers test results indicate that the integrity of the vacuum is deteriorating which is an end of life indicator.

If continued service is required there are a number of maintenance and safety concerns that will need to be attended to and they have been included in the FY06/07 budget, such as;

- Covering of exposed live components on the DC circuit breakers.
- Replacement of the asbestos lining in the circuit breaker arc chutes.
- Bunding for any mercury spill containment.
- Refurbishment of the replaced transformers to keep for contingencies.

### 5.12.3. ASSET RENEWAL AND REFURBISHMENT

The current practice is to allow these assets to run to fail. Repairs are completed if cost effective or the asset is replaced from the spares held.

As noted above, if continued service is required, the asset upgrade and maintenance plan developed by Vector will need to be implemented. This requires customer commitment to funding and would include asset renewal projects consisting of the following.

Year 2006/07 projects

- Replace four converter transformers with new units.
- Procure three solid state rectifiers to be kept as spares.
- Upgrade the protection on the DC circuit breakers to facilitate faster response to faults.

Years 2007/08 – 2010/11 projects

- Replace two converter transformers.
- Replace rectifiers as they fail from spares holding.

Years 2011/12 – 2015/16 projects

- Asset replacement as required due to faults

## 5.13. DISTRIBUTION TRANSFORMERS

### 5.13.1. ASSET DESCRIPTION

Vector owns and operates approximately 24,400 distribution transformers of which 61% are ground mounted and 39% are pole mounted. Ground mounted transformers are either stand alone, enclosed in metal or fibreglass canopies, open enclosures or fully enclosed within other buildings. The transformers are generally 11kV/415V and rated between 30 and 1,500kVA, although there are a small number rated at 1.5kVA, 5kVA, 7.5kVA and 10kVA. There are also a small number of 6.6kV/415V transformers that will be up graded to 11kV/415V. With the development of the 22kV distribution network in the Auckland CBD, 22kV/415V transformers are also being used. There are also some 11/6.6kV auto transformers for special applications.

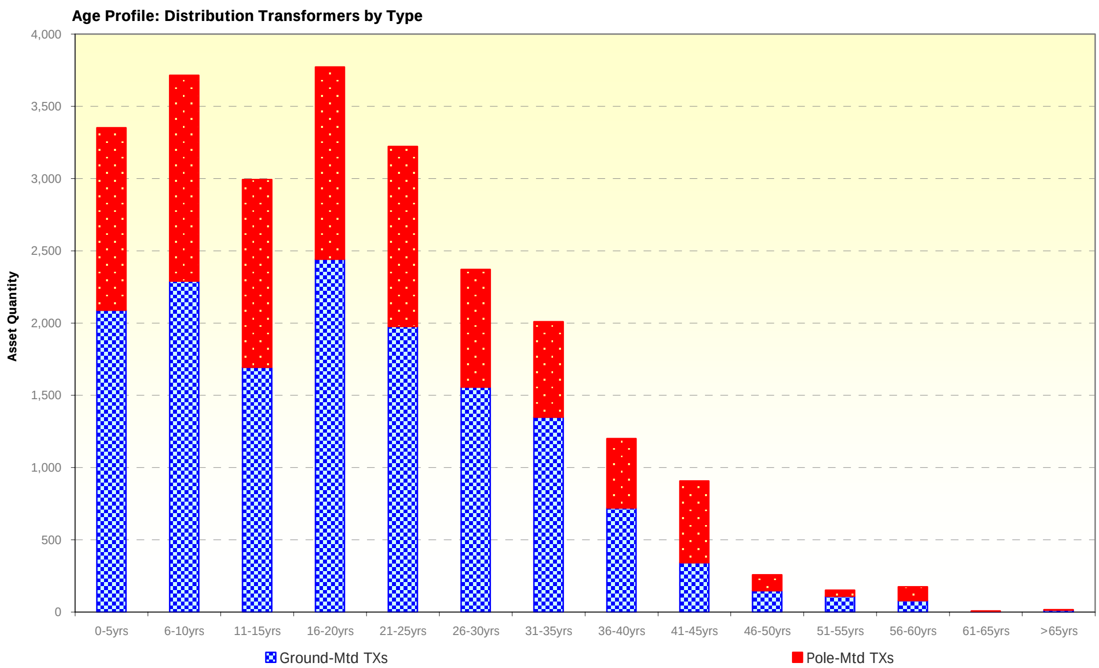



*Figure 5.11 Distribution transformers age profile*

In general asset condition has improved due to recent renewal programmes across all networks. Generally replacements have been due to rust and minor oil leaks and many of these transformers have been replaced with refurbished transformers.

### 5.13.2. ASSET MAINTENANCE

Transformers are inspected for defects at cyclic intervals as shown in Table 5.3.

| DISTRIBUTION SUBSTATION PREVENTATIVE MAINTENANCE | AUCKLAND | NORTHERN | WELLINGTON |
|---|---|---|---|
| Earthing System Inspection & Testing | 3 Yr | 5 Yr | 5 Yr |
| Enclosure Inspection | 12 Month | 4 Yr | 12 Month |
| Equipment Inspection | 3 Yr | 6 Month | 12 Month |
| Remote Function Inspection & Testing | 12 Month | Nil | Nil |
| Switchgear Service | 8 Yr | 8 Yr | 8 Yr |
| Transformer Load Reading | 3 Yr | Nil | Nil |

*Table 5.3 Distribution Transformer Test and Inspection Schedule*

Opportunities to align maintenance frequencies across the regions will be taken as contract terms allow.

Onsite repairs will generally be minor i.e. oil top up, replacement of bolts, minor rust treatment and paint repairs. Where it is uneconomical to complete onsite and the asset will pose a risk to safety and reliability before the next inspection cycle; the asset will be replaced.

The main cause of transformer failure is mechanical (not electrical) summarised as two subgroups:

- Some transformers installed between 1998 and 2001 have been identified as prematurely rusting. Estimated to be 2% of population.
- Ground mounted transformers in the northern network, approximately 25 years old, have increased risk of non compliance due to excessive rust or oil leaks. Estimated to be 5% of population.

### 5.13.3. ASSET RENEWAL AND REFURBISHMENT

Transformer replacement is determined from condition criteria, accessed during regular inspection. Any transformer failure is returned for investigation of failure and a decision is made on the cost benefits of repair, refurbishment, replacement or scrapping of the asset.

Refurbishment and replacement of transformers is an ongoing program with budget allocated for each year. Work packages are developed by each of Vector's contracting partners based on the results of condition inspections.

# 5.14. GROUND MOUNTED DISTRIBUTION SWITHGEAR

### 5.14.1. ASSET DESCRIPTION

Vector owns and operates over 3,550 ground mounted switchgear, made up of oil, $SF_6$ and resin insulated equipment of varying ages and manufacturers. Generally the switchgear is 11kV but there is a very small quantity of 6.6kV units

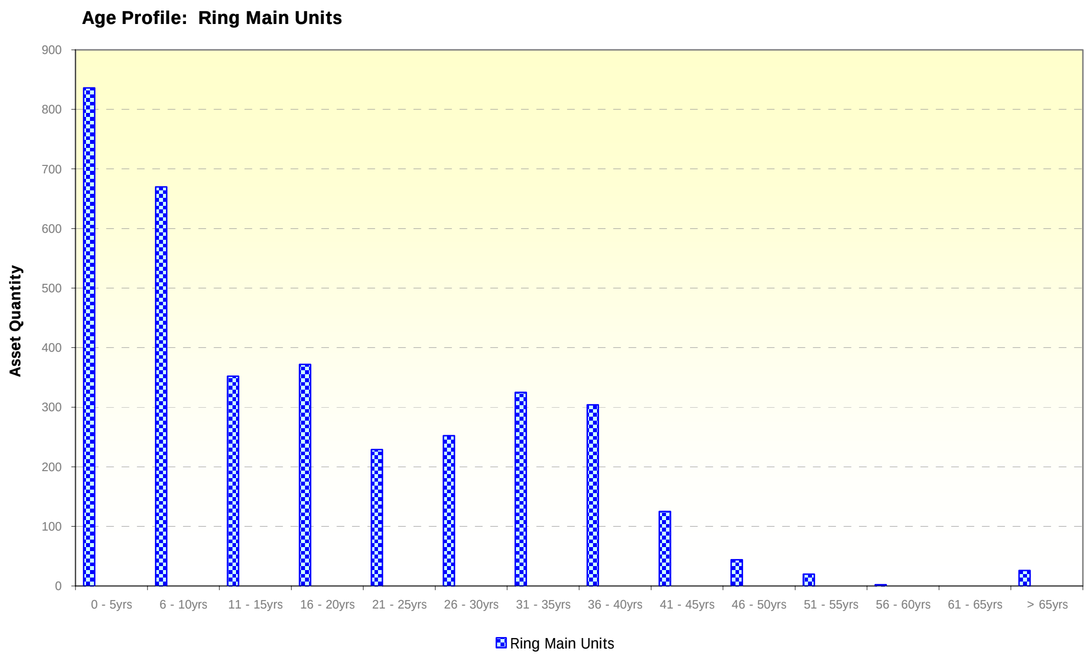



*Figure 5.12* Ground mounted distribution switchgear age profile

In general these assets have had recent renewal programmes similar to the distribution transformers. To a small degree replacements have been driven by transformer replacement, by either being physically attached to a transformer requiring replacement or where there is synergy opportunity to replace during other work. Other general causes for replacement were: vehicle damage, minor oil leaks and to a lesser degree corrosion. The replacement switchgear will provide benefits of safer and more reliable operation with less maintenance.

### 5.14.2. ASSET MAINTENANCE

Switchgear is visually inspected every three years with a full service every eight years. The full service includes both electrical testing and mechanical service. Magnefix switchgear is selectively cleaned every 3 years following visual inspection. Minor defects will generally be repaired onsite i.e. oil top up, replacement of bolts, minor rust treatment and paint repairs. Where it is uneconomic to complete repairs onsite and the switch poses a risk to safety and reliability before the next inspection cycle the asset will be replaced.

#### 5.14.3. ASSET RENEWAL AND REFURBISHMENT

Switchgear replacement is based on condition and availability of components for repair. Any failed switchgear units are returned for investigation of failure and a decision is made on the cost benefits of repair, refurbishment, replacement or scrapping of the asset.

As part of Vector's continual improvement process the use of oil filled switchgear has been reviewed and other types of switchgear investigated. The result has been a change in specification and implementation of $SF_6$ or vacuum switchgear. The use of equipment without oil will eliminate damage to the environment caused by oil spills and leaks.

Refurbishment and replacement of switchgear is an ongoing program with budget allocated for each year. Work packages are developed by each of Vector's contracting partners based on results from the condition inspections.

## 5.15. MOBILE GENERATOR CONNECTION UNITS

#### 5.15.1. ASSET DESCRIPTION

Vector has two Mobile Generator Connection Units (MGCU) which can be transported to site and coupled to hired generators to restore power. Each MGCU contains a 2.5MVA 415V/11kV transformer, LV and 11kV switchgear, protection and accessories. Both MGCUs were commissioned in 2005.

#### 5.15.2. ASSET MAINTENANCE

Routine inspections and maintenance will be carried out in accordance with the maintenance standards for each type of equipment used. When the MGCUs are not in use they will be connected to a LV supply to keep the batteries fully charged.

#### 5.15.3. ASSET RENEWAL AND REFURBISHMENT

As the two MGCUs are brand new there are no plans any refurbishment or asset replacement within the planning period.

# 5.16. POWER FACTOR CORRECTION PLANT

## 5.16.1. ASSET DESCRIPTION

There are a number of capacitor banks installed across the network in order to correct poor power factor and provide voltage support:

In the Auckland network there are currently 25 zone substation 11kV bus connected capacitor banks ranging in size from 3MVAr to 9MVAr. Also in the Northern network there are 75 pole mounted 11kV capacitor banks rated at 750 kVAr and 2 ground mounted 33kV bus connected capacitor banks rated at 18MVAr.

The majority of the 11KV capacitor banks in both regions were installed during the spring of 1998/99 as a cost effective means to ratify a Transpower VAR Support Agreement.

The condition of the indoor capacitor bank assets in the Auckland network is generally good. All vacuum switches have been replaced with 3 phase contactors after the failure of 3 units, and it was determined that the probable cause of failure was excessive number of operations.

The condition of the outdoor capacitor bank assets in the Northern network is also generally good with the very occasional, individual capacitor failure

## 5.16.2. ASSET MAINTENANCE

The Auckland network capacitor banks have an annual service which includes check the operation of equipment, clean primary equipment and filters, checking cooling fan operation, check earthing and visual inspection of all components.

Also a four yearly major service is undertaken which covers secondary injection on SPAJ140 and SPAJ160 relays, checking operation of LOGO and RVS unit, IR and Ductor on SF6 CB, IR on vacuum switches, capacitance measurements and primary injection on reactors.

The Northern network overhead banks have a 12monthly visual inspection and an 8 year major maintenance.

## 5.16.3. ASSET RENEWAL AND REFURBISHMENT

Replacement decisions include consideration of condition, age, function, location, criticality and performance. Replacement expenditure will firstly be required on the switched overhead units. These switches have a stated mechanical life of 10,000 operations and there is no planned replacement program for these assets during the planning period.

## 5.17. ASSET VALUE

The value of the assets on Vectors network are summarized in Table 5.4. The information is derived from the ODV Report – March 2004

| Asset Category | Value ($million) |
|---|---:|
| Sub-transmission | $380.3 |
| Zone substations | $216.7 |
| Distribution cables and lines | $468.6 |
| Distribution switchgear | $109.8 |
| Distribution transformers | $148.5 |
| Distribution substations | $69.6 |
| Distribution miscellaneous | $4.0 |
| LV distribution | $370.5 |
| Other assets | $28.5 |
| Service connections | $60.8 |
| DC | $1.0 |
| Total | $1,858.4 |

Source: ODV Report March 2004

*Table 5.4 Asset Value by Category*

## 5.18. BUDGETS

### 5.18.1. FORECAST NETWORK MAINTENANCE EXPENDITURE

Tables 5.5 and 5.6 shows the Preventative Maintenance and Provisional Preventative Maintenance budget forecast for expenditure on network assets. Omitted from the tables are the budgets for fault response, vegetation management, contractor management and performance fees, cable location services, service changeovers and consents and permit costs.

| Asset Type ($ millions) | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Transmission Network | $0.4 | $0.4 | $0.4 | $0.4 | $0.4 | $0.4 | $0.4 | $0.4 | $0.4 | $0.4 |
| Zone Substations | $1.9 | $1.9 | $1.9 | $1.9 | $1.9 | $1.9 | $1.9 | $1.9 | $1.9 | $1.9 |
| Distribution Network | $8.4 | $8.4 | $8.4 | $8.4 | $8.4 | $8.4 | $8.4 | $8.4 | $8.4 | $8.4 |
| **Grand Total** | **$10.7** | **$10.7** | **$10.7** | **$10.7** | **$10.7** | **$10.7** | **$10.7** | **$10.7** | **$10.7** | **$10.7** |

*Table 5.5 Preventative Maintenance Expenditure Forecast*

| Asset Type ($ millions) | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Transmission Network | $0.5 | $0.5 | $0.5 | $0.5 | $0.5 | $0.5 | $0.5 | $0.5 | $0.5 | $0.5 |
| Zone Substations | $5.1 | $5.1 | $5.1 | $5.1 | $5.1 | $5.1 | $5.1 | $5.1 | $5.1 | $5.1 |
| Distribution Network | $4.7 | $4.7 | $4.7 | $4.7 | $4.7 | $4.7 | $4.7 | $4.7 | $4.7 | $4.7 |
| **Grand Total** | **$10.4** | **$10.4** | **$10.4** | **$10.4** | **$10.4** | **$10.4** | **$10.4** | **$10.4** | **$10.4** | **$10.4** |

*Table 5.6 Provisional Preventative Maintenance Expenditure Forecast*

### 5.18.2. ASSET RENEWAL AND REFURBISHMENT CAPEX FORECAST

Table 5.7 below shows the forecast asset renewal and refurbishment expenditure.

| Expenditure Category ($ millions) | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distribution Network | $57 | $42 | $41 | $55 | $56 | $62 | $63 | $63 | $63 | $64 |
| Sub-Transmission Network | $8 | $7 | $8 | $8 | $4 | $13 | $6 | $19 | $10 | $10 |
| Zone Substations | $1 | $2 | $1 | $1 | $2 | $1 | $3 | $1 | $1 | $2 |
| **GRAND TOTAL** | **$66** | **$51** | **$50** | **$63** | **$61** | **$76** | **$72** | **$84** | **$74** | **$76** |

*Table 5.7 Forecast Asset Renewal and Refurbishment Expenditure*

# 6. RISK MANAGEMENT

Asset risk management in Vector is an integral part of the asset management process. Asset risks, the consequences of failure, current controls to manage these, and required actions to make risks acceptable are all understood and evaluated as part of the asset function and performance analysis.

Risks associated with the assets or operations of the network are evaluated, prioritised and dealt with as part of the asset maintenance, refurbishment and replacement programmes, and work practices. The acceptable level of risk will differ depending upon the level of risk our customer's are willing to accept and the circumstances and the environment in which the risk will occur. This analysis includes consideration of very low probability events with high impacts such as the total loss of a zone substation.

From this analysis contingency plans are developed. Risk is managed in Vector by a combination of:

- Reducing the probability of the failure, through the capital and maintenance work programme and enhanced working practices
- Reducing the impact of failure, through contingency and emergency plan development and insurances

The capital and maintenance asset risk management strategies are outlined in the Asset Maintenance and Development sections. Vector's contingency and emergency planning is based around procedures for restoring power in the event of a fault occurring on the network, and are detailed in Section 6.5.

## 6.1. RISK ACCOUNTABILITY AND AUTHORITY

### 6.1.1. VECTOR BOARD AND BOARD RISK COMMITTEE

The Board oversees risk management for the Vector Group as a key responsibility of its role. It has a specific committee designated to review risk and assurance across the Group, the Board Risk Committee (BRC). Its role includes endorsing the risk context under which Vector operates, and overseeing the Internal Audit Programme and the Insurance Programme.

The Board Risk Committee meets regularly, at least quarterly, to review the Group's risk context, the Group's most serious risks, and its key controls of which the Audit and Insurance programmes are key in terms of its corporate governance responsibilities.

### 6.1.2. EXECUTIVE RISK COMMITTEE

The Executive Risk Committee (ERC) which reports through to the Board Risk Committee, oversees and monitors the implementation of appropriate and consistent risk management across the Group and within each function and business unit, including the Electricity Business, by:

- Developing and maintaining, for the Board's review and approval, a risk management policy for Vector, consistent with the company's objectives
- Overseeing and monitoring the implementation of risk management across Vector to ensure that it is in compliance with the risk management policy

The Executive Risk Committee meets on a six weekly basis. It reviews the key risks facing the group including the most significant risks from the Electricity business. It also on a rotational basis reviews all the risks and the risk practice of each business and function. The Electricity business would be reviewed twice annually.

A key to the delivery of assurance for the Group is the Internal Audit programme managed at a corporate level.

The aim of the audit is to consider:

- The extent to which Vector is applying its risk management structures, accountabilities, processes and reporting mechanisms in support of its risk management policy
- Opportunities for improving Vector's established risk management policy, structures, accountabilities, processes and reporting mechanisms in support of the company's business goals

### 6.1.3. ELECTRICITY BUSINESS MANAGEMENT TEAM RISK MANAGEMENT STRUCTURE

The Electricity Business management team, made up of the unit's CEO and his direct reports, meet monthly to oversee the operation of risks management and assurance within the Electricity Business line. Strategic and Operational risks are reviewed. All risks are reported in a single risk register for the business.

The role of this management team is to:

- Develop and maintain a systematic approach to risk management and assurance.
- Monitor risks and their management regularly - this includes the effectiveness of Controls and progress of Treatments
- Develop a systematic assurance programme for the unit
- Report to the ERC twice annually and Board as required usually annually.

Within the monthly meeting, new risks are reviewed, and as well a single issue and a given area will be reviewed in detail on a rotational basis.

### 6.1.4. ELECTRICITY BUSINESS MANAGEMENT

The management within the Electricity Business are responsible for the management of risk within their area of authority. Each area can have its specific risk identified which has the risks, controls treatments and associated accountabilities reported. Each are is reviewed by the Electricity Business management team on a rotational basis.

Asset related risks are covered in the sections of the register owned by Field Services and Asset Management sub-units, in particular, as well as Capital Delivery and Business Development sub-units.

### 6.1.5. ALL EMPLOYEES

All staff and service providers are responsible for reporting any identified risks that come to their notice. Individuals may then also have responsibility for managing an individual risk, a risk control or be responsible in delivering a specific risk treatment.

## 6.2. RISK MANAGEMENT PROCESS

The risk management process classifies risks based on *Consequence* and *Likelihood*. The process includes understanding the consequences of failure from an event and valuing the impact of the event and defining response plans taking into account the probability of the risk occurring. The combination of *Consequence* and *Likelihood* is input into prioritising the risk and therefore the actions to control and manage it.

The most significant risks identified have visibility through to the ERC and if significant enough through to the Board Risk Committee.

The risk management process adopted by Vector is shown in Figure 6.1.

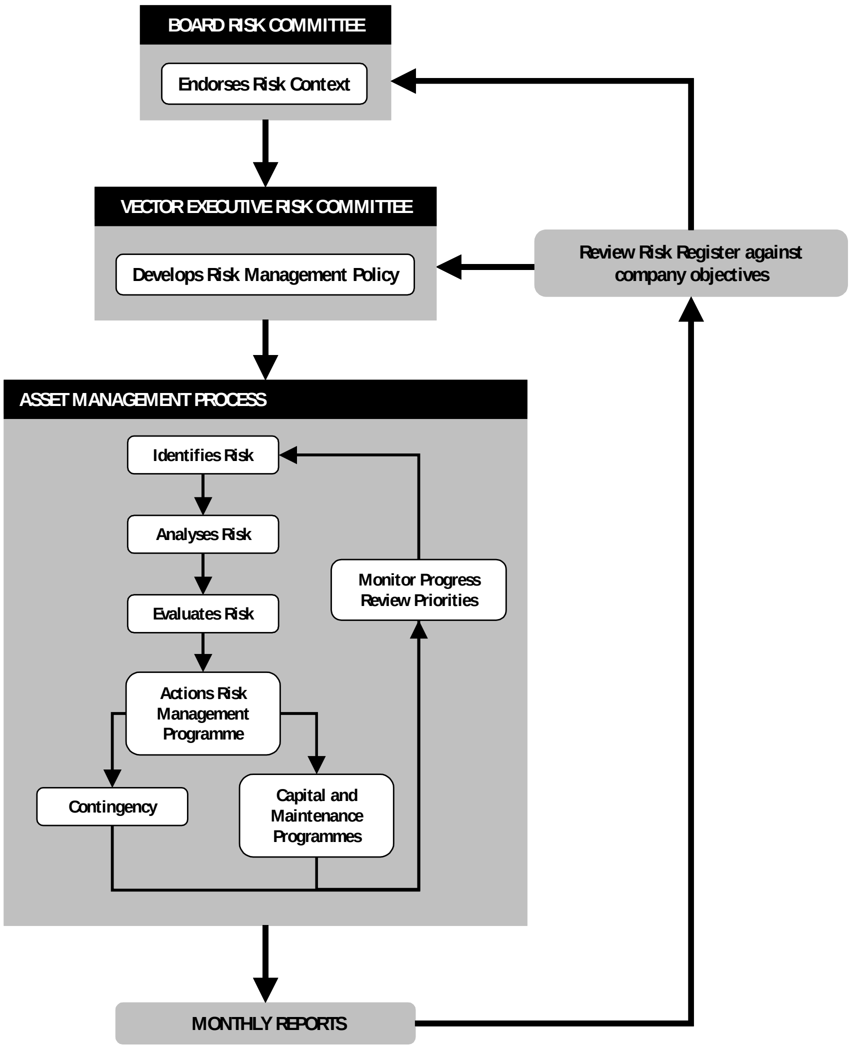



*Figure 6.1 Vector's Risk Management Process (Based on AS/NZ4360)*

Vector's risk management policy is defined to ensure that:

- All risks to the business are identified and understood and works prioritised to mitigate risk. The most significant risks are tracked at the Business, Group and Board level.
- Practices that could cause disruption to service and operations, injury to people or the environment, or significant financial loss are understood, documented and mitigated
- The business is protected by suitable insurance polices, or contingency plans, wherever necessary

## 6.3. RISK IDENTIFICATION AND ANALYSIS

All risks are assigned a risk level based on the *Consequence* and *Likelihood* of the risk. Vector chooses to focus first on *Consequence* and then review *Likelihood* rather than initially looking at the level risks as a combination of these two factors.

The structure and this approach are currently under review.

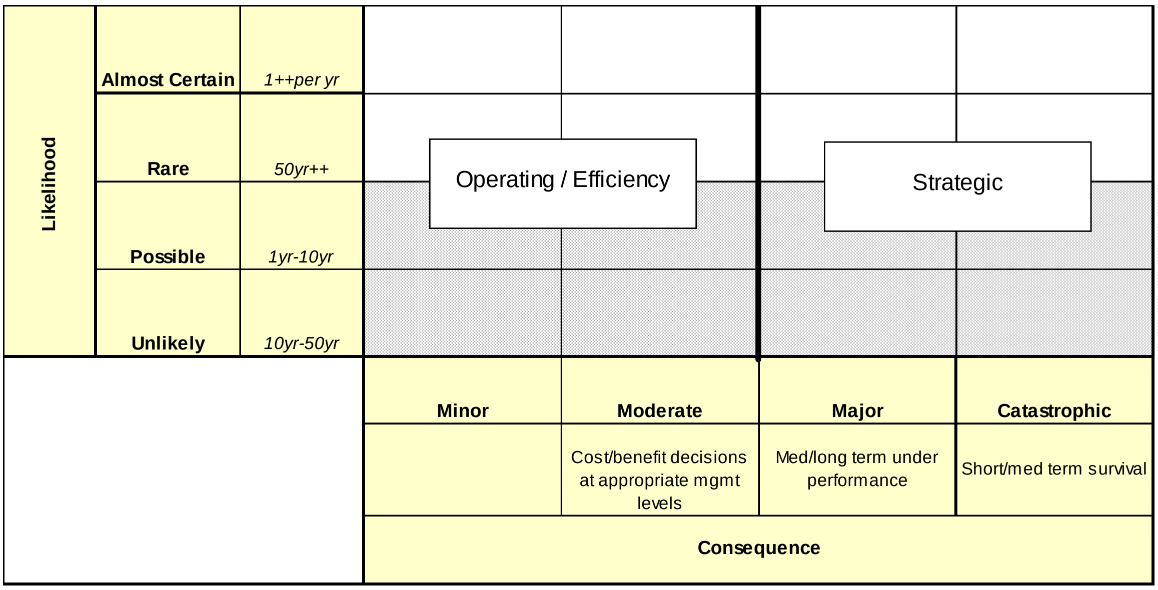



*Figure 6.2 Vector's Risk Prioritisation Matrix*

Catastrophic and major risk includes loss of life, extended loss of supply, or financial loss of a magnitude sufficient to impact on the company.

## 6.4. RISK MANAGEMENT PROGRAMME

The Electricity Business of Vector maintains a risk register, which is formally updated on a monthly basis for presentation to the Business Unit's Leadership team, and on a periodic basis to both the Group Risk Committee and the Board Risk Committee.

The most significant risks are seen by the ERC and the BRC at every meeting.

### 6.4.1. RISK MANAGEMENT ANALYSIS

Of the 140 risk acknowledged on the risk register some 80 risks are directly related to operational issues relating to the asset management / operations of the networks. These risks can relate to a single asset, a process or a whole class of assets. The output from the risk analysis is dynamic; risk evaluations can change from changes in the environment, in information and with the asset themselves.

Current major risk categories relating to the operational nature of the network revolve around:

- Security of supply (both in terms of delivery of energy to Vector's networks and failure to supply within Vector's own network). Operationally, the risk profile of the network in terms of security changes as load demand, environmental factors and asset performance change.
- Asset and process failures where they could cause death/injury, environmental or general damage.
- (Natural) disaster risks such as earthquakes and severe storms are a category of risks which are difficult to prevent but are managed in terms of contingency planning or to some extent through long-term design of the network.
- Network quality risks relate to the company failing to meet quality targets whether set internally or those imposed externally. A number of risks are identified which relate to how these standards could be missed.
- A number of 'input' type risks are also acknowledged. One example is the loss of or non-availability of suitable people who can work on the network. If this was to occur it would lead to network performance being compromised. Another example is the loss of or any failing in the quality of information which leads to poor or compromised decision making again which would have an adverse impact of the performance of the network.

Overall, the whole asset planning process is underpinned by risk management concepts. The company cannot eliminate risk from its operations. Within the constraint of resources it is looking to manage all the risks it faces to an 'acceptable' level on an 'as low as reasonably practical' basis. The output from the risk analysis process is then manifested in the work programme described in its asset management plan.

# 6.5. CONTINGENCY PLANS

## 6.5.1. SWITCHING

For all major feeders, the network is designed to allow reconfiguration by switching so that power can be fed through an alternative path if there is a failure or a need to shift load. In the Wellington CBD, some distribution switching can be carried out remotely via SCADA. A small number of distribution switches in the Northern and Auckland networks can also be operated by SCADA.

In the event of failure of a feeder, Control Room operators undertake network analysis and instruct field crews to undertake manual switching to restore power to as many customers as possible (while the fault is repaired), especially to critical customer's.

The Control Room has prepared contingency switching plans for major outages such as complete loss of a zone substation.

There 168 contingency plans for Auckland region, 84 for Northern, and 69 for Wellington. These are in the main relating to loss of Zone substation transformers and subtransmission feeders. Figure 6.3 and 6.4 are examples of these

ZONE SUBSTATION CONTINGENCIES

Mt Albert SUBSTATION

No Of Transformers: 1

Transformer Size: 12

Sub Peak MVA: 10

No Of Feeders: 4

No Of Customers: 3000

SURROUNDING SUB STATION LOADS AFTER CONTINGENCY

| Surrounding Sub | Normal Peak MVA | Capacity | | LOAD TRANSFERRED | | | | PEAK AFTER CONTINGENCY | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Winter | Summer | n-1 | n-2 | n-3 | n-4 | n-1 | n-2 | n-3 |
| CHEV | 16 | 32 | 29 | 4 | 0 | 0 | 0 | 20 | | |
| ROSE | 23 | 43 | 37 | 2 | 0 | 0 | 0 | 25 | | |
| AVON | 24 | 40 | 40 | 1 | 0 | 0 | 0 | 25 | | |
| SAND | 18 | 40 | 39 | 3 | 0 | 0 | 0 | 21 | | |

*Figure 6.3 Example of Zone Substation contingency*

## VECTOR CONTINGENCY SWITCHING

REGION **Auckland**
Zone Substation: **Mt Albert**

Ref Number: **A 377** Date: **13/03/2002** Revision No: 4 Revision 26/05/2006

Contingency: **N-1 Mt Albert**

Scenario: T1 requires complete off loading

| Time | Operation | Switch Type | Number | Location or Label |
|---|---|---|---|---|
| | **CLOSE** | **CB** | **11** | **Andy Miller via Auto Tr and local @ CHEV** |
| | **OPEN** | **CB** | **19** | **Carrington Rd @ MALB** |
| | | | | **CB 19 (200 A) onto CB 11 CHEV (n/op) 0A = Total 200A** |
| | **CLOSE** | **LINE SW** | **5085** | **UNITEC Gate 1, Carrinton Rd** |
| | **OPEN** | **CB** | **16** | **Wilcott St @ MALB** |
| | | | | **100A to CB4 ROSE (225 A) = Total 325 A** |
| | **CLOSE** | **LINE SW** | **6082** | **Mercury Motors, New North Rd** |
| | **OPEN** | **CB** | **17** | **Allendale Rd @ MALB** |
| | | | | **70 A to CB6 AVON (150 A) = 220 A** |
| | **CLOSE** | **LINE SW** | **5149** | **@ Supermarket, 4 Kitenui Ave** |
| | **OPEN** | **CB** | **20** | **Fowler Ave @ MALB** |
| | | | | **175 A to CB8 SAND 8 (170 A) = 340 A** |

Remarks:

**Re-done, September 2002**
**Updated 26/5/06**

| | | | |
|---|---|---|---|
| Switching Orginated By | R Downey | Date | 11/09/2002 |
| Checked by System Control | B Ashton | Date | 26/05/2006 |

| Revision No: | Revision: | Revised | Revision | Checked By: |
|---|---|---|---|---|
| 4 | Updated B Ashton | 26/05/2006 | | |

*Figure 6.4 Example of switching plan to offload Zone Substation*

In addition there are 8 contingency plans detailing special arrangements for major customers such as Pacific Steel, Fonterra and Auckland Airport

Plans have been drafted to cover emergency situations. These plans are reviewed frequently to ensure currency. Examples of the plans are:

- Major Incident Plan
- Storm response Plan
- Priority notification Procedures
- Total Loss of a Zone Substation Plan
- Loss of Transpower Grid Exit Plan
- Call centre Continuance Plan
- Control Room Disaster recovery Plan

### 6.5.2. 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 construction of a new part of the network is undertaken, an evaluation is made of the spares that will be retained to support repair of any key equipment installed.

A review of unique distribution asset types specific to Northern and Wellington zones has taken place in conjunction with a review of the Facility Management Contract. This process has highlighted a need for some stock rationalisation, the addition of new inventory and increased specific stock holdings. It is proposed that in due course a revised Facility Management Contract will control these distribution assets. Until that time our zone based contractor will continue to control Northern and Wellington critical stocks and our strategic spare store with Transpower will continue to control Auckland's requirements.

### 6.5.3. CONTROL ROOM

The Control Room has two substantial and one temporary back-up facility in place; the major sites being geographically separate. As well as the back-up sites, there are associated activation plans which are tested at least annually.

### 6.5.4. MAJOR INCIDENT TEAM

A Major Incident Team exists comprising of senior staff whose role is to oversee the management of potential loss of and restoration of supply following with a significant event.

The team is experienced and undertakes exercises periodically (at least annually).

### 6.5.5. DISASTER ANALYSIS

Plans are developed, as part of the overall management of the network, which consider the actions that would be taken in the event of a major failure of part of the network. Such plans consider switching options, the rapid construction of temporary lines and emergency generation.

If there is specific concern regarding a risk to the network, detailed contingency plans are developed, which include detailed design of the required temporary lines, emergency generation and the securing of materials required to allow immediate construction.

### 6.5.6. CIVIL DEFENCE AND EMERGENCY MANAGEMENT ACT

Vector is required under the Civil Defence and Emergency Management Act 2002 (CDEM) to be "able to function to the fullest possible extent, event though this may be at a reduced level, during and after an emergency" and also to have plans for functioning during and after an emergency.

A business continuity plan for Vector has been developed and is being reviewed in light of the merger with NGC. Vector is also a member of the Auckland Engineering Lifelines Group (AELG) and through this membership keeps abreast of development in the CDEM area to ensure it is fully prepared for an emergency.

Vector has in place emergency response plans for major events and a Civil Defence and Emergency Management plan that sits above these plans for use in the event of a declared civil defence emergency.

### 6.5.7. HEALTH AND SAFETY

At Vector safety is a value, not merely a priority. The Vector safety culture described below is being adopted in the broader organisation following the acquisition of NGC.

Vector's policy is to:

> *"Create and maintain a safe and injury free work environment for our employees, our service providers, our suppliers and the public we serve."*

To support the Vector safety policy a set of Safety Guiding Principles have been adopted by the company and our service providers. They reflect the principles of other world class companies, and define the ultimate responsibility of management to lead and implement the safety process, while at the same time recognising each individual's responsibility to work safely.

- Everyone is responsible for safety
- We look out for each other
- Safety will be planned into our work
- All injuries are preventable
- Management is accountable for preventing injuries
- Employees must be trained to work safely

Vector's Safe Work Practices define the essentials necessary to maintain an injury free environment. These practices reflect the basic approach necessary for Vector and our service providers to identify and eliminate accident causes.

All service providers working for the company are required, as a minimum, to comply with these Safe Work Practices whilst carrying out any work on the network. Service providers are also required to report all employee accidents/incidents and near misses to Vector together with their relevant investigations and intended corrective actions. The service providers are incentivised through the contract bonus structure to achieve the Vector safety targets.

As part of our focus to continually improve health and safety, we have employee safe teams and a Safety Leadership Team – a task force which encourages all staff to voice their opinion on company safety standards, raise concerns and suggest improvements.

In conjunction with Shaw Group (formerly Duke Energy) we have undertaken a number of audits of our health and safety systems and processes. The latest audit classed us overall as good, and noted that we had made significant progress in a number of areas. Notwithstanding these positive indications, further attention and resources will be applied to deliver further significant improvements.
Our progress on health and safety is shown in Figure 6.3.

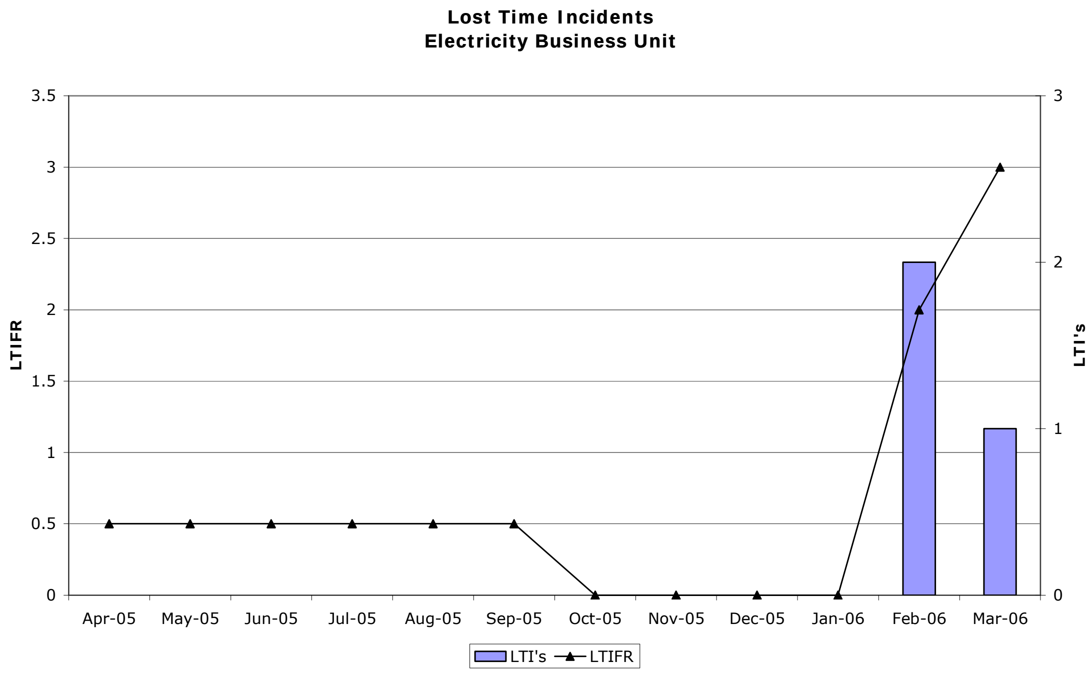



*Figure 6.5 Network Safety Performance*

Our ongoing safety target is simply:

*"No lost time injuries to any person working on our network."*

In terms of public safety, the EBL monitors public safety with staff/contractor safety and undertakes monthly meetings to identify issues and review progress.

A key driver in the development of the EBL's annual capital programme is the mitigation of specific public safety and environmental issues. The management of operations in the field takes in to account HS&E issues, exemplified by the work of the assessors who review issues such as traffic management and pedestrian safety.

With respect to overall community safety, the EBL offers free cable location service and disconnect services. It also undertakes extensive public communication, an example of which is the school programme which was successfully rolled out in 2005.

Vector also puts significant emphasis on environmental management. Recently, environmental specialists, Pattle Delamore Partners Ltd, were engaged to audit our environmental processes and compliance along with those of our service providers. Being the first of such audits, information gathered has enabled further improvement in this area.

Much work has been done by Vector in raising the awareness of the field staff on environmental issues. We work closely and have a good relationship with the ARC. We have done a formal audit of our Environmental System which included auditing our zone based contractors. Action plans have been developed and we are now monitoring their progress. We are also working on the Vector Environmental Management System to make that more robust.

#### 6.5.8. SAFETY

Vector sets safety targets around lost time injury frequency per million man hours worked. These statistics include all lost time injuries sustained by their employees and employees of their service providers whilst working on the network.

The target set for the year ending June 2006 was:

- Achieve a 50% reduction in the TRIFR for all Vector networks

Performance at 31 March 2006 year end was:

- Three lost time injuries during the period for all of the Vector Electricity Network
- A resultant lost time injury frequency of 2.17

# 7. EVALUATION OF PERFORMANCE

## 7.1. PROGRESS AGAINST PLANS

### 7.1.1. CAPITAL PROJECTS IN THE VECTOR NETWORK

The 2005/06 capex plan included a total of $151 million of new capital projects. The total value of network capital projects delivered during the year is projected to be $147 million (year end 30 June 2006).

The variances are due to

- Reprioritisation of projects during the year
- Delays in projects due to unexpectedly long lead times on the delivery of key overseas sourced equipment
- Unforeseen consent issues creating delays
- Delays due to construction resource constraints
- Inclusion of $7.2 million unbudgeted projects during the year

## 7.2. PERFORMANCE AGAINST TARGETS

Vector has in place detailed performance targets that are defined and linked to ensure that we are striving for and achieving the company goals in an optimum and efficient way.

Physical performance in Vector is tracked through the following key measures:

- Reliability
- Standard Service Levels
- Safety and Environmental and
- Customer Satisfaction

These key measures:

- Are directly applicable to the core business
- Support the aims of the strategic business
- Enable Vector to track and easily communicate performance
- Enable direct comparison with other companies for the purposes of benchmarking

The ongoing results of these measures are communicated on a monthly basis to all Vector employees and service providers. Accountability for the performance targets is a function of all employees. Our service providers are incentivised through the contract bonus structure to achieve their targets and Vector direct employees have the physical performance measure embedded in the performance related pay scheme.

### 7.2.1. RELIABILITY

The reliability targets and actuals for the combined network for 2005/06 are shown in Table 7.1.

| Measure | 05/06 Actual | 05/06 Excluding Extreme Weather | 05/06 Target |
|---|---|---|---|
| SAIDI | 118 | 80 | 85 |
| SAIFI | 1.52 | 1.19 | 1.31 |

*Table 7.1 Reliability Statistics (exclusive of Transpower outages)*

Due to the impact of extreme weather events, Vector's most recent year end 05/06 SAIDI performance finished at an overall 118 minutes. However excluding extreme weather events the normalised year end result would be 80 minutes, below the target threshold value of 85 minutes. SAIFI performance on the same basis is finished at an overall 1.52 interruptions. Excluding the impact of extreme weather events from the 05/06 SAIFI performance figures, the year end result would be 1.19 interruptions, below the target threshold value of 1.31 interruptions.

In explanation to the Commission, Vector has identified the following extreme weather events considered outside of reasonable control, affecting the Auckland Area on the 18th September 2005, 8th October 2005, 26th November 2005 and the

24th January 2006, affecting the Northern Area on the 12th July 2005, 18th and 19th September 2005, 8th October 2005, 26th November 2005, 24 January 2006 and the 26th March 2006. Affecting the Wellington Area on the 2nd and 4th of January 2006.

In order to define "extreme weather events", Vector employs a methodology which combines meteorological data (peak average wind speed, >50kph), with excessive HV fault frequency (8-times or greater than the daily average), to identify extreme event days. The extreme event days are then examined by each event casual factor to define a list of exclusion events outside reasonable control. The impact of extreme events days on Vector's HV unplanned events can be seen in figure 7.1.

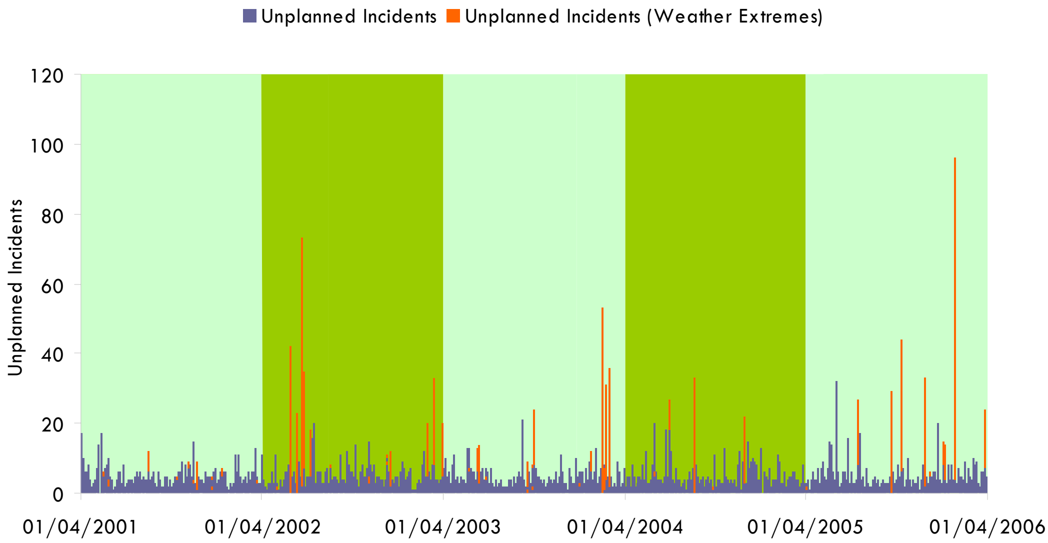



*Figure 7.1 Daily Unplanned Events Performance Profile*

The SAIDI and SAIFI targets set for 06/07, 07/08 and 08/09 years will continue to be aligned with customer and regulatory expectations of the trade-off between price and quality.

In 2006/07, the company has budgeted almost $4 million on proactive reliability of supply improvement initiatives. The initiatives continue to target the worst performing feeders and network areas, aiming to bring performance back in line with customer service expectations. The worst 30 feeders ranked by 05/06 SAIFI performance are shown in figure 7.2. The top ten are shown in red, the next ten orange and the remaining in green.


*Figure 7.2 Worst Performing Feeders Ranked by 05/06 SAIFI*

These proactive initiatives do not just focus on minimising the time customer's are without electricity but will also reduce the number of interruptions customer's experience (customer consultation having identified frequency of interruption as the highest priority item for reliability improvement) and improve the power quality delivered to customers.

Improvement initiatives consider both long and short term solutions. The short term initiatives are generally failure mode specific. All initiatives are evaluated through a cost benefit framework that considers the effect on service area frequency and duration performance, together with standard service level frequency and duration performance.

Key initiatives improve performance include a continuation of the existing program to

- Split up feeders with circuit breakers so that fewer customers are affected in the event of a fault
- Install remote control over these breakers so restoration of sound network may be carried out in the Control Centre rather than incur delays associated with sending a contractor to site
- Install further numbers of fault passage indicators to narrow down the location of the fault for quicker restoration of healthy network
- A number of initiatives have been highlighted under Section 7.3 which includes reviewing the present contracting model to ensure the relationship with our contracting partners is providing the correct outcomes to achieve the improvements sought
- Improved management of vegetation

### 7.2.2. STANDARD SERVICE LEVELS

The standard service level targets and actuals for the combined network for 2005/06 are shown in Table 7.2.

| Measure | 05/06 Actual | 05/06 Target |
|---|---|---|
| Frequency | 77,400 | 90,000 |
| Duration | 63,500 | 70,000 |

*Table 7.2 Service Level Breaches (exclusive of Transpower and Extreme outages)*

The promise payments associated with the breach in standard service levels are shown in Table 7.3.

| Measure | 05/06 Actual | 05/06 Expectation |
|---|---|---|
| Service Level Payouts | $485k | $815k |

*Table 7.3 Service Level Payouts (exclusive of Transpower and Extreme outages)*

The targets set for 2006/07 and future years will continue to be aligned with customer expectations of the trade-off between price and quality. As stated in the reliability section, all improvement initiatives are evaluated through a cost benefit framework that considers the effect on service area frequency and duration performance, together with standard service level frequency and duration performance.

### 7.2.3. SAFETY

Vector, in conjunction with the zone based contractors have identified four key areas that has led to the injuries in this last year. These can be summarised as

- Behaviour – engaging in unsafe behaviours while working on the network
- Engineering – network equipment installation practices and procedures are not rigorous enough
- Tools – ensuring tools used for installing equipment are suitable for use without compromising the safety afforded by PPE equipment
- Policy – ensuring health and safety policies are observed

Considerable work has gone into understanding the behaviour traits that leads to unsafe practices. These broadly fall into any of nine areas.

While there is a focus on all four areas above one of the key initiatives will be to train front line supervisors to identify the traits that that result in "risky" behaviours. Training programs under development will ensure that contracting staff displaying these behaviours are appropriately managed.

Arising from these incidents has been a refocusing on safety within the Health and Safety teams

### 7.2.4. CUSTOMER SATISFACTION

Vector continues to monitor customer satisfaction as a key performance indicator both for Vector staff and our contracting business partners across all three electricity networks. Results are combined to give an overall score. Prior to the 04/05 year measurements were only in place for the Auckland network so Vector reduced the target slightly once measurement commenced across the three areas. For 05/06 this target was raised to 83%. As at March 31st 2006 the combined score for all three networks was 83.4%.

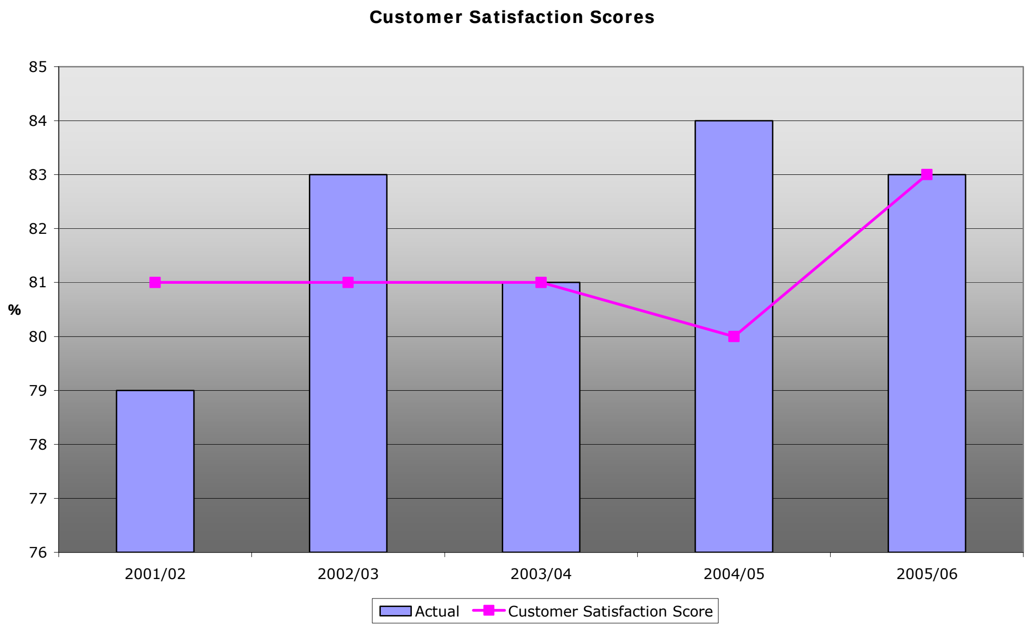



*Figure 7.3 Customer Satisfaction Score*

Vector still continues two different operating models for customer interaction. These are based on contractual agreements with Energy Retailers. On the Auckland network customer's contact Vector directly in fault situations and for general enquiries around pricing and service, while on the Northern and Wellington networks the customer interaction in these incidences is managed via the customer's Energy Retailer. Customers do however contact Vector directly across all networks in regard to tree enquiries, mapping requests and any connection requests around network assets.

## 7.3. PLANNED IMPROVEMENTS FOR PERFORMANCE

, Vector has a number of initiatives planned for 2006/07:

- The requirement for asset replacement expenditure is increasing, driven by the build and condition profiles of the installed asset base. Vector needs to ensure that we are accurately determining and prioritising asset replacements, and providing certainty to our planners and contracting partners by completing scheduled capital works programmes. In addition internal estimating processes need to be reviewed to increase the accuracy of preparing preliminary budgets for capital works.

- CAPEX and OPEX costs within the electricity business are increasing rapidly and our ability to recover these is limited by the Commerce Commission's price path regime. While we are protected from increases in OPEX costs to some extent (via our contracting partner agreements) we must be cognisant of the effects that sustained price pressures will have on our partners.

- In 1997 Vector moved away from an in-house to an outsourced business model for all field activities. This model was appropriate at the time and achieved efficiency and cost improvements. Since then significant changes have occurred in the industry, operating environment and to Vector itself. It is now appropriate to review the drivers for this business model decision.

- International demand for distribution network equipment and materials is increasing beyond manufacturers' installed production capacity, placing pressure on our ability to source critical equipment within reasonable lead times. The development of a procurement strategy for major network equipment is required.

- Accurate data is fundamental to Vector's operations. A review of the processes has identified a number of areas where improvement is necessary. This includes interfaces and obligations on our contracting partners to supply timely and accurate asset data, functionality of IT systems used to hold asset information and data integrity.

- Internal reliability and quality of service standards are more onerous than similar regulatory measures Vector is measured and reported against. This can result in increased costs to Vector that cannot be recovered under the pricing thresholds regime. In addition, continued high performance may have an inequitable effect on Vector's regulatory reset in 2009.