wellington electricity™

# Wellington Electricity

## 10 Year Asset Management Plan
## 1 April 2011 - 31 March 2021

# Wellington Electricity

# 10 Year Asset Management Plan

# 1 April 2011 – 31 March 2021

Any comments or suggestions regarding the Asset Management Plan can be made to:

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| | |
|---|---|
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LIABILITY DISCLAIMER

This Asset Management Plan (AMP) has been prepared by Wellington Electricity Lines Limited (Wellington Electricity) for public disclosure in accordance with the requirements of the Electricity Distribution (Information Disclosure) Requirements 2008.

Information, outcomes and statements in this version of the AMP are based on information available to Wellington Electricity that was correct at the time of preparation. Some of this information may subsequently prove to be incorrect and some of the assumptions and forecasts made may prove inaccurate. In addition, with the passage of time, or with impacts from future events, circumstances may change and accordingly some of the information, outcomes and statements may need to change.

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# Statement from the Chief Executive Officer

Wellington Electricity welcomes the opportunity to submit an updated Asset Management Plan (AMP) for the period 2011-2021. We confirm that this AMP has been prepared to meet the Commerce Commission's "Electricity Distribution (Information Disclosure) Requirements 2008".

Our second year of operations has been focused on bedding down the organisation into business as usual activities that leverage the investment in our best-of-breed Information Technology platforms. The focus has remained on maintaining the existing high levels of safety, reliability, service and performance of the network for its customers.

Committed to continuous improvement, we tested the market during 2010 and re-tendered the out sourced provision of maintenance and faults services. This process focused on selecting a provider that could focus on meeting maintenance standards geared towards condition based risk management of the existing asset fleet and delivery of maintenance and fault data into our information systems to enhance our forward decisions on life-cycle asset management.

The Field Services Agreement has been signed with Northpower who commenced their contract from 1 January 2011 and physically deployed a field services workforce from 1 March this year to deliver substantial efficiencies to our organisation.

The AMP confirms the organisation structure and business drivers that set the policies and procedures around best practice asset management. This includes a summary of the systems employed and an outline of processes adopted around maintenance, planning, investment, risk mitigation and outage management. A more detailed treatment of the major asset classes has been included with a stage-of-life assessment which has prioritised capital and maintenance expenditure for the period. Further ranking will take place based on detailed condition information received through the Field Services provider.

Network capacity still appears adequate for the planning period based on maintaining modest forecast growth rates, load management systems remaining effective and with no large developments being disclosed at the time of AMP review.

The AMP has made a number of assumptions around the outcome of the current appeals of regulatory decisions. The Plan positively forecasts that regulatory outcomes will continue to encourage lines businesses to be able to invest in asset maintenance and renewal on the basis of making a fair market return. Although new technology developments have yet to be fully commercialised, Wellington Electricity continues to evaluate opportunities that benefit the efficient operation and effective utilisation of the network for the long term benefits of shareholders and our customers.

Our customers have been consistent in their feedback and are appreciative of a reliable network that is delivering services at affordable prices.

The control room continues to provide sound operational management of the Wellington network through state-of-the-art communication and control systems. It is our belief that this will position Wellington Electricity to become an industry leader in asset management practices. Being a member of the CKI/Power Assets Group allows Wellington Electricity the ability to access skills and knowledge from our other electricity distribution businesses around the world and have direct access to international best practice in asset management. In conjunction with our service companies and in alignment with its business strategy, Wellington Electricity will continue to focus on the development of asset management strategies in parallel with the short to long term planning of the network to ensure that appropriate levels of capital and operational expenditures are made to deliver a safe, reliable and cost effective supply of electricity to consumers within the Wellington region.

We welcome any comments or suggestions regarding this AMP.

Greg Skelton

**Chief Executive Officer**


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# Contents

# 1. Summary of the AMP

## AMP Purpose

This Asset Management Plan (AMP) has been prepared for the following purposes:

- To inform stakeholders of how Wellington Electricity plans to manage its electricity distribution assets in order to ensure that connected electricity consumers continue to receive electricity supply at a quality level which is reasonably priced and sustainable
- To provide a working plan for use by Wellington Electricity for the management of the network
- To satisfy the Commerce Commission's Electricity Distribution (Information Disclosure) Requirements 2008.

This AMP covers the 10 year period commencing 1 April 2011 and finishing on 31 March 2021. The plans described in this document for the year ending 31 March 2012 reflect Wellington Electricity's current business plan and are relatively firm for the next two to three years. Beyond three years the plans and strategies are reviewed annually and will be adjusted to incorporate any internal and external business environmental factors as they arise.

This AMP was approved by the Wellington Electricity Board of Directors on the 29th of March 2011.

## Assets Covered

Wellington Electricity's distribution network supplies the cities and council jurisdictions of Wellington, Porirua, Lower Hutt and Upper Hutt. A map of the supply area is shown in Figure 1.2. As of 31 December 2010, there were over 164,000 connected customers. The total system length (excluding streetlight circuits and DC cable) is almost 4,600 km, of which 61% was underground. Peak demands and energy distributed for the last four years is shown in Figure 1.1.

| Year to | 30 Sep 2007 | 30 Sep 2008 | 30 Sep 2009 | 30 Sep 2010 |
|---|---|---|---|---|
| System Maximum Demand (MW) | 555 | 537 | 565 | 583 |
| System Energy Injection (GWh) | 2,569 | 2,581 | 2,595 | 2,594 |

Figure 1-1 Peak Demand and Energy Delivery

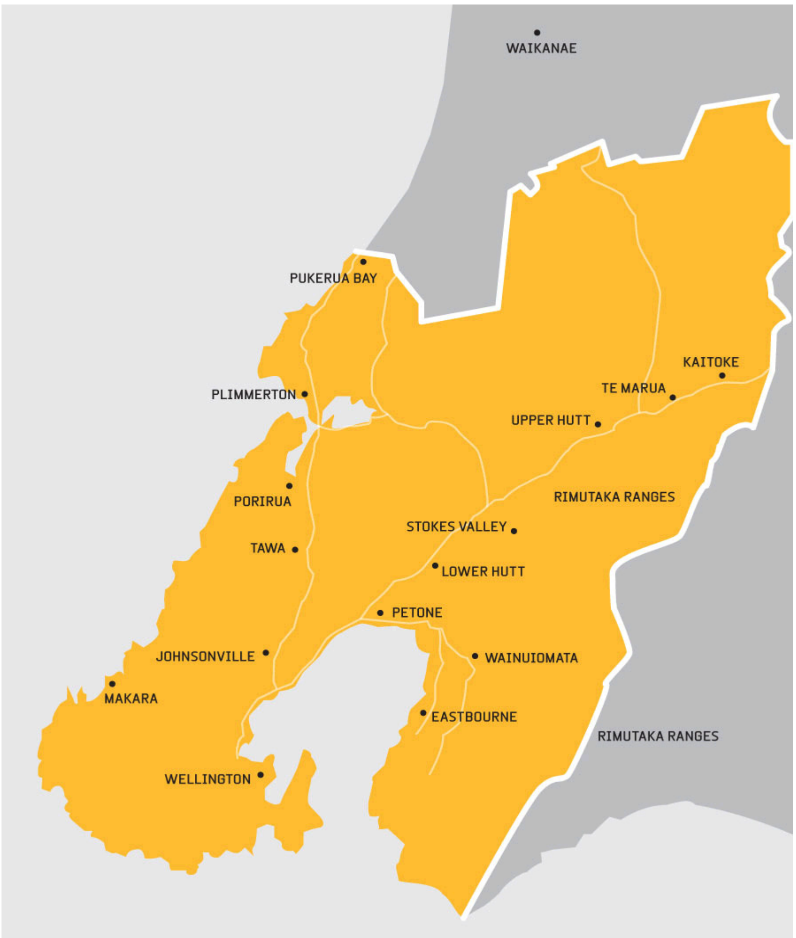


**Figure 1-2 Wellington Electricity Network Area**

## AMP Assumptions

The AMP is based on the following assumptions:

| | |
|---|---|
| Demand growth | Demand growth will continue to be lower than the national average of 2.1% and will remain steady through the forecast period with an annual growth of electricity consumption and demand between 1.0% and 1.5%. |
| Quality targets | The quality targets for the Wellington Electricity business in the period 2010 – 2015 will be maintained as per the Commerce Commission's decision paper on the default price path, November 2009. |
| Regulatory environment | The regulatory environment will encourage Wellington Electricity to continue to employ CAPEX and OPEX to invest in the network to maintain the quality targets. |
| Shareholders | Shareholders will be incentivised to invest in the network to allow the business to achieve market returns. |
| Economy | The commodity markets will remain stable during the forecast period. |
| Business cycle | Wellington Electricity continually undertakes detailed assessments of network assets. It is assumed there will be no uncovering of any new information that changes the premise of network assets being in a reasonable condition. |
| Technology | There will be no dramatic changes that would result in a rapid uptake of new technology leading to higher expenditure or stranding of existing assets. |

### Network Reliability

The reliability of Wellington Electricity's distribution network is high by both New Zealand and international standards. Wellington Electricity plans to maintain supply reliability at current levels over the planning period while the average consumer connected to the network should only experience an outage lasting a little over an hour about once every two years subject to severe storm events and high wind gusts which can frequently occur within the Wellington region. Wellington Electricity's asset management strategies and forecast levels of expenditure and investment are designed to achieve this by replacing assets that are at end of life and maintaining in service assets through to end of life.

### Network Development

The annual growth of electricity consumption and demand in the Wellington Electricity's network area is between 1.0% and 1.5%. This is lower than the national average of around 2.1%.

Wellington Electricity is close to completing a zone substation load transfer project within the CBD to utilise spare capacity however as incremental load increases a new zone substation within the CBD area may be required later in the planning period. Other areas with potential capacity constraints are Mana-Plimmerton, Wainuiomata and the Johnsonville-Paparangi areas. Investment options including reinforcement of sub-transmission into these areas will be analysed and may be required inside the planning period. Development of a reinforcement project for the Johnsonville area is underway, with construction to occur in the 2011/12 regulatory year.

### Asset Replacement and Renewal

The design of the Wellington CBD network is biased towards obtaining high availability and reliability. The Wellington CBD area consists of many high voltage (HV) rings which provide for uninterrupted supply in the event of the loss of any one component. The Wellington Electricity network also comprises a high percentage of underground cabling with 66% of the sub-transmission circuits being cabled. Of this underground cabling, 61km is of pressured gas filled construction, most of which was installed in the 1960's and is being reviewed as part of Wellington Electricity's approach to condition based risk management assessment of its assets. A detailed "Stage of Life" analysis and risk assessment process has been conducted for three major asset types (33kV subtransmission cables, zone substation power transformers and primary distribution circuit breakers) applying a condition based risk management strategy.

The high number of circuit breakers, the HV rings and the predominance of cabling achieve the high levels of reliability but are asset intensive. As the equipment condition factors change and risk increases, Wellington Electricity is forecasting a period of high capital expenditure on asset replacement and renewal being required to maintain present levels of reliability. Ongoing replacement projects on the Wellington network continue to address the condition of switchgear, transformers and other key supply assets.

Wellington Electricity has programmes in place to regularly monitor the condition of its older assets. This ongoing condition assessment indicates that existing assets are still serviceable and generally in reasonable condition for their age. Notwithstanding this, almost 50% of forecast capital expenditure over the planning period is expected to be on the proactive asset replacement and renewal of older assets subject to their condition and risk criteria being met. This level of expenditure is designed to maintain present supply reliability.

### Asset Management Systems

The past 12 months have seen further development and enhancement in the Asset Management systems used by Wellington Electricity. The key Asset Management system goals to address in 2011 are:

- Investigate and correct data quality in systems such as GIS and Gentrack;
- Further develop the maintenance database to enter and record results of Planned Maintenance Activities and to begin the planning for a business integrated maintenance management system; and
- Implement a new GE ENMAC control system and stand-alone automatic load control system at the Haywards Network Control Centre.

The new Field Services Agreement with Northpower includes a number of business processes that over time will assist Wellington Electricity in filling the gaps of both missing and incorrect information as well as cleansing and validating the data in the Wellington Electricity Asset Management systems.

### Risk Management

Wellington Electricity has continued to develop its risk assessment methodologies that inputs to the planning of network development, maintenance strategies and project evaluation. The outcome of this risk based approach has resulted in a Board approved $9.3 million project to install new double circuit 33kV cables from the Wilton GXP to Moore Street. This project will be completed within the 2011/12 regulatory year.

A major objective of the network development and lifecycle asset management plans is to mitigate the risks inherent in operating an electricity distribution business. Risk assessment therefore plays a major role in the prioritisation of network development and asset replacement projects.

The detailed design and operation of the network is not described in this AMP, but it is summarised at a high level to demonstrate it is in accordance with industry standard practices and procedures. These practices and procedures have been developed and refined over time to manage the risks and hazards associated with high voltage electricity distribution.

Wellington Electricity has Emergency Response Plans to cover emergency and high business impact situations and are continuously reviewed and revised to best meet the business emergency management and response requirements.

# 2. Background and Objectives

## 2.1. History and Ownership Overview

Wellington Electricity is an electrical distribution business that supplies electricity to approximately 400,000 consumers through over 164,000 installation connection points (ICP's) in its network that covers the Wellington, Porirua and the Hutt Valley regions of New Zealand.

The ownership of Wellington Electricity has changed significantly since the early 1990's. At the start of the 90's, the Wellington City Council Municipal Electricity Department (MED) and the Hutt Valley Electric Power Board (HVEPB) merged their electricity assets. As part of the Energy Companies Act 1992 two new companies were formed, Capital Power and Energy Direct respectively. In 1996 the Canadian owned Power Company Transalta acquired both companies to form a consolidated Wellington Electricity Distribution Network business. Ownership was passed to United Networks in 1998, which Vector acquired in 2003.

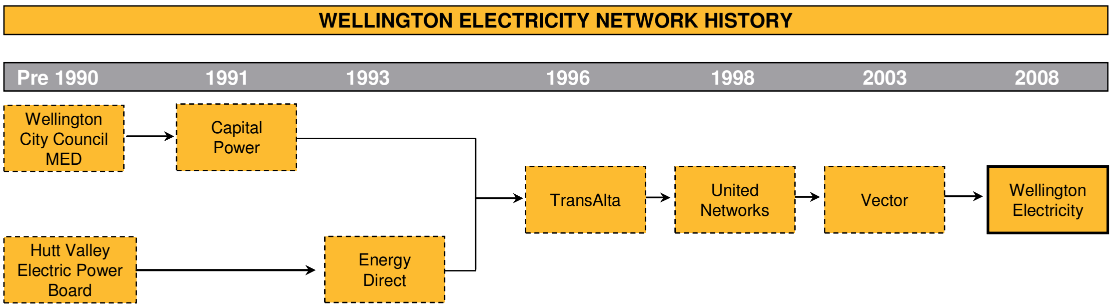


Figure 2-1 Wellington Electricity Ownership History

In July 2008 the network was purchased by Cheung Kong Infrastructure Holdings Limited (CKI) and Hong Kong Electric Holdings Limited (HEH) to create Wellington Electricity Lines Limited (Wellington Electricity). Since then Wellington Electricity has continued to establish the business systems for independent operation and control of the network. Hong Kong Electric Holdings Limited has been renamed as Power Assets Holding Limited (Power Assets) from February 2011 to better reflect the international portfolio of assets.

CKI and Power Assets together own 100 per cent of Wellington Electricity with both companies being members of the Cheung Kong group of companies and are listed on the Hong Kong Stock Exchange (HSE).

For further information regarding the Wellington Electricity ownership structure please visit our website at www.welectricity.co.nz.

## 2.2. AMP Purpose and Objectives

The primary purpose of the AMP is to communicate with consumers and other stakeholders Wellington Electricity's asset management strategies, polices and processes for effective and responsible management of the network assets.

Other goals of the AMP are to:

- Ensure that all stakeholder interests are considered and integrated into the business to achieve an optimum balance between levels of service and the cost effective investment while maintaining regulated service targets. The level of service is reflective of a customer price/quality trade off upon which appropriate pricing can allow the ability of Wellington Electricity to maintain, renew and replace the network assets to meet stakeholder quality needs. The Commerce Commission as the industry Economic Regulator has a part to play in recognising and ensuring that electricity distribution businesses achieve adequate levels of return on investment for their regulated asset base to maintain service quality to consumers;

- Provide a consolidated governance and management framework that encompasses the asset management and planning strategy in a 'live' document;
- Address the strategic goals and objectives of the business by focusing on prudent life cycle asset management planning, stakeholder levels of service and appropriate levels of network investment which provide a sustainable and equitable return to the shareholders;
- Provide a platform for monitoring and demonstrating continuous improvement in alignment with best industry practice.

The AMP is a key internal planning document and has become a consolidated repository for asset management planning. It is a dynamic document requiring continuous review and adjustment to align with the changes in the business environment.

This is a collectively produced document that draws from external stakeholders and from within the Wellington Electricity business. Contributions have been received from consumers, field service providers, asset and planning team, operations and maintenance team, capital works project team, quality, safety and environmental team, commercial and finance and the executive team. The document is approved for disclosure by the Wellington Electricity Board of Directors.

The AMP is compiled in accordance with the Electricity Information Disclosure Requirements 2004 and the 31 October 2008 Amended Requirements.

## 2.3. Legislative and Regulatory Environment

Wellington Electricity's principal activity is distributing electricity. It is an electricity operator pursuant to section 4 of the Electricity Act 1992. As an electricity operator Wellington Electricity provides electricity lines services to customers in its distribution supply area using its electricity supply system.

Wellington Electricity is subject to a range of legislative and regulatory obligations to ensure its network is safely and efficiently planned, constructed, operated and maintained and that the prices charged for its services are appropriate. This includes obligations covering:

- Economic oversight under Part 4 of the Commerce Act 1986 by the Commerce Commission. Economic regulation relates to the method for:
    - Information disclosure - the purpose of which is to ensure that sufficient information is readily available to interested persons to assess whether the purpose of Part 4 is being met; and
    - Regulating revenues received from providing Electricity Lines Services. This may be achieved either under a Default or Customised Price Path
- Reliability of supply of electricity to consumers under the Final 2010-15 Electricity Distribution Default Price-Quality Path Determination (established under the Commerce Act 1986). Reliability is

measured with reference to quantity of interruptions to supply (system average interruption duration index (SAIDI)) and the duration of interruptions to supply (system average interruption frequency index (SAIFI) limits).

- Price path compliance under the Final 2010-15 Electricity Distribution Default Price-Quality Path Determination (established under the Commerce Act 1986).
- Price oversight under the Electricity Industry Act 2010 by the Electricity Authority. Price oversight relates to price setting and price movements, including the principles for price development.
- Connection of customers and embedded generators to the network. These obligation are established under Wellington Electricity's Use of System Agreements (UoSA) and are compliant with the Electricity Industry Act 2010 and the Electricity Industry Participation Code 2010 (Part 11).
- Quality of supply standards. This relates to voltage regulation, harmonic voltages and currents, voltage dips, voltage unbalance and flicker standards as per the Electricity (Safety) Regulations 2010 and AS NZS 61000 Electromagnetic compatibility (EMC).
- Employee and public safety under the Electricity (Safety) Regulations 2010 and the Employment Act 1992 to ensure that Wellington Electricity's network assets do not present a safety risk to staff, contractors or the public. Wellington Electricity monitors electricity related public safety as well as staff and contractor safety incidents around its public assets.
- Environmental obligations under the Resource Management Act 1991, the Building Act 1991, the Local Government Act 1974 (particularly with respect to works on roads), the Dangerous Goods Act 1974 and other relevant local authority bylaws. Wellington Electricity has an Environmental Management Plan which sets out its approach to environmental management of its network including in relation to: noise limits; sediment disposal; dust control; spill management.
- Vegetation management in accordance with Electricity (Hazards from Trees) Regulations 2003. This sets out clearance zones in which vegetation must not encroach.

Wellington Electricity has had regard for each of the above regulatory and legislative obligations in developing best practice asset management policies and procedures, which underpin this AMP.

There are currently no regulated national security standards in force. Accordingly, Wellington Electricity has developed its own security standards which specify the minimum levels of network capacity (including levels of redundancy) for its network. Wellington Electricity's security standards are discussed in section 5 of this AMP.

### 2.3.1. Economic Regulatory Environment

As noted above, Wellington Electricity is a regulated monopoly and its revenue requirements are subject to regulation by the Commerce Commission under Part 4 of the Commerce Act 1986.

Wellington Electricity's revenue requirements for Electricity Lines Services were established under the Final 2010-15 Electricity Distribution Default Price-Quality Path Determination made by the Commission on 30 November 2009 (2010-15 DPP Determination) for the regulatory control period 1 April 2010 to 31 March 2015.

Wellington Electricity recovers its notional revenue, calculated based on a price path form of regulation that applies a weighted average price cap (WAPC), through charges for the use of the distribution system (otherwise known as Electricity Lines Services charges). These charges are payable by customers and are collected via the customers' retailer.

Wellington Electricity's notional revenue requirement determined under the 2010-15 DPP Determination provides the economic foundation for the implementation of this AMP until the commencement of the next regulatory control period on 1 April 2015.

Importantly, substantial changes have been made to the regulatory framework since the commencement of the current regulatory control period. These changes may impact on the 2010-15 DPP Determination and therefore Wellington Electricity's 2011-15 notional revenue requirement, which underpins the expenditure program - projects and works programs - set out in this AMP. Changes to the regulatory framework include:

- The development and publication of the Final Input Methodology Decisions (Final IM Decisions) in December 2010. The final IM Decisions are important because they set out the rules, requirements and processes applying to the regulation of distribution services.

  The regulatory matters addressed under the Final IM Decisions include amongst other things: cost of capital; asset valuation; and pricing methodology.

- The development of the Starting Price Adjustment Framework (SPA Framework). This is a critical component of the regulatory framework as it may impact on the initial prices underpinning the 2010-15 price path and therefore Wellington electricity's revenue requirement over the current regulatory control period.

At the time of drafting this AMP, these regulatory changes had not been finalised. Wellington Electricity will need to assess the impact on its future revenue of these regulatory changes once they are finalised. This may require Wellington Electricity to review its future expenditure program and therefore the projects and work that are detailed in this AMP.

## 2.4. Interaction between AMP and Other Business Plans

The AMP incorporates information from internal business and asset management related documents which cascade down from the Business Plan and Strategy to the asset maintenance and lifecycle plans through to the annual Capital and Maintenance works delivery plans and programmes.

Wellington Electricity's mission sets the context for all strategic positioning and tactical action planning within the business from a top down approach which effectively drives the asset management planning and delivery.

**MISSION – *"To own and operate a sustainably profitable electricity distribution business which provides a safe, reliable, cost effective and high quality delivery system to our customers."***

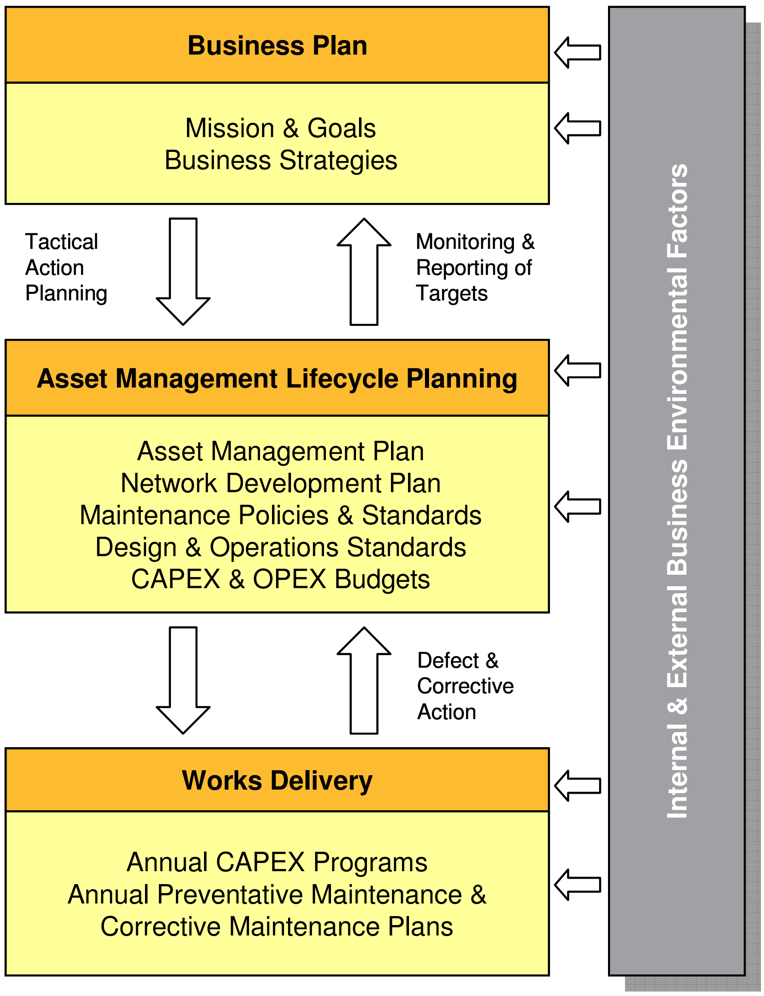


**Figure 2-2 AMP Interaction with Business Planning**

### 2.4.1. Business Plan and Strategy

The company's strategic business direction is supported by the Business Plan and Wellington Electricity aims to deliver a long-term sustainable business to all of its stakeholders.

Wellington Electricity's business strategy is driven in response to both internal and external business environments and defines the company's actions and outcomes to meet the business vision.

| WELLINGTON ELECTRICITY BUSINESS PLAN | |
|---|---|
| **"To own and operate a sustainably profitable electricity distribution business which provides a safe, reliable, cost effective and high quality delivery system to our customers."** | |
| **INTERNAL BUSINESS ENVIRONMENT** | **EXTERNAL BUSINESS ENVIRONMENT** |
| **Financial** | **Consumers** |
| Meeting our financial targets<br>Manage our treasury responsibilities | 163,000 reasons to provide effective and efficient service<br>Understand our investment in their future for a quality service |

| People | Regulatory |
|---|---|
| Working safely | Commerce Act – Price/Quality Path reset & controls |
| Developing a great team & organisational culture | Electricity Act & Regulations |
| Employees are aligned with business goals & direction | Health & Safety in Employment Act |
| Building strong relationships with our service providers | **Economic** |
| Reputable employer | Recession recovery and pressure to maintain price stability |
| **Assets** | **Image & Reputation** |
| Meeting regulatory targets through prudent asset management | Well managed media and stakeholder communication |
| Effective life cycle management of assets | Local people managing the business well with high quality service |
| Appropriate risk management | **Political** |
| Engaged with our stakeholders | Responsibility of 4th largest ELB serving nation's capital |
| | Government & business leaders interested in affordable & reliable supply |
| | Managing local & regional council expectations |

**Figure 2-3 Wellington Electricity Business Plan**

The business strategies effectively 'shape' the AMP taking into consideration the changing regulatory environment and the impacts upon Wellington Electricity meeting the needs and interests of its stakeholders.

| BUSINESS STRATEGIES | |
|---|---|
| **Safety - Our Primary Focus** | Continuous review of incidents/accident reporting<br>Further development of the Public Safety Management System |
| **Financial & Corporate** | Generate an adequate return to shareholders<br>Manage treasury outcomes |
| **Network & Assets** | Produce annual Asset Management Plan<br>Produce Network Development Plan |
| **Our People** | Set personal & company objectives/targets for growth<br>Stimulate & challenge our people |
| **Regulatory** | Establish appropriate business models<br>Manage well all regulatory submissions |
| **Service Providers** | Manage and motivate all service providers to continuously perform ahead of contract requirements and KPI Expectations |
| **Growth** | Explore increased revenue opportunities<br>Leverage ripple control for Demand Side Management opportunities |
| **Image & Reputation** | Support a positive public image through customer engagement<br>Enhance reputation be delivering a consistent & quality service |

Figure 2-4 Wellington Electricity Business Strategies

## 2.5. Planning Period Covered by the AMP

This AMP covers the 10 year period commencing 1 April 2011 to 31 March 2021 and replaces the April 2010 AMP. Plans for subsequent years of the planning period are likely to be affected by the outcomes of the continued development of the asset management reviews as well as changes to the internal and external environment in which Wellington Electricity operates. The AMP provides clear plans for the management of assets over the next 12 to 36 months, with plans for the subsequent three to seven years being broader and plans for the eight to ten year period being indicative only. This reflects the impact of uncertainty over the longer timeframes.

The AMP will be continuously reviewed in conjunction with the development of asset management strategies driven by:

- A greater understanding of the condition of the Network assets and risks
- Assessment of load growth and network constraints
- New and emerging technologies
- Changes to business strategy driven by internal and external factors

The AMP was approved by the Wellington Electricity Board of Directors on the 29th of March 2011.

## 2.6. Managing Stakeholders

### 2.6.1. Stakeholder Interests and Identification

Wellington Electricity has identified stakeholders, their interests and how interactions are managed by all of the business through a number of activities. The following tables identify the key stakeholders, how they are identified and what their interests are with Wellington Electricity.

| Shareholders | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ Governance and Board mandates<br>▪ Board Meetings and committees<br>▪ Business Plan & Strategic Objectives | Shareholders expect a fair economic return for their investment. Shareholders expect the company to meet industry-leading operational and HSE standards. Shareholders look to maintain good working relationships with other key stakeholders in the business through engagement with our consumers needs and effective management of the network | ▪ Customer initiated projects produce appropriate revenue levels to meet the cost of capital<br>▪ Meeting reliability and customer service levels |

| Consumers | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ Customer satisfaction and engagement surveys<br>▪ Feedback received via complaints and compliments<br>▪ Media related enquiries and sponsorship<br>▪ Price / Quality trade-off | The consumers connected to Wellington Electricity's network require a safe and reliable supply of electricity of acceptable quality at a reasonable price. While consumers generally appreciate that delivery of an extremely high quality of supply with no interruptions is unrealistic, expectations can differ as to the level of reliability and quality that can be considered acceptable. | ▪ Meeting reliability and customer service levels<br>▪ Appropriate investment in the network<br>▪ Public safety initiatives<br>▪ Price / Quality trade-off |

| Retailers | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ Electricity Governance Rules<br>▪ Relationship meetings and direct business communications<br>▪ Via Use of Network Agreement terms | As retailers rely on the network to deliver the energy they sell to consumers, they also require the network to be reliable and electricity distribution services to be provided at a reasonable price. Retailers are reliant on electricity distribution services to conduct their business and therefore want Wellington Electricity to assist them in providing innovative products and services for the benefit of their customers. | ▪ Meeting reliability targets<br>▪ Achieving customer service levels<br>▪ Consultation |

| Regulators | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ Commerce Act Part 4 and other legislation<br>▪ Relationship meetings and direct business communications<br>▪ Industry working groups<br>▪ Information disclosure | To ensure that the consumer achieves a supply of electricity at a fair price commensurate with an acceptable level of quality.<br>Regulators need to provide an investment framework for business to make adequate returns on infrastructure. | ▪ Meeting reliability compliance targets and controls for price and quality<br>▪ Compliance with legislation, engagement and submissions as required<br>▪ Monitoring information disclosures |

| Staff & Service Providers | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ Team and individual direct discussion<br>▪ Employee satisfaction surveys<br>▪ Relationship meetings and direct business communications<br>▪ Contractual agreements | Staff and contractors want job satisfaction, a safe and enjoyable working environment and to be fairly rewarded for the services they provide.<br>Contractors also want assurance around work delivery continuity and the mitigation of working hazards by appropriate asset management planning. | ▪ Health & Safety policies and initiatives<br>▪ Forward planning of work through asset management practises<br>▪ Performance reviews<br>▪ Life balance |

| Transpower | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ EPIC<br>▪ Relationship meetings and direct business communications<br>▪ Annual planning documents<br>▪ Grid notifications & warnings | Transpower obtain sustainable revenue earnings from the allocation of connected and inter-connected transmission assets. Wellington Electricity under the Electrical Industry Participation Code (EPIC) will operate and interface under instruction as and when required. Further assurance is required that all downstream connected distribution and generation will not unduly affect their assets. | ▪ Implementation of Operational standards and procedures<br>▪ Appropriate investment in the network |

| Central & Local Government | | |
|---|---|---|
| How are the interests identified? | What are their interests / expectations? | Accommodation of interests / expectations? |
| ▪ Through legislation<br>▪ Relationship meetings and direct business communications<br>▪ Focus working groups | Local Councils require that appropriate levels of investment are made in the electricity network to allow for levels of local growth.<br>Regional Councils require that both current and new network assets do not affect the environment.<br>Central Government's interests are mainly managed through the respective ministries e.g. MED, DOL, to ensure the general public receive a safe, reliable and fairly priced electricity supply.<br>All three require appropriate emergency response and contingency planning to manage a significant civil defence event. | ▪ Compliance with legislation, engagement and submissions as required<br>▪ Emergency Response Plans<br>▪ Environmental Management Plans |

Figure 2-5 Stakeholder Identification

### 2.6.2. Managing Conflicting Interests

Safety will always be a 'non negotiable' attribute when managing a stakeholder conflict. Wellington Electricity will not compromise the safety of the public, its staff or service providers.

Other stakeholder interests that conflict will be managed on a case-by-case basis. This will often involve consultation with the affected stakeholders and may involve the development of innovative "win-win" approaches that are acceptable to all affected parties. However Wellington Electricity is obliged to follow approved business policy to ensure it meets its obligations and responsibilities to deliver an electrical supply in accordance with all legislative requirements.

## 2.7. Wellington Electricity Structure and Asset Management Accountability

### 2.7.1. Governance

The Wellington Electricity Board of Directors is responsible for the overall governance of the business. The Board has approved capital and operational expenditure budgets and business plans for the 2011 calendar year. Information is provided to the Board as part of a monthly consolidated business report that includes health and safety reports, capital and operational expenditure vs. budget, reliability statistics against targets and consumer satisfaction survey results.

All network capital projects greater than $400,000 require approval from the Capital Investment Committee (CIC). The CIC comprises as a minimum one company director and the CEO. The CIC meets on a regular basis to review and approve projects and to be appraised of progress on approved projects.

### 2.7.2. Executive and Company Organisation Structure

The Wellington Electricity CEO leads the business management, implements the company mission and is accountable for overall business performance and direction.

The International Infrastructure Services Company (IISC) is a separate infrastructure services company which provides services to Wellington Electricity.

Further services are contracted to Wellington Electricity through external service providers.

As Wellington Electricity is part of the CKI group of infrastructure companies, it can access skills and experience from across the world. For example, CKI's Australian group companies (which distribute electricity to over 1.7 million customers) have considerable knowledge and experience in electricity distribution business asset management including strategy and planning. This group has provided the IT systems and platforms into Wellington Electricity to allow synergy gains across the business. Being part of a larger CKI group of companies has provided Wellington Electricity with direct access to international best practice systems to support world class asset management.

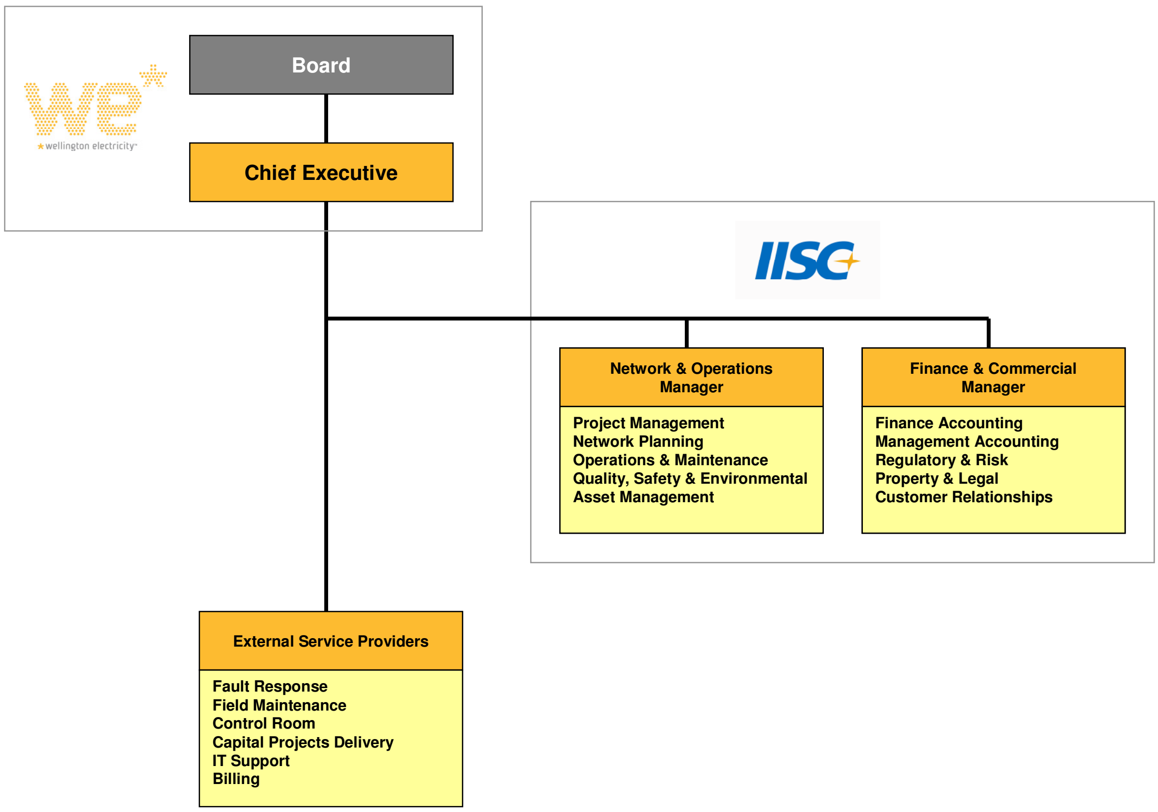


Figure 2-6 Wellington Electricity Organisation Structure

### 2.7.3. Network & Operations Team Structure and Asset Management Accountability

The management of network assets for Wellington Electricity falls under the accountability of the IISC Networks and Operations team, however the entire business has some direct or indirect interaction with the network assets on a daily basis.

The Wellington based Networks and Operation Manager is accountable for delivery of asset management services to Wellington Electricity. These services include asset planning, project management, capital expenditure delivery, operations and maintenance and safety, quality and environmental performance.

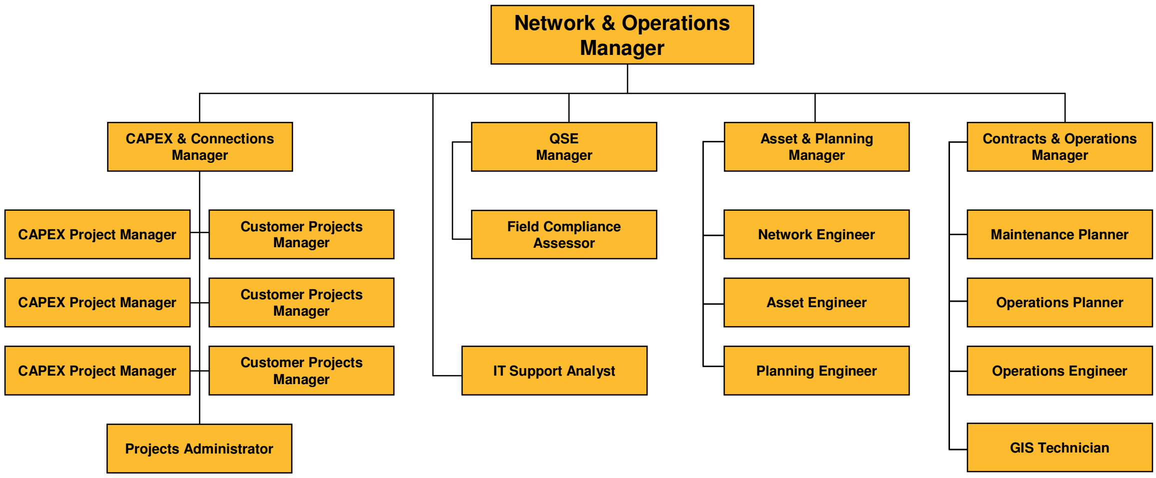


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Figure 2-7 IISC Network and Operations Support Structure for Wellington Electricity

### 2.7.4. Finance and Commercial Team Structure and Asset Management Accountability

Financial and accounting support for the management of network assets is also provided for within the IISC structure for service delivery to Wellington Electricity. The Finance and Commercial team provides indirect interaction with the network assets through managing support systems on a daily basis.

The Wellington based Finance and Commercial manager is responsible for all indirect asset management functions including customer service, retail services, regulatory management, legal and property management as well as financial modelling and accounting support services.

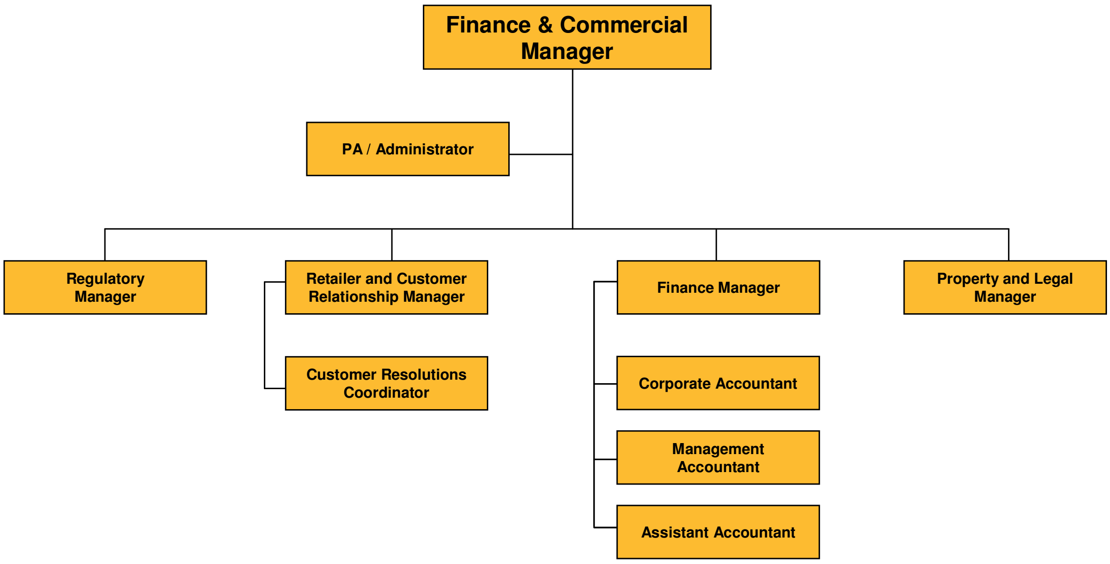



Figure 2-8 IISC Finance and Commercial Support Structure for Wellington Electricity

### 2.7.5. External Service Providers – Field and Network Operations

Wellington Electricity operates a contracted out-sourced field operations model on its network utilising a number of service providers for core field and network functions. During 2010 Wellington Electricity undertook a selective Request for Proposal (RFP) process for the out-sourced provision of field services (fault response and maintenance) culminating in Northpower Ltd being the successful RFP respondent and the implementation of a new Field Services Agreement. A transition period occurred to handover from the existing service provider, Siemens Energy Services, with Northpower commencing the contractual field service duties on 1 March 2011.

The new Field Services Agreement has been designed to deliver a number of strategic objectives for Wellington Electricity. A particular focus is on alignment with the Wellington Electricity asset management strategies, to obtain a greater understanding of the condition of network assets and to improve the integrity of asset data with population into the Wellington Electricity information systems.


**Northpower undertaking overhead network repairs**

In summary, the out-sourced field operations and the approved Wellington Electricity service providers are:

<u>Fault Response and Maintenance (Northpower)</u>

- Fault Management – 24/7 response for fault restoration
- Preventative Maintenance – asset inspection and condition monitoring including capture, storage of asset condition data and feeding back of this information to the asset owner
- Corrective Maintenance – remedial maintenance on defective assets
- Value added services – safety disconnects and reconnects, on site cable mark-outs, sub-transmission standovers and the provision of buried asset plans are provided to third parties by the maintenance contractor
- Minor connection services and livening

Contestable Capital Works Projects (Northpower, Transfield Services and Lineworks)

- Customer initiated works – new connections, subdivisions and substations, undergrounding and relocations
- Network initiated works – asset replacement projects and cable/line reinforcements

Vegetation Management (Treescape)

- Vegetation Management – tree clearance programme, tree owner liaison and reactive availability

Network Control Room (Siemens Energy Services)

- Network Control Services – 24/7 management of Wellington Electricity's Network Control Room (NCR) at Haywards with relocation to the disaster recovery site at Central Park substation if necessary

Contact Centre (Telnet)

- Contact Centre – providing a dispatch function for all HV and LV outages, management of customer and retailer service requests, outage notification to retailers and handling general enquiries

Wellington Electricity manages and audits service providers and also collates reports on network operations and maintenance performance and expenditure, customer satisfaction, safety statistics and network reliability.

Wellington Electricity will continue to review the extent that these activities remain out-sourced in order to achieve optimum asset management outcomes.

## 2.8. Asset Management Systems and Processes

The purchase of Wellington Electricity has seen the stakeholders invest over $12m in state of the art, best of breed IT systems. This level of investment is unprecedented in the New Zealand industry and places Wellington Electricity in a strategically strong position for establishing best practice asset management services to its customers.

This section of the AMP identifies the key repositories of asset data that is used in the asset management process, the type of data held in the repositories and what the data is used for. Areas where asset data is incomplete are identified and initiatives to improve the quality of this data are disclosed.

### 2.8.1. Systems for Managing Asset Data

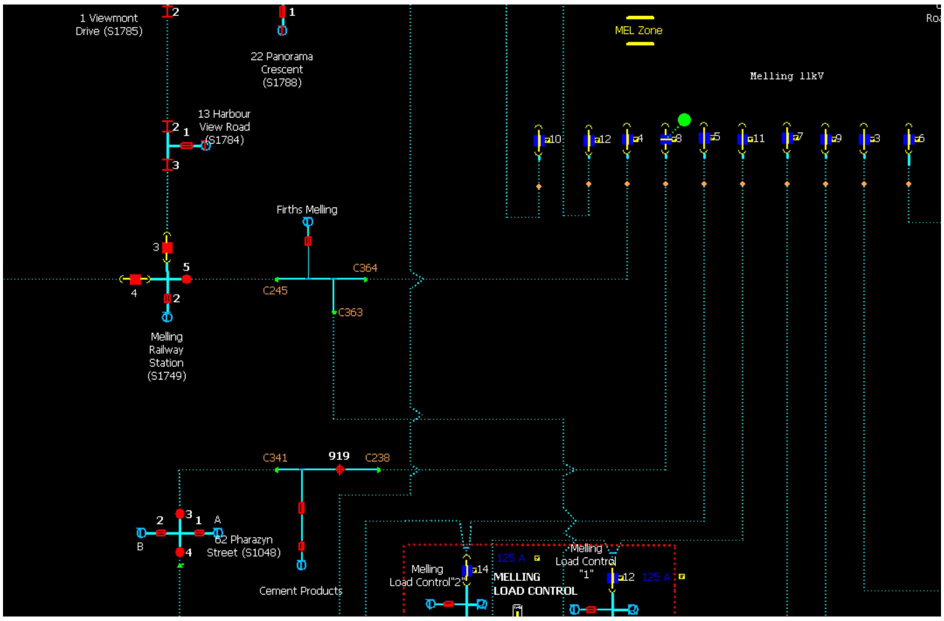
The key repositories of asset data are described below.

#### 2.8.1.1. SCADA

A GE ENMAC SCADA system was installed in 2009 during the business transition to provide real time operational management of Wellington Electricity's network. The ENMAC system will be fully commissioned during 2011 following the separation of the load contol system. Once fully implemented, the ENMAC system will provide a total integrated solution of SCADA, DMS (Distributed Management System) and OMS (Outage Management System) with the legacy Foxboro SCADA system fully separated from the Enmac SCADA to perform the automated load control functionality.

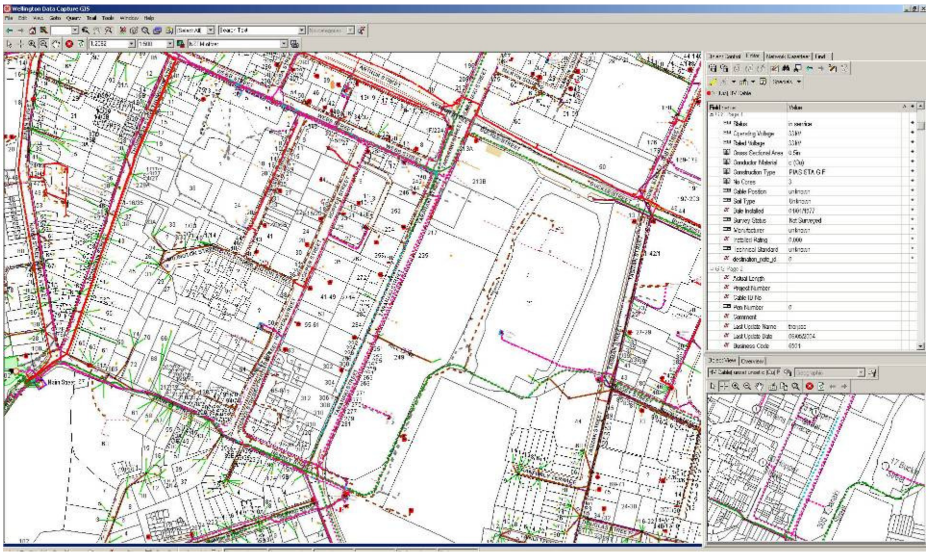
The SCADA system only provides operation, monitoring and control of the network at 11kV and above. Low Voltage (400 Volts or below) outages are managed by the GE ENMAC Calltaker system utilised by the

Outage Manager at the Wellington Electricity Contact Centre. The Calltaker system electronically interfaces with the field service providers outage management system to dispatch field staff for fault response.




## 2.8.1.2. Geographic Information System (GIS)

The geographic information system (GIS) is a representation of the system fixed assets overlaid on a map of the supply area. Wellington Electricity uses the GE Smallworld application for planning, designing and operating the distribution system and is the primary repository of network asset information. A process is required to link asset condition data to the GIS information to further improve asset management outcomes by streamlining manual business processes into linked electronic database for more efficient information management which will aid engineering decision making.



## 2.8.1.3. ProjectWise

Wellington Electricity stores all drawings and historic asset information diagrams in ProjectWise where users can access PDF files of all substation and system drawings.

#### 2.8.1.4. DIgSILENT Power Factory

Power Factory is a leading network simulation tool used in the analysis of load flows, development planning, reliability and protection studies. The Power Factory database contains detailed connectivity and asset rating information. Wellington Electricity is presently reviewing the Power Factory model to determine its accuracy and completeness. As the review proceeds, the model will be progressively updated and processes will be developed to ensure it remains synchronised with the actual power system through such means as an automated cross reference with GIS.

#### 2.8.1.5. Cymcap

Cable rating information is derived via CYMCAP (cable ampacity and simulation tool) which is used to model the ratings of underground cables at all voltages, for both existing cables in service, and also for new developments.

#### 2.8.1.6. DIgSILENT Station Ware

Station Ware is a centralised protection setting database and device management tool. It holds relay and device information, parameters and settings files. Station Ware interfaces directly to Power Factory to allow for protection discrimination studies to be carried out.

#### 2.8.1.7. Hard Copies and Spreadsheets

Wellington Electricity inherited much of the asset condition information of the network in the form of hard copies and/or spreadsheets of inspection records and test results. These are stored in various locations including with the services provider. Examples of hard copies of asset condition data include:

- Scanned copies of inspection results
- Spreadsheets of transformer oil analysis
- Scanned copies and hard copies of historical cable test results

In some cases it has proven difficult to locate asset condition data records more than a few years old. Wellington Electricity has worked through the challenge of establishing electronic records into the new maintenance database in order to more effectively manage asset information for future decision making.

#### 2.8.1.8. Maintenance Database

Wellington Electricity has developed a maintenance management database to store the maintenance history of network assets and to electronically capture maintenance data regularly provided by the field service provider upon completion of maintenance works such as condition assessments, inspection and test results and to record defects against the asset. Over 15,000 historic maintenance records from the period 2007 to 2010 have been entered into this database. The database has reporting functionality to enable Wellington Electricity to verify the work completed by the field services provider, as well as to plan future maintenance and replacement programmes based upon the historic inspection and condition assessment results.

The database, although functional to meet Wellington Electricity's current maintenance management requirements, is considered an interim solution. Further development will occur during 2011 to develop the business rules and strategies needed to move towards an integrated maintenance management system.

The asset data within the database can be migrated to the final maintenance management system once implemented.

#### 2.8.1.9. GenTrack

GenTrack is an application designed to manage Installation Control Point (ICP) and revenue data as well as deliver billing services. GenTrack is populated and synchronised with the central ICP registry. It interfaces with the GIS and ENMAC systems to provide visibility of consumers affected buy planned and unplanned network outages. GenTrack also interfaces to SAP for billing.

### 2.8.2. Financial Systems

In keeping with best-of-breed investment in IT systems, SAP is the financial and accounting application used by the business as the commercial management platform. It is an integrated finance system for billing, fixed asset registers, payroll, accounts payable and general accounting.

#### 2.8.2.1. Summary Table

| | Physical attributes | Equipment ratings | Asset condition | Connectivity | Customer service |
|---|---|---|---|---|---|
| SCADA / ENMAC | | ✓ | | ✓ | ✓ |
| GIS | ✓ | ✓ | | ✓ | ✓ |
| Project Wise | ✓ | ✓ | | | ✓ |
| Power Factory | | ✓ | | ✓ | |
| Station Ware | ✓ | ✓ | | | |
| Spreadsheets / hardcopy | ✓ | ✓ | ✓ | | |
| Maintenance Database | ✓ | ✓ | ✓ | | ✓ |
| GenTrack | | | | ✓ | ✓ |
| SAP (Financial) | | | | | ✓ |

Figure 2-9 Asset Data Repositories

### 2.8.3. Data quality

Wellington Electricity is continuously reviewing its business data to check the quality of the records in the above IT systems as some inconsistencies have been found between some of the data in different locations. Initiatives have been identified to establish one 'source-of-truth' system for each category of information, and the subsequent synchronisation of data between the various repositories. Further development will be undertaken during 2011 to identify and fix the ICP data management between various systems.

The new Field Services Agreement has a number of business processes developed that over time will assist Wellington Electricity in filling the gaps of both missing and incorrect information as well as cleansing the data in the systems (with a particular focus on the GIS data).

## 2.9. Process Overview

The three main processes that Wellington Electricity uses as part of managing network assets are:

- Inspection and maintenance
- Planning
- Investment selection

The interaction of the processes is illustrated in the diagram below. Each of these processes and the asset works plan is described in detail in the following sections.

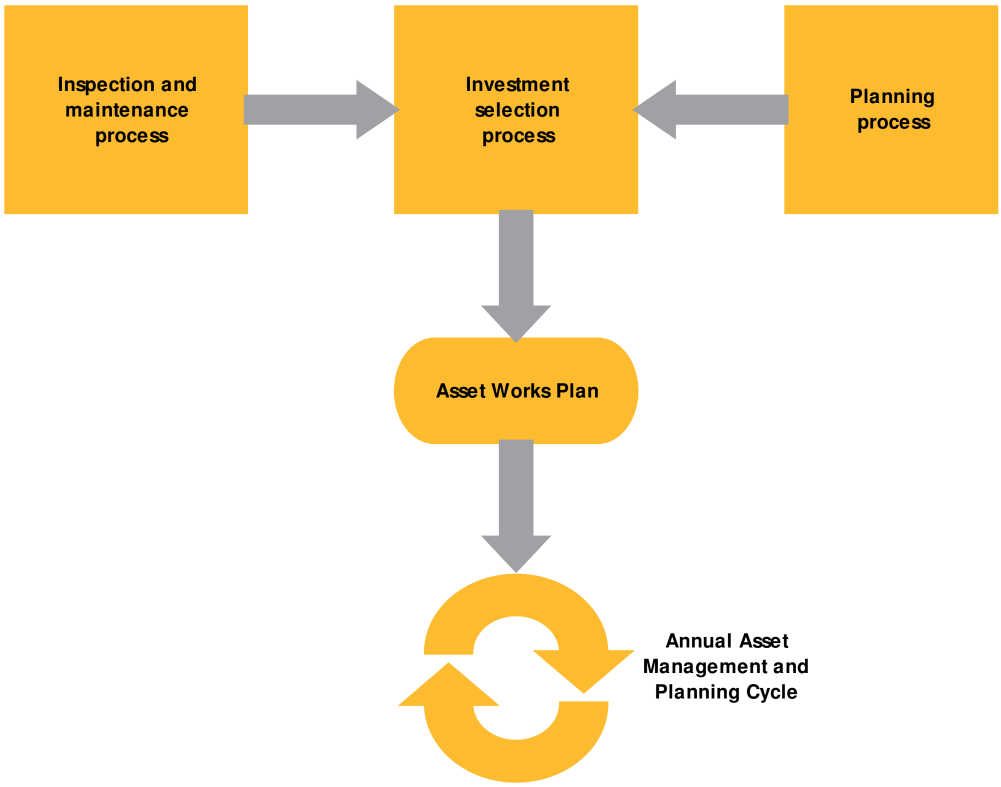



Figure 2-10 Asset Management Processes

A key output from these processes is the Asset Works Plan (AWP), which in turn feeds in to the annual asset management and planning cycle. The AWP is discussed in more detail in a subsequent section of this chapter. The development of the AWP is in its early stages and is being continuously reviewed for input into the AMP process.

### 2.9.1. Inspection and Maintenance Processes

The existing asset inspection and maintenance process is centred around the Preventative Maintenance (PM) plan that is prepared annually by the Wellington Electricity engineering and maintenance groups. The PM plan lists all assets by group and details the inspection and routine maintenance activities that are required for them. Each type of asset has an associated standard driving the policy that details the scope and frequency of the inspection and maintenance required for that asset category. These standards and associated policies are discussed in more detail in Section 6 (Lifecycle Asset Management). The timing and scope of these activities are determined by a number of factors including:

- Safety (both operational and public)
- Condition (assets that show signs of deterioration may be inspected more regularly)
- Age (older assets may be inspected more regularly than new ones)
- Experience of how often inspections are required (e.g. for substation buildings)
- Type history (assets that have known issues may be inspected more regularly)
- Operation frequency (assets that have operated frequently under fault conditions)
- Risk (likelihood and consequence of asset unavailability)
- Manufacturers recommendations

The PM plan is then scheduled by the field services provider into a PM programme. The field services provider is responsible for implementation of the programme and is held accountable for this through their service contract. The services provider will inspect the assets, undertake a condition assessment of the asset or assets, identify any asset defects, carry out the routine maintenance and also carry out corrective maintenance (i.e. correction of issues uncovered during routine inspection) provided the total cost of this is under a threshold set by Wellington Electricity. The inspection and test results, condition assessments, defect assessments and work records are reported to Wellington Electricity on a regular basis with prescribed maintenance data recorded into the Wellington Electricity maintenance database. Wellington Electricity engineering staff analyse the maintenance data via the maintenance database and in discussion with the field service provider may approve further corrective maintenance or initiate the investment selection process to address refurbishment and renewal works. Additionally, the cyclic review of asset performance (e.g. feeder performance) may initiate either corrective or project works.

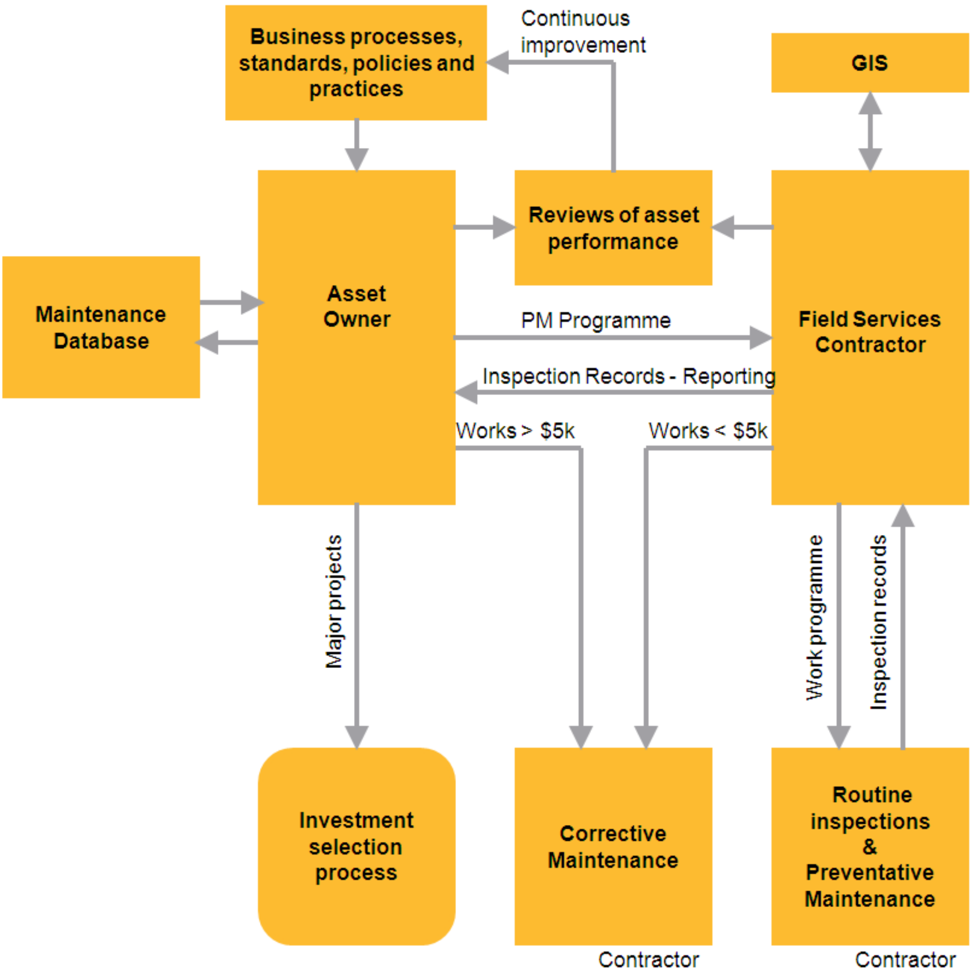



Figure 2-11 Inspection and Maintenance Process

### 2.9.1.1. Review of Inspection and Maintenance Process

Wellington Electricity is continuously reviewing its asset inspection and maintenance processes. A number of initiatives have already been identified that aim to improve data capture and records management such as identifying missing asset information in the GIS and other systems, updating ratings and condition assessment. Increasing the understanding of each type of equipment enables targeted maintenance programmes, or revisions to the standards to be made. The key initiatives being developed are associated with improving the way information is handled in conjunction with continually improving the maintenance standards.

## 2.9.2. Planning Process

Network constraints are identified by reviewing the capacity and the security of the network on a regular basis against network standards and policies. Should a constraint be identified, options for addressing it through reconfiguration of the network (e.g. by moving an open point) will be considered first. Should no reconfiguration options be available, then other options will be investigated as part of the investment selection process. Key inputs to the capacity and reliability review are the planning criteria and load forecasts. These are described in detail under separate headings in Section 5 (Network Planning).

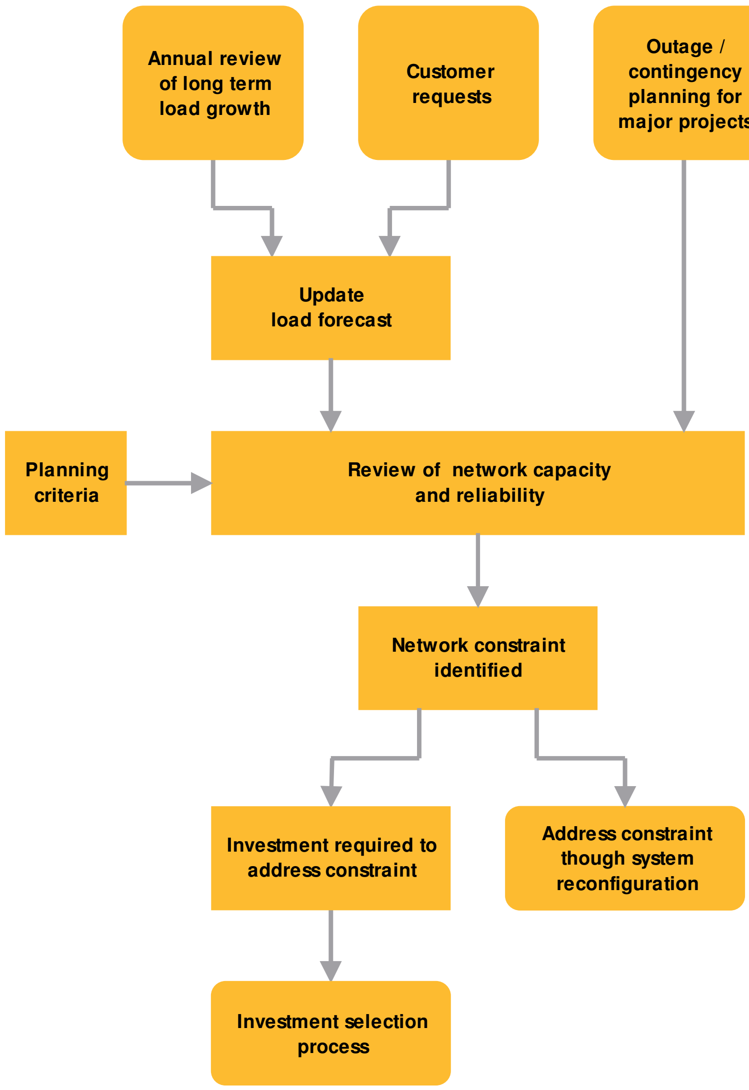



Figure 2-12 Planning Process

### 2.9.3. Investment Selection Process

This process describes the way in which network investments are taken from a high level need though to a preferred investment option that in turn results in a business case. It includes consideration of a long list of options, refinement of the long list to a short list of practicable options followed by detailed analysis and selection of a preferred option. The asset works plan is the repository for all potential network investments including those at the early 'needs have been identified' stage and 'preferred option' stage. This process is a refinement, rather than a replacement of existing processes as described in the previous AMP.

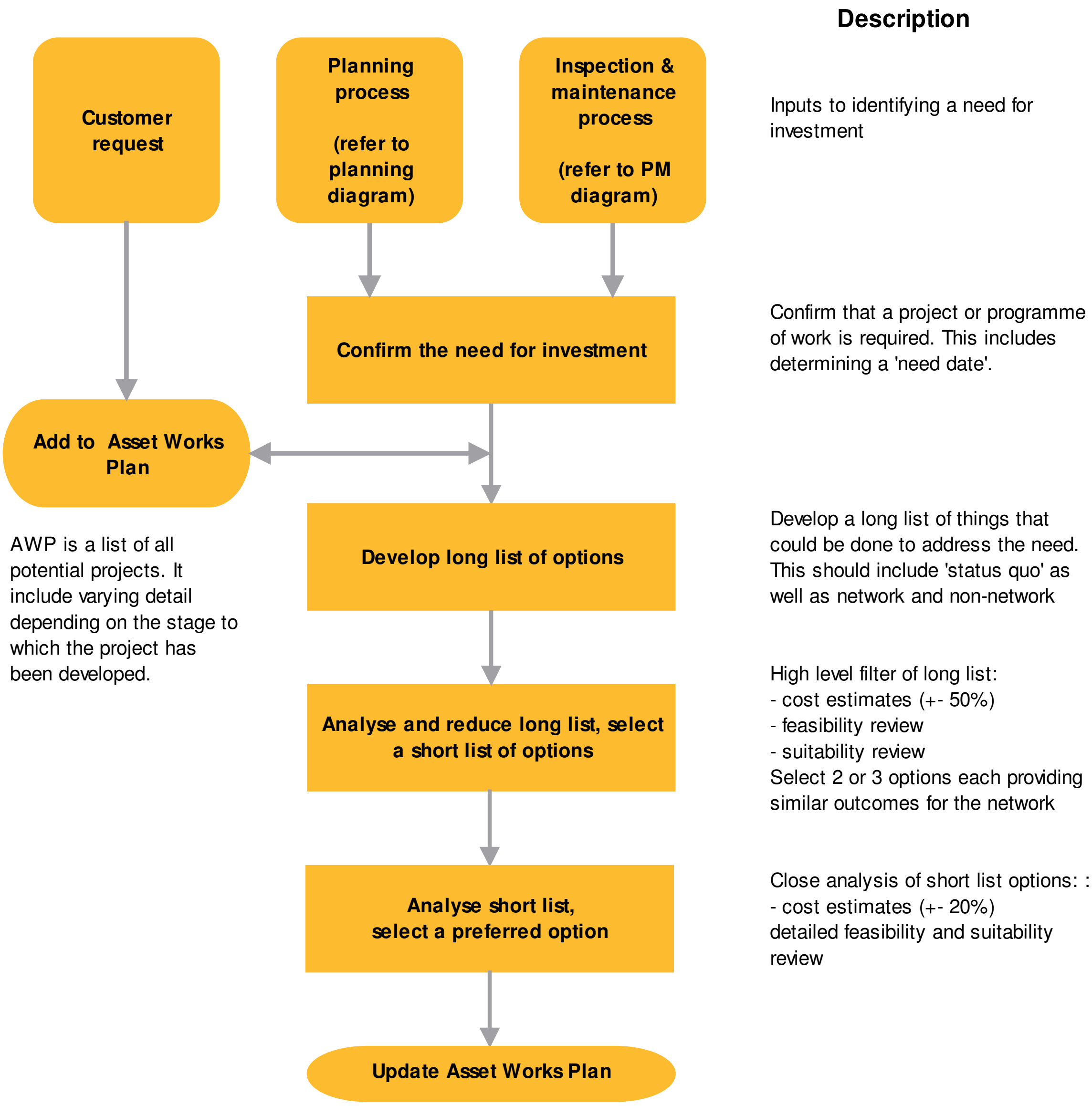



Figure 2-13 Investment Selection Process

### 2.9.4. Asset Works Plan

The Asset Works Plan (AWP) comprises a list of potential projects at the high level 'need has been identified' stage and at the 'preferred option' stage of the 'Investment Selection Process'. The AWP is a dynamic list that includes dates on when projects are required. It includes projects up to ten or more years in the future and is continually updated and amended as new 'needs' are identified, project details are refined and projects are executed. Every year the AWP will be frozen and all projects identified for the next financial year developed to the 'preferred option' stage of the Investment Selection Process. This list of projects will then be prioritised. Following prioritisation, each project will be matched against the available budget for capital works and a list of projects for the following year (i.e. the capital works spend plan) will be prepared for both Board approval and CIC approval.

### 2.9.5. Processes for Measuring Network Performance for Disclosure Purposes

SCADA and ICP allocation information stored within the ENMAC database[1] is extracted using reporting tools to provide the business with fault (unplanned) and planned outage information. All relevant details of HV and LV faults are entered into the ENMAC fault log database, which will calculate the impact of each fault on SAIDI and SAIFI. Where supply is restored progressively through switching over a period of time, the switching sequence will be recorded and used as the basis for recording the actual SAIDI impact on customers. The ENMAC database may also be used to measure other performance metrics, for example the faults per 100 circuit-km performance indicator.

Information on the reliability of the network is available on an ongoing basis throughout the measurement period and will be regularly reported both within the business and to the Board through its monthly reports.

#### 2.9.5.1. Unplanned Outages

The process for handling and recording the impact of unplanned outages is illustrated diagrammatically below.

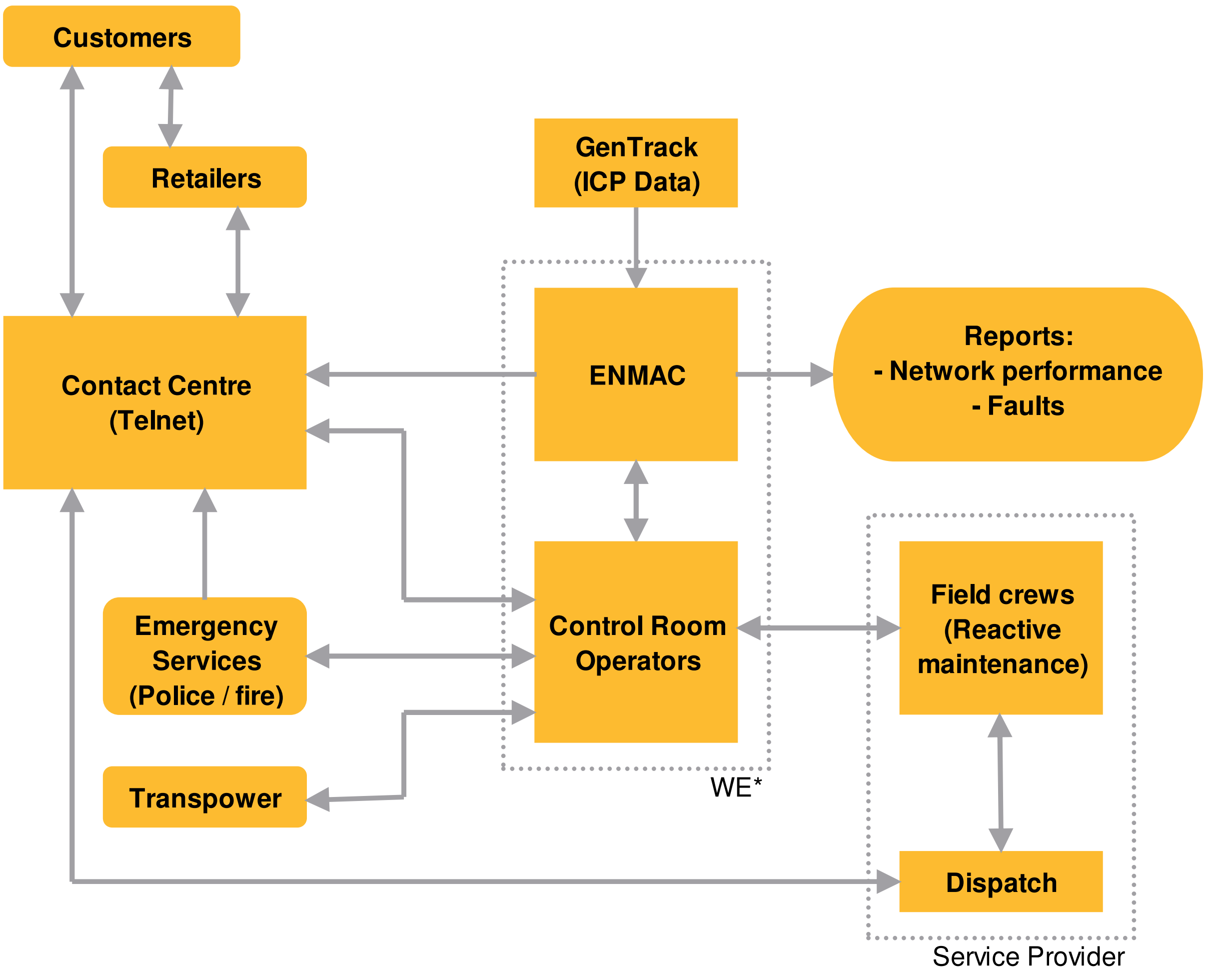



Figure 2-14 Unplanned Outage Process

[1] SCADA includes the status of circuit breakers and switches as well as system voltages and currents. ICP allocation information comprises connections made to each part of the network.

The major components that comprise this system are:

- Contact Centre service provider
- Control Room: Operators and ENMAC
- Field service providers (fault response and maintenance)

Low Voltage Faults (400V or below)

Notification of a LV fault may be raised though calls from customers (either direct to the Contact Centre or via the customer's energy retailer). The majority of energy retailers have an electronic interface into the Wellington Electricity ENMAC Calltaker system to directly input the LV fault details from the customer. Other options available to energy retailers are email and facsimile. The Contact Centre receives this information and dispatches via the ENMAC Calltaker system to the field service provider's dispatching system.

The field service provider dispatches a faultman to the respective faulted customer(s). Updated information is fed back from the field to the Contact Centre via the outage management systems to enable the customer (via their energy retailer) to be kept informed of progress of the fault and its final restoration.

High Voltage Faults (11kV or above)

Currently the Control Room via the Foxboro SCADA system will identify a fault or tripping on the 11kV (or above) network thereby generating a fault within the ENMAC SCADA system. A dispatch request to the field service provider for field response is automatically generated via the ENMAC Calltaker system.

As identification of the fault is carried out and supply is restored, the Control Room operators will (via the field crews) progressively update the fault log in ENMAC.

Fault logs are available from ENMAC via a reporting tool. On a regular basis, these logs are interrogated and network performance statistics are obtained.

#### 2.9.5.2. Planned Outages

Planning of outages for both maintenance and capital works is undertaken by the field services provider and other approved capital works service providers in conjunction with Wellington Electricity.

For both maintenance and capital works the service providers must provide the outage requirements in a prescribed format to comply with the Wellington Electricity Operational Standards requirements such as the minimum prior notification periods to which the request must be made to the Control Room before the day of work. The Control Room shall schedule the planned outage and develop the switching schedule and relevant test and access permits for return to the service provider before the day of the planned outage.

Maintenance Planners use the Preventative Maintenance plan to produce a forward schedule of planned works for the Control Room to assist in the optimisation of planned outages and to minimise the number and duration of planned outages on the network.

The Wellington Electricity customer services team will discuss major outages, and outages that effect sensitive customers directly with them prior to the outage being confirmed. Following the confirmation of an outage, the control room will liaise with the retailers (who notify all affected customers) to advise them in advance of planned works that will interrupt their supply. As the outage takes place, ENMAC is updated with switching operations. A log of effected customers and the duration of interruption to their supplies is recorded in ENMAC. This log is interrogated to determine network performance.

The planned outage process is illustrated below.

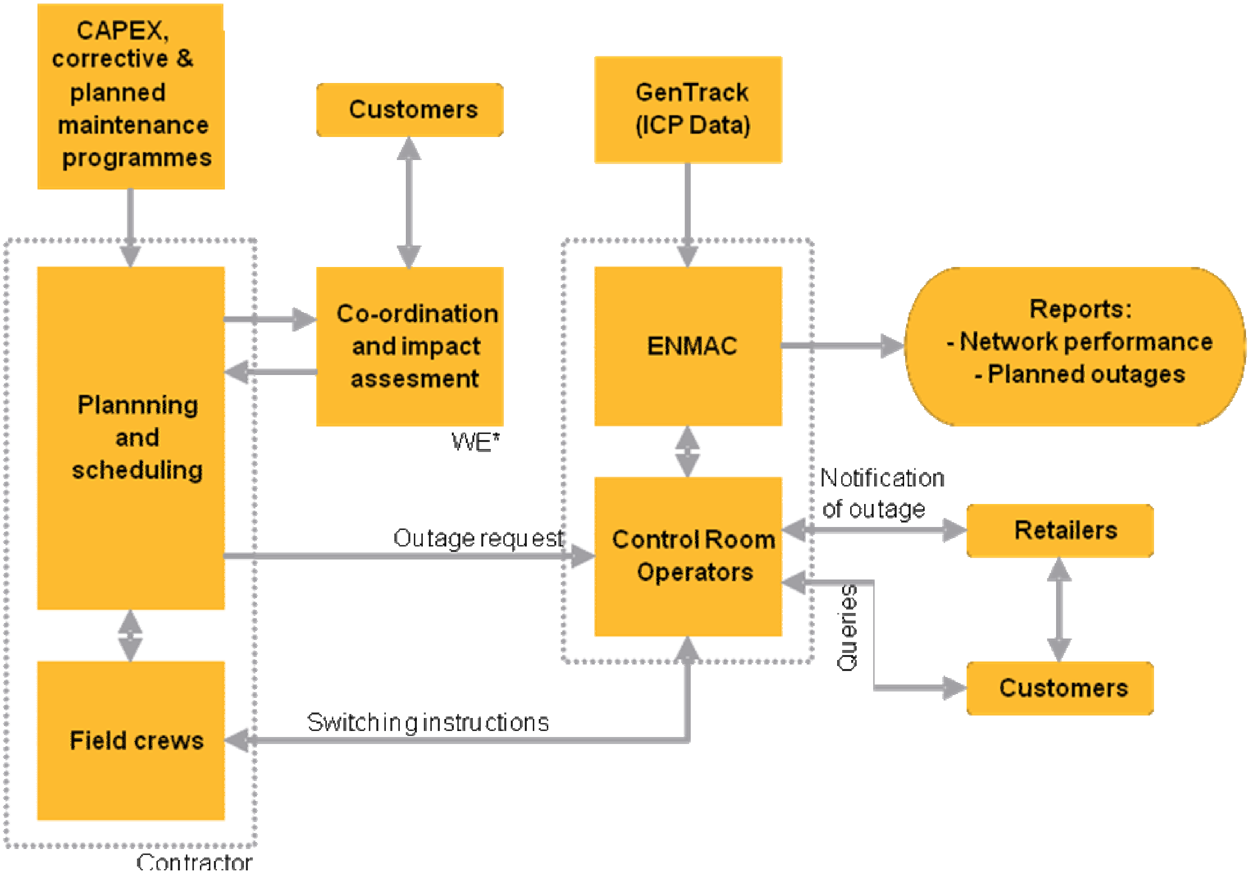



Figure 2-15 Planned Outage Process

# 3. Assets Covered

## 3.1. Distribution Area

Wellington Electricity's distribution network 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 includes Parliament Buildings and the head offices of most government departments. A map of the network area is shown below.


Figure 3-1 Wellington Electricity Network Area

As of 31 December 2010, there were over 164,000 connected customers. The total system length (excluding streetlight circuits and DC cable) was 4,610 km, of which 61.5% was underground.

## 3.2. Load Characteristics

Peak demands and energy distributed for the last four years is shown below.

| Year to | 30 Sep 2007 | 30 Sep 2008 | 30 Sep 2009 | 30 Sep 2010 |
|---|---|---|---|---|
| System Maximum Demand (MW) | 555 | 537 | 565 | 583 |
| System Energy Injection (GWh) | 2,569 | 2,581 | 2,595 | 2,594 |

Figure 3-2 Peak Demand and Energy Delivery

The Wellington CBD is the largest business and retail centre for the region, although there are also significant retail centres in Lower Hutt, Porirua and Upper Hutt. Apart from the CBD there is widespread residential load throughout the area. This is interspersed with pockets of commercial and light industrial load.

The network area covers four local councils, namely Wellington City, Hutt City, Upper Hutt City and Porirua City. In addition to the local councils, the Wellington Regional Council covers the entire network area. The different council areas have varying requirements for permitted activities in relation to being an electrical utility, road corridor access and environmental compliance.

Major customers with significant loads include Parliament, Councils, Wellington Airport and Victoria University. Wellington Electricity also supplies the electrified suburban railway network and the trolley bus network. The supply area is notable for the absence of large industrial loads.

The trolley bus network is supplied through Wellington Electricity owned DC assets comprising 15 converter transformers, 19 mercury arc rectifiers, 2 solid state rectifiers and 53 DC circuit breakers. There are approximately 53 km of underground DC cables linking various DC substations. These DC assets are managed in accordance with a network connection and services agreement with NZ Bus Limited (the sole customer supplied by these assets) and are therefore not covered by this AMP.

Typical load profiles for CBD and residential loads are shown below. These graphs illustrate that CBD loads are relatively even throughout the year with a slight trend towards a summer peak, and their daily profile is relatively flat though the day. Residential loads however are winter peaking with a pronounced dip in demand during the middle of a typical working day. Load profiles that are representative of urban and residential areas are shown on the following graphs of Nairn Street and Naenae zone substation demand respectively.

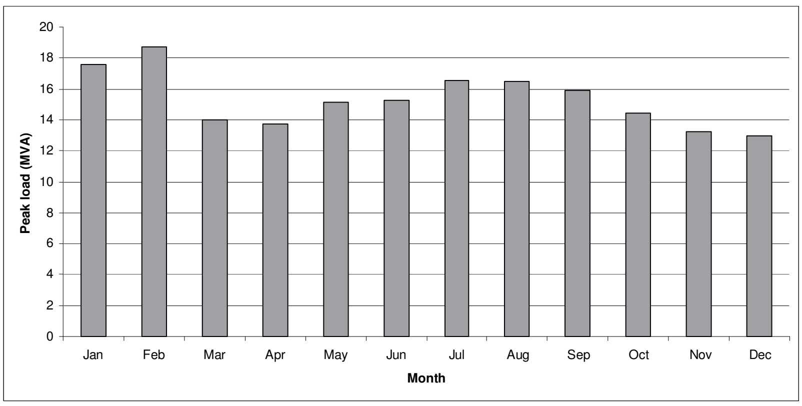



Figure 3-3 Typical CBD Monthly Peak Load Profile

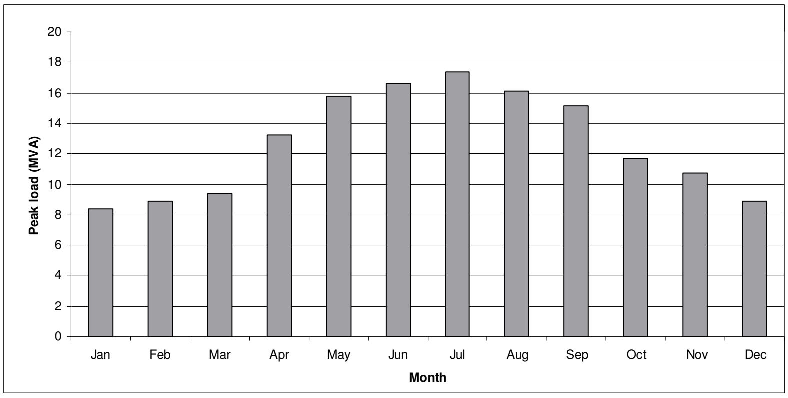



**Figure 3-4 Typical Residential Monthly Peak Load Profile**

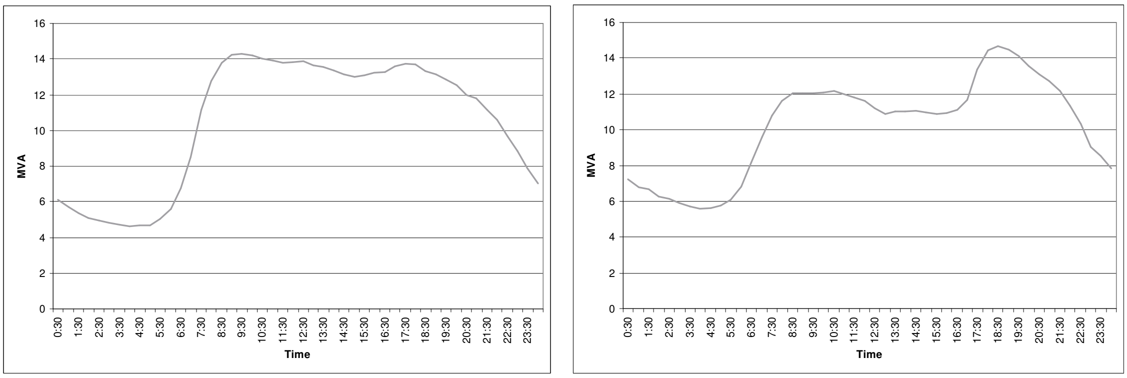



**Figure 3-5 and 3-6 Typical CBD (L) and Residential (R) Daily Load Profile**

## 3.3. Network Configuration and High Level Asset Description

Any electricity distribution system can be broadly categorised into primary and secondary assets. The primary assets carry the energy that is distributed to consumers, typically at higher voltages and currents. The secondary assets are an integral part of the distribution system and support the operation of the primary assets and include protection and control equipment, as well as communications systems.

### 3.3.1. Grid Exit Points

Wellington Electricity's network is supplied from the Transpower owned national transmission grid through nine grid exit points (GXPs), as shown in Figures 3-7 to 3-10. Central Park, Haywards and Melling supply the network at both 33 kV and 11 kV, and Kaiwharawhara supplies at 11 kV only. The remaining GXPs (Gracefield, Pauatahanui, Takapu Rd, Upper Hutt and Wilton) all supply the network at 33 kV only. The GXPs are described in more detail below.

#### 3.3.1.1. Upper Hutt

Upper Hutt GXP comprises a conventional arrangement of two parallel 110 / 33 kV transformers nominally rated at 37 MVA each. Maximum demand on the Upper Hutt GXP in 2010 was 32.1 MVA. Upper Hutt GXP supplies Maidstone and Brown Owl zone substations via duplicated 33kV underground circuit connections.

#### 3.3.1.2. Haywards

Haywards GXP comprises an unconventional arrangement of one 110/11kV transformer nominally rated at 20 MVA feeding an 11kV point of supply at the Haywards site, and one 110/33 kV transformer nominally rated at 20 MVA supplying Trentham zone substation via duplicate 33kV connections. Maximum demand at the 11kV and 33kV busses in 2010 were 17.7 MVA and 14.1 MVA respectively. A 5MVA transformer supplies the Haywards local service switchboard and also links the 33 and 11kV switchboards.

This arrangement provides satisfactory service at present however a review is planned for the Haywards GXP to consider whether the existing arrangement will provide the security appropriate for the Wellington Electricity network in the future.

Transpower has advised that the 33kV circuit breakers have been scheduled for refurbishment.

#### 3.3.1.3. Pauatahanui

Pauatahanui GXP comprises a conventional arrangement of two parallel 110 / 33 kV transformers nominally rated at 20 MVA each. Maximum demand on the Pauatahanui GXP 2010 was 19.9 MVA. This is within the transformers 22 MVA cyclic rating, however loads growth in this area is relatively strong and Wellington Electricity will review the adequacy of the existing arrangement. Pauatahanui GXP supplies Mana and Plimmerton zone substations via single 33kV overhead circuit connections. Note that these two zone substations are linked at 11kV providing a degree of redundancy should one of the 33kV connections be out of service.

Transpower has advised that taking additional load out of Pauatahanui will affect the ability of down stream customers at Paraparaumu to supply their demand. This is due to constraints on the Transpower 110kV system. Transpower has indicated in their Annual Planning Report that this issue is planned to be addressed circa 2014.

#### 3.3.1.4. Takapu Road

Takapu Road GXP comprises a conventional arrangement of two parallel 110/33kV transformers nominally rated at 90 MVA each. Maximum demand on the Takapu Road GXP in 2010 was 92.7 MVA. This is close to the transformers 92 MVA cyclic rating. Takapu Road GXP supplies zone substation at Waitangirua, Porirua, Tawa, Ngauranga and Johnsonville via duplicated 33kV connections. These circuits leave the GXP as overhead lines across rural land and become underground at the urban boundary.

Transpower has advised that capacity out of Takapu road is presently constrained by a secondary systems limit that will be removed in 2011, allowing the full cyclic n-1 capacity of 116 MVA to be utilised. Once this work is complete, there will be no capacity constraints at Takapu Road inside of the forecast period, subject to load growth continuing at present levels.

A review is planned for the Takapu Road GXP to consider how future load growth may be accommodated and whether the existing arrangement will provide the security appropriate for the Wellington Electricity network in the future. Transpower has advised that Takapu Road is a high salt pollution site and washing of the bus is taking place at six monthly intervals.

#### 3.3.1.5. Melling

Melling GXP comprises two parallel 110/33kV transformers nominally rated at 50 MVA each supplying zone substations at Waterloo, Naenae and Petone via duplicated 33kV underground circuit connections. It also accommodates an 11kV point of supply fed via two parallel 110/11kV transformers nominally rated at 25 MVA each. Maximum demand on the Melling GXP in 2010 (including both 33kV and 11kV busses) was 68.4 MVA.

A grid emergency was declared at Melling on 16 June 2009 when the 11kV transformer cyclic capacity was exceeded (the load was above 27MVA). Following this event, a secondary systems constraint was removed by Transpower allowing the full cyclic transformer rating of 32MVA to be utilised, alleviating capacity constraints for the forecast period.

Melling GXP is located within a flood zone of the Hutt River and in recent times there have been two floods that caused damage at this site. Transpower redeveloped the site and moved all sensitive equipment, including the POS 11kV switchgear into a raised building. A flood barrier was erected to deflect floating debris away from Transpower's switchyard. Unfortunately this barrier will deflect debris into Wellington Electricity owned equipment such as 33kV cable risers and the Melling ripple plant (which may also be submerged in high water). Wellington Electricity has raised this issue with Transpower and a full risk review will be undertaken in 2011 to identify solutions to this problem, including, if necessary, relocation of the Wellington Electricity owned ripple equipment and extension of the flood barrier.

#### 3.3.1.6. Gracefield

Gracefield GXP comprises a conventional arrangement of two parallel 110/33kV transformers nominally rated at 85 MVA each. Maximum demand on the Gracefield GXP in 2010 was 54.7 MVA. Gracefield GXP supplies Seaview, Korokoro, Gracefield and Wainuiomata zone substations via duplicated 33kV connections. There are no issues with the Transpower owned assets at Gracefield GXP at present.

#### 3.3.1.7. Kaiwharawhara

Kaiwharawhara is an 11kV point of supply where Wellington Electricity takes bulk 11kV supply from Transpower and distributes this via a Wellington Electricity owned switchboard within the GXP. Kaiwharawhara is supplied at 110kV via Transpower owned circuits from the Wilton GXP, and has two 20/40MVA transformers in service. These assets are owned by Transpower.

Kaiwharawhara supplies load at the northern end of the Wellington CBD such as Thorndon and surrounds, and also light commercial and residential load around Ngaio Gorge and Khandallah areas.

Maximum demand at Kaiwharawhara in 2010 was 35.1 MVA.

#### 3.3.1.8. Central Park

Central Park GXP comprises three 110/33kV transformers, T5 (120 MVA), T3 and T4 (100 MVA units) supplying a 33kV bus. There are also two Transpower owned 33/11kV (25 MVA) units supplying local service and an 11kV point of supply to Wellington Electricity. Maximum demand at Central Park GXP in 2010 was 175.4 MVA, which is well within the n-1 rating of the supply transformers. However, due to not having a 110kV bus, should a contingency occur at times of high load that results in the loss of a 110kV infeed (i.e. a circuit or transformer outage), Transpower will split the 33kV bus in order to allow them to manage any subsequent contingency. Load management is required to prevent transformer overloading in this configuration, which reduces peak loading to 109 MVA.

The two 100 MVA units (T3 and T4) are relatively old single phase units, whereas T5 is a new 120 MVA three phase unit. One possible solution to the capacity issue would be to replace these units with new units similar to T5, which has a cyclic rating of close to 150 MVA.

Wellington Electricity has raised a high level request (HLR) for an investigation into options for addressing the capacity issue with Transpower. Discussions on the outcome from the HLR and possible solutions will take place through early 2011. This will also include discussions on the security need for a 110kV bus to alleviate the requirements for controlled load shift during contingencies. Due to the location of Central Park GXP and the risk associated with supply from this site, as well as the space constraints faced, close liaison has occurred between Wellington Electricity, Transpower and the Wellington City Council to develop workable solutions which the council will be able to assist with implementing.

#### 3.3.1.9. Wilton

Wilton GXP comprises two 220/33kV transformers operating in parallel, supplying a 33kV bus that feeds to zone substations at Karori, Moore Street, and Waikowhai Street. These transformers are nominally rated at 100 MVA each, and the maximum demand in 2010 was 51.7 MVA. There are no issues with the Transpower owned assets at Wilton GXP at present. The 220/110kV interconnecting transformer T8 has been replaced at Wilton in the first quarter of 2010, whilst not directly supplying Wellington Electricity, this allows improved operational flexibility and allows paralleling of Kaiwharawhara and other zone substations supplied from the Wilton 220kV bus.

### 3.3.2. Embedded Generation

The network currently has a range of connected embedded generation including several connections of less than 10kW (typically residential), two landfill sites greater than 1 MW, and a hospital with synchronised generation of approximately 8 MW. In addition, there are a number of customers with standby generation plant of varying sizes (typically less than 1 MW), which generally cannot be synchronised to the network.

Resource consent has recently been granted for a wind farm with an installed capacity of approximately 8 MW, located on the south coast of Wellington. Wellington Electricity is working with the wind farm developer on options for providing a connection into the 11kV network.

There is a larger scale wind farm operated by Meridian (West Wind), connected into the Transpower 110kV system between Wilton and Central Park. Whilst not directly connected to the Wellington Electricity network, it may have an impact on ripple signal propagation and also the introduction of harmonics into the system. Wellington Electricity are in discussions with Meridian over this potential issue.

The Wellington Regional council is currently reviewing a number of small scale hydro generation plants at existing water facilities storage and pumping facilities around the region. These are in the order of 1 MW each.

### 3.3.3. Subtransmission

The 33kV subtransmission system is comprised of assets that take supply from the Transpower grid exits points and feed a total of 28 Wellington Electricity zone substations, incorporating 54 33/11kV transformers. This 33kV system is radial with each feeder supplying its own dedicated power transformer, with the exception of Tawa and Kenepuru where two feeders supply four transformers (one feeder shared per bank at each substation). All 33kV feeders supplying zone substations in the Wellington area are underground while those in the Porirua and Hutt Valley areas are a combination of overhead and underground. The total length of the 33kV system is 212 km, of which 153 km is underground.

All zone substations have N-1 subtransmission supply at 33kV, generally with one supply from each side of a Transpower bus (where available). Plimmerton and Mana each have a single 33kV supply to a single power transformer, however they are connected together on the 11kV bus, and as a result they operate as an N-1 substation with a geographic separation of 1.5 km. At certain times the 11kV bus tie cable can be constrained, although load control and 11kV network switching can alleviate this constraint.

The 33kV subtransmission system is also backed up by a limited number of “express” 11kV circuits that perform a subtransmission function in that they do not supply any directly connected loads. These are used as backups to the 11kV supply at some zone substations and also to supply a number of 11kV switching nodes, which in turn are used as the source for 11kV distribution feeders.

A list of each zone substation’s capacity, incorporating 33kV cables and transformers, is provided in the section on demand forecasts.

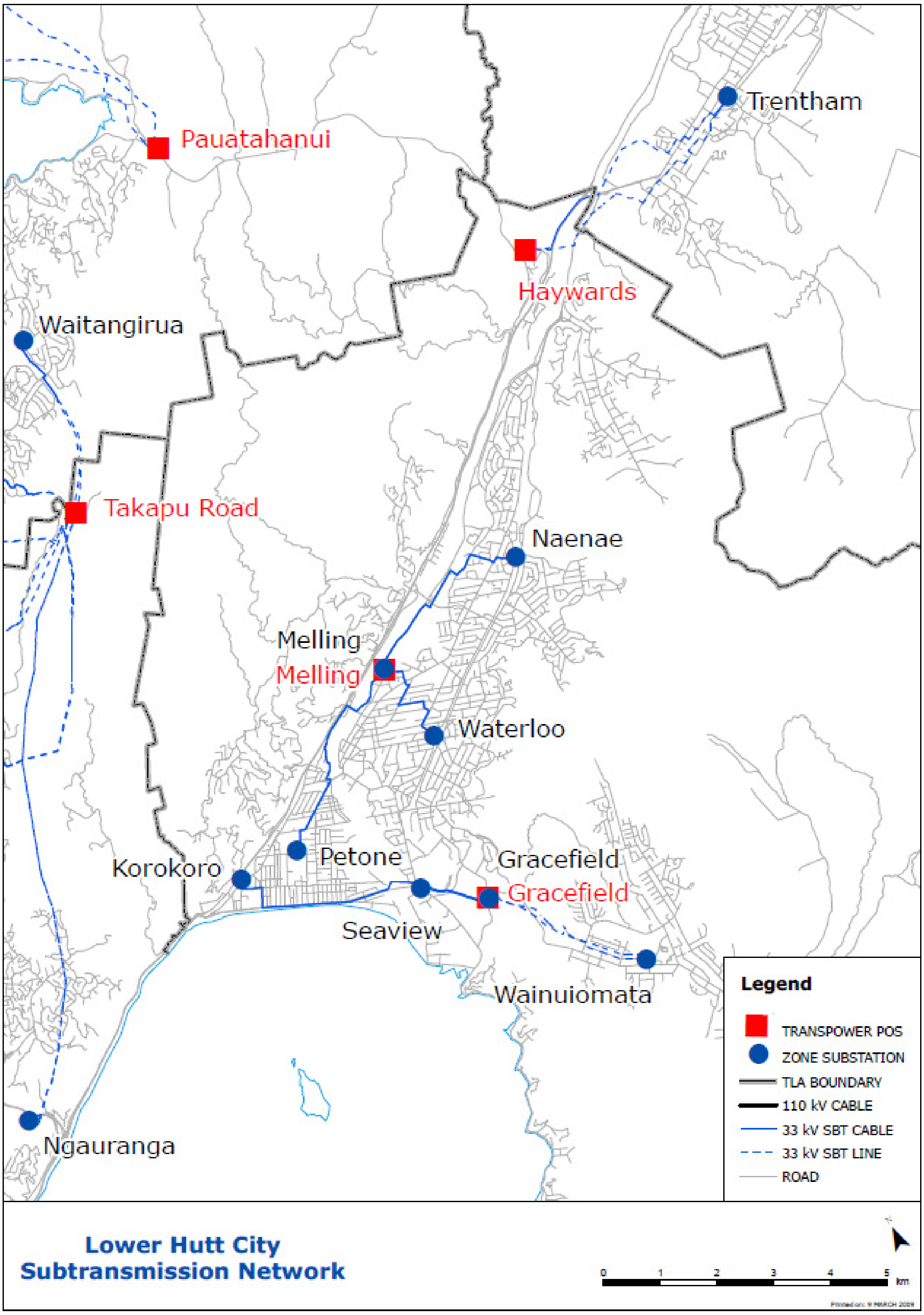



Figure 3-7 Lower Hutt Subtransmission Network

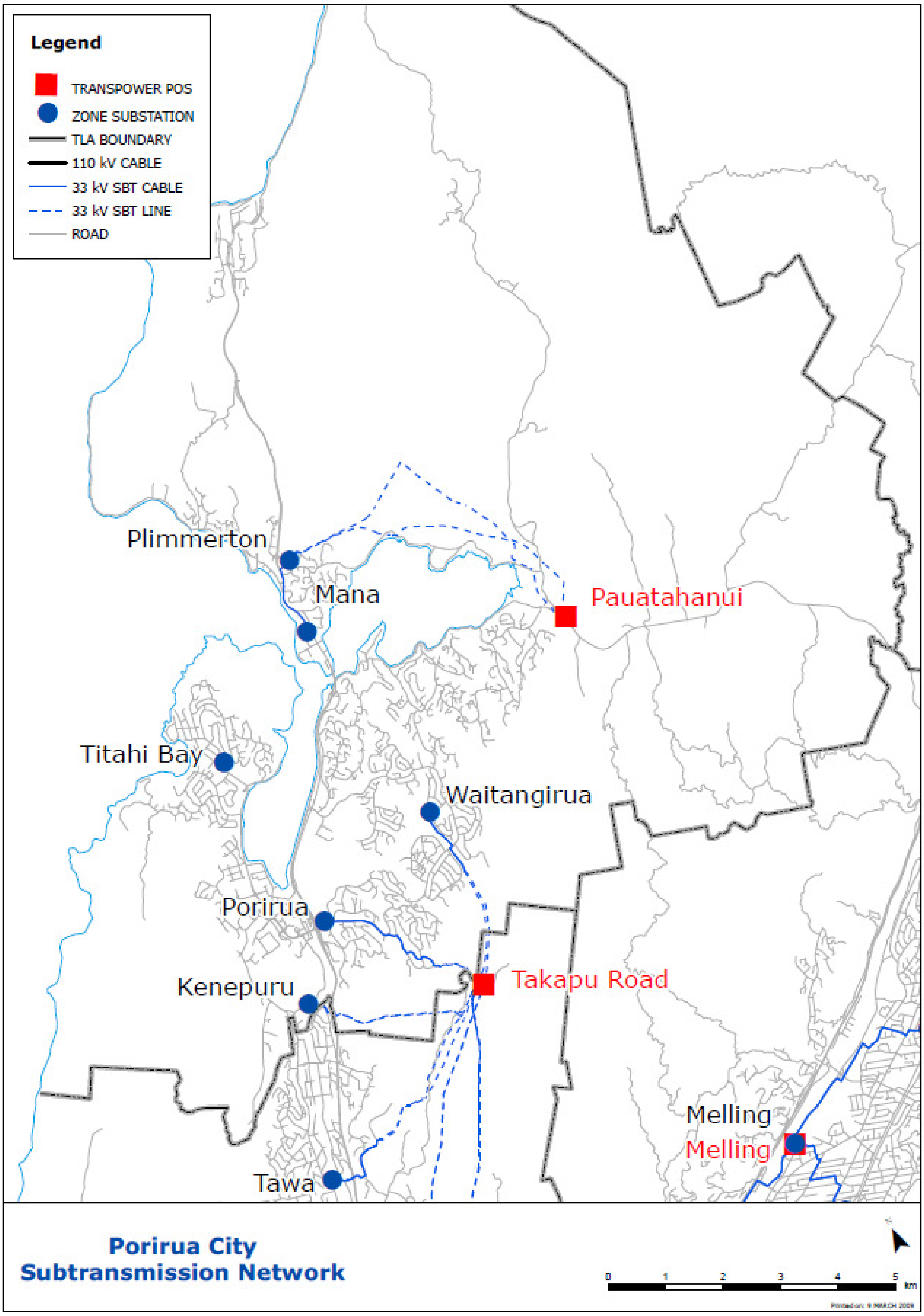



Figure 3-8 Porirua City Subtransmission Network

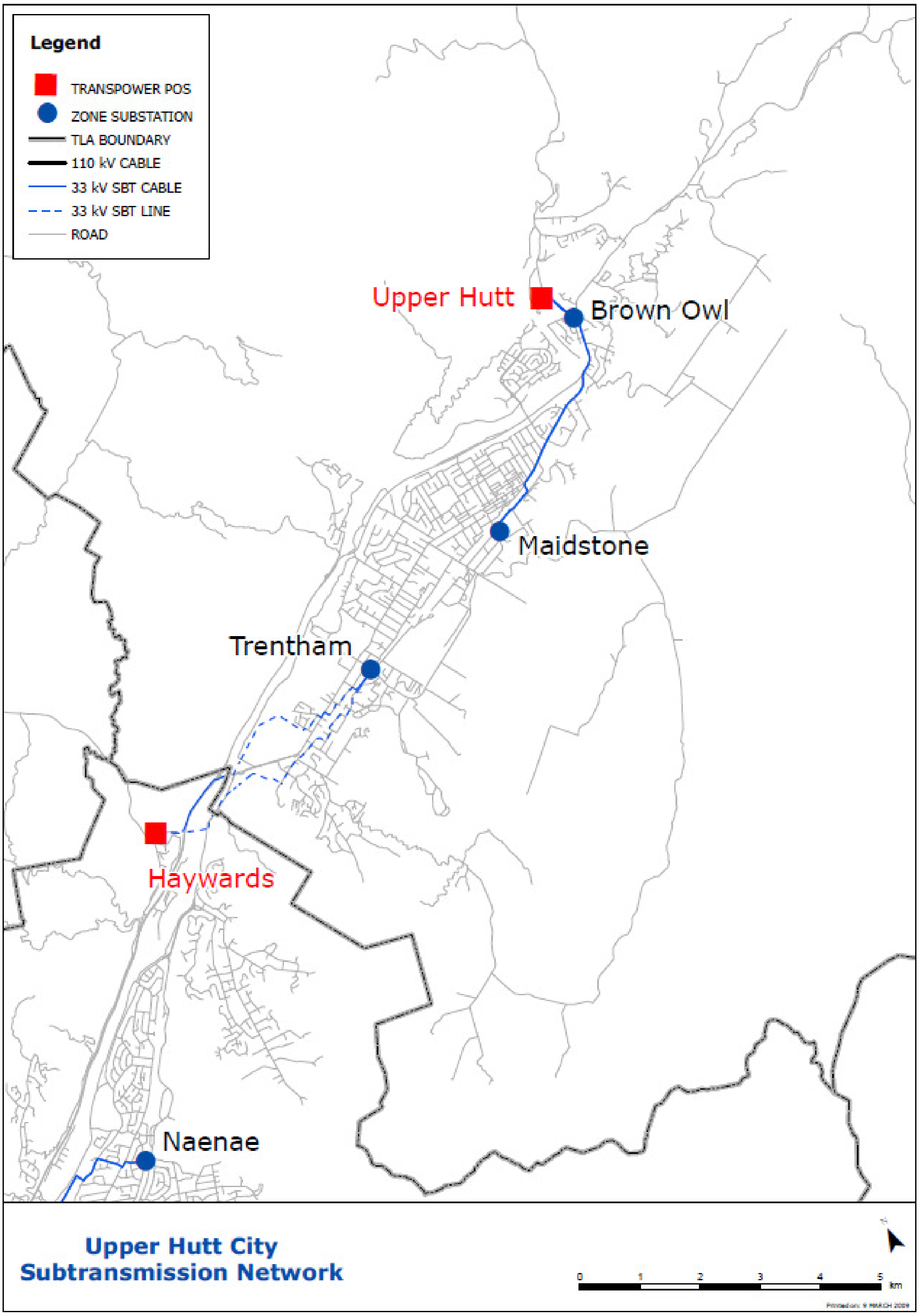



Figure 3-9 Upper Hut City Subtransmission Network

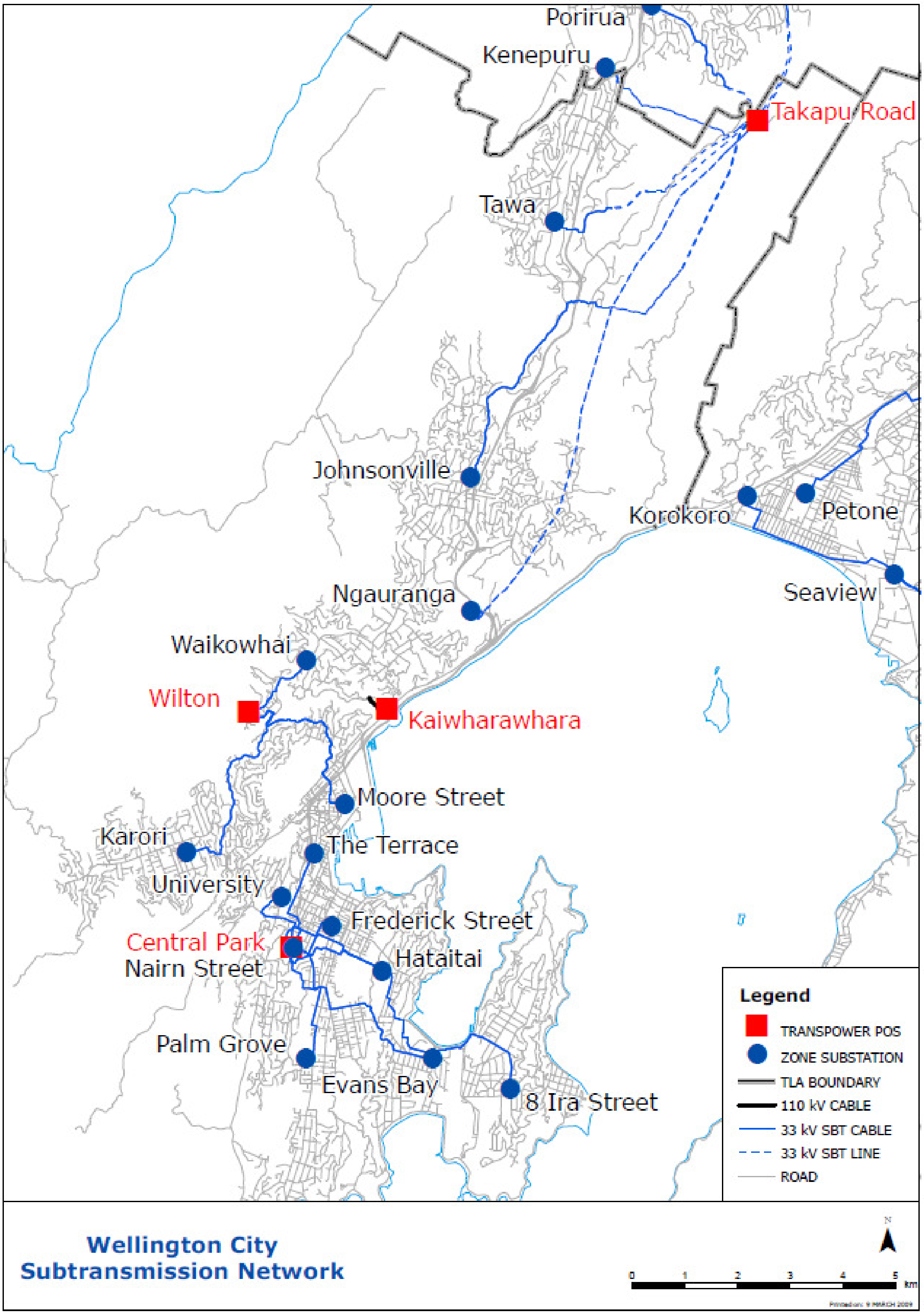



**Figure 3-10 Wellington City Subtransmission Network**

### 3.3.4. Distribution System

The 11kV distribution system is supplied from the zone substations, or directly from the grid in the case of the 11kV supply points at Central Park, Melling, Haywards and Kaiwharawhara. While some larger consumers are fed directly at 11kV, the system mainly supplies approximately 4,170 distribution substations (11kV/415V) located in commercial buildings, industrial sites, kiosks, berm-side and on overhead poles. The total length of the 11kV system is approximately 1,720 km, of which 65% is underground. In Wellington City, the 11kV network is largely underground whereas in the Hutt Valley and Porirua areas there is a higher proportion of overhead 11kV lines. The varying proportions of overhead and underground distribution on the different parts of the system reflect the different design philosophies of earlier network owners, as well as geography of the various areas.

Most of the 11kV feeders in the Wellington CBD[2] are operated in a closed ring configuration with radial secondary feeders interconnecting neighbouring rings or zone substations. This arrangement provides a high level of security and hence a high level of supply reliability. Most of the 11kV network outside the Wellington CBD, both in the Wellington City and Hutt Valley areas, comprises radial feeders with a number of mid feeder switchboards with circuit breakers and normally open interconnectors to other feeders so that, in the event of an equipment failure, supply to customers can be switched to neighbouring feeders. To allow for this, distribution feeders are not operated at their full thermal rating under normal system operating conditions.

There are approximately 1,780 11kV circuit breakers operating within the distribution system. Almost 400 of these are located at the zone substations and control the energy being injected into the distribution system. The remainder are located within distribution substations, mostly situated within or close to the Wellington CBD or in the Wellington City area, and allow the primary feeders in their respective areas to be operated in a closed loop arrangement. These circuit breakers are used to automatically isolate a faulted section of the network and to improve the ability to maintain an uninterrupted supply to all customers not directly connected to the faulted section. This is subject to cables having sufficient rating to carry extra load to support these contingent events.

The number of circuit breaker used in the distribution network is high in relation to other networks in New Zealand as illustrated in Figure 3-11.

[2] The CBD area is considered to be the commercial areas supplied by Frederick St, Nairn St, University, The Terrace, Moore St and Kaiwharawhara GXPs.

| Network | ICP count (approx.) | CB count (approx.) | ICP/ CB ratio (approx.) |
|---|---|---|---|
| Vector Networks | 520,000 | 1550 | 330 |
| Orion NZ | 190,000 | 800 | 240 |
| **Wellington Electricity** | **164,000** | **1780** | **92** |
| Unison | 107,000 | 270 | 400 |
| WEL Networks | 84,000 | 380 | 220 |
| Aurora Energy | 81,000 | 400 | 200 |
| NorthPower | 53,000 | 200 | 260 |

Figure 3-11 Comparison of Number of Circuit Breakers in Various Networks

The high number of circuit breakers in the Wellington Electricity network is a result of historic design practices aimed at delivering a very reliable network. The present network configuration will be reviewed to consider the opportunity for further system automation as equipment condition determines the need for replacement. The economics for smart network developments will be considered based on a fair return for the investment in line with the improved customer services.

### 3.3.5. Distribution Substations

Throughout the distribution network there are approximately 4,170 distribution substations sites (3,460 owned by Wellington Electricity as standalone sites and 710 housed on consumer sites) with around 4,350 associated distribution transformers in service, as some sites have multiple transformers installed. Pole-mounted distribution transformers are typically less than 150kVA and are generally simple platform structures or hanging bracket type arrangements. Ground-mounted distribution substations include a range of designs from the more significant reinforced concrete block buildings that can accommodate single transformers (typically a switch unit and low voltage (LV) distribution panel or frame) up to larger style three-transformer, multiple circuit breaker (CB) switchboards and extensive LV distribution framing. The more compact substations are generally the kiosk style, with an LV frame, transformer and ring main unit enclosed in a metal canopy. Other common styles are stand alone, open fenced enclosures or fully enclosed within customer owned buildings.

In Wellington city the majority of the distribution transformers are ground mounted. The Hutt and Porirua areas are a combination of ground mounted and overhead installations. Individual capacities range from 5kVA to 2,000kVA, and the weighted average capacity is approximately 300kVA.

| Enclosure type | Quantity |
|---|---|
| Outdoor cage | 275 |
| Indoor | 961 |
| Padmount | 1,112 |
| Pole | 1,813 |

Figure 3-12 Overview of Distribution Substation Types

Large distribution substation – concrete block / indoor type

### 3.3.6. Low Voltage Lines and Cables

Low voltage lines and cables are used to connect individual customers to the low voltage network supplied from the distribution transformers. The total system length is around 2,670 circuit-km, of which approximately 58% is underground.

Consumers are supplied via a low voltage fuse, which is the installation control point (ICP) used by the network to connect the consumer installation. This fusing is either an overhead pole fuse or located within a service pillar or pit near the consumers boundary. Some other styles of fuse installation exist, however these are being progressively replaced following faults, or when work is required on them.

In addition to service pillars there are approximately 400 link pillars on the network that allow isolation, reconfiguration and back feeding of certain LV circuits. These vary in age and condition and are being replaced in situations where their condition is poor and where they provide operational flexibility, or where the type of load served is sensitive to outages on the low voltage network, and back feeding will ensure compliance with service levels. In some cases, the LV network configuration has changed and there is no longer a requirement for a link pillar and they are removed if they have become unserviceable.

### 3.3.7. Secondary Systems

#### 3.3.7.1. Protection Assets

Protection assets are used to automatically detect thresholds that indicate a potential equipment fault and to automatically issue control signals to disconnect faulted equipment. This ensures that the system remains safe, that damage is minimised and also limits the number of consumers affected by an equipment failure.

On the HV system, there are more than 1,200 protection relays in operation. Around 95% are older electromechanical devices. The remainder are newer relays that use solid state electronic and microprocessor technology. Relays are generally mounted as part of the substation switchboard and are normally changed at the time of switchgear upgrade. At distribution level, 11kV fuses are used for protection of equipment.

On the LV system, fuses are used for the protection of cables and equipment.

#### 3.3.7.2. Supervisory Control and Data Acquisition (SCADA)

The SCADA system is used for real time monitoring and to provide an interface to operate the network. SCADA can monitor and control the operation of primary equipment at the zone substations and larger distribution substations, as well as providing indication from Transpower owned assets at GXPs. It is used to:

- Monitor the operation of the network from a single control room by remotely indicating key parameters such as voltage and current at key locations
- Permit the remote control of selected primary equipment in real time
- Graphically display equipment outages on a dynamic network schematic
- Transmit system alarms to the controller for action.

System information is collected by remote terminal units (RTUs) at each substation and is transmitted to a central master station located in a control room at Haywards substation through dedicated communication links. Control signals travel in the opposite direction over the same communications links.

#### 3.3.7.3. Load Control

Wellington Electricity uses a ripple injection signal load control system to control selected loads at consumer premises such as water heating and storage heaters, to control street lighting and also to provide some tariff signalling as required by retailers using the network. The system is automatically operated by the master station at the Haywards Control Centre to control loads at peak times.

#### 3.3.7.4. Communication

Operation of secondary systems requires the use of high security communication links between the master station and the different control points. Like most distribution businesses, Wellington Electricity operates its own communications system with a small number of communications links being leased from service providers such as Telecom, Vector Communications and Transpower.

Wellington Electricity's own network comprises mainly copper pilot cable with a small amount of fibre-optic and UHF radio infrastructure. Communications links leased from other service providers are either fibre-optic or radio links.

## 3.4. Categories of Assets and Age Profiles

### 3.4.1. Subtransmission Cables

Wellington Electricity own approximately 153km of subtransmission cable operating at 33kV. These cables, comprise some 52 circuits connecting Transpower grid exit points to Wellington Electricity's zone substations. Around 11 km of subtransmission cable is of XLPE construction and requires little maintenance. The remainder is of paper insulated construction, with a significant portion of these cables being relatively old pressurised gas or oil filled, with either aluminium or lead sheath. A section of the subtransmission circuits supplying Ira St zone substation are fluid filled PIAS cables with copper conductors rated for 110 kV but operating at 33 kV. The lengths, age profile and spare holdings of this asset class are shown below.

| Construction | Design voltage | Percentage | Quantity |
|---|---|---|---|
| Paper Insulated, Oil Pressurised | 33kV | 32% | 49 km |
| Paper Insulated, Gas Pressurised | 33kV | 53% | 82 km |
| Paper Insulated | 33kV | 2% | 3 km |
| XLPE Insulated | 33kV | 7% | 11 km |
| Paper Insulated, Oil Pressurised | 110kV | 6% | 9 km |

Figure 3-13 Summary of Subtransmission Cables

There are also 33kV rated oil cables supplying the Titahi Bay switching station from Porirua zone substation which are operated at 11kV, these are not counted in the subtransmission circuit length. These could in future be energised at 33kV if Titahi Bay was developed into a full substation and operated as subtransmission cables, although the likelihood of this occurring is low. Elsewhere in the network, there are abandoned 33kV cables being run at 11kV that will not be used as subtransmission again.

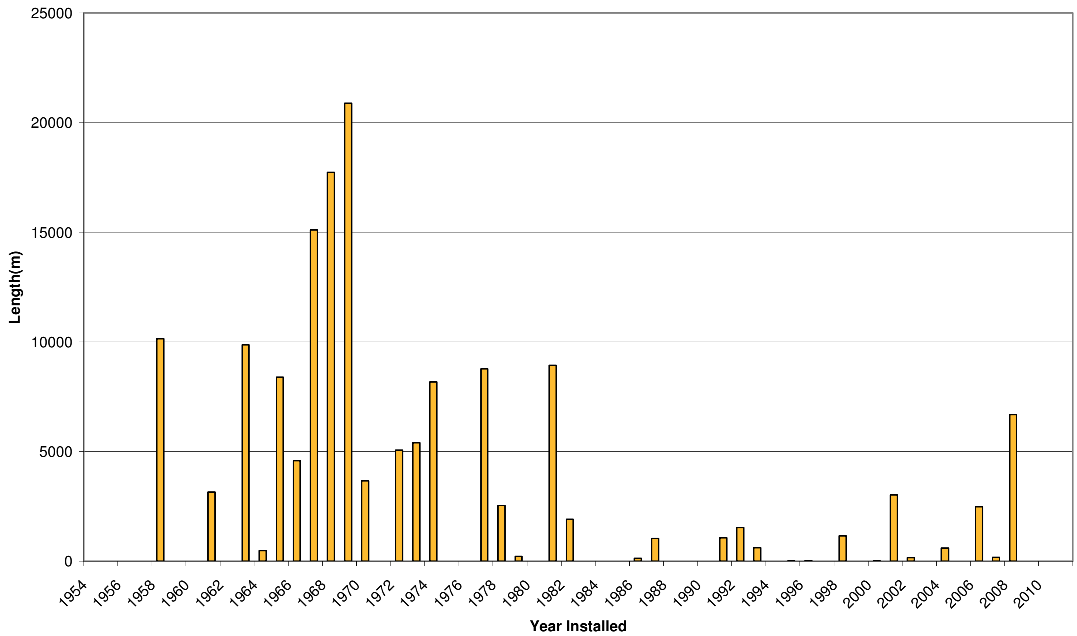



Figure 3-14 Age Profile of Subtransmission Cables

| Strategic Spares | |
|---|---|
| Medium lengths of cable | It is necessary to hold medium lengths of oil and gas cable in store to allow replacement of short sections following damage. By holding oil and gas cable lengths, field contractors are able to repair without requiring termination and transition to XLPE cable. |

| Strategic Spares | |
|---|---|
| Standard joint fittings | Stock is held by the field service provider to repair standard oil and gas joints, these need to have a minimum stock level held, and where stock levels drop replacement parts need to be sourced and if necessary be manufactured locally. |
| Termination/transition joints | Two gas to XLPE cable transition joints have been purchased and are held in storage to allow quick repair and alteration to gas cables using XLPE cables. |

Figure 3-15 Spares Held for Subtransmission Cables

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.2. Zone Substation Buildings

There are 30 major substation buildings, 28 of which are located at zone substation sites and 2 at major 11kV switching stations. The buildings generally stand alone and have switchgear, protection equipment, local AC and DC supplies installed inside. Some buildings also contain transformers and ripple injection plant. Wellington Electricity also has a large number of kiosk type distribution substations. These are covered separately later in this section as they form part the distribution substation asset class. The age profile of zone substation buildings is shown below.

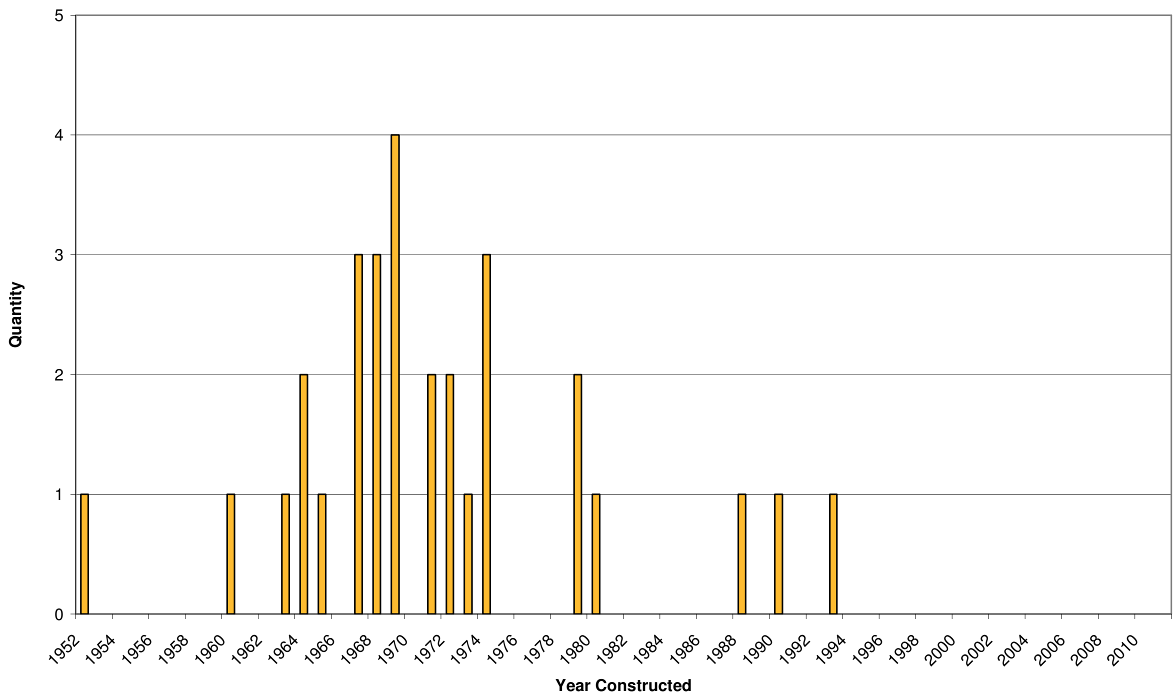



Figure 3-16 Age Profile of Zone Substation Buildings

The average age of the buildings is 39 years and they are generally in a good condition, however from time to time require maintenance or replacement of some components such as doors, roofs and spouting. Wellington Electricity is required to undertake seismic strengthening activities on buildings as required by the local councils on some of the older buildings. A seismic review and assessment has been undertaken on the majority of zone substation buildings. Remedial work has been undertaken as a result of this review, including securing plant inside substations.

In some cases, Wellington Electricity does not own the land under the zone substation, and has arrangements in place for a long term lease with the landowner.

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.3. Zone Substation Transformers

Wellington Electricity has 54 33/11kV power transformers in service on the network. All zone substation transformers are operated well within their specified ratings and are regularly tested and condition assessments undertaken. Overall the transformer fleet is in a generally sound condition even though a number of transformers are reaching their end of design life of 55 years. However, based on their operating conditions and maintenance it is expected that most transformers will continue to operate beyond their design life. Nevertheless older transformers require more intensive monitoring to assess and evaluate their condition. Estimated DP tests[3] on the transformers completed in 2009, using the Furan analysis method, indicate a high level of remaining life given the age. Whilst not as conclusive as taking internal paper samples, this is a good indicator of internal condition. Mechanical deterioration is an issue that needs to be monitored on older units, both for condition of external fittings, as well as internal components such as tap changer contacts and mechanisms.

The age profile and spares holdings for zone substation transformers are shown below.

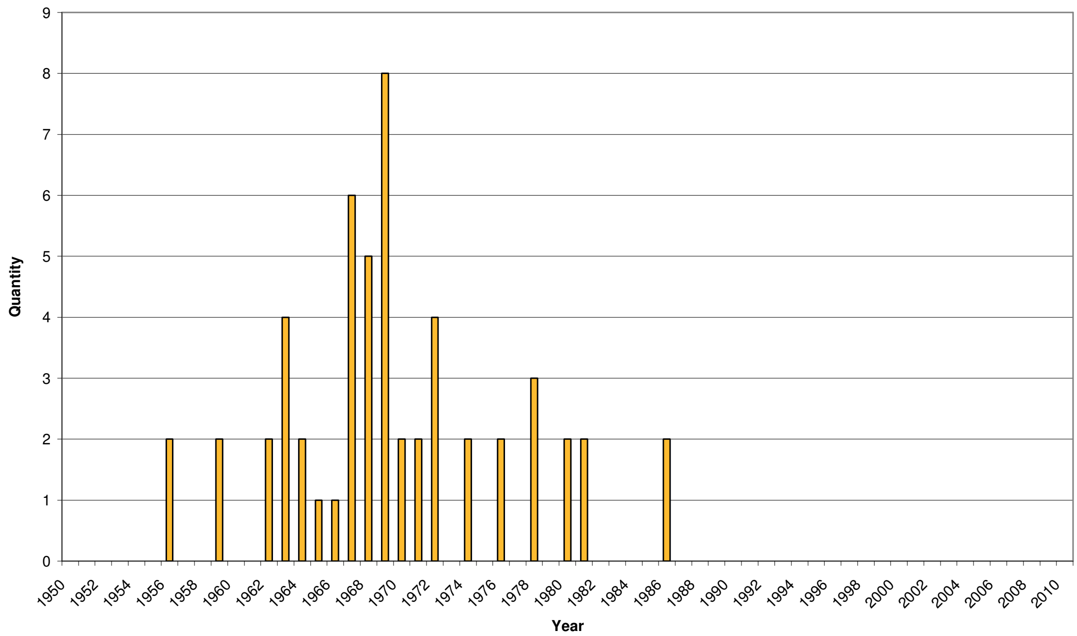



Figure 3-17 Age Profile of Zone Substation Transformers

The age profile indicates that the average age of the transformer fleet is reasonably high (around 40 years). Based on the assumption that zone transformers have an economic life of around 55 years then all of the

[3] Degree of Polymerisation, an indicator of dielectric strength of paper insulation.

zone transformers have exceeded midlife and around 65% of transformers have exceeded an age of 40 years.

Wellington Electricity holds certain spares for the power transformers and tap changers in the system, and a list of current and target spares is listed below:

| Strategic Spares | |
|---|---|
| Tap Changer fittings | Wellington Electricity holds a number of spares for the tap changers on Zone substation transformers, typically contacts and related components. These components have high wear and are eroded by arcing during operations. Generally, the components held are for tap changers that have not had recent maintenance, and are therefore used in the next maintenance cycle. Where excessive wear is noted during maintenance, spares are ordered and held in stock for that model of tap changer. Spares are generally available for all models that are operated on the network. |
| Transformer misc. fittings | Various other transformer fittings have been identified and held for sites where having a transformer out of service for a prolonged period is unacceptable for minor repairs. Fittings include Buchholz relays, high voltage bushings etc. For major repairs, a unit will be swapped out. |
| Spare transformer | There is one unit from Trentham that can be easily removed from service due to low loadings and ease of back feeding should a spare transformer be required.<br>Should Wellington Electricity require a second spare transformer, one of the units from Petone substation can be utilised. This area also has good 11kV backfeed options and low loadings.<br>Trentham has external bushings, and Petone has a cable box, so there is a transformer for either situation.<br>Other sites with low loading include Gracefield, Tawa and Kenepuru. In extreme cases, these sites can be evaluated for transformer removal. |

Figure 3-18 Spares Held for Zone Substation Transformers

### 3.4.4. Substation DC Systems

The DC auxiliary systems provide power supply to the substation protection, control, metering, monitoring, automation and communication systems, as well as circuit breaker tripping and closing mechanisms. The standard DC auxiliary system comprises batteries, battery chargers, DC/DC converters and a battery monitoring system. Wellington Electricity has a number of different voltages, 24, 30, 36, 48, and 110V largely for historical reasons, however has standardised on 24V for all new or replacement installations.

A range of spares is held, mostly chargers of different voltages that have been removed from sites over recent time. Batteries are available locally at short notice so these are not held.

### 3.4.5. Switchboards and Circuit Breakers

11kV circuit breakers are used in zone substations to control the power injected in to the 11 kV distribution network and also within the network to increase the reliability of supply in priority areas such as in and around the CBD. The largest single type is Reyrolle Pacific type LMT circuit breakers but other types are also in service in large numbers. There are approximately 1,780 CBs forming 400 11kV switchboards on the Wellington Network.

An age profile of the circuit breakers and spare parts holdings are shown below.

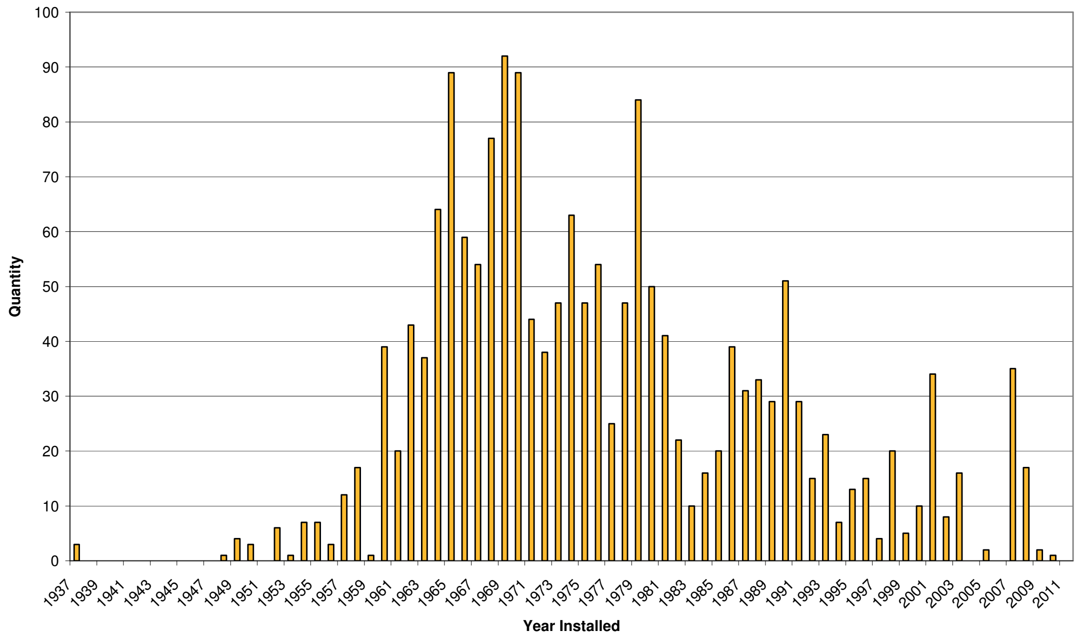



**Figure 3-19 Age Profile for Circuit Breakers**

The age profile indicates that the average age of circuit breakers in the Wellington Network is around 35 years, with the age of individual breakers ranging from relatively new to more than 50 years. The mix of circuit breaker technologies reflects the age of the equipment. The oil type circuit breakers are the oldest in the network followed by SF6 and vacuum type circuit breakers. Most circuit breakers are oil insulated with relatively intensive maintenance regimes.

There are two 33 kV oil circuit breakers at Ngauranga which have been in service at this site for approximately 18 years having been installed in 1993 when the substation was constructed, however they were originally manufactured in the 1960s. A protection scheme proposed for the subtransmission circuits from TP Takapu Rd will see these being made redundant and all circuit breakers remaining will be 11kV. Certain oil-type circuit breakers are approaching or have passed the end of their technical life of 40 years. Inadequate fault level rating, equipment failures, lack of spare parts, and increased maintenance costs compared to newer $SF_6$ or vacuum equipment are areas of concern for this aging equipment.

| Category | Quantity |
|---|---|
| 33kV Circuit Breakers | 2 |
| 11kV Circuit Breakers | 1,794 |

**Figure 3-20 Summary of Circuit Breakers**

Given the high number of circuit breakers in service on the Wellington network, it is important to keep adequate quantities of spares to enable quick repair of minor defects. Some types of circuit breakers, such as early Statter and AEI CBs have limited numbers of spares available; however there are low numbers of these types installed on the system. There are large numbers of spares held for the Reyrolle type circuit breakers; this is reflective of the number in service.

The largest quantity of CBs on the network, and used predominantly at zone substations, are Reyrolle type LMT. The RPS Switchgear (formerly Reyrolle Pacific) factory is located in Petone, there is a good relationship between parties and spares above those normally held by the network are available within short timeframes if required for LMT type switchgear

| Strategic Spares | |
|---|---|
| Circuit breaker trucks | At least one CB truck of each rating (or the maximum rating where it is universal fitment) shall be held for each type of withdrawable CB on the network. |
| Trip/Close Coils | Spare coils held for each type of circuit breaker, and all operating voltages. |
| Spring Charge Motors | Spare spring charge motors held for each voltage for the major types of switchgear in service (Reyrolle C gear, LMT, etc). |
| Current Transformers and primary bars | Where available, spare CTs and primary bars should be held to replace defective units. In particular 400A CTs for Reyrolle LMT as this type of equipment has a known issue for partial discharge. |

Figure 3-21 Spare Parts Held for Circuit Breakers

Full details of maintenance, refurbishment and renewal are covered in Section 6.

11kV Gas Insulated Switchgear at The Terrace Zone Substation

### 3.4.6. Protection and Control Systems

Due to the closed-ring architecture of the central Wellington distribution network there are a large number of protection relays, the majority (close to 90%) of which are electromechanical type. Numerical type relays are the latest additions to the network but constitute only 9% of the population. Solid state or static type relays ranging in age from around 15 to 25 years represent around 4% of the total number of relays.

The average age of the protection relays on the Wellington network is around 32 years and it is estimated that around 400 or 30% of the protection relays are 40 years or over in age. Generally all protection relays are in good condition with the exception of PBO electro mechanical and Nilstat ITP solid state relays. These relays have performance and functionality issues, which had triggered an ongoing replacement programme under previous owners. The majority of PBO type relays were replaced in the old Hutt Valley area but few have been replaced in the Wellington City area.

Full details of maintenance, refurbishment and renewal are covered in Section 6.

### 3.4.7. SCADA

Wellington Electricity's SCADA master station is located at the Transpower-owned Haywards substation. It is a Foxboro (formerly Leeds & Northrup (L&N)) LN2068 system and was initially installed in 1986 and is being replaced with a GE ENMAC system, which is in the process of being fully commissioned. The Foxboro system will be retained in the short term to provide the automatic load control function until the ENMAC system is upgraded to undertake this function, or an alternative standalone system is implemented. Wellington Electricity is investigating the replacement of the automatic load control system, and an independent system may provide other benefits such as supporting demand-side management initiatives.

Data is communicated to the master station by remote terminal units (RTUs) that are located at the different control and monitoring sites. The age and technology of the RTUs vary and many are now obsolete. The protocols in use on the Wellington network are Conitel, DNP3.0 and IEC61850. Wellington Electricity has 238 RTUs installed in sites from GXP level down to small distribution substations. An age profile of SCADA RTUs is shown below.

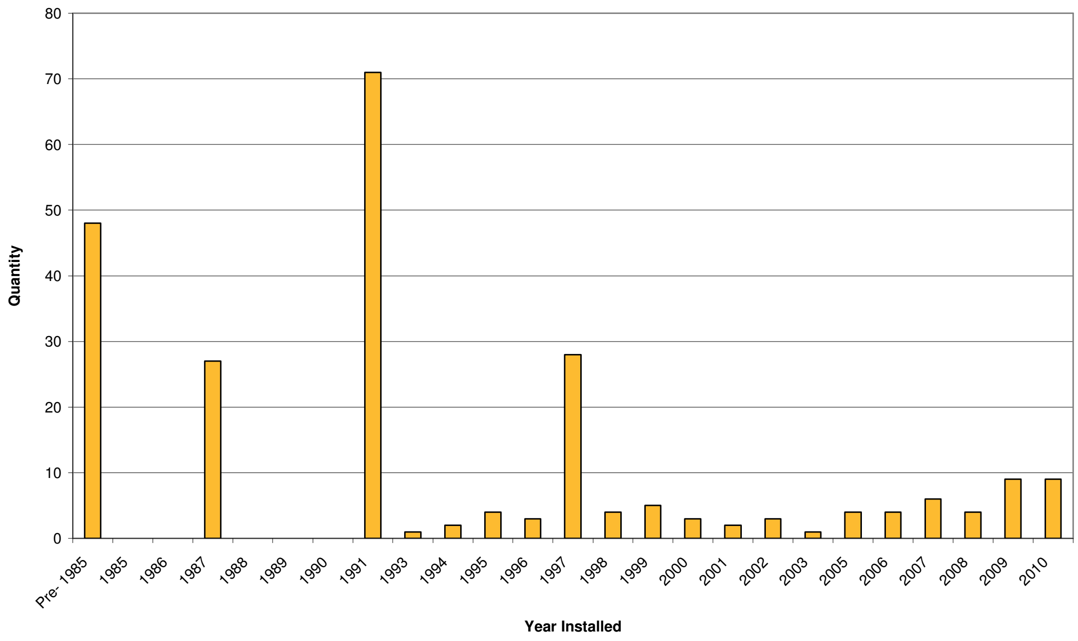



**Figure 3-22 Age Profile of SCADA RTUs**

Full details of maintenance, refurbishment and renewal are covered in Section 6.

#### 3.4.7.1. Substation Level TCP/IP Communications

Presently the substation level TCP/IP (a protocol used in data communications, Transmission Control Protocol/Internet Protocol) network hardware is leased from Vector Communications Ltd, a subsidiary of the previous network owner.

The contract with Vector Communications will expire in June 2012 at which point it is envisaged that Wellington Electricity will review these arrangements.

As substation sites are being upgraded or developed, and if IP network connections are available, the station RTU is upgraded and moved onto the substation TCP/IP network. Presently there are 18 sites (a mixture of zone and distribution substations) on the substation TCP/IP network.

There is one Siemens Power Automation System (PAS) unit that acts as a protocol converter between the Siemens IEC61850 field devices and that of the DNP3 SCADA master station and is seen as a single point of failure as multiple sites are reporting to one point, the PAS. Substation base equipment will be installed, in due course, to eliminate the reporting of multiple sites through a single device and reduce this risk.

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.8. Load Control Systems

Wellington Electricity uses a ripple injection signal load control system to inject 475Hz and 1050Hz signals into the network for the control of selected loads at consumer premises such as water heating and storage heaters, to control street lighting and also to provide some tariff signalling as required by retailers using the network. There are 24 ripple injection plants on the network and these are located at GXPs and zone substations. The Wellington city area has a 475Hz signal injected into the 33kV network with one plant per

GXP and two plants injecting at Kaiwharawhara 11kV point of supply. The Hutt and Porirua areas have a 1050Hz signal injected at 11kV at each zone substation. All ripple injection is controlled by the master station at the Haywards Control Centre. An age profile of ripple plant is shown below.

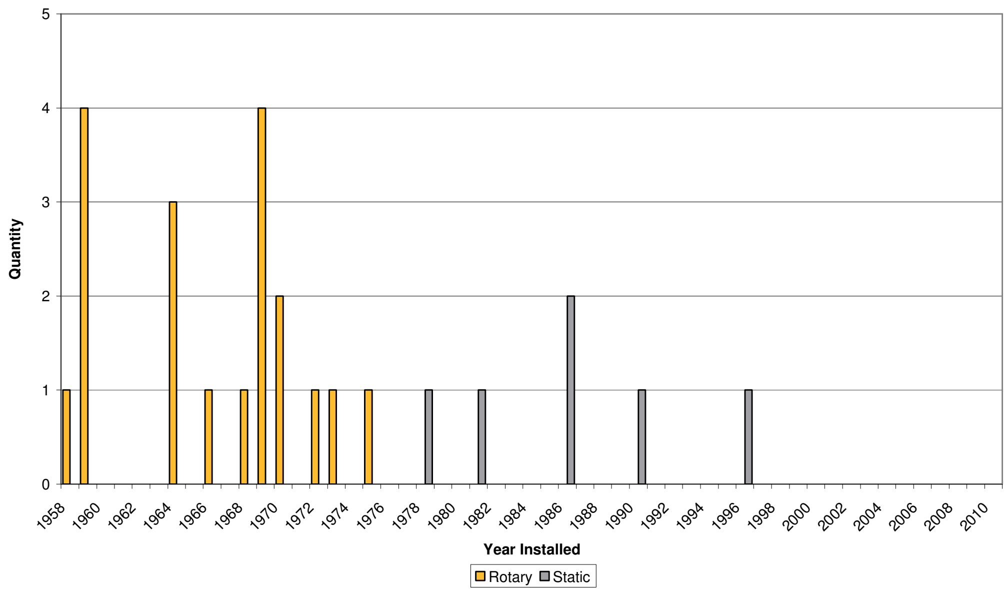



**Figure 3-23 Age Profile of Ripple Plant**

There is significant benefit in having a fully functional load control system and being able to control loads at peak times and to defer energy consumption by interruptible loads until times of lower demand on the system. This allows for better asset utilisation as the distribution network does not need to be oversized to allow for short duration peaks. Wellington Electricity does not own the ripple receivers installed at consumer premises and is experiencing decreasing levels of control as these devices fail and are not replaced by the asset owner. As receivers fail, Wellington Electricity has noted that they are not being replaced by the retailers, hence over time the network will continue to lose controllable load which may accelerate the need for investment in the distribution system. Wellington Electricity is encouraging retailers and metering providers to ensure investments and upgrades preserve the ripple control system due to its importance to managing loading on the network and transmission system. Wellington Electricity believes ripple control is the most cost effective technology for load control due to the existing installed base and will continue to operate this system. Wellington Electricity also uses ripple control to participate in the Instantaneous Reserves market, and for supporting the Transpower AUFLS (Automatic under frequency load shedding) system.

There are some small areas of network that receive DC bias load control signals. This system is no longer supported and it is unknown how many consumer installations still use the DC bias system. It is proposed to decommission this system in 2011-2012 and affected consumers will be moved to ripple load control. The process required, and the implications both in terms of technical and commercial arrangements need to be fully worked through as this affects the incumbent metering owner's receiver assets.

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.9. Overhead Lines

The overhead lines in Wellington Electricity's network consist of 50% wooden and 50% concrete pole lines. There are a total of approximately 50,000 poles in the network at present, however Wellington Electricity is reviewing its pole ownership policy for common service lines, and has recently completed a pole survey to determine network and non-network poles. This work is likely to alter the total number of poles owned by Wellington Electricity.

#### 3.4.9.1. Poles

The average age of concrete poles is around 24 years. Although the standard asset life for concrete poles is 60 years, there are a number of concrete poles that have been in service for longer. The average age of wooden poles is around 36 years of age and nearly 38% of all wooden poles are older than 45 years, the standard asset life of wooden poles. Crossarms are predominantly hardwood and are generally in a fair condition. Crossarms have a shorter life than poles, especially concrete poles, and will generally require replacement approximately half way through the life of the pole.

Along with Telecom accessing the poles for their services, a previous network owner entered into agreement with Saturn (now TelstraClear) to support cable TV circuits from the majority of the network poles across the region. This is now causing problems for maintenance and operations due to congestion on the poles. Due to this congestion, Wellington Electricity must consider the impact and full life cycle costs of future access for wide scale attachment to poles. Each case will be evaluated on its own merits. An age profile of the poles on the network is shown below.

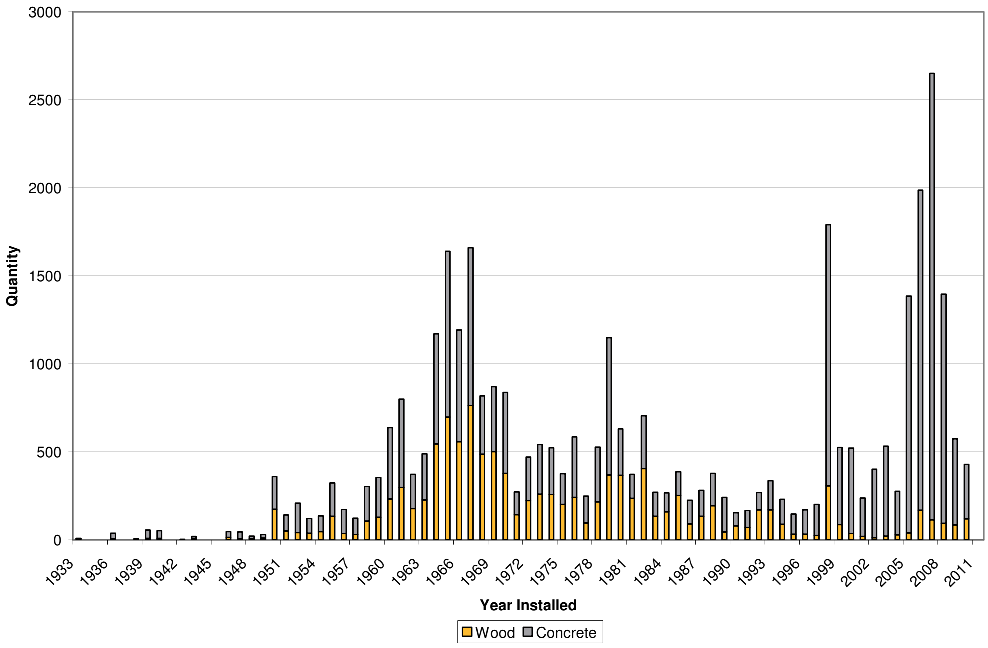



Figure 3-24 Age Profile of Poles

#### 3.4.9.2. Lines/Conductor

Overhead conductors are predominantly copper (Cu), all aluminium conductor (AAC) and aluminium conductor steel reinforced (ACSR). New line reconstruction generally utilises all aluminium alloy conductor

(AAAC). Where possible, low voltage aerial bundled conductor (LVABC), and covered conductor thick (CCT) for 11 kV lines are used in areas susceptible to tree damage. An age profile of overhead line conductors is shown below.

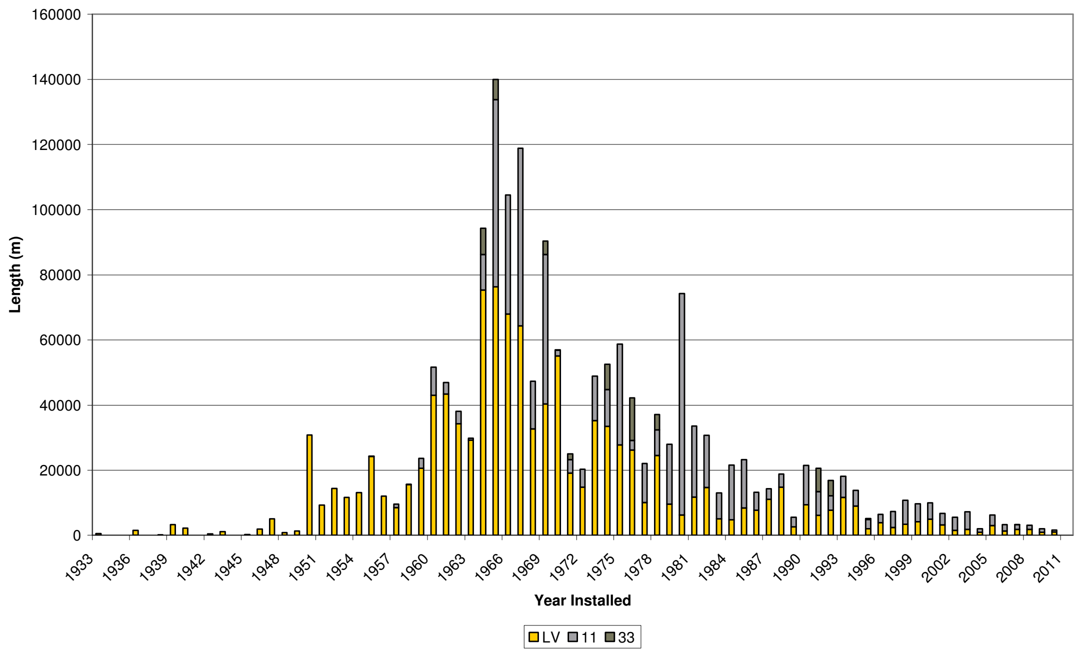



Figure 3-25 Age Profile of Overhead Line Conductors

| Category | Quantity |
|---|---|
| 33kV Line | 58 km |
| 11kV Line | 598 km |
| Low Voltage Line | 1115 km |

Figure 3-26 Summary of Overhead Lines

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.10. Overhead Switchgear and Devices

There are 335 air break switches (ABS), 27 auto-reclosers, 171 knife links, 42 gas insulated overhead switches and a mix of expulsion type drop out fuses for breaking the overhead network into sections.

Most of the ABSs are more than 20 years old and are not cost effective to refurbish and generally range from fair to poor condition. Switch replacement occurs when poles or crossarms are replaced, or upon inspection results. Gas insulated load break switches are being used in strategic areas, and are equipped with motor actuation for future automation. Conventional air break switches are also widely used.

The majority of the 27 overhead auto-reclosers are oil filled, with only five being gas insulated.

Wellington Electricity has a single 400V voltage regulator that was installed in the mid 1980s.

An age profile of these overhead line devices is shown below.

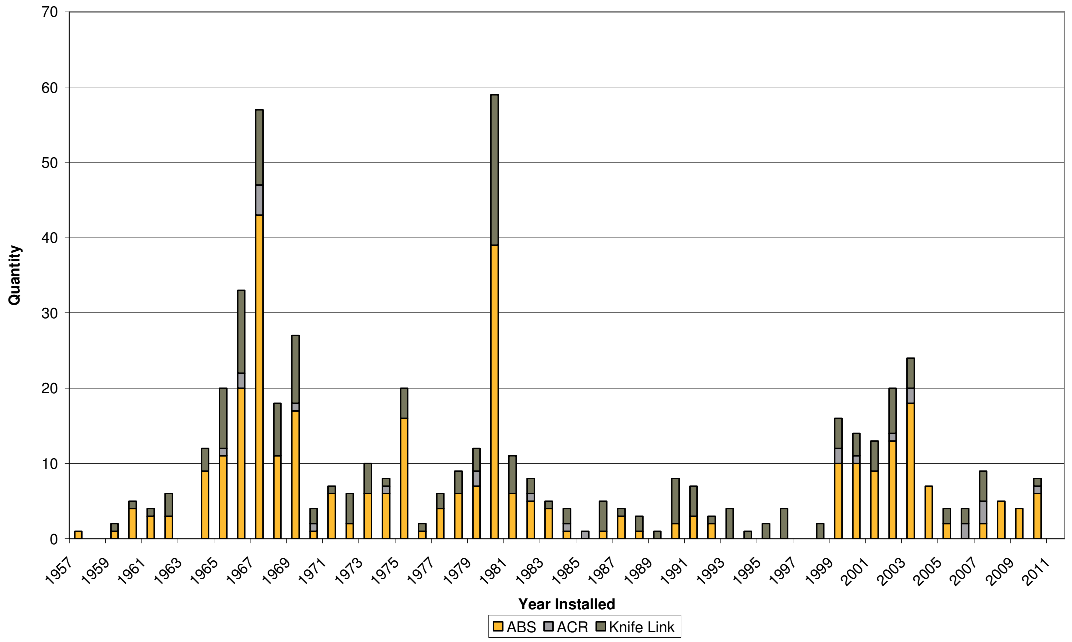



**Figure 3-27 Age Profile of Overhead switchgear and devices**

Fault passage indicators, both remote and local, have been installed at a number of major tee offs on the overhead lines. This practice will continue to aid fault detection to allow quicker restoration of areas affected by interruptions.

### 3.4.11. Distribution Transformers

Approximately 57% of the distribution transformer population is ground mounted and the remaining 43% is pole mounted. The pole mounted units are installed on single and double pole structures and are generally 3 phase units rated between 10 and 200kVA. The ground mounted units are also generally 3 phase units rated between 100 and 1,500kVA. Wellington Electricity holds a variety of spare distribution transformers, in serviceable condition, to allow for quick replacement following a major defect. Other than complete units, few other spares are held for this type of asset. The standard life of a distribution transformer is 45 years, although in indoor environments a longer life may be achieved, and in some outdoor environments a transformer will not reach this age. The age profiles of distribution transformers are shown below.

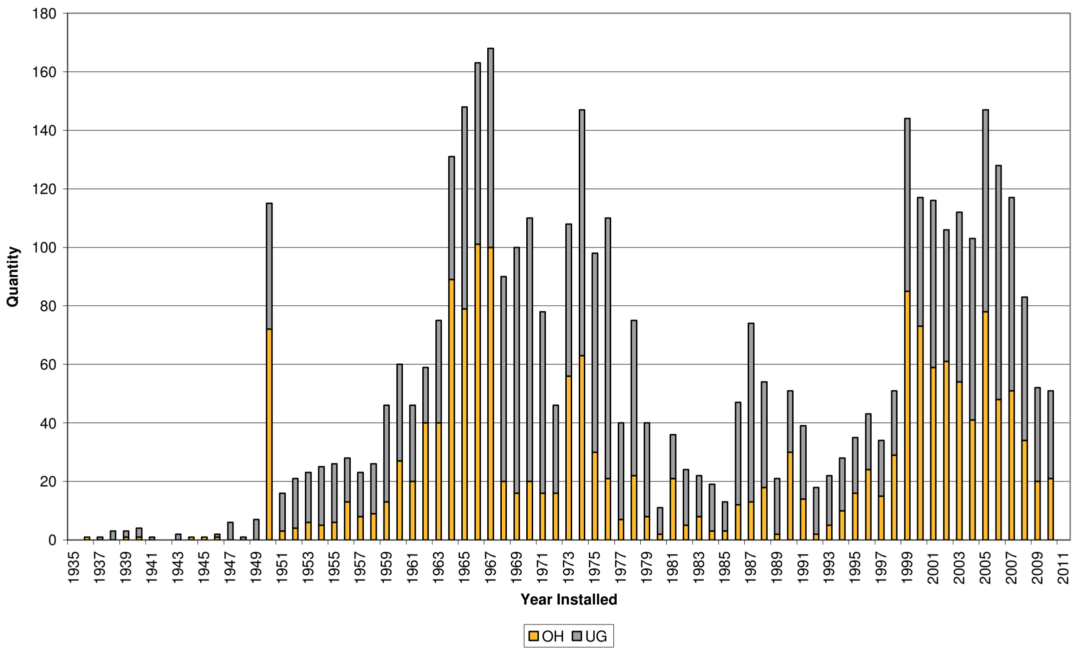



Figure 3-28 Age Profile of Distribution Transformers

In addition to pole and integral berm substations, Wellington Electricity has over 400 indoor type substations (typically of masonry or block construction) in the Wellington City and Hutt Valley areas. These are categorised under substation enclosures, although a large number are quite sizeable and reside on Wellington Electricity owned plots of land.

| Category | Quantity |
|---|---|
| Distribution Transformers | 4,303 |
| Distribution Substations (enclosures, earthing, land) | 3,461 |

Figure 3-29 Summary of Distribution Transformers and Substations

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.12. Ground Mounted Distribution Switchgear

This section covers ring main units and similar switching equipment, which is often mounted outdoors. It does not cover indoor circuit breakers which are widely used on the distribution network outside of zone substations. There are around 1,700 ground mounted switchgear units in the Wellington Electricity network, both of the Holec Magnefix type and conventional oil insulated ring main switches such as ABB, Long and Crawford, and similar. Most of the older switchgear is oil insulated; however the newer ones use $SF_6$ as the main insulating medium, Magnefix has a resin casing to provide insulation. The age profile of ground mounted switchgear is shown below.

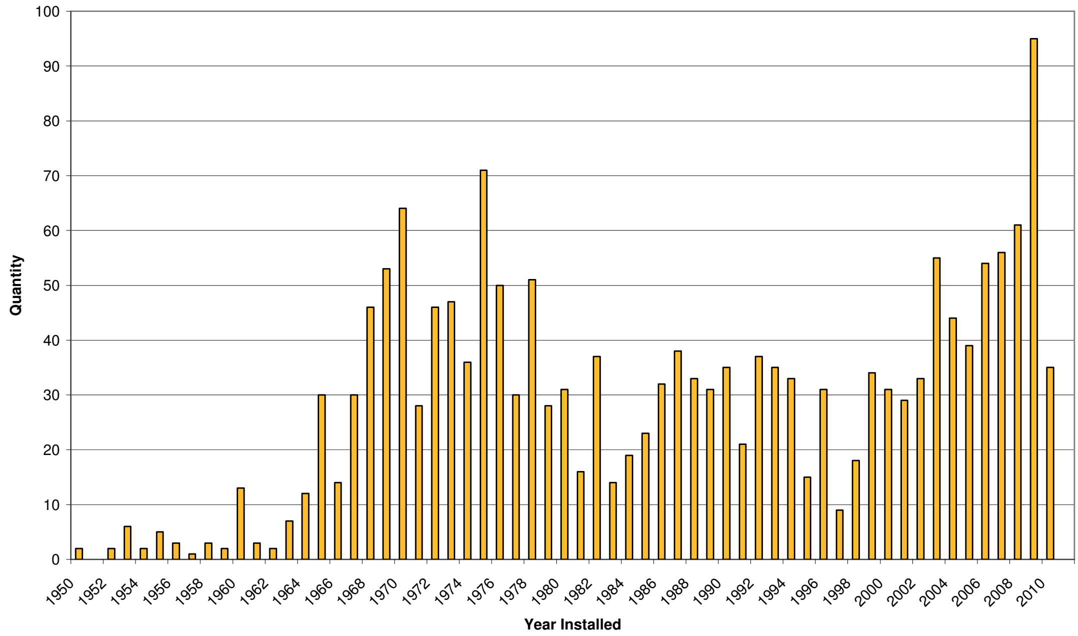



Figure 3-30 Age Profile of Ground Mounted Distribution Switchgear

The average age of the ground mounted switchgear is 23 years.

| Category | Quantity |
|---|---|
| Ring Main Units | 1,762 |

Figure 3-31 Summary of Ground Mounted Distribution Switchgear

Full details of maintenance, refurbishment and renewal are covered in Section 6 (Lifecycle Asset Management).

### 3.4.13. HV and LV Distribution System

Wellington Electricity's network has a relatively high percentage of underground cables, which has contributed to its relatively high level of reliability. The 11kV underground distribution system has normally open interconnections between feeders, and feeders are segmented into small switching zones using locally operated ring main switches. In the event of a cable fault the faulted cable section can be isolated and supply to downstream customers can be switched to neighbouring feeders.

Wellington CBD is operated in a closed ring configuration with radial feeders interconnecting neighbouring rings or zone substations. This part of the network uses automatically operating circuit breakers, using Solkor differential protection between sites, rather than manually operated ring main switches between switching zones. This results in higher reliability as smaller sections of network are affected by cable faults, however due to the nature of the CBD, any repairs required to the distribution system take considerably longer than standard replacement times. CBD repairs also incur considerable costs for traffic management and pavement reinstatement.

In rural areas, the lines are generally radial, with limited back feeds in areas such as Akatarawa, Paekakariki Hill and Wainuiomata towards the south coast. The use of auto reclosers and sectionalisers aims to reduce the impact on these feeders, an outage is likely to affect customers for the duration of the repair.

| Category | Quantity |
|---|---|
| 11kV Cable (incl. risers) | 1,126 km |
| Low Voltage Cable (incl. risers) | 1,559 km |
| Pillars and Pits | 14,500 |

Figure 3-32 Summary of Distribution Cables and Pillars

### 3.4.13.1. HV and LV Distribution Cables

Approximately 95% of the underground distribution cables are PILC and PIAS and the remaining 5% are newer XLPE insulated cables. PILC cables use a relatively old technology but are in good condition and have proven to be very reliable.

The majority of low voltage cables are PILC or PVC insulated, and a much smaller number are newer XLPE insulated cables. In general the low voltage cables are in good condition.

An age profile of distribution cables of both voltages is shown below.

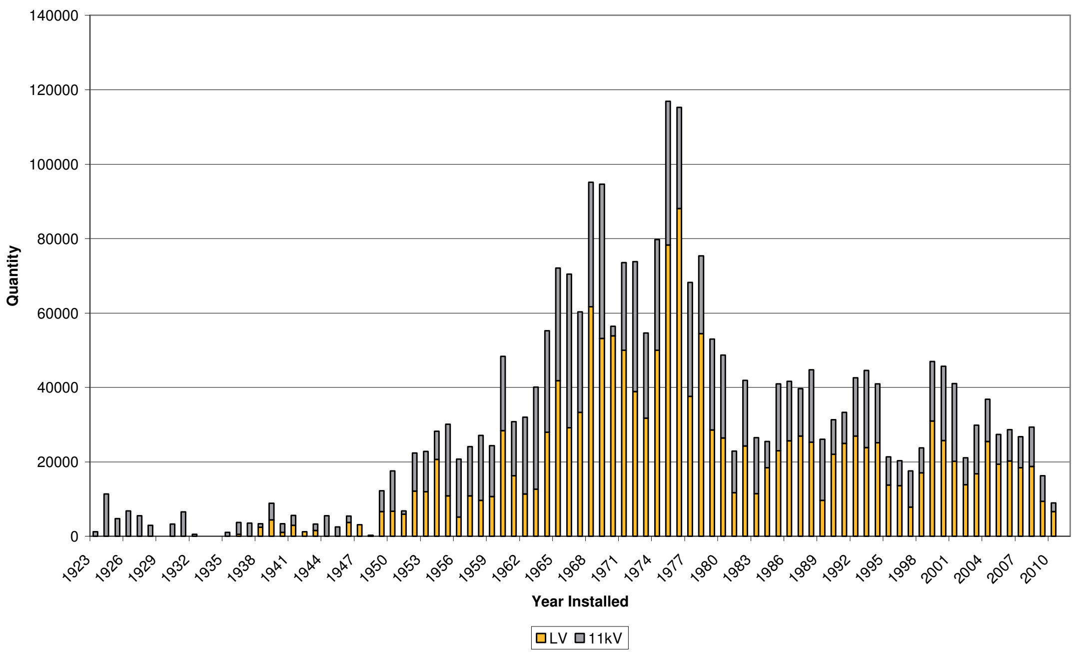



Figure 3-33 Age Profile of Distribution Cables

### 3.4.13.2. LV Pillars and Pits

Pillars and pits provide the point for the connection of customer service cables to the Wellington Electricity underground low voltage reticulation. They contain the fuses necessary to isolate a service cable from the network. Pits are manufactured from polyethylene as are most of the newer pillars. Earlier style pillars were constructed of concrete pipe, steel, or aluminium. There are approximately 400 link pillars and pits in service on the Wellington network; these are used to parallel adjacent LV circuits to provide back feeds during outages, as well as providing the ability to sectionalise large LV circuits. A high level breakdown of types is listed below.

| Type | Approximate quantity |
|---|---|
| Customer Service Pillar | 13,250 |
| Customer Service Pit | 850 |
| Link Pillars and Pits | 400 |

Figure 3-34 Summary of LV pillars and pits

### 3.4.14. Metering

Wellington Electricity does not own any revenue metering assets as these are owned by retailers and metering companies supplying consumers.

There are check meters installed at GXPs and a large number of Maximum Demand Indicator (MDI) meters installed in distribution substations. These are for operational and planning purposes only and are considered to be part of that asset.

### 3.4.15. Generators and Mobile Substations

Wellington Electricity does not own any mobile generators or substations. There is a fixed generator supporting the network control room at the Haywards substation, and Wellington Electricity is making provision for shared use of a generator at the corporate office in Petone.

All generation required for network operations and outage mitigation is provided by the works contractor.

Wellington Electricity own a kiosk with 11kV switchgear installed and this is used in instances where switchgear replacement or other major works is occurring at a substation and 11kV supply cannot be out of service for extended periods.

Wellington Electricity is evaluating where in the network private backup generation is installed, particularly large generators in the CBD that can be synchronised, and how this can be utilised for maintaining customer supply or assisting during network outages or Grid Emergencies.

### 3.4.16. Asset Category Value

The value of Wellington Electricity network assets is summarised by ODV category below:

| Asset category | Category value (ODRC at 31 March 2010) |
|---|---|
| Subtransmission Assets | $59.6 m |
| Zone Substations | $41.8 m |
| Distribution LV Lines and cables | $255.2 m |

| Asset category | Category value (ODRC at 31 March 2010) |
|---|---|
| Distribution Substations and Transformers | $59.5 m |
| Distribution Switchgear | $36.0 m |
| Other System Fixed Assets | $17.1 m |

Figure 3-35 Asset Category Values

## 3.5. Asset Justification

The distribution system is designed to provide an electricity supply of sufficient capacity and reliability to meet the customer service levels for the load type and with consideration of the price/quality trade-off consumer groups are prepared to make. In addition, the network is planned and constructed with some additional capacity to cater for forecast load increases. This strategy (which is generally adopted by electricity network businesses) is an efficient approach to network development due to the high cost and long life cycles of electricity distribution assets.

**Urban Network**

The urban network, both in residential and business/CBD areas, is designed to support present and recent forecast loads, and to be operated within the disclosed service levels for the period of this AMP. Where shortfalls are identified, network reinforcement projects or demand side initiatives (or a mixture of both) may be undertaken. There are different network architectures between the old Capital MED and Hutt Valley areas, and as such there is a higher level of security in the Wellington CBD, and surrounding suburbs, which incorporates an increased number of circuit breakers and protection devices, a predominantly underground network due to the building density, as well as offering a high level of redundancy. This legacy system architecture is appropriate to meet the security criteria for the CBD and also reflects the significance of the Wellington CBD as being the centre of Government, Government departments and commerce, and their reliance upon secure electricity supply. Supply is taken at 33kV to supply zone substations from Transpower grid exit points, this is an industry standard voltage and is appropriate to minimise losses, as well as carry the required loads. Distribution feeders are all 11kV, which is stepped down at distribution substations to 400V for distribution to consumer premises. In some areas, supply is taken from Transpower at 11kV where the load centre is close to the GXP. There has been reasonably low load growth in the Wellington network over recent years and the decline of manufacturing industry from the 1980s onwards has created headroom in some areas of the network, especially the Hutt Valley and Porirua areas. Despite this, changing load demands (apartment conversions, air conditioning etc) in the CBD has created some constraints that will require further network development.

**Rural Network**

The rural network is supplied at 11kV from Urban zone substations, and often a rural feeder passes through an urban area supplying load before entering a rural area. There are fewer back feed options for rural feeders and this is reflected in lower service levels. Less than 30% of the Wellington network is rural and the load served is very low density. There is no major rural sector in the Wellington area so loading and voltage is not an issue, however the exposure to weather and vegetation interference necessitates a large number of line reclosers, remote switches and sectionalisers to meet service level targets.

**Voltage Levels**

11kV has been the predominant distribution voltage as this was the original supply voltage from the Khandallah substation established in 1924 to supply Wellington, and the subsequent development and connection of Melling and Central Park substations in the 1930s and 40s.

33kV was introduced in the late 1950s for subtransmission when load growth exceeded the capacity of the 11kV system. Wellington Electricity has no intention in the short term to use other voltages for distribution or subtransmission.

110kV cabling was installed by the Wellington MED in the early 1980s to future proof supply capacity to the Eastern Suburbs area (incorporating Evan's Bay and Miramar) , although this is presently operated at 33kV. Wellington Electricity is considering the use of 110kV in this area during the planning period for two main reasons:

- The age and condition of the gas filled 33kV cables indicates the replacement of the cables to Evan's Bay and Hataitai is likely during the planning period, as well as the age and condition of the Evan's Bay 33/11kV transformers indicates replacement will be required in the medium term. A viable solution, and likely to be a least cost option, is to replace the Evans Bay transformers with three winding 110/33/11kV transformers to provide local 11kV supply, as well as 33kV supply to Hataitai and Ira St substations, and re-energise these cables at 110kV from Central Park, which by that time is likely to have a 110kV bus to allow connection of the circuits. The total demand is forecasted to be over 60 MVA in this area making 110kV a viable operation voltage. Replacement of the multiple 33kV gas filled circuits in their present arrangement is likely to be considerably more expensive than this 110kV option. The dual circuit 110kV provides the required N-1 security. The exact timing of these asset replacements, and any alternative supply configurations, will be subject to cost/benefit analysis to determine the optimal time to replace the assets, at a point where the cost of repairs and increased likelihood of failure provides an unacceptable risk to Wellington Electricity.
- To improve security to the Wellington area by completing the loop from the Gracefield GXP (which operates at 110kV) on the other side of the harbour, through to Central Park GXP which also operates at 110kV. A submarine cable could be laid between Gracefield and Evan's Bay with relative ease when compared with laying a new 110kV cable through Wellington City, or building an overhead line in a dense urban area. This option will be further explored as part of continuing discussions between Wellington Electricity and Transpower over security of supply into the Wellington City area.

# 4. Service Levels

## 4.1. Consumer Orientated Performance Targets

### 4.1.1. Network Reliability

Network reliability is measured using two internationally recognised performance indicators, SAIDI and SAIFI, which taken together are indicators of the availability of an electricity supply to the average customer connected to the network.

- SAIDI[4] is a measure of the total time in a measurement year that an electricity supply is not available to the average consumer connected to the network. It is measured in minutes.
- SAIFI[5] is a measure of the total number of supply interruptions that the average consumer experiences in the measurement period. It is measured in number of interruptions[6].

These indicators include both planned and unplanned outages. On average, planned outages account for approximately 25% of the total number of outages every year but only contribute to 6% of the annual SAIDI minutes. Consistent with the approach taken by the Commerce Commission the following supply interruptions are not included in the measured performance indicators.

- Interruptions caused by the unavailability of supply at a GXP, or as a result of automatic or manual load shedding directed by the transmission grid operator[7], or as a result of some other event external to the Wellington Electricity network.
- Interruptions lasting less than one minute. In these cases restoration is usually automatic and the interruption will not be recorded for performance measure purposes, however, it is recorded in Wellington Electricity's systems for future analysis.
- Interruptions resulting from an outage of the low voltage network or a single phase outage of the 11kV distribution network. The Commerce Commission does not require these interruptions to be recorded for information disclosure or for the operation of the threshold control regime. In practice such interruptions do not have a material impact on measured system reliability and the business processes required to accurately record these interruptions and measure their impact are not cost effective.

Wellington Electricity has calculated reliability thresholds using the methodology set down by the Commerce Commission[8]. This method adopts a reference sat of reliability data taken from the period 1 April 2004 to 31 March 2009. The mean reliability over this period is set as the threshold for network and the mean plus one standard deviation become the limit. This method is applied to both SAIDI and SAIFI. The mean and limit values for Wellington Electricity calculated using this method presented below.

---

[4] System Average Interruption Duration Index

[5] System Average Interruption Frequency Index

[6] Due to the effect of averaging, SAIFI is reported as a non integer number.

[7] The transmission grid operator has the authority to direct electricity distributors to shed load. This is necessary during emergencies to ensure that the power system continues to operate in a secure and stable state.

[8] Commerce Commission, Decisions paper on the initial reset of the DPP, 30 November 2009.

| | 2010-11 | 2011-12 | 2012-23 | 2013-14 | 2014-15 |
|---|---|---|---|---|---|
| **SAIDI threshold (mean)** | **33.90** | **33.90** | **33.90** | **33.90** | **33.90** |
| SAIDI limit (mean + 1SD) | 40.74 | 40.74 | 40.74 | 40.74 | 40.74 |
| **SAIFI threshold (mean)** | **0.52** | **0.52** | **0.52** | **0.52** | **0.52** |
| SAIFI limit (mean + 1SD) | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |

**Figure 4-1 Reliability Thresholds (as defined by the Regulator)**

Note 1: SAIDI is measured in minutes and SAIFI in average number of interruptions.

The thresholds have been calculated in accordance with the Commerce Commission's current requirements for the reporting of reliability and include the impact of major event days when the number of outages exceeded the ability of Wellington Electricity's contractor to respond in a timely manner. The impact of these major event days on the reported reliability can be significant – there were two major event days in 2003-04 when a SAIDI of over twice that recorded in a normal year was experienced. These events fall outside of the 'reference dataset' five year averaging period and hence are not included in the above table however should a similar event occur in the future, it would have a significant impact not only on this years SAIDI, but also on a rolling average.

Major event days are usually caused by environmental factors, such as severe storms, that are outside Wellington Electricity's direct control. They are relatively infrequent – Wellington Electricity has experienced only three major event days in the last six years, two in 2003-04 and one in 2004-05. They generally have a much bigger impact on SAIDI than on SAIFI because during such events consumers may only experience one interruption but can be without power for hours or, in extreme situations, days.

The measured historic reliability of Wellington Electricity's network is illustrated in the graphs below. In broad terms, the graphs show that, under normal circumstances, the average consumer can expect one sustained interruption every two years and that this interruption will last a little over an hour.

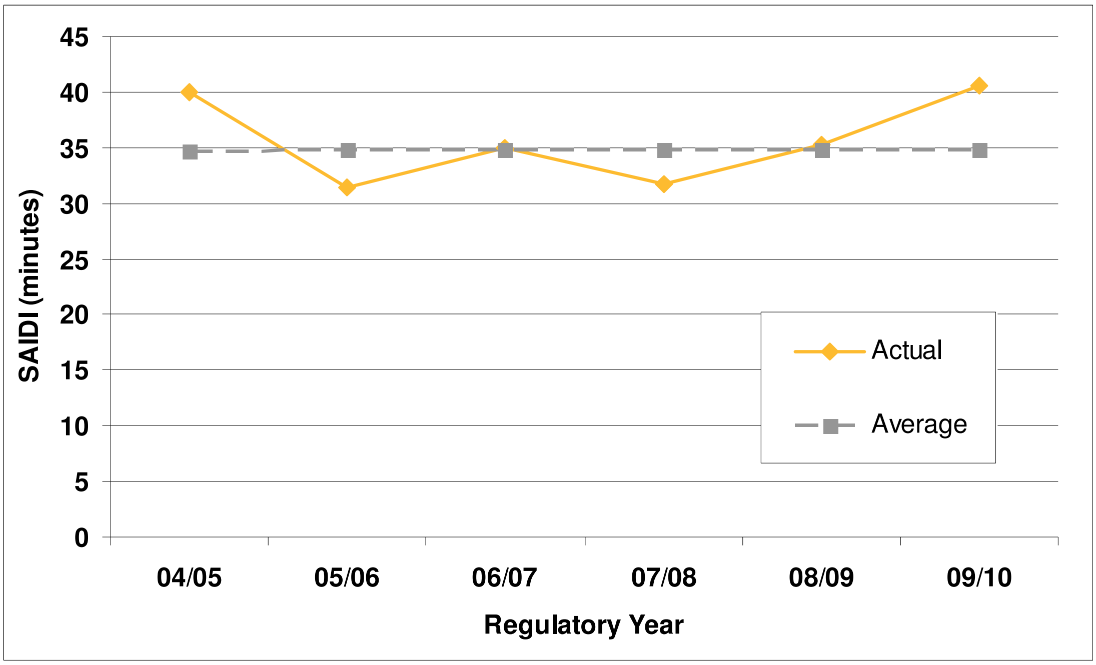



Figure 4-2 Historic SAIDI of the Wellington Electricity Network

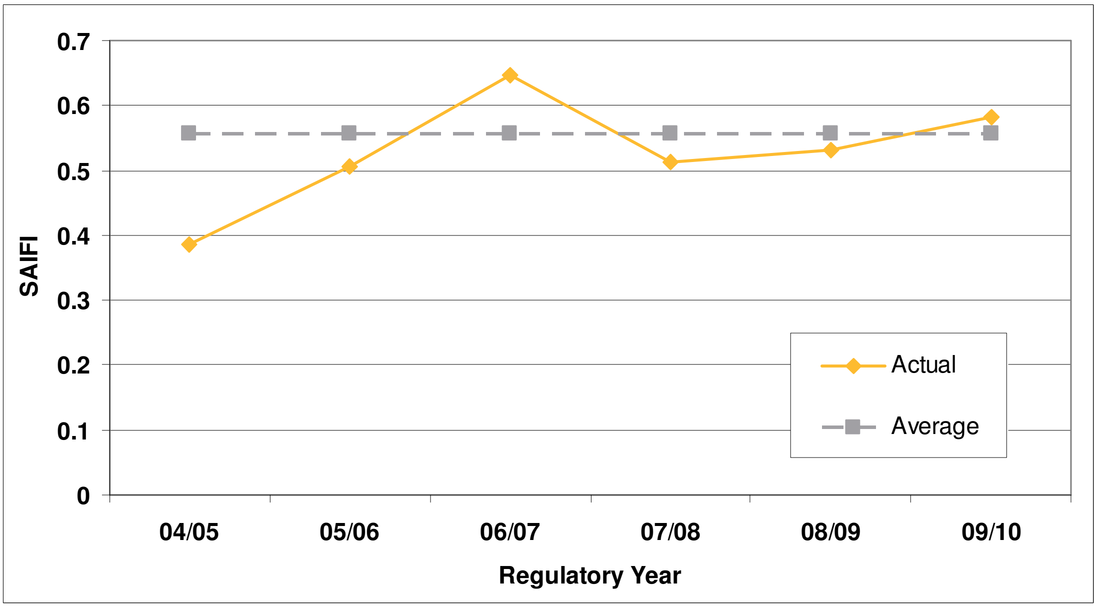



Figure 4-3 Historic SAIFI of the Wellington Electricity Network

### 4.1.2. Contact Centre Service Levels

Wellington Electricity is has developed a set of key performance indicators and financial incentives that will serve as service levels with its call centre provider – Telnet and these are set out below.

#### 4.1.2.1. General Contact Centre Service Levels

| Service level | Service element | Measure | Method | KPI |
|---|---|---|---|---|
| A1 | Overall Service Level | Average service level across all campaign categories | Telnet monthly online Executive Summary Report | 80% |
| A2 | Call response | Average wait time across all campaign categories | Telnet monthly online Executive Summary Report | 20 seconds |
| A3 | Missed calls | Total missed /abandoned calls across all campaign categories | Telnet monthly online Executive Summary Report | 4% tbc |

Figure 4-4 General Contact Centre Service Levels

#### 4.1.2.2. Customer Experience

All customer contact should contribute to customer satisfaction in dealings with the service provider when representing Wellington Electricity.

| Service level | Service element | Measure | Method | KPI |
|---|---|---|---|---|
| D1 | Specific Contact Centre experience | Wellington Electricity is properly represented during specific calls | Sample aural survey of calls (Call calibration) | Qualitative assessment 80% |

Figure 4-5 Customer Experience

Note D1: Contact Centre contribution to customer experience will be monitored as part of Wellington Electricity's monthly survey of Contact Centre calls. The relevant results of this survey will be discussed with Telnet with a view to constant performance improvement.

#### 4.1.2.3. Energy Retailer Satisfaction

All energy retailer contact should contribute to energy retailer satisfaction in dealings with the service provider when representing Wellington Electricity.

| Service level | Service element | Measure | Method | KPI |
|---|---|---|---|---|
| E1 | Overall retailer satisfaction with Contact Centre performance | Wellington Electricity is properly represented with retailer interaction | Annual survey | 80% satisfied |

Figure 4-6 Energy Retailer Satisfaction

### 4.1.3. Customer Enquires and Complaints

Enquiries and complaints are channelled to Wellington Electricity via a number of avenues including retailers, service contractors, call centre and direct approaches. When an enquiry or complaint is received, it is entered into a central registry (SAP–CARE database). The target response time for enquires is eight working days, and for complaints is ten working days. Failure to meet these targets will result in automatic prompting for seven days followed by internal escalation.

## 4.2. Asset Management Performance Targets

Other performance targets used by Wellington Electricity relate to the efficiency with which Wellington Electricity manages its fixed distribution assets. The indicators have been selected on the basis that Wellington Electricity considers them particularly relevant to the operation and management of its assets. The selected asset performance targets use indicators that are required to be reported to the Commerce Commission under its information disclosure regime.

### 4.2.1. Standard Service Levels for Restoration of Power

Wellington Electricity's published 'Electricity Network Pricing Schedule' provides standard service levels for three different categories of customers as shown in the map below. These service levels are agreed to between Wellington Electricity and all of the retailers who are signatories to the use of network agreement. This agreement provides Wellington Electricity with financial incentives to not exceed the maximum restoration times detailed below.

| | Urban | Rural |
|---|---|---|
| Maximum time to restore power | 3 hours | 6 hours |

Figure 4-7 Standard Service Levels for Residential Customers

| | Urban | Rural |
|---|---|---|
| Maximum time to restore power | 3 hours | 6 hours |

Figure 4-8 Standard Service Levels for Business Customers

| | CBD / Industrial | Urban | Rural |
|---|---|---|---|
| Maximum time to restore power | 3 hours | 3 hours | 6 hours |

Figure 4-9 Standard Service Levels for Industrial Customers

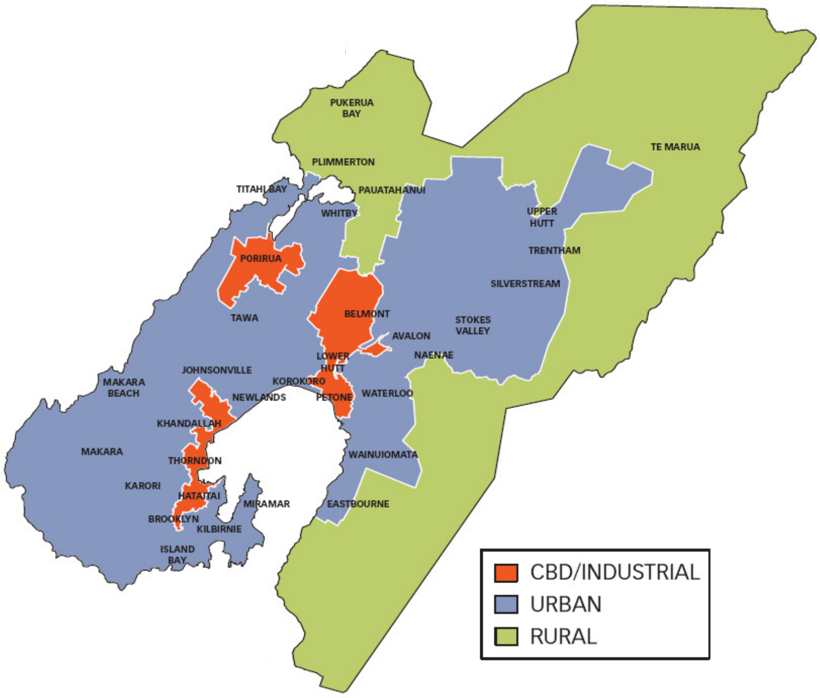



**Figure 4-10 Standard Service Level Areas**

Time taken to restore power is recorded in ENMAC. Refer to Section 2 (Background and Objectives) for details on how unplanned outages are recorded.

### 4.2.2. Faults per 100 Circuit-km

This is a measure of how well the system is designed and operated from a technical perspective. Wellington Electricity designs its network to withstand the environmental conditions to which it is exposed, particularly the severe Wellington winds and the high level of atmospheric salt contamination. As discussed in Section 6, Wellington Electricity has a preventive maintenance system in place whereby assets are regularly inspected to identify and remedy defects that could potentially cause an asset failure. Further, Wellington Electricity has a vegetation management system in place to reduce the number of faults resulting from trees coming into contact with overhead power lines. Faults also are subject to a root cause analysis aimed at identifying systemic issues that may be causing unplanned outages followed by projects that will address the issue. This performance indicator is a measure of the effectiveness of these asset management strategies.

For the purpose of this performance indicator a fault is considered an unplanned failure of an in-service line or cable asset on the subtransmission or high voltage distribution systems, irrespective of whether or not it causes a loss of supply to customers. Circuit-km relates to the total circuit length of the subtransmission and high voltage distribution systems, irrespective of whether the circuit is overhead or underground.

The current target for the planning period is shown in the table below and has been set on the basis of the current performance of the network. It is intended to set targets for the planning period that reflect a continuation of the current level of asset performance.

| 2011-12 | 2012-23 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 |
|---|---|---|---|---|---|---|---|---|---|
| 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 |

Figure 4-11 Performance Targets for Faults per 100 Circuit km / annum

## 4.3. Justification for Targets

Wellington Electricity operates its distribution system in accordance with all relevant legal requirements, including the Electricity Act 1992, the Health and Safety in Employment Act 1992, and the Resource Management Act 1991. This legislation and its subsidiary regulations have a significant influence on the way in which Wellington Electricity manages its assets. In the main the legal requirements are non-discretionary and therefore act as a constraint on the way in which the system must be managed (and on the cost of managing the network).

Within these legal constraints Wellington Electricity has discretion in managing its assets to meet the requirements of its stakeholders. It must ensure that the reliability of supply meets or exceeds the reasonable expectations of the retailers and consumers that use the network. Further, it must ensure that the assets that provide distribution service are used efficiently if the conflicting expectations of stakeholders regarding price and profitably are both to be met in a reasonable way.

### 4.3.1. Consumer Survey

Wellington Electricity surveys its consumers to determine their expectations on a regular basis. The most recent survey was completed in February 2010 and involved sampling:

- All of the top 25 consumers
- A random sample of 25 of the top 26 to 130 consumers
- A random sample of 1100 mass market consumers

The survey involved phoning consumers and asking a series of questions. Of the 1150 consumer's phoned, a total of 251 completed the survey, a response rate of 22%. The questions included:

- What is important to consumers (e.g. keeping power on?, low prices? etc)
- How well Wellington Electricity are performing
- What price / quality tradeoffs are consumers prepared to make (e.g. pay less for lower quality etc)

Graphs of the responses to these questions are provided below.

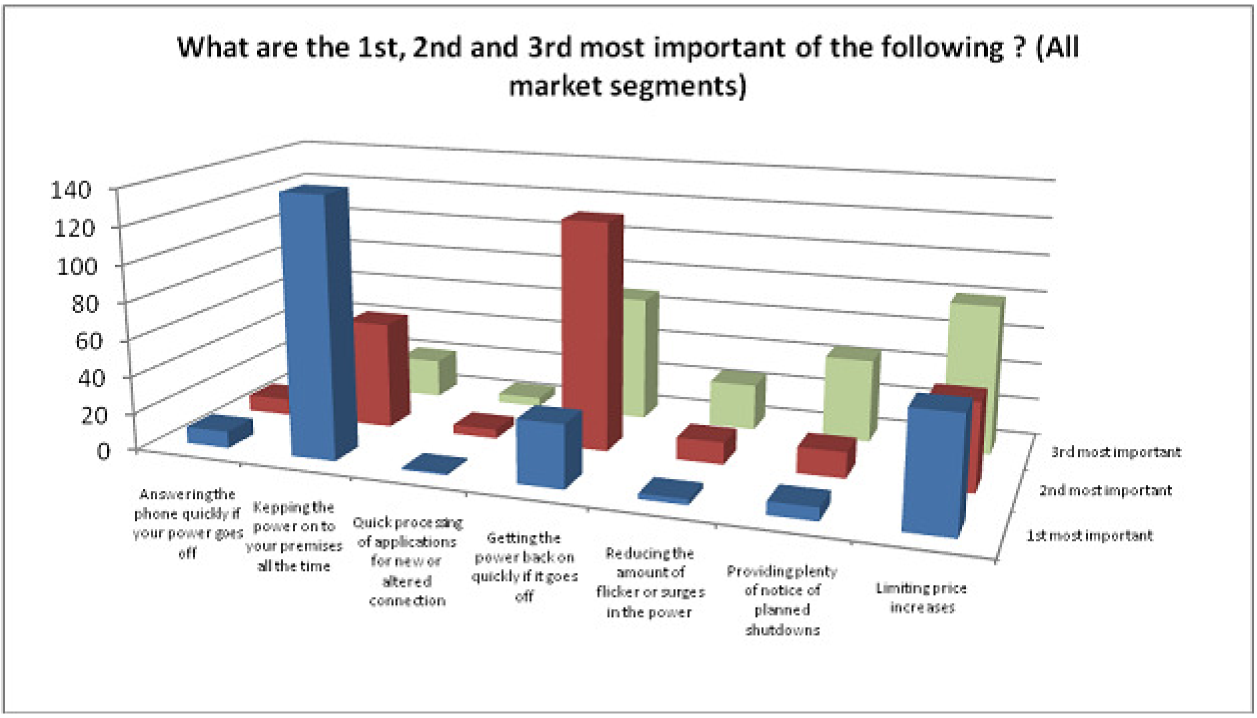



Figure 4-12 What is most important to consumers?

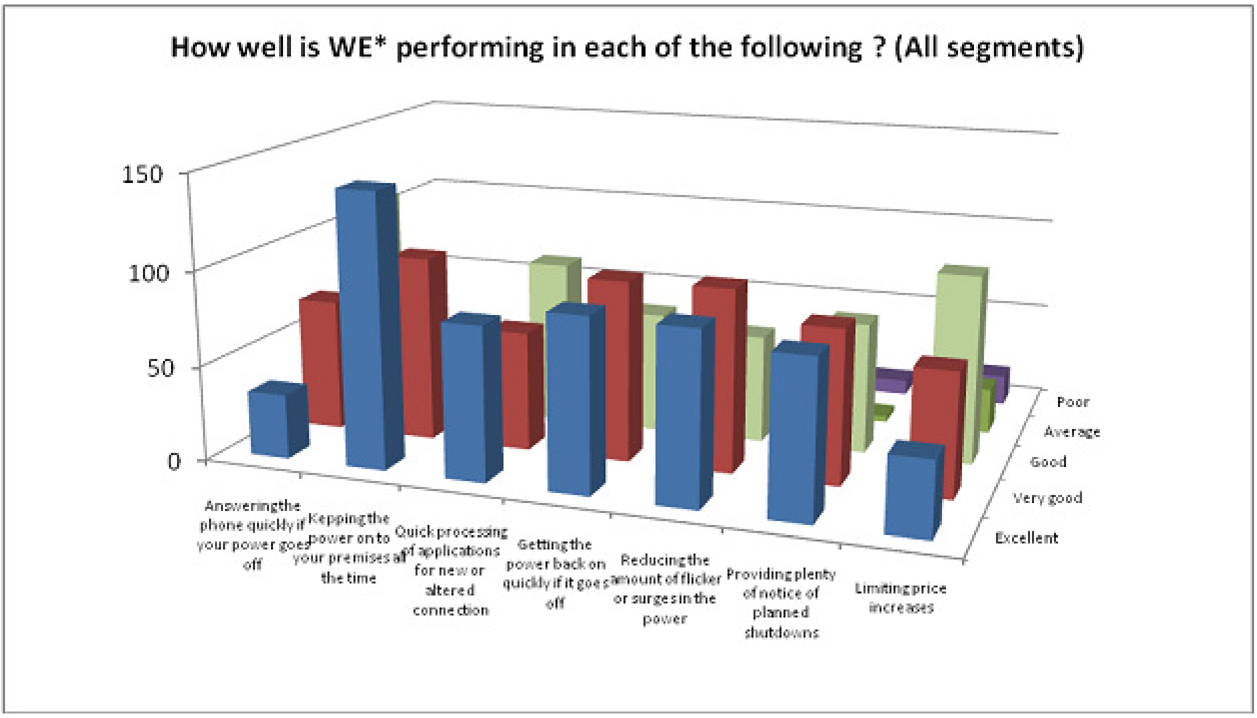



Figure 4-13 How well are Wellington Electricity performing?

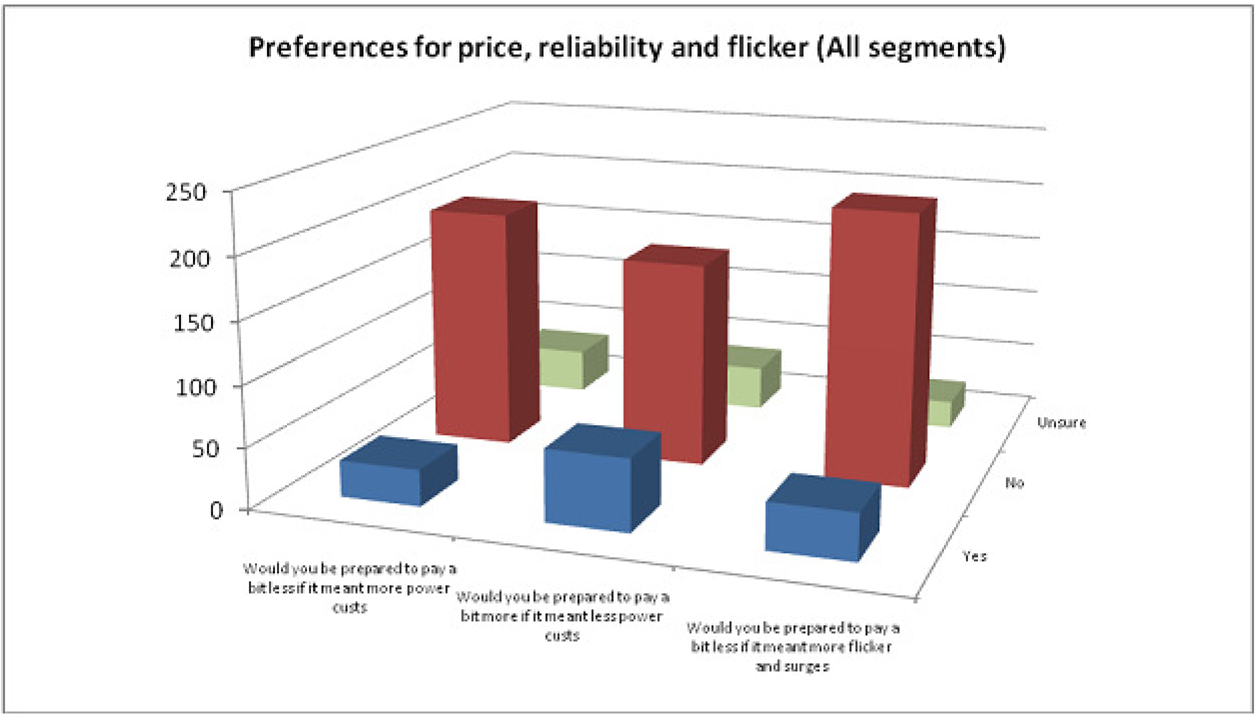



Figure 4-14 What price / quality tradeoffs are consumers prepared to make?

Key results from the survey are:

- Consumers in all segments regard continuity ('keeping the power on') and restoration ('getting the power back on') as the first and second most important components of electricity line services
- Consumers across all segments regard Wellington Electricity's performance in regard to the above two components as either excellent or very good
- Limiting price increases is the third most important component behind 'keeping the power on' and 'getting the power back on'
- The majority of consumers across all segments indicated a clear preference against paying either a bit less if it meant more power cuts or a bit more if it meant less power cuts, i.e. a strong preference for paying about the same line charges to have about the same reliability
- The majority of consumers across all segments indicated a clear preference against paying a bit less to have more flicker or surge, i.e. a strong preference for having either the same or less flicker

The survey shows that consumers are advising Wellington Electricity that:

- Efforts and resources should be focused on continuity and restoration
- Price increases matter less than maintaining the status quo on quality
- Present levels of quality are about right

These results are reflected in Wellington Electricity's asset management approach of investing to maintain reliability at present levels. This approach focuses on managing an aging fleet of assets and replacing those assets that are at their and of life before they fail.

# 5. Network Planning

## 5.1. Planning Criteria and Assumptions

Network development planning is concerned with delivering network performance and security in an economic and sustainable manner at a price level which is acceptable to customers, and maintains risk at a level which is acceptable to the Board. The planning principles are encapsulated in a number of standards, with the key document being the security standard. The main planning principles are as follows:

- All network assets will be operated within their design rating to ensure they are not damaged by overloading.
- Network assets will not present a safety risk to staff, contractors or the public.
- The network is designed to meet statutory requirements including acceptable voltage and Power Quality (PQ) levels.
- Customers[9] reasonable electricity capacity requirements will be met. In addition, the network is designed to include a prudent capacity margin to cater for foreseeable near term load growth.
- Equipment is purchased and installed in accordance with network standards to ensure optimal asset life and performance.
- Varying security standards apply to different areas and customer segments, broadly reflecting customers' price/quality trade-off.
- Network investment will provide an appropriate commercial return for the business.

Wellington Electricity has a number of key policies and standards underpinning its network planning approach. These policies and standards cover the following areas:

- Network security – specifies the minimum levels of network capacity necessary (including levels of redundancy) to ensure an appropriate level of supply service
- Service level – established as part of the Use of Network Agreement with retailers and customers. The service levels reflect expected restoration timeframes and fault frequencies
- Technical standards – ensure optimum asset life and performance is achieved (i.e. capital cost, asset ratings, maintenance costs and expected life are optimised to achieve overall lowest cost). Standardisation also reduces design costs and minimises spare equipment holding costs leading to lower overall project costs
- Network parameters – including acceptable fault levels, voltage levels, power factor, etc., providing an appropriate operating framework for the network.

## 5.2. Voltage Levels

Sub-transmission voltage is nominally 33kV in line with the source voltage at the supplying GXP. The voltage used at MV distribution level is nominally 11kV. The LV distribution network supplies the majority of customers at nominally 230V single phase or 400V three phase. By agreement with the customers, supply can also be connected at 11kV or 33kV depending upon their load requirements.

[9] This includes customers with non standard requirements, where special contractual requirements apply.

Regulation 28 of the Electricity (Safety) Regulations 2010 requires that standard LV supply voltages (230V single phase or 400V three phase) must be kept within +/-6% of the nominal supply voltage, calculated at the point of supply except for momentary fluctuation. Supplies made at other voltages must be kept within +/-5% of the nominal supply voltage except for momentary fluctuation, unless agreed otherwise with the customers.

Design of the network takes into account the voltage variability due to changes in loading and embedded generation under normal and contingency conditions. All Wellington Electricity zone transformers are fitted with on-load tap changers (OLTC) to maintain the supply voltage within acceptable limits. Distribution transformers typically have an off-load tapchanger which can be manually adjusted to maintain acceptable voltage in localised areas of low voltage distribution.

## 5.3. Security Criteria and Assumptions

The security criteria on which the design of the system is based is shown in Figures 5-1 and 5-2. As there are no regulated national standards currently in force, this security criteria was adopted from the previous network owners and was the basis on which the network was designed and operated. These security standards are consistent with industry best practice, and are designed to:

- Match the security of supply with customers' requirements and what they are prepared to pay for
- Optimise capital expenditure (Capex) without a significant increase in supply risks
- Increase asset utilisation.

These security standards accept a small risk that customer supplies may be interrupted when a network fault occurs during peak demand times[10]. The length of time (based on percentage measures) when the sub-transmission network could not meet the N-1 security and the distribution network did not have full backstop was defined with different durations for different categories of customers.

However, even in the event that an interruption should occur, limits are set on the maximum load that would be lost.

| Type of Load | Security Criteria |
|---|---|
| CBD | N-1 with a break[2] for 99.5% of the time in a year.<br>For the remaining times, supply will be restored within 3 hours following an interruption. |
| Mixed commercial / industrial / residential substations | N-1 with a break[1] for 98% of the time in a year.<br>For the remaining times, supply will be restored within 3 hours following an interruption. |
| Predominantly residential substations | N-1 with a break[1] for 95% of the time in a year.<br>For the remaining times, supply will be restored within 3 hours following an interruption. |

Figure 5-1 Security Criteria for the Subtransmission Network

[10] A true deterministic standard, such as N-1, implies that supply will not be lost after a single fault at any time. The Wellington Electricity security standard accepts that for a small percentage of time, a single fault may lead to outages. By somewhat relaxing the deterministic standard, significant reductions in required asset capacity and redundancy levels become possible.

| Type of Load | Security Criteria |
|---|---|
| CBD or high density industrial | N-1 with a break[2] for 99.5% of the time in a year.<br>For the remaining times, supply will be restored within 3 hours following an interruption. |
| Mixed commercial / industrial / residential feeders | N-1 with a break[3] for 98% of the time in a year.<br>For the remaining times, supply will be restored within 3 hours following an interruption. |
| Predominantly residential feeders | N-1 with a break[3] for 95% of the time in a year.<br>For the remaining times, supply will be restored within 3 hours following an interruption. |
| Overhead spurs supplying up to 1MVA urban area | Loss of supply upon failure. Supply restoration upon repair time. |
| Underground spurs supplying up to 400kVA. | Loss of supply upon failure. Supply restoration upon repair time. |

Note 1: A brief supply interruption of up to 5 minutes may occur following an equipment failure, while the network is reconfigured.

Note 2: A brief supply interruption of up to 1 minute may occur following an equipment failure, while the network is automatically reconfigured.

Note 3: In areas other than the CBD, an operator may need to travel to the fault location to manually operate network switchgear, in which case the supply interruption could last for up to one hour.

**Figure 5-2 Security Criteria for the Distribution Network**

While the reliability of the Wellington Electricity distribution system is high, notwithstanding the difficult physical environment in which the system must operate[11], it is uneconomic to design a network where supply interruptions will never occur. Hence the network is designed to limit the amount of time over a year when it is not possible to restore supply by reconfiguring the network following a single unplanned equipment failure. This approach recognises that the electricity demand on the network varies according to the time of day and season of the year, and that the time over which the system is exposed to its peak demand is very small during the course of a year. It also recognises that equipment must at times be taken out of service for planned maintenance and that, when this occurs, parts of the network are exposed to a lower level of security and, as a consequence, a higher risk of interruption. The security criteria detailed above also highlights that some areas are supplied by spur lines, as this is the most efficient supply configuration, and these areas will lose supply on failure until the repair is completed. Network planning guidelines indicate how much load will be supplied by spur lines and determine at which point additional supplies or back feed points are considered for a supply area.

Wellington Electricity's network design and asset management systems also have regard for the time taken to restore supply following an interruption. When an unplanned equipment outage does occur, considerable effort is made to restore supply to customers not directly affected by the equipment fault by switching load to other parts of the network. However at times of peak demand, or where equipment is out of service for

[11] Much of Wellington Electricity's supply area is renowned for its high winds. There can also be a high concentration of salt in the atmosphere, blown in from the sea.

maintenance at the time of the unplanned outage, it may not be possible to switch all load in this way, and in these cases an extended outage may occur with maximum restoration times as shown in Figures 5-1 and 5-2.

The criteria generally do not apply to the low voltage network or to failures of connection assets used to supply individual customers, which are usually designed for ‘n’ security. In such situations an interruption will last for the time taken to make a repair.

The criteria also do not apply when multiple equipment outages affect the same part of the network or when major storms or other severe events have a high impact on the system and can stretch the capacity of Wellington Electricity or its contractors to respond in a timely manner. Wellington Electricity has emergency plans in place to mitigate the impact of such situations but when they occur, longer supply interruptions than shown in the tables are possible.

### 5.3.1. Capacity of New Plant

When planning an augmentation to the network to increase its existing capacity, it is necessary to determine the capacity of the new equipment to be purchased and installed. This often involves a trade-off between cost and the size of the increased capacity because:

- If the capacity is too large either Wellington Electricity or its consumers have to pay the cost of any capacity that will not have been economically utilised before the equipment reaches the end of its economic life
- If the capacity is too small then premature asset replacement will be required and this generally increases costs.

The problem of determining the optimum capacity is made more difficult by the fact that the economic life of most primary distribution assets is between 40 and 60 years and the difficulty of forecasting electricity demand over this period into the future other than from underlying growth averages.

Wellington Electricity uses the Commerce Commission’s 10 year planning period as the starting point for making equipment capacity decisions and then takes the following into consideration:

- On the basis of the current load forecast, determine the maximum potential load on the equipment at the end of the planning period under the most severe operating condition that the network is planned to withstand.
- Select the next highest standard equipment size as per the tables below.

#### 5.3.1.1. 11kV Switchgear

| Application | Standard Ratings | Fault Rating |
|---|---|---|
| Zone Incomer CB | 1200A, 2000A | 25kA |
| Zone Feeder CB | 630A | 25kA |
| Dist Feeder CB | 630A | 20kA |
| Dist transformer CB | 200A | 20kA |

| Application | Standard Ratings | Fault Rating |
|---|---|---|
| Ring main unit | 400A minimum | 20kA |

Note 1: These are manufacturer's standard ratings.

Note 2: Existing equipment may have rating different form those listed in the table.

**Figure 5-3 Standard ratings for 11kV switchgear**

#### 5.3.1.2. 11kV Cable

| Application | Standard Ratings |
|---|---|
| Feeders – backbone | 300A minimum |
| Feeders – branch | 200A minimum |
| Dist transformer | Match transformer |

Note 1: Larger cable ratings may be employed on a case by case basis.

**Figure 5-4 Standard ratings for 11kV cable**

#### 5.3.1.3. Distribution Transformers

| Standard Ratings (kVA) |
|---|
| 15, 30 50, 100, 200, 300, 500, 750, 1000 |
| 1500kVA upon request for special customer projects |

Note 1: All distribution transformers: 11kV/400V delta-wye.

Note 2: These are manufacturer's standard ratings.

**Figure 5-5 Standard ratings for distribution transformers**

It is important to note that this is only a starting point for making capacity decisions. An engineering and economic judgement is then made as to whether this size is appropriate taking other factors into account. Such factors include:

- Compliance with the network security criteria
- Margin between the required capacity and the next highest standard size
- Incremental cost of different equipment sizes
- Forecast rate of demand growth
- Back-up capacity to adjacent areas

In certain cases customers may desire a level of security above that offered by a standard connection. Should this arise, Wellington Electricity will offer a range of alternatives that provide different levels of security at different prices. The customer can then choose to pay for a higher a level of security that meets their expectations for the load they are supplying.

Given the relatively modest demand growth in its supply area, it is unlikely that Wellington Electricity would expose itself to optimisation risk by installing asset capacities greater than indicated by the above approach.

## 5.4. Prioritisation of Capital Works Projects

The processes described in this document invariably identify more potential work than can be accommodated by budgets or resources available to Wellington Electricity, hence the need for a project prioritisation process.

Every year, as part of the capital works budgeting process, the list of potential projects will be reviewed for currency and all of the projects will be ranked. The details of how projects are ranked and selected is a work in progress, however the present method, which will be developed into a ranking tool, include the assessment of a number of weighted project 'drivers' that are assigned values based on their assessed impact to the Wellington Electricity. These drivers, which assist with ranking projects, are:

- Health and Safety
- Legal and statutory obligations
- Company policies and standards
- Risk to the network
- Environmental
- Financial value
- Quality of supply
- Strategic benefit
- Stakeholder satisfaction

A subset of the projects will be non-discretionary and will not be deferred. These projects include:

- Works necessary to ensure public and employee safety
- Works necessary to meet legal requirements.

  However, where changes to legal requirements impose significant additional costs it may be necessary to undertake the required works over an extended period of time. This is usually agreed with the authority responsible for monitoring compliance with the changed requirement.

All other projects will generally be prioritised on the basis of cost-benefit and risk analyses using an assessment of the project 'drivers' as outlined above . Projects that mitigate extreme or high risks to the business and projects with high benefit-cost ratios will be generally given the highest priority.

### 5.4.1. Current Prioritisation Process

Wellington Electricity's general prioritisation sequence for including projects in its capital expenditure programme is as follows:

- Essential safety or legal compliance
- Customer initiated projects, Network integrity projects, meeting capacity requirements
- Reliability and security of supply projects
- Other economically attractive investments.

Wellington Electricity's top priority is to operate a safe and reliable network, and prioritises those projects which provide safety and reliability benefits above others. However all projects must provide an appropriate return to its shareholders either financially, in the case of asset replacement, network growth and reinforcement projects, or non-financial benefits such as safety, compliance or to meet regulatory requirements.

Customer driven growth projects generally result from the development of new subdivisions, commercial or industrial projects. Where possible, these projects are prioritised to meet customer's needs. These customer priorities (where Wellington Electricity has been advised in advance) are incorporated into Wellington Electricity's project execution schedules. Related to customer driven projects are those that are implemented to ensure that Wellington Electricity can meet the load capacity requirements on all parts of its network; in general no shortfalls in supply capacity would be tolerated. Network integrity projects are those that address the continued effective operation of the distribution network and include renewal and refurbishment projects.

Reliability and security of supply projects are focused on ensuring that the required reliability standards on the network are met and that the security of supply standards are maintained.

Projects are prioritised in accordance with the risk that they are intended to address, while the outcome of the planning process identifies actual and potential network security breaches. These are assessed in accordance with Wellington Electricity's risk matrix which considers the likely frequency and consequences of the breach ("frequency" is a measure of how often breaches of the security standards are likely to occur. The "consequences" are a measure of the health and safety, reputation, customer impact and financial risk to Wellington Electricity as a consequence of not addressing the problem), The higher the risk assessment factor the higher the priority attached to a project.

Wellington Electricity may also consider other asset investment projects if these are demonstrated to provide an acceptable rate of return to shareholders.

## 5.5. Demand Forecasts

### 5.5.1. Methodology

Loads on individual feeders and zone substations are captured by the SCADA system. The load at each GXP is metered through the time of use revenue metering. This information allows Wellington Electricity to trend actual demands at the GXP, zone substation and feeder level and to project these trends into the future using an extrapolation analysis model.

Demand forecasting is carried out using a 'bottom up' approach, starting at the zone substation level. The first stage of this process involves extrapolating historical zone substation load data into the future, to the extent of the 10 year planning horizon. Known step changes are then applied to the forecasts. These steps may be the result of:

- System reconfigurations where load has been moved between substations
- Major developments that introduce large new loads onto the network
- Changes to the Wellington Electricity load control system
- New generation that is expected to affect peak demand
- Load reductions caused by movement of businesses or the closure of businesses.

A subjective review of the load forecasts for each zone substation is then undertaken. This comprises a check of the forecasts against local knowledge of network developments. Reviewers will include project managers and customer service staff who have a good overview of customer connection trends. Property developers and businesses are also canvassed for information on plans that may result in introducing new loads to the network. Forecasts are modified if necessary to reflect this local knowledge. The zone substation load forecasts are then 'rolled-up' to the GXP level, taking diversification factors into consideration as the peak zone substation demands may not always occur at the same time as each other.

The Wellington Electricity 'bottom up' GXP forecasts are then compared to Transpower's 'top down' GXP forecasts. It is understood that Transpower's forecasts are derived from the national load and energy forecasts which take into account economic and population growth indicators. While this forecast is usually accurate at the national level, it can be difficult to aggregate the national growth down to the GXP level which in turn can lead to discrepancies with 'bottom up' forecasts. Any significant differences between the two forecasts are investigated and addressed or explained.

Detailed forecasts for the planning period are provided in the next sections. They indicate that forecast growth in Wellington Electricity's supply area is relatively low when compared to demand growth in many parts of the country.

### 5.5.2. GXP Demand Forecast

The forecast demand at each GXP supplying Wellington Electricity's distribution network is shown below.

| GXP | System Maximum Demand MW [2] (including DG) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Central Park 33 kV | 182.6 | 185.3 | 188.1 | 190.9 | 193.8 | 196.7 | 199.7 | 202.7 | 205.7 | 208.8 |
| Central Park 11 kV | 16.5 | 16.7 | 17.0 | 17.2 | 17.5 | 17.8 | 18.0 | 18.3 | 18.6 | 18.8 |
| Gracefield 33kV | 55.4 | 56.1 | 56.8 | 57.5 | 58.2 | 59.0 | 59.7 | 60.4 | 61.2 | 62.0 |
| Haywards 33 kV | 14.3 | 14.5 | 14.8 | 15.0 | 15.2 | 15.4 | 15.7 | 15.9 | 16.1 | 16.4 |
| Melling 33 kV | 45.5 | 45.8 | 46.2 | 46.5 | 46.9 | 47.2 | 47.6 | 47.9 | 48.3 | 48.7 |
| Pauatahanui 33kV | 20.1 | 20.4 | 20.6 | 20.9 | 21.2 | 21.4 | 21.7 | 22.0 | 22.2 | 22.5 |
| Takapu Road 33 kV | 93.8 | 95.0 | 96.2 | 97.4 | 98.6 | 99.9 | 101.1 | 102.4 | 103.7 | 104.9 |
| Upper Hutt 33 kV | 32.7 | 33.2 | 33.8 | 34.4 | 35.0 | 35.6 | 36.2 | 36.9 | 37.5 | 38.2 |
| Wilton 33 kV | 52.2 | 52.7 | 53.3 | 53.8 | 54.3 | 54.9 | 55.4 | 56.0 | 56.5 | 57.1 |
| Kaiwhara'11 kV [1] | 35.6 | 36.2 | 36.7 | 37.3 | 37.8 | 38.4 | 39.0 | 39.5 | 40.1 | 40.7 |
| Haywards 11 kV | 17.9 | 18.2 | 18.5 | 18.8 | 19.0 | 19.3 | 19.6 | 19.9 | 20.2 | 20.5 |
| Melling 11 kV | 23.5 | 23.8 | 24.1 | 24.4 | 24.7 | 25.0 | 25.3 | 25.6 | 26.0 | 26.3 |

Note 1: Kaiwharawhara GXP has a summer peak. All other GXPs have a winter peak

Note 2: Base MD value for the projection is the actual for the year ending 30 September 2010

Figure 5-6 GXP Demand Forecast

### 5.5.3. Zone Substation Demand Forecasts

| Zone substation | 98th Percentile Demand (MVA, Calendar year) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | '12 | '13 | '14 | '15 | '16 | '17 | '18 | '19 | '20 |
| 8 Ira St | 16.5 | 16.7 | 16.9 | 17.2 | 17.4 | 17.7 | 17.9 | 18.2 | 18.4 | 18.7 |
| Brown Owl | 15.9 | 16.1 | 16.4 | 16.7 | 17.0 | 17.3 | 17.6 | 17.9 | 18.2 | 18.5 |
| Evans Bay | 16.4 | 16.7 | 16.9 | 17.1 | 17.4 | 17.6 | 17.9 | 18.1 | 18.4 | 18.6 |
| Frederick St | 34.8 | 35.3 | 35.8 | 36.3 | 36.9 | 37.4 | 38.0 | 38.5 | 39.1 | 39.7 |
| Gracefield | 13.6 | 13.7 | 13.8 | 13.9 | 14.0 | 14.1 | 14.2 | 14.3 | 14.4 | 14.5 |
| Hataitai | 18.0 | 18.2 | 18.5 | 18.8 | 19.1 | 19.4 | 19.6 | 19.9 | 20.2 | 20.5 |
| Johnsonville | 23.0 | 23.4 | 23.7 | 24.1 | 24.4 | 24.8 | 25.2 | 25.5 | 25.9 | 26.3 |
| Karori | 16.5 | 16.6 | 16.8 | 16.9 | 17.0 | 17.2 | 17.3 | 17.4 | 17.5 | 17.7 |
| Kenepuru | 13.1 | 13.2 | 13.3 | 13.3 | 13.4 | 13.4 | 13.5 | 13.6 | 13.6 | 13.7 |
| Korokoro | 12.7 | 12.8 | 12.9 | 12.9 | 13.0 | 13.1 | 13.2 | 13.3 | 13.4 | 13.5 |
| Maidstone | 15.7 | 16.0 | 16.2 | 16.5 | 16.8 | 17.1 | 17.3 | 17.6 | 17.9 | 18.2 |
| Mana-Plmtn | 19.1 | 19.3 | 19.6 | 19.8 | 20.0 | 20.3 | 20.5 | 20.8 | 21.0 | 21.3 |
| Moore St | 24.9 | 25.1 | 25.3 | 25.5 | 25.7 | 25.8 | 26.0 | 26.2 | 26.4 | 26.6 |
| Naenae | 15.5 | 15.7 | 15.8 | 16.0 | 16.1 | 16.3 | 16.5 | 16.6 | 16.8 | 17.0 |
| Nairn St | 16.9 | 17.1 | 17.4 | 17.6 | 17.9 | 18.2 | 18.4 | 18.7 | 19.0 | 19.2 |
| Ngauranga | 7.8 | 7.9 | 8.0 | 8.1 | 8.2 | 8.4 | 8.5 | 8.6 | 8.7 | 8.9 |
| Palm Grove | 26.8 | 27.2 | 27.6 | 28.0 | 28.4 | 28.9 | 29.3 | 29.7 | 30.2 | 30.6 |
| Petone | 10.7 | 10.7 | 10.8 | 10.9 | 11.0 | 11.0 | 11.1 | 11.2 | 11.3 | 11.4 |
| Porirua | 15.9 | 16.1 | 16.3 | 16.5 | 16.7 | 16.9 | 17.1 | 17.3 | 17.6 | 17.8 |
| Seaview | 14.4 | 14.5 | 14.6 | 14.7 | 14.8 | 14.9 | 15.0 | 15.1 | 15.2 | 15.3 |
| Tawa | 14.9 | 15.0 | 15.1 | 15.3 | 15.4 | 15.6 | 15.7 | 15.9 | 16.0 | 16.2 |
| The Terrace | 38.7 | 39.3 | 39.8 | 40.4 | 41.1 | 41.7 | 42.3 | 42.9 | 43.6 | 44.2 |
| Trentham | 14.3 | 14.5 | 14.7 | 14.9 | 15.1 | 15.3 | 15.5 | 15.8 | 16.0 | 16.2 |
| University | 26.5 | 26.9 | 27.2 | 27.6 | 28.0 | 28.5 | 28.9 | 29.3 | 29.7 | 30.1 |
| Waikowhai | 15.6 | 15.7 | 15.8 | 15.9 | 16.0 | 16.1 | 16.3 | 16.4 | 16.5 | 16.6 |
| Wainuiomata | 16.6 | 17.0 | 17.4 | 17.9 | 18.3 | 18.8 | 19.2 | 19.7 | 20.2 | 20.7 |

| Zone substation | 98th Percentile Demand (MVA, Calendar year) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | ‘12 | ‘13 | ‘14 | ‘15 | ‘16 | ‘17 | ‘18 | ‘19 | ‘20 |
| Waitangirua | 14.2 | 14.4 | 14.7 | 14.9 | 15.1 | 15.3 | 15.6 | 15.8 | 16.0 | 16.3 |
| Waterloo | 17.4 | 17.5 | 17.6 | 17.7 | 17.8 | 17.9 | 17.9 | 18.0 | 18.1 | 18.2 |

Note 1: 98th percentile demands are used for zone substation forecasts because short term peaks that result from operational switching of loads between substations can give a misleading impression of ‘normal’ loads

Figure 5-7 Zone Substation Demand Forecast

### 5.5.4. Step Load changes

Wellington Electricity has identified the following new major loads that may occur over the next few years.

| Anticipated start date | Likely Peak Demand (MW) | Expected Load Factor (%) | Type of demand | GXP | Likelihood |
|---|---|---|---|---|---|
| 2011/12 | 10.6 | 0.35 | Commercial | Central Park | Most Likely |
| 2011/12 | 0.3 | 0.2 | Residential | Central Park | Certain |
| 2011/12 | 1.9 | 0.35 | Commercial | Gracefield | Most Likely |
| 2011/12 | 0.2 | 0.2 | Residential | Gracefield | Certain |
| 2011/12 | 2.4 | 0.35 | Commercial | Haywards | Most Likely |
| 2011/12 | 0.3 | 0.2 | Residential | Haywards | Certain |
| 2011/12 | 0.9 | 0.35 | Commercial | Melling | Most Likely |
| 2011/12 | 0.8 | 0.35 | Commercial | Pauatahanui | Likely |
| 2011/12 | 0.1 | 0.2 | Residential | Pauatahanui | Certain |
| 2011/12 | 4.3 | 0.35 | Commercial | Takapu Road | Most Likely |
| 2011/12 | 0.9 | 0.2 | Residential | Takapu Road | Certain |
| 2011/12 | 2.1 | 0.35 | Commercial | Upper Hutt | Most Likely |
| 2011/12 | 0.1 | 0.3 | Residential | Upper Hutt | Certain |
| 2011/12 | 4.5 | 0.35 | Commercial | Wilton | Most Likely |

Figure 5-8 New Step Change Loads

These loads have been incorporated into the demand forecasts for the network as described in the previous section.

### 5.5.5. Embedded Generation and Demand Control

The load forecast figures provided are inclusive of embedded generation and demand control. Further details on embedded generation and demand control is presented under separate headings.

## 5.6. Network Constraints

### 5.6.1. Grid Exit Points

The table below provides grid exit point capacities and forecast demands for the beginning and end of the forecast period. This table is intended to provide an indication of loadings on the GXPs.

| GXP | Installed Transformers (MVA) | Cyclic n-1 Capacity (MVA) | System Maximum Demand MW [2] (including DG) | |
|---|---|---|---|---|
| | | | 2011 | 2021 |
| Central Park 33 kV | 2x100 + 1x120 | 228 | 182.6 | 211.9 |
| Central Park 11 kV | 2x25 | 30 | 16.5 | 19.1 |
| Gracefield 33kV | 2x85 | 89 | 55.4 | 62.7 |
| Haywards 33 kV | 1x20 | 0 | 14.3 | 16.6 |
| Haywards 11 kV | 1x20 | 0 | 17.9 | 20.8 |
| Melling 33 kV | 2x50 | 52 | 45.5 | 49 |
| Melling 11 kV | 2x25 | 32 | 23.5 | 26.6 |
| Pauatahanui 33 kV | 2x20 | 24 | 20.1 | 22.8 |
| Takapu Rd 33 kV | 2x100 | 116 | 93.8 | 106.3 |
| Upper Hutt 33 kV | 2x37 | 37 | 32.7 | 38.8 |
| Wilton 33 kV | 2x100 | 106 | 52.2 | 57.7 |
| Kaiwharawhara 11 kV | 2x38 | 41 | 35.6 | 41.3 |

Figure 5-9 GXP Capacities

**Haywards**

The Haywards 33kV and 11kV supply points each have only a single transformer. However the Haywards 33kV supply can be backed up from the Upper Hutt GXP and the 11kV supply points can be backed up from the Melling GXP though Wellington Electricity owned 11kV sub transmission circuits. Transpower has proposed that a 33/11kV transformer be installed at Haywards, to serve as a back up to both the 33kV and 11kV supply bus. Wellington Electricity is considering the suitability of this arrangement for the future, but because there are backup options at the distribution system level, there is no short term concern. This situation will be kept under review[12].

**Melling and Kaiwharawhara**

The Melling 33kV and Kaiwharawhara 11kV supply points may be approaching firm capacity near the end of the forecast period. Wellington Electricity will monitor the situation and take action as necessary to ensure that the security of supply is not compromised. Actions may include transferring load to adjacent GXPs or increasing the capacity of the 11kV point of supply.

**Central Park**

The operational constraints at Central Park as discussed in section 3 (Assets Covered) of this plan, effectively restrict the n-1 capacity of the 33kV system to 114 MVA. Wellington Electricity and Transpower have worked together to implement a short term solution which was commissioned in December 2010 and comprised a special protection scheme (SPS) that would be armed to automatically control loads should one 110kV circuit be out of service. This scheme would prevent the need for pre contingency load control at Central Park following a single contingency. A long term solution is also being developed that may include a 110kV bus at Central Park. The time frames for implementing the long term solution are 2011 – 2012.

### 5.6.2. Distribution System

The table below provides installed sub-transmission capacities and forecast demands for the beginning and end of the forecast period. This table is intended to provide an indication of loadings on the sub-transmission system.

| Zone Substation | Transformer Cyclic Capacity (MVA) | Single Incoming Circuit Capacity (MVA) | Peak season | Forecast demand (MVA) | |
|---|---|---|---|---|---|
| | | | | 2011 | 2021 |
| 8 Ira Street | 24 | 21/15 | Winter | 16.5 | 19.0 |
| Brown Owl | 23 | 19/13 | Winter | 15.9 | 18.8 |
| Evans Bay | 24 | 19/15 | Winter | 16.4 | 18.9 |
| Frederick Street | 36 | 28/20 | Winter | 34.8 | 40.2 |
| Gracefield | 23 | 17 | Winter | 13.6 | 14.6 |
| Hataitai | 23 | 20/10 | Winter | 18.0 | 20.8 |
| Johnsonville | 23 | 19/12 | Winter | 23.0 | 26.7 |
| Karori | 24 | 21/11 | Winter | 16.5 | 17.8 |
| Kenepuru | 23 | 19/14 | Winter | 13.1 | 13.8 |

[12] The installation of an interconnecting transformer would not impact the capital expenditure in this asset management plan as the asset would not be owned by Wellington Electricity. It would result in an increase in transmission connection charges, which are not included in any of the forecasts presented in this plan.

| Zone Substation | Transformer Cyclic Capacity (MVA) | Single Incoming Circuit Capacity (MVA) | Peak season | Forecast demand (MVA) | |
|---|---|---|---|---|---|
| | | | | 2011 | 2021 |
| Korokoro | 23 | 13/10 | Winter | 12.7 | 13.6 |
| Maidstone | 22 | 18/10 | Winter | 15.7 | 18.6 |
| Mana-Plmtn | 16 | 27/23 | Winter | 19.1 | 21.6 |
| Moore Street | 36 | 33/29 | Summer | 24.9 | 26.8 |
| Naenae | 23 | 19/14 | Winter | 15.5 | 17.1 |
| Nairn Street | 30.1 | 25 | Summer | 16.9 | 19.5 |
| Ngauranga | 11 | 20/14 | Summer | 7.8 | 9.0 |
| Palm Grove | 24 | 17/13 | Winter | 26.8 | 31.1 |
| Petone | 20 | 19/13 | Winter | 10.7 | 11.5 |
| Porirua | 20 | 22/14 | Winter | 15.9 | 18.0 |
| Seaview | 22 | 21/13 | Winter | 14.4 | 15.5 |
| Tawa | 16 | 21/14 | Winter | 14.9 | 16.3 |
| The Terrace | 36 | 50/45 | Winter | 38.7 | 44.9 |
| Trentham | 23 | 20/14 | Winter | 14.3 | 16.4 |
| University | 24 | 32/28 | Winter | 26.5 | 30.6 |
| Waikowhai | 19 | 22/15 | Winter | 15.6 | 16.8 |
| Wainuiomata | 23 | 18/12 | Winter | 16.6 | 21.2 |
| Waitangirua | 16 | 22/16 | Winter | 14.2 | 16.5 |
| Waterloo | 23 | 21/13 | Winter | 17.4 | 18.3 |

**Figure 5-10 Zone Substation Capacities and Loadings**

Consideration of zone substation asset capacities compared against loads forecasts using the planning criteria indicates that there is sufficient capacity available in most instances, however there are eight situations where the potential peak demand at individual substations either exceeds, or could exceed during the planning period, the firm transformer or incoming circuit capacity at that substation. These substations are:

- Fredrick Street
- Moore Street
- Palm Grove
- Johnsonville

- Mana - Plimmerton
- Korokoro
- Naenae
- Wainuiomata

For each of these sites, the mismatch between firm capacity and maximum demand is only a problem should an equipment failure occur since under normal operating conditions the load is shared between the two transformer feeders in service at each substation. In all of the above cases, potential overloads can be reduced by transferring the excess load to adjacent substations using spare capacity available in the distribution system should an equipment fault occur[13]. Where there is a potential for equipment to become overloaded following an unplanned equipment failure, Wellington Electricity monitors the ability to offload the affected substation and puts operating plans in place to ensure that this will occur should the need arise. The nature of the situation at each of the above substations is detailed below.

#### 5.6.2.1. Frederick Street

At present, the maximum demand loading at the Wellington CBD substations is uneven, with Frederick Street being highly loaded, while the adjacent Nairn Street substation has spare capacity. Wellington Electricity's initial approach to this type of issue is to move load via existing network assets by changing network open points, to achieve better utilisation of assets. In the case of Frederick Street, there was insufficient interconnected network capacity at 11kV levels to allow this. A project is underway in 2011 to increase 11kV interconnectivity between Frederick and Nairn Streets, and to move a portion of the Frederick Street substation load to Nairn Street. Following the load transfer, peak loads at Frederick Street zone substation will be within n-1 capacity limits.

#### 5.6.2.2. CBD (Palm Grove, Moore Street, The Terrace, University)

Following the transfer of load from Fredrick Street to Nairn Street, all CBD zone substations will be roughly evenly loaded. Analysis shows that loads, and importantly, load densities, will continue to grow in the CBD with the result that all of the substations will be approaching their firm capacity at about the same time. This highlights an emerging problem within the forecast period. Most of the substations identified as potentially constrained, including Frederick Street, Moore Street, Palm Grove, Terrace and University supply the CBD or surrounding inner city area. As this constraint is towards the end of the planning period, detailed solution options have not been developed at this time. Possible solutions to this are:

- Lowering demand, or offsetting the demand in this area through embedded generation, or dispatch of standby generation on consumer premises, as a demand-side management programme. The majority of the load served is commercial and does not have a high level of controllable load through the existing ripple control system, and consumers would need to be incentivised to participate in such a programme.

- Increasing installed capacity by the use of higher rated components at the time of renewal or refurbishment of existing zone substations, or developing a new zone substation in the CBD area (Wellington Electricity owns a bare land site in Bond Street which could be utilised for this purpose).

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[13] Transformers and cables have short term emergency ratings that provide some time for load to be transferred manually after an equipment failure without interrupting supply.

- Improving dynamic or cyclic ratings of existing components through the use of on-line temperature and condition monitoring as the peak loads may exceed the plant ratings for only a few periods per day. This can be managed through cyclic loading in known operating conditions.

Wellington Electricity is also presently undertaking a detailed review of the distribution system in the CBD with a view to determining the best way to configure the distribution system for the future with respect to the ring system presently in place. Historically, the Wellington City MED developed the CBD area with a meshed 11kV system with multiple feeds from a zone substation into an interconnected ‘zone’ of load, commonly referred to as rings. With the use of differential protection over key cables in the rings, this provided a high level of security and reliability to the CBD. As loads within the CBD rise, the ability of the meshed system to respond to a single event (such as a cable fault) decreases as the loading on the remaining feeders may cause overloads, potentially leading to cascade failures. Overall, ring systems provide high levels of reliability but at the cost of flexibility. The review will include a look at how other utilities have addressed similar issues with CBD ring type distribution systems. One of the outcomes may be a recommendation to radialise the CBD network system. Radial systems are a more conventional configuration for distribution systems, however converting the CBD ring system to a radial system will have an impact on reliability. These reviews will be completed in the short term, and if it is determined that the ring systems shall be abandoned then this work will occur over time, possibly towards the end of the planning period, or sooner as load growth dictates. Any change to the security levels will require consultation with consumers, and the resulting security level provided will have to be in line with consumer’s price/quality trade-off requirements.

#### 5.6.2.3. Hutt Valley

Constraints in the Lower Hutt Valley area out of Korokoro, and Naenae zone substations are relatively minor and can be managed within the forecast period through operational load shifts as required.

#### 5.6.2.4. Wainuiomata

The level of constraint expected at Wainuiomata within the forecast period is relatively low but as there are no back feed options for this area, a project aimed at addressing this may be required within the forecast period. Wellington Electricity will monitor actual load growth in this area as it may be lower than forecast hence the need for investment could be deferred.

#### 5.6.2.5. Johnsonville

Load at Johnsonville presently exceeds the n-1 capacity of the sub-transmission system at peak times. Back feed connections from adjacent substations allow n-1 operation at present for the majority of the time, but this capacity is close to being eroded. Reinforcement of the sub-transmission system or reinforcing 11kV interconnections with adjacent zones will be required within the planning period.

#### 5.6.2.6. Mana - Plimmerton

Load at the combined zone substations of Mana and Plimmerton may presently exceed the capacity of the sub-transmission transformers at peak times. Back feed connections from adjacent substations allow n-1 operation at present, but this capacity will be eroded over time. Uprating of the sub-transmission transformers, or offloading the substations via the 11kV system, may be required near the end of the planning period.

## 5.7. Network Development – Options Available

The process that Wellington Electricity follows when analysing major network investment opportunities includes the long listing of options. The long list represents a range of possible solutions to address a clearly defined investment need. The long list of options will be relatively similar for most of the investment opportunities that occur on the network and projects will usually fall under one or more of the following headings:

- Do nothing (status quo)
- Network solutions such as:
  - Redistributing demand (e.g. network reconfiguration)
  - Reinforcing the network (this may include many sub-options)
- Non-network solutions such as:
  - Reducing network demand (e.g. energy efficiency, load control, demand side initiatives)
  - Installing generation (e.g. distributed generation)

Non-network solutions are discussed in more detail in the following sections.

Each long listed option will have a cost estimate associated with it, a benefit in terms of how it addresses the need for reinforcement and an assessment of its feasibility. The long list will be ranked using the above criteria (i.e. cost, benefit and feasibility) in order to allow for a short list of options to be developed. The short list will typically be limited to 2 or 3 options that have roughly similar cost, benefits and feasibilities.

The implementation of this part of the network investment process is presently under development. Once the process is embedded in the company, major investment projects will each have associated with them a long list of alternatives that had been considered.

## 5.8. Distributed Generation Policy

There is already a small but significant amount of generation embedded within the network. Wellington Electricity welcomes third parties investing in initiatives such as the installation of embedded generation that might defer the need for capital investment on the network. However if such investment is to achieve the required outcomes there are a number of issues that need to be managed. In particular:

- The risk of non-provision of service needs to be managed. There is little point in paying a third party for a service such as generation or load reduction if the service cannot be guaranteed at the time that the network demand is at a peak.
- The service must comply with relevant technical codes and not interfere with other consumers.
- Any payments made to third parties must be linked directly to the provision of a service that gives the required technical and commercial outcomes.
- Commercial arrangements must be consistent with avoided cost principles.
- Commercial agreements must be reached on other issues not directly related to any benefit provided to Wellington Electricity. These can include the cost of connection and payment of use of network charges.

If the issues above can be managed, and the despatch of generation can be co-ordinated with system peaks or constraints, then the use of embedded generation as part of a demand side management programme could bring real benefits to Wellington Electricity. The reduction of load in constrained parts of the network such as the CBD, could defer network investment that may be required within the planning period.

Wellington Electricity is presently reviewing the distributed generation policy that was inherited from the previous owners of the network. Until the review is completed and any changes to the policy are approved internally, the existing policy is being used.

## 5.9. Non-Network Solution Policy

Wellington Electricity's load control system is already used to manage peak demands on the network, and therefore has the effect of deferring demand driven system augmentations. Wellington Electricity tariff structure also encourages retailers to offer time of use pricing and other supply products that provide an incentive for consumers to shift electricity consumption away from periods of peak network demand. The load control system provides significant benefits to the network by reducing peak demand and moving it to the shoulder periods. This has resulted in the significant deferral of network investment as well as providing an effective means of dealing with network loading during outages.

Other non-network solutions may include demand response, where consumers may be given an incentive to switch off demand at certain times when the network is approaching a period of constraint. For Wellington Electricity, the type of demand that may prove useful in deferring network investment is air conditioning plant in the CBD. Demand response is less likely to provide benefit in suburban areas as the loads are diluted amongst a large number of consumers and the load control system already provides a similar benefit.

Wellington Electricity has not pursued demand response to date because the load control system is so effective. Demand response will however be included as a long list option in any major network investment options analysis where it may be useful. Should it prove to warrant further investigation as a way of meeting the needs of an investment opportunity in the short term, then Wellington Electricity will pursue it accordingly. Not withstanding this, a non-network solution policy that includes demand response will be developed over the longer term as Wellington Electricity progresses with establishing such systems and processes.

## 5.10. Emerging Technologies

In recent times there has been much industry excitement around so called "smart grids" and smart technologies that will find their way into transmission and distribution networks, the metering and retail space, as well as at consumer level within homes and businesses.

As the topic is largely undefined and there are many different technologies emerging, Wellington Electricity is not actively pursuing smart grid projects or trials. By design, the Wellington Electricity network has a large number of features that may now be considered to be part of a "smart network" such as closed ring feeders with differential protected zones that trip out, leaving healthy sections in service, on demand load control via the existing ripple control system, and a widely SCADA-ised network with over 230 sites offering remote control and indication.

To develop and maintain the network that Wellington Electricity presently operates in parts of the Wellington City area, providing a higher level of reliability than a conventional radial network requires a higher return to cover the higher costs of asset utilised. The price-quality trade off made now for the level of technology means that future increases to price to improve quality may be less than if this technology was not presently being used.

As new technologies emerge that may improve the ways in which Wellington Electricity may design, build, maintain or operates the network, they will be thoroughly investigated. New technologies will be implemented if the benefits to the network and stakeholders meet or exceed any additional costs incurred by installing and using them.

## 5.11. Investment Programme – Growth, Customer Connections and Asset Relocations

Major network investment works covered in this section include new development works to maintain security levels driven by system Growth, and to enable Customer Connection and Asset Relocation work to occur. Asset Replacement and Renewal projects to address asset age or condition are covered in section 6 (Lifecycle Asset Management).

### 5.11.1. Major Network Investments for the Current Year

The following major projects and programmes of work are expected to take place or commence in the 2011 calendar year.

#### 5.11.1.1. 2011 Growth, Security and Reinforcement Projects

| Johnsonville Zone Substation - Reinforcement | |
|---|---|
| Driver: Growth<br>Estimated cost:<br>$1.5 million | Load on Johnsonville zone substation is exceeding the incoming cable ratings by a significant margin, to the extent that it will soon be difficult to manage the situation operationally should an equipment failure occur. This project will focus on addressing the load on the sub-transmission cables. Options that will be investigated include reinforcing the 33kV network, shifting load away from Johnsonville via the 11kV network, of controlling demand at peak times. |

| Queen’s Wharf North – Protection Reconfiguration | |
|---|---|
| Driver: Security<br>Estimated cost:<br>$150,000 | Presently, the circuits connected via Queens Wharf North substation form a tee in a differential circuit; however differential protection is only configured at two ends. This limits the configurations possible from Queens Wharf and reduces the security of supply in this area. This project is to alter the cable configuration and split the tee into two zones to ensure correct differential operation under all configurations. |

| Adelaide Rd Cable Reinforcement | |
|---|---|
| Driver: Security, Safety<br>Estimated cost:<br>$400,000 | The 11kV circuit between the Riddiford St and Newtown substations comprises two old, undersized PILC cables operating in duplex. One cable runs down each side of Adelaide Rd over a distance of approximately 1km. This configuration presents an operation rating constraint, has a potential to overload one cable if one fails open circuit, and leads to a safety risk if the wrong cable is identified or cut into as they are geographically separate but form one circuit. This risk affects the Palm Grove zone 1 ring including the Wellington Hospital. |

#### 5.11.1.2. HV Reinforcement - General

This is an aggregated budget allowance of $750,000 for minor HV network reinforcement projects that are not able to be directly attributed to individual customers. Examples of such projects include installing a new 11kV cable section. Projects expected in 2011 include reinforcement of a short section of 11kV cable on the Trentham 8 feeder, reconfiguration of Johnsonville 3 and 10 feeders, and other small network reconfiguration and reinforcement projects.

#### 5.11.1.3. LV Reinforcement - General

This is an aggregated budget allowance of $250,000 for minor LV network reinforcement projects that are not able to be directly attributed to individual customers. Examples of such projects include installing a new berm substation in response to network loading or voltage concerns, or a 400V cable reinforcement project.

#### 5.11.1.4. Customer Growth and Relocations

These projects have been aggregated in the budget as per the categories below. Overall, the 2011 budgeted expenditure is slightly higher than the 2010 budget, reflecting a slight decline in the amount of enquiries for carrying out this type of work. In general this is being attributed to a partial recovery of the recent economic slow down.

**New Connections**

A signal of how this partial recovery is affecting new connections is emerging with the trend for the number of new dwellings authorised by local Councils. Excluding apartments this figure has been increasing since March 2009. In May 2010, numbers rose by 64 units to 141 compared with May 2009, this being the second largest increase in New Zealand. While the first half of 2010 is reflecting a steady increase in new connections, next years forecast is tempered by the reduction of building deprecating allowance which is likely to impact on the small residential developments.

Overall it is predicted in 2011 new connections requiring infrastructure will exceed 200 for the first time since 2008. Supplementary to this increase is Telecom continuing with its program to provide telecommunications services from roadside cabinets (rather than the local exchange) where each requires an electrical supply connection.

**Substations**

Increased expenditure in customer substations is being predicted due to developers' plans indicating a number of medium scale substation reinforcements. This is partially attributed to five Wellington CBD developments being undertaken that were placed on hold during the economic downturn. Overall it is predicted substation related spend, including transformer capacity changes, will closely match 2010. This is well down on previous years where it exceeded $3m year on year for the past 4 years.

**Subdivisions**

While small and infill subdivisions look to remain at similar levels of previous years, local developers are showing little appetite for large scale residential (>100 lots) subdivisions. New industrial property development activity has all but ceased because of insufficient demand and surplus vacant sites that can be easily converted for tenancy needs. As such only one single business subdivision in Upper Hutt is being recognised in the 2011 expenditure. While a number of potential medium size subdivision projects have been identified it is expected that some may not be undertaken in the 2011 year. However this is offset by smaller subdivision projects being undertaken although not allowed for in original expenditure. Overall it is predicted new subdivision connections will be above 400 in 2011 compared to around 350 lots being completed this year.

Installation of a new customer service pillar

### Streetlights

Expenditure is budgeted to install new infrastructure associated with the New Zealand Transport Agency's (NZTA) project to upgrade lighting on State Highway 1 between Johnsonville and Tawa. Note that replacement of existing streetlight network is funded from network integrity.

### Capacity Changes

Expenditure associated with transformer upgrades or downgrades is included with customer substations to align with the function code structure adopted at the time of company sale.

### Relocations

The estimated 2011 budget is significantly lower than in recent years. For 2010 the NZTA will be investing little in infrastructure projects requiring relocation of existing electricity network. Minor relocation works has been identified by local city councils in 2011. An allowance for these and other customer initiated relocations has been made based on an average of the previous three years.

## 5.11.2. Prospective Investments for 2012 – 2021

Projects included in this section are less certain in nature. Whether or not they proceed, and their timing, will depend largely on whether forecast load growth materialises. It is possible that over the period before construction of any project must be committed, Wellington Electricity may identify more cost effective, including non-network, approaches that will supply the required load in accordance with the planning criteria.

#### 5.11.2.1. Prospective Investments for 2012 – 2016

In addition to budgeted programmes for minor network growth reinforcement, customer connection and asset relocation work, the following major project have been identified as potentially occurring within the period this plan covers.

| Reinforcement of 33 kV Capacity at Palm Grove Zone Substation | |
|---|---|
| Driver: Growth<br>Estimated cost:<br>$5 million | The current load at Palm Grove zone substation exceeds the capacity of the existing incoming cables. One of the options for addressing this issue is to connect the two existing cables in parallel to supply one transformer and to run a new 33kV XLPE cable to supply the second unit. This will allow the two transformers to be operated up to their full rated capacity.<br>At this stage it is not intended to upgrade the two Palm Grove transformers so that the firm transformer capacity exceeds the current and forecast substation load. Should a transformer fail, the situation will be managed using load transfers.<br>This project is linked to the possible building of a new substation in the CBD as it will allow the feeders in all CBD and surrounding areas to be reconfigured thus reducing the load on the Palm Grove substation, but not releasing installed capacity that is constrained by under-rated cables. |

| Mana and Plimmerton Zone Substation Reinforcement | |
|---|---|
| Driver: Security<br>Estimated cost:<br>$2-5 million | Each of these zone substations is supplied by a single 33kV transformer feeder. Loss of one feeder at peak times can be accommodated by load transfer and load control at present, however by around 2015 there may be a short fall in capacity. Possible options to address this issue include up-rating the transformers, transferring load to adjacent substations at the 11kV level, installing additional transformers and/or load control. |

| New Wellington CBD Zone Substation | |
|---|---|
| Driver: Growth<br>Estimated cost:<br>$10-15 million | It is envisaged that a new substation will be required during the planning period to reinforce the supply to the CBD. All substations supplying the CBD are heavily loaded and incremental upgrades can only defer the need for a more substantial reinforcement for a limited time.<br>Investment in a single new zone substation may defer expenditure required to increase subtransmission and transformer capacity at multiple Wellington City zone substations around the CBD. |

| Petone Zone Reinforcement / Supply Reconfiguration | |
|---|---|
| Driver: Security<br>Estimated cost: $2-5 million | The subtransmission cables supplying Petone zone substation have reached the end of their effective service life and suffer from age and condition issues. With the decrease of heavy industrial load in the Petone area, the loadings on both Petone and Korokoro zone substations has decreased and both substations are underutilised. It is proposed that the Petone zone substation be converted to a switching station taking 11kV supply from Korokoro substation and supplying a reduced Petone area. Fringe areas can be offloaded to Seaview and Melling 11kV feeders. |

#### 5.11.2.2. Prospective Investments for 2017 – 2021

| Whitby / Pauatahanui Zone Substation | |
|---|---|
| Driver: Growth<br>Estimated cost: $8-10 million | Load growth in the Whitby and Aotea areas is steadily increasing, and more land is being developed for residential housing. The existing supplies from Waitangirua are expected to exceed their ratings and provide insufficient security for the increased loads towards the end of the planning period. Development of a substation in this area will also provide increased security to the Mana and Plimmerton areas which are expected to also require reinforcement earlier in the planning period. |

| Zone Reinforcement – University / Frederick St / Moore St / Terrace | |
|---|---|
| Driver: Growth<br>Estimated cost: $2-5 million | Following the development of a new CBD zone substations, these substations are expected to require intra-zone reinforcement to provide acceptable security levels in their meshed zones. It may be determined that converting the meshed systems to radial feeders will provide adequate security and reduce the constraints in a more economic way. |

#### 5.11.2.3. Capital Expenditure Forecasts

From the details in the section above, Wellington Electricity's network development and growth capital expenditure forecast is shown in the table below. It includes the large projects described in Section 5.11 as well as expenditure on other growth related capital works such as customer projects and relocations. In comparison to asset renewal expenditure, the expenditure on growth projects is relatively modest, reflecting the low growth rates forecast. Expenditure on other line items generally reflects historic expenditure levels. The combined capital expenditure forecast is shown in Appendix A.

| | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 |
|---|---|---|---|---|---|---|---|---|---|---|
| Customer Connections | 7,789 | 6,195 | 5,989 | 5,919 | 9,030 | 8,577 | 6,654 | 7,226 | 6,186 | 6,325 |
| Growth | 3,624 | 8,793 | 5,653 | 4,282 | 6,506 | 6,983 | 2,390 | 5,099 | 5,180 | 5,135 |
| Asset Relocations | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 956 | 959 |
| Total | 12,653 | 16,228 | 12,882 | 11,441 | 16,776 | 16,800 | 10,284 | 13,565 | 12,322 | 12,419 |

**Figure 5-11 Capital Expenditure Forecasts**

From the table above, it can be seen that network development and growth expenditure is cyclic over the planning period. Notable network reinforcement projects are seen around 2012-2014 and 2016-2017 reflective of the prospective need for zone substation development. Customer Connection expenditure is forecast to rise around the middle of the planning period, this reflects the increased development of residential areas as the economy comes out of recession and existing vacant land is fully developed, this corresponds with a second wave of expenditure in network growth projects.

# 6. Lifecycle Asset Management

## 6.1. Asset Lifecycle Planning Criteria and Assumptions

This section provides an overview of Wellington Electricity's asset maintenance, refurbishment and replacement strategies over the planning period. The objective of these asset maintenance strategies is to ensure that the network is capable of meeting the consumer service level targets and to mitigate the risks inherent in running an electricity distribution network.

Generally, asset lifecycle management consists of the following:

- Routine asset inspections, condition assessments and servicing of in-service assets
- The evaluation of the results in terms of meeting customer service levels, performance expectations and risks
- Adjusting maintenance requirements, and equipment specifications to reflect known issues
- Repair, refurbishment or replacement of assets when required

The preventative maintenance programme is typically based on a time based cycle, with each asset type, or maintenance task across a group of assets having a set cycle. Some maintenance activities may have an intervention activity outside the normal time based programme either based on the number of operations undertaken by the asset (e.g. circuit breaker maintenance following fault trips) or based upon external testing results (e.g. tap changer maintenance based on oil tests). All inspections are undertaken on a time based cycle, which may vary for certain assets in each category based upon known issues and risks. In time, as condition assessment data improves for each asset category, planned maintenance cycles for some assets may be able to be extended as the risks associated with the assets may be reduced, conversely, some assets may need a shorter cycle due to their increased risks. Some assets, with a low value, low replacement cost and where the risks of failure are low, may simply be replaced at failure as this is more efficient than a full maintenance and refurbishment programme.

Electricity distribution assets do not have an infinite life and must eventually be replaced. Ideally assets should be replaced before they fail. However premature asset replacement is costly since it means that the service potential of the replaced assets is not fully utilised. Hence asset replacement requires the costs of premature replacement to be balanced against the risks of asset failure and the deterioration of supply reliability that will occur if assets are allowed to fail in service. There is a balance to be found, between the costs of maintaining an asset against the cost to replace it. Also for some asset types, it may be more cost effective, and have minimal impact on safety and service levels, to allow the asset to run to failure and replace on expiry of service.

Wellington Electricity uses the following criteria to determine whether an in-service asset should be replaced:

- The asset condition has deteriorated to the extent that there is a high risk that it will fail if left in service and repair or refurbishment is not practical or economic.
- The asset technology is obsolete and spare parts are no longer available.
- The asset presents an unacceptable risk to the environment or to the safety of public or operating and maintenance personnel.

- The maintenance cost of the asset over its remaining life is expected to be higher than the asset replacement cost.
- The asset failure creates a large impact to customer service or network reliability that would adversely impact our business reputation.

The remainder of this section focuses on the different asset classes and provides an insight into the condition and maintenance of each class with an overview of the specific asset class, maintenance programs and renewal and refurbishment programmes.

One of the key assumptions Wellington Electricity has based its maintenance and renewal programmes on is that the assets are old, but are generally in fair condition. This is due to sound maintenance programmes early in their service life and a better view will be known upon further condition assessment.

## 6.2. Stage of Life Analysis

During 2010, Wellington Electricity undertook a “Stage of Life” analysis on three major asset categories, namely subtransmission cables, zone substation power transformers, and zone substation 11kV switchboards.

The main feature of this analysis is to combine the disciplines of Asset Management with Network Planning to ensure optimal investment on the network. When considered holistically, factors such as age, condition and utilisation can provide an indication of where investment is required based upon total risk to the system. If these factors are considered independently, investment may occur in areas where the risk is not significant (for example an old transformer that has 100% back feed capacity is a lower risk than a better condition transformer where back feeds are not possible or constrained and load may be un-served following a failure).

Each of the factors of age, condition and utilisation are given weightings. The highest weighting is given to utilisation as the consequence of failure is more quantifiable than the likelihood of failure due to age or condition. Ultimately loading and back feed constraints have a longer term consequence if load cannot be supplied.

These three asset categories were selected as they present the highest risk to the system, they can be easily considered as discrete assets (compared to asset categories that may have thousands of items), and they represent the areas where investment will be the largest, often millions of dollars per single asset. It is not anticipated that discrete site “Stage of Life” analysis will be undertaken on any other categories. Other categories generally have a lower risk profile and will have renewal programmes driven by type issues, defect and condition information. There are also network policies created for those assets which include elements of “Stage of Life” analysis.

The factors in the “Stage of Life” analysis will change over time as work is completed on the network such as improving capacity or making more spare parts available for older switchboards.

One area to improve in the “Stage of Life” analysis in future is the optimal timing of investment. For some assets this is quite clear from an immediate need due to lack of back feed or exceptionally poor condition. However for some assets where there is not an immediate need, the use of network investment decision making tools is required.

The result of the “Stage of Life” analysis for each of the three categories is provided in the relevant section below. The analysis does not aim to provide solutions but rather to identify areas where further investigation is required.

The “Stage of Life” analysis is a constantly changing assessment and needs to be updated on a regular basis. As the network changes and more or less capacity is available in certain areas, or as asset condition deteriorates or improves, or as spare parts are used up or made available from replacement work, the scores found in the “Stage of Life” analysis will change. As a result, any prospective investment arising from this analysis may vary over the planning period.

## 6.3. Maintenance Practices

Wellington Electricity uses a Field Services Provider to undertake and manage execution of the maintenance programme on the network. A significant project was undertaken in 2010 to review the existing field services model. A process was completed to tender out the field services contract under a new agreement to achieve different outcomes from the field services contractor. The result of this process is that Northpower replaces the previous provider (Siemens Energy Services) in 2011. Northpower brings a wealth of knowledge and robust processes obtained from managing their own distribution network, as well as contracting on a number of other networks in New Zealand and overseas.

A difference in the new field services contract is that the scheduling of inspection and maintenance activities will now be driven by Wellington Electricity, rather than by the Field Services Provider as it was previously. This arrangement still enables the network owner to receive proposals from the field services contractors’ for further reliability centred investment above the present maintenance expenditure guideline set by the network owner.

The biggest and most significant change is a move towards condition based risk management of assets through improved condition assessment and defect identification during planned inspection and maintenance activities. There is also a requirement for the contractor to provide improved data back to Wellington Electricity for determination and scheduling of maintenance or replacement activities.

Vegetation management is provided by Treescape in accordance with Wellington Electricity policies and in accordance with the Hazards from Trees Regulations 2003. Wellington Electricity is reaching the end of the first cut and trim programme, and in future tree owners will be responsible for maintaining their vegetation to a distance that provides safe clearance of subsequent growth. There is potential that this maintenance may not occur and vegetation related outages may start to increase again if tree owners neglect their obligations under the regulations.

The maintenance budget is categorised into the following areas:

1. Planned/Preventative Maintenance (PM) works – this PM plan is developed between the maintenance contractor and Wellington Electricity based upon the requirements in the maintenance standards and asset quantities in service. The PM plan consists of routine inspections, as well as maintenance and servicing work undertaken on the network. The results of planned inspections, and also planned maintenance, drive corrective maintenance or renewal activities.

2. Corrective Maintenance works – this work is undertaken in response to defects raised from the planned inspection and maintenance activities, or from observations in the field. Generally the complete programme is unknown at the beginning of the financial year and budgets are set based on rolling

averages from previous years, adjusted (if required) for any known defects beyond what would normally be expected. When common fault modes occur these may be progressed into an asset renewal programme to more efficiently manage the defect.

3. Reactive Maintenance works – this work is undertaken in response to faults or third party incidents and includes equipment replacement and repairs following failure or damage.

4. Management Fee and Value Added – this is to provide for the contractor management overhead and to provide customer services such as cable mark outs, stand over provisions for third party contractors, provision of asset plans for the 'B4U Dig' service etc.

5. Vegetation Management – covering planned and corrective vegetation work undertaken by Treescape.

The maintenance budget costs for 2011 are summarised at the end of this section.

### 6.3.1. Maintenance Standards

The following maintenance standards are referred to in this section. These standards have evolved from previous network documents and during 2010 were rewritten to include additional requirements, including the previously mentioned condition and defect assessment requirements. These documents have been reviewed internally and also by senior engineers within another CKI group company, Citipower-Powercor, in Australia. Citipower-Powercor operates and manages electricity distribution networks in the Melbourne CBD and large parts of the state of Victoria, and has very well developed practices which add value to Wellington Electricity's maintenance standards. Some specialist standards, in particular earthing, have been developed internally and reviewed by industry specialists within New Zealand.

| Standard | Name |
|---|---|
| EMS-300 | Maintenance of Substation Fire Systems |
| EMS-301 | Maintenance of Mineral Insulating Oil |
| EMS-302 | Maintenance of Grid Exit Points |
| EMS-303 | Maintenance of Subtransmission Cables |
| EMS-304 | Maintenance of Zone Substations |
| EMS-305 | Maintenance of Substation Buildings and Enclosures |
| EMS-306 | Maintenance of Zone Substation Transformers |
| EMS-307 | Maintenance of 33kV Bulk Oil Circuit Breakers |
| EMS-308 | Maintenance of 11kV Metalclad Switchboards and Circuit Breakers |
| EMS-309 | Maintenance of Protection Systems |
| EMS-310 | Maintenance of Distribution Substations |

| Standard | Name |
|---|---|
| EMS-311 | Maintenance of Ripple Injection Equipment |
| EMS-312 | Maintenance of Traction DC Systems |
| EMS-313 | Maintenance of Substation Earthing |
| EMS-314 | Maintenance of Batteries and Chargers |
| EMS-315 | Maintenance of Overhead Lines and Components |
| EMS-316 | Maintenance of Fault Passage Indicators |
| EMS-317 | Maintenance of Overhead Switches |
| EMS-318 | Maintenance of Reclosers and Sectionalisers |
| EMS-319 | Maintenance of Distribution Transformers |
| EMS-320 | Maintenance of Distribution Earthing |
| EMS-321 | Maintenance and Inspection of Poles |
| EMS-322 | Maintenance of 11kV Ground Mounted Switchgear |
| EMS-323 | Maintenance of Low Voltage Distribution Equipment |
| EMS-324 | Maintenance of Communications Systems |
| EMS-325 | Planned Maintenance Intervals |

Figure 6-1 Maintenance Standards

## 6.4. Maintenance and Renewal Programmes

This section includes excerpts taken directly from the Preventative Maintenance programme, illustrating the maintenance activities undertaken for particular asset classes and their frequency. Commentary is provided on renewal and refurbishment policies or criteria plus known systematic issues associated with each asset class.

### 6.4.1. Subtransmission Cables

#### 6.4.1.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on subtransmission cables.

| Activity | Description | Frequency |
|---|---|---|
| Cable sheath tests | Testing of cable sheath and outer servings, continuity of sheath, cross bonding links and sheath voltage limiters. | 2 yearly |
| Subtransmission - cable gas / oil injection equipment inspection | Inspection and minor maintenance of equipment in substations, kiosks and underground chambers. | 6 monthly |
| Subtransmission - general maintenance, weekly patrol | General maintenance and management of subtransmission network. | Ongoing |

Figure 6-2 Inspection and Routine Maintenance Schedule for Subtransmission Cables

In conjunction with the above routine maintenance, all oil filled and pressurised gas cables have pressure continuously monitored via the centralised SCADA system. This monitoring provides information that identifies cables where pressure is reducing and allows the situation to be promptly investigated. Leaks will occur either at joints, which can be rebuilt, or along the length of the cable which makes location and repair significantly more difficult.

One of the key tests is the sheath test, this will indicate where there is damage to the outer sheath and gives an early indication of where corrosion or further damage may occur (leading to leaks), as well as proving the integrity of the earth return path. Most of the subtransmission cables installed on Wellington Electricity's network are three core aluminium or lead sheathed, with very few circuits consisting of single core cables with wire screens.

Subjective condition assessment on cables with oil or gas pressurisation is difficult and quite limited, a number of techniques, including partial discharge testing, are not applicable to these types of cables. By their very nature, the pressurisation of the cables fills any voids in the insulation and prevents partial discharge. The main mode of failure of these cables is stress on the joints and resulting failures, as well as sheath failures allowing gas leaks and areas of low pressurisation along the length of the cable. Leaks however are detected through routine operations and the cable can be repaired before the electrical insulation properties are compromised.

The historic fault information for each cable, where known, is used to assess and prioritise the need for cable replacement, as well as determining the strategic spares are required to be held.

#### 6.4.1.2. Cable Condition

**Gas filled cables**

Gas filled HV cables have been in use internationally since the 1940's and are still in service in many utilities in New Zealand and Australia. They have been proven to perform well when they are installed in benign environments that are not prone to disturbance or damage. Wellington Electricity however has many of its gas filled cables installed under busy roads in urban environments, through structures such as bridges and crossing earthquake fault lines. This therefore requires close monitoring of their performance to manage any deterioration and consequent reduction in levels of service. For example, most of the Evans Bay gas filled cables run under State Highway 1. These cables in particular have been repaired numerous times as a result of third party damage or through gas leaks being found. Vibration from traffic has been identified as a contributing factor to some mechanical failures.

When these cables develop a gas leak, they can usually be dug up and repaired without having to cut the cable. However when a more serious electrical fault occurs, a new section of cable will be necessary. On some occasions a transition joint is employed to join the pressurised gas cables to XLPE cables. These joints are relatively expensive at circa $100,000 each and therefore it is not expected that it will be economic to have a large number of such joints in a cable. The likely outcome of this is that economically for any replacement projects, long lengths of cable will be required for replacement rather than for a number of short lengths.

A brief summary of the gas filled cable circuits is listed below:

| Circuit | Length (km)[14] | Year installed |
|---|---|---|
| Central Park - Evan's Bay | 10.1 | 1958 |
| Central Park - Frederick Street | 3.1 | 1978 |
| Central Park - Hataitai | 4.8 | 1968 |
| Central Park - Palm Grove | 5.8 | 1967 |
| Central Park - University | 1.0 | 1986 |
| Evan's Bay - Ira Street | 5.1 | 1961 |
| Melling - Petone | 8.4 | 1963 |
| Upper Hutt - Maidstone | 10.7 | 1968 |
| Wilton - Karori | 9.8 | 1967 |
| Wilton - Waikowhai Street | 3.7 | 1962 |
| Wilton - Moore Street | 16.6[15] | 1965 |

Figure 6-3 Summary of Gas Filled Cable Circuits

The Evan's Bay cables are the oldest on the network and over time they have suffered from a number of leaks which have been repaired. These are however well supported by back-feed options and the load they support is predominantly residential.

The Moore Street gas cables have experienced minor sheath faults over recent times, and since the 1990s have experienced two catastrophic joint failures. The heavy loading and varying terrain put a considerable mechanical strain on joints on this cable (further details under Cable Joints below).

The Petone gas cables have had, and continue to suffer from, heavy corrosion to the outer metallic sheath due to poor servings. These cables are lightly loaded due to decline in load around Petone with the closure of several large manufacturing plants. Network studies are being undertaken to determine if these cables

[14] Circuit length is the total of all parallel circuits, divide length by number of circuits for route length.
[15] The Wilton-Moore Street cables are duplexed with the old Wilton-Terrace cables for capacity.

should be replaced, or if the load can be supplied from existing 11kV feeders in the area, reducing the need for subtransmission supply.

**Cable Joints**

A known issue on some cables installed on steep terrain is where joints expand and contract under cyclic loading, and have been known to pull the conductor from the joint ferrule under contraction. This was experienced in March 2010 when one of the Moore Street circuits was out of service to enable maintenance by Transpower at the Wilton GXP. The consequence of this was significant given the type of load served (CBD, Government) and the unavailability of the second circuit.

X-raying of joints was undertaken during United Networks ownership, and little remedial work occurred as the problem had not proved to be significant. This mode of failure is experienced on average every 10 years, with the most recent occurrences on the Moore Street cables which follow a steep and varying circuit route.

**Cable Strikes**

Wellington Electricity, like most lines businesses and other utilities, experiences a number of third party strikes on its underground assets each year. These impact on network performance, pose a serious risk to health and safety, and incur a large cost to repair.

To minimise the number of third party strikes, Wellington Electricity uses a service provider, B4U-DIG to facilitate the provision of obstruction plans to contractors working in the area. Wellington Electricity is planning to target these contractors with a road show to educate them on the importance of cable location and excavation practices.

Additionally, cable maintenance staff patrol the routes of key subtransmission circuits on a regular basis and note any activities that may impact upon underground services.

#### 6.4.1.3. Renewal and Refurbishment

The need for cable replacement is determined and prioritised by a combination of the consequence of a cable failure, condition and performance assessments, analysis of failure and defect rates, and a comparison of the estimated cost of maintaining the cable in service with the cost of replacement, as well as system capacity for supporting load whilst the subtransmission circuit is under repair. These factors are considered in the “Stage of Life” analysis of subtransmission circuits.

Unfortunately for cables there are almost no options for refurbishment or extension of life once major leaks, discharge and electrical insulation breakdown has occurred. The solution in most cases is replacement of sections, or the entire length, of cable. Gas and oil filled cable require special transition and stop joints that range in cost from $100,000 upwards each. To relocate, replace sections or extend a cable would cost a minimum of $250,000 using this technology.

#### 6.4.1.4. Subtransmission Circuit “Stage of Life” Analysis

During 2010, a “Stage of Life” analysis was undertaken on all subtransmission circuits, and a summary of the analysis is provided below.

**Parameters Considered**

The 'Stage of Life" analysis method considers the attributes of each subtransmission cable circuit as defined over three categories, each containing a number of measurable properties. A rating between one and ten is given to each property, with 1 being the most favourable (good) and 10 being the least favourable (bad).

| Category | Property | Rating (normalised) |
|---|---|---|
| Age | Age | 1 (good) to 10 (poor) |
| Condition | Total number of joints | 1 (good) to 10 (poor) |
| Condition | Number of non-original joints | 1 (good) to 10 (poor) |
| Condition | Joint density (Joints / km) | 1 (good) to 10 (poor) |
| Condition | Environment that the cable is installed in | 1 (good) to 10 (poor) |
| Condition | Assessment of cable condition (from field staff) | 1 (good) to 10 (poor) |
| Condition | Assessment of sheath condition (from field staff) | 1 (good) to 10 (poor) |
| Condition | Leakage history (for pressurised cables) | 1 (good) to 10 (poor) |
| Utilisation | N-1 capacity shortfall | 1 (good) to 10 (poor) |
| Utilisation | Residual capacity following transfer of load | 1 (good) to 10 (poor) |
| Utilisation | Type of connected load | 1 (good) to 10 (poor) |

**Figure 6-4 Categories, Properties and Ratings for Subtransmission Circuits**

The ratings are normalised over all of the subtransmission circuits so that they can be used as a direct comparison between circuits. Ratings are then weighted as some properties have a greater impact on "Stage of Life" than others.

**Category Scores**

The weightings allocated to each of the three main categories of age, condition and utilisation are as follows:

| Category | Weighting |
|---|---|
| Age | 10% |
| Condition | 40% |
| Utilisation | 50% |

**Figure 6-5 Category Weightings**

The rationale behind these weightings is that age and condition are considered as asset related properties and together they are given equal weighting (i.e. 50%). Utilisation (also 50%) is considered as a planning related property. Age is considered to be less relevant to overall stage of life of the circuit than the condition parameters; hence it is given a rating of 10%, compared to 40% for condition.

Applying the above weightings to the normalised ratings of each category gives the following ranking of circuits requiring attention, ordered with the highest priority circuit (i.e. highest score) at the top of the list.

| Zone Substation | Age score | Condition score | Utilisation score | Weighted Total score |
|---|---|---|---|---|
| Frederick Street | 6.6 | 2.9 | 54.7 | **29.1** |
| Moore Street | 9.0 | 7.2 | 5.8 | **6.7** |
| Johnsonville | 5.9 | 4.4 | 7.7 | **6.2** |
| Petone | 9.4 | 6.8 | 4.1 | **5.7** |
| Palm Grove | 8.6 | 3.3 | 6.9 | **5.6** |
| Hataitai | 8.4 | 4.2 | 6.2 | **5.6** |
| University | 4.8 | 5.3 | 5.7 | **5.4** |
| Maidstone | 8.4 | 5.3 | 4.9 | **5.4** |
| Evans Bay | 10.4 | 8.1 | 2.1 | **5.4** |
| Karori | 9.4 | 3.8 | 5.4 | **5.2** |
| Terrace | 0.4 | 2.1 | 8.3 | **5.0** |
| Waterloo | 5.3 | 2.9 | 6.1 | **4.7** |
| Tawa | 4.6 | 3.5 | 5.6 | **4.7** |
| Korokoro | 5.1 | 3.8 | 5.3 | **4.7** |
| Seaview | 4.7 | 2.0 | 6.0 | **4.3** |
| Mana | 4.0 | 3.1 | 5.2 | **4.2** |
| Waikowhai | 8.2 | 3.8 | 3.7 | **4.2** |
| Waitangirua | 5.9 | 4.4 | 3.7 | **4.2** |
| Porirua | 5.4 | 1.7 | 5.9 | **4.2** |
| Plimmerton | 4.0 | 2.3 | 5.1 | **3.9** |
| Ira Street | 9.8 | 3.9 | 2.5 | **3.8** |
| Ngauranga | 3.8 | 2.3 | 5.0 | **3.8** |
| Wainuiomata | 4.7 | 1.2 | 5.4 | **3.7** |
| Gracefield | 4.7 | 1.0 | 4.7 | **3.2** |
| Naenae | 5.9 | 1.3 | 4.1 | **3.1** |
| Brown Owl | 6.0 | 1.7 | 3.3 | **2.9** |

| Zone Substation | Age score | Condition score | Utilisation score | Weighted Total score |
|---|---|---|---|---|
| Trentham | 6.6 | 2.3 | 2.3 | **2.7** |
| Kenepuru T off | 4.5 | 0.0 | 4.4 | **2.6** |

Figure 6-6 Stage of Life Category Scores

**Top Ranked Circuits**

The top five circuits which have been identified as being most in need of attention are:

| Subtransmission link | Ranking (1st = highest priority) |
|---|---|
| Frederick Street | 1st |
| Moore Street | 2nd |
| Johnsonville | 3rd |
| Petone | 4th |
| Palm Grove | 5th |

Figure 6-7 Stage of Life Ranking of Subtransmission Links

Fredrick Street, Johnsonville and Palm Grove are all in relatively good condition with scores below 5, but all have issues with utilisation. Moore Street has a high condition score and a mid range utilisation score hence it's position as second highest, where as Petone has a poor condition score (second highest at 6.8) but a relatively good utilisation score making it fourth on the priority list.

**Outcome of "Stage of Life" Analysis**

**Frederick Street**

The Fredrick Street subtransmission cables are not old and are in relatively good condition. The only reason they feature in the top five is due to the very poor utilisation score, which has been forced to 'high' because of the lack of ability for the subtransmission system to feed peak demand after load transfer. It should be noted that if the utilisation score is not forced, the utilisation drops to 10 and the total weighted score becomes 6.6, putting it second on the list behind Moore Street, i.e. still in urgent need of attention.

A project was undertaken in late 2010, which is yet to be completed, that permanently transfers away load from Fredrick Street zone substation to the adjacent Nairn Street substation. At the completion of this project, the utilisation rating of the Fredrick Street subtransmission system will drop significantly and it will not feature on the top five list.

**Moore Street**

The Moore Street subtransmission circuits featured in a high profile failure in 2010 that resulted in outages to the CBD and an urgent repair. The link comprises two circuits, each with two parallel connected cables (i.e. four cables in total). The majority of the Moore Street subtransmission link of elderly gas filled cable, with two short sections of new XLPE on the end of two of the cables. The cables are also known to be in relatively poor condition (second only to Evans Bay). Therefore, even though the link is not heavily utilised, it features as the second ranked link in need of attention.

A business case was prepared for the Moore Street circuits following the recent cable faults, outlining a number of potential options and risk analysis. The recommended option of full replacement was approved by Wellington Electricity's Board and a project is presently underway to replace the circuits with two new 800mm$^2$ XLPE cable circuits. The value of this project is $9.343 million.

**Johnsonville**

The cable sections of the Johnsonville subtransmission link are at about mid life and in relatively good condition, but their utilisation is very high. Back feed options for Johnsonville are limited and should a subtransmission circuit fail at peak times, a short fall of about 11MVA will result. 11MVA equals the back feed capacity for the area, hence the residual transfer capability for Johnsonville is zero MVA, i.e. any load growth at Johnsonville will result a shortfall of capacity. The need for attention is therefore urgent which is consistent with its ranking at number three.

An investigation is planned to take place in 2011 for this issue, however as the issue is capacity rated it will be treated as a network planning study. The first options that will be investigated are strengthening of back feed at the distribution level or transfer of load to adjacent substations. A budget allocation of $1,500,000 has been allowed for in the 2011 spend plan under Network Augmentation.

**Petone**

The Petone subtransmission circuits are old and in poor condition, but it is lightly loaded. An investigation into this subtransmission link is likely to identify options other than investment in the cables due the light loading. These options may include investment in the distribution network to move load away from the zone substation and the eventual decommissioning of the 33kV subtransmission link.

**Palm Grove**

The Palm Grove subtransmission link is old but in good condition. The utilisation of the link is high which has resulted in it being featured in the top five. No investigation or analysis has been carried out for the Palm Grove link to date.

### 6.4.2. Substation Buildings and Equipment

#### 6.4.2.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on substation buildings and related equipment.

| Activity | Description | Frequency |
|---|---|---|
| Zone Substation - Routine Inspection | Routine visual inspection of zone substation to ensure asset integrity, safety and security. Record and report defects, undertake minor repairs as required. Thermal inspection of all equipment, handheld PD and Ultrasonic scan. Inspect and maintain oil containment systems, inspect and test transformer pumps and fans. | 3 monthly |

| Activity | Description | Frequency |
|---|---|---|
| Grounds maintenance - Lump sum | General programme of grounds and building maintenance for zone substations | Ongoing |
| Fire Suppression System Inspection and Maintenance | Inspect, test and maintain fire suppression system (Inergen / gas flood) | 3 monthly |
| Fire Alarm Test | Inspect and test passive fire alarm system | 3 monthly |
| Fire Extinguisher Check | Inspect and change fire extinguishers as required | Annually |
| Test Zone Substation Earthing system | Test zone substation earthing systems | 5 yearly |

**Figure 6-8 Inspection and Routine Maintenance Schedule for Zone Substations and Equipment**

Routine 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 to ensure access security, condition and safety. Where appropriate, annual building warrant of fitness inspections are carried out and any defects rectified. Building maintenance varies depending upon the site and minor defects are corrected as they are identified.

#### 6.4.2.2. Renewal and Refurbishment

The substation building refurbishment program includes tasks such as roof replacement, exterior and interior painting, security and fencing improvements to maintain the assets in good condition on an as-needed basis.

Given the average age of substation buildings, Wellington Electricity is approaching a period of increased spend to replace doors, roofs and other building components. Deterioration from the natural elements have resulted in maintenance being uneconomic to address weathertightness issues. This work is critical to ensure ongoing reliability of electrical plant.

In addition to routine maintenance, the local councils require seismic improvement works on some of the older buildings. These are undertaken as required following engineering advice. During 2010 a project was undertaken to reinforce the 70 Adelaide Road distribution substation to improve the seismic strength of the 1930s vintage brick and masonry. This work cost in excess of $100,000. While these projects are essential for the security and safety of the network they can be costly.

### 6.4.3. Zone Substation Transformers and Tap Changers

#### 6.4.3.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on zone substation power transformers.

| Activity | Description | Frequency |
|---|---|---|
| Transformer oil test (TjH2B TCA) | Sample and test transformer oil using TjH2B TCA (Transformer Condition Assessment) method for power transformer main tank. | Annually |
| On Load Tapchanger (OLTC) oil test (TjH2B TASA) | Sample and test tap changer oil using TjH2B TASA (Tap Changer Activity Signature Analysis) method for power transformer OLTC | Annually |
| Transformer Maintenance, Protection and AVR Test | De-energised transformer maintenance, inspection and testing of transformer, replacement of silica crystals, diagnostic tests as required. Gas injection for testing of buchholz. Testing of temperature gauge and probe. Confirmation of correct alarms. Test AVR and ensure correct operation and indications. | 4 yearly |
| On Load Tap changer (OLTC) Maintenance | Programmed maintenance of OLTC on a 4 yearly cycle if not maintained before as a result of test. | 4 yearly |

**Figure 6-9 Inspection and Routine Maintenance Schedule for Zone Substations Transformers and Tap Changers**

A programme of full oil analysis of all zone substation transformers and tap changers was initiated by Wellington Electricity and completed in late 2009. Presently Wellington Electricity uses TjH2b analytical labs for oil analysis. TjH2b undertake a TCA and TASA test to measure dissolved gasses, particles, moisture and furans. These reports return a score of 1 to 4*, with 1 being normal and 4* being worst. Activities such as tap changer maintenance can be programmed based on these results as well as on time or operation based intervals. The TCA result and information in the report can be used to determine whether major maintenance or repairs need to be undertaken on the transformer. In 2010, only a basic oil dissolved gas analysis was undertaken, however full oil analysis will be undertaken again in 2011 to get full particle, dissolved gas and furan results.

#### 6.4.3.2. Transformer Condition

Generally the condition of all transformers on the network indicates normal performance. Where evidence of heating or arcing is present, corrective maintenance is undertaken if economic, such as tightening or renewing internal connections outside of the core, or undertaking tap changer maintenance. By far, the most common issue is not electrical performance but rather mechanical problems with transformers. Examples include tap changer mechanism wear, contact wear, and similar problems associated with moving machinery. External condition includes leaking gaskets, fan and cooling system problems and for outdoor installations corrosion and weathering of the transformer tanks, especially the tops where water can pool at times.

Oil tests can also give an estimated Degree of Polymerisation (DP) value that can be used to provide an initial overview of the transformer condition, and signal the need for further maintenance, refurbishment or replacement. Estimated DP tests completed in 2009 (furan analysis) show the majority of transformers to be above 450. It is proposed that once a transformer reaches 300 a paper sample will be taken to prove accuracy of the furan analysis and determine what further steps are required. A profile of estimated DP (as measured in 2009) vs. age, is shown below.

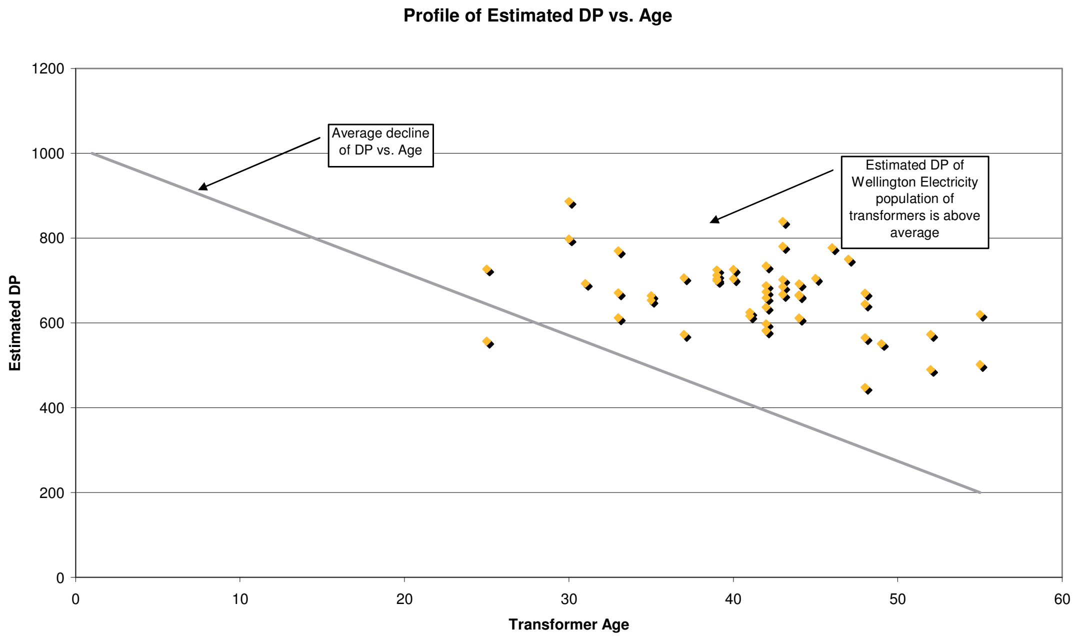



**Figure 6-10 Profile of Estimated DP vs. Age (based on 2009 Testing)**

From observation of maintenance and testing results, the following site specific issues are known to Wellington Electricity:

### Evan's Bay

The transformers installed at Evan's Bay are two of the oldest on the network, having been installed in 1959. These transformers have experienced problems in recent years mostly relating to mechanical performance of the tap changer, however corrective works have been possible and the transformers returned to service. The high level of redundancy at this site makes a long duration transformer outage possible with minimal risk to supply.

### Ngauranga

Ngauranga has the two oldest power transformers installed. These transformers are generally reliable however have experienced problems with the tap changer diverter switches.

### Waikowhai Street

The transformers at Waikowhai Street substation are in good condition. They are however fitted with vertical Reinhausen tap changers which are the only two on the system. These are more difficult to maintain and are maintained on a 6-8 yearly cycle depending on the results of oil testing.

### The Terrace

The Terrace substation is located in the basement of the James Cook Hotel in central Wellington. The hotel was built around the zone substation and replacement or removal of a power transformer could be challenging in the future. This transformer is carefully monitored to ensure no major issues occur that may lead to removal being required.

Several other sites have had minor issues with tap changers over the years but are generally in good condition.

#### 6.4.3.3. Renewal and Refurbishment

Where a transformer is identified for relocation, refurbishment is generally performed if it is economic to do so, based on the condition and residual life of the transformer. A non-invasive test to determine the moisture content of the winding insulation is used to aid the economic decision regarding major transformer refurbishments.

Transformer replacement and life-maintaining refurbishments are prioritised through a combination of invasive and non-invasive tests and inspections to determine the condition of the transformer. Tests are carried out on the oil and winding insulation to provide an indication of probable remaining life of the transformer. Based on this a decision can be made in conjunction with functional, financial and performance requirements of the transformer on whether to retain the transformer in service, to refurbish the transformer or to replace it outright.

The following has been allowed for in the asset maintenance and replacement forecasts for the planning period:

- Transformer replacements at two zone substations
- Ongoing transformer refurbishment costs
- Ongoing preventative maintenance including testing and inspections.

Based on age information, and condition test results, replacement of at least two transformers can be expected to require replacement during the period 2011-2015. The replacement units need not be the oldest nor the worst condition, but where capacity and security constraints indicate a high risk associated with failure. All factors are considered in the replacement decision making which is covered in the “Stage of Life” analysis.

In some instances, where a power transformer is approaching, or at, its service half life, subject to condition assessment results, a refurbishment including mechanical repairs, drying and tightening of the core and associated electrical repairs can be justified. There are 8 - 12 transformers that are at a stage where refurbishment is still economic, and some that are showing slight signs of arcing which may require minor refurbishment to check and tighten electrical components. For the majority of the power transformers in the Wellington Electricity network, the testing and inspection programme will aid in getting the best life from the transformer and timing replacement of the unit. This may however not necessarily lead to full refurbishment.

#### 6.4.3.4. Power Transformer “Stage of Life” Analysis

During 2010, a “Stage of Life” analysis was undertaken on all zone substation transformers, and a summary of the analysis is provided below.

**Parameters Considered**

The “Stage of Life” analysis method considers the attributes of each power transformer as defined over three categories, each containing a number of measurable properties. A rating between one and ten is given to each property, with 1 being the most favourable (good) and 10 being the least favourable (bad).

| Category | Property | Rating (normalised) |
|---|---|---|
| Age | Age | 1 (good) to 10 (poor) |
| Condition | Estimated Remaining Life | 1 (good) to 10 (poor) |
| Condition | Environmental Protection | 1 (good) to 10 (poor) |
| Condition | Electrical Condition | 1 (good) to 10 (poor) |
| Condition | Assessment of known issues (from field staff) | 1 (good) to 10 (poor) |
| Utilisation | Load vs. Load Rating | 1 (good) to 10 (poor) |
| Utilisation | Type of connected load | 1 (good) to 10 (poor) |
| Utilisation | Number of ICPs served | 1 (good) to 10 (poor) |
| Utilisation | Residual capacity following transfer of load | 1 (good) to 10 (poor) |

Figure 6-11 Categories, Properties and Ratings for Power Transformers

The ratings are normalised over all of the power transformers so that they can be used as a direct comparison between transformers. Ratings are then weighted, as some properties have a greater impact on stage of life than others. The properties along with the ratings and weightings applied to them for are described in detail below.

**Category Scores**

The weightings allocated to each of the three main categories of age, condition and utilisation are as follows:

| Category | Weighting |
|---|---|
| Age | 20% |
| Condition | 30% |
| Utilisation | 50% |

Figure 6-12 Category Weightings

The rationale behind these weightings is that age and condition are considered as asset related properties and together they are given equal weighting (i.e. 50%). Utilisation (also 50%) is considered as a planning related property. Age is considered to be less relevant to overall stage of life of the transformer than the condition parameters; hence it is given a rating of 20%, compared to 30% for condition.

Applying the above weightings to the normalised ratings of each category gives the following ranking of transformers requiring attention, ordered with the highest priority transformer (i.e. highest score) at the top of the list.

| Transformer | Substation | Age score | Condition score | Utilisation score | Weighted Total score |
|---|---|---|---|---|---|
| Frederick Street 1 | Frederick Street | 5.9 | 3.1 | 9.3 | **6.8** |
| Johnsonville B | Johnsonville | 7.6 | 3.5 | 8.3 | **6.7** |
| Johnsonville A | Johnsonville | 7.6 | 3.2 | 8.3 | **6.6** |
| Frederick Street 2 | Frederick Street | 5.9 | 2.4 | 9.3 | **6.6** |
| Palm Grove 1 | Palm Grove | 8.0 | 3.1 | 8.0 | **6.5** |
| Palm Grove 2 | Palm Grove | 8.0 | 3.1 | 8.0 | **6.5** |
| Terrace 2 | Terrace | 8.1 | 2.7 | 8.0 | **6.4** |
| University 1 | University | 4.4 | 3.3 | 9.1 | **6.4** |
| Terrace 1 | Terrace | 8.3 | 2.4 | 8.0 | **6.4** |
| University 2 | University | 4.4 | 2.6 | 9.1 | **6.2** |
| Mana A | Mana | 8.7 | 2.2 | 6.3 | **5.6** |
| Tawa B | Tawa | 8.7 | 3.4 | 5.5 | **5.5** |
| Hataitai 1 | Hataitai | 7.8 | 2.8 | 6.3 | **5.5** |
| Tawa A | Tawa | 8.7 | 3.3 | 5.5 | **5.5** |
| Waikowhai 1 | Waikowhai | 8.9 | 3.3 | 5.4 | **5.5** |
| Evans Bay 1 | Evans Bay | 9.4 | 4.7 | 4.3 | **5.5** |
| Karori 1 | Karori | 7.4 | 3.0 | 6.2 | **5.5** |
| Porirua B | Porirua | 8.0 | 3.3 | 5.5 | **5.4** |
| Porirua A | Porirua | 8.0 | 3.3 | 5.5 | **5.4** |
| Evans Bay 2 | Evans Bay | 9.4 | 3.8 | 4.3 | **5.2** |
| Maidstone A | Maidstone | 7.8 | 3.8 | 5.0 | **5.2** |
| Seaview A | Seaview | 7.6 | 3.2 | 5.4 | **5.2** |
| Seaview B | Seaview | 7.6 | 3.1 | 5.4 | **5.1** |
| Plimmerton A | Plimmerton | 8.7 | 1.7 | 5.7 | **5.1** |
| Waitangirua A | Waitangirua | 8.5 | 3.6 | 4.5 | **5.0** |
| Maidstone B | Maidstone | 7.8 | 3.3 | 5.0 | **5.0** |
| Karori 2 | Karori | 7.4 | 1.5 | 6.2 | **5.0** |
| Wainuiomata B | Wainuiomata | 7.2 | 3.8 | 4.8 | **5.0** |

| Transformer | Substation | Age score | Condition score | Utilisation score | Weighted Total score |
|---|---|---|---|---|---|
| Waikowhai 2 | Waikowhai | 8.9 | 1.7 | 5.4 | **5.0** |
| Wainuiomata A | Wainuiomata | 7.2 | 3.7 | 4.8 | **5.0** |
| Hataitai 2 | Hataitai | 7.8 | 0.9 | 6.3 | **5.0** |
| Ngauranga B | Ngauranga | 10.0 | 2.0 | 4.6 | **4.9** |
| Waitangirua B | Waitangirua | 8.5 | 2.8 | 4.5 | **4.8** |
| Ngauranga A | Ngauranga | 10.0 | 1.5 | 4.6 | **4.8** |
| Waterloo A | Waterloo | 7.0 | 1.2 | 5.8 | **4.7** |
| Waterloo B | Waterloo | 7.0 | 1.2 | 5.8 | **4.6** |
| Naenae B | Naenae | 7.8 | 3.1 | 4.1 | **4.5** |
| Moore St 2 | Moore St | 6.7 | 1.7 | 5.4 | **4.5** |
| Petone A | Petone | 8.0 | 3.9 | 3.4 | **4.5** |
| Petone B | Petone | 8.0 | 3.8 | 3.4 | **4.5** |
| Brown Owl A | Brown Owl | 7.6 | 3.5 | 3.8 | **4.4** |
| Korokoro B | Korokoro | 6.3 | 2.9 | 4.6 | **4.4** |
| Kenepuru B | Kenepuru | 7.6 | 2.8 | 4.1 | **4.4** |
| Korokoro A | Korokoro | 6.3 | 2.8 | 4.6 | **4.4** |
| Moore St 1 | Moore St | 6.7 | 1.2 | 5.4 | **4.4** |
| Kenepuru A | Kenepuru | 7.6 | 2.6 | 4.1 | **4.3** |
| Brown Owl B | Brown Owl | 5.9 | 3.3 | 3.8 | **4.1** |
| Naenae A | Naenae | 7.6 | 1.6 | 4.1 | **4.0** |
| Gracefield B | Gracefield | 7.0 | 3.8 | 2.9 | **4.0** |
| Gracefield A | Gracefield | 7.0 | 3.1 | 2.9 | **3.8** |
| Trentham B | Trentham | 5.6 | 3.2 | 3.1 | **3.7** |
| Trentham A | Trentham | 5.6 | 3.2 | 3.1 | **3.7** |
| 8 Ira Street 2 | 8 Ira Street | 5.4 | 0.8 | 4.3 | **3.5** |
| 8 Ira Street 1 | 8 Ira Street | 5.4 | 0.5 | 4.3 | **3.4** |

Figure 6-13 Stage of Life Category Scores

**Top Ranked Circuits**

The top five power transformers which have been identified as being most in need of attention are:

| Transformer | Ranking (1st = highest priority) |
|---|---|
| Frederick Street 1 | 1st |
| Johnsonville B | 2nd |
| Johnsonville A | 3rd |
| Frederick Street 2 | 4th |
| Palm Grove 1 | 5th |

Figure 6-14 Stage of Life Ranking of Power Transformers

Frederick Street, Johnsonville and Palm Grove are all in relatively good condition with scores below 4, but all have issues with utilisation. These results align closely with the findings from the subtransmission circuit "Stage of Life" analysis work. This indicates that these transformers are not the oldest, nor in the worst condition, however due to the heavy loading and type of load served, the consequence of failure of these transformers is considered to be the highest.

**Outcome of "Stage of Life" Analysis**

**Frederick Street**

The Fredrick Street transformers are not old and are in relatively good condition. The only reason they feature in the top five is due to the utilisation score as a result of the lack of ability for the subtransmission system to feed peak demand after load transfer.

A project was undertaken in late 2010, which is yet to be completed, that permanently transfers away load from Fredrick Street zone substation to the adjacent Nairn Street substation. At the completion of this project, the utilisation score of the Fredrick Street transformers will drop significantly and it will not feature on the top five list.

**Johnsonville**

The Johnsonville transformers are at about mid life and in relatively good condition, but their utilisation is very high. Back feed options for Johnsonville are limited and should a transformer fail at peak times, a short fall of about 11MVA will result. 11MVA equals the back feed capacity for the area, hence the residual transfer capability for Johnsonville is zero MVA, i.e. any load growth at Johnsonville will result a shortfall of capacity. The need for attention is therefore urgent which is consistent with its ranking at number two and three.

An investigation is planned to take place in 2011 to address the utilisation issue, however as the issue is capacity rated it will be treated as a network planning study. The first options that will be investigated are strengthening of back feed at the distribution level or transfer of load to adjacent substations. A budget allocation of $1,500,000 has been allowed for in the 2011 spend plan under Network Augmentation.

**Palm Grove**

The Palm Grove transformers are old but in good condition. The utilisation score is high which has resulted in it being featured in the top five. No investigation or analysis has been carried out for the Palm Grove transformer to date. As it is utilisation related issue, any work carried out will be a Network Augmentation project not an asset renewal.

## 6.4.4. Substation DC Systems

### 6.4.4.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on substation DC supply systems.

| Activity | Description | Frequency |
|---|---|---|
| Inspection and monitoring of battery & charger condition | Routine visual inspection of batteries, chargers and associated equipment. Voltage check on batteries and charger. | Annually |
| Comprehensive battery discharge test | Comprehensive battery discharge test for all batteries, measurement and reporting of results. | 2 yearly<br>(Zone only) |

Figure 6-15 Inspection and Routine Maintenance Schedule for Zone Substation Battery Banks

Valve regulated lead acid (VRLA) batteries are now the only type of battery used. Maintenance 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).

### 6.4.4.2. Battery and Charger Condition

It was discovered in 2009 that a large number of batteries were allowed to reach a point where they had passed their service life. Some batteries had already failed in-service when called upon to operate substation devices during fault or switching conditions. From this, a comprehensive survey of battery installation dates was undertaken and, following replacement where required, there are now no batteries outside the manufacturer's design life. The overall condition of the battery population is very good. In some installations, where heat is excessive and cannot be controlled, the batteries are replaced earlier than usual due to thermal deterioration.

Battery chargers are generally in good condition. The majority have SCADA supervision and the Control Room can know if the output has failed and initiate a swift repair. One charger failed during 2010. It was able to be repaired by the local vendor and a spare charger was installed for the duration of the repair.

### 6.4.4.3. Renewal and Refurbishment

Batteries are replaced using VRLA batteries either as they fail, based on condition assessment results, or when they exceed the manufacturers design life. For a number of sites, with higher ampere-hour (Ah) demand, 10 year life batteries are available. For smaller sites, or communications batteries where the ampere-hour demand is lower, batteries are only available with 5 year lives. As part of primary plant replacements, Wellington Electricity is intending to standardise the voltages used for switchgear operation as well as communications equipment.

Following failure of a large number of batteries in 2009, Wellington Electricity undertook a major project to replace 244 battery banks which had exceeded the manufacturers design life. A further 173 banks were replaced during 2010. Going forward all batteries will be replaced every 4-5 years to ensure the standard design life of 5 years is not exceeded. Major replacement will be required again in 2014 and 2015, although the replacement may be staged from 2013 onwards. Battery replacement between 2011 and 2013 will be minor with only around 150 banks requiring replacement (50 per year average).

Battery chargers generally have no serviceable parts, maintenance is limited and they are generally replaced upon failure with spares held locally. Some zone substations have an automated battery charger with supervisory monitoring which will alarm in the event of failure.

### 6.4.5. Switchboards and Circuit Breakers

#### 6.4.5.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on metalclad switchboards and circuit breakers.

| Activity | Description | Frequency |
|---|---|---|
| General Inspection of 33kV Circuit Breaker | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. Handheld PD and Ultrasonic scan. | Annually |
| General Inspection of 11kV Circuit Breaker | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. Handheld PD and Ultrasonic scan. | Annually |
| 33kV Circuit Breaker Maintenance (Oil) | Maintenance of OCB, drain oil, ensure correct mechanical operation, dress or replace contacts as required, undertake minor repairs, refill with clean oil, return to service. Trip timing test before and after service. | 4 yearly |
| 11kV Circuit Breaker Maintenance (Oil) | Withdraw and drain OCB, ensure correct mechanical operation, dress or replace contacts as required, undertake minor repairs, refill with clean oil, return to service. Trip timing test before and after service. | 4 yearly (Zone)<br>5 yearly (Distribution) |
| 11kV Circuit Breaker Maintenance (Vacuum or Gas) | Withdraw CB and maintain carriage and mechanisms as required, record condition of interrupter bottles where possible, clean and return to service. Trip timing test before and after service. | 4 yearly (Zone)<br>5 yearly (Distribution) |
| 11kV Switchboard Major Maintenance (zone) | Full or bus section shutdown, removal of all busbar and chamber access panels, clean and inspect all switchboard fixed portion components, undertake condition and diagnostic tests as required. Maintain VTs and CTs. Return to service. | 8 yearly (Zone)<br>10 yearly (Distribution) |
| 11kV Circuit Breaker - Annual Operational Check | Back feed supply; arrange remote and local operation in conjunction with Network Control Room to ensure correct operation and indication. | Annually<br>(Zone only) |

| Activity | Description | Frequency |
|---|---|---|
| PD Location by External Specialist | External specialist to undertake partial discharge location service, presently HV Diagnostics | Annually (Zone only) |

**Figure 6-16 Inspection and Routine Maintenance Schedule for Zone Substation Circuit Breakers**

In addition to the routine maintenance programme above, oil circuit breakers are maintained as required following a number of fault operations.

#### 6.4.5.2. Switchgear Condition

The switchgear installed on the Wellington Electricity network is generally in very good condition. The equipment has been installed indoors and has not been exposed to extreme operating conditions. Historically it has been well maintained which means that whilst the equipment is old, the majority of it is in good condition. In some locations, the type of load served, or the known risks with the type of switchgear mean that an enhanced maintenance programme is required whilst a replacement programme is undertaken, for example Reyrolle Type C and Yorkshire SO-HI switchgear.

Examples of poor condition assessment outcomes include partial discharge (particularly around cast resin components), corrosion and compound leaks visible externally and also arising from service activities slow or worn mechanisms or unacceptable contact wear. The majority of these observations either do not present a significant risk to the network, or can be easily remedied under Corrective Maintenance programmes.

The condition of zone substation switchboards is considered in the Circuit Breaker "Stage of Life" analysis.


**Testing of an 11kV circuit breaker carriage**

### 6.4.5.3. Renewal and Refurbishment

Based on the condition assessment carried out as part of the preventative maintenance routine, assets are identified for replacement, or targeted inspection and maintenance programmes to manage risks until replacement is possible. A large number of older circuit breakers remain in place and provide good service as they are in excellent condition due to regular maintenance over the majority of their service life. Some of the older units are showing their age with pitch leaks and failing mechanisms.

Condition, performance, ratings and operational history across the industry are considered when determining the timing for replacement of a circuit breaker. However other drivers that influence the decision for replacement include safety, operability and co-ordination with modern equipment.

Following the implementation of the new planned maintenance programme, and the resulting improved condition assessment data, it is expected that by 2012 there will be sufficient data to compile longer term renewal programmes by both equipment make and model (type replacement) and also individual units.

Specific programmes of replacement have been identified for the planning period.

**Reyrolle Type C**

Reyrolle Type C circuit breakers were installed between 1938 and the late 1960's. Therefore the majority of units have reached the end of their effective service life. There are 133 units in service on the Wellington network which are being replaced progressively, prioritised by condition and location. These circuit breakers need to be inspected for leaks (oil, compound) and thermal imaging and partial discharge inspections are undertaken on an annual basis. This inspection programme ensures defects or potential issues are detected early so corrective actions can be taken. Several units are not able to be operated due to mechanical failure. Replacements are based on the following programme:

| Substation | No. of Circuit Breakers | Year installed | Replacement year | Estimated cost (2011) |
|---|---|---|---|---|
| Palm Grove | 11 | 1966 | 2011 | $ 1,500,000 |
| 46 Hania Street | 5 | 1938 | 2011 | $ 380,000 |
| 9 Duncan Terrace | 3 | 1938 | 2011 | $ 180,000 |
| 33 Brooklyn Road | 4 | 1938 | 2011 | $ 340,000 |
| Newtown | 8 | 1941 | 2011 | $ 500,000 |
| Evans Bay | 12 | 1958 | 2012 | $ 1,600,000 |
| Cable Car Lane | 5 | 1950 | 2012 | $ 380,000 |
| Hankey Street | 9 | 1941 | 2012 | $ 550,000 |
| 69 Miramar | 8 | 1954 | 2012 | $ 500,000 |
| 139 Thorndon Quay | 5 | 1954 | 2012 | $ 380,000 |
| Chaytor Street | 7 | 1954 | 2012 | $ 480,000 |

| Substation | No. of Circuit Breakers | Year installed | Replacement year | Estimated cost (2011) |
|---|---|---|---|---|
| Karori | 11 | 1962 | 2013 | $ 1,500,000 |
| Kilbirnie | 9 | 1956 | 2013 | $ 550,000 |
| 9 Parkvale Road | 9 | 1964 | 2013 | $ 550,000 |
| Gracefield | 13 | 1958 | 2014 | $ 1,600,000 |
| Cornwell Street | 5 | 1945 | | $ 380,000 |
| Flag Staff Hill | 5 | 1953 | | $ 380,000 |

**Figure 6-17 Proposed C-type Circuit Breaker Replacement Programme**

**(L) Before and (R) After - Type C replacement at a Wellington Distribution Substation**

**Yorkshire SO-HI**

Yorkshire SO-HI switchgear was installed during the 1970s and 80s in indoor kiosk type substations and there are approximately 130 units in service. SO-HI has a history of failing in service and a number of utilities have removed the equipment entirely, or had operational cautions imposed. The installations in the Wellington Electricity network are in secondary sites and a programme of inspection, testing and bus bar chamber cleaning is being implemented to reduce service failure risks.

Wellington Electricity has imposed an operational restriction on these units so they are not operated manually under fault conditions. The constraint has been evaluated against the potential impact on network performance. Wellington Electricity has reviewed all installations of SO-HI switchgear and in 2011 will initiate a programme of replacement for switch units at sites identified as being higher risk initially, with a view to remove the entire population during the planning period.

The majority of SO-HI installations do not have protective elements enabled or remote control, and the units can be replaced with conventional ring main units. In a few cases the units have full protection and control, and are located on feeders with high cumulative SAIDI. These will be replaced with modular secondary class circuit breakers.

| Replacement solution | No of Sites |
|---|---|
| Single 3/4 way RMU | 25 |
| Duplicate 3/4 way RMUs | 6 |
| Circuit Breakers | 4 |

Figure 6-18 Proposed SO-HI Replacement Quantities

Priority will be given to the following sites based upon location, historic SAIDI, and customer numbers (potential SAIDI and SAIFI).

| Sub No. | Location | Feeder | No. of switches | Customer building | Customers beyond | Feeder SAIDI (10 year) |
|---|---|---|---|---|---|---|
| S2381 | Gower Street | TRE 12 | 3 | YES | 1440 | 4.18 |
| S2559 | Maidstone Mall | MAI 06 | 3 | YES | 750 | 1.45 |
| S3294 | W R Grace A | KEN 9 | 5 | YES | 250 | 0.71 |
| S3183 | Todd Motors | KEN 2 | 14 | YES | 10 | 0.58 |
| S2808 | Park Street B | MAI 12 | 4 | YES | 68 | 0.13 |
| S1066 | Computer Centre | TRE 02 | 4 | YES | 13 | 0.09 |
| S2938 | Horokiwi Road Kiosk | NGA 4 | 5 | NO | 485 | 13.96 |
| S1059 | Whitemans Road | HAY 2722 | 4 | NO | 1311 | 10.19 |
| S2867 | Fraser Avenue No 1 | NGA 9 | 2 | NO | 488 | 4.95 |
| S1036 | Britannia Street | PET 07 | 3 | NO | 462 | 0.28 |
| S3297 | 9 Semple Street | POR 4 | 4 | NO | 152 | 0.12 |
| S2450 | Main Street | MAI 08 | 4 | NO | 621 | 0.00 |

Figure 6-19 Proposed SO-HI Replacement Priority Sites

| Replacement year | No/Type of Sites | Proposed Budget |
|---|---|---|
| 2011 | 5 RMU | $500,000 |
| 2012 | 4 CB | $1,000,000 |
| 2013 | 15 RMU | $1,000,000 |
| 2014 | 15 RMU | $1,000,000 |

Figure 6-20 Proposed SO-HI Replacement Spend Plan

One site (Todd Motors) has a large, mostly unused switchboard following the closure of the motor assembly plant. Negotiation will be required with the new site owner to find the best solution for replacement of the switchgear. It is expected a number of ring main units can be deployed around the site to provide supply. The budget for this site is not finalised at this time.

**Reyrolle LMT - Current Transformers (CTs)**

Reyrolle LMT circuit breakers were installed on the network from 1970 onwards. There are over 400 units in service. Recent partial discharge (PD) testing has indicated potential issues around the CTs / or the CT chamber on units with cast resin encapsulated CTs. Full partial discharge testing (or handheld TEV testing) and corrective maintenance will be completed on all Reyrolle LMT circuit breakers over a 2 year period.

Two sets of CTs were replaced during 2010 with mixed results. In one case the PD was reduced to a normal level, in the other there was no change, and the cast resin monoblock riser (cable box to CT) is suspected to be a likely contributor to PD levels.

Further investigation, as well as replacement work, will improve the knowledge of the partial discharge issues being experienced, and will help develop corrective refurbishment plans for this type of equipment. The estimated average cost of retro-fitting CTs is under $20,000 per set.

### 6.4.5.4. Circuit Breaker “Stage of Life” Analysis

During 2010, a “Stage of Life” analysis was undertaken on all zone substation 11kV switchboards, and a summary of the analysis is provided below.

**Parameters Considered**

The ”Stage of Life” analysis method considers the attributes of each switchboard as defined over three categories, each containing a number of measurable properties. A rating between one and ten is given to each property, with 1 being the most favourable (good) and 10 being the least favourable (bad).

| Category | Property | Rating (normalised) |
|---|---|---|
| Construction | Age | 1 (good) to 10 (poor) |
| Construction | Number of Circuit Breakers | 1 (good) to 10 (poor) |
| Condition | Partial Discharge Testing Results | 1 (good) to 10 (poor) |
| Condition | Internal Condition assessment | 1 (good) to 10 (poor) |
| Condition | Spares availability | 1 (good) to 10 (poor) |
| Utilisation | Loading vs. load rating | 1 (good) to 10 (poor) |
| Utilisation | Fault level vs. fault rating | 1 (good) to 10 (poor) |
| Utilisation | Type of load served | 1 (good) to 10 (poor) |
| Utilisation | Number of ICPs served | 1 (good) to 10 (poor) |

| Category | Property | Rating (normalised) |
|---|---|---|
| Utilisation | 11kV back feed capacity | 1 (good) to 10 (poor) |

Figure 6-21 Categories, Properties and Ratings for Switchboards

The ratings are normalised over all of the switchboards so that they can be used as a direct comparison between switchboards. Ratings are then weighted, as some properties have a greater impact on stage of life than others. The properties along with the ratings and weightings applied to them for are described in detail below.

**Category Scores**

The weightings allocated to each of the three main categories of construction, condition and utilisation is as follows:

| Category | Weighting |
|---|---|
| Construction | 20% |
| Condition | 20% |
| Utilisation | 60% |

Figure 6-22 Category Weightings

The categories have been given these weightings on the basis that utilisation, in particular, will be one of the main drivers for remedial action to be taken on a switchboard. Wellington Electricity cannot operate equipment outside its ratings, or have underrated equipment that will affect the proper working of the system.

Construction and condition have equal weightings of 20% each, as neither by itself would be a major driver for remedial attention. Wellington Electricity has a number of medium sized switchboards in service in distribution substations that are over 60 years old. Minor defects or deteriorating condition alone can generally be resolved by partial replacement or increased levels of corrective maintenance. However when combined with high utilisation scores, construction and condition become more important in determining risks associated with each switchboard.

Applying these weightings to the normalised scores from each category allows an overall score to be derived for each switchboard, in turn giving a priority ranking.

| Substation name | Switchboard type | Construction score | Condition score | Utilisation score | Total score |
|---|---|---|---|---|---|
| Frederick Street | LM23T | 7.4 | 5.8 | 9.2 | **8.2** |
| Palm Grove | C | 9.0 | 6.5 | 8.2 | **8.0** |
| Evans Bay | C | 9.3 | 8.0 | 6.7 | **7.5** |
| University | LMT | 5.6 | 4.8 | 8.5 | **7.2** |
| Moore Street | LM23T | 8.6 | 4.8 | 7.2 | **7.0** |

| Substation name | Switchboard type | Construction score | Condition score | Utilisation score | Total score |
|---|---|---|---|---|---|
| Hataitai | LM23T | 8.8 | 3.8 | 7.4 | **6.9** |
| Kaiwharawhara | LMVP | 4.8 | 3.8 | 8.7 | **6.9** |
| Karori | C | 9.1 | 8.5 | 5.5 | **6.9** |
| Gracefield | C | 9.4 | 6.5 | 5.6 | **6.5** |
| Johnsonville | LM23T | 8.6 | 3.8 | 6.7 | **6.5** |
| Nairn Street | LMT | 7.1 | 4.8 | 6.8 | **6.4** |
| Porirua | LM23T | 9.3 | 4.8 | 5.7 | **6.2** |
| Waterloo | LMT | 8.0 | 2.8 | 6.7 | **6.2** |
| Tawa | LM23T | 8.8 | 5.8 | 5.2 | **6.0** |
| Ira Street | LM23T | 8.0 | 3.8 | 6.1 | **6.0** |
| Seaview | LM23T | 8.9 | 2.8 | 5.9 | **5.9** |
| Brown Owl | LM23T | 8.6 | 4.8 | 5.2 | **5.8** |
| Waikowhai | LMT | 8.3 | 1.8 | 6.2 | **5.7** |
| Naenae | LM23T | 8.9 | 2.8 | 5.5 | **5.7** |
| Waitangirua | LM23T | 8.8 | 4.8 | 4.7 | **5.5** |
| Petone | LM23T | 9.0 | 2.8 | 5.2 | **5.5** |
| Wainuiomata | LMT | 8.7 | 2.8 | 5.1 | **5.4** |
| Maidstone | LM23T | 8.9 | 3.8 | 4.5 | **5.2** |
| Korokoro | LM23T | 8.1 | 3.8 | 4.6 | **5.1** |
| Kenepuru | LM23T | 8.3 | 2.8 | 4.8 | **5.1** |
| Terrace | NX-PLUS | 2.9 | 2.0 | 6.6 | **4.9** |
| Titahi Bay | LMT | 8.0 | 4.8 | 3.8 | **4.8** |
| Trentham | LM23T | 9.4 | 3.8 | 3.6 | **4.8** |
| Mana | LM23T | 6.2 | 4.8 | 4.1 | **4.7** |
| Plimmerton | LM23T | 7.4 | 3.8 | 3.6 | **4.4** |
| Ngauranga | LMT | 4.2 | 4.8 | 3.1 | **3.6** |

Figure 6-23 Stage of Life Category Scores

**Top ranked switchboards**

The top five ranked switchboards which have been identified as being in need of attention are:

| Switchboard | Ranking (1st = highest priority) |
|---|---|
| Frederick Street | 1st |
| Palm Grove | 2nd |
| Evans Bay | 3rd |
| University | 4th |
| Moore Street | 5th |

Figure 6-24 Stage of Life Ranking of Zone Substation Switchboards

Frederick Street and University rank highly due to high utilisation scores. This is reflective of the loading and high fault levels when operated as a closed bus. Palm Grove and Evans Bay score highly due to construction and condition scores. Moore Street has a medium Construction score, and a medium Utilisation score reflecting its age as well as loading, fault rating and type of load served.

**Outcome of "Stage of Life" Analysis**

**Frederick Street**

Frederick Street features highly in this analysis as a result of its utilisation score. It has a loading of over 30MVA, and supplies over 8,000 consumers in the CBD area. Being a CBD substation, the bus is operated split, reducing the prospective fault level. However under some switching conditions it is likely to exceed its fault rating. It is generally in sound condition, apart from some identified partial discharge activity around the CTs which is most likely to be resolved under corrective maintenance. This switchboard features highly due to the consequence of failure.

This switchboard may be a suitable candidate for a retrofit upgrade using new components from RPS Switchgear to improve load and fault ratings. Early LM23T boards such as this have been re-rated by the manufacturer to 25kA based upon the fixed portion design. The replacement of circuit breaker carriages is required to achieve this rating, and new blast protection panels provide improved safety. At Frederick Street specifically, the installation of vacuum circuit breakers, improved protection with arc-flash detection, and replacement of the double 1200A incomer arrangement with single 2000A incomers will see the rating issue reduced.

The Frederick Street 11kV reinforcement project presently underway will move some load away from this site, improving its utilisation score as the loading will be reduced. A re-scoring of the switchboard will be undertaken once the load transfer has occurred and a new load figure is known.

**Palm Grove**

Palm Grove switchboard is one of the oldest on the network and is Reyrolle Type C switchgear. It scores highly on both construction and utilisation scores, as it is at the end of its technical life. It is also heavily loaded and has inadequate fault rating for closed bus operation. Spares availability is poor, although there are no major or reoccurring issues identified with this switchboard.

Given the age of the equipment and limited ratings, this switchboard is a suitable candidate for replacement, and is recommended to the first switchboard to be replaced on the network in the short term. A replacement project is budgeted to commence in 2011 for an estimated cost of $1,500,000.

**Evans Bay**

Evans Bay is the oldest 11kV zone substation switchboard on the network, having been installed in 1958. It is past the end of its technical life and as a result scores highly in construction. The condition score is also high as it has limited spares and has a history of mechanical faults and poor tests. These condition scores are offset by the low utilisation score, as the number of ICPs, the type of load served and the overall loading are moderate.

This switchboard is also a suitable candidate for replacement following Palm Grove, due to age and condition. However following the removal of the Palm Grove substation, the spares availability will increase and with some clever swapping of circuit breakers the condition score may be reduced. Following the Palm Grove replacement, should it proceed, the Evans Bay score will need to be re-evaluated.

**University**

University has relatively modern switchgear compared to the majority of Wellington Electricity zone substations, having been installed in 1988. The utilisation factor on this substation is the main reason it is included in the top five list. The substation has a fault level under closed bus situations that exceeds the fault rating of the switchgear, as well as supplying CBD load. The loading level is moderate.

This substation does not need switchgear replacement at the present time as the age and condition is good, however operational restrictions regarding the closed bus need to be observed. Following the evaluation of retrofit upgrades and re-rating at Frederick Street this may be able to be applied to University to improve fault ratings.

**Moore Street**

Moore Street scores highly due to both its construction (age, and number of circuit breakers), as well as its utilisation, as it supplies CBD load, is heavily loaded and has inadequate fault rating under closed bus operation. The condition score is low, therefore indicating few issues with the switchgear given its age.

A number of options exist for Moore Street, however as it is ranked fifth, investigation work at other substations, particularly around re-rating the fault level may allow an alternative to replacement at this site.

### 6.4.6. Substation Protection Relays

#### 6.4.6.1. Maintenance Activities

The following routine planned testing and maintenance activities are undertaken on protection relays.

| Activity | Description | Frequency |
|---|---|---|
| Protection Testing for Electromechanical Relays | Visual inspection and testing of relay using secondary injection. Confirm as tested settings against expected settings. Update of test record and results into Protection Database | 2 yearly (Zone)<br>4 yearly (Distribution) |
| Protection Testing for Numerical Relays | Visual inspection, clearing of local indications, and testing of relay using secondary injection. Confirm as tested settings against expected settings. Confirm correct operation of logic and inter-trip functions. Update of test record and results into Protection Database | 2 yearly (Zone)<br>4 yearly (Distribution) |
| Numerical Relay Battery Replacement | Replacement of backup battery in numeric relay | 2 yearly (Zone)<br>4 yearly (Distribution) |

**Figure 6-25 Inspection and Routine Maintenance Schedule for Zone Substation Protection Relays**

Regular testing of protection relays is undertaken to determine correct operating functionality. Protection relay testing will continue on a regular basis and budgetary provision for this has been made in the maintenance expenditure projections.

The key focus of protection relay maintenance is to identify any equipment that is not operating correctly or has failed. In order to maintain network reliability performance it is necessary to identify these issues before a failed or mal-operating protection relay is required to operate. This is especially relevant with the large number of older electromechanical relays on the network.

Testing of the large number of differential relays on the network (Reyrolle SOLKOR, or similar) also serves to test the copper pilot cables between substations. Upon a failed test, the protection circuit is either moved to “healthy” pairs on the pilot cable, or the cable is physically repaired. Due to deteriorating outer sheaths on pilot cables, some early pilot cables are now suffering from moisture ingress and subsequent degradation of insulation quality. A grease filled pilot joint is now being used to block moisture from spreading though entire sections of cable.

Numerical relays, although equipped with self-diagnostic functions, are tested as shown in the table above. With more complex protection schemes coming into service, these need to be tested to ensure the correct functions and logic schemes are still operating as expected.

### 6.4.6.2. Renewal and Replacement

The majority of electromechanical relays are approaching the end of their technical life and ideally should be replaced over the next 10 years. However the economic impact of replacement with modern numerical protection relay equivalents is being carefully considered. Therefore, the replacement programmes that are in place generally focus on relay condition and coordination with other replacement programmes or projects especially for assets such as switchgear and transformers. At the time of primary equipment replacement the opportunity is taken to upgrade associated protection schemes to meet the current standards because the relays are usually mounted within switchgear panels as an integral system. To date, electromechanical relays have provided reliable service and are expected to remain in service for the life of the switchgear it controls – generally greater than 40 years. For newer numeric relays, it is not expected that the relay will provide the same length of service and a service life of less than the ODV standard life is expected.

The following programmes and projects have been allowed in the asset replacement and maintenance budgets.

- Ongoing replacement of PBO relays in conjunction with switchgear replacements in the short term, or individually where known risks exist. Sites with PBO relays will be identified in the maintenance programme over the next two years, and any replacement programme determined from then.
- There are around 10 Nilstat relays still in service which will need to be replaced, however they are in a Reyrolle Type C switchboard, so total replacement will occur in the short term (switchboard scheduled for replacement in 2014) and an individual replacement project is not justified.
- Ongoing zone substation and network protection and control replacement/upgrades for assets supplied from GXPs, particularly Takapu Rd, Haywards, Gracefield, Upper Hutt and Wilton as part of upgrades Transpower may undertake.
- Ongoing protection and control replacements/upgrades across the network as identified by asset condition monitoring.

### 6.4.7. Load Control Equipment

#### 6.4.7.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on load control equipment. Wellington Electricity owns the injection plants located at substations and blocking cells at GXPs, but not any of the consumer receivers. As such the full end to end testing of the ripple system is not possible.

| Activity | Description | Frequency |
|---|---|---|
| General Inspection | Check output signal, visual inspection, thermal image and partial discharge scan, motor generator test run | 6 monthly |
| Maintain Ripple Injection Plant | Clean and inspect all equipment, maintain motor generator sets, coupling cell test and inspection | Annually |
| Blocking Cell Testing and Maintenance | Visual inspection, cleaning and maintenance of ripple blocking cells at GXPs as required | 5 yearly |

Figure 6-26 Inspection and Routine Maintenance Schedule for Ripple Plant

#### 6.4.7.2. Renewal and Refurbishment

Wellington Electricity has no short terms plans to replace any ripple injection plant due to age or condition. Repairs and maintenance are undertaken as required, and the plant is generally reliable. Basic spares are held locally. In late 2010 when a power module failed in an Enermet ripple plant, spares were air freighted from Europe in a little over a week from an aftermarket parts supplier. This was an acceptable time to repair due to redundancy on the network.

In the Hutt Valley area, interconnectivity at 11kV allows ripple signal to be provided from adjacent substations in the event of failure. In the Wellington city area, there is dual plant located to supply each of the GXPs at 33kV, with two 11kV plants supplying the Kaiwharawhara 11kV point of supply.

In the medium term, Wellington Electricity will look to replace older rotary plant installed on the 11kV system in the Hutt Valley and Porirua areas as these assets are approaching the end of their service life. It is likely that replacement may involve rationalisation of plant by installing larger plant at GXP level, using modern low frequency ripple signals, rather than high frequency injection at Zone Substation level. Whilst technically straightforward it may become a complex issue involving retailers and meter/relay asset owners.

The ripple control injection plant for the Central Park GXP area is a Brown-Boveri plant located at the Frederick Street zone substation and comprises two units operated in parallel. With one unit out of service, ripple signal strength is marginal in some parts of the network. This matter has been investigated and it is related to the increased load on the Central Park 33kV bus following the reconfiguration of supply to The Terrace substation from Central Park (previously from Wilton GXP), and the moving of the Central Park 11kV point of supply (Nairn St substation) transformers from the 110kV bus to the 33kV bus. The installation of a larger plant connected to the Central Park 33kV bus is not necessarily the best option. A move to a modern low frequency plant (resulting in better signal propagation) would involve changing adjacent GXPs to the same frequency to ensure ripple control is available under any supply configuration. The overall solution for this area is still being developed, although investment will be required within the planning period.

### 6.4.8. Poles and Overhead Lines

#### 6.4.8.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on poles and overhead lines.

| Activity | Description | Frequency |
|---|---|---|
| Inspection and condition assessment overhead lines by zone/feeder | Visual inspection of all overhead equipment including poles, stay wires, crossarms, insulators, jumpers and connectors, switchgear and transformers. All HV and LV circuits by feeder. Recording and reporting, and minor repairs as required. | Annually |
| Concrete and steel pole inspections and testing | Visual inspection of pole, tagging and reporting of results. | 5 yearly |
| Wooden pole inspections and testing (Deuar) | Visual inspection of pole, testing and analysis of pole using Deuar MPT40 test, tagging and reporting of results. | 5 yearly |
| LFI inspections | Visual inspection of line fault passage indicator, testing in accordance with manufacturer recommendation. | Annually |
| LFI battery replacement | Removal of unit, assessment of condition and replacement of onboard battery, replacement onto live line using hot stick. | 8 yearly |

Figure 6-27 Inspection and Routine Maintenance Schedule for Poles and Overhead Lines

All overhead lines get an annual, visual inspection to determine any immediately obvious issues with the lines, condition of components such as crossarms and insulators, and to note any prospective vegetation, third party encroachments or safety issues. In addition, all connectors in the current carrying path get a thermal scan to identify any high resistance joints which may fail. These inspections drive a large part of the overhead corrective maintenance works, as well as contribute to asset replacement programmes for insulators and crossarms.

Soon after taking ownership of the Wellington network, Wellington Electricity identified shortcomings in the regular pole inspection and testing method being used on the network and initiated a review of industry practice with respect to pole inspections. This review was undertaken for the purpose of helping to define the options available for a regular pole inspection programme, with a particular focus on how wooden poles are inspected. The review concluded that any inspection method should include a test of the below ground condition of wooden poles and that the existing standard for pole inspection should be modified.

Three different methods for inspecting wooden poles were reviewed, namely:

- Digging around the pole to expose and allow inspection below ground level
- Pole Scan and Mole probe test
- Mechanical strength test using the Deuar MPT40 partial loading system.

Of the three methods reviewed, it was concluded that the Deuar MPT40 best satisfies the need for objectivity, repeatability and accuracy. This conclusion is supported by independent analysis and referees.

The next stage of implementing a new pole inspection method involves confirming commercial arrangements with the vendor and procuring licenses and test equipment. Once these steps are competed, operator training will take place and the programme will be initiated. The target for having the revised inspection programme in place is early 2011.

In the interim period, poles identified from previous tests with less than half their remaining strength are being retested and replaced as required.

#### 6.4.8.2. Pole Condition

The poles on the Wellington Electricity network are generally in good condition as a large scale testing and replacement programme occurred between 2004 and 2006. Around half the poles are concrete, which are durable and in good condition. The remainder are timber poles which are tested and replaced in accordance with their serviceability index and visible structural defects.

Common condition issues with timber poles are deterioration of pole strength, either through internal or external decay, leaning poles, head splits and third party damage.

Common condition issues with concrete poles include cracks, spalling (loss of concrete mass due to corrosion of the reinforcing steel), leaning poles and third party damage.

A significant contributor to leaning poles on the Wellington network is third party attachments. There is an existing agreement to support telecommunications cables from TelstraClear and Telecom on network poles, and in some areas the additional loading exceeds the designed foundation strength leading to slight leaning of poles across the network. Many of these can be remedied with corrective maintenance to straighten the pole and improve the foundation design through blocking or compacting course metal around the pole base.

### 6.4.8.3. Overhead Line Condition

All new insulators are of the solid core post type as they provide a higher level of reliability in polluted environments and lightning prone areas than the pin type insulator historically used on the network. Pin type insulators are no longer used for new 33 kV or 11 kV line construction. There is no programme to proactively replace existing pin type insulators. This will occur under system maintenance or when crossarms require replacement.

High wind loadings can sometimes result in fatigue failures around line hardware such as compression sleeves, line guards and armour rods on the older All Aluminium Conductor (AAC) lines that have historically been used on the Wellington network. Recent incidents have also shown fatigue problems with fittings supporting strain points. Conductor fatigue issues such as these can not be visually detected, therefore it is proposed to take a sample of conductor and components from service and have these analysed by materials scientists to determine remaining asset life in order to plan for a proactive replacement program. Where a conductor issue is identified, All Aluminium Alloy Conductor (AAAC) will be used as a replacement material due to its increased strength and improved fatigue resistance.

It should be noted that steel reinforced conductors have not been widely used in the Wellington region due to high salt pollution causing shortened service life from corrosion of the steel core.

During 2010 it was observed that a number of Fargo sleeve type automatic line splices were failing in service. These sleeves are only suitable for a temporary repair and in some cases had been in service for over 10 years. The failure of these caused lines to fall and resulted in feeder faults. These are no longer used on the network and, where large quantities are found in a line, they will be replaced with compression type full tension sleeves or the area will be re-conductored.

### 6.4.8.4. Renewal and Refurbishment - Lines

In early 2010 a section of overhead line was replaced in the Korokoro area as this was prone to high winds and had suffered fatigue related failures. A larger area in Korokoro will be re-conductored during 2011 as a result of a network performance project, details of this are later in this section.

Also during late 2010, due to poor overhead network performance, a large section of the Ngauranga 4 feeder was rebuilt, including poles, crossarms, conductor and several pole mounted distribution transformers. The LV conductors were not replaced as these were assessed to be in acceptable condition.

It is likely that similar reconductoring or area rebuild projects will occur as further issues arise on the network, or where there are increased instances of conductor or component failure. This work usually involves sections of line of only a few hundred metres up to several kilometres. Details of prospective overhead network renewal and refurbishment projects are covered later in this section under Feeder Performance.

### 6.4.8.5. Renewal and Refurbishment - Poles

Following inspection of poles, and failing the serviceability test, they are categorised as red tagged, or yellow tagged. Red tagged poles have a serviceability index of less than 0.5 or have a major structural defect, and are programmed for immediate replacement (6 weeks). Yellow tagged poles have a serviceability index of 0.5 to 1.0, or have moderate structural defects, and are programmed for replacement within 6 months. Crossarms are identified for replacement from the detailed line inspections.

With the introduction of the Deuar pole testing methodology, it is expected that a better assessment of pole strength and remaining life will occur and that pole replacements will decrease over time, and that the poles that are replaced are the most “at-risk” on the network.

Concrete poles are replaced following an unsatisfactory visual inspection, with large cracks, structural defects, spalling or loss of concrete mass. All replacement poles are concrete, except where the location requires the use of timber for weight, access constraints or loading design.

It is expected that if a third party user of the poles wishes to extend their existing network or use Wellington Electricity’s overhead network as a carrier, such as a telecommunications company stringing aerial fibre optic cables, an assessment of existing poles will be required. Replacement will need to occur where design strength parameters are exceeded or height clearance issues are encountered.

Replacement of an aged timber pole with a new concrete pole

### 6.4.9. Overhead Switches, Links and Fuses

#### 6.4.9.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on overhead switches, links and fuses.

| Activity | Description | Frequency |
| --- | --- | --- |
| Visual Inspection and Thermal Image | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. | Annually |

| Activity | Description | Frequency |
|---|---|---|
| ABS Service | Maintain air break switch, clean and adjust contacts, check correct operation. | 3 yearly |
| HV Knife Link Service | Maintain knife links, clean and adjust contacts, check correct operation. | 3 yearly |
| Gas Switch Service | Maintain gas switch, check and adjust mechanism as required. | 9 yearly |
| Remote Controlled Switch - Annual Operational Check | Bypass unit or back feed, arrange remote and local operation in conjunction with Network Control Room to ensure correct operation and indication. | Annually |
| Inspection and Testing of Earthing | Visual inspection of earthing system installation and mechanical protection, testing of individual and combined earth bank resistance. | 5 yearly |

**Figure 6-28 Inspection and Routine Maintenance Schedule for Overhead switch equipment**

All overhead switches and links are treated in the same manner, and are maintained under the preventative maintenance programme detailed above. Overhead HV fuses are visually inspected during both the annual overhead line survey and also at the time of transformer maintenance (for fuses supplying overhead transformers), however the large quantity and low risks associated with fuses does not justify an independent inspection and maintenance programme. Remote controlled overhead switches are operationally checked annually to ensure correct operation and indication, from both local and remote (SCADA) control points.

#### 6.4.9.2. Condition of overhead switches, links and fuses

Generally, the condition of overhead equipment on the Wellington network is good. The environment subjects equipment to wind, salt spray, pollution and debris which causes a small number of units to fail annually. Common modes of deterioration are corrosion of steel frame components and operating handles, mechanical damage to insulators, as well as corrosion and electrical welding of contacts. In harsh environments, fully enclosed gas insulated switches with stainless steel components are now being used.

A problem has previously been identified with some types of expulsion drop out (EDO) fuses that are overheating, which as a result of the use of different metals is causing the pivot point on the fuse holder to seize and this is preventing the fuse holder from operating as designed. The situation is being monitored and, if warranted, a replacement programme will be put in place.

The coastal environment around Wellington causes accelerated corrosion on galvanised overhead equipment components and where possible, stainless steel fittings are preferred as they have proven to provide a longer component service life.

#### 6.4.9.3. Renewal and Refurbishment

There is no proactive programme to replace overhead switchgear or devices. Any renewal activity on these assets is driven from standard inspection rounds and resultant maintenance activities from the identification for corrective work. With the extensive pole and crossarm replacements undertaken over recent years, a large number of overhead switches have been replaced. Replacement generally occurs at the time of pole or crossarm replacement if the condition justifies replacement.

A small allowance is made in the CAPEX programme for HV switchgear replacement which funds any required replacements that do not occur in conjunction with other projects.

### 6.4.10. Auto Reclosers and Sectionalisers

#### 6.4.10.1. Maintenance Activities

The following routine planned inspection, testing and maintenance activities are undertaken on auto reclosers and sectionalisers.

| Activity | Description | Frequency |
|---|---|---|
| Visual Inspection and Thermal Image | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. | Annually |
| Recloser and Sectionaliser - Annual Operational Check | Bypass unit or back feed, arrange remote and local operation in conjunction with Network Control Room to ensure correct operation and indication. | Annually |
| Recloser & Sectionaliser Service | Maintenance of recloser, inspect and maintain contacts, change oil as required, prove correct operation | 3 yearly |
| Inspection and Testing of Earthing | Visual inspection of earthing system installation and mechanical protection, testing of individual and combined earth bank resistance | 5 yearly |

Figure 6-29 Inspection and Routine Maintenance Schedule for Auto Reclosers and Sectionalisers

#### 6.4.10.2. Condition of auto reclosers and sectionalisers

The majority of the units in service are in good condition. From inspection activities the bases of a number of units have surface corrosion that can be addressed under the corrective maintenance programme. Testing of some recloser units in-situ is limited, and it has been found that several McGraw-Edison KFE reclosers have not been working as intended. One unit was replaced in 2010 and another is under investigation to be replaced in 2011.

The operational performance of auto reclosers is evaluated from fault information, which indicates whether the unit performed as expected.

#### 6.4.10.3. Renewal and Refurbishment

Presently there are no programmes underway to replace auto reclosers as there are no major issues with the majority of the assets. In recent years there have been reliability and automation projects undertaken, and as a result there are appropriately placed reclosers and sectionalisers in service.

During 2011, one KFE recloser (Army Magazine recloser) on Trentham 8 feeder is likely to be replaced following further investigation. Other KFE reclosers are likely to be replaced should more be found to fail to operate and are not able to be repaired economically.

Reyrolle OYT reclosers are now beyond their service life, and some have been known to mal-operate, leading to the zone substation feeder tripping. Upon re-energisation of the feeder the recloser continues its cycle and trips again. These units are simply replaced when this is found due to their age.

Other units will be replaced as required following unsatisfactory inspection or testing, or if the units are found to not operate correctly in service.

### 6.4.11. Voltage Regulators

#### 6.4.11.1. Maintenance Activities

The following routine planned inspection and maintenance activities are undertaken on voltage regulators.

| Activity | Description | Frequency |
|---|---|---|
| Visual Inspection and Thermal Image | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. | Annually |
| Inspection and Testing of Earthing | Visual inspection of earthing system installation and mechanical protection, testing of individual and combined earth bank resistance. | 5 yearly |

Figure 6-30 Inspection and Routine Maintenance Schedule for Voltage Regulators

#### 6.4.11.2. Renewal and Refurbishment

Wellington Electricity has only one voltage regulator in service, operating at 400V. There are no plans to renew this in the short term. Replacement will be driven by unsatisfactory performance in service, or if inspection and maintenance programmes identify major issues. When the time comes to replace this unit, an 11kV reinforcement project will be considered to alter the 400V circuits in the area, eliminating the need for the voltage regulator.

During 2010 the only 11kV voltage regulator on the network, located at Pukerua Bay, was removed due to poor condition. This unit was past the end of its technical life. It had been installed prior to the Plimmerton zone substation being built and network modelling indicated it was no longer required to maintain voltage in that location.

### 6.4.12. HV Distribution Substations and Equipment

#### 6.4.12.1. Maintenance Activities

The following routine planned inspection and maintenance activities are undertaken on distribution substations and associated equipment.

| Activity | Description | Frequency |
|---|---|---|
| Inspection of Distribution Substations | Routine inspection of distribution substations to ensure asset integrity, security and safety. Record and report defects, undertake minor repairs as required. Record MDIs where fitted. | Annually |

| Activity | Description | Frequency |
|---|---|---|
| Grounds maintenance - Lump sum | General programme of grounds and building maintenance for distribution substations | On going |
| Fire Alarm Test | Inspect and test passive fire alarm system | 3 monthly |
| Visual Inspection and Thermal Image<br>(Ground Mount Transformer) | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. Handheld PD and Ultrasonic scan. | 2 yearly |
| Visual Inspection and Thermal Image<br>(Pole Transformer) | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. | 2 yearly |
| Inspection and Testing of Earthing | Visual inspection of earthing system installation and mechanical protection, testing of individual and combined earth bank resistance | 5 yearly |

**Figure 6-31 Inspection and Routine Maintenance Schedule for HV Distribution Substations and Transformers**


**Typical Wellington Distribution Substation (Compact Berm type)**

| Activity | Description | Frequency |
|---|---|---|
| Visual Inspection of Switchunit | Visual inspection of equipment, and condition assessment based upon visible defects. Thermal image of accessible connections. Handheld PD and Ultrasonic scan. | Annually |

| Activity | Description | Frequency |
|---|---|---|
| Switchunit Maintenance (Magnefix) | Clean and maintain Magnefix unit, inspect and replace link caps as required, test fuses, check terminations where possible. | 5 yearly |
| Switchunit Maintenance (Oil Switch) | Clean and maintain oil switch unit, drain oil and check internally, check terminations and cable compartments. Ensure correct operation of unit. Refill with clean oil. | 5 yearly |
| Switchunit Maintenance (Vacuum or Gas Switch) | Clean and maintain switch unit, check terminations and cable compartments. Ensure correct operation of unit. Check gas / vacuum levels. | 5 yearly |

Figure 6-32 Inspection and Routine Maintenance Schedule for HV Switch Units

#### 6.4.12.2. Distribution Switchgear Condition

The switchgear installed on the Wellington Electricity network is generally in good condition and comprises both oil and gas insulated ring main units, as well as solid resin insulated equipment. Routine maintenance addresses the majority of minor defects, and on occasion a unit requires replacement when the condition is unacceptable. Common condition issues experienced include mechanical wear, both of the enclosure/body as well as operating mechanisms, electrical discharge issues or poor oil condition and insulation levels.

Some specific condition issues are noted below:

**Solid Insulation Units - Magnefix/Krone**

Magnefix switchgear is cleaned five-yearly, with targeted cleaning for a number of sites undertaken more frequently as a corrective maintenance activity. Magnefix switchgear is generally reliable however there are specific cleaning requirements to avoid tracking problems associated with the resin body casing due to the accumulation of dust and other deposits.

There have been recent experiences of Magnefix failures on the network due to a suspected termination failure mode. It is believed that the early style “figure 8” connectors on some older units (typically installed between 1968 and 1975) fail under heavy loads due to heating and thermo-mechanical problems. The failures have all been experienced on residential feeders with recent load growth, during the winter evening peak. A survey of older units has shown a number with low or leaking termination grease levels which may be a physical sign of heating in the connector. These units are prioritised for termination replacement using new connectors and heatshrink terminations if evaluation indicates the unit does not need replacement due to age, other conditions or operational factors.

**Andelect SD Series 1**

There is presently an operational restriction on Series 1 SD switchgear. This equipment is being replaced when it is identified as requiring defect repairs, or when opportunities exist to replace it in conjunction with other distribution assets. There have been no failures on this network with this type of equipment; however replacement due to age and known issues is prudent. Following a complete condition assessment as part of the 2011 inspection programme, the overall condition of these units will be known and a prioritised replacement programme will be established to replace these during the planning period.

**Statter, and Long and Crawford**

There are a number of Statter and Long and Crawford type ring main switches installed on the Hutt Valley network. These have been installed in outdoor cage substations and are subject to harsh environments. Where possible these are being replaced in conjunction with other distribution upgrades due to age and condition. Some networks have experienced catastrophic failures of early Statter switches in outdoor environments.

### 6.4.12.3. Renewal and Refurbishment

**HV Distribution Switch Gear (Ground Mounted)**

Note – This section excludes circuit breakers which are discussed in a previous section.

Any minor defects or maintenance issues are addressed on-site during inspections. This may include such maintenance as topping up oil reservoirs, replacing bolts, rust treatment and paint repairs. Major issues that cannot be addressed on site usually result in replacement of the device. Likewise, replacement of the device is carried out if it is unsafe or if it is uneconomic or impractical to undertake a repair on site. Wellington Electricity has an ongoing refurbishment and replacement programme for all ground mounted distribution switchgear. Provision is included in the asset replacement forecast to fund this programme. The drivers for replacement of ground mounted switchgear include:

- The assessed condition of the equipment
- The availability of spare parts
- The switchgear insulating medium
- The location on the network and consequence of failure.

The continued use of oil insulated switchgear has been reviewed and the decision made to make use of other types such as vacuum or gas ($SF_6$) insulated types in future. When any switchgear device fails, the reason for the failure is studied and followed up with a cost benefit analysis to determine the best option from repairing, refurbishing, replacing or decommissioning the device and others of the same type. There are several types of ring main switch that have identified issues around age, condition and known operational or historic issues. These include early Reyrolle oil switches (LDI, JKSS, IA18), AEI, Statter, Long and Crawford, and early Andelect switches. These will be replaced based on the risks associated with each type, and summarised later in the document (these programmes are in addition to the annual budget for switch replacement).

**Low Voltage Distribution Switch Gear (Substation)**

Low voltage distribution switchgear and fusing is maintained as part of routine substation maintenance and any issues arising are dealt to at that time. The Wellington city area has a large number of open LV distribution boards in substations, and a safety programme has been undertaken to cover these with clear Perspex covers, as additional sites are identified they are completed, with a small annual allowance made to capture and sites missed in the original programme.

The overall performance of LV distribution switchgear and fusing is good and there are no programmes underway to replace this equipment. All new installations use DIN-style fuse disconnectors which are safe, reliable and low maintenance.

**Distribution Transformers**

If a distribution transformer is found to be in an unsatisfactory condition during its regular inspection it is programmed for corrective maintenance or replacement. An in-service transformer failure is rare and if it should occur it is investigated to determine the cause. Based on this assessment a decision is made to repair, refurbish, or scrap the unit. Typical condition issues include rust, heavy oil leaks, integrity and security of the unit. Some minor issues such as paint, spot rust and small leaks can be repaired and the unit will be returned to service on the network. The refurbishment and replacement of transformers is an ongoing programme, which is provided for in the asset maintenance and replacement budget, however it is undertaken on a needs basis (condition, loading, etc) arising from inspection rather than by age.

In addition to the transformer unit itself, the substation structures and associated fittings are inspected and replaced as need be. Examples include distribution earthing, substation canopies and kiosk buildings. Some renewal may be costly and time consuming as a large number of berm substations in the Hutt Valley area are an integral substation manufactured during the 1970s and 80s by the likes of Tolley Industries. Replacement of these units will require complete foundation replacement and extensive cable works.

Wellington Electricity now uses a canopy type substation with independent components (LV switchgear, HV switchgear and transformer) as a standard, as opposed to integral substations. This allows for component replacement or upgrade, or canopy replacement, without affecting the entire installation and will reduce the overall life cycle cost.

Wellington Electricity is also reviewing the construction standards for overhead transformers. Previously, transformers up to 300kVA were mounted on overhead structures. A number of electricity lines businesses have made a move away from mounting transformers above 150kVA due to seismic and safety concerns. It is recognised that the present standards may change following review.

**Distribution Cables**

Maintenance of the underground distribution cable network is limited to visual inspections and thermal imaging of cable terminations. Cables are operated to failure and then either repaired or sections replaced. A more intensive maintenance regime is not considered cost effective, given that the network is generally designed so that supply can be maintained while cable repairs are undertaken.

A known issue on the 11kV network is a type of joint kit installed on early XLPE cables between 1980 and 1983 that did not adequately seal between XLPE and PILC cables on the outer sheath. These have been mostly remedied, however some may still exist. No active programme is in place to test or repair these joints however it is noted and in time if performance deteriorates then a programme may be initiated.

Cable replacements are prioritised based on a combination of fault history and frequency together with tests undertaken after earlier cable fault repairs. Cable replacements will be targeted at cables exhibiting high fault rates, or showing poor test results following a repair. The small number of natural polyurethane insulated cables is most likely to show high failure rates and hence this type of cable is more likely to be replaced following a cable fault. An allowance is made each year in the CAPEX programme to replace cable based upon historic trends and known defects.

**Cable Terminations**

Cable termination replacement is driven by visual inspection, either showing signs of discharge, or significant compound leaks, as well as analysis of fault rates. The exception to this is 11kV cast metal pothead terminations where analysis of fault rates, together with a risk assessment, has resulted in a decision to replace them with heat shrink terminations.

During recent years, there has been an increase in the number of older outdoor heatshrink terminations that have failed in-service. This is not yet a major concern as only a couple fail each year. Upon examination of the failed asset it appears that workmanship is often the cause, with sealing mastic at the lug end of each phase not appropriately applied, or the heatshrink not adequately shrunk down or cut back too far. Over time moisture ingress occurs and eventually the termination blows out at the crutch. The terminations were all in excess of 15 years old, and the heatshrink material had not failed. Reminders and training refreshers are given to staff following such findings.

### 6.4.13. Low Voltage Pits and Pillars

#### 6.4.13.1. Maintenance Activities

The following routine planned inspection and maintenance activities are undertaken on low voltage pits and pillars, either for consumer service connection and fusing, or network low voltage linking.

| Activity | Description | Frequency |
|---|---|---|
| Inspection of Service Pillars | Visual inspection and condition assessment of service pillar, minor repairs to lid as required. | 5 yearly |
| Inspection of Service Pits | Visual inspection and condition assessment of service pit, minor repairs as required. | 5 yearly |
| Inspection of Link Pillars | Visual inspection and condition assessment of link pillar, thermal imaging and minor repairs as required. | 5 yearly |
| U/G link box inspection including Thermal Image | Visual inspection and condition assessment of link box, thermal imaging and minor repairs as required. | 5 yearly |

**Figure 6-33 Inspection and Routine Maintenance Schedule for LV Pits and Pillars**

During 2011, Wellington Electricity will review whether the pillar inspection should include a loop impedance test to check the condition of the connections from the fuses to the source. Where practical, damaged pillars are repaired but otherwise a new pillar or a pit is installed.

#### 6.4.13.2. Renewal and Refurbishment

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. When large groups of older pillars, such as concrete or ‘mushroom’ type, are located and their overall condition is poor they are replaced as repair is impractical or uneconomic.

There are a number of different variants of service connection pillars on the network that are being replaced in small batches, notably under-veranda service connection boxes in older commercial areas.

There is ongoing replacement of underground link boxes around Wellington city. Many have deteriorated to a point where they may not be safe to operate under some conditions or they may not provide reliable service. The link boxes are either being jointed through, where the functionality is no longer required, or they have been replaced entirely to provide the same functionality. These replacements are driven from an incident where a link box failed catastrophically, as well as the general poor condition of some of these link boxes which are now over 50 years old. A complete survey was undertaken in 2009 that provided condition assessment data to allow for renewal programmes in 2010 and 2011. The majority of unserviceable link boxes were replaced in two projects during 2010, so it is expected that fewer than 10 will require replacement during 2011. For the remainder of the planning period the link boxes will be replaced following an unsatisfactory inspection outcome.

An allowance is made each year in the CAPEX programme to replace service pillars with pits in areas subject to vehicle damage. This budget is based upon historic trends but rarely exceeds 60 units per year.

### 6.4.14. SCADA

The SCADA system is generally self monitoring and as such is there is no preventative maintenance carried out on it. Master station maintenance is broken up into two categories: (a) hardware (b) software.

(a) Hardware support for both Haywards and Central Park (disaster recovery site) will be provided as required by Wellington based maintenance contractors.

(b) Software maintenance and support is to be provided by CHED services, part of Powercor, out of Melbourne via the TCP/IP linking between their control centres and Wellington Electricity's.

Existing RTUs do not have full back up and maintenance is based on failure. First line maintenance on the system is carried out as required by the maintenance contractor within the scope of its substation maintenance contracts. The substation level IP network is monitored and supported from within New Zealand by the respective service providers of the IP network infrastructure.

The network control centre at Haywards has a UPS system to provide backup supply to the master station and operating terminals. This is subject to a maintenance programme provided by the supplier of the equipment. In addition, this unit has dual redundancy of converters and batteries so provides a high level of supply security in the unlikely event of failure.

#### 6.4.14.1. Condition Assessment of SCADA System Components

**C225 RTU**

There are 26 of this type of RTU in service on the network. Power supply failure is the most common failure mode with around one failure a year. Spares are held at a central location and repairs are carried out when possible. These are being replaced in conjunction with substation switchgear replacements and the redundant units held as spares.

**C5 RTU**

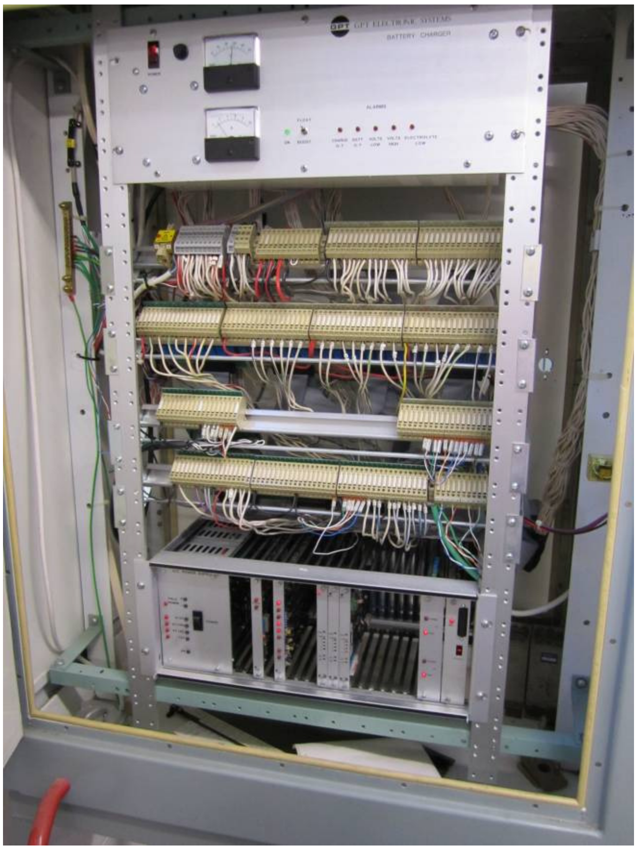
These RTUs are placed in very small distribution substations and there are six in service. These RTUs are no longer manufactured and are difficult to repair so as they fail they are interchanged with current technology alternatives.

**Load Control PLC**

There are 23 of this type of PLC in service on the network. Installed in 1996, these Toshiba PLC's are used to drive load control equipment. This type of PLC is an obsolete item however one spare is held for cases of failure. These will be addressed as part of any Load Control upgrade and are unlikely to be replaced outside of any other replacement programme.

**Dataterm RTU**

There are 9 of these in service on the network. These RTU's have an inherent design flaw in the analogue card which, over time, causes the analogues to "jump". This is repairable with the replacement of reed relays on the analogue card with an approximate cost of $500 per card. There are normally four cards per RTU and the cards fail at a rate of about five per year. These units are being replaced with Foxboro SCD5200 RTUs as zone substations are upgraded and moved onto the IP network.



Plessey Dataterm RTU at Palm Grove zone substation

**Miniterm RTU**

There are 72 of these in service on the network. These units fail at the rate of approximately two a year due to board level IC failure, with replacement ICs gradually becoming harder to source. These RTU's cannot be directly replaced by current technology, however spare units are becoming available as a result of the switchgear replacement works. There is no active programme for replacing these however they are being replaced in conjunction with substation switchgear replacements, or where a risk or shortfall is identified with having this type of RTU installed.

**Common Alarms**

There are 50 of these in service on the network. These are a custom built device, placed in minor "ringed" distribution substations to give an indication back to control room of a tripping event. They are prone to failure and there are no spares. On failure, the units are being replaced by current technology.

**Siemens Power Automation System (PAS)**

There is one PAS unit that acts as a protocol converter between IEC61850 field devices at three sites and that of the DNP3 SCADA master station. This is seen as a single point of failure as multiple sites are reporting to one point, the PAS.

#### 6.4.14.2. Asset Renewal and Refurbishment

The asset replacement budget also provides for the ongoing replacement of obsolete RTUs throughout the network. Obsolete RTUs that may present a significant impact on network reliability are being targeted first with special attention being paid to the zone and major switching substations.

Where there is an RTU which exists at a zone substation or major switching points in the network that is adjacent to the existing TCP/IP network, consideration is given to upgrade equipment to allow TCP/IP connection in order to continuously improve communication system reliability.

Further, the TCP/IP infrastructure will also allow other substation based equipment, such as security alarms etc., to efficiently communicate with distant receive devices.

**Master Station**

As detailed earlier in this document, the SCADA master station has been replaced with a GE ENMAC system. This new unit will last at least 15 years, so no major expenditure is foreseen during this planning period on the master station. Elements of the existing Leeds and Northrup 2068 master station will be retained in the short term to run the automatic load control packages. This will in time be integrated with the ENMAC system.

A new UPS system will be installed at the disaster recovery site at Central Park during 2011. This site has an operating terminal and is linked to both the Haywards master station, as well as a backup ENMAC server based in Melbourne. The expected cost of this upgrade is $150,000.

**Siemens Power Automation System (PAS)**

There is one PAS unit that acts as a protocol converter between IEC61850 field devices and that of the DNP3 SCADA master station. Substation base equipment will be installed in the medium term, which consists of SCD5200 RTUs than can convert the substation 61850 protocol directly to DNP3.

**Remote Terminal Units - Zone Substation and GXP RTUs**

Projects are underway to replace all Foxboro C25 and C225 RTUs at GXPs during 2011 for two reasons.

1. The new GE ENMAC SCADA master station has no automatic load management facility and in order to implement this, the present Foxboro L&N2068 master station will be required to be maintained in the short

term to provide the load management system. This will be achieved with use of SCD5200 RTUs at the GXPs providing information to both master stations.

2. The upgrade coincides with Transpower's move to TCP/IP networks and the resulting loss of the serial link presently used by Wellington Electricity from GXPs back to Haywards.

These units were installed in 1987 and will be 25 years old by the time the last is removed.

The substation RTU replacement will start with the 6 sites in the Wellington city area that have Plessey Dataterm RTUs installed. Three of these sites: Evans Bay, Karori and Palm Grove, have Reyrolle Type C gear switchboards that are targeted for replacement between 2011 and 2014. At these sites the RTU upgrades will occur at that time. The remaining three sites (Frederick Street, Hataitai and Ira Street) are targeted for replacement following these upgrades, however as spares are made available from the first sites, the remaining sites may be able to be kept in service longer.

There is no medium-long term programme to replace RTUs at distribution substations, as these sites generally have a lower risk profile than GXPs and zone substations. However where a risk or need is identified, the RTU upgrade will be scheduled. In 2010 two sites, one a key CBD site (176 Wakefield Street), and the second, with a hospital and Distributed Generation connected (25 Mein Street) were identified for RTU replacement and migration to the IP network. The 25 Mein Street RTU replacement did not occur during 2010 and was considered in the 2011 renewal programme. However due to the previously mentioned programme to replace GXP RTUs, it is more likely to occur during 2012. Additionally, sites that have switchgear upgrades may have an RTU upgrade, however these are incorporated as part of the specific project.

From 2013 onwards, Wellington Electricity will commence the replacement of the remaining C225 RTUs installed at 19 zone substations with an aim to complete all replacements by 2018.

The medium term replacement plan is shown below.

| Site | Site type | Present RTU | Proposed RTU | Replacement year |
|---|---|---|---|---|
| Palm Grove | Zone Substation | Dataterm | SCD5200 | 2011 |
| 25 Mein Street | Distribution Sub | Miniterm | SCD5200 | 2011 |
| Gracefield | GXP | C225 | SCD5200 | 2011 |
| Haywards | GXP | C225 | SCD5200 | 2011 |
| Wilton | GXP | C25 | SCD5200 | 2011 |
| Takapu Road | GXP | C225 | SCD5200 | 2011 |
| Upper Hutt | GXP | C225 | SCD5200 | 2011 |
| Kaiwharawhara | GXP | C225 | SCD5200 | 2011 |
| Pauatahanui | GXP | C225 | SCD5200 | 2011 |

| Site | Site type | Present RTU | Proposed RTU | Replacement year |
|---|---|---|---|---|
| Evans Bay | Zone Substation | Dataterm | SCD5200 | 2012 |
| Frederick Street | Zone Substation | Dataterm | SCD5200 | 2012 |
| Ira Street | Zone Substation | Dataterm | SCD5200 | 2013 |
| Karori | Zone Substation | Dataterm | SCD5200 | 2013 |
| Hataitai | Zone Substation | Dataterm | SCD5200 | 2013 |

Figure 6-34 Proposed RTU Replacement Programme

## 6.5. Asset Renewal and Refurbishment Programme

### 6.5.1. Asset Replacement Projects for Current Year

The major asset replacement projects (greater than $100,000) that Wellington Electricity is planning to complete in the 2011 period, as detailed in section 6, are summarised below.

| Moore Street 33kV Cable Replacement | |
|---|---|
| Driver: Asset Integrity<br>Estimated cost:<br>$9.3 million total<br>$5.0 million in 2011 | Moore Street zone substation feeds some of the most important loads in the Wellington Electricity network area, including parliament, courts of law, sea ports and the Central railway station. The two gas filled, 33kV subtransmission cable circuits that feed Moore Street zone substation from Wilton GXP are adequately rated for existing loads, but both cables have recently experienced poor reliability due to gas leaks and electrical faults. In particular it has been found that a section of the cables across the Molesworth Street bridge have deteriorated to a point where replacement is required.<br>These cables have been prioritised for replacement from the Stage of Life analysis.<br>Therefore, Wellington Electricity is currently undertaking the full replacement of the two cables with new 800mm$^2$ XLPE cables. This involves installing new cables over the 5km route, with a complete protection upgrade. The project will significantly reduce the risk rating of the sub-transmission supply to Moore St zone substation, and the rating of the cables will meet forecast load growth in this area. |

| Pole Replacement Programme | |
|---|---|
| Driver: Asset Integrity and Safety<br>Estimated cost: $2.4 million | Replacement of red and yellow tagged poles will continue in 2011, these are managed as packages of work following inspection. This work includes replacement of associated pole hardware. |

| Palm Grove 11kV Switchboard Replacement | |
|---|---|
| Driver: Asset Integrity and Safety | Following the Stage of Life Analysis of zone substation switchboards, the Palm Grove substation switchboard was found to have the highest consequence of failure due to high loading, given its age and condition. Full replacement of this switchboard and associated protection, control and secondary systems is planned to commence in 2011. |
| Estimated cost: $1.5 million | |

| Reyrolle Type C Replacement | |
|---|---|
| Driver: Asset Integrity | This includes for the replacement of Reyrolle C-type 11kV switchgear as described in section 6, at the following distribution substations:<br>Newtown, Hania Street and 25 Brooklyn Road |
| Estimated cost: $1.225 million | |

| Yorkshire SO-HI Replacement | |
|---|---|
| Driver: Asset Integrity | This project is the first stage of a proposed four year programme to replace Yorkshire SO-HI 11kV switchgear from distribution substations on the network. It is expected that eight of the highest priority sites will be addressed in 2011. |
| Estimated cost: $500,000 | |

| Lock Replacement Programme | |
|---|---|
| Driver: Asset Integrity and Safety | Wellington Electricity has an ongoing programme of lock replacement on all HV distribution assets. This is to ensure safety and integrity of the asset and network, by having one series of controlled keys in service. |
| Estimated cost: $100,000 | |

| Central Park DR Site UPS Replacement | |
|---|---|
| Driver: Asset Integrity | This project is to replace the UPS at the Central Park disaster recovery site, to provide backup power to the alternative control terminal at this location. |
| $150,000 | |

| GXP RTU Replacement | |
|---|---|
| Driver: Asset Integrity | Continuation of GXP RTUs upgrades with SCD5200 RTUs and upgrade to TCP/IP communications. |
| Estimated cost: $485,000 | |

| Korokoro 9 Overhead Line Rebuild | |
|---|---|
| Driver: Asset Integrity | Following poor performance in the Korokoro and Maungaraki areas (as detailed in Section 7), a full line rebuild will occur over an area of 4.2km of 11kV line, including pole, crossarm, transformer and switch replacements split over two stages. |
| Estimated cost:<br>$191,000 – Stage 1<br>$210,000 – Stage 2 | |

In addition to the specific projects above, Wellington Electricity also makes provision for programmes of replacements that arise from condition assessment programmes during the year, a list of programmes with a forecast cost greater than $100,000 are listed below.

| Driver | Programme | Forecast cost |
|---|---|---|
| Asset Integrity | Transformer and Canopy Replacement | $400,000 |
| Asset Integrity | Cable and Conductor Replacement | $350,000 |
| Asset Integrity | Switchgear Replacement | $250,000 |
| Asset Integrity | Protection and Secondary Systems | $200,000 |
| Asset Integrity | Crossarm Replacement | $180,000 |
| Safety | Earthing Upgrades and Compliance | $300,000 |
| Safety | LV Pillar and Pit Replacement | $200,000 |
| Safety | Cast Metal Cable Pothead Replacement | $150,000 |

Figure 6-35 Asset Replacement Programme

### 6.5.2. Prospective Asset Replacement Projects for 2012 – 2016

The projects included in this section are less certain in nature. Whether of not they proceed, and their timing, will largely depend on the risks to the network that need to be mitigated, and the relative risk compared with other asset replacement projects. The timing of asset renewal projects is directly related to the risks associated with the works, and changes to these alter the timing of the projects. It is assumed that the rate of deterioration, aging, and the increases of load remain constant. Should the loading or type of load served significantly change, and hence increase in the consequence of failure, or if the asset deteriorates faster than expected, then renewal may need to be brought forward. Conversely, should the risk level decrease, then the project may be able to be deferred until later in the planning period, or an alternative found. These projects are aimed at ensuring existing service levels are maintained in a sustainable manner, and in line with the surveyed feedback from consumers.

| 33kV Cable Replacement | |
|---|---|
| Driver: Asset Integrity<br>Estimated cost: $13 million | Following the Stage of Life analysis, there are a number of subtransmission circuits that have utilisation constraints that will be addressed under Network Augmentation projects; however there are several in the top ten that have age and condition constraints. It is expected that at least one set of circuits will require complete replacement during this medium term period, and that a medium section of at least one other set of circuits will require replacement due to condition. |

| Pole Replacement Programme | |
|---|---|
| Driver: Asset Integrity and Safety | Replacement of red and yellow tagged poles will continue, these are managed as packages of work following inspection. This work includes replacement of associated pole hardware. It is expected that the introduction of the Deuar test method, and the decrease in the numbers of wooden poles, the rate of replacement will decline in the medium term. |
| Estimated cost: $7.0 million | |

| Evans Bay 11kV Switchboard Replacement | |
|---|---|
| Driver: Asset Integrity and Safety | Following the Stage of Life Analysis of zone substation switchboards, the Evans Bay substation switchboard was found to have the second highest consequence of failure due to high loading, given its age and condition. Full replacement of this switchboard and associated protection, control and secondary systems is planned to commence in the medium term. |
| Estimated cost: $1.6 million (2012) | |

| Karori 11kV Switchboard Replacement | |
|---|---|
| Driver: Asset Integrity and Safety | Following the Stage of Life Analysis of zone substation switchboards, the Karori substation switchboard was found to have a high consequence of failure due to high loading, given its age and condition. Full replacement of this switchboard and associated protection, control and secondary systems is planned to commence in the medium term. |
| $1.5 Million (2013) | |

| Gracefield 11kV Switchboard Replacement | |
|---|---|
| Driver: Asset Integrity and Safety | Following the Stage of Life Analysis of zone substation switchboards, the Gracefield substation switchboard was found to have a high consequence of failure due to high loading, given its age and condition. Full replacement of this switchboard and associated protection, control and secondary systems is planned to commence in the medium term. |
| Estimated cost: $1.6 million (2014) | |

| Various 11kV Switchboard Refurbishments | |
|---|---|
| Driver: Asset Integrity and Safety | Following the Stage of Life Analysis of zone substation switchboards, a number of zone substation switchboards were found to have a high consequence of failure due to high loading, but not particularly old age or poor condition. Full replacement of this switchboard is not justified, and retrofit components with higher ratings can be used to reduce the risks and provide a mid life refurbishment extending the overall life. Upgrades of associated protection, control and secondary systems is planned.<br><br>The sites are Frederick St, University, Moore St, Hataitai, Kaiwharawhara and Johnsonville. |
| Estimated cost: $3.0 million (2012-2015)<br><br>($0.5 million per site) | |

| Reyrolle Type-C Replacement | |
|---|---|
| Driver: Asset Integrity | This includes for the ongoing programmed replacement of Reyrolle C-type 11kV switchgear as described in section 6. This will target the remaining circuit breakers on the network in the medium term (to 2014). |
| Estimated cost: $4.7 million | |

| Yorkshire SO-HI Replacement | |
|---|---|
| Driver: Asset Integrity | The continued replacement of Yorkshire SO-HI switchgear will occur during this period, due to the assessed risks of this equipment. |
| Estimated cost: $3.0 million | |

| Load Control Plant Replacement | |
|---|---|
| Driver: Asset Integrity | Wellington Electricity has identified a number of concerns around reliability and performance of early solid state ripple injection plant in the Wellington City area. During the medium term it is anticipated that plant at three locations will require upgrade to a modern low frequency. The plan for this is under development. |
| Estimated cost: $3.0 million | |

In addition to the specific projects indicated above and programme allocations for undefined annual projects, the following table gives indicative asset category investment that is not yet defined, however is estimated due to asset age and known condition across the category.

| Investment driver | Asset category | Investment |
|---|---|---|
| Asset Renewal | Distribution Switchgear Replacement | $5.0M |
| Asset Renewal | SCADA and RTU Replacement | $0.7M |
| Asset Renewal | Distribution Transformer Replacement | $1.1M |
| Asset Renewal | Substation Buildings | $0.6M |
| Asset Renewal | Distribution Cable and Conductor Replacement | $2.0M |
| Asset Renewal | Zone Substation Switchboard Replacement | $1.5M |
| Safety | Cast Metal Pothead Replacement | $0.3M |
| Safety | Earthing Compliance Upgrades | $1.3M |
| Safety | Asbestos Removal | $0.3M |
| Reliability | Reliability Improvement Projects | $0.2M |

Figure 6-36 Prospective Asset Replacement Programme 2012-2016

This investment profile is to maintain existing service levels, over time as condition information becomes better known, the category split may change.

### 6.5.3. Prospective Asset Replacement Projects for 2017 – 2021

Asset replacement and renewal projects that are listed in this section are less specific that the previous sections and are more uncertain in nature. There are few specific projects identified at this time, and the prospective investments are broken down as far as asset category only. As risks and needs change on the network, individual projects will change, however to maintain safety, security and reliability levels that the consumers are presently prepared to accept in their price/quality trade-off decision, the following investment levels will be required over this period. In addition, there will be programme works across each category to allow for unscheduled projects in each year.

| Investment driver | Asset category | Investment |
|---|---|---|
| Asset Renewal | Pole Replacement | $5.0M |
| Asset Renewal | Subtransmission Cable Replacement | $25.0M |
| Asset Renewal | Load Control Plant Replacement | $6.0M |
| Asset Renewal | Power Transformer Replacement | $8.0M |
| Asset Renewal | Distribution Switchgear Replacement | $9.0M |
| Asset Renewal | SCADA and RTU Replacement | $0.5M |
| Asset Renewal | Distribution Transformer Replacement | $5.4M |
| Asset Renewal | Substation Buildings | $1.0M |
| Asset Renewal | Distribution Cable and Conductor Replacement | $7.0M |
| Asset Renewal | Zone Substation Switchboard Replacement | $3.0M |
| Safety | Earthing Compliance Upgrades | $1.9M |
| Reliability | Reliability Improvement Projects | $0.4M |

**Figure 6-37 Prospective Asset Replacement Programme 2017-2021**

This investment profile is to maintain existing service levels, over time as condition information becomes better known then the category split may change to reflect the changing risks.

## 6.6. Asset Renewal and Replacement Expenditure

For clarity, the forecast provided below does not include the cost of operating the network from the network control centre at Haywards and does not include other non-maintenance related operational expenditure. Asset replacement and refurbishment costs are shown below. It can be seen that the line item on which Wellington Electricity proposes to invest the most capital expenditure is asset replacement and renewals. This reflects the increasing age of the asset base.

| Category | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 |
|---|---|---|---|---|---|---|---|---|---|---|
| Asset Replacement and Renewal | 13,286 | 12,550 | 15,967 | 18,481 | 13,779 | 13,488 | 19,464 | 16,883 | 18,525 | 17,865 |
| Reliability, Safety and Environment | 637 | 493 | 492 | 487 | 653 | 635 | 517 | 560 | 409 | 408 |
| **Subtotal - Capital Expenditure on Asset Replacement and Safety** | **13,923** | **13,043** | **16,459** | **18,968** | **14,432** | **14,123** | **19,981** | **17,443** | **18,934** | **18,273** |
| | | | | | | | | | | |
| Routine and Preventative Maintenance | 5,764 | 5,816 | 5,883 | 5,888 | 5,943 | 5,999 | 6,055 | 6,112 | 6,169 | 6,227 |
| Refurbishment and Renewal Maintenance | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 |
| Fault and Emergency Maintenance | 4,865 | 4,910 | 4,966 | 5,013 | 5,060 | 5,107 | 5,155 | 5,203 | 5,250 | 5,298 |
| **Subtotal - Operational Expenditure on Asset Management** | **11,274** | **11,371** | **11,494** | **11,546** | **11,648** | **11,751** | **11,855** | **11,960** | **12,064** | **12,170** |

**Figure 6-38 Lifecycle Asset Management Expenditure Forecast – 2011 to 2021 ($000 real as at 31-03-10)**

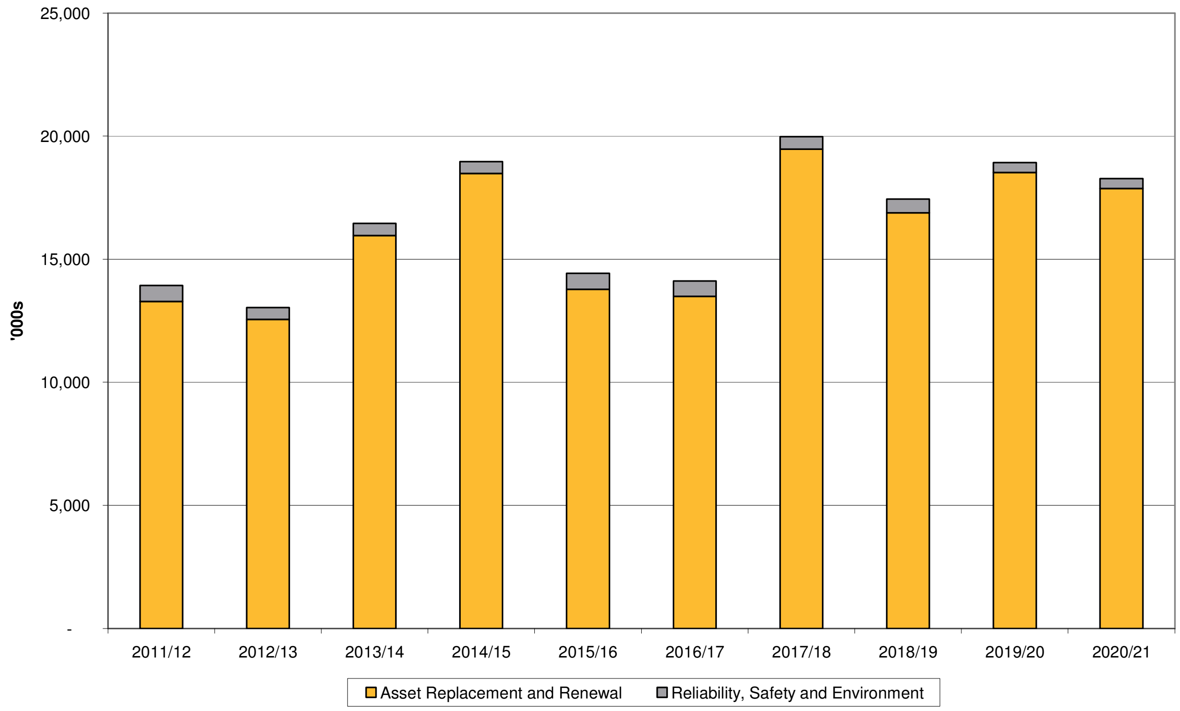



**Figure 6-39 Lifecycle Asset Management Capital Expenditure Forecast – 2011 to 2021**

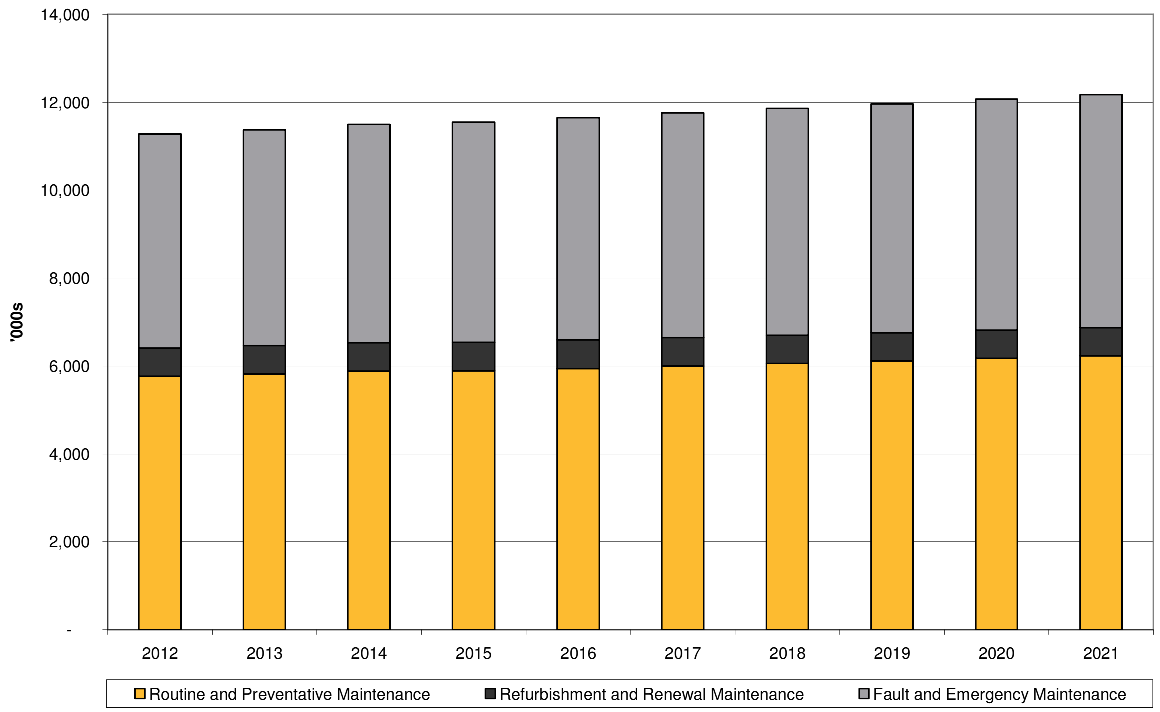



**Figure 6-40 Lifecycle Asset Management Operational Expenditure Forecast – 2011 to 2021**

# 7. Network Performance

In addition to the management of assets at the component level, Wellington Electricity also monitors the performance of asset groups at the feeder level. The root cause analysis is part of the investigation to improve systems, standards and procurement. This provides a useful input to the asset maintenance process as it identifies feeders that are experiencing the most unplanned outages and hence may require remedial action to be undertaken in order to maintain network reliability.

Performance will also be compared with the security of supply standard to check that expected outage times are being met. In some cases, the terrain, exposure to elements or vegetation may conspire to result in multiple faults. Review of network configuration to reduce impact is considered as part of post-fault reviews.

## 7.1 Network Performance Analysis

The following charts from 2008-09 and 2009-10 provide analysis of fault types on the Wellington network. Short term variations and remedial actions and outcomes are discussed further below.

A complete set of data for 2010/11 regulatory period is not available at the time of writing this Asset Management Plan.

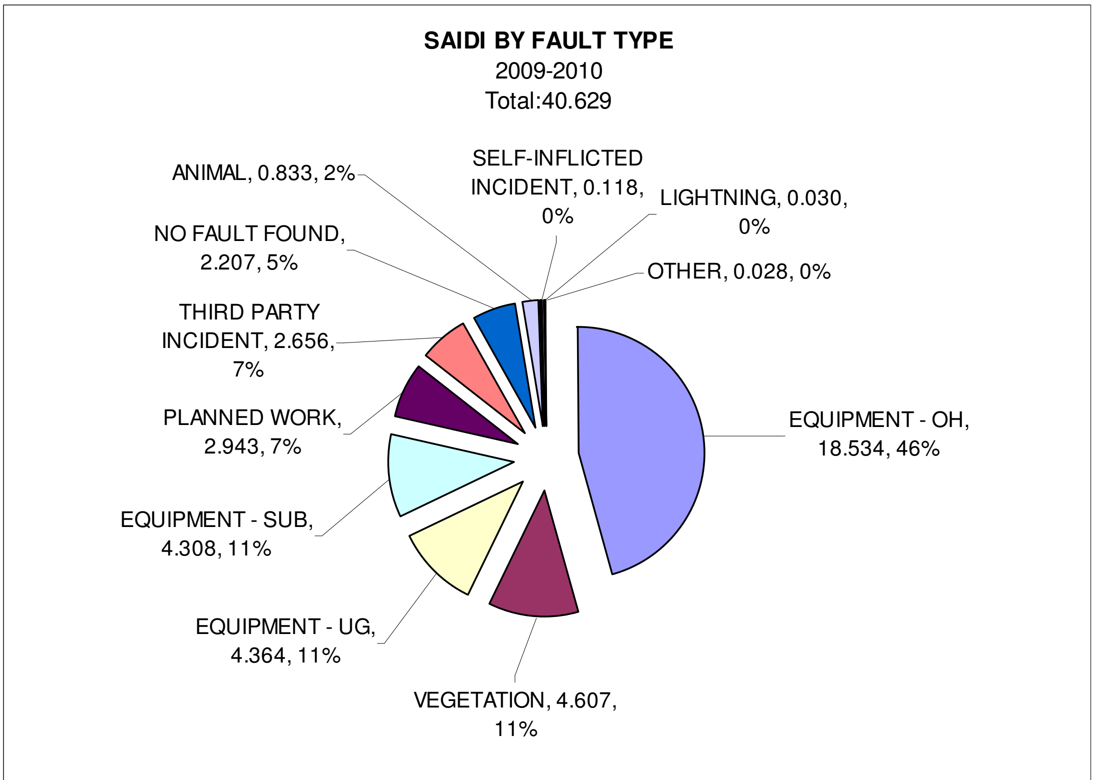



Figure 7-1 SAIDI by Fault Type 2009-10

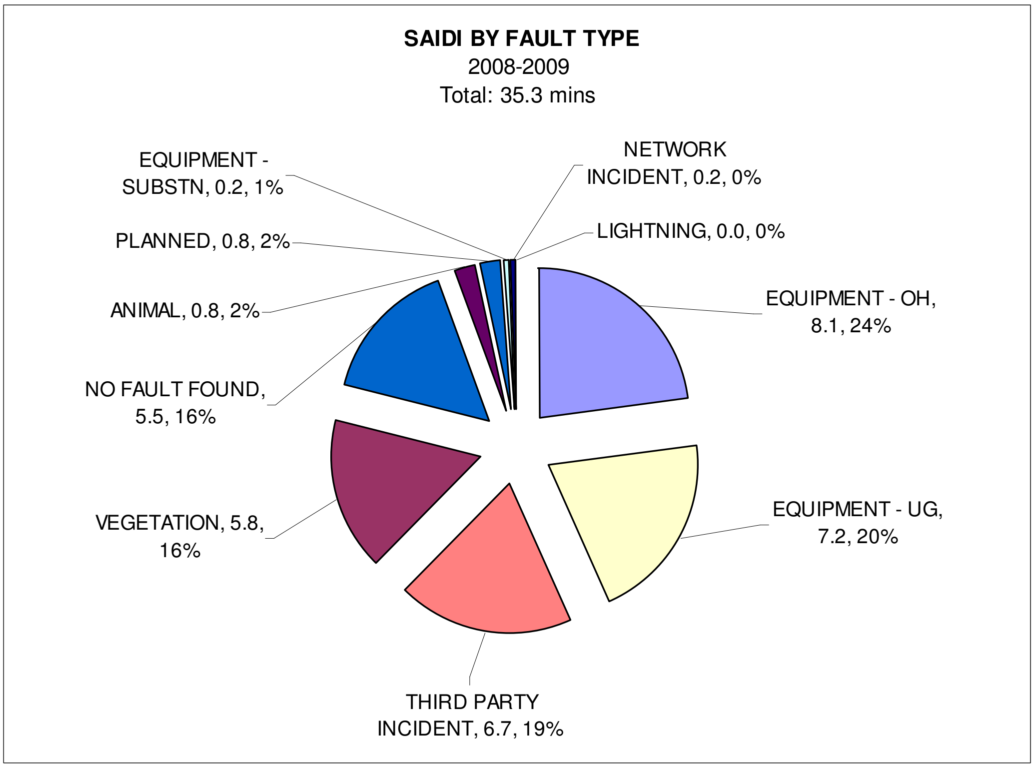



**Figure 7-2 SAIDI by Fault Type 2008-9**

Unplanned outage records from the 2008/09 year have been analysed to determine the leading contributor to network faults. This allows the maintenance and renewal plans to target specific areas for supply quality improvement where the assets are not performing as expected.

After taking ownership of the network in July 2008, Wellington Electricity has undertaken to achieve its targeted quality levels through improvement in the areas which have the highest impact on quality. The following initiatives were introduced:

- Strong focus on corrective maintenance
- Improvements in record keeping;
- Continued vegetation management – current issue under this is tree owner's failure to comply with the second cut policy which affects network reliability;
- Improvements in implementing post fault follow up actions by the field services provider - meaning "No Fault Found" incidents were investigated and remedied where possible; and
- Work with councils and civil contractors to reduce the number of third party incidents, as well as providing improved access to services such as "B4U Dig", cable markouts and safety standovers. Aside from this, a general downturn in the economy saw reduced work occurring around the network.

These initiatives contributed to the following reductions in SAIDI contribution for the 2009/10 period and are highlighted in the table and graph below (2010/11 9 months YTD included for interest):

| Fault Cause | 2008/09 | 2009/10 |
|---|---|---|
| No Fault Found | 16% | 5% |
| Third Party Incident | 19% | 7% |
| Vegetation | 16% | 11% |
| Underground Equipment Faults | 20% | 11% |

Figure 7-3 Targeted Fault Improvements

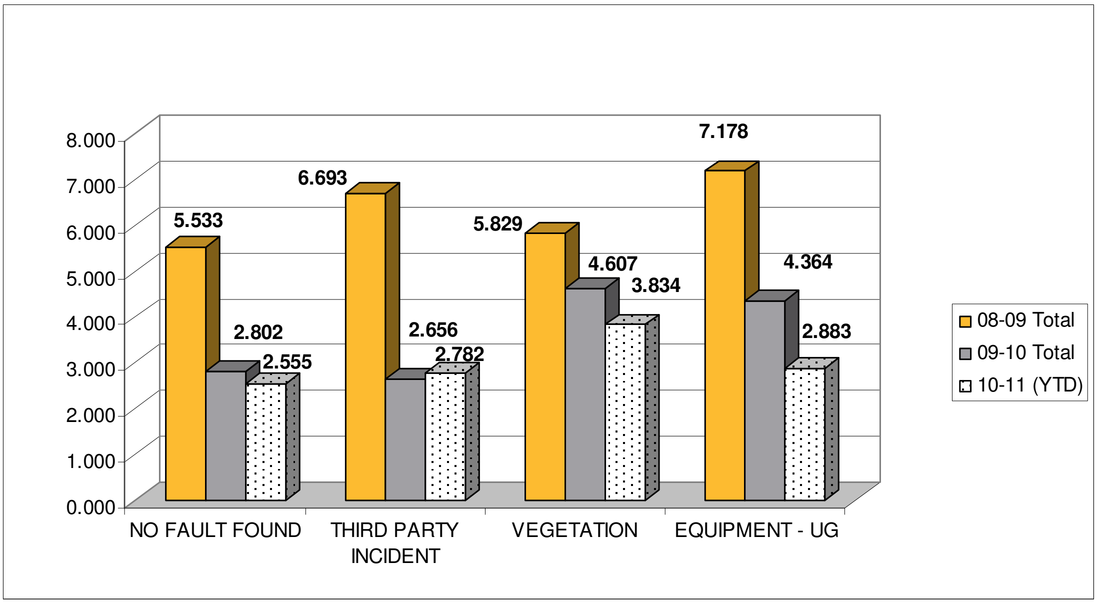



Figure 7-4 Areas of Improvements Achieved (SAIDI)

These improvements were negated by the overall impact of the weather related events on the overhead network, which increased from 23% of SAIDI in 08/09 to 46% in 09/10.

### 7.1.1. Challenges and Solutions Identified in 2009-10

The following graph highlights some asset management challenges identified in the current regulatory year (2010/11 9 months YTD included for interest).

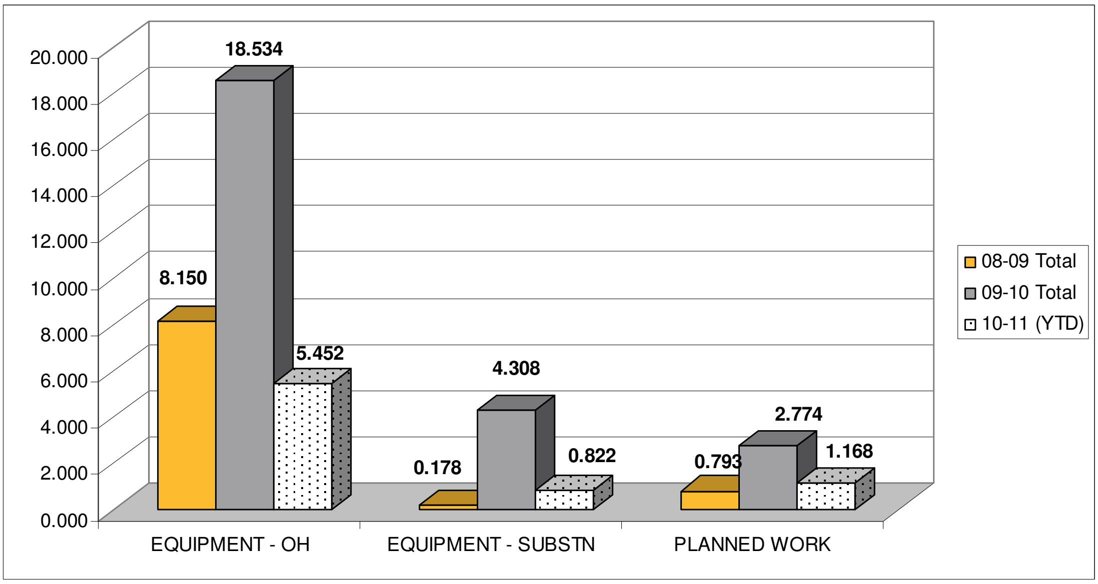



Figure 7-5 Asset Management Focus Areas (SAIDI)

Whilst a significant driver of the increase in overhead equipment failures was extreme weather events, as described in Section 8 (Risk Management) of this AMP, the following sets out immediate initiatives (as part of Wellington Electricity's longer term asset management strategies) to ensure targeted quality levels can be achieved.

### 7.1.2. Maintenance Activities

Both planned and corrective maintenance activities are being undertaken on a larger scale than what has been undertaken over the preceding 5 years. This has driven a higher SAIDI and SAIFI contribution from planned work where live techniques cannot be used. Longer term this strategy this will help to maintain reliability through improved equipment condition.

### 7.1.3. Maintenance and Inspection Standards

Wellington Electricity is reviewing and improving existing maintenance standards and practices on its network, including information capture. By improving the inspection process, and better analysis of data, investment and maintenance can be better focussed. For example, Wellington Electricity will be conducting a detailed survey of overhead lines and components in high wind areas to see whether their integrity is sufficient to meet the higher wind loads seen during 2009/10.

## 7.2 Worst Performing Feeders

Wellington Electricity's approach to find the worst performing feeders of the network is based upon the previous feeder performance over a five year period. There are three categories considered, SAIDI, SAIFI and the number of interruptions a feeder experiences in a year. The top ten from each category were taken and plotted in a chart for further analysis, as shown in the graphs below.

The factors to determine which feeders are considered to be "worst performing" is if a feeder is included in each of the three categories, or if the feeder performance has deteriorated in the last regulatory period in any of the three categories.

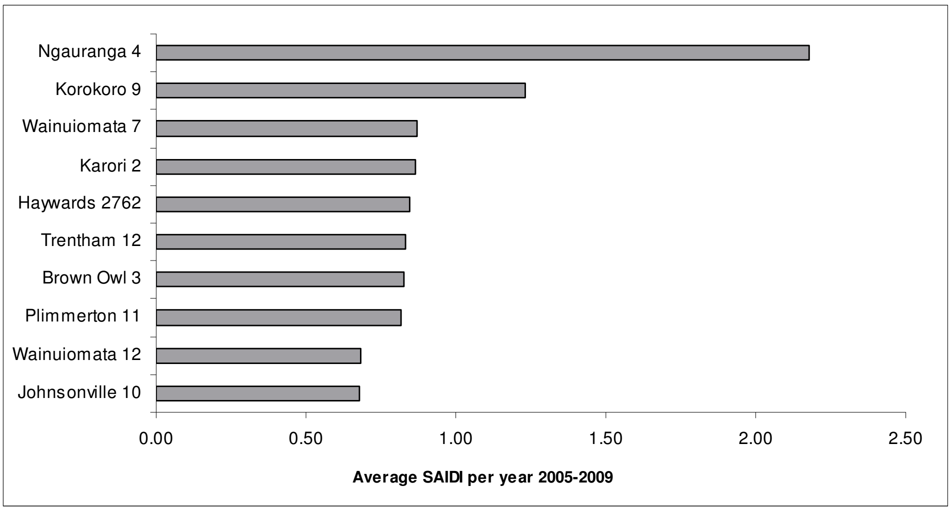



**Figure 7-6 2010 "Top Ten" Feeders - SAIDI**

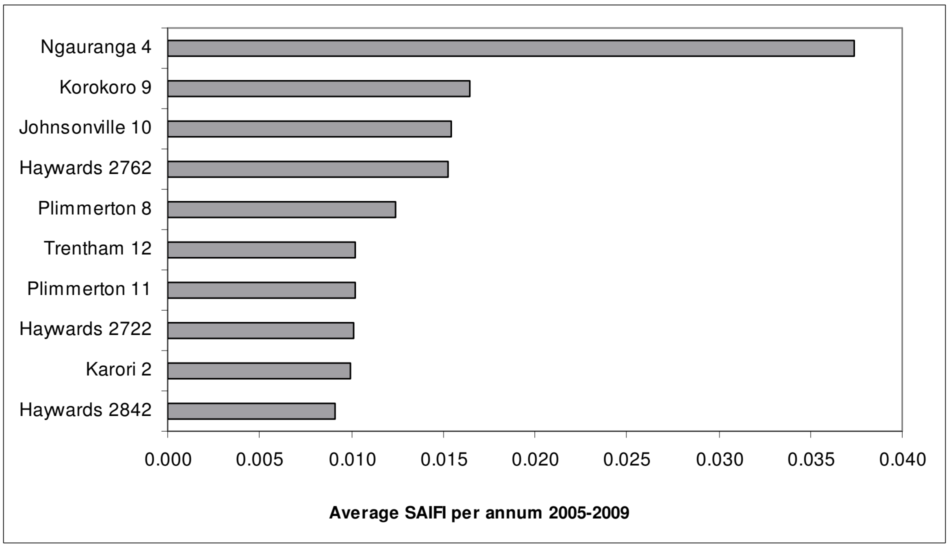



**Figure 7-7 2010 "Top Ten" Feeders - SAIFI**

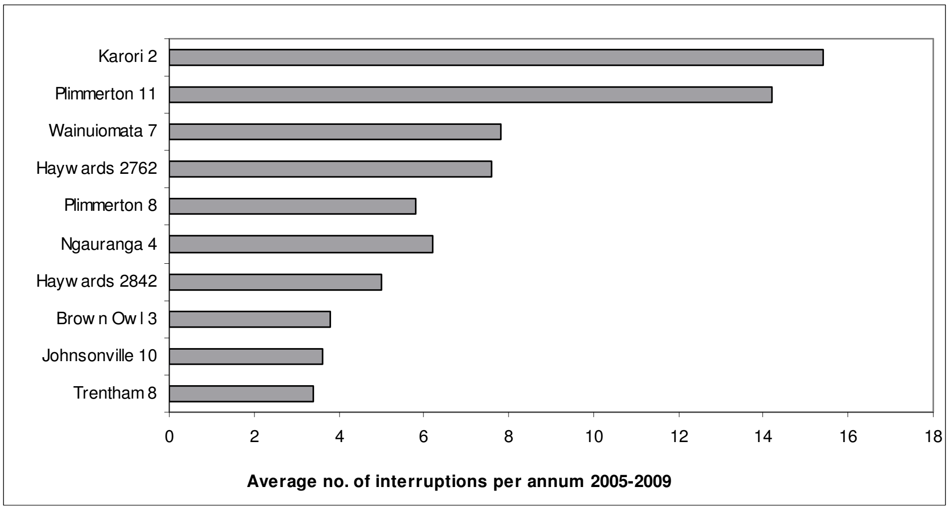



**Figure 7-8 2010 "Top Ten" Feeders – Interruption Frequency**

In the three graphs shown above, it can be seen that the worst performing feeders are Ngauranga 4 (NGA 4), Korokoro 9 (KOR 9), Wainuiomata 7 (WAI 7), Karori 2 (KAR 2), Johnsonville 10 (JOH 10), and Plimmerton 11 (PLI 11). Historic faults on these feeders are reviewed to determine if there is a common root cause that needs to be addressed. The remedial actions identified as part of this review are fed back into the maintenance process where the resulting activities are carried out either under corrective maintenance (OPEX), or as a network project (CAPEX), depending on the scope of the work required.

The table below shows each of the worst performing feeders SAIDI contribution and number of interruptions experienced during the 2009-2010 regulatory period.

| Feeder | SAIDI | No. of interruptions |
|---|---|---|
| Ngauranga 4 | 4.61 | 12 |
| Korokoro 9 | 2.85 | 6 |
| Wainuiomata 7 | 2.32 | 8 |
| Johnsonville 10 | 1.43 | 8 |
| Plimmerton 11 | 1.42 | 21 |
| Karori 2 | 0.96 | 10 |

Figure 7-9 “Top Ten” Feeder Performance 2009-10

## 7.3 Reliability Improvement Programme

**Ngauranga 4**

Ngauranga 4 has in recent times been a major contributor to high SAIDI on the Wellington network, for example in two separate incidents between November and December 2009, over 1.7 SAIDI minutes were accumulated. During the 2009 regulatory period there were 12 unplanned outages totalling 4.6 SAIDI minutes.

To improve its reliability, overhead line refurbishment was undertaken in the mid section of the feeder which included reconductoring and rebuilding 1.5 km of overhead 11kV line, replacement of crossarms and old pin insulators with post insulators, replacement of glass or porcelain strain insulators with new polymer strain insulators, replacement of overhead switches and transformers, and installation of additional new overhead switches to improve isolation capability.

**Korokoro 9**

Over the previous five years, Korokoro 9 has consistently contributed to network SAIDI and SAIFI. Out of the 15 recorded outages in this period, 11 were entire feeder outages. Between 2005 and 2008 it contributed around 2 percent of the total SAIDI figure for each year. However, in 2009 it increased to 10 per cent of the total SAIDI figure.

The major causes of faults recorded in the last 5 years are attributed to overhead lines which include conductor failure, connector failure and tree contact, in almost all overhead areas of the feeder.

To improve its reliability, an area-wide overhead line refurbishment is planned for 2011 including refurbishing and reconductoring 4.2 km of 11kV line reconductoring, replacement of crossarms, selected poles, overhead transformers and replacement of pin insulators with post insulators. In addition, a new overhead switch will be installed to allow feeder reconfiguration and improved isolation.

**Johnsonville 10**

Johnsonville 10 supplies a mixture of urban and rural load, with nearly 1,300 consumers connected, predominantly in the urban area, with only around 150 consumers connected in the rural area of Ohariu Valley. The majority of faults have occurred in the vicinity of Ohariu Valley from vegetation, third party incidents and vandalism. An auto recloser was installed in Ohariu Valley Road to reduce the impact of these events however following faults in April and May 2010, the recloser failed to operate and affected the entire feeder. Subsequent testing indicated the recloser was faulty and this was replaced during 2010. This simple project brought improvements in feeder SAIDI and SAIFI immediately, with a fault occurring less than one week after installation affecting only limited customers.

Root cause analysis is being undertaken on this feeder to understand the nature of outages, and measures will be undertaken to improve the overhead assets, and also to minimise vegetation impact in this area which is now in the “second cut” phase. Full overhead line refurbishment in the Ohariu Valley Road area may be considered in the coming years.

**Wainuiomata 7**

Wainuiomata 7 is a combination of urban underground and rural overhead line, with around 70 per cent of its length being overhead line in the rural area along Coast Road all the way to Baring Head on the south coast of Wellington. There are 813 customers connected to Wainuiomata 7, and 114 customers are in the Coast Road area. This feeder has two auto reclosers along its length to minimise the impact of an outage. The majority of faults on this feeder were around the Coast Road area, and were common rural fault causes such as overhead line equipment failure, vegetation, animal and bird strikes, as well as third party incidents.

To improve its reliability in the short term, overhead line maintenance has commenced at the tail end of Coast Road and at Baring Head, which includes replacement of identified faulty insulators, poles and crossarms. Full overhead line refurbishment in areas of this feeder along Coast Road will be done in stages, commencing in late 2011 or early 2012 following a comprehensive condition assessment.

**Karori 2**

Karori 2 supplies both urban network around Karori, which is entirely underground, and the nearby large rural areas of Wrights Hill and Makara which are overhead. The majority of the faults recorded on this feeder come from the Makara area. Makara is a rural area with sparse development and has about 190 customers in this area. Like Ohariu Valley (Johnsonville 10) and Coast Road (Wainuiomata 7), it is a highly vegetated area and faults are usually due to animal and bird strikes, third party incidents, overhead equipment failures, as well as a number of undetermined causes.

To improve its reliability, a thorough pole by pole inspection was carried out and a number of identified faulty insulators have been replaced. In the near future, full line refurbishment including the installation of additional overhead switches will be considered.

**Plimmerton 11**

Plimmerton 11 is a rural feeder with the majority of the circuit being overhead lines running along Grays Road and Paekakariki Hill Road. Its circuit length is 54 kilometres but has only 190 customers connected to this feeder. Faults recorded in this area are mostly due to vegetation, animals, vandalism, and third party incidents. Detailed pole by pole inspection of this feeder showed mostly vegetation issues. To improve its reliability, tree trimming in this area will be the main focus for 2011.

## 7.4 Other Reliability Initiatives

All overhead feeders are subject to an annual inspection, and other network equipment is inspected and maintained at prescribed intervals. Other initiatives to improve the speed and accuracy of fault finding and restoration include:

**Fault Passage Indicators**

Line fault indicators are used widely on the overhead network and earth fault indicators are used on the underground network. These are placed on the distribution network as an aid in the identification of faulty sections of the network. Patrolling a fault is time consuming and some network sections may be hard to access, or the faultman may encounter traffic jams in urban areas, difficult terrain in rural areas or long outgoing feeders with many spur lines and tee points.

**Line Circuit Breakers / Autoreclosers**

Auto reclosers are used on most rural feeders to provide a quick, automated reclose function to clear transient faults such as wildlife, vegetation or line clashes in stormy weather. The use of automatic reclosers in strategic areas of the network also reduces the number of customers affected in the event of a permanent fault on that feeder.

**Remote controlled overhead switches**

Remote overhead switches are used to enable remote operation of the network by the control room, in conjunction with a faultman on the ground to improve isolation and restoration times.

# 8. Risk Management

## 8.1 Introduction

Risk management is an integral part of the asset management process. The consequences and likelihood of failure or non-performance of controls to manage this, and required actions to make risks acceptable all need to be understood, reviewed and evaluated as part of the asset management function.

Risks associated with network assets are evaluated, prioritised and dealt with as part of the network development and asset maintenance, refurbishment and replacement programmes. They are also taken into account in developing standard work practices. The acceptable level of risk will differ depending upon the level of risk that all key stakeholders are willing to accept and the circumstances and environment in which the risk will occur.

Risks associated with system assets are managed through a combination of:

- Reducing the probability of asset failure, through the capital and maintenance work programme and enhanced working practices.
- Reducing the impact of failure, through contingency and emergency plan development and insurance, and through the development of an efficient fault response capability.

High probability, low impact risks and conversely low probability, high impact risks are managed through a combination of Wellington Electricity's network planning and design, asset maintenance and fault response strategies. Sections 5 and 6 of this AMP describe the network planning and asset maintenance strategies in some detail. In addition, Wellington Electricity's design standards, which are not described in detail in this AMP, are aligned with industry best practice and aim to take due account of the weather and environment conditions in the Wellington area, including the high impact earthquake risk. Further, Wellington Electricity has procedures in place to restore power in a timely manner should an asset failure cause a supply interruption.

While it is impractical and uneconomic to design an electricity network that is immune to all risks, low probability high impact events can occur that are either outside the network design envelope or require a response that is beyond the normal capacity of Wellington Electricity, or its service providers. For such events Emergency Response Plans (ERP) have been put in place as detailed later in this section.

## 8.2 Risk Accountability and Authority

Wellington Electricity's Board of Directors oversees the risk management reporting from the CEO as a part of its corporate governance responsibilities via the Audit and Risk Committee as part of regular management reporting functions.

Wellington Electricity's Senior Management Team monitors the effectiveness of the risk controls by providing a report for the CEO to present to the Directors.

In developing and implementing its risk management strategy the CEO meets with senior management regularly to review business risks and controls. Strategic and operational risk categories are reviewed. High level risks are reported in a risk register while more detailed operational risks are captured in risk control procedures and processes.

In developing the risk management strategy and process, the senior management team is supported by other CKI group companies. The aim is to migrate the risk management strategy of these utilities into Wellington Electricity's operation so that there will be a common risk management strategy and process across all businesses.

## 8.3 Risk Framework

Wellington Electricity adopts the New Zealand Risk Management Standard AS/NZS 4360:2004 to provide a structured and robust methodology in managing risk. The risk framework provides a process for:

- Identification of the risk event, assessment of the potential causes and possible consequences of the event and quantification of the likelihood and consequence ratings to determine the inherent and residual risk ratings for the event.
- Identification of risk controls and assessment of the effectiveness and reliance of these controls to reduce or mitigate the risk – this generates the residual risk rating.
- Development of risk treatment plans to address unacceptable residual risk (high and extreme risks) or allow the business to accept a high risk activity.
- Creation of a risk register to capture the above information.

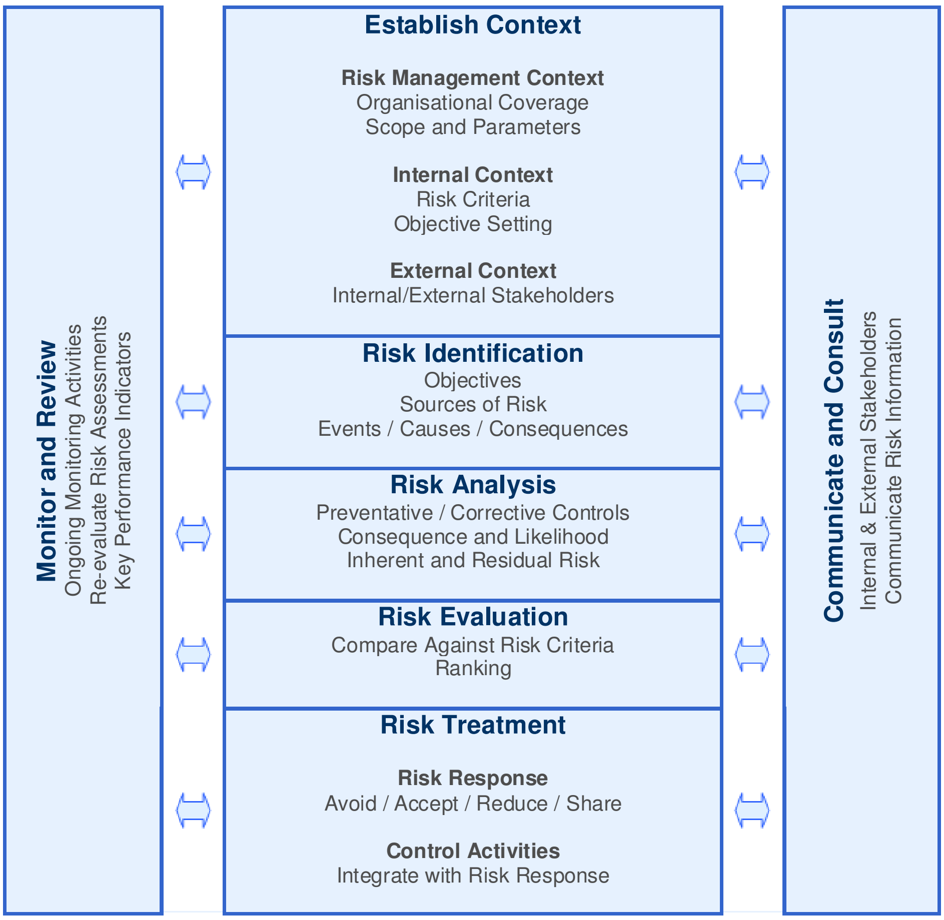



**Figure 8-1 Risk Assessment Process**

The intention of the risk treatment plans is to improve the control environment to reduce the residual risk as far as practicable. As the risk management process evolves Wellington Electricity shall develop appropriate risk treatment plans, these plans shall be assigned to a business risk owner and monitored to ensure that the business is taking proactive steps to mitigate risk. These plans shall include a basic cost analysis to assess the practicability of the improvement options for existing controls and/or additional control initiatives to further reduce the risk to an acceptable level.

## 8.4 Risk Rating

The magnitude of the consequences of an event, should it occur, need to be chosen based on the ***most likely or most realistic*** impact to the whole business and its stakeholders. The following risk profiling matrix is used to determine the level of the risk or risk rating based on a function of consequence and likelihood.

| LIKELIHOOD | CONSEQUENCE | | | | |
|---|---|---|---|---|---|
| | Minimal | Minor | Moderate | Major | Catastrophic |
| Almost Certain | Medium | High | High | Extreme | Extreme |
| Likely | Low | Medium | High | High | Extreme |
| Possible | Low | Low | Medium | High | High |
| Unlikely | Negligible | Low | Low | Medium | High |
| Rare | Negligible | Negligible | Low | Medium | High |

**Figure 8-2 Levels of Risk Rating**

Wellington Electricity uses the following consequence and likelihood criteria (in no order of priority) with consideration of the business' long-term objectives and criteria for measuring success:

- Financial (cash loss & earnings)
- Health & Safety (employees, public & service providers)
- Environment (land, vegetation, waterways & atmosphere)
- Reputation (media coverage & stakeholders)
- Compliance (legislation, regulation & industry codes)
- Customer Service/Reliability (quality & satisfaction)
- Employee Satisfaction (engagement, motivation & morale)

The criterion is combined with a consequence scale, determining the level of consequence to the business of a particular risk ranging from minimal to catastrophic.

## 8.5 Risk Method Application

Controls are introduced to reduce/mitigate the likelihood or consequence of the risk with varying levels of effectiveness and reliance on the particular control. This helps reduce the inherent risk to a more acceptable residual risk to the business.

| Risk score | Inherent<br>9500 / Extreme | Residual<br>400 / High |
|---|---|---|
| **Likelihood** | 95 | 25 |
| | Almost Certain | Likely |
| **Consequence** | 100 | 16 |
| Compliance | Major | Minor |
| Customer Service / Reliability | Major | Minor |
| Employee Satisfaction | Major | Minor |
| Environment | Moderate | Minimal |
| Financial | $1m to $5m | $100k to $500k |
| Health & Safety | Major | Moderate |
| Reputation | Major | Minor |

Figure 8-3 Risk Scoring

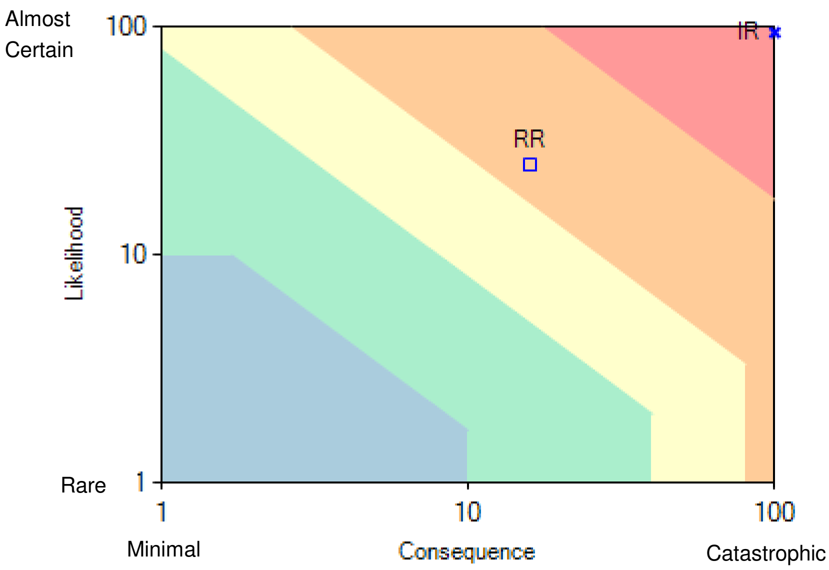



Figure 8-4 Example of Risk Methodology Application

## 8.6 Risk Application Example – Moore Street 33kV Gas Cable Replacement

### 8.6.1 Background to 33kV Cable Fault

The Wellington Electricity Moore Street zone substation located in the Wellington CBD is fed by two duplex 33kV subtransmission circuits utilising gas filled cables supplied from Transpower's Wilton Grid Exit Point (GXP). These circuits are configured as transformer feeders, with no 33kV bus or switching at the Moore Street zone substation end. The 11kV switchboard bus coupler is typically operated as normally open due to the fault levels present.

The load fed from Moore Street zone substation supplies some of the most sensitive loads on the Wellington Electricity network. It includes:

- Parliament (Beehive, Parliament buildings, Bowen House)
- The Supreme, High and District Courts
- The Port of Wellington (container port)
- Wellington Stadium and Central Railway Station and ferry terminal
- Several government departments (including MED, ACC, Department of Statistics)
- Significant parts of Wellington CBD (Featherston Street, Waterloo Quay, part of The Terrace.

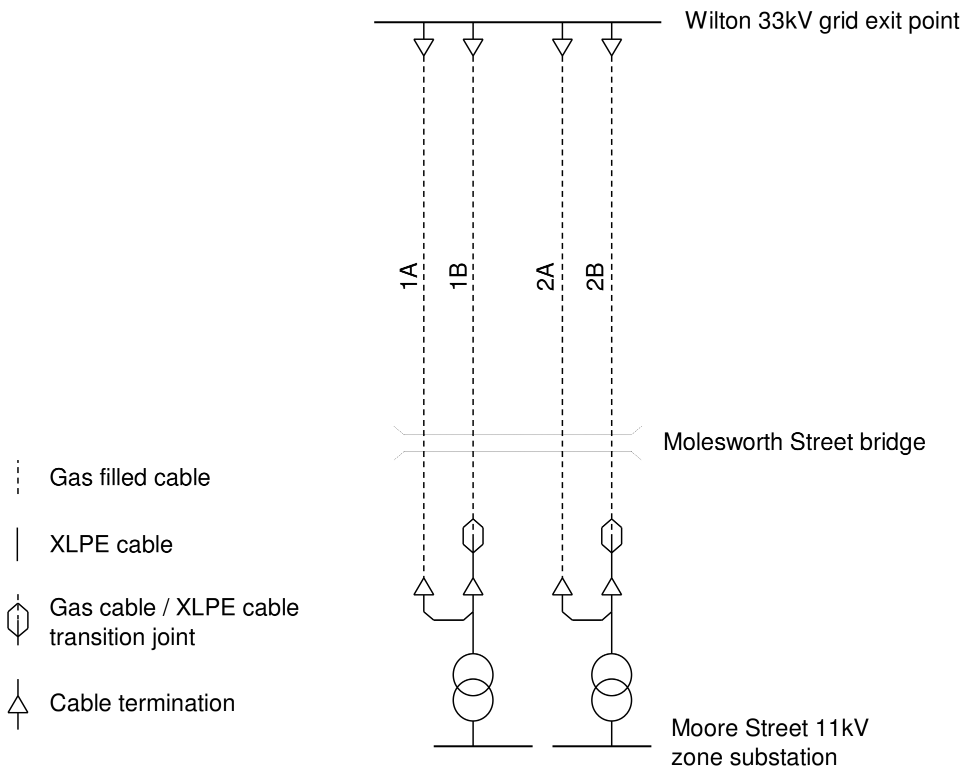



Figure 8-5 Schematic of Moore Street Zone Substation Subtransmission System

| Circuit | Cable | Originally | Type s | Length | Installed |
|---|---|---|---|---|---|
| 1 | Moore 1A | Moore 1 | 0.5in$^2$ Cu PIAS GF | 4.3 km | 1966 |
| | Moore 1B | Terrace 1 | 0.5in$^2$ Cu PIAS GF | 4.0 km | 1966 |
| | | New | 630mm$^2$ Al XLPE | 0.3 km | 2008 |
| 2 | Moore 2A | Moore 2 | 0.5in$^2$ Cu PIAS GF | 4.3 km | 1966 |
| | Moore 2B | Terrace 2 | 0.5in$^2$ Cu PIAS GF | 4.0 km | 1966 |
| | | New | 630mm$^2$ Al XLPE | 0.3 km | 2008 |

**Figure 8-6 Moore Street Zone Substation Subtransmission Cable Details**

The Moore Street zone substation gas filled subtransmission cables have been in service for 45 years and during recent years a number of leaks and events have occurred that have raised concerns on the overall condition and longevity of the cables.

The most recent and highest impact fault occurred on 9 March 2010 on a through joint located slightly below the half-way point in cable 1B. Prior to the fault occurring there was a gas leak under investigation on the cables, and work was being undertaken to narrow down the location of the leak which was on the Molesworth Street bridge. On the day of the fault, Moore Street zone substation switchboard was being fed by circuit 1 (1A and 1B cables) with the switchboard bus coupler closed as circuit 2 was isolated to allow Transpower to carry out bus maintenance work occurring at Wilton GXP. An electrical fault occurred on the Moore Street zone substation 1B cable taking circuit 1 out of service and resulting in a power cut to all loads normally fed from Moore Street zone substation.

Within a short period, circuit 2 (2A and 2B cables) was bought back into service and power was restored to all effected consumers. Within about 30 minutes of livening circuit 2, gas pressure alarms were raised and large volumes of gas were detected leaking from the 2A cable leading to a cascading failure. Demand was transferred away from Moore Street zone substation via the distribution system and the substation was manually reconfigured to be supplied by the 1A and 2B cables only, although at reduced capacity. Substation load was partially restored but limited to the capacity of one cable with the balance of load being supplied at 11kV from adjacent zone substations. Affected customers experienced a series of small duration outages as the fault occurred and as power was progressively restored then shifted to adjacent substations.

Leak detection identified that the 1B and 2A cables had extensive sheath damage on the Molesworth Street bridge, leading to gas leaks. In addition, it was noted that the 1A and 2B cables, on the opposite side of the service trench were in very poor condition due to the poor method of cable support within the bridge

Following the fault, cable 1B was repaired and protective sleeves were fitted to the 1B and 2A cables on the Molesworth Street bridge however this did not address long term reliability concerns for the cables. This prompted Wellington Electricity to carry out a detailed risk assessment on the ongoing viability of the Moore Street gas cables and the entire in-service gas and oil filled cables installed on the network.

### 8.6.2 Cable Risk Assessment Process

A detailed study was conducted which considered a number of network risks, constraints and business impacts. Some of the areas considered were:

- Network load profiles (both existing forecast)
- Equipment ratings and fault levels
- Capacity, back feed and load transfer capability
- Cable condition assessment (where known or visible)
- Economic investment evaluation

A number of options were determined to address the problem ranging from a single circuit replacement, partial replacement of both circuits with targeted ongoing condition surveys and replacement of both circuits along the entire length. The partial and total replacements of both circuits were ranked the highest and were taken through the risk management methodology process.

The significant risk that existed was the sensitivity of the loads in the Wellington network that are supplied from two 33kV subtransmission circuits in poor condition. The outage of one cable will result in a short duration power cut while the system is reconfigured. This will place the entire load on the remaining cable which in the past has demonstrated cascading failure under similar conditions. Should both 33kV cables fail, there would be a requirement for another short duration power cut while reconfiguration occurs at the 11kV level.

The duration and frequency of the outages would vary depending on the configuration of the remainder of the network at the time of the fault. The March 2010 incident confirmed that there may be the need for many short duration outages to move load around following a fault.

The two highest ranking options were fed in to the risk management process.

| | Inherent<br>(existing system) | Residual (option 1)<br>Partial replacement | Residual (option 2)<br>Total replacement |
|---|---|---|---|
| Likelihood | The condition of the sub transmission cables is such that there is almost certain to be a fault in the next year.<br>**Classification** – Almost certain | Replacing the most 'at risk' sections of the subtransmission cables will still leave considerable length of gas cable in service. The likelihood of an outage will remain relatively high.<br>**Classification** - Possible | Replacing the entire length of gas cable will reduce the likelihood of a cable fault to 'rare'.<br>**Classification** – Rare |

Figure 8-7 Risk Likelihood Comparison

| | Inherent (existing system) | Residual (option 1) Partial replacement | Residual (option 2) Total replacement |
|---|---|---|---|
| Financial consequences | Loss of revenue and potential claims for compensation from affected consumers. **Classification** - < $100k | Loss of revenue and potential claims for compensation from affected consumers. **Classification** - < $100k | No consequences. **Classification** – No impact |
| Health & Safety consequences | No H+S consequences. **Classification** – No impact | No H+S consequences. **Classification** – No impact | No H+S consequences. **Classification** – No impact |
| Environment consequences | No environmental consequences. **Classification** – No impact | No environmental consequences. **Classification** – No impact | No environmental consequences. **Classification** – No impact |
| Reputation consequences | Consumers have been sensitised to outages in this part of the network, and any further outages are likely to attract significant negative media coverage and will impact on central government operations. **Classification** - Major | Less outages will be expected, but they are still 'possible'. The sensitisation of consumers will drop if outages are less frequent but long term loss of reputation will remain. **Classification** - Moderate | Investment will effectively remove the risk cable failure. Consequence to reputation is therefore minimal. **Classification** – Minimal |
| Compliance consequences | Multiple outages will impact on regulatory quality indicators SAIDI and SAIFI leading to possible breaches of thresholds. **Classification** – Major | Fewer outages but still 'possible' with risk for potential impact. **Classification** - Moderate | Investment will effectively remove the risk cable failure. Consequence to compliance is therefore minimal. **Classification** – Minimal |
| Customer Service / Reliability consequences | Blackouts will affect consumers and impact on network reliability metrics. **Classification** – Moderate | Fewer blackouts but they will still affect consumers and impact on network reliability metrics. **Classification** – Minor | No consequences. **Classification** – No impact |
| Employee satisfaction consequences | No consequences. **Classification** – No impact | No consequences. **Classification** – No impact | No consequences. **Classification** – No impact |

**Figure 8-8 Risk Consequence Comparison**

It was decided that option 2, total replacement of the gas cables along the entire length, was the most appropriate solution to mitigate the risk to Wellington Electricity providing a 'Negligible' residual risk rating as demonstrated in the tables below.

| Risk Analysis | Inherent | Residual |
|---|---|---|
| **Likelihood** | **95** | **3** |
| | Almost Certain | Rare |
| **Consequence** | **72** | **3** |
| Financial | <$100k | No impact |

| | | |
|---|---|---|
| Health & Safety | No Impact | No Impact |
| Environment | No Impact | No Impact |
| Reputation | Major | Minimal |
| Compliance | Major | Minimal |
| Customer Service / Reliability | Moderate | No Impact |
| Employee Satisfaction | No Impact | No Impact |
| **Level of Risk (Risk Rating)** | **6801** | **8** |
| | Extreme | Negligible |

Figure 8-9 Risk Analysis Table for Option 2

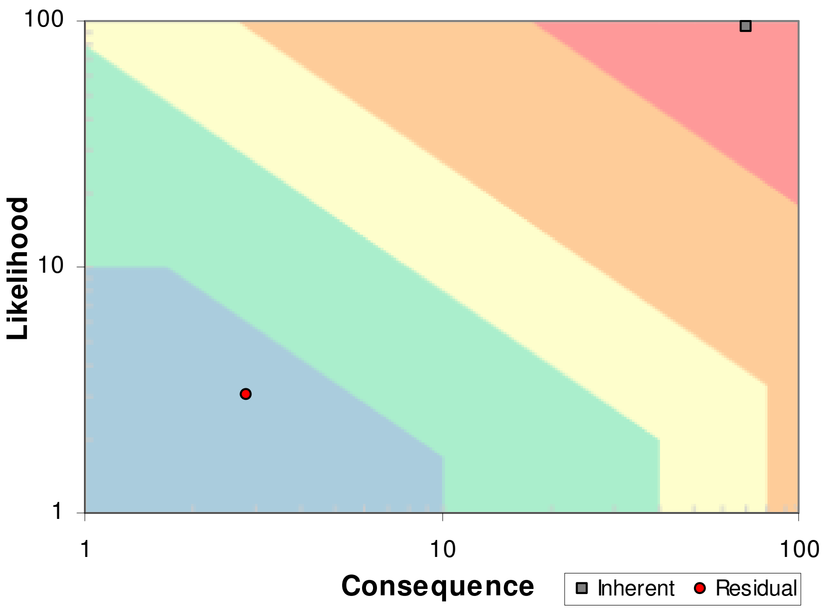



Figure 8-10 Risk Analysis Chart for Option 2

The outcome and recommendation of the risk analysis was collated into a business case and presented to the Capital Investment Committee in September 2010. The business case was approved and the cable replacement project commenced in late 2010 with an expected completion by July 2011.

Wellington Electricity has carried out a detailed "Stage of Life" analysis on all of its substransmission cables which is discussed in more detail in Section 6 (Lifecycle Asset Management).

## 8.7 Risk Based Approach to Asset Management

The AMP assists the decision making process for phasing out an asset through a planned replacement programme, or continue in service supported with additional inspection and preventative maintenance activity. In addition to this, the prioritisation of capital works (refer to Sections 5 and 6) is based on an assessment of the risk that each potential project carries.

## 8.8 Risk Identification

All staff members are encouraged to identify hazards and raise these to the appropriate supervisor or manager. Risks are identified as part of the incident management process. New risks are added to the incident management register for evaluation, recommendation, action and close out. All risks that follow the incident management process will undergo root cause analysis to identify the underlying problem and appropriate mitigation action.

Business risk is managed through regular risk profiling workshops with the objective to identify and assess the risks which may impact on the business achieving its strategic objectives. Some risks which cannot be eliminated are assigned controls to minimise or mitigate the impact to the business should the risk occur.

Wellington Electricity will further develop the incident management process over the next 12 months.

## 8.9 Network Risks

There are a number of areas within a network business where certain types of assets can exhibit performance which is sub-optimal, or they may deteriorate to an in-service failure point ahead of their expected life. Provided these issues are understood and monitored, the risk of in-service failure can be managed to a point where it is tolerable and controls can be put in place to reduce their impact should they occur.

Areas where monitoring programs or additional controls have been implemented around certain specific assets are discussed within this section of the AMP.

### 8.9.1 Zone Substation Battery Supplies

Battery supplies are of critical importance for the correct operation of substation and field devices. Battery banks are therefore important assets to regularly monitor and service to ensure the batteries remain in good serviceable condition.

Programmed maintenance and inspection to ensure healthy battery condition is in place with programmed replacement of DC battery banks after five years of age. Refer to Section 6 (Lifecycle Asset Management).

### 8.9.2 Zone Substation Supply Security

The network is configured to maintain a level of redundancy at zone substation supply points so that continuity of supply can be maintained should a single element become unavailable for service. At peak demand times there can be insufficient capacity headroom to maintain the security level at some sites without the use of load control or reconfiguring the network connectivity to shift load to adjacent supply points.

These operational solutions are more efficient than investment in additional capacity however they need to be well planned and carefully thought through. Further monitoring and network reconfiguration plans to allow for load shifting during contingencies will be worked through for a number of substations during the planning period. Should load shifting not provide satisfactory security, then additional connectivity or capacity investment would be considered. Refer to Section 5 (Network Planning) for details of further options and potential programmes of work.

### 8.9.3 HV Gas Filled Cables

The pressurised gas filled sub-transmission cables system is generally operating reliably. The cables are mature and supported with gas replenishment which is remotely monitored. There are a small number of cables consuming larger volumes of gas. These will be inspected to identify and repair leaks and their condition will be assessed to determine if there are other remedial requirements. A major leak on a gas cable that necessitates removal from service for repair can take a number of weeks before the cable can be returned to service. Refer to Sections 5 and 6 for management of these assets.

### 8.9.4 HV Oil Filled Cables

There are a number of pressurised oil filled cables in service on the network which are monitored. The risk of oil being lost from a cable is being reviewed with a proposed move to replacement with biodegradable oil. Refer to Sections 5 and 6 of the AMP.

### 8.9.5 Cast Iron HV Cable Terminations

A program is in place which systematically renews the older technology with modern materials to manage the known service problems from the cast iron cable termination design.

### 8.9.6 High Voltage Switchgear

There are a number of high voltage switchboards within the network which are being programmed for end-of-life replacement. The circuit breakers will be monitored by routine inspection and any operational controls put in place to manage the equipment effectively prior to replacement. The replacement programme has prioritised the switchgear based on condition and operational capability.

### 8.9.7 Ripple Injection Plant

Wellington Electricity operates a ripple system to control network loads (via operating hot water storage outside peak demand periods) and to initiate functions such as public lighting. The consequences of the load control system being unavailable are being reviewed and a set of controls for this risk is being developed. Mitigation measures include maintaining a stock of critical spares and investigating the commercial justification for investment in additional plant or alternative means of providing similar control.

### 8.9.8 Earthing and Neutral Connection Integrity

Earthing and neutral connections perform important electrical functions for service quality and safety. The network earthing system is regularly inspected and tested however the neutral integrity is difficult to assess and problems are addressed on discovery. A review of neutral connector performance will be undertaken should the frequency of neutral integrity problems increase above the present low incident levels.

### 8.9.9 Utilities Sharing Wellington Electricity Poles

The Government's broadband fibre roll out will require evaluation of the risks introduced from attaching additional services to power poles and the affect this will have on foundation strength, wind loading, structure integrity as well as operational considerations. A review of the consequences of supporting additional assets will be evaluated and the liabilities introduced allocated through contract to the parties introducing the additional services.

### 8.9.10 Earthquake Preparedness

The Wellington region is a seismically active area with multiple known fault lines, with risk of liquefaction in some areas and risk of tsunami in low lying coastal areas. Due to the events of the Christchurch earthquakes in September 2010 and February 2011 there has been increasing social and business awareness and dependency on a safe and reliable electricity supply and the need to restore power as safely and quickly as practically possible.

Wellington Electricity's network assets date back to early the 1900's and over the intervening years design codes and building practices have been revised as materials, costs and construction techniques have improved. Wellington Electricity has developed Emergency Response Plans to respond to various network incidents and events. While a specific seismic event plan has not been formulated Wellington Electricity have an operational Major Event Management Plan and other supporting plans described in detail in Section 8.10.

Wellington Electricity has been proactive in surveying and identifying any potential seismic issues with regards to the network buildings and assets. Major equipment within zone substations such as transformers and switchgear, service transformers, battery stands have been seismically strengthened. Also any heavy loose equipment has been removed from substations and relocated to a centralised store. Ongoing maintenance inspections will continue to identify any assets requiring additional seismic restraining.

Substation building installations generally comply with the relevant building code applicable at time of construction. Wellington City Council (WCC) conducts assessments of all buildings that have been built or strengthened to pre-1976 structural design codes to ensure compliance with their Earthquake Prone Buildings Policy initiated in 2006. A building is evaluated using the Initial Evaluation Process (IEP) as set out in the New Zealand Society for Earthquake Engineering Recommendations for the assessment and Improvement of the Structural Performance of Buildings in an Earthquake.

Wellington Electricity has received three IEPs from WCC to date. Of the three buildings assessed by WCC, only one has been identified as potentially earthquake prone. Consequently, Wellington Electricity have engaged external consultants to confirm the council's findings and to carry out a detailed design to seismically strengthen the non-compliant substation building at 70 Adelaide Road, Newtown.A project has commenced to provide strengthening works include constructing a new concrete wall behind the existing façade with planned completion in 2011.

Wellington Electricity's design and construction standards and specifications comply with current seismic design codes. Typical issues in respect of the new codes are tie down of distribution transformers (older transformers may have their wheels chocked) and older brick buildings that do not meet current seismic codes. Newer berm type substations are bolted to concrete plinths which have been placed on a formed flat ground platform. No specific restraint has been integrated into these installations.

Underground subtransmission cables utilising gas and oil filled technologies can be vulnerable to seismic events. Repair to extensively damaged gas and oil filled cables could take a number of months to repair which is unacceptable. Wellington Electricity has engaged with WCC to specifically address this issue in the event of an earthquake and to develop the protocols regarding the emergency installation of overhead 33kV lines should sub-transmission cables become unavailable for an extended period following a seismic event. Engagement with the remaining Wellington area councils will also occur during 2011.

Wellington Electricity is compliant in respect to current codes and captures required substation risk mitigation works in its network planning and is active in forming and maintaining coordinating relationships with key local area utilities and national disaster response organisations.

## 8.10 Emergency Response Plans

Wellington Electricity has a number of Emergency Response Plans (ERPs) to cover emergency and high business impact situations. All of the ERP's require annual simulation exercises to test the plans and procedures and feedback any areas for improvement. All of the ERP's shall be continuously reviewed and revised to best meet the emergency management and response requirements of Wellington Electricity.

Details of the various ERPs are provided below.

### 8.10.1 Major Event Management Plan

The purpose of the Major Event Management Plan (MEMP) is to ensure that Wellington Electricity is prepared for, and responds quickly to, any major event that occurs or may occur on its network. The MEMP defines a major event and describes the actions required and the roles and responsibilities of staff during a major event.

A particular focus of the MEMP is how the internal and external communications is managed. The plan contains detailed contact lists of all key stakeholders who may contribute or be affected by the major event.

### 8.10.2 Storm Response Plan

The purpose of the Storm Response Plan is to ensure that Wellington Electricity is prepared for and responds to any storm or potential storm that may impact on the network. The Storm Response Plan describes actions required and responsibilities of staff during a storm emergency and focuses on continuously improving systems and communications (internal and external) to benefit customers and retailers.

The regional weather patterns are monitored by the Wellington Electricity Network Control Room (NCR) on a daily basis using Metservice real-time information. The Storm Response Plan is invoked by the NCR if a storm warning or severe weather warning is declared by the Metservice for the Wellington region.

The Storm Response Plan has four stages of action: Storm Warning, Storm Standby, Storm Response and Storm Stand Down – each having varying levels of response and preparedness. The Storm Response Plan can escalate to the MEMP if required.

### 8.10.3 Emergency Evacuation Plan

The purpose of the Emergency Evacuation Plan is to ensure that the NCR is prepared for, and responds quickly to any incident that requires the short or long term evacuation of the NCR located at the Transpower Haywards Substation.

### 8.10.4 Civil Defence Emergency Management (CDEM) Plan

As an energy distributor providing essential services, Wellington Electricity belongs to the Lifeline Utilities group. There is an emphasis in the Civil Defence Emergency Management Act 2002 on ensuring that utilities provide continuity of operation, particularly where their service supports essential CDEM activity.

Wellington Electricity has prepared the CDEM Plan to comply with the relevant provisions of the CDEM Act. It provides information for the initiation of measures for saving life, relieving distress and restoring electricity connections.

This CDEM Plan follows the four 'Rs' approach to dealing with hazards that could give rise to a civil emergency:

- Reduction - identifying risks and developing plans to reduce these risks
- Readiness - developing emergency operational contingency plans
- Response - actions taken immediately before, during or after an emergency
- Recovery - rehabilitating and restoring to pre-disaster conditions.

### 8.10.5 Pandemic Preparedness Plan

The purpose of the Pandemic Preparedness Plan is to manage the impact of a pandemic related event by:

- Protecting employees as far as possible from spread of disease
- Create a safe working environment
- Maintain essential business functions with reduced staffing levels if containment is not possible.

The Pandemic Preparedness Plan shall be reviewed annually by the Wellington Electricity QSE manager.

### 8.10.6 Other Emergency Plans

- Business Continuity Plan
- Priority Notification Procedures to key staff and contractors
- Total Loss of a Zone Substation Plan
- Loss of Transpower Grid Exit Point Plan (Transpower Plan)
- Emergency Load Shedding Plan
- Participant Outage Plan (as required by the Electricity Commission)
- Call Centre Continuance Plan

In addition contingency plans are prepared as necessary detailing special arrangements for major customers.

## 8.11 Health and Safety

Wellington Electricity has developed a comprehensive set of health and safety policies and procedures and prioritises safety as a core business value.

Summarising its policy, Wellington Electricity endeavours to:

- Provide a safe and healthy work place for all its people, contractors and visitors
- Ensure health and safety considerations are part of all business decisions
- Monitor and continuously improve health and safety performance across the business

- Communicate and engage with its people, contractors, consumers, and stakeholders on health and safety matters
- Operate in a manner that encourages the correct safety behaviours and values
- Encourage safe and healthy lifestyles, both at work and at home.

It aims to achieve this by:

- Complying with all relevant legislation, standards and codes of practice for the management of health and safety
- Identifying, assessing and controlling workplace hazards
- Accurately reporting, recording and learning from all incidents and near misses
- Establishing health and safety goals at all levels both internally and externally, and regularly monitoring and reviewing the effectiveness of its health and safety management system
- Consulting, supporting and encouraging participation from its people on issues that have the potential to affect their health and safety
- Promoting its leaders', employees' and contractors' understanding of the health and safety responsibilities relevant to their roles
- Providing information and advice on the safe and responsible use of its products and services;
- Suspending activities if safety would be compromised
- Taking all practicable steps to ensure its contractors work in line with this policy.

All employees and contractors are responsible for ensuring their own and other's health and safety by adhering to safe work practices, making appropriate use of plant and equipment (including protective clothing and equipment) and promptly reporting incidents, near misses and hazards.

Wellington Electricity's key health and safety values in regard to the conduct of its employees and contractors are:

- 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.

### 8.1.1. Contractor Health and Safety

A safe work practices manual defines the essentials necessary to maintain an injury free environment. These practices reflect the basic approach necessary for Wellington Electricity and its contractors to identify and eliminate accident causes.

All contractors working for Wellington Electricity are required, as a minimum, to comply with these safe work practices whilst carrying out any work on the network. Contractors are also required to report all employee accidents/incidents and near misses to Wellington Electricity together with the results of their investigations and intended corrective actions. It is important to note that all contractors are responsible for developing, implementing and monitoring their own safe work practises.

Wellington Electricity has a comprehensive competency framework which comprises network access induction training, work type competency standards and contractor pre-qualification processes. Any internal staff and external service providers must obtain and be able to demonstrate the appropriate levels of competency under the framework as well as safety management systems before accessing, working on or near to the network.

### 8.1.2. Contractor Safety Performance 2010

During 2010 Wellington Electricity contractors achieved a 12 month period with no lost time incidents. With a Lost Time Injury Frequency Rate (LTIFR[16]) of 10.4 at the beginning of 2010 and no reported lost time injuries an LTIFR of zero was achieved in December 2010. The graph below shows the LTIFR trend for 2010.

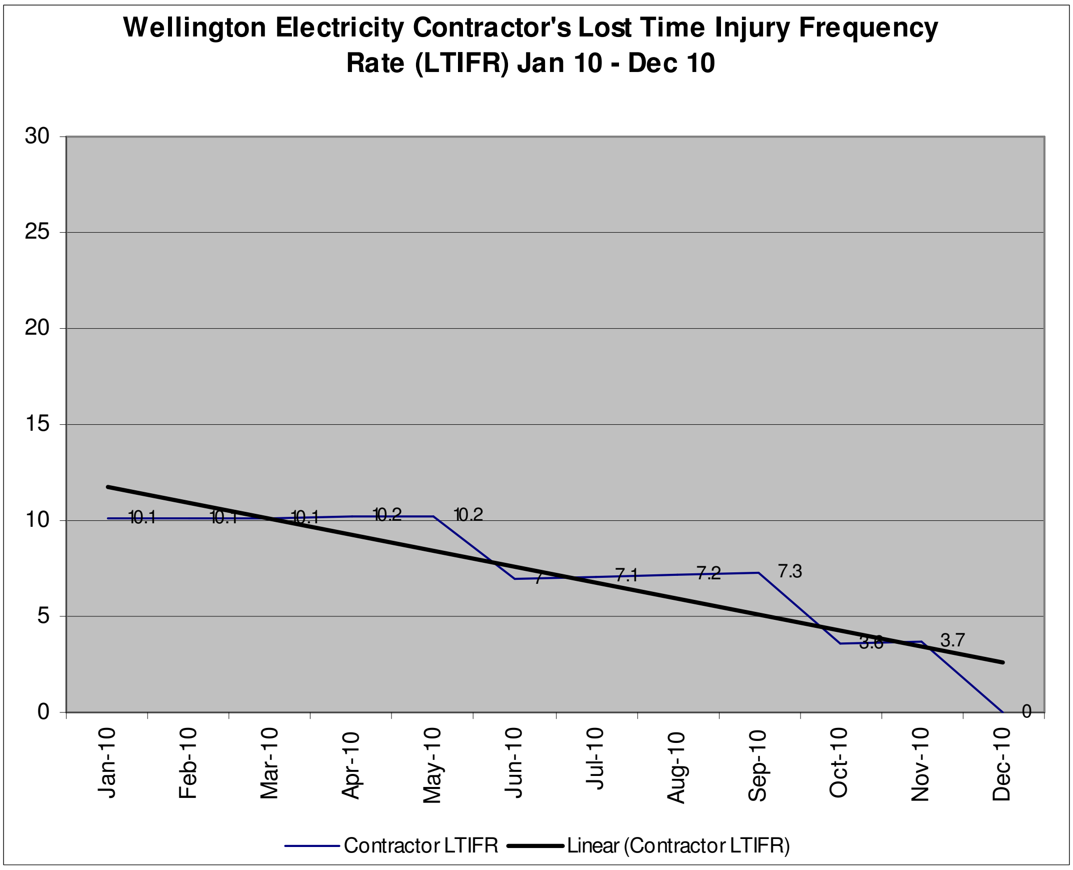



Figure 8-11 Wellington Electricity Contractor LTIFR – Jan 2010 to Dec 2010

During 2010 Wellington Electricity took part in an industry led safety initiative called the Great Safety Performance (GSP) Programme. This programme was initiated by the Electricity Engineers Association and saw Wellington Electricity partnering with its field service provider. The GSP programme involved field staff undertaking a series of behavioural based surveys aimed at gauging attitudes and perceptions around safety behaviour. The results of these surveys were used to measure the safety culture within Siemens and

[16] The LTIFR is determined by dividing the number of lost time injuries recorded by the total hours worked during the reporting period multiplied by 1,000,000.

as a tool to design safety initiatives that would lead to an improved safety culture. As a direct result of the survey, Wellington Electricity was able to better tailor its field assessment programme so that contractors were better informed and new what to expect from these assessments.

### 8.1.3. Third Parties

A large number of third parties work around or close to Wellington Electricity's network assets. These third parties can range from the general public up to large contracting businesses (and their subcontractors) working under contract.

Wellington Electricity experiences a significant number of third party incidents on the network on a regular basis, typically these are:

- Road vehicles hitting power poles and LV pillars
- Civil excavation equipment striking live underground cables
- Various vehicles and equipment striking or touching live overhead lines

While these types of incidents can cause damage to the network assets, power outages to large numbers of customers and significant cost to the business, most significantly these incidents can result in serious harm, injury or death to the third party or nearby public.

Wellington Electricity provides a number of free of charge services to third parties to assist them in working around or near the electricity network. These consist of:

- Dial B4 U Dig – the provision of underground plans showing Wellington Electricity's assets in the requested work area
- Cable mark-outs
- 33kV cable stand-over
- Close Approach Consents

Unfortunately not all of these third party incidents are identified and reported at the time of incident which may lead to future safety and network reliability problems.

Wellington Electricity works closely with national and local territorial authorities and contracting bodies in educating their contractors and subcontractors on working safely around the electrical network.

Examples of how Wellington Electricity works to educate third party stakeholders are evidenced in the activities which took place during 2010. During this period a number of third party network safety presentations were delivered with the assistance of the Department of Labour to WCC, Capacity and NZTA service providers.

### 8.1.4. Public Safety

In 2006 significant amendments were made to the Electricity Act 1992. As a consequence of these amendments changes to the Electricity Regulations 1997 were required. The major change affecting Wellington Electricity is the requirement for electricity distributors to have in place a Safety Management System (SMS) directed at public safety.

Wellington Electricity has extensive policy and standards around maintaining a safe and reliable network which includes the assets that are installed in the public areas. Wellington Electricity already monitor public safety of these assets and staff/contractor safety incidents around its public assets. On a regular basis these incidents are reviewed to ensure lessons are captured and where appropriate incorporated into its safety programmes.

With respect to community safety, Wellington Electricity offers cable location and residential isolation services. Public safety awareness and communications programmes on electricity have been undertaken.

During 2010 Wellington Electricity, as part of its schools *"Stay Safe Programme",* delivered educational information regarding network safety to schools around Wellington. This programme has proved popular with many schools and is currently being integrated into Wellington Electricity's SMS.

Wellington Electricity has continued to review and develop the systems, policy and processes around asset safety and welcomes the overlay of SMS certification by April 2012. Wellington Electricity has developed an SMS framework which outlines the steps to implement an SMS within this deadline. Key elements of the SMS are already inherent in our asset policy and standards which includes asset description, hazard identification, risk assessment and controls, safety and operating processes and performance monitoring.

During 2011 Wellington Electricity will be ensuring that the SMS elements capture the current business, quality, and health and safety management systems and practices. The SMS will require public safety driven performance indicators which compliment our current network safety initiatives around public safety.

## 8.2. Environmental Practices

Wellington Electricity is committed to the principles of sustainable development and managing our business in an environmentally responsible manner. This is managed via an Environmental Management Plan. The key purposes of the Environmental Management Plan are:

1. To identify the range of environmental obligations associated with the project and to set guidelines for the allocation of responsibilities for the management of environmental issues between Wellington Electricity and the contractor.
2. To provide some assistance to the contractor to identify and meet its obligations throughout the course of the project.
3. That all environmental concerns are considered in the design, construction, operation, maintenance and disposal of network assets.

### 8.2.1. Asbestos

All asbestos-covered cables and DC circuit breaker arc chutes are located within non-publicly accessible substations and are only accessed by Wellington Electricity approved contractors with the appropriate competencies. The asbestos-covered cables are primarily short lengths used to connect switchgear and transformers. Surveys have been conducted to identify all asbestos cables and all asbestos cables have been tagged on the actual cable itself. The asbestos hazard has been inspected and the type of asbestos analysed has been categorised as a low risk.

Wellington Electricity has instigated an annual program within the capital expenditure budget to progressively replace the DC mercury arc rectifiers and associated equipment based on the asset condition and age. A risk assessment shall be conducted regarding the removal of the asbestos-covered circuit breaker arc chutes.

In addition to the asbestos cabling and DC equipment a limited number of Wellington Electricity substations have roofs which contain asbestos. Wellington Electricity plans to replace these roofs in the short to medium term.

In order to better manage the asbestos on the network and to meet its responsibilities in accordance with the Health and Safety in Employment (Asbestos) Regulations 1998, Wellington Electricity has developed an Asbestos Management Policy. This policy acts as a guide that advises on location, type and state of the asbestos on the network. This policy will serve as a hazard management guide for Wellington Electricity service providers and employees alike. When work is being undertaken where asbestos is present, the policy will allow for better project management and enable appropriate procedures to be developed.

When asbestos is removed, specialist asbestos removal contractors are used to remove and dispose of the equipment and to ensure the remaining site is free of any asbestos dust or particulates. Also contractors working in areas containing asbestos have received appropriate training in working around asbestos.

### 8.2.2. Site Contamination Management

The Petone zone substation site in Bouverie Street was previously a gas works site and has been identified as having ground contamination. An environmental assessment study has been carried out, which concluded that the risk to general site users from contamination is low and the risk to local groundwater or surface water is also low. Additionally an environmental management plan has been developed to manage the site contamination going forward.

# 9 Performance Evaluation

## 9.1 Review of progress against the previous AMP

Appendix A provides a comparison of forecast financial performance against actual for the previous year financial year (1 April 2009 to 31 March 2010). The variance for CAPEX was -13.9% and the OPEX variance was -2.6% as shown in the summary below.

| | Previous plan Forecast ($'000s) | Actual ($'000s) | Variance ($'000s) | Variance ($'000s) |
|---|---|---|---|---|
| OPEX | 11,125 | 10,840 | -285 | -2.6 |
| CAPEX | 22,290 | 19,190 | -3,100 | -13.9 |
| TOTAL | 33,415 | 30,030 | | |

Figure 9-1 Target vs. Actual Financial Performance for 2009/2010

The variation of -13.9% for CAPEX is a reflection of:

- A large number of commercial substations and subdivisions not proceeding due to economic recession, and the low demand for residential growth development projects;
- Savings were gained on several large projects due to the scale and nature of the works, such as switchboard replacement and cabling reinforcement projects where economy of scale was achieved with bulk order procurement;
- A large overhead line relocation to allow a wind farm development no longer proceeding due to customer withdrawal; and
- The CAPEX variance was slightly offset by a higher number of third party damage incidents on the network requiring reactive capital investment
-

## 9.2 Evaluation of Performance against Target

The service targets that Wellington Electricity has adopted are described in detail in section 4. These targets include:

- Network reliability (SAIDI, SAIFI)
- Contact Centre Service Levels
- Power Restoration times
- Faults per 100 circuit-km

### 9.2.1 SAIDI & SAIFI

The comparison of target and actual SAIDI and SAIFI for the year 2009/2010 is provided below.

| | Target 2009/10 | Actual 2009/10 | Variance |
|---|---|---|---|
| SAIDI | 29.70 | 40.629 | +36.8% |
| SAIFI | 0.44 | 0.583 | +32.5% |

Figure 9-2 Target vs. Actual Network Reliability for 2009/2010

It has been observed that the targets for 09/10 were set based on an average of the network performance between 1998 and 2003, which are not representative of the rolling average over the entire period (i.e. they were lower). This is illustrated in the SAIDI graph for the period since 1998, which is provided below.

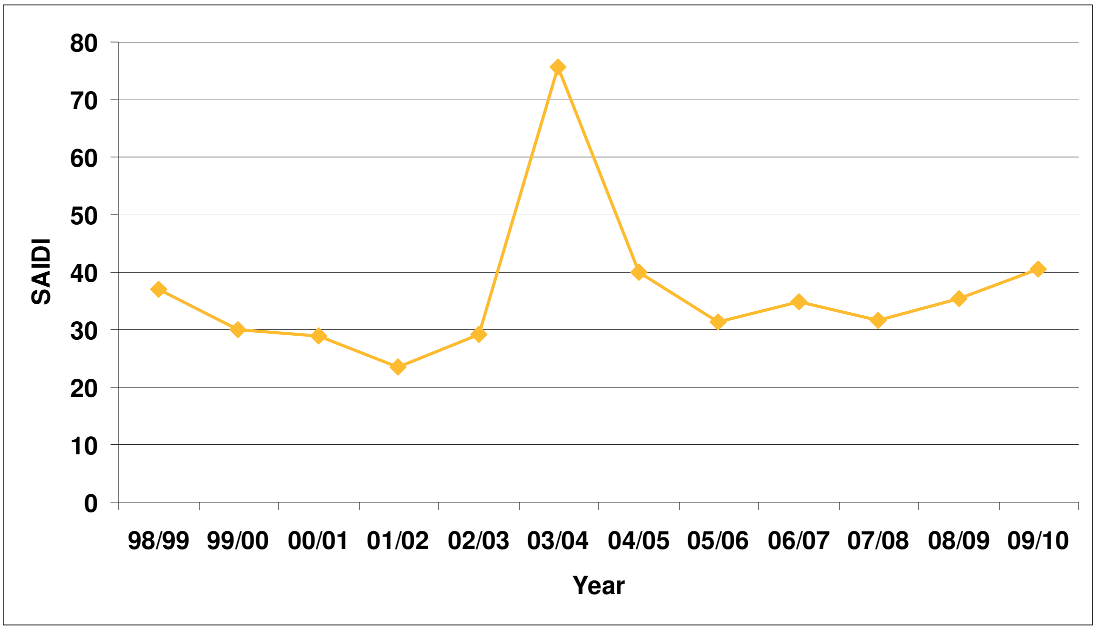



Figure 9-3 Historical SAIDI for Wellington Network 1998 to 2010

**2009-10 Quality Threshold Breach**

WELL has breached its reliability thresholds for SAIDI and SAIFI in the 2009/10 regulatory year as set out in the table in Figure 8.2 above:

**2009-10 Quality Threshold Breach Analysis**

There are two events which have contributed to the increase in interruption duration. Neither event reaches the "Beta"[17] level, however, these events do register as unusual weather related events which are outside of WELL's control, namely:

[17] The frequent but short duration outages that is characteristic of the WELL network result in a Tmed of approximately 9 SAIDI minutes. Given the highly interconnected nature of the network, it makes it extremely unlikely that any one event will be excluded from the statistics using this methodology.

- a period of eight days where there was a high frequency of sustained periods of gale force winds in May 2009. Two of these days (23 & 30 May 2009) were described by the MetService as “weather bombs” due to the magnitude and characteristics of the gale force winds involved. The timely network fault response to these events ensured the outages were minimised to a level well below the “Beta” event level. The severity associated with this event was experienced in only one of the five years of the reference period. Interestingly, only the 23 May “bomb” caused interruption to supply; and
- A further “weather bomb” occurred on 12 March 2010. A rapidly moving, southerly weather pattern developed into a severe storm front across Wellington. The hurricane force winds from this front resulted in significant vegetation debris, as well as more unusual objects such as trampolines, being stripped and transported across roads and into power lines and resulting in interruption to ten HV feeders.

Taken together, the above two events contributed a total of 8.293 minutes of SAIDI and 0.093 units of SAIFI. When deducted from the actual totals for 2009/10, the adjusted SAIDI and SAIFI for WELL becomes 32.345 and 0.486 respectively.

It is noted that under the revised thresholds, Wellington Electricity’s performance for 2009/10 would have been between the threshold target and limits.

The revised regulatory threshold for SAIDI and SAIFI are:

| | Target for 2010/11 | Limit for 2010/11 |
|---|---|---|
| SAIDI | 33.9 | 40.7 |
| SAIFI | 0.52 | 0.60 |

Figure 9-4 Reliability Targets for 2010/11

### 9.2.2 Contact Center Service Level

**A – General Contact Centre Service Levels**

| SL | Service Element | KPI | Actual 2009/10 |
|---|---|---|---|
| A1 | Overall Service Level | 80% | 88% |
| A2 | Call response | 20 seconds | 13.94 seconds |
| A3 | Missed calls | 4% | 1.89% |

Figure 9-5 Target vs. Actual General Contact Centre Service for 2009/2010

**B - Customer Experience**

All Customer contact should contribute to customer satisfaction in dealings with the Service Provider when representing Wellington Electricity.

| SL | Service Element | KPI | Actual 2009/10 |
|---|---|---|---|
| D1 | Specific Contact Centre experience | 80% | 87.29% |

Figure 9-6 Target vs. Actual Contact Centre Customer Experience for 2009/2010

**C - Energy Retailer Satisfaction**

All energy retailer contact should contribute to energy retailer satisfaction in dealings with the Service Provider when representing Wellington Electricity.

| SL | Service Element | KPI | Actual 2009/10 |
|---|---|---|---|
| E1 | Overall retailer satisfaction with Contact Centre performance | 80% | Survey yet to be completed |

Figure 9-7 Target vs. Actual Contact Centre Retailer Satisfaction for 2009/2010

### 9.2.3 Power Restoration Time

| | Less than 3 hours | More than 3 hours | More than 6 hours |
|---|---|---|---|
| Maximum time to restore power | 82% | 12% | 5.3% |

Figure 9-8 Performance - Power Restoration Time for 2009/2010

### 9.2.4 Faults per 100 Circuit Kilometre

| | Target 2009/10 | Actual 2009/10 |
|---|---|---|
| Faults per 100 circuit kilometre | 12.3 | 12.55 |

Figure 9-9 Performance – Faults per 100 Circuit KM for 2009/2010

## 9.3 Gap Analysis and Identification of Improvement Initiatives

During the past year, Wellington Electricity has reviewed many aspects of its asset management strategy and field service provision, and made a number of significant changes. However, there are gaps and improvement initiatives that have been identified in a number of key business areas, these gaps and areas for improvement are referred to throughout the report in the sections were they occur, and are summarised below.

| Section | Item | Description |
|---|---|---|
| 2.8.1 | ENMAC Implementation | Following the commissioning of the GE ENMAC SCADA system in 2011, Wellington Electricity shall continue to evaluate the functionality from the system allowing the full value to be extracted to better |

| Section | Item | Description |
|---|---|---|
| | | enhance the network real time operations. |
| 2.8.1 | Automatic Load Control System | A needs and benefits analysis needs to be undertaken to review the use and future options for automatic load control, as part of the overall load management / ripple strategy. An evaluation process will be conducted on the appropriate load control system replacement for the legacy Foxboro load control system. |
| 2.8.1 | Maintenance Management System | Development of the business rules and processes that are required under our maintenance policies, strategies and programmes to drive the development and implementation of an integrated maintenance management system to replace the maintenance database. |
| 2.9 | Field Services Agreement Implementation | The continued development and enhancement of the asset risk based condition assessment and defect management processes with the Field Service Provider to ensure the strategic intent and delivery is obtained from the Field Services Agreement |
| 2.9 | Data validity and improvement | Dedicated project initiatives will be conducted to address the data validity for both the ICP and GIS data within the Wellington Electricity information systems. Leverage from the processes provided within the Field Services Agreement will assist in the filling of data gaps and general cleansing of the asset data. |
| 2.9.5 | ICP verification | Improvement of the of ICP data integrity by reviewing the business process relating to ICP management to ensure the correct ICPs are attributed to the correct assets and the linkage exists between systems to validate the accuracy of ICPs. |
| 2.9.5 | Low Voltage Network Management | The Field Services Provider in conjunction with Wellington Electricity shall develop a LV network management plan to provide a works authority request process for all Wellington Electricity approved service providers accessing the LV network and to ensure the upkeep of the LV network system configuration is kept current in the Wellington Electricity information systems. |
| 3.4 | Spares Management | The requirements for network critical, emergency and general stock spares needs to be reviewed, and identification of required spares needs to occur. Many of the spares held needs to be evaluated, existing spares may become obsolete and potentially additional spares may be required. |
| 5 | Design and Construction Standards | Wellington Electricity has a range of old standards and designs from previous owners that are satisfactory, however these need to be reviewed, updated and compiled into a Design and Construction |

| Section | Item | Description |
|---|---|---|
| | | Manual. These now need to consider design for public safety. |
| 5.4 | Prioritisation of Capital Works | Ongoing development on existing processes for the prioritisation of Capital works projects, including the assessment of drivers such as network risk, financial benefit and option analysis and prioritisation. |
| 5.10 | Emerging Technologies | Develop plans to detail how emerging technologies will impact upon, and can be incorporated into, the existing network. |
| 5.11 | Network Development Plan | Wellington Electricity will develop a Network Development Plan to outline all the known constraints and improvements to be undertaken in the Planning area |
| 6 | Asset Lifecycle Planning | Develop and refine a "whole of life" management plan for each individual asset category to develop the existing knowledge, plans and programmes of work in the lifecycle asset management section. |
| 6.4.8 | Pole Testing | With the proposed introduction of the Deuar testing method for wood poles, the maintenance regimes and standards relating to poles will require revision. |
| 6.4.14 | Communications Strategy | Develop a full communications strategy for development and replacement of network infrastructure communications for SCADA and Protection, and other business communications needs. |
| 8.10 | Emergency Response Plans | Ongoing development and testing of Major Event Management Plan, Business Continuity Plan and other emergency response plans. |
| 8.1.4 | Public Safety Management System (PSMS) | Wellington Electricity will continue development of its PSMS and associated processes in preparation for the 2012 audit in accordance with the 2010 Electricity Safety Regulations. |
| 9.2 | Network Performance Evaluation | Better categorisation of outage durations of < 3hours, 3-6 hours and > 6 hours for Urban and Rural customers. |

**Figure 9-10 Gaps & improvements identified in the 2011 AMP**

Wellington Electricity aims to address these gaps and areas for improvement over the coming years by refining existing processes or adopting new processes, enhancing information systems to extract the full value to the business and to improve the data integrity, continuing to build asset condition information and holistically challenge and enhance the asset management strategies to meet both business and stakeholder requirements.

# Appendix A Expenditure Forecast and Reconciliation

## ASSET MANAGEMENT PLAN REQUIREMENT: EXPENDITURE FORECAST AND RECONCILIATION ($000 real as at 31 March 2010)

For initial forecast year ending 31/03/2012

### Ten Yearly Forecasts of Expenditure

| | Actual | Previous forecast | Forecast | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year Ending | 31/03/2010 | 31/03/2011 | 31/03/2012 | 31/03/2013 | 31/03/2014 | 31/03/2015 | 31/03/2016 | 31/03/2017 | 31/03/2018 | 31/03/2019 | 31/03/2020 | 31/03/2021 |
| Capital Expenditure: Customer Connection | 6,222 | 5,704 | 7,789 | 6,195 | 5,989 | 5,919 | 9,030 | 8,577 | 6,654 | 7,226 | 6,186 | 6,325 |
| Capital Expenditure: System Growth | 1,144 | 2,395 | 3,624 | 8,793 | 5,653 | 4,282 | 6,506 | 6,983 | 2,390 | 5,099 | 5,180 | 5,135 |
| Capital Expenditure: Asset Replacement and Renewal | 9,976 | 13,609 | 13,286 | 12,550 | 15,967 | 18,481 | 13,779 | 13,488 | 19,464 | 16,883 | 18,525 | 17,865 |
| Capital Expenditure: Reliability, Safety and Environment | 1,373 | 475 | 637 | 493 | 492 | 487 | 653 | 635 | 517 | 560 | 409 | 408 |
| Capital Expenditure: Asset Relocations | 475 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 | 956 | 959 |
| **Subtotal - Capital Expenditure on asset management** | **19,190** | **23,423** | **26,576** | **29,270** | **29,341** | **30,408** | **31,207** | **30,922** | **30,264** | **31,008** | **31,256** | **30,692** |
| Operational Expenditure: Routine and Preventative Maintenance | 5,953 | 5,778 | 5,764 | 5,816 | 5,883 | 5,888 | 5,943 | 5,999 | 6,055 | 6,112 | 6,169 | 6,227 |
| Operational Expenditure: Refurbishment and Renewal Maintenance | 575 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 |
| Operational Expenditure: Fault and Emergency Maintenance | 4,312 | 4,817 | 4,865 | 4,910 | 4,966 | 5,013 | 5,060 | 5,107 | 5,155 | 5,203 | 5,250 | 5,298 |
| **Subtotal - Operational Expenditure on asset management** | **10,840** | **11,241** | **11,274** | **11,372** | **11,495** | **11,546** | **11,648** | **11,751** | **11,855** | **11,959** | **12,064** | **12,170** |
| **Total direct expenditure on distribution network** | **30,030** | **34,663** | **37,850** | **40,642** | **40,835** | **41,955** | **42,855** | **42,673** | **42,120** | **42,968** | **43,321** | **42,862** |

**Overhead to Underground Conversion Expenditure** No overhead to underground conversion expenditure included in the above expenditure.

### Variance Analysis

| | Actual | Previous | % Variance | |
|---|---|---|---|---|
| | 31/03/2010 | 31/03/2010 | | |
| Capital Expenditure: Customer Connection | 6,222 | 7,323 | -15.0% | Note 1 |
| Capital Expenditure: System Growth | 1,144 | 3,276 | -65.1% | Note 2 |
| Capital Expenditure: Asset Replacement and Renewal | 9,976 | 10,019 | -0.4% | |
| Capital Expenditure: Reliability, Safety and Environment | 1,373 | 492 | 179.1% | Note 3 |
| Capital Expenditure: Asset Relocations | 475 | 1,180 | -59.7% | Note 4 |
| **Subtotal - Capital Expenditure on asset management** | **19,190** | **22,290** | **-13.9%** | |
| Operational Expenditure: Routine and Preventative Maintenance | 5,953 | 5,936 | 0.3% | |
| Operational Expenditure: Refurbishment and Renewal Maintenance | 575 | 614 | -6.4% | |
| Operational Expenditure: Fault and Emergency Maintenance | 4,312 | 4,575 | -5.7% | |
| **Subtotal - Operational Expenditure on asset management** | **10,840** | **11,125** | **-2.6%** | |
| **Total direct expenditure on distribution network** | **30,030** | **33,415** | **-10.1%** | |

**Notes:**

1 The variance compared to forecast is due to a large number of commercial substations and subdivisions not proceeding in 2010 due to economic drivers
2 The variance compared to forecast is due to savings gained on several large projects and lower growth than expected
3 The variance compared to forecast is due to a higher number of third party damage incidents on the network
4 The variance compared to forecast is due to a larger overhead relocation not proceeding in 2010

# Appendix B Glossary of Terms

| | |
|---|---|
| AAC | All Aluminium Conductor |
| AAAC | All Aluminium Alloy Conductor |
| ABS | Air Break Switch |
| ACSR | Aluminium Conductor Steel Reinforced |
| AMP | Asset Management Plan |
| CB | Circuit Breaker |
| CBD | Central Business District |
| CCT | Covered Conductor Thick |
| CEO | Chief Executive Officer |
| CHED Services | Cheung Kong Infrastructure Holdings Limited & Hong Kong Electrical International Electricity Distribution Services Pty Ltd |
| CIGRE | Conference Internationale des Grands Reseaux Electriques (International Council for Large Electric Systems) |
| CKI | Cheung Kong Infrastructure Holdings Limited |
| Cu | Copper |
| DC | Direct Current |
| DGA | Dissolved Gas Analysis |
| DTS | Distributed Temperature Sensing |
| EDO | Expulsion Drop-out |
| FPI | Fault Passage Indicators |
| GWh | Gigawatt Hour |
| GIS | Geographical Information System |
| GXP | Grid Exit Point |
| HV | High Voltage |
| ICP | Installation Control Point |
| IEEE | Institute of Electrical and Electronic Engineers |
| IISC | International Infrastructure Services Company |
| km | Kilometre |
| KPI | Key Performance Indicator |
| kV | Kilovolt |

| | |
|---|---|
| kVA | Kilovolt Ampere |
| kW | Kilowatt |
| LV | Low Voltage |
| LVABC | Low Voltage Aerial Bundled Conductor |
| MW | Megawatt |
| MVA | Mega Volt Ampere |
| NICAD | Nickel Cadmium Battery |
| Nilstat ITP | Protection Relay |
| ODV | Optimised Deprival Value/Valuation |
| O&M | Operating and Maintenance |
| PDC | Polarisation Depolarisation Current |
| PIAS | Paper Insulated Aluminium Sheath Cable |
| PILC | Paper Insulated Lead Cable |
| PLC | Programmable Logic Controller |
| PVC | Polyvinyl Chloride |
| 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 |
| TASA | Tap Changer Activity Signature Analysis |
| TCA | Transformer Condition Assessment |
| VRLA | Valve Regulated Lead Acid Battery |
| W/S | Winter / Summer |
| XLPE | Cross Linked Polyethylene Cable |