Electricity Transmission Regulatory Reset

2008/09 – 2013/14

Appendix E

Asset Management Strategy

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Asset Management Strategy

Victorian Electricity Transmission Network

SP AusNet
A member of Singapore Power Group

ISSUE/AMENDMENT STATUS

Issue Number	Date	Description	Author	Approved by
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Foreword

SP AusNet owns and operates the Victorian electricity transmission network, directly serving the energy needs of Australia's second largest economy. SP AusNet also serves the National Electricity Market (NEM) via the national transmission grid.

This network transfers bulk power from NEM generators to the electricity distributors who service in excess of 2.2 million Victorian households and businesses. It interconnects high voltage customers such as the Portland Aluminium Smelter and the transmission networks of neighbouring New South Wales, South Australia and Tasmania. In total, this network transferred over 41,706 GW hours of energy in 2005/06 and serviced a peak demand of 8730 MW.

The Victorian Energy Network Corporation (VENCorp) and Victoria's electricity distributors jointly plan the augmentation of Victoria's electricity transmission network. They forecast that continuing augmentation is necessary to meet the 0.9% p.a. growth in Victorian electricity consumption and the 1.9% p.a. growth in maximum demand over the next decade.

SP AusNet's vision is to be ***"the best networks business".*** Our mission is to ***"deliver energy and associated services safely, reliably, responsibly and profitably to enhance the lives of our customers today and into the future".***

The SP AusNet company values are:

- **Commitment** to the highest standards of service and performance when creating value for customers, the public, employees and shareholders
- **Integrity** to act with honesty and to practise the highest ethical standards
- **Passion** to take pride and ownership in all that we do
- **Teamwork** – to support, respect and trust each other, with continual learning through sharing of ideas and knowledge

This Asset Management Strategy (AMS) is a key tool in achieving the SP AusNet vision. This AMS facilitates delivery of agreed performance levels and optimised asset life cycles.

With a time horizon of 2020, this AMS and its supporting documentation provides the technical direction for responsible stewardship of Victoria's electricity transmission assets on behalf of the NEM, energy generators, stakeholders, regulators, government and energy users.

Norm Drew
General Manager,
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1 Executive Summary

This Asset Management Strategy (AMS) is a primary resource in the management of Victoria's power transmission assets, determining the delivery of quality services to customers and value to shareholders. It summarises the medium-term strategic actions to achieve regulatory and business performance targets, which are implemented via the programs of work listed in Asset Management Plans.

1.1 Aims

The aims of asset management for the electricity transmission network are to:

- Create sustainable asset and network risk-profiles to underpin future performance
- Meet reliability and availability performance targets
- Improve health, safety, environment and infrastructure security performance
- Comply with codes and regulations
- Minimise life-cycle costs

1.2 Asset Management Drivers

The Business Environment Assessment section of this AMS explores the main influences on network performance and therefore future network investment.

The following are significant drivers:

- Sustainable Network Risks – Reliability and availability expectations, maintenance of asset condition and sustainable network and asset risk profiles are driving high maintenance, refurbishment and replacement volumes
- Network Augmentation Levels – Continuing growth in demand, increasing network fault level restraints and high equipment utilisation levels are increasing the levels of network augmentation
- Performance Improvements – Code compliance, and health and safety, environment and infrastructure security performance improvements
- Efficiency – Continuing efficiency demands elevated asset management practices
- Technology - Emerging viability of new technologies
- Workforce – Potential workforce skilling demands

1.3 Key Metrics

The following figure (Figure 1) summarises metrics, defining the current performance and future trends of the Victorian electricity transmission network.

Key Metrics – Victorian electricity Transmission Network		
Metric	**Recent Performance[1]**	**2011 Forecast**
Annual Energy Transmitted	41,706 GWH	+ 0.9 % p.a.
Summer Maximum Demand	8730 MW	+ 1.9 % p.a.
Winter Maximum Demand	7644 MW	+ 1.3 % p.a.
Average Transformer Utilisation[2]	95 % of N-1 capacity	+ 2.2 % p.a.
Average 220kV Fault Levels[2]	17 kA	+ 1 % p.a.
Reliability (retail interruptions)	4 p.a.	
Reliability (system minutes)	0.5 p.a.	
Availability (Peak Critical Circuit)	99.945 %	Meet ACCC Target
Availability (Peak Non-critical circuit)	99.857 %	Meet ACCC Target
Availability (Intermediate Critical Circuit)	99.745 %	Fail ACCC Target
Availability (Intermediate Non-critical Circuit)	98.210 %	Fail ACCC Target
Availability Lines	99.5 %	Meet VENCorp Target
Availability Transformers	99.7 %	Renegotiate Target
Availability Capacitors	99.3 %	Meet VENCorp Target
Availability SVAR Compensators	98.1 %	Renegotiate Target
Availability Synchronous Condensers	90.0 %	Meet VENCorp Target
Network Risk	Improving	Stable
Reliability Risk	Improving	Stable
Availability Risk	Increasing	Increasing
Health and Safety Risk	Improving	Improving
Environmental Risk	Improving	Improving
Infrastructure Security Risk	Improving	Improving
Code Compliance Risk	Improving	Improving
Average Network CAPEX		
Average Network OPEX		

Figure 1 – Key Metrics

[1] Refer to Section 5, Performance, for measurement details.
[2] Established by Distribution Business and VENCorp planning processes.

2 Introduction

This section provides relevant context and background to the AMS through summaries of the following areas:

- Purpose
- Scope
- Asset management process
- Structure
- Network overview
- Asset summary
- Development history
- Asset Age
- Economic regulation
- Victorian planning framework

2.1 Purpose

With a time horizon of 2020, the AMS and its supporting documentation provide robust technical direction for the responsible stewardship of electricity transmission assets. SP AusNet is steward of these assets on behalf of Victoria's energy users, generators, shareholders, regulators, government and the NEM more broadly.

This stewardship includes:

- Assessment of the dynamic business environment
- Consideration of stakeholders interests and needs
- Commitment to sustainable risk, value and performance levels
- Skilled and expert management of critical assets through rigorous analysis, sophisticated policy and robust operating processes

2.2 Scope

The scope of this AMS includes electricity transmission assets in Victoria including:

- Transmission lines[3], power cables and associated easements and access tracks
- Terminal stations, switching stations, communication stations and depots including associated electrical plant[4], buildings and civil infrastructure
- Protection, control, metering and communications equipment
- Related functions and facilities such as spares, maintenance and test equipment

[3] 500 kV, 330 kV, 275 kV and 220 kV transmission lines and cables
[4] 500 kV, 330 kV, 275 kV, 220 kV, 66 kV and 22 kV switchgear and transformers

- Asset management processes and systems such as System Control and Data Acquisition (SCADA) and asset management information systems (including MAXIMO)

More specifically, the AMS relates to the electricity transmission sites and facilities:

- Listed in the Network Agreement between SP AusNet (then PowerNet Victoria) and VENCorp (then the Victorian Power Exchange) 1994
- Listed in 1994 Connection Agreements between SP AusNet and connected parties largely consisting of generators, direct connect customers and distributors
- Listed in various supplementary network and connection agreements, detailing SP AusNet's unregulated transmission assets
- Illustrated on SP AusNet's system diagram T1/209/84

The AMS excludes the assets and infrastructure owned by:

- Generators
- Exit customers
- Other companies providing transmission services within Victoria

The AMS excludes SP AusNet corporate processes and associated information technology systems such as business communication, human resources and financial management systems. It does not include information on corporate offices or general business equipment such as computers and motor vehicles.

2.3 Asset Management Process

This AMS is informed by corporate visions, business plans and an assessment of the external business environment. It is a critical guide for the development of longer-term asset management plans as well as more immediate work programs for enhanced performance and efficiency.

As illustrated in the figure below (Figure 2), this AMS is a pivotal step in the SP AusNet asset management process.

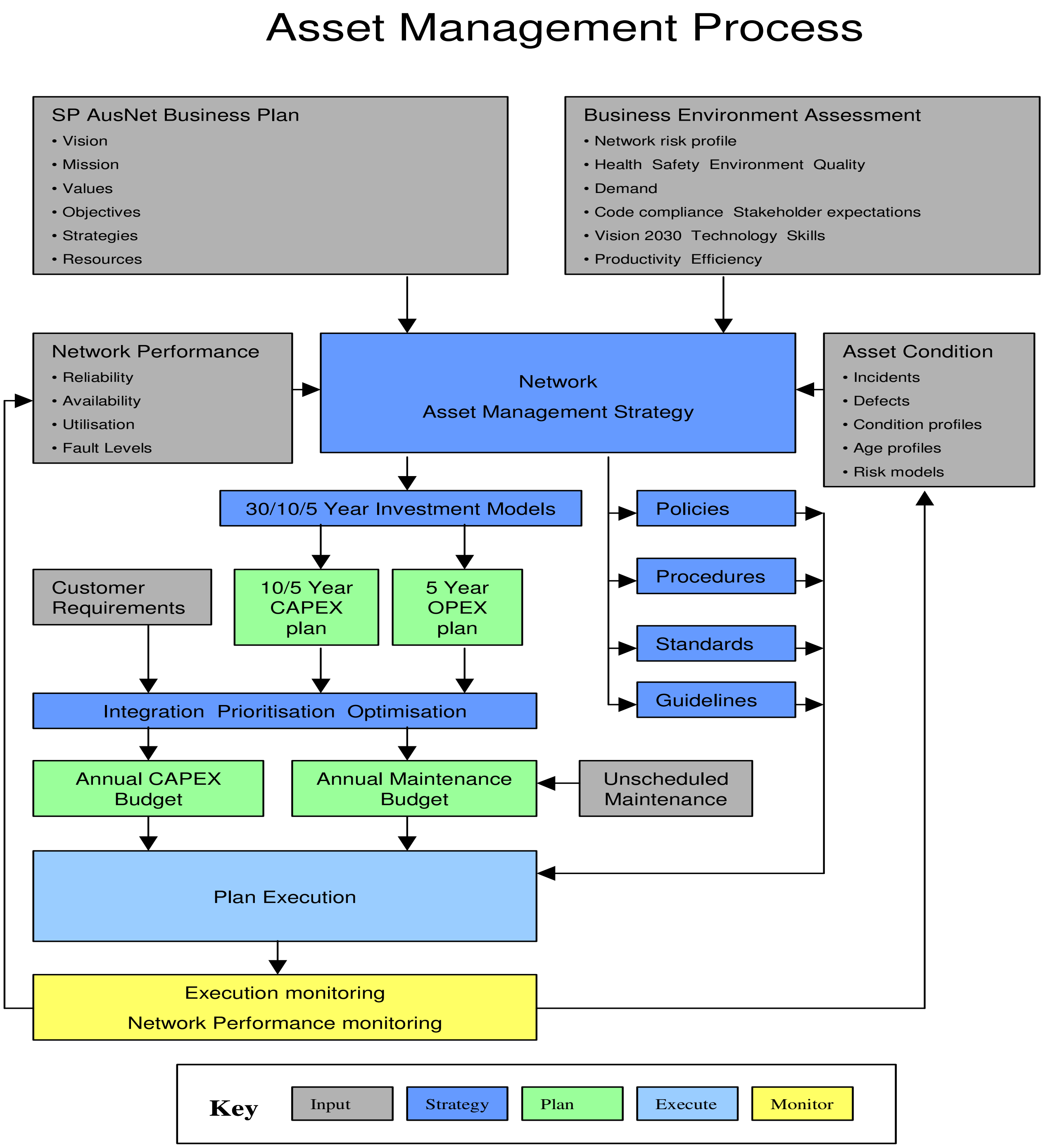

Figure 2 – Asset Management Process Flowchart

2.4 Asset Management Strategy Structure

This AMS forms the apex of a three-tiered hierarchy of documents that guide the asset management process. The hierarchy covers strategy, policy, procedures and plans for asset management. The resource documents in the Foundation and Implementation levels support the AMS, as illustrated in the figure below (Figure 3).

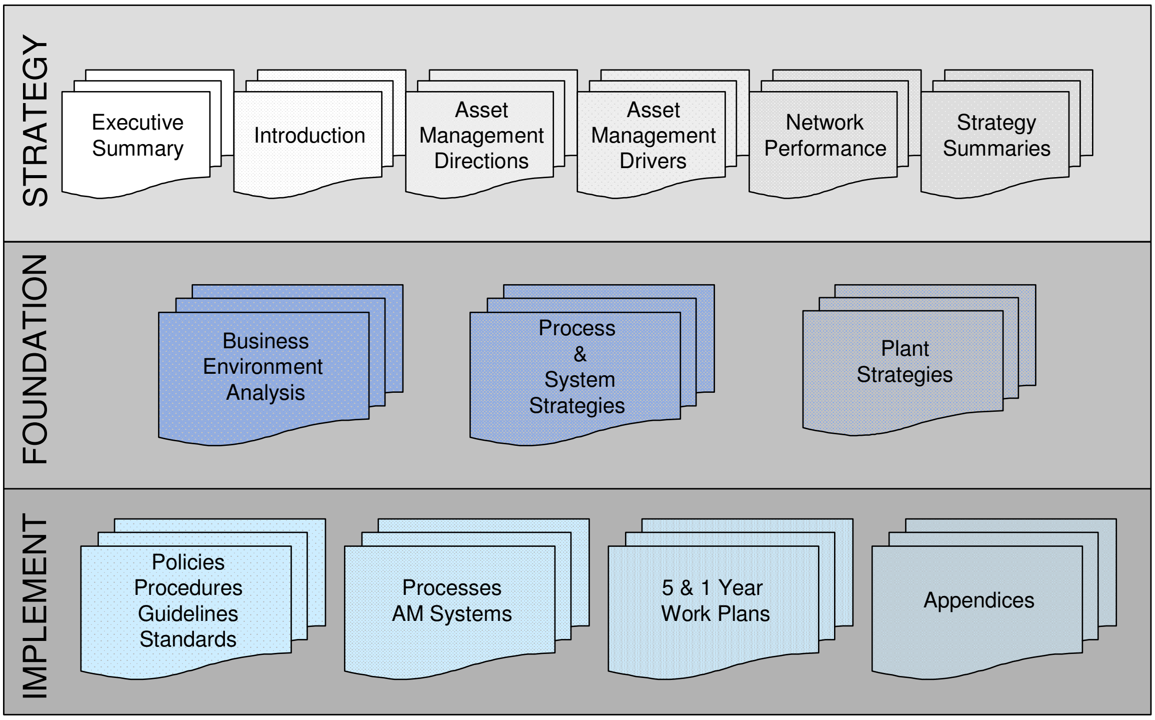

Figure 3 – Hierarchy of the Asset Management Strategy

At the highest level, the AMS brings together the external influences, investment drivers, business values and asset management directions with a high-level summary of the required resources and the strategies selected to deliver challenging and sustained performance for the benefit of stakeholders. Hyperlinks integrate this highest level with supporting documents in the foundation and implementation levels.

The second level contains the foundation documents that the AMS is built upon. This level includes a detailed analysis of the business environment that the network must operate within. This level also details the assets, issues and investment drivers behind each technical, procedural and support system strategy that is necessary to achieve agreed performance outcomes.

The third level outlines the implementation of the AMS. At this level, strategies are integrated with SP AusNet's business systems and practices, providing direct links between strategies for asset management and company policies, procedures, support system developments, work programs and plans.

2.5 Network Overview

SP AusNet's electricity transmission network interconnects generators, distributors, high voltage customers and the transmission systems of neighbouring New South Wales, South Australia and Tasmania. It serves approximately 5 million Victorians living in an area of approximately 227,600 square kilometres.

A 500 kV network backbone runs from the Latrobe Valley through to Melbourne and across the south-western part of the state to Heywood. This 500 kV network facilitates the transfer of power between the coal and gas-fired generators in Gippsland, hydro-electric generators in the Victorian Alps and the significant load centres of Melbourne, Geelong and the Portland aluminium smelter.

As illustrated in Figure 4, the 500 kV network is reinforced by a 220 kV circuit around Melbourne, two 220 kV rings in rural Victoria and interconnections to neighbouring states.

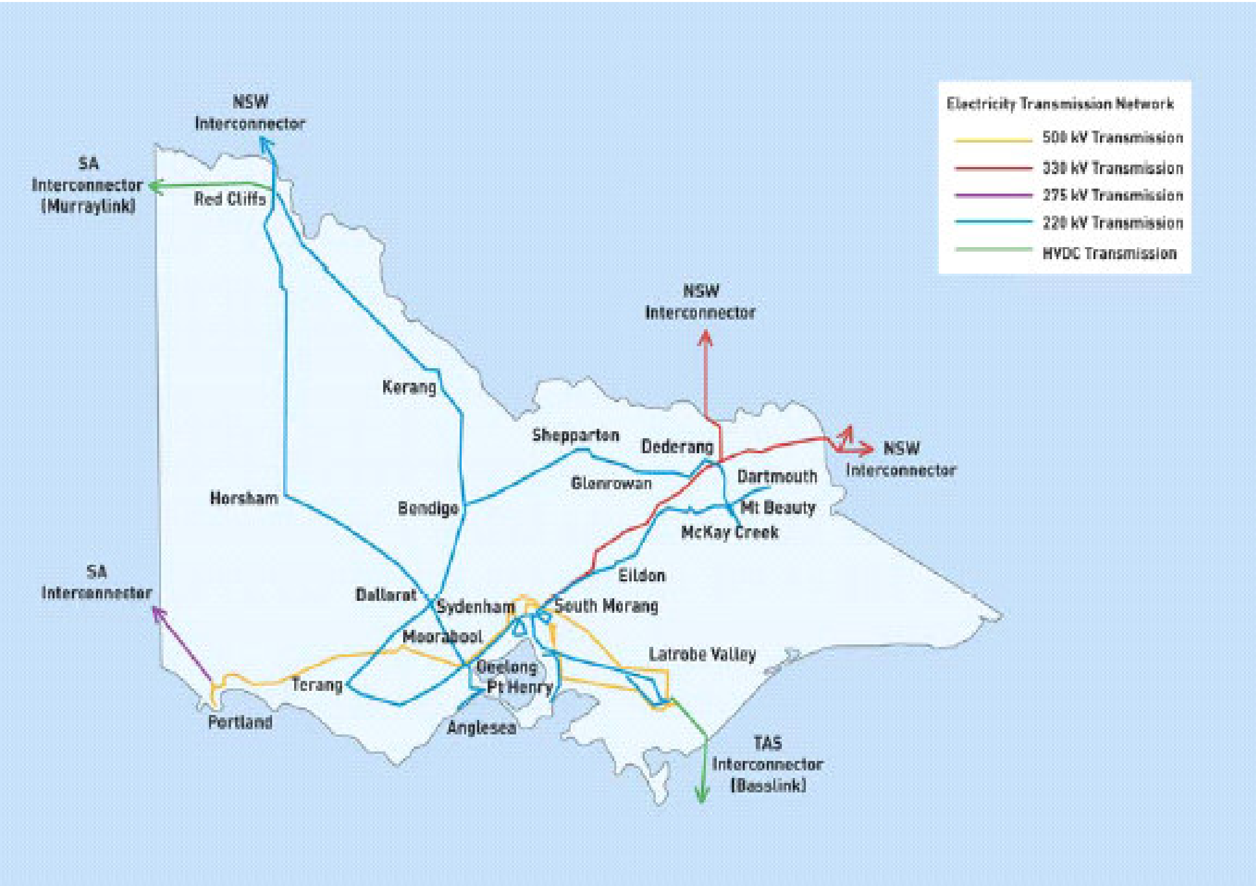

Figure 4 – Victorian Electricity Transmission Network

2.5.1 Metropolitan Melbourne

The 500 kV and 220 kV networks serving metropolitan Melbourne are shown in the following figure (Figure 5),

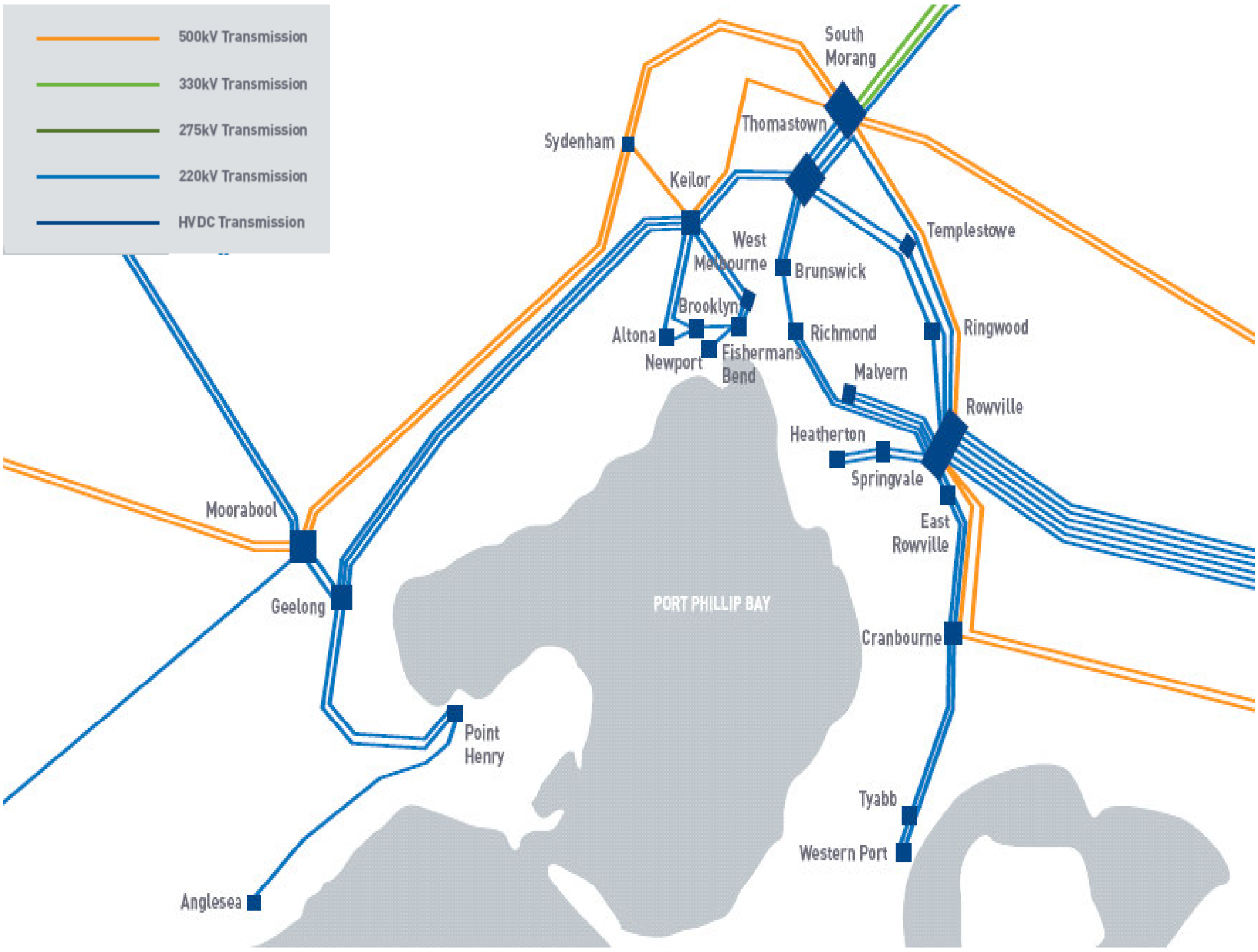

Figure 5 – Metropolitan Melbourne Electricity Transmission Network

The Latrobe Valley to Melbourne transmission link comprises four 500 kV lines and six 220 kV lines. The 500 kV network supplies power from the Loy Yang and Hazelwood power stations to Keilor, South Morang, Rowville and Cranbourne Terminal Stations. The 220 kV network transfers power from the Hazelwood and Yallourn generation into the eastern metropolitan area at Rowville Terminal Station.

2.5.2 Regional Network

Regional Victoria is supplied via a 220 kV network from terminal stations at Geelong, Terang, Ballarat, Bendigo, Shepparton, Glenrowan, Kerang, Horsham and Red Cliffs. This network is energised by 500 kV to 220 kV transformation at Moorabool, Keilor and South Morang Terminal Stations. Morwell Terminal Station provides the supply to Gippsland and the Latrobe Valley.

A 500 kV connection supplies the single largest regional load – the Portland aluminium smelter in the state's far west.

2.5.3 Interstate Connections

The NEM interconnections include:

- Two 330 kV lines from Dederang Terminal Station, to the Murray Switching Station (NSW)
- One 330 kV line from Wodonga Terminal Station to Jindera (NSW)
- One 220 kV line from Red Cliffs Terminal Station to Buronga (NSW)
- Two 275 kV lines from Heywood Terminal Station to South East Substation (SA)
- One 220 kV circuit from Red Cliffs Terminal Station to Berri (SA)
- One 300 kV circuit from Loy Yang to Bell Bay (TAS)

2.6 Asset Summary

Summarised in the figure below (Figure 6), are the major facilities, assets and systems of the Victorian electricity transmission network.

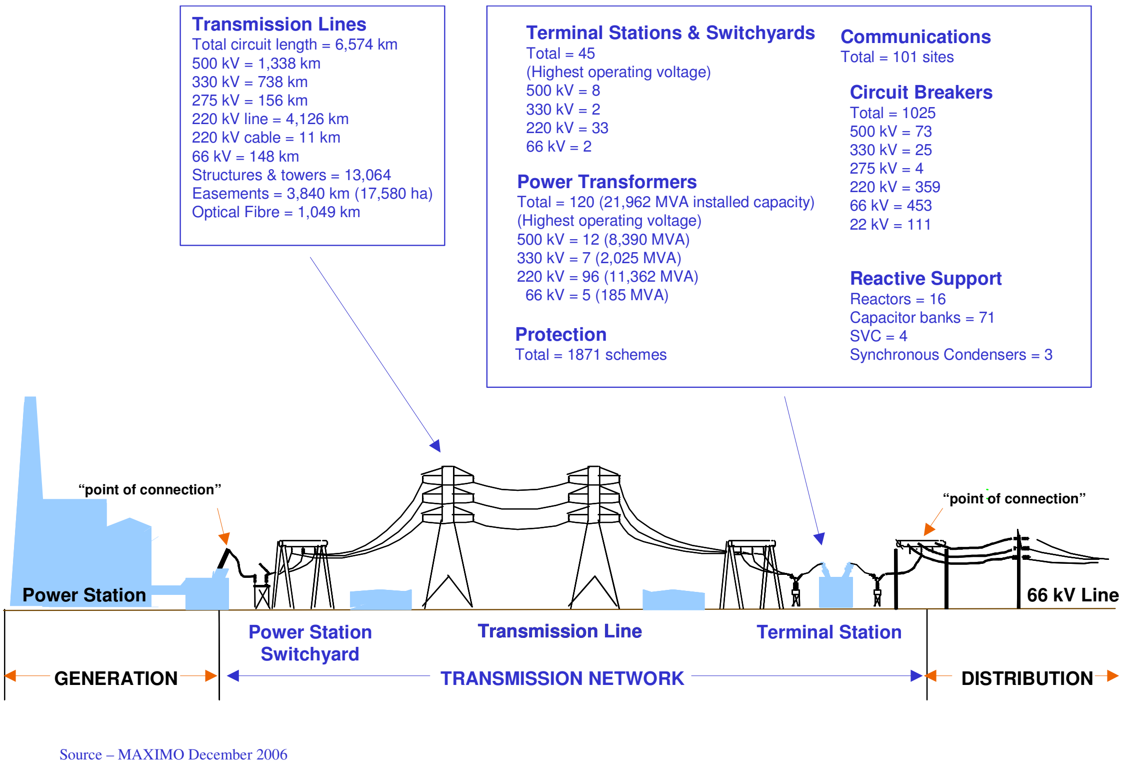

Figure 6 – Summary of Facilities and Assets in the Victorian Electricity Transmission Network

2.7 Development History

The development of the Victorian electricity transmission network commenced in the 1940s with connection of metropolitan Melbourne to hydroelectric generators located in the Victorian Alps.

The brown coal fired generators in the Latrobe Valley were interconnected in the mid 1950s via a 220 kV network. This network developed progressively through the 1960s to interconnect the rural areas of Victoria.

The first elements of the 500 kV transmission network were established in 1970 and later elements were added in the mid 1980s. The first interstate connections occurred with the establishment of the NSW interconnector in the early 1970s. Interconnection with South Australia occurred in 1991 from Heywood and 2001 from Redcliffs via the Murray Link DC interconnector. Interconnection with Tasmania via an undersea DC cable link was effected late in 2005. The development history of this network is summarised in the figure (Figure 7) below.

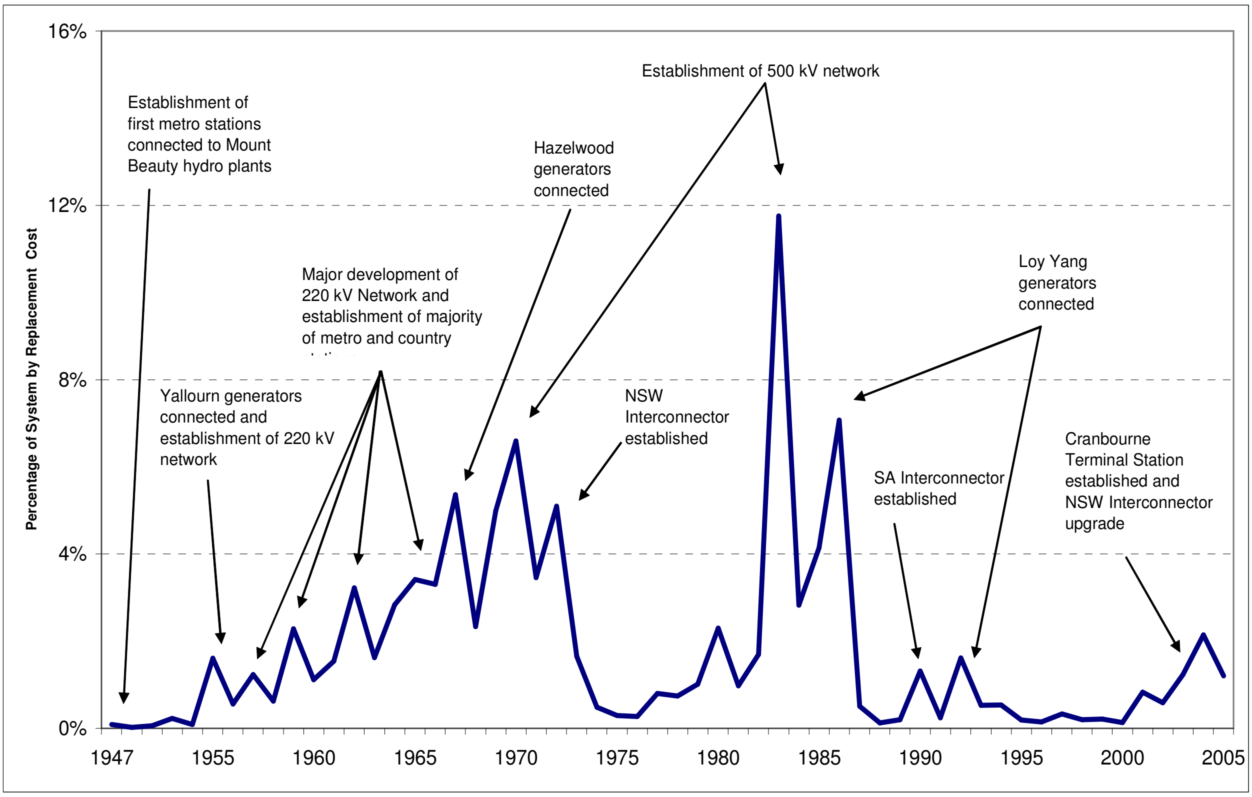

Figure 7 – Development of the Victorian Electricity Transmission Network

2.8 Asset Age

Consistent with its development history, assets forming the Victorian electricity transmission network are relatively old when compared with assets in other Australian and international networks.

The figure below (Figure 8) compares the average age of assets in the Victorian network with those of 19 international and four other Australian networks participating in the 2005 ITOMS[5] benchmarking exercise.

[5] ITOMS 2005 Report - International Transmission Operations & Maintenance Study – Revision 6 May 2006

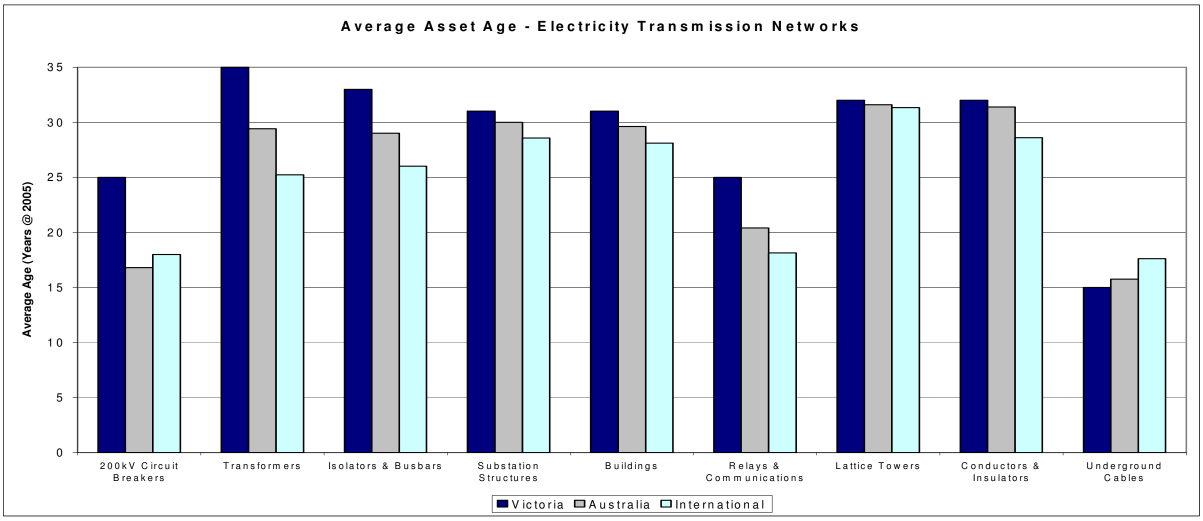

Figure 8 – Average Asset Age

Of particular note are the significant differences between the average ages of circuit breakers, power transformers, isolators & busbars and relays & communications equipment in the Victorian network compared with its Australian and international peers. These age differences are the major driver for the terminal station refurbishment program, which commenced in 2001.

2.9 Economic Regulation

This section outlines the regulatory framework and economic policy pertaining to the electricity industry in Victoria. It summarises the NEM regulatory and statutory bodies from the perspective of transmission asset management. The following figure (Figure 9) illustrates the commercial relationships described in the subsequent text.

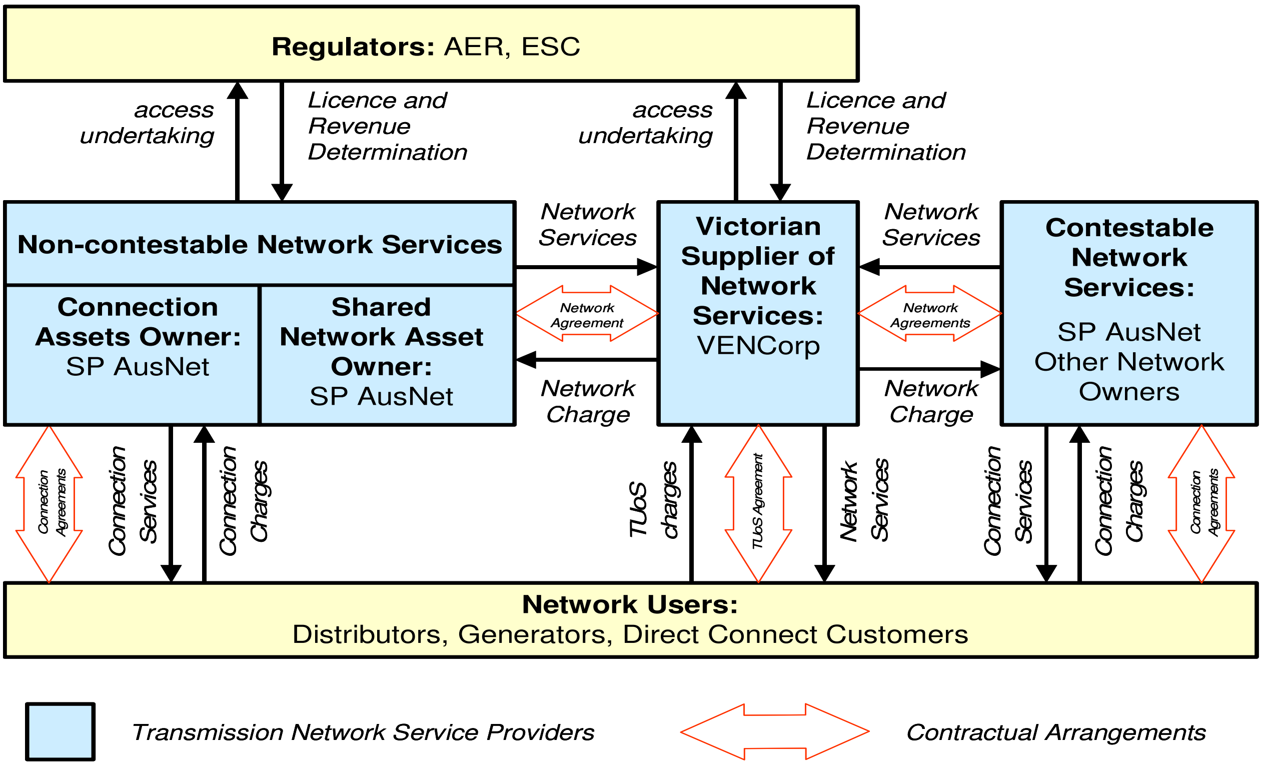

Figure 9 – Regulatory Commercial Framework

2.9.1 New National Electricity Law and Rules

Reforms to governance arrangements were implemented in the National Electricity Law (NEL) and National Electricity Rules (NER) finalised in early 2005. Energy specific regulatory bodies, including the Australian Energy Regulator (AER) and Australian Energy Market Commission (AEMC) commenced operations on 1 July 2005.

The AER is responsible for economic regulation (replacing the ACCC and eventually the state regulators in this role) and rule enforcement (replacing NECA functions in this area) in the energy sector. It has been established under recent amendments to the Trade Practices Act 1974.

The AEMC is responsible for rule-making and market development for the energy sector (replacing NECA functions and ACCC authorisation in this area). It has been established under the Australian Energy Market Establishment Act 2004, a South Australian Act.

The ACCC continues to perform its regulatory functions, as outlined the Trade Practices Act, including the assessment of mergers and acquisitions in the energy industry.

A Memorandum of Understanding between the ACCC, the AER and the AEMC guides interaction between these bodies and their functions. It provides a balance between development and implementation of energy market rules, industry regulation and general competition regulation.

2.9.2 Australian Energy Regulator

Clause 6.2.2 of the NER sets out the objectives of the transmission revenue regulatory regime to be administered by the AER. In terms of asset management, the AER is seeking to ensure transmission businesses deliver:

- The appropriate standard and scope of services
- An efficient level of investment within the transmission sector
- Efficient operating and maintenance practices
- Efficient use of existing infrastructure

2.10 Victorian Planning Framework

Under Victorian governance, planning functions are separated from the ownership and operation of the transmission network.

2.10.1 NEMMCO

The National Electricity Market Management Company Limited (NEMMCO) is a government owned company with primary responsibility for the operation and development of the wholesale market in the NEM. It also has specific responsibilities for the maintenance and improvement of power system security and for undertaking the coordination and planning of augmentations to the national electricity system. NEMMCO provides relevant information via the Annual National Transmission Statement and the Annual Statement of Opportunities.

2.10.2 VENCorp

VENCorp is a non-profit entity owned by the State Government and it is an integral part of Victoria's privatised gas and electricity industries. VENCorp is responsible for the overall coordination, planning and augmentation of the shared transmission network. Principle VENCorp information resources are an Annual Planning Report, Demand Forecasts, Network Planning Criteria and a 25 year network Vision for energy transmission in Victoria.

2.10.3 Connected Parties

In Victoria, connected parties are responsible for the planning and augmentation of their connection assets.

The five distribution businesses (DBs) have responsibility for planning and directing the augmentation of those facilities that connect their distribution systems to the shared transmission network. DBs plan and direct the augmentation in a way that minimises costs to customers, taking into account distribution losses and transmission losses that occur within the transmission connection facilities. Other connected parties (major consumers or generators) are responsible for their own connection planning. They can choose to delegate this task to a DB if they wish.

In the event that a new connection, or augmentation of an existing connection, is required the connected parties must consult with and meet the reasonable technical requirements of VENCorp, SP AusNet and other affected parties.

Each year the DBs publish a Transmission Connection Planning Report that assesses the risk of lost load, network planning criteria and options for meeting forecast demand.

3 Asset Management Directions

The Australian Energy Regulator has established a single, clear national objective for a competitive, open and unbiased electricity energy market:

> To promote efficient investment in, and use of, electricity services for the long-term interests of consumers of electricity with respect to price, quality, reliability and security of supply and the safety, reliability and security of the national electricity system.

3.1 Vision

Acknowledging the national objective, SP AusNet's corporate vision *"to recognised as the leading supplier of reliable, safe and efficient energy-delivery services"* underpins the asset management Vision, below:

> To be recognised as a leader and an innovator in the management of transmission assets.

3.2 Aims

The asset management aims for the electricity transmission network are:

- Create sustainable asset and network risk profiles to underpin future performance
- Meet reliability and availability performance targets
- Improve health, safety, environment and infrastructure-security performance
- Comply with codes and regulations
- Minimise life-cycle costs

4 Asset Management Drivers

4.1 Introduction

The performance and efficiency of the Victorian electricity transmission network continues to benchmark well against the transmission networks of other service providers. However, SP AusNet faces significant challenges from:

- Sustainable Network Risks – Reliability and availability expectations, maintenance of asset condition and sustainable asset/network risk profiles are driving high maintenance, refurbishment and replacement volumes
- Network Augmentation Levels – Continuing growth in demand, increasing network fault level restraints and high equipment utilisation are increasing network augmentation levels
- Performance Improvements – Code compliance and health and safety, environment and infrastructure security performance improvements
- Efficiencies – Continuing efficiency demands are elevating asset management practice
- Technology – Emerging viability of new technologies
- Workforce – Potential workforce skilling demands

The following sections summarise each of the main influences on network performance. Further analysis and quantification can be found in the Business Environment Assessment section.

4.2 Sustainable Risk Profiles

> "Reliability and availability expectations, maintaining asset condition and sustainable asset/network risk profiles are driving high maintenance, refurbishment and replacement volumes"

4.2.1 Risk Modelling

The Risk Management section of this strategy contains more detail on the risk modelling that is summarised in this section.

Over the last 18 months SP AusNet has invested significant intellectual and practical effort in improving the sophistication, accuracy and reliability of its risk modelling practices to aid comprehension of historic, current and possible future risk positions. Failure histories, asset condition and contingency consequences have been quantified. Models have been constructed, calibrated and integrated to illustrate the relationships between management initiatives and maintenance, refurbishment and replacement programs on performance risk.

The hierarchy illustrated in the following figure (Figure 10) has been established to define the concepts of asset risk, program risk and ultimately network risk.

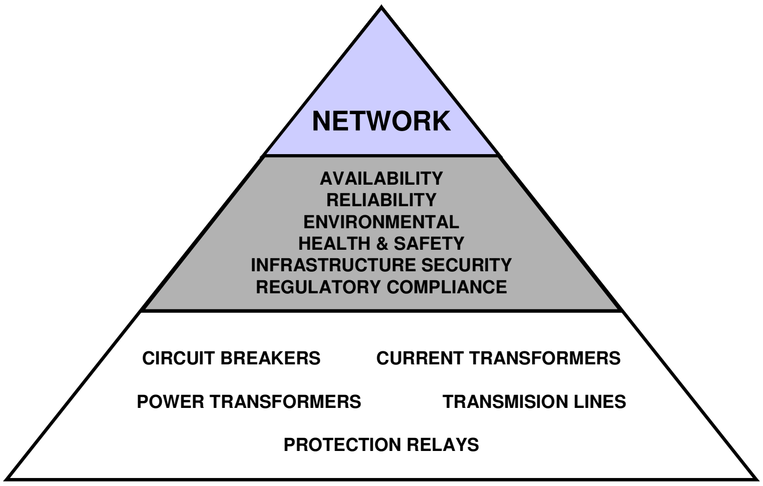

Figure 10 – Risk Model Hierarchy

Individual asset failure risk forms the base of SP AusNet's modelling. Models have been created for each of the circuit breaker, current-transformer, power-transformer, transmission line and protection relay fleets. Each model is based on the condition and hence probability of failure of individual items within the fleet and the consequences of failure of each item. Changes in the summated risk of failure are compared for a variety of asset replacement scenarios to assist in determining the volume and timing of proposed replacement programs necessary to deliver a selected risk profile.

Program risk models in the areas of network availability, network reliability, environment, health and safety, infrastructure security and regulatory compliance form the next tier. These models use historical data on unplanned events and assessments of the degree of control SP AusNet has over these events through asset replacement programs (as represented by the asset failure risk models) and management improvement programs.

Network risk is measured by aggregating the program risks to a single assessment, which enables comparisons of sustainability over time.

4.2.2 Asset Failure Risks

4.2.2.1. Circuit Breakers

The SP AusNet circuit breaker fleet is now one of the oldest operated by international Transmission Network Services Providers[6] and the circuit breaker failure rate now exceeds the average of international TNSPs[7].

The 2008 failure risk profile shows that most circuit breakers are within the Low and Medium/Low risk rankings but significant groups of 500 kV and 220 kV circuit breakers are within the Very High ranking as shown in the following figure (Figure 11).

Also of concern is the huge volume of old 66 kV bulk oil circuit breakers which will migrate from the Medium/Low risk band in to the Medium risk band over the period 2008 to 2013.

[6] ITOMS 2005 Report - International Transmission Operations & Maintenance Study – Revision 6 May 2006
[7] G Mazza, R Michaca, "The first International Enquiry on Circuit Breaker Failures and Defects in Service" Electra No. 79 Dec 1981.

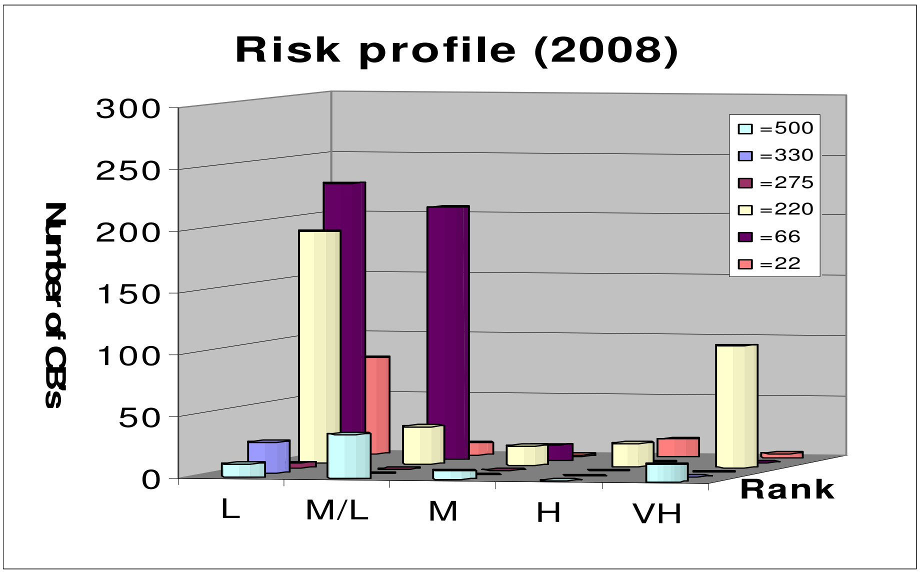

Figure 11 – Circuit Breaker Risk Profile

The integrated work program for 2006 – 2013 will improve circuit breaker risk through the progressive replacement of 260 air blast and bulk oil circuit breakers at Brooklyn, Dederang, Geelong, Glenrowan, Hazelwood, Horsham, Kerang, Morwell, Redcliffs, Ringwood, Rowville, Springvale, and Thomastown terminal stations and the Loy Yang and Hazelwood power station switchyards. The following figure (Figure 12) illustrates the:

- Risk compared with an old CB fleet (100 % of CBs with remaining life = 0 years)
- Rapid rise in risk if no renewal is undertaken
- Theoretical reduction in risk if no new or unforeseen issues arise in the old CB fleet, and
- Practical outcome of the renewal program (based on the difference observed between theoretical models and practical outcomes over the period 2002 to 2006.)

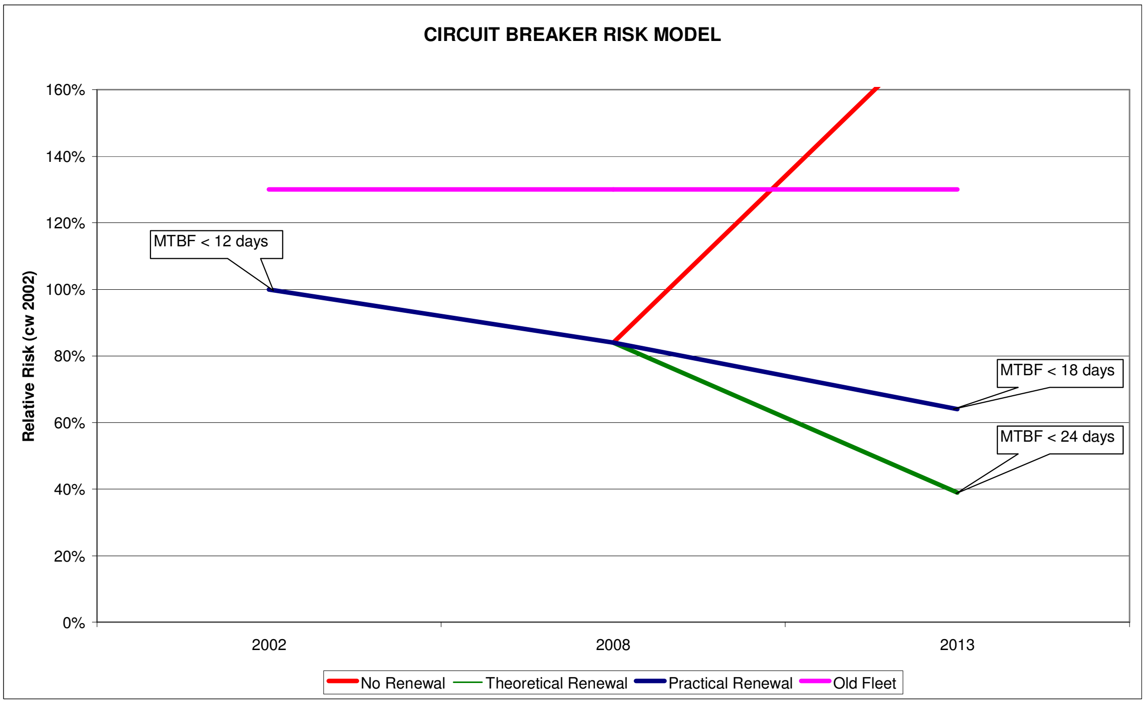

Figure 12 – Circuit Breaker Risk Summary

4.2.2.2. Current Transformer Risks

Several explosive failures[8] and the current, 120 day, Mean Time Between Failure (MTBF) rate confirm that single phase porcelain clad, oil insulated current transformers units now present an unacceptable risk of incurring availability penalties, supply outages, collateral equipment damage, environmental damage and possible injury to staff. A progressive replacement program has commenced in favour of toroidal CTs incorporated within plant such as dead-tank circuit breakers.

SP AusNet will remove a minimum of 580 single phase oil insulated CTs at Altona, Dederang, Fishermans Bend, Geelong, Moorabool, South Morang, Tyabb, Templestowe and Wodonga terminal stations by 2013 as part of a portfolio of terminal station refurbishment projects, bay replacements and like for like replacements.

This is the minimum acceptable risk reduction program consistent with the deterioration of single-phase oil insulated CTs as illustrated in the following figure (Figure 13).

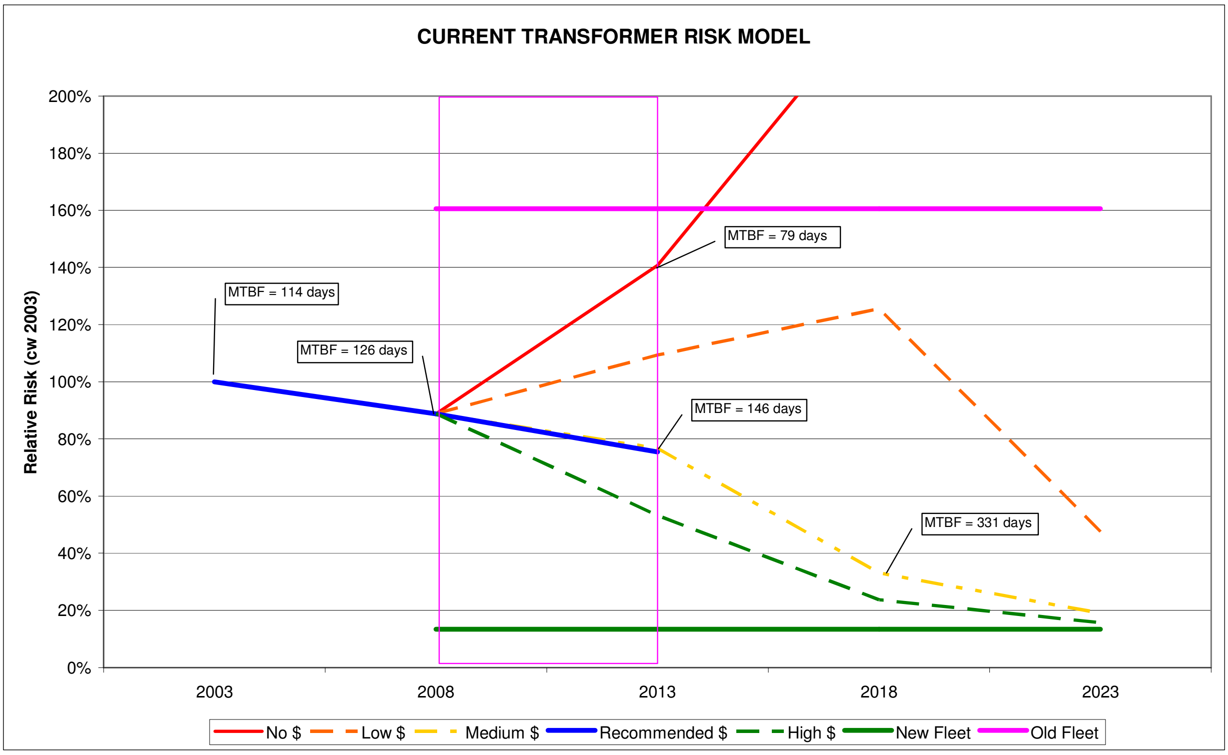

Figure 13 – Current Transformer Risk Summary

Also illustrated in the figure above (Figure 13) are the risks associated with a replace-on-failure strategy (No $) and comparisons with the risk position of an entire fleet of old CTs with no remaining life or alternatively the risk position of an entirely new fleet of oil insulated CTs. The issues driving current transformer risk are summarised in Section 7.2.

4.2.2.3. Transmission Line Insulator Risks

The decline in the line insulator MTBF rate since 1998 represents an unacceptable safety risk to society in the form of potential bushfires or motor vehicle accidents and an unacceptable business risk to SP AusNet through line availability penalties and potential liability claims associated with EHV conductors falling to ground.

[8] Moorabool Terminal Station 2002 & 2005, Jeeralang Terminal Station 2003, Ballarat Terminal Station 2006 and Terang Terminal Station 2006.

As shown in the following figure (Figure 14) the 2008 – 2013 insulator replacement program is focussed on maintaining a stable risk profile through the replacement of approximately:

- 9600 off 16mm pin diameter insulator strings located on 3200 tower-sides on 220 kV lines
- 1500 insulator strings located on 500 tower-sides on the Murray Switching Station to Dederang Terminal Station 330 kV lines, and
- 1500 insulator strings located on 250 tower-sides on the Hazelwood Terminal Station to South Morang Terminal Station and South Morang Terminal Station to Keilor Terminal Station 500 kV lines

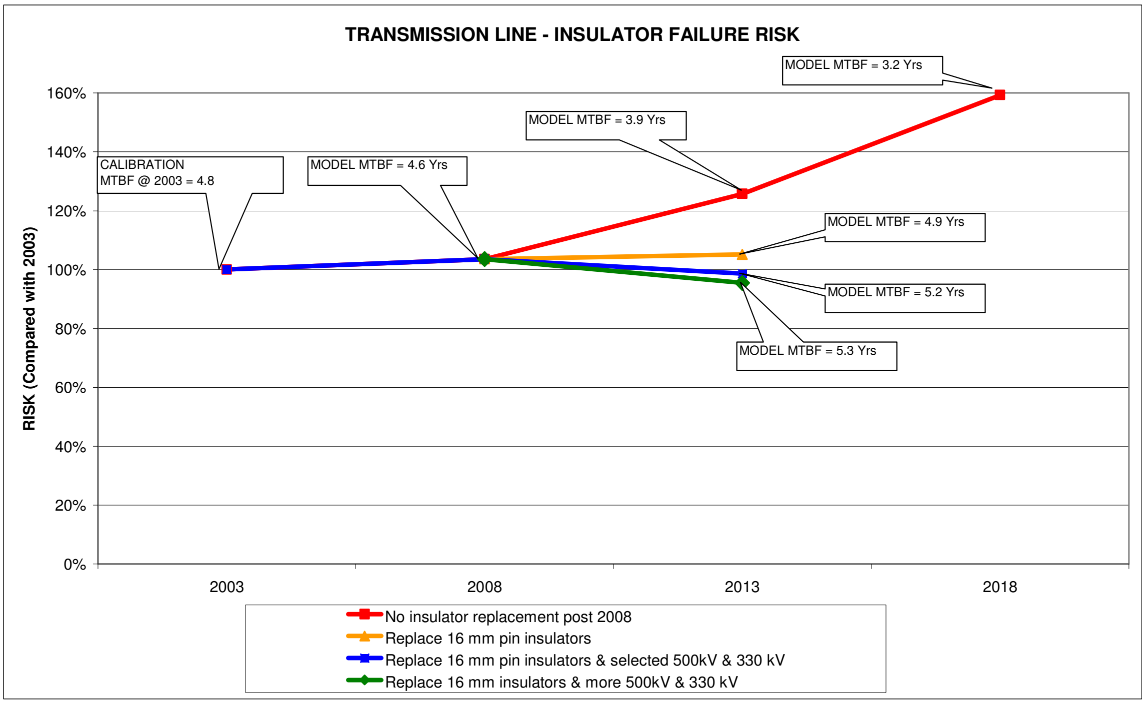

Figure 14 – Transmission Line Insulator Risk

The principle factors driving transmission line reliability and the remedial actions underway are summarised in Section 7.3.

4.2.2.4. Power Transformer Risks

The 2006 Power Transformer risk model is a quantitative model, which simulates the safety, environmental, reliability, availability and business risks associated with major failures on the entire fleet of more than 200 power transformers.

SP AusNet has set an objective of a sustainable risk position with respect to power transformers for the next decade.

The 2008 to 2013 work program includes replacement of two 3 phase units at Geelong Terminal Station and 57 single phase units at Bendigo, Brunswick, Dederang, Glenrowan, Ringwood, and Thomastown Terminal Stations and the removal of the Group 5 units at Yallourn Power Station to provide the stable risk position shown in the figure below (Figure 15).

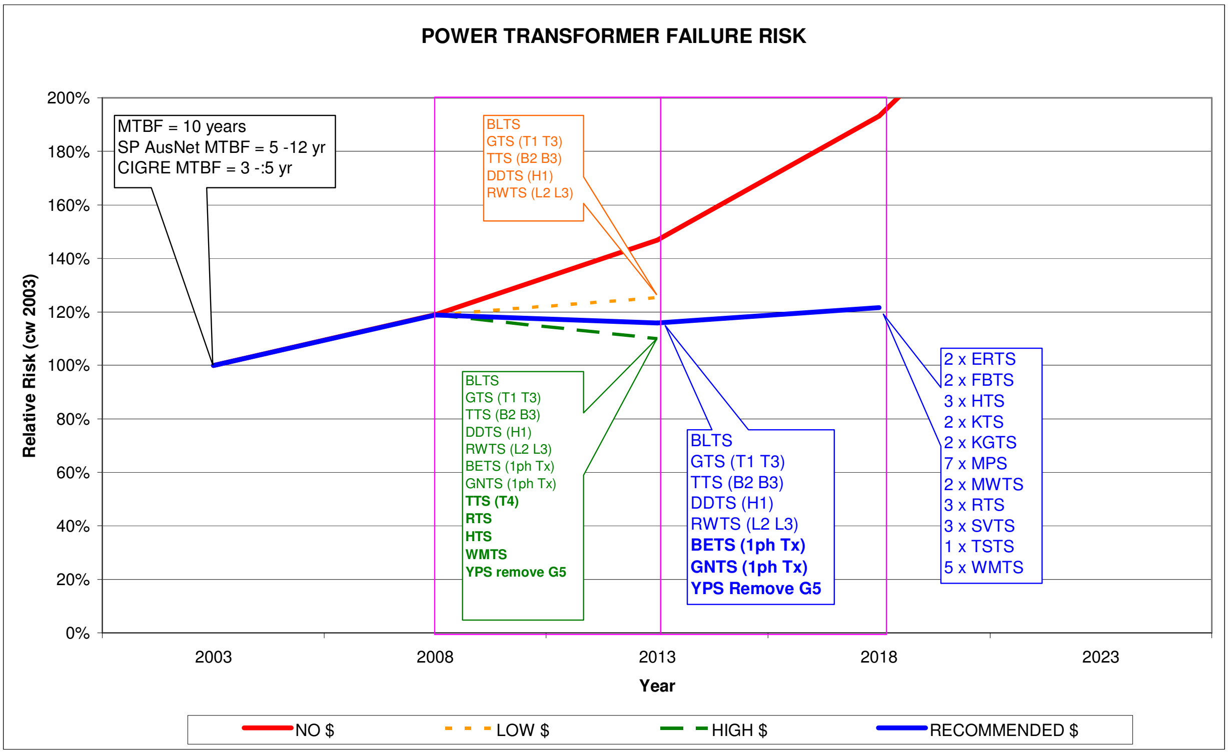

Figure 15 – Power Transformer Risk

Preliminary modelling of the period 2013 to 2018 indicates that replacement of a further 26 (mostly) three-phase transformers will continue to provide a stable risk position.

4.2.2.5. Protection Relay Risks

The protection relay model quantifies the functionality risk of more than 2300 measurement relays protecting lines, transformers, buses and reactive plant. It calculates, over time, the relative reduction in functionality of each relay when compared with that of an equivalent electronic digital relay and the associated risk of incurring unnecessary operating costs to ensure that protection schemes operate correctly, remain calibrated and meet the regulatory demands for increased operating speed and verifiable availability.

Acknowledging the low estimated remaining life of secondary systems, SP AusNet set an objective to improve the risk position of protection relays for the period 2008 to 2013 and scenarios were modelled to quantify the work required to deliver this outcome as illustrated in the following figure (Figure 16).

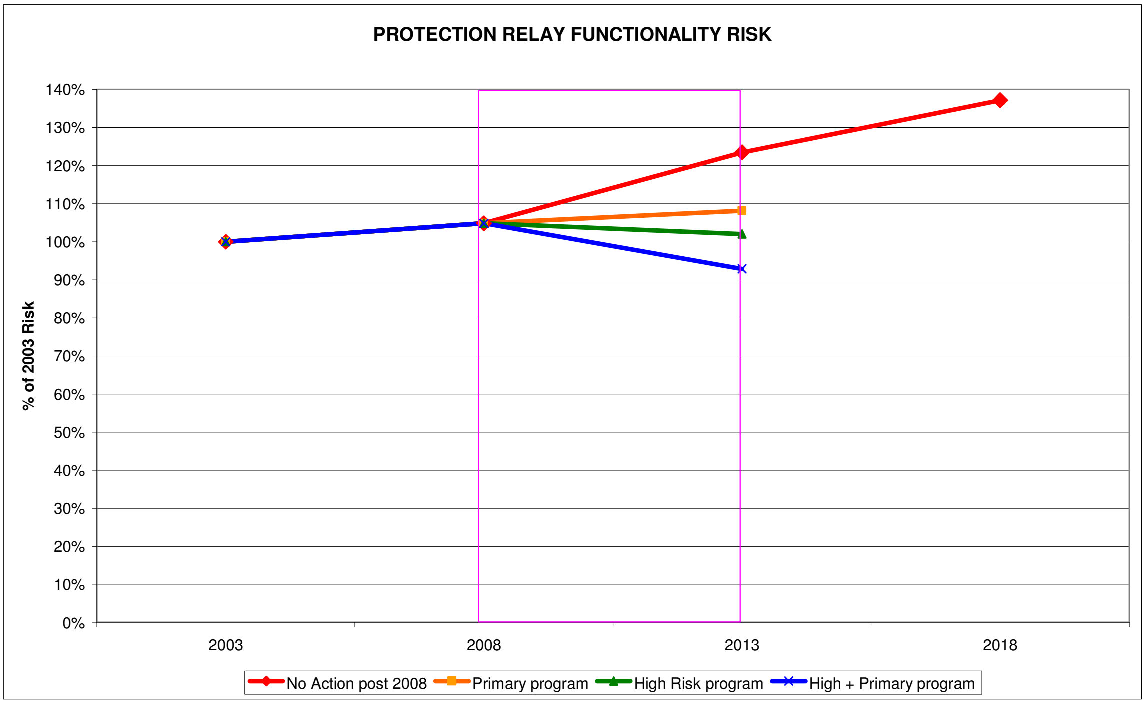

Figure 16 – Protection Relay Functionality Risk

The 'High + Primary program' in the figure above (Figure 14) includes replacement of 433 relays (19% of fleet) either, in conjunction with high-risk primary equipment or as stand-alone high-risk relay replacement projects. This program is a key factor in meeting the NER requirements for operating speed, protection availability and redundancy. It is the minimum acceptable risk reduction program which, based on current models, will provide a 7% improvement over the 2003 risk position.

4.2.3 Program Risk

Models in the areas of network-availability, network-reliability, environment, health and safety, infrastructure security and regulatory compliance form the program tier. Program models use historical data to establish the frequency and consequences of unplanned events and assessments of changes in the degree of control SP AusNet has over these events through completion of asset replacement programs (as represented by the asset failure risk models) and management improvement programs.

4.2.3.1. Reliability Risk

Modelling indicates a stable risk profile based around a long-run average of four retail interruptions and 0.5 system minutes unsupplied per annum. Over time the number of unplanned interruptions, numbers of system incidents, levels of equipment utilisation and the value of energy not supplied are placing upward pressure on reliability risk.

The base level of network reliability is established through network configuration, the levels of asset redundancy and equipment utilisation set by the five distribution businesses and VENCorp.

SP AusNet's condition monitoring, contingency preparations and maintenance, refurbishment and replacement programs are pivotal in stabilising reliability risk at levels equivalent or slightly better than the previous decade.

4.2.3.2. Availability Risk

Modelling suggests an increasing wedge of availability risk in future years that is driven by:

- The relatively high number of planned outages essential to the maintenance, refurbishment and replacement of deteriorating assets
- Increases in incentive rates and broadening of the scope of the incentive schemes to include customer projects
- Increasing exposure to incentive downside due to the higher utilisation of lines and transformers
- The high number and complexity of control system switching sequences needed to manage system fault levels

The volume of planned maintenance, refurbishment and replacement work that is necessary to manage the reliability of deteriorating assets is the main control over availability risk. Online condition monitoring, improved risk modelling and sophisticated outage planning will only partially offset the impact of planned outages.

> SP AusNet also notes that VENCorp's VISION 2030 foresees the need to up-rate a number of 220 and 330 kV circuits prior to 2015. If these projects were included within the scope of an availability incentive scheme then the dynamics rating of the availability model would feature a sharp rise. They have not been included in this edition of this model as the need and timing are yet to be confirmed in the VENCorp Annual Planning Report.

Modelling suggests an increasing wedge of availability risk in future years that is driven by increasing financial consequences and the increasing high volumes of maintenance, refurbishment and replacement projects necessary to manage deteriorating asset condition.

4.2.3.3. Health and Safety Risk

Factors in an improving health and safety risk for the forecast period include:

- Gradual improvement in the number of health and safety incidents
- Slow linear increase in the consequential costs of health and safety events
- Replacement programs for transmission line insulators and oil insulated single phase current transformers
- Removal of Asbestos Containing Materials (ACMs)
- Progressive completion of tower safe access, working at heights, fire detection and suppression, cooling tower operation, RF field and EMF mitigation programs

Modelling suggests a measurable improvement in health and safety risks through the next decade, largely driven by continuing progress on replacement programs for line insulators, oil insulated current transformers and ACMs.

4.2.3.4. Environmental Risk

Environmental risk has varied in recent years. Modelling indicates stability in the number of environmental events and a very slow linear increase in the consequence of events. Key factors in the assessment of improving control over environmental risks include:

- Power transformer, current transformer and circuit breaker replacement programs that will significantly reduce the volume of oil-insulated equipment in service over the next decade

- Progressive completion of oil spill containment and site water treatment programs at terminal stations
- Systematic improvements in transformer noise emissions, switchgear SF_6 gas emissions, vegetation management, bushfire mitigation, PCB removal and visual impact of major installations.

Modelling suggests a measurable improvement in environmental risks driven predominantly by a significant reduction in the volume of insulating oils in service and improved oil spill control and site water treatment.

4.2.3.5. Infrastructure Security Risk

Infrastructure security risk has been driven by cyclic variations in the numbers of security events and the increasing consequences associated with public safety. Terrorism has emerged as a new factor in the last eight years.

The majority of security events are attempted thefts, motivated by high scrap metal prices for copper and aluminium. However, the recent changes in anti-terrorism legislation highlight the potential for an extreme consequence event, should an intruder damage key equipment causing loss of supply to large numbers of customers. The risk associated with a member of the public suffering an electric shock following unauthorised access to infrastructure continues.

Sound progress is being made on an extensive security enhancement program that includes measures to deter, delay, detect and respond to intruders. This is improving control over security risk.

Modelling indicates a stable and declining security risk with observable performance improvements. This modelling is heavily dependent on the prioritised completion of electronic access controls, security fencing, building exterior hardening, motion detection, CCTV, continuous alarm monitoring, emergency management and contingency planning for terminal stations.

4.2.3.6. Code Compliance Risk

After a significant increase in code compliance risk associated with the re-structuring of the Victorian electricity industry and the emergence of a National Electricity Market, recent years have seen a gradual improvement as these regimes mature. Models suggest slow linear increases in the volume and complexity of regulation. Process transparency expectations and due diligence expectations are also providing upward pressure on compliance risks.

A regulatory management team and a formal compliance management process, which includes risk assessments, reviews and audits is providing stability and improving control.

SP AusNet's protection and communication investments contribute to improving code compliance in the areas of EHV protection operating-speeds and redundancy. Significant investments are required in communication systems to enable full compliance with the technical requirements of the National Electricity Rules.

Overall progressive improvement is expected in Code Compliance risk.

4.2.4 Network Risk

As represented in the following figure (Figure 17), the network risk profile includes historic, current and forecast risk. Aggregating the aforementioned assessments of reliability, availability, health and safety, environment, infrastructure security and code compliance risks creates a Network Risk profile for the period 1995 to 2015 which suggests improving and stabilizing risk for the Victorian electricity transmission network.

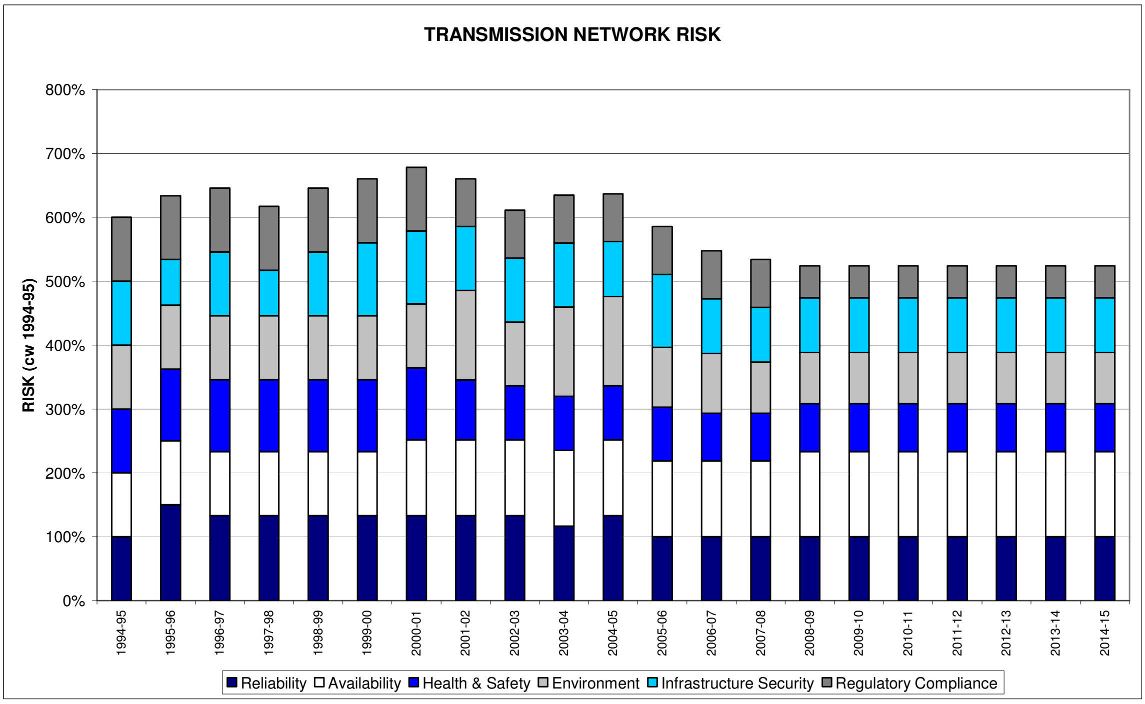

Figure 17 – Network Risk Profile

4.3 Network Augmentation

> "Continuing growth in demand, increasing network fault level restraints and high equipment utilisation levels are increasing network augmentation levels"

4.3.1 Demand

Summer maximum demand is forecast[9] to grow faster than annual electricity consumption at an average growth rate of 2.0% pa over 2006/07 - 2010/11, and then 1.9% pa over the following five years to 2015/16. This change reflects a slower penetration of cooling appliances and the impact of state greenhouse policies. This forecast is illustrated in the following figure (Figure 18).

[9] Electricity Annual Planning Report 2006 - VENCorp

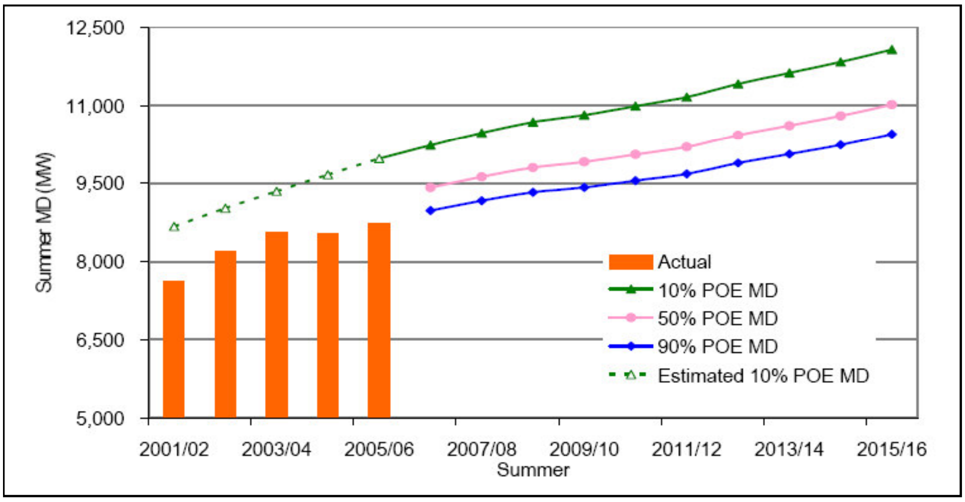

Figure 18 – Summer Maximum Demand

To meet this demand:

- Approximately 2,250 MW of new generation capacity will need to be added by 2015/16 (assuming 1,900 MW import from NSW and 600 MW import from Tasmania)
- Augmentation of the Victoria to Snowy interconnector capability[10] will require investigation
- Fourteen shared-transmission network transformer and line constraints[11] will require resolution
- Thirty-four constraints[12] in the transmission connection networks will need to be addressed

In the longer-term, the VISION 2030[13] identifies 44 shared-transmission network development opportunities for the next 25 years. For further information on continuing demand please refer to Business Environment Assessment.

4.3.2 Network Fault Levels

Annual analysis[14] shows network fault levels are continuing to rise at approximately 1% per annum as illustrated in the following figure (Figure 19).

[10] NEMMCO Statement of Opportunities 2005 - Annual National Transmission Statement
[11] Electricity Annual Planning Report 2006 - VENCorp
[12] Transmission Connection Planning Report – Victorian Electricity Distribution Businesses 2005
[13] 25 Year Vision for Victoria's Energy Transmission Networks OCTOBER 2005 – VENCorp
[14] Transmission Network Short Circuit Levels 2006-2010 Victoria – VENCorp December 2005

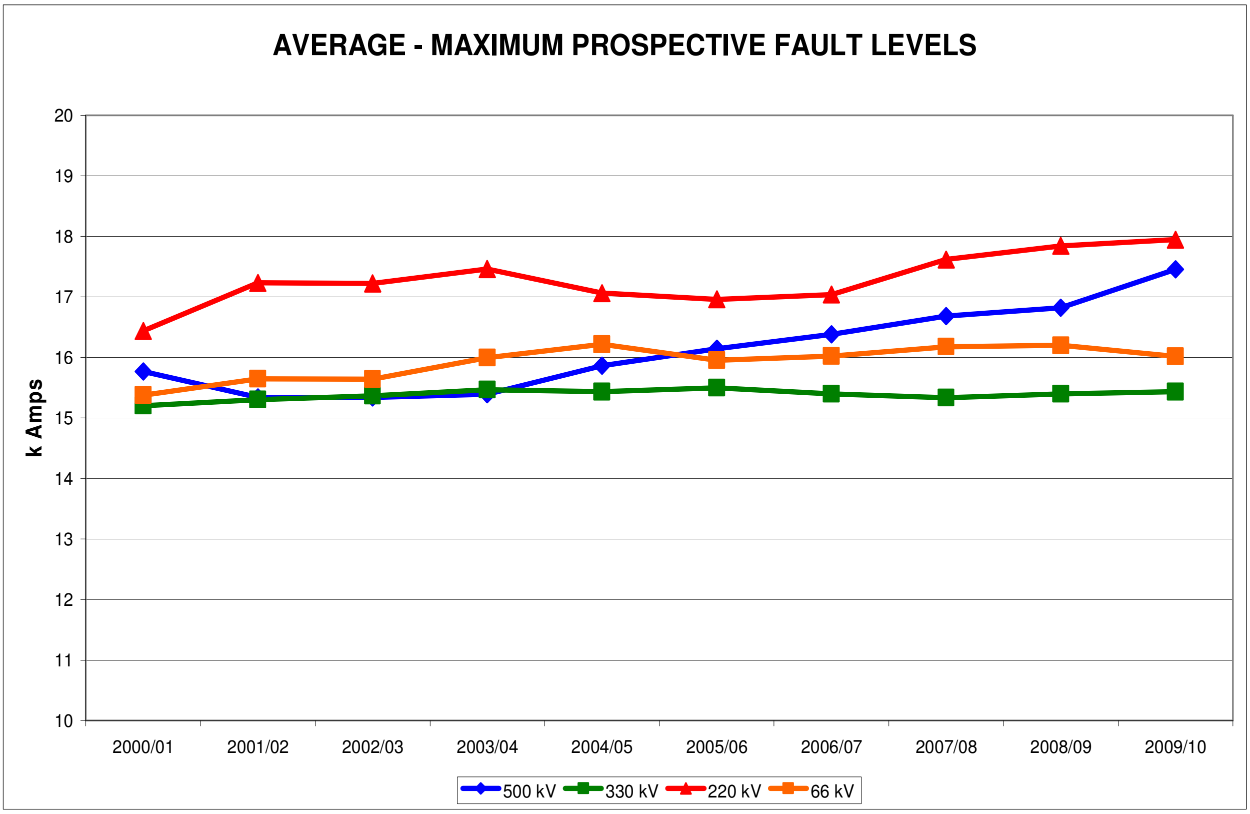

Figure 19 – Average Maximum Prospective Fault Levels

Significant proportions of switchgear are operating at fault levels that are close to their rating. In particular, 45% of 220 kV and 29% of 66 kV circuit breakers are exposed to maximum prospective fault levels, exceeding 90% of the rating assigned when they were manufactured.

Operational switching arrangements have been implemented to maintain fault levels within plant ratings at 39% of terminal stations. The complexity of the operational controls coupled with the inherent reduction in plant redundancy (and hence network reliability), the increased operational costs and associated business risk borne by the network owner/operator make this approach unsustainable.

A significant challenge involves management of the 220 kV fault levels at Hazelwood Power Station and Keilor, Rowville, Thomastown and West Melbourne terminal stations where the bus fault level already exceeds, or is forecast to exceed, the rating of the lowest rated circuit breaker.

VENCorp has initiated the collaboration of generators, DBs and SP AusNet on a strategy for fault level mitigation, considering the impact of network augmentations and VENCorp's VISION 2030 outcomes.

For further information please refer to Business Environment Assessment.

4.3.3 Equipment Utilisation Levels

Maximum load on the transmission network has been growing at almost 3% per year since 1994 and is forecast to continue at 2% p.a. for the next ten-year period[15].

> At present, 35% of transformer banks[16] and 14% of transmission lines[17] are now operating with a redundancy level less than 'N–1' during periods of peak demand.

[15] Electricity Annual Planning Report 2006 – VENCorp.

While increased utilisation is generally desirable because it lowers the unit cost of transporting power, it increases losses and places additional demands on asset reliability and availability as:

- Assets are deteriorating at faster rates than has been the case historically, increasing the need for sophisticated condition assessment programs and accelerating asset replacement programs
- Diminishing plant redundancy imposes limits on when equipment can be accessed for maintenance, repair, modification or replacement, which necessitate increases in on-site project labour and out-of-business hours workloads
- Contingency plans and higher levels of strategic spares are necessary to avoid the situation where failure of one piece of equipment places customer load at risk for long periods
- Reliability of protection and control systems must increase

To manage the risks associated with high utilisation levels, SP AusNet has implemented:

- Sophisticated condition monitoring of in-service equipment with specialised equipment, data acquisition and analysis
- Sophisticated outage planning with emphasis on efficient manning levels, availability of specialised maintenance and test equipment, temporary network configurations and task sequencing to reduce contingency risks and to limit availability penalties
- Increased strategic spares holdings, including major plant holdings
- Accelerated plant and equipment replacement programs

For further information please refer to Business Environment Assessment.

4.4 Compliance and Performance Improvements

> "Code compliance and health and safety, environment and infrastructure security performance improvements"

Unplanned events and new regulatory obligations have focussed SP AusNet on securing major performance improvements in code compliance, health and safety, environment and infrastructure security.

4.4.1 Code Compliance

After a significant increase in regulatory obligations associated with the re-structuring of the Victorian electricity industry and the emergence of a National Electricity Market, recent years have seen a steady improvement in code compliance as these regimes mature.

Improving compliance to the National Electricity Rules in the areas of EHV protection operating speeds and redundancy is a specific focus of SP AusNet's protection and communication investments. Further investments are required in communication systems to enable full compliance with the technical requirements of the National Electricity Rules.

[16] SP AusNet monitoring
[17] Electricity Annual Planning report 2006 - VENCorp

4.4.2 Health and Safety

Victoria's Occupational Health and Safety (Asbestos) Regulations 2003 imposed more rigorous restrictions on the control of asbestos materials to prevent contamination of the work environment with asbestos dust. The major issue is the progressive removal of asbestos from terminal station buildings, generally in the form of wall, roof, eave and ceiling cladding and/or panels supporting electrical relays.

Compliance with the Occupational Health and Safety (Prevention of Falls) regulations require more rigorous job safety assessments and the increased use of ladders, motion control screens, fall restraint systems, mobile plant, scaffolds, handrails and walkways and to ensure the safe performance of work at heights greater than 2 m.

Pending recommendations from ARPANZA on electro-magnetic fields are expected to require additional control measures to ensure safe working conditions near energised, extra-high voltage electrical equipment. Further improvement in SP AusNet's health and safety performance will be largely driven by:

- Removal of asbestos containing materials as part of terminal station redevelopment projects
- Progress on the installation of ladders, screens and fall restraint on transmission line towers and in terminal stations

For further information on health and safety please refer to Health and Safety Management.

4.4.3 Environment

Greenhouse gas emission legislation is expected to mandate additional obligations in the management of SF_6 gas insulated switchgear. Risk management processes driven by the SP AusNet Environmental Management System[18] have identified the following environmental obligations:

- Oil discharge - comply with EPA Victoria's 'Bunding Guideline Publication 347', AS1940 and standards on water quality discharges
- Noise - comply with the State Environment Protection Policy (Control of Noise From Commerce, Industry and Trade)"
- Electro-magnetic fields – responding to the federal Telecommunications Act and community health concerns about long-term exposure to Electro-magnetic fields
- Greenhouse gas emissions - SF_6 usage and gas insulated switchgear leakage rates are the most significant elements of emission reductions
- Poly chlorinated biphenyls (PCBs) – outworking an Environment Improvement Plan submitted to the Victorian EPA
- Vegetation - minimise fire hazards and risks to supply security
- Visual intrusion – improving the appearance of existing installations and amending the design of new installations to secure community support

A major improvement in environmental performance is expected through the next decade; when the reduction in the volume of oil-insulated equipment in service, delivered by the power transformer, current transformer and circuit breaker replacement programs, is coupled with progressive completion of oil spill containment and site water treatment plants at terminal stations.

For further information on remedial programs please refer to Environmental Management

[18] ENV01 Environmental Policy & Guide

4.4.4 Infrastructure Security

The Victorian Terrorism (Community Protection) Act 2003 requires electricity and gas providers to develop and monitor risk management plans, including all appropriate, preventative security and emergency restoration measures. In addition, critical comment from a 2003 NSW Coroner's investigation into several fatalities was the impetus for the Electricity Supply Association of Australia (ESAA) to release new guidelines for the prevention of unauthorised access to various electrical installations.

Security risks have been quantified using a purpose built Infrastructure Security Risk Assessment Tool (ISRAT), which integrates the principles of AS/NZS 4360, National Guidelines for the Prevention of Unauthorised Access to Electricity Infrastructure[19] within REALM[20], an objective risk assessment methodology.

The Terminal Station & Communication Site Physical Security Policy[21] provides the context and rationale supporting the progressive introduction, improvement and integration of security measures including, fencing, electronic access controls, intrusion detectors, closed circuit television cameras, security lighting, building exterior hardening and remote alarm monitoring by the Network Operations Centre. Improvements include event investigation and reporting, control measure audits and contingency plans.

For further information please refer to Infrastructure Security.

4.5 Efficiency

> "Continuing efficiency demands are elevating asset management practice"

4.5.1 Asset Management Planning

In 2002, The Office of Gas and Electricity Markets (Ofgem), the UK market Regulator conducted an asset risk management survey of the large electricity and gas network operators "to explore the medium/long term asset risk management practices".

Recently, Jervis Consulting conducted this survey (using the Ofgem information), to analyse SP AusNet's current "asset risk management performance and where to target improvements"[22].

It was found:

> "SP AusNet is undertaking its asset risk management activities in a structured and sound manner and is at, or better than, most best practices identified in the UK Ofgem study".

[19] National Guidelines for Prevention of Unauthorised Access to Electricity Infrastructure – ENA DOC 015-2006
[20] 30-2650 Risk Assessment Methodology
[21] Terminal Station & Communication Site Physical Security Policy – SP AusNet 2006
[22] Report on Asset Risk Management Survey conducted for SP AusNet – Jervis Consulting August 2006.

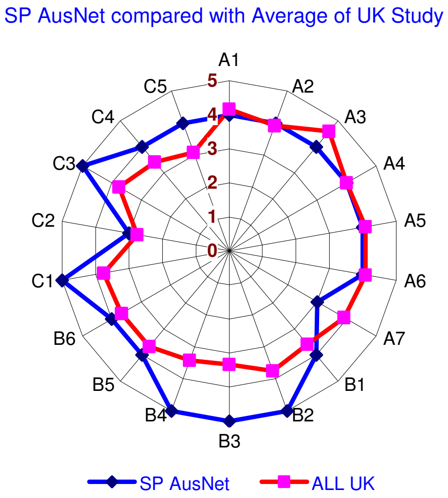

Figure 20 – Comparison with UK Average

The preceding figure (Figure 20) shows SP AusNet performs well against the average of the 12 UK companies:

- In Section A, Business Strategy and Direction, performance is generally equal to the average
- In Section B, Asset and Network Strategy, SP AusNet outpoints the average in all categories.
- In Section C, Asset Life Cycle Management, SP AusNet again shows superior performance in all segments.

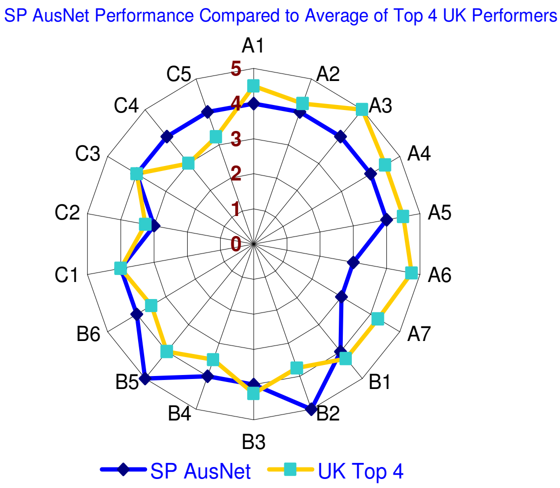

Figure 21 – Comparison with UK Best Practice

The preceding figure (Figure 21) shows SP AusNet will benefit from establishing relationships with the best performers to improve in Section A, *Business Strategy and Direction*.

SP AusNet had been monitoring the maturity of the British Standards Industry's publicly available *Specification for the optimised management of physical infrastructure assets* (PAS 55) for some time.

The findings of the Jervis review[23] have focussed SP AusNet's asset management improvements on achieving accreditation to this recognised international standard. SP AusNet is now seeking partners to facilitate preparation, and ultimately accreditation to BSI PAS 55 by 2008.

4.5.2 Asset Management Delivery

The 2005 International Transmission Operations and Maintenance Study (ITOMS) confirmed SP AusNet's continuing 'top quartile' performance in transmission line related maintenance and terminal station related maintenance amongst international Transmission Network Service Providers (TNSPs). As in previous years, the 2005 study[24] compared TNSPs from Asia, Australia, New Zealand, Europe, Middle East, North America and South Africa on 12 detailed measures and two high-level composite measures of line and station maintenance.

The 2005 results again illustrated significant variations in the 'study-to-study' performance of participants due to differing interpretations of the data definitions, improving asset and financial data capture and re-balancing of individual maintenance priorities to meet short-term needs. This makes detailed spot comparisons between companies unwise, but broader comparisons of performance with peer and region averages over several studies are sufficiently accurate to determine SP AusNet's continuing 'top quartile' productivity and efficiency.

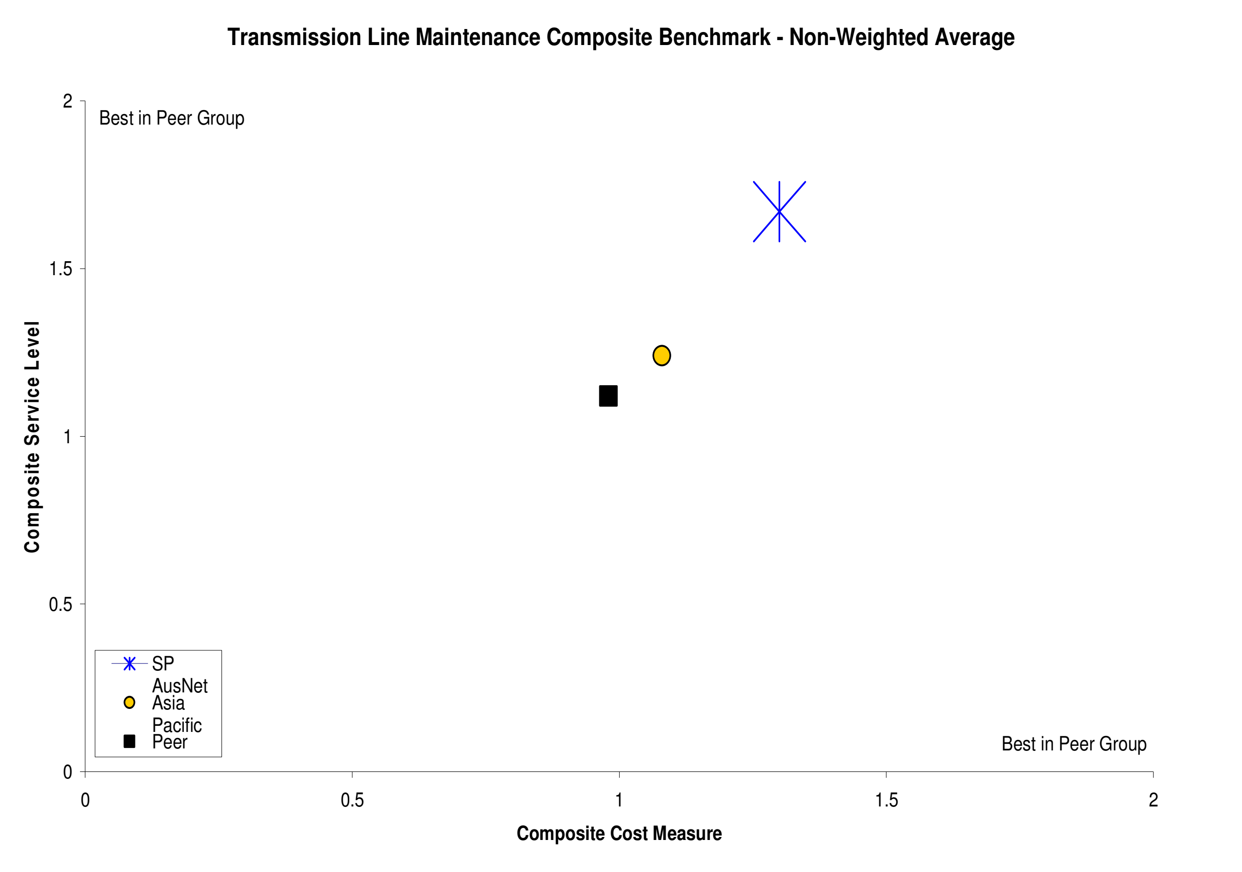

Figure 22 – ITOMS 2005 Line Maintenance Benchmark

The preceding figure (Figure 22) compares SP AusNet's performance with the averages for international and Asia Pacific peers in the composite category of line related maintenance. The following figure (Figure 23), compares performance in the composite category of Station related maintenance.

[23] Report on Asset Risk Management Survey conducted for SP AusNet – Jervis Consulting August 2006.

[24] International Transmission Operations and Maintenance Study 2005 Report

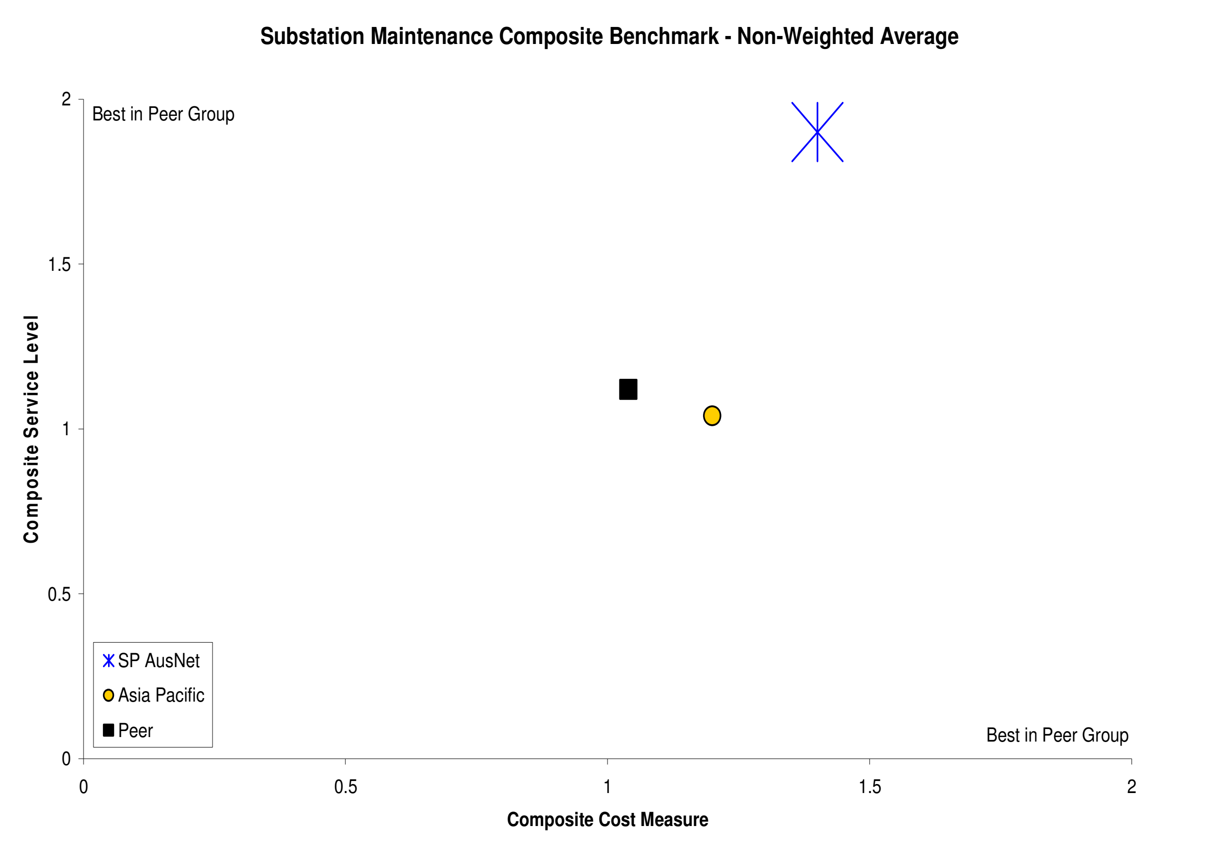

Figure 23 – ITOMS 2005 Station Maintenance Benchmark

The following table (Figure 24) demonstrates SP AusNet's 2005 service and cost was independently assessed by ITOMS as '"superior" to that of international or Asia - Pacific peers on 70% of detailed comparisons and was "competitive" on a further 15% of detailed comparisons.

SP AusNet Performance Compared with 2005 ITOMS Averages				
	Service		**Cost**	
Maintenance Category	International Peers	Australian Service Providers	International Peers	Australian Service Providers
Overhead Line	Superior	Superior	Superior	Superior
Overhead Line Inspection and Patrol	Superior	Superior	Superior	Superior
Right of Way	Superior	Competitive	Competitive	Inferior
Relay SCADA and Communications	Superior	Superior	Superior	Superior
Transmission Circuit Breaker	Competitive	Superior	Superior	Competitive
Transformer	Superior	Superior	Superior	Superior
Compensation Equipment	Superior	Superior	Superior	Superior
Disconnector and Earth Switch	Superior	Superior	Superior	Competitive
Instrument Transformer and Circuit End Equipment	Inferior	Inferior	Superior	Superior
Substation Site and Auxiliary Equipment	Superior	Superior	Inferior	Inferior
Field Switching Operations	Inferior	Inferior	Superior	Superior
Support Services Expenditure	NA	NA	Competitive	Competitive

Figure 24 – ITOMS 2005 Comparative Performance Benchmarks

4.6 Technology

> "Emerging viability of new technologies"

4.6.1 Vision 2030

VENCorp's Vision 2030[25] outlines a 25-year vision for Victoria's core energy transmission infrastructure. It details the potential requirement for a $1 to $2 billion investment in new transmission capacity to meet the state's growing needs, including key findings on:

> "The overall topology of intra-state networks is likely to remain largely unchanged but each class of elements within that topology may require substantial augmentation"
>
> "Long-haul, bulk energy transmission may be required to bring more remote gas to Victoria or to support major, bulk exchange of electricity with other states"

Vision 2030 also highlighted a number of issues that are likely to require special attention in the next 25 years:

- Need for an audit of existing electricity and gas transmission easements to identify potential, additional capacity and actions to protect future access to easements and nominated sites
- Joint planning studies are required between distributors and planning authorities to define long-term options for bulk energy supply to inner Melbourne and Geelong
- Definition and communication of transmission project requirements so that market participants are fully informed of the need for early investment signals
- A technical investigation is warranted to define a long-term for the management of electricity transmission network fault levels, especially in Melbourne and the Latrobe Valley
- A detailed review of operational constraints on the network caused by high utilisation levels, and a discussion of available options to accommodate them
- A study to identify the effects of increasing wind-power generation on the electricity transmission network
- An in-depth assessment of skills availability and the surety of market place provision, especially in electricity transmission engineering
- A review of the suitability of current regulatory approaches to network planning and investment justification

4.6.2 25 Year Transmission Network Vision

Guided by the NOUS group, SP AusNet developed its own long term thinking on the future for electricity transmission, through a 25-year Vision[26] – primarily to increase strategic awareness and

[25] 25 Year Vision for Victoria's Energy Transmission Networks OCTOBER 2005 – VENCorp

[26] SP AusNet Transmission Vision 2030 –"*A 25 year Vision for the electricity transmission business",* July 2006 – The NOUS Group.

flexible thinking among managers and staff but also to influence planning organizations and to inform shareholders.

4.6.2.1. Critical Business Capabilities

A scenario planning approach was used to explore the boundaries of the possible 25-year future and clarify three critical business capabilities:

- Capability for strategic network development
- Capability to deliver modular relocatable plant designs
- Capability to deploy digital systems

4.6.2.2. Implications for SP AusNet

Network Planning - SP AusNet's relatively passive role in network planning may not continue unaltered, especially in intra-state transmission planning. Potential drivers for change include moves towards a national planner and possibly increased contestability, e.g. of connection assets. Any moves to make infrastructure owners more accountable for overall reliability and security will also necessarily increase their involvement in network planning.

New Technology Adoption - Scenarios underline the importance of SP AusNet maintaining core expertise on a range of transmission technology developments. The continuing need for cost efficiency and performance improvements will drive comprehension and the adoption of:

- HVDC lines and converters
- EHV cable technology
- High temperature conductors
- Super conducting plant
- Cheap modular station builds
- Modular embedded generation units
- Relocatable transmission plant
- FACTS devices and power electronics
- High capacity fibre telecoms networks
- Integrated secondary systems
- IP based communications networks
- Risk management/trading models
- Network planning tools.

Workforce Capability - Scenarios illustrate that a strong asset base and access to new technology will not by themselves ensure business success – the capabilities of SP workforce will be critical. In particular, balanced commercial/technical acuity and flexible strategic thinking must be present throughout the organization at all levels. It is more likely that regulatory and market developments will drive change, rather than technology. SP AusNet will need a workforce that understands these developments and is capable of harnessing new technology in strategic responses that ensure business success.

For further information please refer to Business Environment Assessment.

4.7 Skills and Resources

"Potential workforce skilling demands"

An important business driver is the increasing age of the SP AusNet technical workforce.

The average age of the transmission engineering workforce is 49 years, of whom 44 % exceed the potential retirement age of 55 years as illustrated in the figure below (Figure 25).

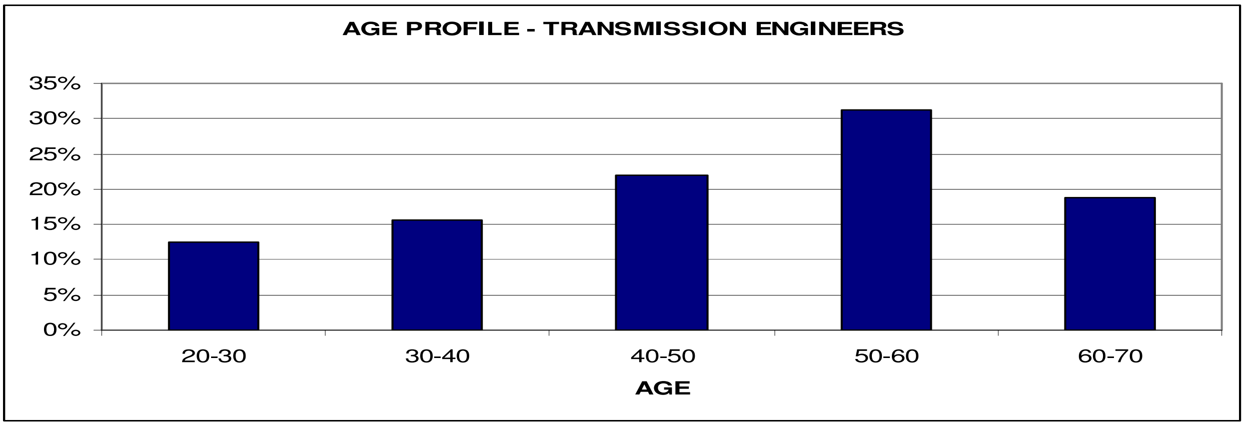

Figure 25 – Age Profile Transmission Engineers

In the field, 59% of transmission power technicians are over the age of 45 and 31% have reached a potential retirement age as illustrated in the figure below (Figure 26).

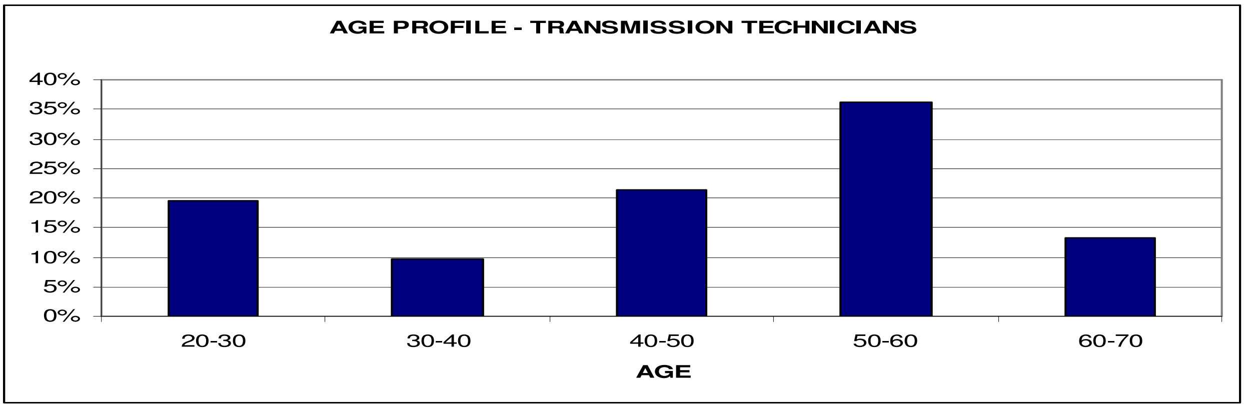

Figure 26 – Age Profile Transmission Power technicians

The Queensland Electricity Review[27], acknowledged a growing shortage of skilled resources in the electricity industry, particularly in planning, protection engineering and line workers. The increased capital programs that are taking place in Queensland, NSW and SA together with the projected requirements in Victoria will place a significant strain on the already limited resources.

This finding was confirmed by a 2004 KPMG study that noted, there are "two key developments affecting the supply of skilled labour in the Victorian electricity industry, specifically the aging workforce and an emerging skills shortage"[28].

The Industry Skills Report[29] confirmed that utility skill shortages are widespread and likely to be sustained in a number of allied industries, as illustrated by the following extracts:

[27] Report of the Independent Panel on Electricity Distribution and Service delivery for the 21st Century, Queensland, July 2004
[28] Draft - Trends in Labour Rates and CPI-X Regulations – October 2004 KPMG
[29] Industry Skills Report – Electro Comms & Energy Utilities Industries Skills Council October 2004

> "The electricity and gas industries have higher proportions of their workforces aged 40 to 54 years, compared with the average across all industries. It remains to be seen whether these workers will continue on until the attainment of retirement age."
>
> "Skill shortages are widespread across the industry with many enterprises experiencing difficulty in locating suitable candidates to fill available positions."
>
> "Employment in electricity supply industry, which directly employs 45,000 people, is forecast to decline over the period 2011-12"

This potential reduction in skilled labour is a significant business risk.

SP AusNet has commenced the progressive renewal of its workforce and Workforce Planning to establish and secure its medium to long-term skilled resource requirements.

In addition to expected staff turnover, recruitment of up to six graduate electrical engineers and up to 30 power technicians is planned for the period 2006 – 2011 to underpin transmission network engineering and technical capability for the longer term.

Further analysis and detailed remedial strategies can be found in Skills and Competencies.

5 Performance

The Performance Outcomes section of the AMS is a high-level summary of the forecast capabilities, performance and resource requirements of the Victorian electricity transmission network for the period 2005–2020. Further information can be found in Business Environment Assessment.

5.1 Energy

The annual electricity consumption[30] is projected to grow at an average rate of 0.5% over the next five years to 2010/11, and then at 1.3% pa to 2015/16 as illustrated in the following figure (Figure 27).

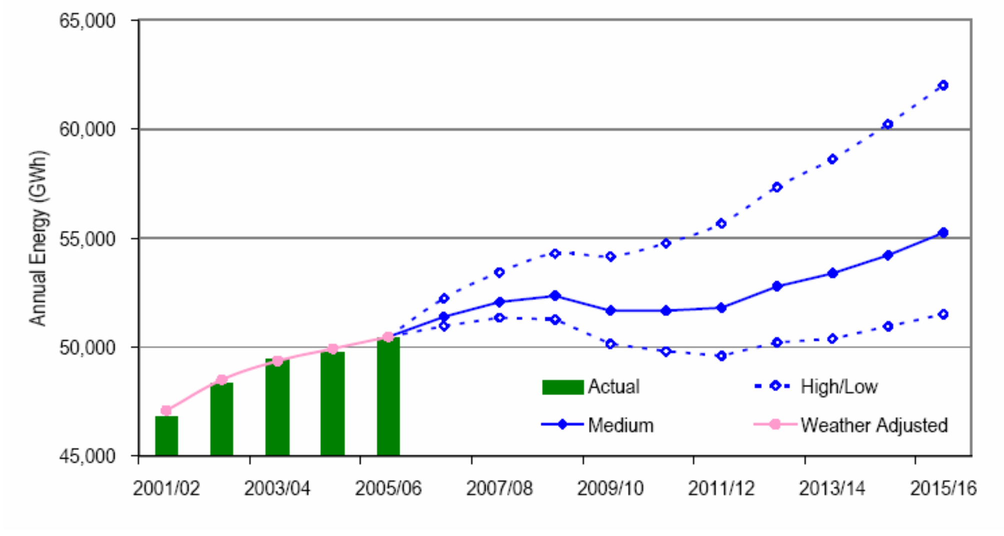

Figure 27 – Electricity Consumption

[30] Electricity Annual Planning Report 2006 - VENCorp

5.2 Demand

Summer maximum demand is forecast[31] to grow faster than annual electricity consumption at an average growth rate of 2.0% pa over 2006/07 - 2010/11, and then 1.9% pa over the following five years to 2015/16 reflecting a slower penetration of cooling appliances and the impact of state greenhouse policies as illustrated in the following figure (Figure 28).

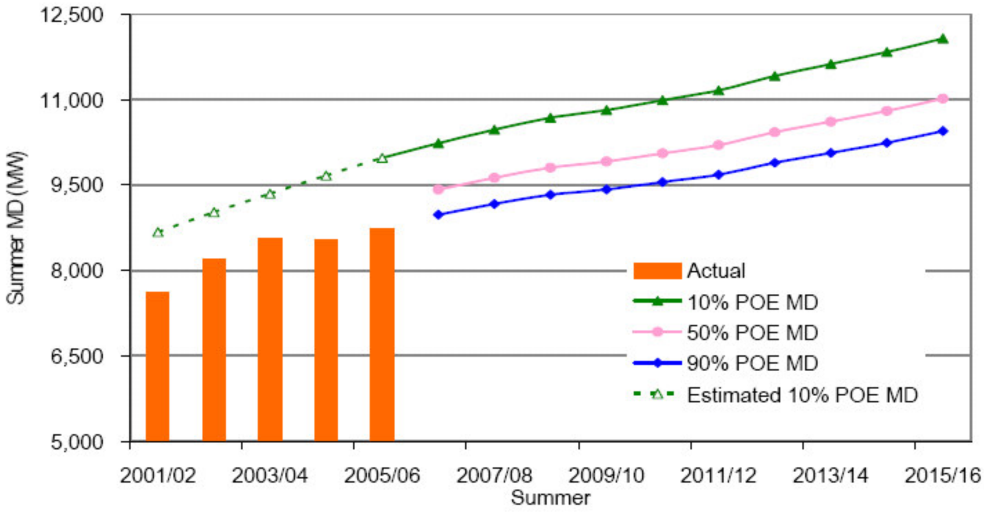

Figure 28 – Summer Maximum Demand

The 10% POE winter maximum demands are forecast to grow from 7,795 MW in 2005 to 8,222 MW in 2010 and 8,875 MW in 2015. The projected average growth rate for the first five years to 2010 is 1.1% pa. Stronger average growth of 1.5% pa is projected for the following five years to 2014, reflecting stronger economic growth and increased penetration of reverse cycle conditioners as shown in the figure below (Figure 29).

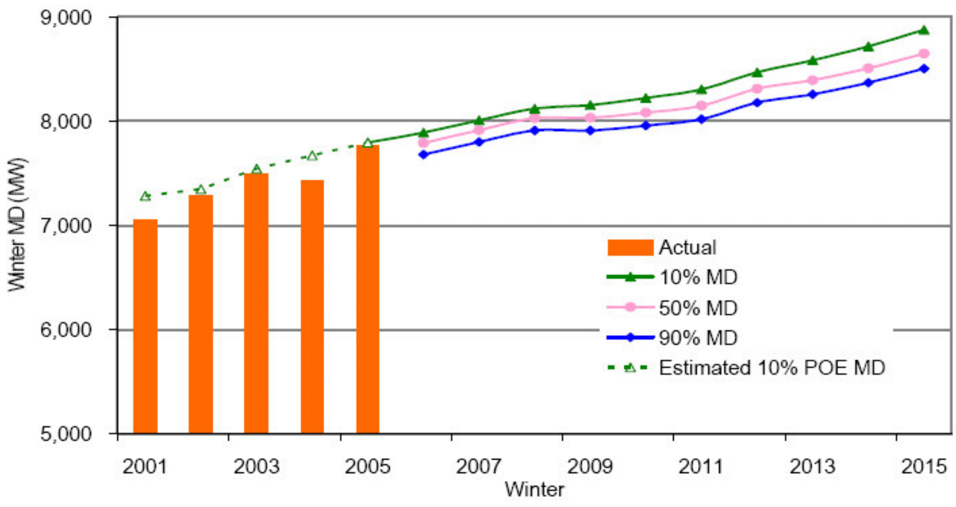

Figure 29 – Winter Maximum Demand

[31] Electricity Annual Planning Report 2006 - VENCorp

5.3 Utilisation

Maximum load on the transmission network has been growing at a compound rate of around 3% per year since 1994. As illustrated in the following figures (Figure 30) and (Figure 31), 35% of transformer banks[32] and 14% of transmission lines[33] are now operating with a redundancy levels less than 'N–1' during periods of peak demand.

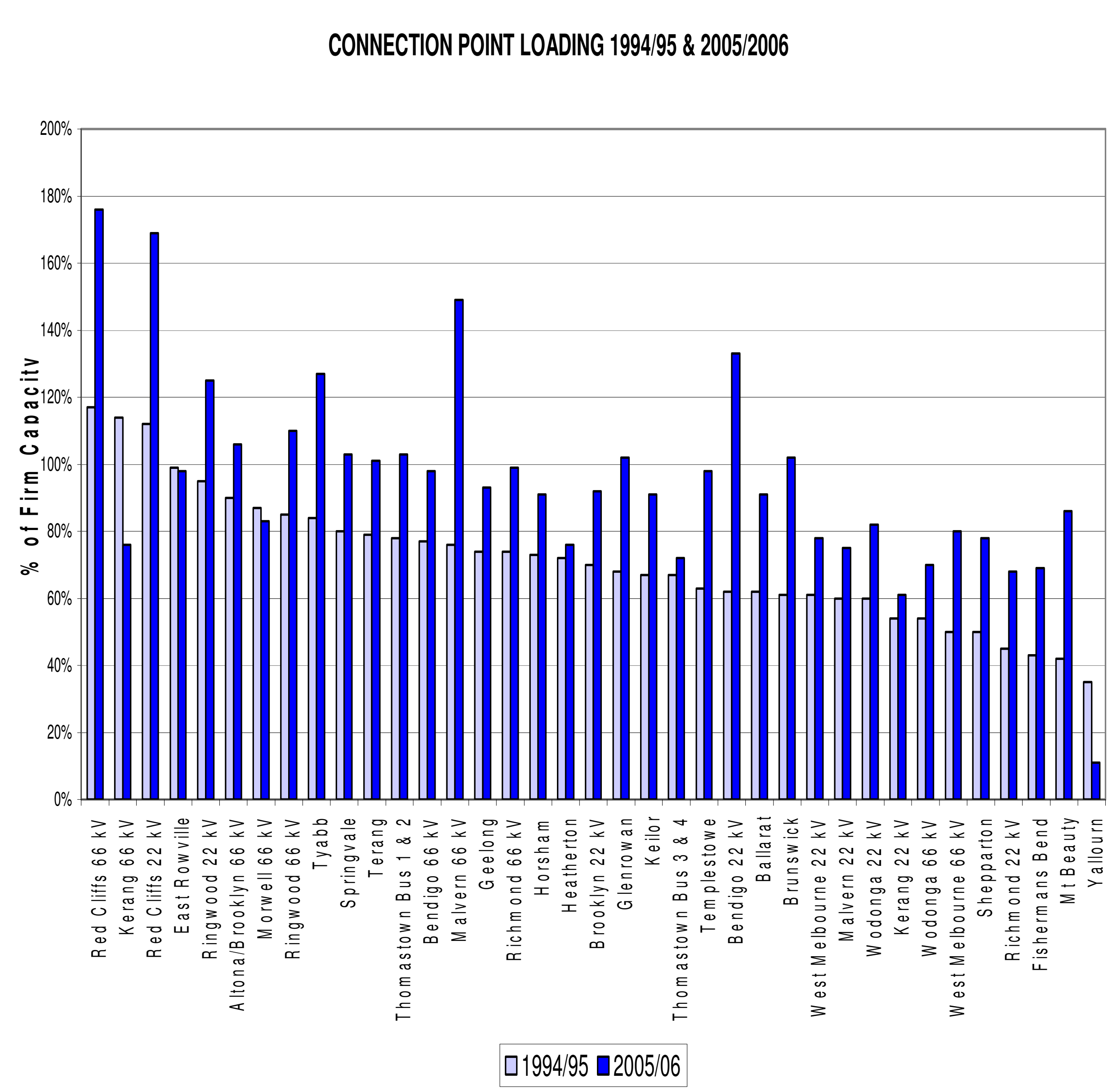

Figure 30 – Electricity Connection Network Loadings

32 SP AusNet monitoring.
33 Electricity Annual Planning Report 2006 – VENCorp

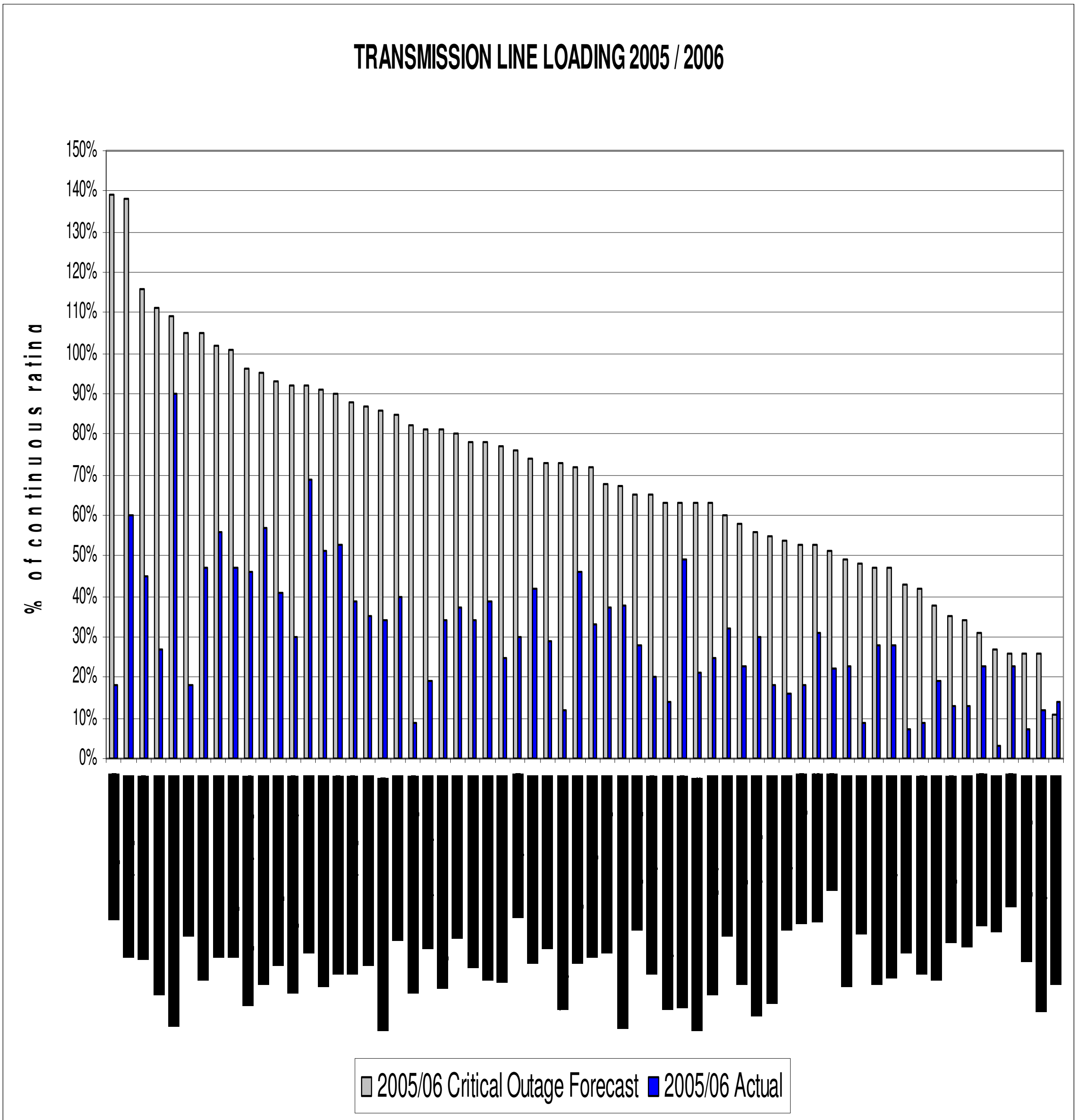

Figure 31 – Electricity Transmission Line Loadings

5.4 Fault Levels

Analysis[34] of the transmission network has shown that fault levels at 275 kV, 330 kV and 500 kV buses are well within the existing switchgear ratings, and it is unlikely that fault levels will be a constraint on development at these voltages within the foreseeable future. However, at 220 kV, 66 kV and 22 kV buses, fault levels are approaching, and over the next five years are forecast to exceed, the rated fault capability of switchgear at a number of Terminal Stations.

Network fault levels are continuing to rise at approximately 1% per annum. The following figure (Figure 32) illustrates the growth in the average of maximum prospective fault levels for the period 2000/01 through 2009/10.

[34] Transmission Network Short Circuit Levels 2006-2010 Victoria – VENCorp December 2005

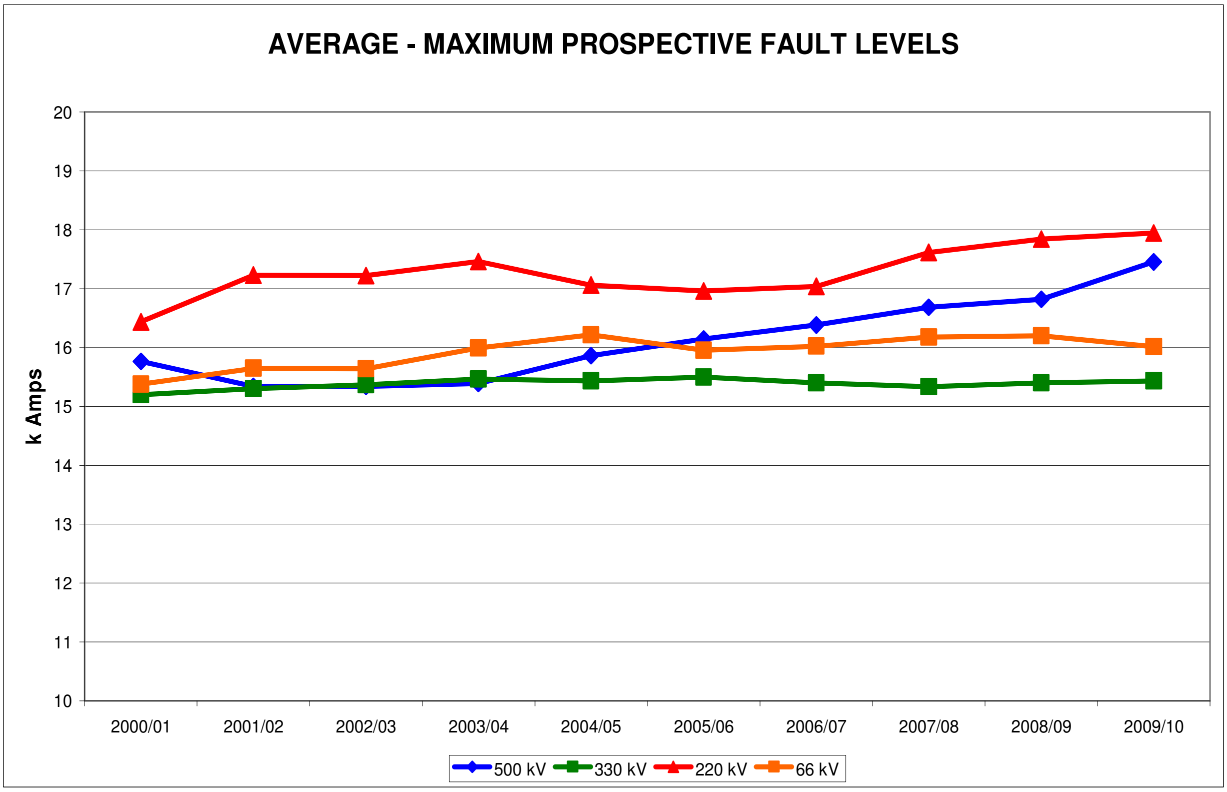

Figure 32 – Average maximum prospective fault levels

Figures 33 and 34 below illustrate that 45% of 220 kV and 29% of 66 kV circuit breakers are exposed to maximum prospective fault levels exceeding 90% of the maximum rating assigned when they were manufactured.

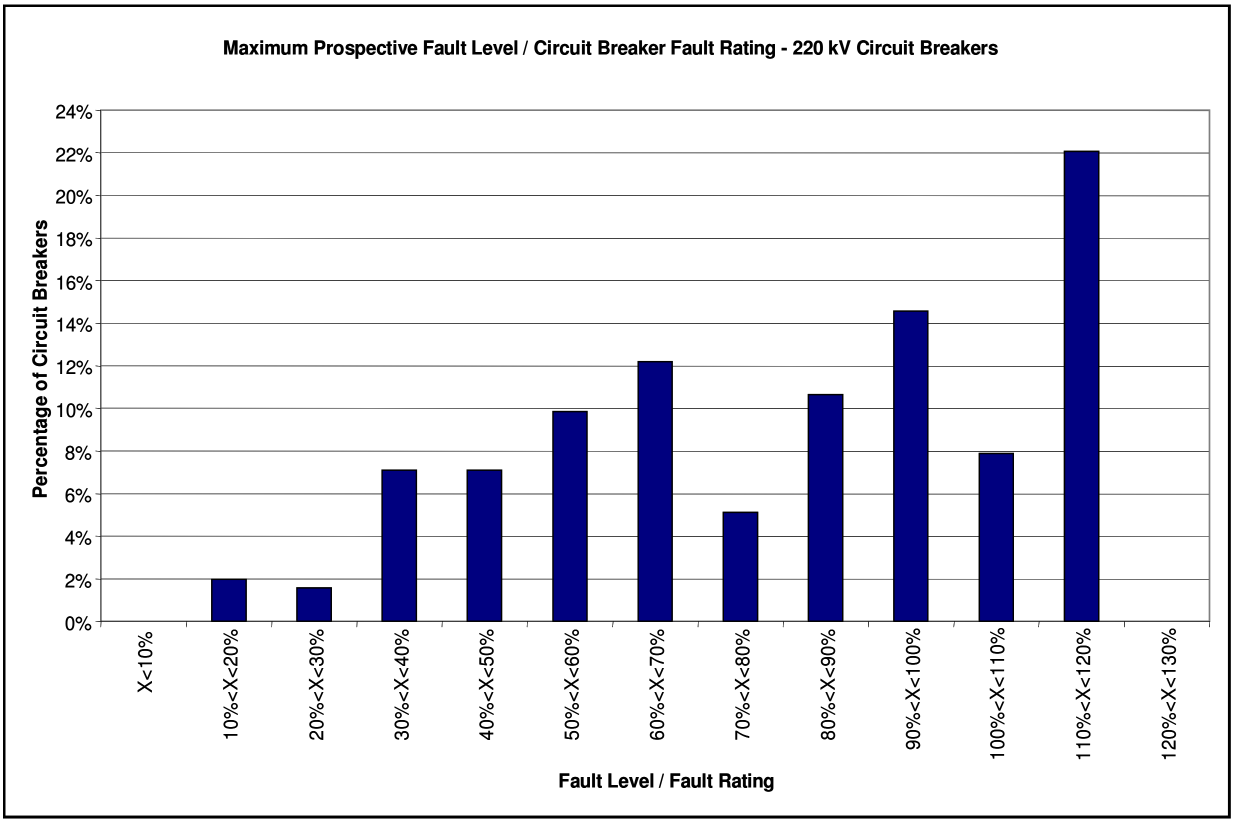

Figure 33 – 220 kV CBs X Fault Levels 2005

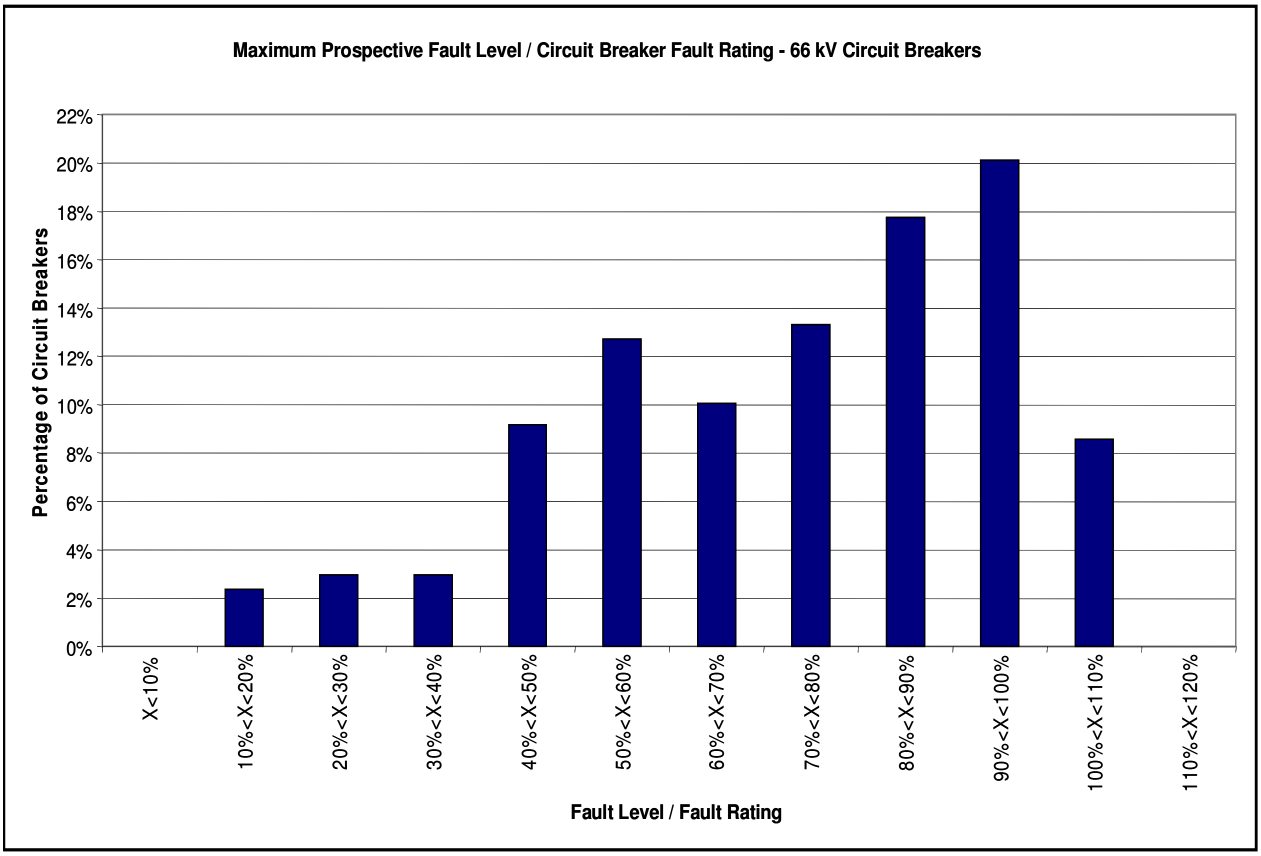

Figure 34 – 66 kV CBs X Fault Levels 2005

For many years, operational switching arrangements have been implemented to maintain fault levels within plant ratings at critical locations. This is illustrated in Appendix - Transmission Network Short Circuit Levels, which summarises the "headroom" available based on the summer 2005/06-fault level review undertaken by VENCorp.

However, the number of locations (now 39% of terminal stations) and the complexity of the operational controls coupled with the inherent reduction in plant redundancy (and hence network reliability), the increased operational costs and associated business risk borne by the network owner/operator make this approach unsustainable.

Consideration of fault levels over the last few years has highlighted the challenges involved in maintaining 220 kV fault levels at Hazelwood Power Station and Keilor, Rowville, Thomastown and West Melbourne terminal stations where the bus fault level already exceeds or is forecast to exceed the rating of the lowest rated circuit breaker at the terminal station.

5.5 Reliability

Principally initiated by equipment failure, the consequences and frequency of reliability events are predetermined by network configuration, equipment utilisation levels and asset condition (age).

5.5.1 Incentive Targets

In 2005 performance targets, set in the Network Service Agreement[35] between VENCorp and SP AusNet, were achieved for the following measures[36]:

- Forced outage frequency for transmission lines
- Mean outage duration for transmission lines
- Forced outage frequency for main and connection transformers
- Mean outage duration for main and connection transformers

However, the Network Service Agreement performance targets for successful auto-reclose rates for transmission lines were not achieved.

In 2005 performance targets, set by the AER (ACCC) as part of the current revenue cap decision[37], were achieved for the following measures[38]:

- Loss of supply event frequency
- Average outage duration

5.5.2 Benchmarking

The Victorian electricity transmission network has consistently proven more reliable[39] than that of other Transmission Network Service Providers (TNSPs). Reliability has varied widely around a 10-year average of 0.5 system minutes not supplied, as illustrated in the following figure (Figure 35).

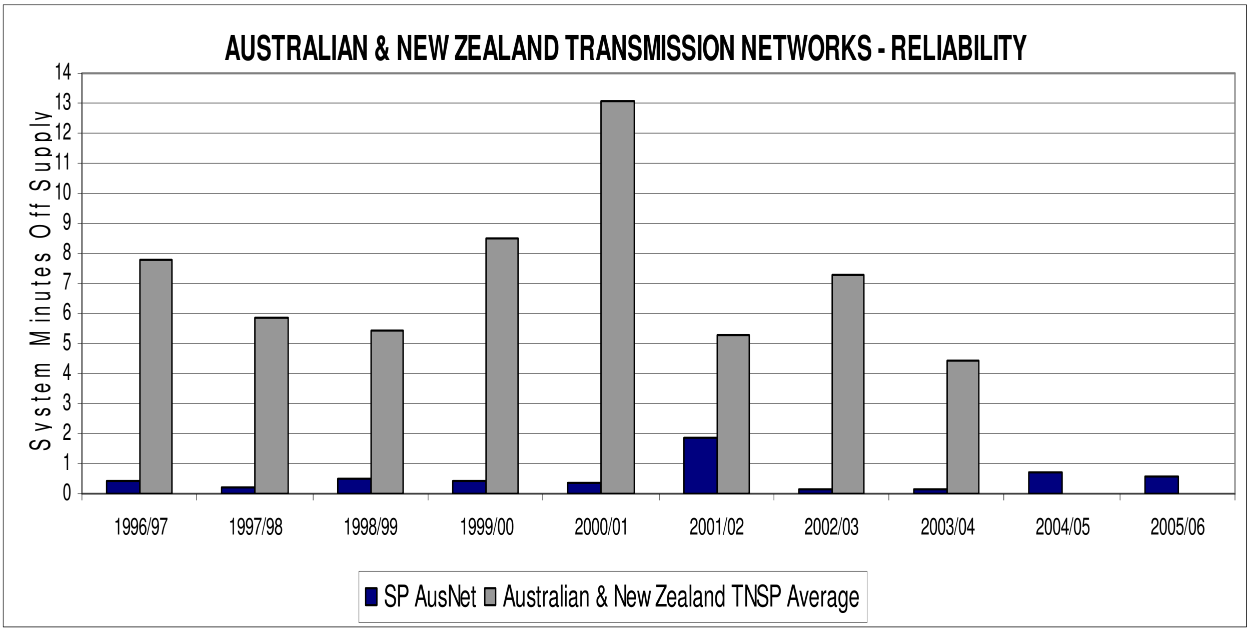

Figure 35 – System Minutes off Supply

[35] Network Service Agreement
[36] Appendix 1 - Network Services Agreement Performance Measures
[37] Victorian Transmission Network Revenue Cap Decision - ACCC December 2002
[38] Appendix 2 – ACCC Service guidelines - performance measures
[39] Electricity Australia 2004 – Electricity Supply Association of Australia

Retail interruptions to supply[40] have also varied widely around a 10-year average of 4 p.a. with an unfavourable performance trend possibly emerging in the latter years of the figure below (Figure 36).

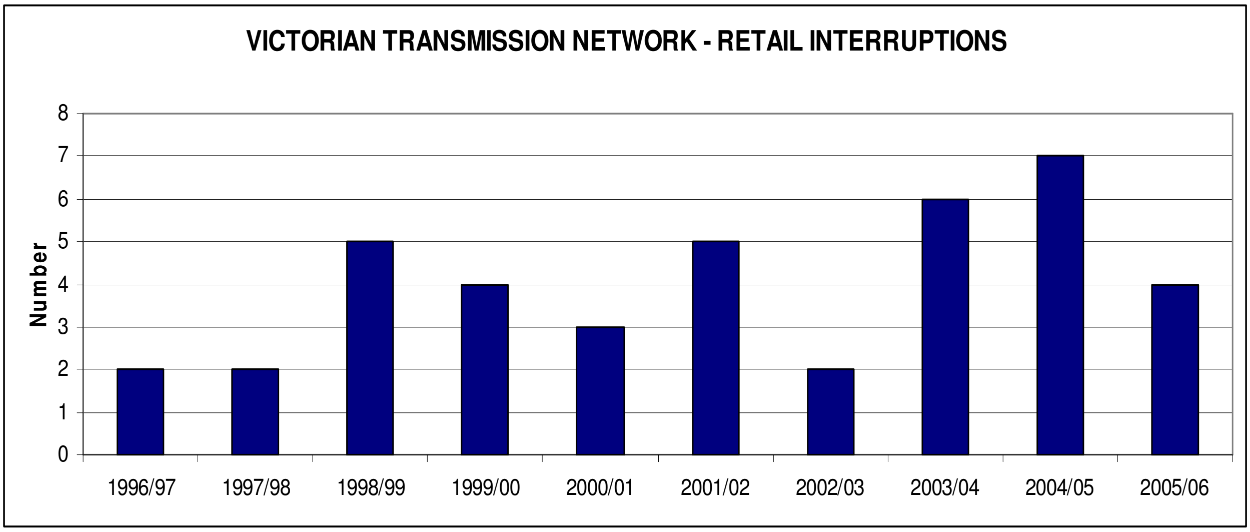

Figure 36 – Retail Interruptions to Supply

5.5.3 Lines

In 2005/06, forced outages of transmission lines, due to equipment failure, bettered the Network Services Agreement target for the first time since 2001/02. By contrast, the mean duration of forced outages has met its target since 2001/02. The wide variance in year-to-year performance over the last decade provides indications of low levels of control over transmission line reliability.

5.5.4 Transformers

Forced outages of main and connection transformers have met the Network Services Agreement targets since 2001/02 and the mean duration of forced outages has met the respective target since 2002/03. However, the wide variations over the last decade suggest that further efforts are necessary to stabilise transformer reliability at target levels.

5.6 Availability

5.6.1 Peak Loading Periods

In 2005, availability performance targets set by the AER (ACCC) as part of the current revenue cap decision[41], were achieved by SP AusNet for both critical and non-critical circuits during peak network loading periods as illustrated in the following figures (Figure 37 and Figure 38).

[40] SP AusNet monitoring
[41] Victorian Transmission Network Revenue Cap Decision - ACCC December 2002

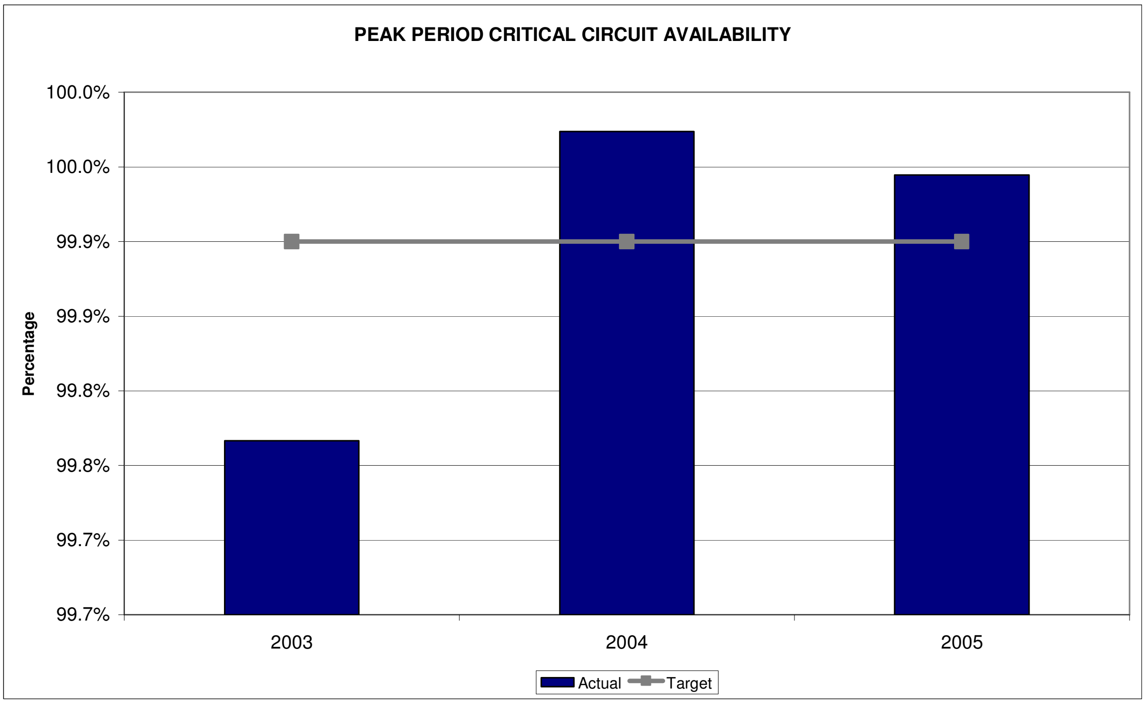

Figure 37 – Availability Peak Period Critical Circuits

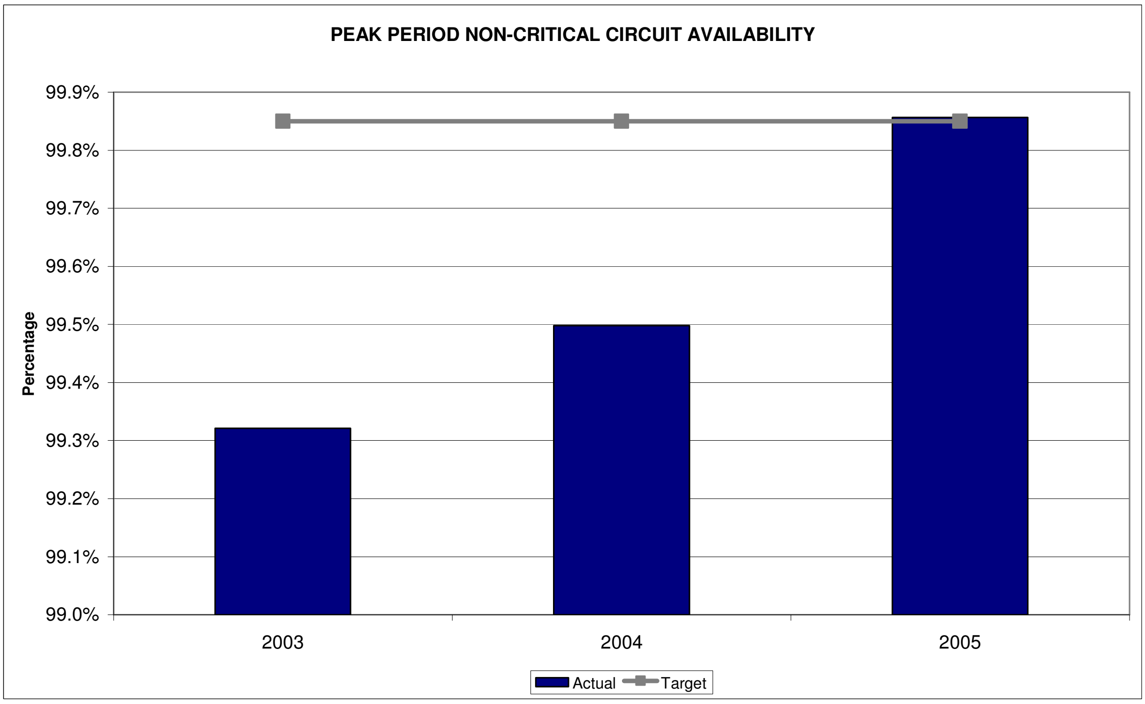

Figure 38 – Availability Peak Period Non-critical Circuits

5.6.2 Intermediate Loading Periods

However, due to the volume of maintenance, refurbishment and replacement works the availability performance targets for intermediate network loading periods have not been met in the last 3 years as illustrated in the following figures (Figure 39 and Figure 40)

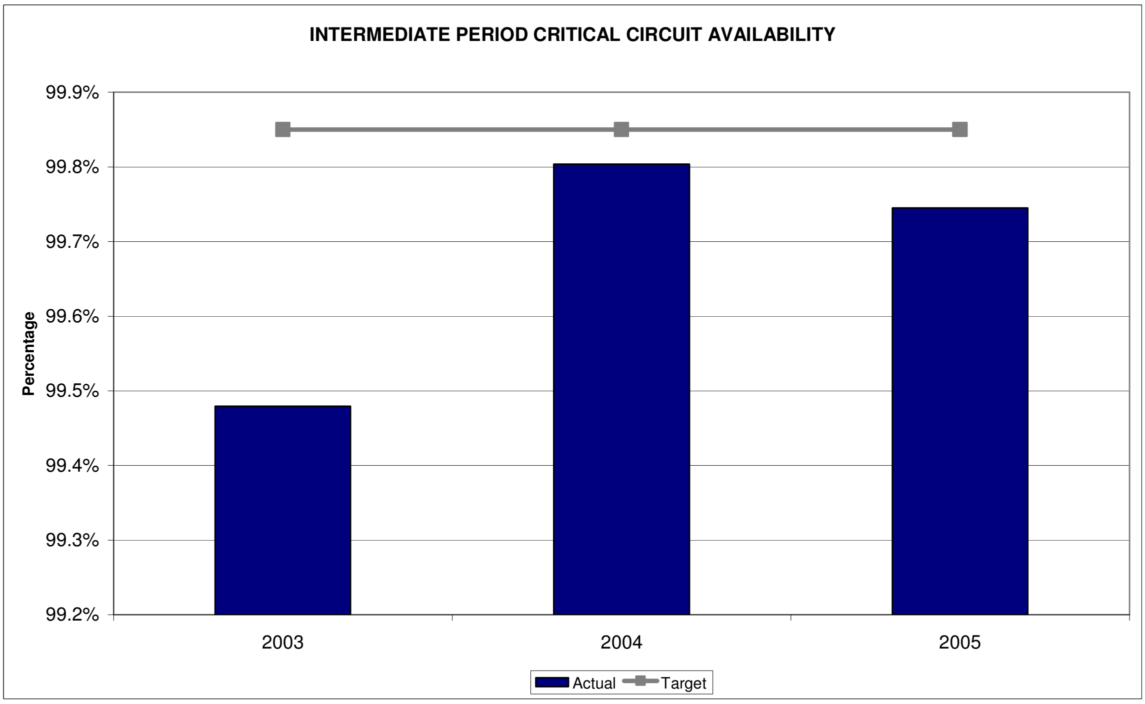

Figure 39 – Availability Intermediate Period Critical CCTS

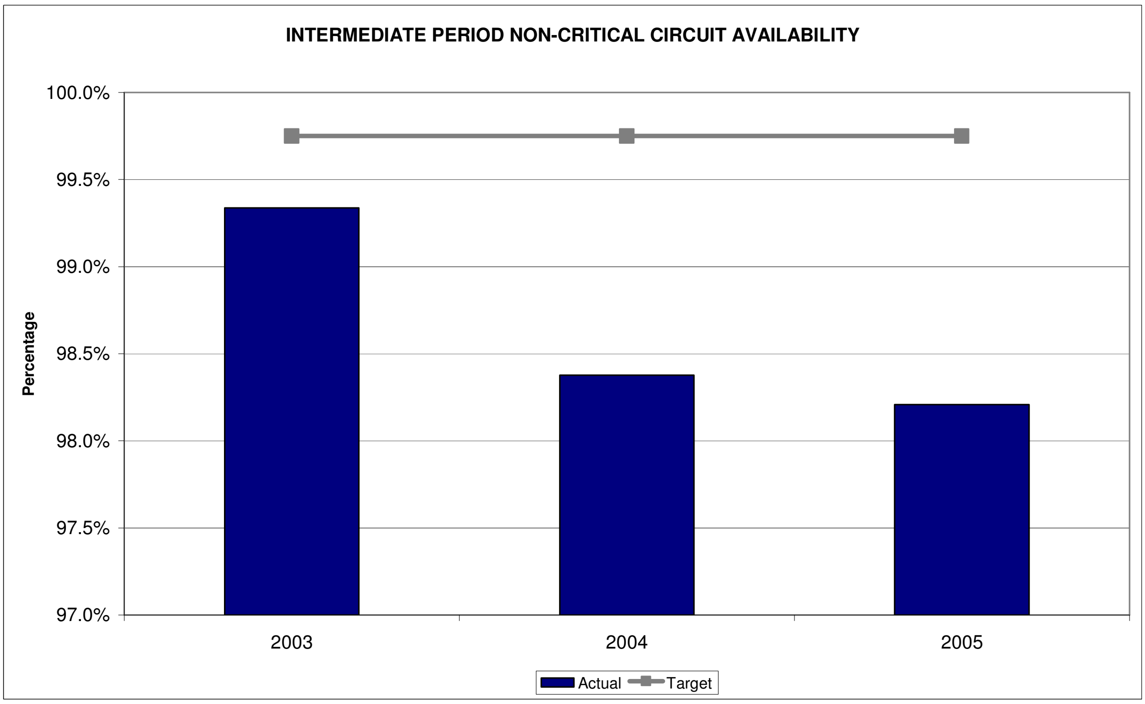

Figure 40 – Availability Intermediate Period Non-critical CCTS

5.6.3 Lines

Victorian electricity transmission lines have exhibited near "best-practice"[42] availability over the last decade with levels exceeding the Network Services Agreement target of 99.5% in all but 2004/05 as illustrated in the figure below (Figure 41).

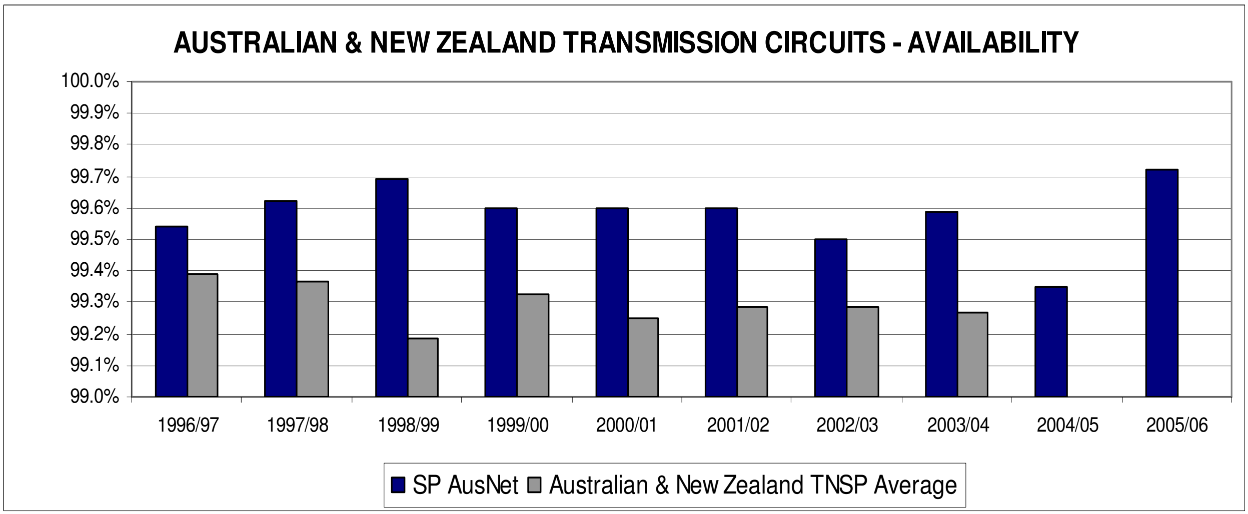

Figure 41 – Transmission line availability

Risk-modelling suggests increasing proportions of line hardware will require replacement over the next 15 years to sustain conductor-drop risks within an acceptable range. Additionally, Vision 2030[43] indicates new circuits and significant uprating and re-conductoring of existing circuits will be necessary in the period to 2015. Thus SP AusNet faces a significant challenge in maintaining transmission line availability near historic levels in the period after 2010.

5.6.4 Transformers

Main and connection power transformer availability has varied over the last decade. On three occasions the Network Services Agreement target of 99.7% was met but in other years performance was below expectations, as shown in the following figure (Figure 42)

[42] Electricity Australia 2004 – Electricity Supply Association of Australia
[43] 25 Year Vision for Victoria's Energy Transmission Networks October 2005 – VENCorp.

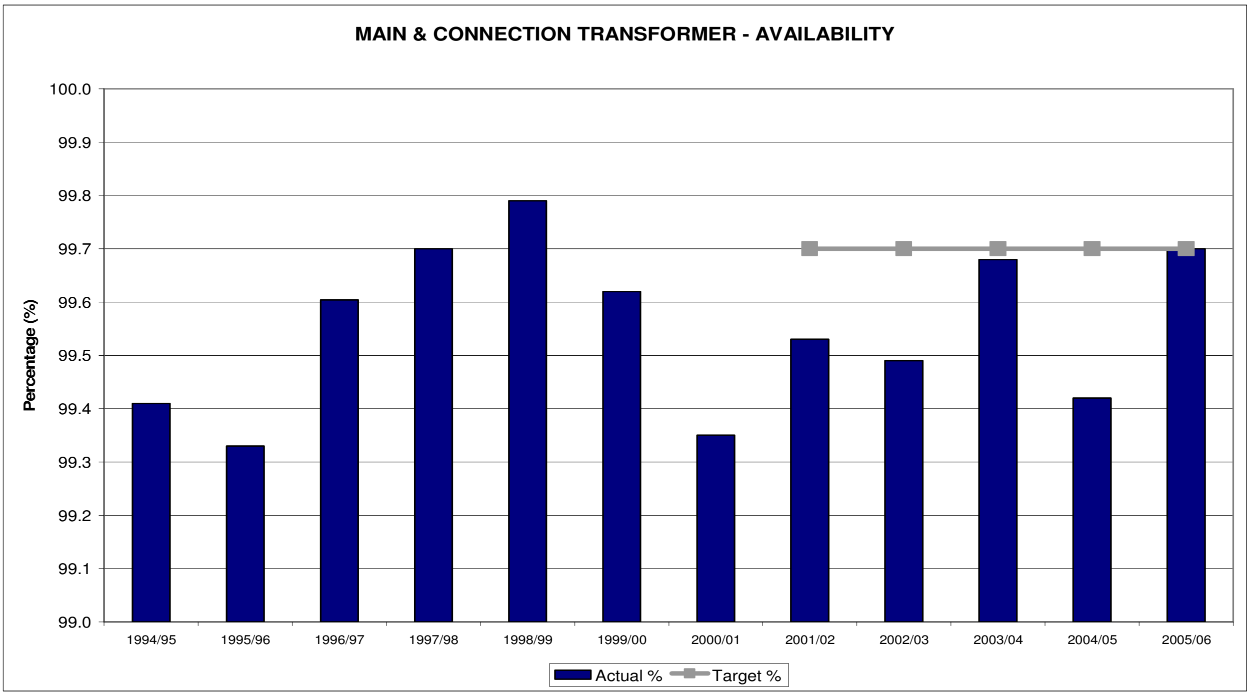

Figure 42 – Main and Connection Transformer Availability

In recent years, transformer availability has been determined by outages arising from failures and the increased testing, maintenance, refurbishment and replacement to manage the reliability risks of a fleet with an average age of 36 years and older units in excess of 52 years.

Framed around a stable risk position, the 2008 to 2013 work program includes continuation of the condition testing program and an increase in replacement activity. It is unlikely that the current availability targets will be met in the next decade. Targets may need to be re-negotiated in order to establish more meaningful incentives to balance current and future transformer availability risks.

5.6.4.1. Capacitor Banks

Capacitor bank availability has varied around the target level of 99.3% for most of the last decade. Only when an intensive capacitor-can testing program coincided with high levels of new plant installation and augmentation, during 2000 – 2002, has availability fallen significantly below target.

VENCorp[44] forecasts ongoing installation of new plant and augmentation of existing capacitor banks to meet reactive demand over the next 15 years. Capacitor bank availability should average 99% over the next 5 years rising to 99.5% as identified issues associated with heavily utilised, older and 1995 specification banks are resolved.

5.6.4.2. Static VAR Compensators

The small population of static compensators has infrequently achieved the target levels of availability in recent years, due predominantly to issues with inadequate thyristor cooling capacity and unreliable control systems no-longer supported by manufacturers.

SP AusNet has commenced a multi-year program of mid-life refurbishment and renewal, which includes replacement of control systems. This is expected to progressively restore availability to the

[44] Electricity Annual Planning Report 2005 - VENCorp

99% target level by 2010. Post 2015, 'end of life' management issues will again begin to limit availability.

5.6.4.3. Synchronous Condensers

The Victorian electricity transmission network includes three synchronous condensers, whose availability has largely met stakeholder expectations of 91% over the last decade. In 2003 availability fell below target levels, when a refurbishment program commenced to ensure that degradation of stator winding sidewall insulation and deterioration of rotor pole insulation do not prematurely restrict service life.

Synchronous condenser availability should return to target levels over the next five years with the progressive completion of refurbishments. Availability is forecast to achieve target until 2015 - 2020 when 'end of life' management issues will impinge on performance.

5.7 Resources

5.7.1 Capital Expenditure

The figure below (Figure 43) summarises the asset replacement, additions and refurbishment CAPEX required to deliver the performance summarised in the preceding pages.

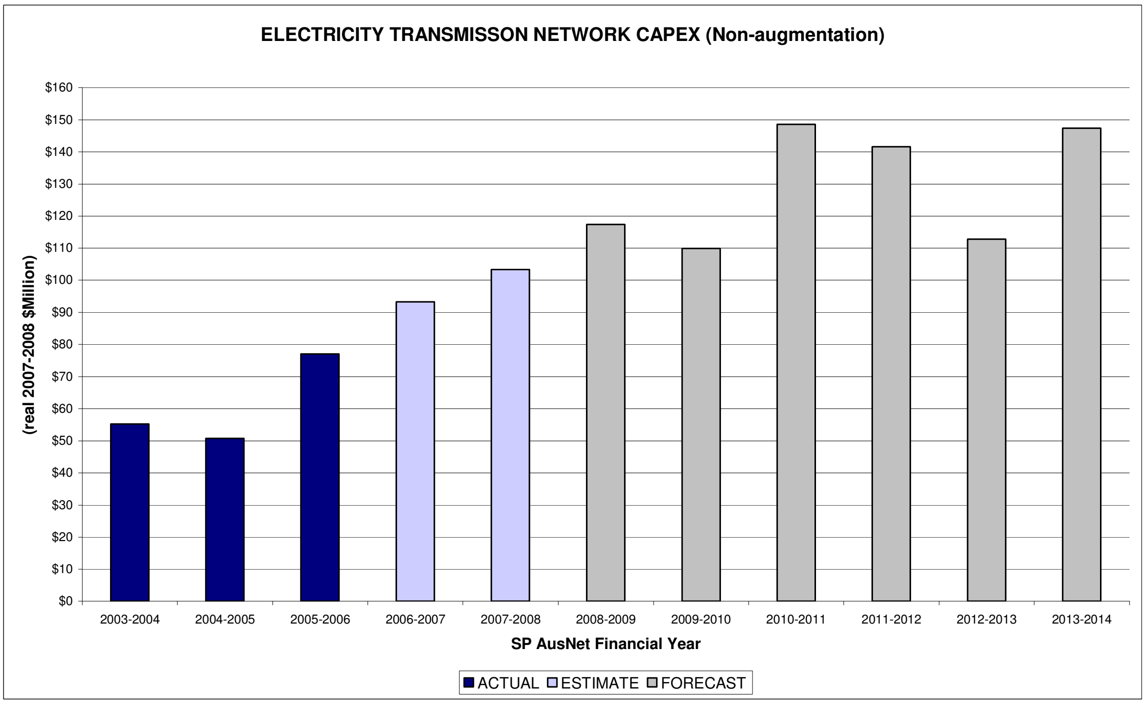

Figure 43 - Network CAPEX

5.7.2 Operating Expenditure

The following figure (Figure 44) summarises the OPEX required to deliver 'system recurrent expenditure' (on regular and ongoing activities such as routine plant maintenance) and 'system non-recurrent expenditure' (one-off programs to respond to specific problems such as tower corrosion mitigation) and underwrite the network performance summarised above.

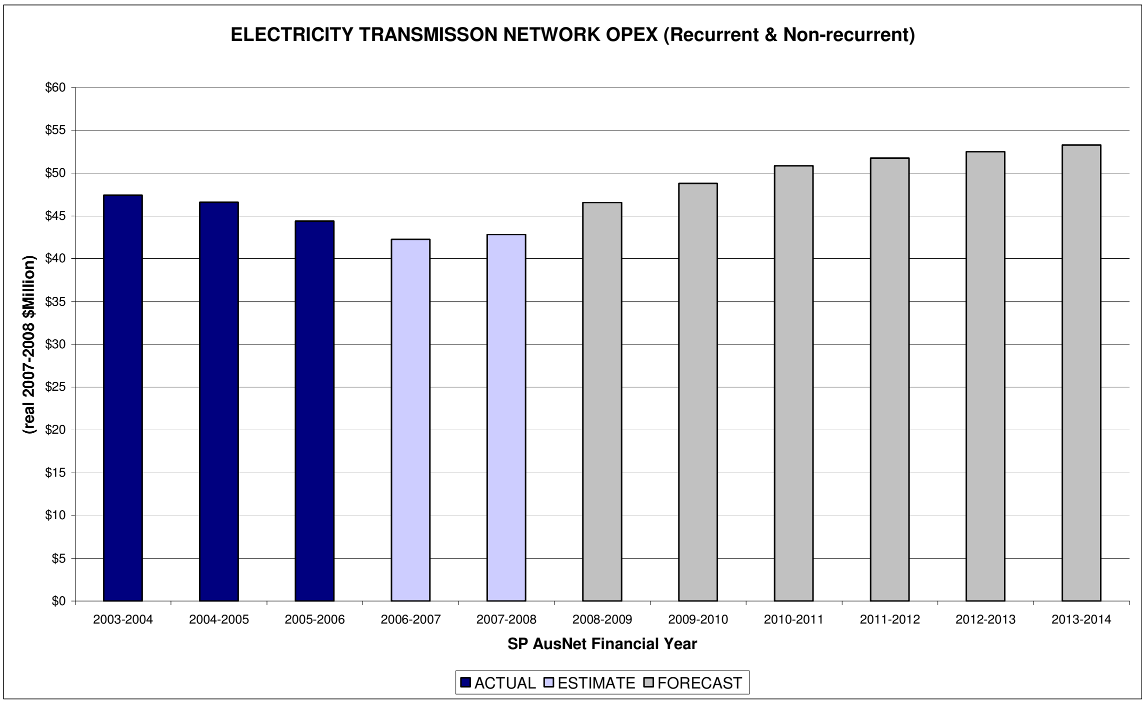

Figure 44 – Network OPEX

6 Process and System Strategy Summary

This section of the AMS provides a summary of issues relating to SP AusNet's processes and systems for the management of transmission assets. These issues are documented in full in the foundation level of resource documents. Each of the following sub-sections details an issue and provides a summary of the key strategies for its management.

6.1 Risk Management

SP AusNet is committed to understanding and effectively managing risk to provide greater certainty for our shareholders, employees, customers, suppliers and the community.

A systematic and consistent approach to risk management and alignment of corporate philosophies and objectives are key principles. The Risk Management Policy defines the governance of risk and the Risk Management Framework sets out the overarching philosophy, principles, requirements and responsibilities for a sound approach. The Group Risk Committee aligns the business objectives with the approved risk appetite and risk management strategy.

Within the above framework, SP AusNet uses a sophisticated suite of models to assess, monitor and mitigate asset failure risks and reliability, availability, health, safety, environment, infrastructure security and code compliance program risks.

Asset risk models guide decisions on the volume and timing of efficient refurbishment and replacement projects necessary to deliver a selected risk position. Program risk models combine asset risk and management improvement programs to guide decisions on the capability of the Victorian electricity transmission network to sustain selected performance levels.

Key Strategies:

- Use asset risk models to guide the volume and timing of asset refurbishment and replacement programs.
- Use program risk models to guide the decisions on sustainable performance levels.
- Further develop contingency plans (to guide recovery from major incidents) for specific critical stations, assets or programs in support of the overarching System Contingency Plan.
- Influence the transmission network-planning process to minimise network outage risks.
- Use risk management as a key driver in project selection, design, procurement, and maintenance of transmission assets.

For further information please refer to Risk Management.

6.2 Health and Safety Management

SP AusNet is committed to providing a safe and healthy workplace for employees and contractors, through the commitment and contribution of every employee. Occupational Health and Safety Management System (OHSMS) for transmission assets is certified against the AS/NZ 4801 standard and compliance is checked by regular internal and external audits.

Key Strategies:

- Continue regular worksite audits to confirm compliance with electrical safety procedures and the Blue Book.
- Continue the implementation of the tower safe-access program.
- Conduct risk assessments for identified working at height tasks and implement recommended actions.
- Implement recommended actions to improve fall restraint on new and existing line towers (in consultation with Victorian WorkSafe Authority).
- Design and operate assets prudently to reduce exposure to Electro-Magnetic Fields.
- Continue to monitor EMF levels associated with transmission assets.
- Progressively remove asbestos containing materials as recommended in the Asbestos Management Strategy.
- Complete the implementation of immediate recommendations of the Human Error Incidents review.
- Minimise exposure of employees and contractors to new and decomposed SF_6 gas.
- Continue the ongoing program of testing the insulating fluid in plant items for PCB and replace the fluid as required.
- Conduct awareness training for relevant personnel on the operation of the INERGEN fire suppression systems.
- Complete the delivery of radio frequency awareness-training courses for people required to access structures near antennae.

For further information please refer to Health and Safety Management.

6.3 Environmental Management

SP AusNet maintains an International Organization of Standards (ISO 14001) certified Environmental Management System (EMS) for its transmission assets. Through the auspices of the EMS, policies, procedures and objectives pertinent to vegetation management, bushfire mitigation and environmental management are integrated and linked to the SP AusNet Environmental Policy and Environmental Objectives.

The EMS is regularly audited internally and externally to assess compliance with the ISO 14001 standard, regulatory requirements and good environmental practice.

Key Strategies:

- Increase community awareness of vegetation management policy and procedures.
- Regularly review environmental policy and procedures in consultation with relevant groups.
- Risks assess line easement access tracks that are publicly accessible and mitigate risks.
- Audit all line easement access bridges to ensure that they are fit for the purpose.
- Complete the program of oil containment, treatment and drainage improvement works.
- Ensure any contaminated soil is disposed of appropriately and affected sites are remediated.
- Remove the lead based paint from three towers on the 220 kV transmission line from the Fisherman's Bend Terminal Station to West Melbourne Terminal Station.
- Continue to monitor noise levels at terminal station sites and address any noise complaints.
- Minimise the visual impact of existing and new transmission assets.
- Continue to monitor SF_6 leaks from equipment and repair identified leaks.
- Complete the repair of significant SF_6 gas leaks and weather sealing on the Gas Insulated Switchgear at South Morang Terminal Station in 2008.
- Continue to support revegetation of transmission line easements with sustainable vegetation.

For further information please refer to Environmental Management.

6.4 Condition Monitoring

SP AusNet has embarked on the development of a knowledge-based asset management system that utilises both online and off-line condition monitoring data to maintain acceptable levels of network reliability and availability.

New condition monitoring techniques are continuously being developed as the knowledge and understanding of equipment performance expands, aided by the increasing computing capability and high-speed digital communication.

To supplement assessments undertaken during maintenance and analysis of system incidents and equipment defects, SP AusNet has installed a number of online condition monitoring devices and is implementing a number of SCADA based condition monitoring programs including CVT voltage balance and plant current balance systems. As the Asset Data Gathering Network comes into service, the existing condition monitoring devices are connected to allow remote data access and logging. These systems are providing robust data and informing better asset management decisions.

Key Strategies:

- Purchase new assets and retrofit critical existing assets with on-line condition monitoring sensors and install fibre optic cabling within terminal stations to connect to LAN/WAN.
- Integrate diverse condition data and information (from maintenance reports, test reports, failure reports, on-line condition monitoring sensors, Intelligent Electronic Devices, and SCADA) in MAXIMO.
- Automate the analysis of condition assessments and risk ranking of major assets such as transformers, current transformers and circuit breakers.
- Validate models for failure risk, remaining life and maintenance scheduling
- Use simple centralised administration, WAN access and web-based browser technology for remote and wireless access of asset condition reports and failure warnings.
- Migrate to real-time performance management.

For further information please refer to Condition Monitoring.

6.5 Plant and Equipment Maintenance

The overarching strategy for the maintenance of SP AusNet's transmission assets is:

"…the application of safe, efficient and cost effective work practices to optimise the security, reliability and operational capability of the transmission system under normal and abnormal conditions. Further, to preserve the good condition and functional capability of the plant and equipment in order to maximise its service life".

Plant and equipment maintenance includes both recurrent and non-recurrent works.

Recurrent works are activities of a regular and ongoing nature and include scheduled, unscheduled, and breakdown maintenance.

Scheduled maintenance programs are derived from SP AusNet's asset management information system (Maximo) database. A maintenance plan, which lists all of the scheduled maintenance (OMS) tasks for the following 12 months, is produced as a part of the budget process leading up to the new financial year. Forecasts of scheduled maintenance for future years are obtained by generation of virtual work orders in Maximo.

Forecasts for unscheduled and breakdown maintenance are based on historical actual levels.

Non-recurrent works are those that cannot be capitalised and have scopes that are too large or specialised to be included in the maintenance plan (for recurrent works). They are not time or operation based and are generally non-repetitive one-off programs put in place to address specific problems. Examples are tower-corrosion mitigation works and condition assessment programs.

Key Strategies:

- Progressively increase the safe use of live maintenance work on transmission lines where there are work efficiencies and cost savings to be achieved.
- Carry out further investigations into the possibility of performing live maintenance work on selected items of primary plant in terminal stations where such work can be performed safely and there are work efficiencies and cost savings to be achieved.
- Increase the use of reliability and risk assessments to determine the need for scheduled maintenance or refurbishment or replacement.
- Give greater consideration to the criticality of system elements in prioritising the maintenance or refurbishment or replacement effort.
- On the basis of the technical and economic evaluation of proposals, selectively refurbish or replace plant and equipment that is maintenance intensive.
- Continue to participate in industry benchmarking studies relating to the maintenance and operation of transmission plant and equipment and progressively implement appropriate, identified, best practice approaches.
- Selectively increase the use of condition monitoring and diagnostic testing methods to predict the need for and extent of maintenance.
- Ensure that, as much as possible, new assets have built-in condition monitoring and self-testing facilities.
- Progressively refine the use of the handheld devices to enable field personnel to more easily initiate defect reports in the Defect Management system.
- Review spare equipment and ensure appropriate stocks are held at strategic locations to support both scheduled and unscheduled maintenance.
- Review Plant Outage Management System (POMS) workflows and progressively refine the use of POMS.

For further information please refer to Plant and Equipment Maintenance.

6.6 Asset Management Information Systems

The main asset management information systems are MAXIMO for asset and work management, TRESIS for relay settings, Ratings Database Repository (RADAR) for plant and equipment ratings and Mobile Inspection System (MIS) for recording asset inspections.

The progressive development of asset management information systems is co-ordinated by the Enterprise Asset Management program within the Business Systems Asset Management Strategy.

The principle drivers of improvement in information systems are:

- Improved data quality for informed operation and strategic decision making
- Increasing costs of supporting disparate, customised, non-interfaced systems
- High risks associated with reliance on “local knowledge” of mature-aged workforce
- Repeatable, transparent and auditable processes to assure compliance to regulatory and safety obligations
- Replacement of obsolete legacy systems

Key development strategies include:

- Extend the electronic collection of data via mobile computing devices and automatic links between MAXIMO and SCADA.
- Progressively implement the Enterprise Asset Management program to form a single authoritative asset and inventory register incorporating works management, and logistics management which includes:
    - Consolidation of asset data from disparate systems within MAXIMO
    - De-commission disparate systems
    - As necessary, establish links from MAXIMO to other systems to facilitate automatic updates
- Establish web browser architecture to facilitate remote access by authorised stakeholders to view information and reports.
- Implement a flexible reporting capability that caters for routine and ad hoc requests from stakeholders.
- Ensure that there are appropriate data security and data recovery plans in place.

For further information please refer to Asset Management Information Systems.

6.7 Network Performance Monitoring

The effectiveness of SP AusNet's asset management policies and practices is measured directly by the performance of high-voltage electrical plant and its impact on the availability of the transmission system that it operates within. The development of these policies requires the reliable capture of accurate data, effective decision support tools for trending and analysis, and comparison with externally benchmarked performance standards.

The vision for network performance management is to raise this data collection and analysis process to a level that will maximise our return on investment during the next regulatory period.

Key Strategies:

- Update the spreadsheet used to calculate the System Code Performance Measures, utilising the functionality that is now available through changes to POMS and MAXIMO.
- Enhance the IT system used to calculate the measures for the ACCC Service Standards Performance Incentive Scheme.
- Develop the ability to model outcomes of 'what if' scenarios for forecasts about the impact of ramped-up, Group1 capital works program and asset works refurbishment programs.
- Develop the System Incident Report (SIR) system such that the data it provides can be more readily used to trend asset performance and extracted for benchmarking purposes.
- Build improved functionality into the IT solutions for Network Performance measures made possible by the upgrade of MAXIMO to Version 5.2.
- Build a robust system to capture data required for the various network transmission operations and maintenance benchmarking studies that SP AusNet regularly participates in.
- Develop performance benchmarks for specific plant types and compare them with international rating systems such as used by the International Council for Large Electrical Systems (CIGRE).
- Undertake performance analysis on power transformers and isolators.

For further information please refer to Network Performance Monitoring.

6.8 Operations Management

The operation of the overall system and of individual assets is a key to asset management and to ensuring that system performance targets are achieved. Successful operations management also ensures that the integrity of the assets is not compromised, and safety and environmental requirements are met.

Key Strategies:

- Maximise asset utilisation with the support of control schemes and support systems such as System Overload Control Scheme (SOCS), RADAR and Overload Shedding Scheme for Connection Assets (OSSCA).
- Optimise the timing of planned asset outages with the support of systems such as POMS and MAXIMO.
- Utilise proactive and real-time condition monitoring of assets.
- Provide rapid fault response with the assistance of SCADA and real-time fault analysis.
- Record and analyse fault events using the SIR and Defective Apparatus Report (DAR) processes.
- Audit the short circuit ratings of primary plant in stations that are operating at or close to the designed rating.

For further information please refer to Operations Management.

6.9 Program Delivery

The Program Delivery group provides management and resources to deliver the SP AusNet maintenance (OPEX) and capital works (CAPEX) programs relating to transmission assets.

The resource model includes the use of internal and external resources in the delivery of maintenance and capital works programs. Strategic alliances have been formed with companies that provide design services, installation services and maintenance services. Contract arrangements are performance based with benchmarking of costs and standards to ensure that quality and value is maintained throughout the contract.

Key Strategies:

- Improve the planning and control of projects by:
  - Refining the scope and specification of projects through constructability analysis and scenario modelling
  - Completing the implementation of the Project Change Control process
  - Engaging the project manager early and retain NDD representation through the project
- Complete the review and electronic publication of the project execution manual to guide the authorised delivery processes.
- Maintain the project estimating system with relevant project completion, quotation, and tender and benchmarking data.
- Ensure engineering and quality standards by the pre-qualification of design service providers and provision of comprehensive technical specifications, guidelines and standards via the electronic Station Design Manual (SDM).
- Improve quality control of complex projects through on-site supervisors and formal technical compliance audits
- Improve the Constructability, Operability and Maintainability (COM) review process by contractor involvement, pre-commissioning inspections and promptly outworking action items
- Refine the Post Implementation Review (PIR) process to identify innovation and learning opportunities

For further information please refer to Program Delivery.

6.10 Asset Replacement and Refurbishment

In deciding whether to replace or refurbish assets a range of options for asset management are identified and evaluated, utility practices analysed and supporting arguments developed. Primary requirements for any decision on replacement or refurbishment are a well-defined asset management strategy and sound knowledge of the asset's condition and related factors affecting performance and expected technical life.

Key Strategies:

- Establish relationships with best performing electricity and gas network operators in the United Kingdom to improve the "Business Strategy and Direction" part of SP AusNet's asset renewal practice.
- Seek partners to facilitate preparation and ultimately accreditation of asset management practices to BSI PAS 55 by 2008.
- Broaden and enhance the use of on-line-condition-monitoring tools and techniques to uniformly gather, analyse and rank condition assessment data for major assets including power transformers, transmission lines and circuit breakers.
- Broaden and enhance the use of asset risk models to optimise the volume and timing of asset renewal programs.
- Refine the process used to manage ongoing changes to the selected portfolio to ensure that the business is continually resourcing the most optimal set of capital projects

For further information please refer to Asset Replacement and Refurbishment.

6.11 Capital Expenditure Prioritisation

The prioritisation process directs capital expenditure toward those projects, which are most efficient in delivering stakeholder benefits and the regulatory commitment. The process involves quantifying the benefits and resource requirements of candidate projects and ranking them according to stakeholder and corporate values including:

- Asset condition – performance and reliability
- Health & safety (staff and/or public)
- Environmental impact
- Compliance – statutory, regulatory and code
- System and community impact
- Financial impact, and
- Corporate image

Modelling the quantum and the timing of benefits from each candidate project against target outcomes provides an optimal list of projects, which following ratification, forms the basis of the near term budget and capital works program.

Key Strategies:

- Refine the process used to manage ongoing changes to the selected portfolio i.e. have a rolling selection process to continually resource the optimal set of capital projects.
- Further refine the metrics used to quantify desired outcomes and the benefits of candidate projects.
- Provide earlier quantification of alternate options for significant projects.

For further information please refer to Capital Expenditure Prioritisation.

6.12 Process and Configuration Management

Process and configuration management includes:

- The standardisation of design, hardware and configuration of protection and substation automation systems
- Database management – consolidation of secondary systems data, firmware and configuration in accessible engineering data bases
- Power system protection, control and monitoring - development of protocols for the application of standard designs, the implementation of settings and the testing of secondary devices.

Key Strategies:

- Document the vision for substation automation concept, including the implementation of international substation automation standard IEC 61850
- Complete repeatable configuration templates for two alternative System Control and Information Management Systems (SCIMS)
- Complete the development of standard bay cubicles and interfaces for typical high-voltage circuit bays in terminal stations.
- Reduce the number of communication protocols used between the SCIMS and Intelligent Electronic Devices (IEDs).
- Identify the data and relevant ports of IEDs that are accessed remotely for engineering purposes.
- Implement IEC 61850 in terminal station refurbishment projects.
- Develop a philosophy for Local Area Network (LAN) based engineering access to IED data (possibly using the IEC1850 standard) and implement where available.
- Develop support tools for monitoring and disturbance analysis in order to maximise the benefits of a quick and accurate assessment of system conditions.
- Adapt station configuration to support the introduction of “station to station to control centre” network communication based on international standards.

For further information please refer to Process and Configuration Management.

6.13 Knowledge and Record Management

The establishment of robust knowledge management systems, processes and culture is pivotal to the achievement of network performance targets, optimised life-cycle costs and a sustainable risk profile.

Knowledge and record management includes maintaining accurate records of asset types and locations; condition assessments from periodic inspections, risk based testing programs and automated online condition monitoring systems.

It also includes the real-time acquisition and management of data regarding network operating parameters and event circumstances. This data will facilitate confident, safe and reliable operation of the network, the modelling of future scenarios and the forecasting of performance.

It extends to include the transfer of intellectual property and informal knowledge through training and mentoring programs.

Key Strategies:

- Identify policies and standards that require documentation and prioritise these for implementation.
- Refine the Protection and Control Design Guide document.
- Realise a compendium of supporting, secondary-system databases that is accurate, easy to use, readily manageable and that matches the applied technology.
- Review the requirements of communication system documentation and produce a plan to meet organisational needs.
- Review the requirements of secondary-system documentation and, in conjunction with other organisational IT initiatives, produce a plan to best meet organisational needs.

For further information please refer to Knowledge and Record Management.

6.14 Skills and Competencies

Opportunities to leverage human skills and competencies within SP AusNet have proved somewhat limited due to the common problems of an aging technical workforce and increasing technical workloads. Independent analysis reveals that the wider Victorian and Australian utilities workforces are confronted by the same challenges.

Key Strategies:

- Model business development to quantify the volumes of traditional and emerging skills required to meet projected work programs.
- Develop action plans to close resourcing gaps.
- Retain existing baby boomer skilled resources beyond nominal retirement.
- Retain existing and future generation X & Y employees, by improving the employee value proportion.
- Focus recruitment and development programs on core skills.
- Establish commercial alliances with industry partners to secure access to non-traditional skills and business practices.
- Increase use of consultant and contractor resources for non-core skilled tasks.
- Increase employee and contractor productivity through training and improved access to Information Management Systems (IMS).

For further information please refer to Skills and Competencies.

7 Plant Strategy Summary

7.1 Introduction

To meet network performance targets and maintain a sustainable risk profile, SP AusNet faces a number of major plant management challenges over the next 15 years. This section summarises the issues and the strategies selected to address these challenges and identifies the location of further information on these assets, including their age and condition.

In the first 10-year period covered by the AMS, issues are concentrated on terminal station assets. In the latter part of this 15-year time frame, issues with transmission lines are expected to predominate.

Transformers - The most financially significant asset management issue is the reliability of a large part of the power transformer fleet. With high and increasing utilisation, increasing network fault levels and an old age-profile, power transformers have only met availability expectations in three of the last 10 years. High maintenance and condition monitoring activity has been necessary to manage the increasing risk of major failures. A comprehensive condition assessment, maintenance, refurbishment and replacement program is focussed on addressing known issues, assessing remaining life and replacing uneconomic units over the next 25 years.

Switch Bays - In 2001, the 25-year task of modernising an old and unreliable circuit breaker fleet commenced. With fault levels approaching ratings at 39% of stations and benchmarking showing failure rates above international averages, the progressive replacement of air-blast operation and bulk oil-insulated circuit breakers are key factors in managing availability performance, operating costs and environmental risks such as noise and oil spills.

Targeted condition monitoring and replacement programs are the basis for management of the health and safety and reliability risks associated with deteriorating insulation of particular current and voltage transformers. Replacement of manual operation disconnector switches with remote control units, to improve network control and mitigate health and safety risks, will continue.

Secondary Systems - The progressive replacement of electromagnetic protection relays with integrated digital protection/control/instrumentation relays that feature serial communications facilities is a key step in improving the reliability and accuracy of protection operations, managing maintenance costs and acquiring the information necessary for effective real-time control of an increasingly complex network. Another major element is the systemic movement toward broadband, Optic Fibre Ground Wire (OPGW) based communications between terminal stations and control centres in order to meet NER mandated performance levels.

Civil Infrastructure – The progressive establishment of suitable accommodation for digital protection/control/instrumentation equipment remains a focus in the augmentation of civil infrastructure for the next 10 years. Asbestos removal from building claddings and equipment mounting panels will take prominence following the completion of the PCB removal program. The recent enhancement of site and network data security will remain a high priority for the next five years.

Lines – Insulator and fitting failures and tower footing corrosion are the observable factors associated with the emerging deterioration of transmission lines. Carefully focussed risk assessment followed by remedial maintenance and selected replacement are the first steps in managing the significant health and safety and environmental risks associated with the mechanical failure of a transmission line. SP AusNet's challenge is to manage these escalating risks prior to the major line up-rating and augmentation program forecast by VENCorp to commence within the 15-year time frame of this strategy.

The following sections discuss in more detail the assets, issues and strategies selected to meet future network performance targets and to maintain a sustainable risk profile.

7.2 Transformers

This section summarises the issues and management strategies associated with the 117 main tie and connection power transformers, 19 oil-filled reactors, 1852 current transformers (CTs), 991 inductive and capacitive voltage transformers, and 85 station service transformers.

The average age of power transformers is 36 years, with the oldest unit being 56 years. The allocated technical life ranges from 40 to 60 years depending upon suitability for 'mid-life' refurbishment. The ITOMS 2005 report[45] indicates that SP AusNet power transformers are on average 19 % older than Australian peers and 39 % older than international peers. Notable is the large number of old single-phase transformer banks in service. These units have high losses compared with their three phase equivalents.

[45] ITOMS 2005 Report - International Transmission Operations & Maintenance Study – Revision 6 May 2006

Similar in construction to power transformers, the oil insulated reactors range in capacity from 15 to 121 MVAR, and have operating voltages of 500 kV, 220 kV, 66 kV and 22 kV.

Inductive type VTs predominate up to 66 kV and capacitive type VTs are principally used for voltages of 220 kV and above. The VT fleet has an even age profile but notable is the 47% of units with a service life in excess of 35 years.

In general, the condition of power transformers is good with few incipient faults or major defects. The failure rate (requiring major repair) remains low when compared with CIGRE averages. Principle technical issues are associated with power transformers that are subject to extended periods of high operating temperatures and high numbers of operating cycles include:

- Low dielectric strength of both solid and fluid insulations due to high moisture content, oil degradation and sludge restricted cooling
- Excessive noise and low resistance to electro-mechanical forces of fault currents due to loose windings and deteriorating mechanical strength of solid insulation
- Environmental, explosion and fire risks arising from insulating oil leaks from bushings, main tanks and ancillaries due to deteriorating seals and corroding radiators
- Increasing maintenance requirements of tap changer contacts and drive mechanisms
- Rising Winding Temperature Indicator calibration errors and secondary wiring degradation
- Non-scheduled PCB contamination of insulating oils

The violent failure mode of some instrument transformers presents safety risks to field staff working in the vicinity, risk of collateral damage to nearby equipment and unplanned network outages with attendant availability penalties. The frequency and sophistication of the condition monitoring, testing and analysis regime has been increasing to ensure insulation degradation rates are assessed accurately and units are replaced prior to failure.

Principal power transformer management strategies:

- Replace two 3-phase units at Geelong Terminal Station and 57 single-phase units at Bendigo, Brunswick, Dederang, Glenrowan, Ringwood and Thomastown Terminal Stations and remove the Group 5 units at Yallourn Power Station to provide a stable risk position.
- Utilise the condition assessment/testing and performance/reliability monitoring programs to prioritise units for additional testing, addition of online condition monitoring facilities, refurbishment or replacement.
- Progressively replace inaccurate winding temperature indicators and inadequate cooling controls with digital equipment enabling monitoring and cooling control from NOC.
- Integrate DDF re-testing of identified bushings with the Toshiba 220 kV SRBP and Micanite Oil impregnated paper bushing monitoring programs and ASEA 220 kV SRBP bushing replacement program.
- Insulating oil condition management program shall incorporate OLTC diverter switch tests, shunt reactor PCB tests, oil leak repairs, oil filtering and reclamation, progressive replacement of non-scheduled PCB oils and implementation of oil preservation system for identified transformers.
- Contingency response planning shall include confirmation and implementation of the contingency spare holdings review and progressive installation of fire suppression systems and blast / fire barriers between transformers based on network criticality and terrorism risks.

Principal instrument transformer management strategies include:

- Replace a minimum of 580 single phase oil insulated CTs at Altona, Dederang, Fishermans Bend, Geelong, Moorabool, South Morang, Tyabb, Templestowe and Wodonga terminal stations by 2013 as part of a portfolio of terminal station refurbishment projects, bay replacements and like for like replacements to minimise the risk of catastrophic failure.

- Condition monitoring program will focus on annual Radio Frequency Interference (RFI) scans, CVT output voltage monitoring via CAMS, DGA analysis of nominated CTs and inductive VTs during scheduled maintenance, off line electrical tests (eg DDF where DGA is impractical), SF_6 gas purity and density monitoring on 500 kV SF_6 CTs, comparisons with other utilities and forensic examination of units removed from service.

For further information please refer to the detailed plant strategies: Power Transformers and Oil-filled Reactors and Instrument Transformers.

7.3 Transmission Lines

SP AusNet manages more than 6,500 km of transmission lines, operating at voltages of 500 kV, 330 kV, 275 kV, 220 kV and 66 kV, supported by more than 12,700 towers located on 3,800 km (21,500 ha) of easement. Including conductors, insulators, line hardware, towers, rack structures, access tracks and bridges, transmission lines represent 60% of the Victorian electricity transmission network's total asset value.

Mainly constructed between the early 1950s and late 1980s, 65% of towers now exceed their technical half-life.

The emerging management issues are:

- Legislative change in the areas of worker safety, unauthorised access and electromagnetic radiation limits.
- Mechanical failure of insulators due to bonding cement failure, mechanical wear or corrosion of fittings and electrical failure due to insulator cracking from excessive loading or lightning strike
- Corrosion of tower and rack structure foundations, steel work and fasteners
- Loosening, corrosion, metal fatigue and wear erosion of line hardware, dampers and spacers particularly in coastal and wind incident areas
- Galvanised steel ground wire corrosion and ACSR conductor metal fatigue and mechanical abrasion due to wind initiated vibration
- Soil erosion of access tracks and bushfire damage to bridgeworks

For the most part asset deterioration is progressive with localised exceptions determined by site-specific environments. Reliability events due to failures of insulators, spacers and mid-span conductor joints have occurred in 200 kV circuits with service lives of approximately 50 years.

To date, remedial monitoring and maintenance programs have not had a material impact on circuit availability.

Principal strategies to address the risks outlined above include:

- Maintain a stable risk profile by focussing the 2008-2013 insulator replacement program on approximately 9600 off 16mm pin diameter insulator strings located on 3200 tower-sides on 220 kV lines, 1500 insulator strings located on 500 tower-sides on the Murray Switching Station to Dederang Terminal Station 330 kV lines, and 1500 insulator strings located on 250 tower-sides on the Hazelwood Terminal Station to South Morang Terminal Station and South Morang Terminal Station to Keilor Terminal Station 500 kV lines
- Consolidate asset inspection program and focus criteria, methods and management on quantified risks.
- Risk assessment program to quantify asset condition and adjacent land use to facilitate mitigation programs for conductor drop, vehicle impact, and hazardous land use and EMF compliance.

- Grillage foundation corrosion assessment and sacrificial anode installation at up to 4000 sites over 10 years as required.
- Ground level corrosion monitoring, and as required, re-coating and member replacement.
- Full tower painting and selected steel member and bolt replacement at 15 high atmospheric corrosion sites over the next 15 years.
- Progressive replacement of steel ground wires at terminal stations over the next five years.
- Selective replacement of deteriorated line hardware at high-risk sites, including vibration dampers, conductor spacers and insulators.
- Risk based line pollution monitoring and insulator washing programs.
- Progressive fitting and replacement of circuit identification signs, fall prevention devices, anti-climbing devices and warning signs.
- Continue to work with the Department of Sustainability and Environment (DSE) to ensure the ongoing management of line easement issues.

For further information refer to the detailed plant strategies, Transmission Lines and Line Easements.

7.4 Circuit Breakers - Switches - Surge Diverters

The Victorian electricity transmission network includes more than 980 circuit breakers, 1970 disconnectors, 1250 earth switches, and 1800 surge diverters operating at voltages from 22 kV to 500 kV.

Circuit breaker (CB) types include air-blast (9%), bulk oil (42%), minimum oil (21%) and SF_6 (28%). Vertical break and hookstick operation disconnectors predominate (87%) but the fleet includes SF_6, rotary double-break and semi-pantograph styles. Two-thirds of surge diverters are of zinc oxide construction (age < 20 years) and the remainder are of silicon carbide construction (20 < age < 45 years).

In summary, the principal technical issues are:

- CB fleet is one of the oldest operated by Australian and international TNSPs[46]
- Failure rate of CBs exceeds the average of international TNSPs[47]
- CB full-refurbishment costs are approaching replacement costs
- Shortages of skilled and experienced technicians
- High cost of severely limited technical support from original equipment manufacturers
- Corrosion induced SF_6 gas insulation leakage rates
- Excessive air-blast CB operating noise
- Insulating oil leakage rates and hydraulic operating mechanism leakage rates
- Disconnectors are on average 14 % older than those on Australian networks and 27 % older than those on international networks. A high proportion of the fleet are manually operated, are prone to stiction when idle for extended periods, have lower availability and higher maintenance costs.
- Silicon carbide type surge diverters are prone to seal degradation, moisture ingress and explosive failure. They offer inferior protection when compared with zinc oxide units.

Reliability events due to circuit breaker, disconnector and surge diverter failures have occurred at all voltages. Risk mitigation monitoring and remedial maintenance programs are expensive and have a material impact on future OPEX and circuit availability.

Principal management strategies include:

[46] ITOMS 2005 Report - International Transmission Operations & Maintenance Study – Revision 6 May 2006
[47] G Mazza, R Michaca, "The first International Enquiry on Circuit Breaker Failures and Defects in Service" Electra No. 79 Dec 1981.

- Deliver a 20% improvement in circuit breaker risk through the progressive replacement of 260 off air blast and bulk oil circuit breakers at Brooklyn, Dederang, Geelong, Glenrowan, Hazelwood, Horsham, Kerang, Morwell, Redcliffs, Ringwood, Rowville, Springvale, and Thomastown terminal stations and the Loy Yang and Hazelwood power station switchyards by 2013.
- Replace air blast CBs by 2013 and most bulk oil insulated CBs over the next 15 years.
- Salvage replaced CBs to provide spares for in-service JW420, JW419 and LG4C CBs
- Opportunistic replacement of minimum oil insulated CBs controlling reactive plant.
- Review the performance of older SF_6 CBs and develop refurbishment programs as required.
- Establish a 6-year program for the overhaul of CB hydraulic mechanisms and upgrade of control circuits.
- Increasing use of SF_6 gas insulated CBs with on line condition monitoring.
- Progressive introduction of motorised disconnectors at 220 kV and above.
- Introduction of systemic monitoring of thermal imaging and third harmonic discharge currents to assess surge diverter condition.
- Selective replacement of surge diverters with inadequate pressure relief or known corrosion problems.

For further information refer to the detailed plant strategies, Circuit Breakers, Disconnectors and Earth Switches and Surge Diverters.

7.5 Gas Insulated Switchgear

SP AusNet manages 28 circuit breaker bays of gas-insulated switchgear (GIS) across four stations. In addition, there is one bay that is comprised of bus-only at fifth station.

The 500 kV GIS is located outdoors at South Morang (SMTS), Sydenham (SYTS) and Rowville Terminal Stations (ROTS) and the 220 kV GIS is located indoors at Newport D Power Station (NPSD) and West Melbourne Terminal Station (WMTS). The 66 kV GIS is located indoors at WMTS.

The GIS population falls into two age brackets. The majority is between 23 and 27 years old and include the switchgear installed at SMTS, SYTS, NPSD and ROTS. The GIS at WMTS is under five years old.

The GIS has experienced few failures and has performed well in comparison to international installations. However, the number of major failures on the older outdoor GIS has dramatically increased in recent years.

The main issues are:

- Increasing numbers of major CB interrupter failures, resulting in internal flashovers, at SMTS and SYTS. Many of these failures are due to design and manufacturing problems. Protracted and expensive repairs due to the requirement for significant plant outages, highly skilled manpower resources and specialised tools and clean-room facilities.
- Increasing requirement for effective condition monitoring techniques.
- Leaks in the drive mechanism hydraulic system of the CB's at SMTS and SYTS.
- Availability of spares and manufacturer support.
- Corrosion of flanges, resulting in moisture entry and increasing SF_6 gas leaks, especially evident at SMTS and SYTS.

Key strategies to address the issues outlined above are:

- Install an emergency by pass facility at SMTS to ensure network security during repair of major SF_6 gas leaks and weather sealing on the Gas Insulated Switchgear in 2007/08.
- Install permanent, partial discharge sensors on GIS at SMTS, during SF_6 leak repairs.
- Complete the refurbishment of the CB hydraulic mechanisms at SMTS by 2010/11
- Continue monitoring disconnector and earth switch operation at SMTS and overhaul if required.
- Upgrade the control circuits for 500 kV CB hydraulic mechanisms at SYTS to avoid potential "slow operations"
- Implement GIS repairs and refurbishment at SYTS by 2008/09.
- Monitor bushing corrosion and gas leakage at SYTS and reseal as required.
- As required, complete drying of SF_6 gas, fitting of drying canisters and re-establish external weather sealing at SYTS.
- Implement automatic detection of bus-current imbalance from ESCA data to quickly identify hot joints in GIS.
- Schedule six-monthly, in–service monitoring of partial discharge using UHF sensors on the GIS at SMTS, SYTS and NPSD.

For further information refer to the detailed plant strategy Gas Insulated Switchgear.

7.6 Reactive Plant

Increasing maximum demand on the Victorian electricity transmission network has increased the operating duty of the 90 capacitor banks installed to provide steady-state voltage support, the four Static VAR Compensators (SVCs) and the three synchronous condensers installed to provide dynamic reactive capacity.

In total, there are more than 13,000 capacitor cans operating in the 90 banks at seven voltages ranging from 4.5 kV to 330 kV. The capacitor cans are up to 27 years old with an expected life of 40 years. The SVCs have ratings of +50-25 MVar and +100-60 MVar and are 18 and 22 years old respectively with a technical life of between 40 and 60 years. The synchronous condensers have ratings of +110-64 MVar and +125-75 MVar and are 36 and 40 years old respectively with a technical life of between 40 and 50 years.

Capacitor cans are generally in good condition. However, rising network utilisation requires more frequent and longer operation of reactive plant. This has increased the switching duty on capacitor cans such that increasing failure trends have been observed in cans subjected to high numbers of operational cycles and greater times at elevated operating temperatures.

Recent replacement of thyristor cooling systems to restore capacity, and address corrosion and circulation pump deterioration has overcome the tripping of SVCs at times of high ambient temperature. Thyristor failures, due to control system malfunctions have been exacerbated by the absence of spare parts and diminishing OEM support and this is raising the priority of control system refurbishment and replacement proposals.

Deterioration of rotor pole insulation has led to shorted rotor turns on all synchronous condensers and partial discharge is evident on some stators. Defects in automatic voltage regulation and impulse exciters and other auxiliary systems have increased the frequency and complexity of maintenance activities.

In recent years availability targets for capacitors, synchronous condensers and, in particular SVCs have not been achieved. This is due to half-life refurbishment requirements and augmentation projects in critical stations.

Thermo-vision scanning, coupled with electrical testing of higher-risk capacitors and the preventative replacement of deteriorating cans, is necessary to raise the availability of capacitor banks to target levels.

Close monitoring of the performance of SVC thyristor control systems is necessary to determine the timing of a progressive refurbishment and replacement program that will include air conditioning of thyristor halls to moderate ambient operating temperatures.

Increased condition monitoring in the form of vibration analysis (shorted rotor turns), online partial discharge monitoring (stators), analysis of main exciter brush wear and exciter currents as well as main bearing lubricating oil will determine the timing of rotor and possibly stator refurbishment, necessary for each synchronous condenser to reach its nominal technical life.

Key management strategies include:

- Replace capacitor cans and associated series reactors in selected older banks over the next five years, subject to appropriate economic evaluations.
- Upgrade the control system (including thyristors) on one of the SVCs at Rowville Terminal Station and monitor the performance of the control systems of the other three SVCs to determine the need for future upgrade.
- Refurbish the synchronous condensers at Fishermans Bend and Templestowe terminal stations using the knowledge acquired from re-furbishment of the unit at Brooklyn Terminal Station.

For further information refer to the detailed plant strategies, Capacitor Banks, Static VAR Compensators and Synchronous Condensers.

7.7 Power Cables

SP AusNet owns significant quantities of HV underground power cables arranged in 97 circuits operating at voltages of 220 kV, 66 kV, 22 kV, 11 kV and 6.6 kV. Mass impregnated paper is the main insulation type but there are XLPE and oil filled insulation cables predominantly located within terminal station sites. An 11 km circuit of 220 kV, 3 x single core XLPE insulated cable is located in easements on public property between the Richmond and Brunswick Terminal Stations.

The majority of 220 kV and 66 kV cable terminations are of air insulated, out-door configuration. However, there are also some SF_6 and oil-immersed terminations. Lower voltage terminations are of compound filled, outdoor configuration. Only the Brunswick Terminal Station to Richmond Terminal Station (BTS – RTS) and Eildon Power Station to Thomastown terminal Station (EPS – TTS) 220 kV cables, within the South Morang Terminal Station site, have cable joints.

The 220 kV cables were installed between 1979 and 1992, while the 66kV cables were installed between 1981 and 2001. The lower voltage cables were mostly associated with equipment installation as part of station developments between 1951 and 1998. Underground cables have been allocated a technical life of 60 years.

In general, the condition of power cables is good, however some problems are becoming apparent with the joints in the BTS - RTS 220 kV cable. In the immediate future the main investment drivers will be related to the replacement of further joints and continued investigation of the cause of low sheath insulation resistance and oil leaks from joints in the BTS - RTS 220 kV cable and addressing deficiencies in the management of power cables including availability of:

- Materials (including spares)
- Specialised equipment
- Maintenance expertise, in particular to carry out repairs of EHV cables after failures

Specific strategies include:

- Produce a power cables contingency plan that addresses issues in the management of power cables, in particular repairs after failures.

- Replace original oil filled joints in the BTS - RTS 220 kV cable to address low sheath-insulation resistance, faulty oil pressure sensors, oil leaks and failure risks.

For further information refer to the Power Cables detailed plant strategy.

7.8 Station Auxiliaries

Station auxiliaries include diesel generators, compressed air systems, fire detection and suppression systems, secondary cables, AC and DC power supplies, and earth grids.

7.8.1 Diesel Generators

Seventeen diesel generator sets provide emergency 415 V AC supplies at 15 critical terminal stations and communications sites in the event of the total loss of auxiliary power supplies. Ranging in age from 12 to 35 years, the diesel-fuelled generators are a low cost contingency measure to facilitate rapid restoration of supply during large unplanned outages. Operation is confined to regular test start and run sequences. Although the assets are quite old there are few issues of significance.

For further information refer to the Diesel Generators detailed plant strategy.

7.8.2 Station Air Systems

Station air systems can be duplicated high pressure, high capacity and high quality for air blast circuit breakers and some ‘CB close’ mechanisms or low pressure, low air quality for general purpose, workshop or fire service purposes.

There are 62 air systems containing 81 compressors. The majority were installed between the mid 1950s and mid 1960s and the last was installed in 1970. Air receivers are registered and inspected in accordance with statutory provisions

Galvanised pressure vessels have performed well and have a long life. Safety valves seal well until operated, after which sealing can deteriorate. High-pressure hard drawn copper or stainless steel airlines remain in good condition. However, compressors require a significant level of planned maintenance to ensure inlet and outlet valves remain reliable. After 15 years of operation, compressor breakdowns increase and replacement becomes an economic option.

- Progressively retire station air systems as the CBs they support are retired.
- Rationalise and relocate compressors to minimise purchase of new equipment.
- Review need for workshop and fire service air systems periodically.

For further information refer to the Station Air Systems detailed plant strategy.

7.8.3 Fire Detection and Suppression Systems

Fire detection and suppression systems protect key transformers and protection, control and communication facilities to minimise fire damage and resultant outages, availability restrictions and network constraints. HALON fire suppression systems were removed from terminal stations during the 1990s.

Since 2000, VESDA fire detection systems have been installed in critical locations within terminal stations to supplement less sensitive smoke and heat detectors.

Water-deluge fire suppression systems have protected the 500 kV and 330 kV network transformers since their installation. INERGEN gaseous fire suppression systems have been recently installed to protect communications, protection and control facilities at South Morang, Hazelwood and Rowville Terminal Stations. FM200 suppression systems have been recently installed at the back up Network Operations Centre (NOC) and back-up Data Management Centre (DMC). Installation of fire barriers between power transformers and in cable ducts to protect the protection, control and communications facilities has recently commenced.

The water deluge and gaseous fire suppression systems are in good condition with periodic maintenance, as per the Australian Standards, essential for continued reliable operation.

In recent years environmental and occupational health and safety legislations have driven investment. Increased security and risk management approaches may enhance coverage of existing detection systems and precipitate further installations of suppression and barrier systems.

- Review VESDA installations and functionality with a view to enhancing coverage.
- Review INERGEN installations and functionality prior to progressive installation (on an assessed risk basis) at additional 500 kV and interstate inter-connector stations.
- Where practical, supplement water deluge suppression systems with transformer fire barriers and progressively install transformer fire barriers at additional terminal stations.
- Progressively install cable duct fire barriers and tamper proof fire service facilities at additional terminal stations.

For further information refer to the detailed plant strategy, Fire Detection and Suppression.

7.8.4 Secondary Cabling

More than 43,000 secondary cables totalling more than 6000 km in length interconnect primary plant such as circuit breakers and power transformers with low-voltage AC and DC power supplies, protection relays, control systems and measurement systems located in control and relay buildings. By length, 91% of secondary cables are associated with switch bays, 8% with transformers and 1% are installed in control or relay rooms. Four and eight core construction predominates and there are more than 260,000 individual cores in service.

More than 90% of secondary cables are insulated and sheathed with PVC and have installation dates from the early 1950s to 2005. An estimated 7% (420 km) of secondary cabling is of vulcanised rubber construction. It is now more than 50 years old and can be found in significant quantities in older stations such as Brooklyn, Mount Beauty, Malvern, Morwell, Richmond and West Melbourne terminal Stations and Yallourn Power Station. PVC insulated and sheathed cabling is in good condition with no significant deterioration and only isolated examples of damage where inadequately protected by cable ducts or trenching. PVC insulated and sheathed cables have proven reliable and are expected to remain serviceable for a further 20 to 30 years attaining a service life in excess of 60 years.

However, the vulcanised rubber cabling has deteriorated to the extent that battery earth-faults and short circuits have occurred in older installations (such as Malvern terminal Station) following heavy rainfalls. In some locations it has been necessary to run temporary cabling across switchyard surfaces as all existing cable cores were utilised and cable ducts and trenches were full. The vulcanised rubber cables have reached the end of their reliable life and care is required to ensure they remain undisturbed until their replacement.

The transition from copper secondary cabling to fibre-optic cabling and digital communications within terminal station switchyards is expected to be driven by the standardisation of interfaces on secondary equipment, availability of interfaces on primary equipment and commercial viability of interfacing with existing primary equipment. The use of fibre optic communication circuits is expected to progressively grow from Asset Data Gathering Networks into instrumentation, control systems and finally protection systems.

Principal strategies to address the risks outlined above include:

- Progressively abandon vulcanised rubber secondary cabling and establish replacement PVC cabling in conjunction with network augmentation and plant/equipment replacement projects.

For further information refer to the detailed plant strategy, Secondary Cabling.

7.8.5 Auxiliary Power Supplies

7.8.5.1. AC Systems

Duplicated AC systems supply transformer tap changers and cooling, battery chargers, station lighting, air compressors, air conditioning, computer servers and general-purpose outlets at 415 V.

AC supplies date from the station's inception with progressive augmentation and refurbishment only during major station re-builds. Conceptually sound and generally in reasonable condition, AC supplies and changeover schemes are not remotely monitored. Some failures have occurred and there have been problems related to cable insulation and asbestos in distribution panels.

The AC system supplies to transformer tap changers and cooling is critical to power transformer rating. Inadequate AC supplies can precipitate outages, restrict availability or constrain the network.

AC systems strategies include:

- Review AC system component ratings including auxiliary and station service transformers, cables, fuses and contactors.
- Assess the condition of AC supply changeover schemes with a view to installation of monitoring facilities.
- Progressively replace AC distribution and auto changeover switchboards containing asbestos.

7.8.5.2. DC Systems

Station DC power systems[48] supply protection, SCADA, instrumentation, metering, communications equipment, CB controls and auxiliary power, emergency lighting and alarm systems. Prior to 1995, two 48 V communications batteries, a single 250 V protection and control battery, and a single 48 V control battery were standard.

Since 2000, 27 key, new and refurbished stations have received duplicated 250 V battery chargers and batteries of lead acid, flooded cell construction. 48 V supplies are derived from DC-DC converters. Battery condition is monitored and so too is abnormal voltage and earth faults.

There are 17 DC systems that date from station commissioning, they are generally in good condition, but the age and condition of batteries varies widely. Batteries are subject to regular maintenance and planned replacement of cells after the expected life. Chargers are replaced on failure or as required by station augmentation. Older distribution and monitoring boards contain asbestos.

'On-load' maintenance of batteries forming the sole power source for protection, control or SCADA facilities present risks to the safety of personnel and the security of the network. The older stations have large distribution boards that contain asbestos, and are fitted with exposed, copper knife switches with attendant health and safety risks.

DC systems strategies include:

[48] Batteries, battery chargers and associated wiring and switchgear

- Complete the installation of a second 250 V control battery in the remaining 19 terminal stations by 2012
- Replace the 48 V Control Battery with standard DC-DC converters supplied from duplicate 250 V batteries in 34 stations. Re-use cells, having sufficient life, released by this work in 250 V batteries.
- Develop a DC supply policy that includes capacity requirements for time-off supply, recharge, and boost charging and testing.
- Focus battery condition assessments on cell design lives and replace cells on assessed condition.
- Review modern battery technologies as potential replacements for flooded lead-acid type cells.
- Include battery-sizing review in all major projects and audit battery sizing in a selection of sites where recent incremental upgrades have been completed.
- Develop a battery failure recovery strategy for sites without duplicate batteries.

For further information refer to the detailed plant strategy, Auxiliary Power Supplies.

7.8.6 Earth Grids

Earth grids are installed below ground in all terminal stations and communication sites. Typically, the grids comprise stranded copper conductor welded at connection and crossover points. Vertical copper risers (typically flat-copper conductor) are then welded to the grid and either welded or bolted to the installed plant and equipment items. The switchyard surface material placed over the grid is an integral part of this earth grid system.

Ground wires, connected to the station earth grid via termination hardware and plant structure steelwork, are strung above switchyard plant in all terminal stations to provide protection from direct lightning strikes. These ground wires are 'slack strung' compared with transmission line ground-wires.

Transmission line towers (including those inside terminal station boundary fences) do not normally have an installed earth grid but rely on the tower foundations. In the few cases where this footing resistance is not adequate, the tower foundations have counterpoise (earth conductors) installed. Ground wires are strung between the tops of towers above the line conductors. This ground wire is connected to the steelwork of each tower and also to the rack structure steelwork at the line termination point in terminal stations.

Earth grids were installed when the terminal station switchyards and communication sites were originally established. They have been progressively augmented as additional plant was installed. The ground wires above transmission lines were installed at the time the lines were constructed.

The condition of the belowground earth grids can generally be regarded as good. This is due to comparatively neutral Ph soils, low salinity water tables, and the use of long-life materials with high-reliability welded joints. Some of the station ground wires are showing deterioration due to surface corrosion, but testing has shown acceptable tensile strengths.

Corrosion problems have been identified in the footings of towers with grillage-type foundations, located close to terminal stations. This is caused by currents circulating between the line ground wire and the station earth grid. The installation of insulators to prevent circulating currents also helps the calibration of station earth grid current-injection tests in that the station earth grid and ground wire may then be separated from the line ground wire. A recent failure of a ground wire (installed between a tower inside a station and the station rack structure) due to overheating from circulating currents has led to the implementation of a program bridging the termination hardware to make a solid connection between the ground wire and tower steelwork in such situations.

SP AusNet employs portable earthing devices in order to earth plant items to the station earth grid or tower steel work to ensure safe access for personnel. These devices usually comprise a flexible copper conductor with plug or clamp fittings and are applied to electrically isolated plant using insulated switch-sticks in most cases.

In 2001 a review was conducted on the requirements of these portable earthing devices. This was due to the increasing fault levels in terminal stations. The recommendations of this review are presently being re-assessed and will be updated as required.

The main investment driver is the requirement to ensure the ongoing integrity of existing earth grids from both an electrical safety and plant operation limit viewpoint. This is achieved by a program of station earth grid current injection tests, establishing the best switchyard surface material and checking the condition of foundations for some at-risk transmission line towers.

Strategies to manage the integrity of earth grids include:

- Undertake current injection testing of station earth grids every seven years and of selected transmission line towers located near to significant residential developments.
- Excavate a sample of existing earth grid copper joints in terminal stations during refurbishment to confirm condition.
- Investigate switchyard surface materials to satisfy both electrical safety and surface stability issues.
- Develop a program, to install insulators between the transmission line ground wire and terminal station rack structures to prevent circulating currents corroding the grillage type foundations of towers near terminal stations,.
- Complete the program of the installation of bridge connections across the termination hardware for line ground wires located at power station switchyards and on 500 kV line ends.
- Replace deteriorated terminal station ground wires as the opportunity arises, such as during refurbishment projects.
- Complete the re-assessment and update of the 2001 review of the requirements of portable earthing devices.
- Carry out a study on the future system fault requirements and station earth grid performance to identify stations that will require augmentation of their earth grids.

For further information please refer to the detailed plant strategy, Earth Grids.

7.9 Protection Systems

The ITOMS 2005 Report[49] indicates that SP AusNet's relays are on average 25 % older than relays protecting other Australian networks and 38 % older than relays protecting international transmission networks.

7.9.1 EHV Lines

There are 456 main protection relays that are supplemented by 1000 trip relays, interposing relays and remote trip receive relays providing duplicate protection for 122 EHV lines (220 kV and above). There are 23 different types of main relays including electro-mechanical pilot wire relays, electro-mechanical, electronic and microprocessor type distance protection relays, and microprocessor based current differential relays.

The oldest electro-mechanical relays have delivered 40 years service and 26% of electro-mechanical relays and electronic relays are older than 20 years.

[49] ITOMS 2005 Report - International Transmission Operations & Maintenance Study – Revision 6 May 2006

7.9.2 Transformers

A total of 277 biased differential relays, differential relays, overcurrent relays and high impedance zone protection relays provide duplicated protection for the 105 transformer banks. Buchholtz, trip and auxiliary relays totalling more than 1000 additional items complete these protection schemes. Main protection relay technologies include electro-mechanical (57%), electronic 14% and microprocessor types 29%.

A total of 48% of main protection relays are electro-mechanical types over 30 years old. Electronic relays ranges from 10 to 30 years in age and microprocessor relays are less than 10 years old.

7.9.3 HV Feeders

There are 457 schemes with a total of 555 main relays that provide duplicated protection for 227 off 66 kV feeders. Auxiliary relays including trip relays, interposing relays and remote trip receive relays add 2000 items to these schemes.

A recorded 42 different types of main relays include electro-mechanical pilot wire protection, electro-mechanical, electronic and digital microprocessor type distance protection, electro-mechanical and microprocessor types, over-current protection, and microprocessor based digital current differential protection. Further, 53% of relays are electro-mechanical, 6% are electronic and 41% are digital.

Electro-mechanical relay age is up to 40 years. It is calculated that 46% of electro-mechanical and electronic relays have provided more than 20 years service.

7.9.4 Bus-Zone Protection

Seventy-seven percent of the 354 bus-zone protection systems are electro-mechanical high-impedance differential schemes with the balance being mainly differential over-current or low/medium impedance differential schemes. A few installations are also protected by busbar overload schemes.

Most of the high impedance schemes are in good condition and do not require attention.

Some low impedance differential and overcurrent schemes however have electro-mechanical relays with rotating induction discs and these are in need of replacement due to component wear, stiction, and large operating and maintenance costs as they are no-longer supported by the manufacturers. From a system security and protection dependability perspectives, the ‘unstabilised’ and single scheme installations need to be replaced/upgraded as this presents a system operational risk.

7.9.5 Reactive Plant Protection

Reactive plant protection systems (with the exception of the old synchronous condensers) are mainly of electronic design. These relays are generally in good condition and most relay types are still supported or have compatible replacement products. The electro-mechanical relays that make up the balance of the installed assets are also sound with the exception of capacitor bank current balance relays, which are exhibiting non-operation and measurement error. The D21SE relays protecting reactors at Horsham and Redcliffs terminal stations are prone to inrush tripping. Protection on the synchronous condensers at Fishermans bend, Templestowe and Brooklyn terminal stations would benefit from the installation of relays with recording facilities to assist in the analysis of network transients.

7.9.6 Principal Issues

Principal issues associated with protection systems include:

- Bearing wear, stiction, corrosion, loss of magnetism and insulation breakdown in electro-mechanical relays
- Component failure caused by thermal stress and auxiliary voltage variation in electronic relays
- Slow operation of the Duo Bias relays
- Inrush tripping on the D21, D202 and D203 relays
- High number of relay types and unique relays protecting major transformers
- Lack of fault logging information
- Software and firmware management of the microprocessor based relays

7.9.7 Main Investment Drivers

The main drivers of investment in protection systems include:

- Network reliability - replace schemes prone to failure and mal-operation
- Lower Opex costs - replace schemes requiring intensive maintenance
- Increased functionality - monitoring and disturbance-recording capabilities
- Functional integration – standardised integrated protection, controls, instrumentation and serial communication systems reduce accommodation, installation and maintenance costs

7.9.8 Main Strategies

Key management strategies include:

- In conjunction with the replacement of high-risk primary equipment or as identified below replace up to 433 relays to provide a 7 % improvement in relay functionality risk by 2013.
- Comply with the network agreement requirement for duplicated high-speed protection on Moorabool to Terang, Terang to Ballarat, Ballarat to Horsham, Horsham to Redcliffs, Redcliffs to Kerang and Kerang to Bendigo lines.
- Progressively remove electro-mechanical relays within 10 years commencing with older Type H electro-mechanical relays on the Geelong Terminal Station to Keilor Terminal Station line in 2009, and the Ballarat Terminal Station line and Redcliffs Terminal Station line at Horsham Terminal Station in 2010. Progress to replacement of one older DS5 and DSF7 pilot wire relays on each line with a digital current differential relay in 2011.
- Replace the remaining four DT2 and DTA2 transformer protection relays at West Melbourne and Wodonga Terminal Stations.
- Replace unique relays and slow operating Duo Bias relays protecting the eleven 500 kV and 330 kV transformers at Hazelwood, Keilor, Moorabool and South Morang Terminal Stations to achieve faster operation and fault recording.
- Replace the remaining fifteen D21, D202 and D203 relays to reduce false transformer tripping at six stations.
- Where slow operating Duo Bias relays provide both X and Y scheme transformer protection replace one Duo Bias relay to achieve fault recording, faster operation and limit transformer damage
- Progressive replacement of electromechanical feeder protection relays based on condition and risk of failure with microprocessor relays integrating protection, control and instrumentation functions with serial communication to SCIMS.

- Research the application of digital information busses and digital control signalling using fibre-optic cabling to facilitate protection schemes.
- Monitor the performance of reactive plant protection systems.
- Replace main protection relays on synchronous condensers to improve reliability and transient fault recording.
- Replace protection on one SVC at Rowville Terminal Station in conjunction with replacement of control system.
- Where appropriate, install new reactive plant protection systems, which incorporate primary plant condition monitoring capabilities.

For further information refer to the detailed plant strategy, Protection Systems.

7.10 Control and Monitoring Systems

Control and monitoring systems refer to the control and monitoring of station plant (particularly circuit breakers) both locally and remotely from the NOC. This includes instrumentation (Volts, Amps, Frequency, Watts and VARs) and CB status and station alarm reporting. Local control is by hard-wired switches and analogue indicating instruments in Remote Terminal Unit (RTU) stations, and via a Human Machine Interface (HMI) in SCIMS stations. Remote control from NOC is either by hard-wired RTU or by a SCIMS.

More than 100 RTUs dating from 1974 are located at 53 sites. SCIMS equipment dating from 2002 has been installed at 15 locations. General controls (re-close relays, potential selectors, instruments) range in age up to 40 years. RTU and SCIMS systems are operating satisfactorily. However, repair of faulted cards is becoming increasingly difficult due to technical obsolescence and the need to match new components with existing.

Some failures have occurred in older general controls where mechanical relays (timers) in re-close circuits can run fast or slow and cause non-operation. Similarly, electronic relays may have component failures, be inoperative, and only found on a six-year maintenance interval or by not re-closing after a fault. The remaining electro-mechanical voltage regulating relays are suffering bearing wear and are no longer repairable.

RTU equipment has undergone huge technological change over the past 30 years and the older RTUs are now completely outmoded, and no longer supported by the makers.

The SCIMS concept is a developing technology and migrating station controls from the old configurations to the new in a coherent and cost effective way is a major challenge.

Management of the software programs and supporting documentation of PLC based control schemes is a major issue. For the Emergency Control Scheme (ECS) information is very poor and the PLCs that are the main components (Toshiba EX500) are obsolete and are no longer produced or supported.

The overall functionality and inter-relationship of some schemes and the network is not well documented. This presents a problem to the network controllers, engineering and maintenance leading to delays, and at worst mal-operation or failure to operate.

Principal strategies for control and monitoring systems include:

- Replace RTU models for which spares have been consumed.
- Install SCIMS control systems in new terminal stations and when undertaking major station refurbishment or replacement projects.
- Remove Station Mimic Controls and transducer instrumentation through incorporation of their functions into IEDs and SCIMS.
- Research the use of digital information busses and digital control signalling within terminal stations using fibre optic cabling.

- Provide a comprehensive database of design principles, operation and software for control schemes.
- Replace SCV controls.
- Research the potential for Network Control and Information Management (NCIMS) to provide functions such as load management and contingency switching.

For further information refer to the detailed plant strategy, Control and Monitoring - SCADA and Control and Monitoring - General.

7.11 Revenue Metering

There are approximately 410 revenue and 50 check meters installed at connection points with distribution customers. There are approximately 20 meters at connection points with generator customers and 10 meters at bulk supply and interstate connections to monitor energy flows, to calculate losses and facilitate invoicing amongst NEM participants.

Approximately 460 EDMI MK1 energy meters were installed in 1993 and 1994 to facilitate the disaggregation of the State Electricity Commission of Victoria (SECV). During the period 2001 to 2004, 67% of these meters were replaced with EDMI MK3 energy meters to provide a more secure, reliable, centralised metering installation compliant with the requirements of the National Electricity Code (NEC). Replacement of the remaining 33% is scheduled for completion in 2007.

The MK3 energy metering installation is modular with one meter module housing up to two energy meters including associated test switches, and the voltage selection module housing up to four voltage selection relays. The EDMI MK 3 energy meter has a typical life expectancy of 15 years and it is expected that 67% of the energy meter population will require replacement before 2020.

The design, installation and maintenance requirements associated with these metering installations are defined within Chapter seven of the NEC. The main drivers for investment would be changes to the NEC or new technologies providing superior outcomes at reduced cost.

Beyond the replacement of the remaining MK1 installations there are no specific asset management strategies relating to revenue and check metering.

Principal strategies for revenue metering include:

- Complete the progressive replacement of non-compliant MK1 energy meters with MK3 energy meters in 2007.
- Provide a more secure, reliable, centralised metering installation as part of the upgrade from the MK1 to the MK3 energy meters.
- Monitor the functional reliability of energy meter installation.
- Research the potential for future NEC compliant metering functions to be provided from Station Control and Information Management System (SCIMs) with information security provided by encryption.

For further information refer to the detailed plant strategy, Revenue Metering.

7.12 Communication Systems

Communications equipment is installed at more than 100 SP AusNet sites to provide:

- Electrical protection signalling between generating stations and terminal stations

- Electrical protection signalling between terminal stations
- Monitoring and control signalling between the Network Operations Centre (NOC), generators, terminal stations, and the National Electricity Market Management Company (NEMMCO), and
- Operational voice and business communication between NOC, offices, depots, terminal stations, generating stations, distribution zone substations, and VENCorp.

The communication system includes more than 200 links/nodes formed from optical fibre cables, radio, power line carrier and copper supervisory cables as well as operational and corporate telephone networks. At an average age of 25 years, SP AusNet communication assets are 25 % older than their Australian peers and 38 % older than international peers.

Optical Fibre in Ground Wire (OPGW) and underground fibre optic cables are now less than 20 years old. In good condition, with few incipient issues and a technical life of 40 to 45 years, little replacement is expected in the next 20 years. All Dielectric Self Supported (ADSS) fibre optic cables are predominantly installed on distribution company poles in metropolitan Melbourne. Most ADSS is now more than 10 years old and has suffered relatively high accidental damage rates. Carrying high priority EHV line protection and terminal station SCADA traffic and with a predicted life of 20 years, significant replacements of ADSS are forecast.

A majority of the electronic components forming the digital microwave-radio communications system were installed less than 10 years ago. However, with a short life expectancy of seven to 15 years, significant replacement rates are expected over the next 20 years. Most radio towers are less than 30 years old and associated antennas are less than 10 years old. Having expected lives of 40 to 70 years, few replacements are expected in the planning period.

Some of the Power Line Carrier (PLC) equipment, carrying protection signals for the 275 kV, 330 kV and 500 kV lines, does not meet the redundancy requirements of the National Electricity Code (NEC). Most of this equipment has been in service over 30 years. Manufacturers no longer provide support and there are few or no spares available for critical components. Recent failures have resulted in prolonged equipment outages while re-design and assembly workarounds were implemented. Performance tests also indicate that operating times are slower than Code specifications.

Like ADSS, aerial copper supervisory cables in metropolitan Melbourne are predominantly located on poles managed by others. Carrying system frequency and voltage control signals, industry operational traffic and 66 kV protection signals, most has been in service for 25 years. With a predicted life of only 30 years significant replacements are forecast. In the Latrobe Valley, SP AusNet owns the aerial copper supervisory cables carrying generator operational traffic and pilot wire protection signals. Most of the supervisory cable is more than 30 years old and in acceptable condition but failures are rising due to the ingress of water and broken cores.

The Operational Telephone Network (OTN) is being progressively replaced as failure rates increased on 20-year-old exchanges that were unsupported by manufacturers and limited spares were available through second hand distributors.

Voice Frequency (VF) tele-protection systems, comprising discrete analogue electronic components have been protecting generator connections for more than 30 years. Failure rates are rising and no manufacturer support is available. A seven-stage replacement program is under way.

7.12.1 Investment Drivers

The following is a list of investment drivers for plant:

- Higher standards of moisture, dust and temperature control are required for digital microprocessor based communication equipment. At several locations accommodation including cable trays and ducts is fully utilised with insufficient room for new equipment or maintenance. Security of remote location radio sites is compromised by past access key management practices.

- The progressive replacement of tele-protection and PLC systems by microwave radio links, and optical fibre bearers ensure compliance with NEC mandated performance.
- The progressive replacement of ADSS optical fibre cables and copper supervisory cables with OPGW or underground optical fibre cables to maintain network reliability and plant availability.
- Compliance with communications availability standards specified in the NEC 'Standard for Power Systems Data Communications.'
- Provision of fall restraint devices and safe working procedures for radio antenna support structures and associated training to comply with occupational health and safety legislation. Refer to the Health and Safety Management process and system strategy.
- Increasing demands for digital bandwidth and digital multiplexed signalling to efficiently integrate protection, SCADA and conditioning monitoring communications needs, refer to the Asset Data Gathering Networks document for further information.

7.12.2 Strategies

In consideration of the investment drivers mentioned above, long-term, stringent availability requirements and functionality under system black-conditions of the NEC and network agreement will prove challenging.

Key strategies include:

- Audit communications equipment rooms, cable trays and ducts and plan removal of out-of-service items
- List future requirements and where necessary plan extensions to communications rooms.
- Audit the communications network that carries protection signals to ascertain compliance with the requirements of the National Electricity Code and develop plans to rectify any no-compliances.
- Examine the practices of carrying protection signals for multiple EHV lines on a single communications bearer, and also of carrying current differential signals on switched communications networks.
- Monitor the performance of the SCADA network to ensure compliance with the NEMMCO Standard for Power Systems Data Communications.
- Outwork the seven-stage VF tele-protection replacement program.
- Replace traditional PLC equipment functions with fast digital tele-protection, SCADA and operational voice systems utilising OPGW or microwave radio bearers.
- Consider modern PLC technology as a back up to microwave radio and/or OPGW bearers where there is a concentration of operational risk (e.g. in main power corridors).
- Secure the use of existing microwave radio frequency bands to avoid stranding antennae and transmitter assets.
- Extend the installation of microwave radio and OPGW in the metropolitan area by 2009 to reduce dependence on circuits mounted on distributor's poles.
- Progressively migrate from PDH to SDH technology where link capacity is constraining traffic.
- Integrate OPGW installations with ground wire replacement plans.
- Develop methods to harden OPGW joint boxes and cable against bush fire damage.
- Progressively extend the Wide Area Network to each terminal station where wide bandwidth digital communications are available to create an asset-based' operational information system with WAN/LAN connectivity.
- Undertake a pilot application of Dense Wave Division Multiplex (DWDM) and/or Course Wavelength Division Multiplex (CWDW)
- Develop a plan to remove SP AusNet traffic from the Gippsland copper supervisory network by 2009 and transfer ownership to distributors or generators.

For further information refer to the detailed plant strategy, Communication Systems.

7.13 Asset Data Gathering Networks

Various online monitoring devices now available are capable of being periodically polled to get a snapshot of equipment's condition over time. The devices can either be retrofitted to existing equipment or integrated with new equipment.

Asset data gathering equipment falls into three distinct categories, communications equipment, IT equipment and engineering devices:

- The main communications equipment assets are the optic fibre links and associated equipment that provide network connectivity to most sites
- Associated with the optic fibre links are the switches and routers used to construct the WAN
- The third and most broad category of devices is engineering devices. These range from simple weather monitors to online transformer or circuit breaker monitors that also provide certain control functions (for example, fan control in the case of a transformer). Other prominent devices include Closed Circuit TV cameras (CCTV), building security devices, system disturbance recorders and protection relays

There are currently 46 condition-monitoring connections to equipment located in terminal stations. This number is increasing rapidly with a conservative forecast of 160 connections by 2008/2009. With the increase in devices, network infrastructure must evolve to accommodate the bandwidth, protocols, connection and other system requirements that these devices demand. Much of the data collected requires some sort of processing and storage for historical analysis. Historically, devices for asset data gathering have not been present on the power system. As such, many existing documentation, cataloguing and equipment spares systems have not been set-up to accommodate these devices.

The data from engineering devices allows maintenance and replacement strategies to be optimised, equipment availability to be maximised and equipment failures to be minimised.

For further information refer to the detailed plant strategy, Condition Monitoring.

A high-bandwidth digital network allows rollout of advanced security measures including CCTV cameras and intelligent intrusion detection devices, refer to Infrastructure Security for further information.

Network upgrades are required to support increased bandwidth needs from devices, refer to Communication Systems for further information.

Key strategies for Asset Data Gathering Networks are focussed on the following:

- Establish more detailed policies regarding procurement, spares and documentation of asset data gathering devices.
- Establish a processing and storage facility for collected engineering data – by 2008/9.
- Review performance and operation of serial interfacing equipment with the view to replace the equipment – starting 2009/10.
- Rollout high-bandwidth options across the WAN, allowing 1 GB/s operation to most nodes – commencing in 2006/7 and concluding by 2009/10.
- Introduce 1 GB/s network operation within most terminal stations – commencing 2008/9.
- Explore options for 10 GB/s operational WAN – commencing by 2012/13. Commence installation of selected option in 2013.

7.14 Civil Infrastructure

Assets within the classification of civil infrastructure include buildings, roads, surfaced areas, foundations, support structures, cable ducting, drains, fences, and water and sewerage pipes. These generally date from the time of original construction of the terminal station, depot or communication site.

About 56 km of security fencing encloses more than 532 ha of land at more than 100 individual sites. One hundred and thirty three hectares has been graded, drained and surfaced for the installation, operation and maintenance of electrical equipment in all weather conditions. Approximately 13 km of reinforced roads provide transport for heavy equipment and 29 km provide all weather access to electrical equipment. Two hundred and sixteen buildings provide all weather housing for control equipment, protection relays, communication facilities, batteries, rotating machinery, generators, compressors, switchgear, stores, workshops, laboratories, warehouses, worker amenities and office equipment.

Security fencing made from chain-wire mesh and topped with barbed wire varies from 'serviceable' to 'new' condition. However, increasing security standards and neighbouring land usage changes frequently mean that security fencing becomes inadequate before reaching its nominal service life.

The return to average rainfall after a prolonged drought and the increasing volume of augmentation works has placed greater construction traffic in switchyards with a negative impact on switchyard and access road condition. Large investments over the last five years have maintained switchyards and access roads in serviceable condition, but forecasts of increasing augmentation works over the next decade suggest continuing investment will be required.

Heavy vehicle transport roads were infrequently used at their load bearing capacity in the last decade. However, with utilisation now nearing 100% and transformer age and condition suggesting increasing refurbishment works, the next decade will involve more frequent movement of heavy equipment with consequent road augmentation and repairs necessary.

Approximately 15% of the buildings are in discrete communication sites constructed within the last 45 years. These brick walled and steel roofed buildings are in good condition with little maintenance or augmentation needs. However, the remaining buildings (mainly located in terminal stations and depots) vary widely in age, construction materials and condition. These buildings range from multi-storied brick and masonry construction to single storied timber and asbestos cement sheet construction. Many are in need of augmentation, refurbishment or replacement to provide adequate ambient temperature, dust and humidity control for an increasing volume of digital protection, control and communications equipment.

The main issues associated with civil infrastructure can be summarised by:

- Compliance with environmental legislation such as oil spill control, site water run-off and noise
- Compliance with occupational health and safety legislation such as working at heights, confined spaces and asbestos
- Extended periods of non-availability of key plant (inefficient maintenance and refurbishment, due to complex operational risk mitigation processes)
- Infrastructure security – to reduce risks of unauthorised persons in close proximity to electrical equipment, terrorist acts, theft and damage to equipment
- Provision of adequate environmental housing for the increasing volume of digital equipment that requires the superior control of dust, humidity and ambient temperature

The principle management strategies are:

- Develop annual asset works budget/program for major civil infrastructure maintenance from the annual inspection of assets and the prioritisation of identified work.
- Carry out civil infrastructure maintenance work in an ongoing manner to minimise costly replacement work.

- Consider the use of relocatable buildings when constructing new or re-furbishing existing terminal stations.
-
- Ascertain the best switchyard surface material to be used to satisfy both electrical safety and ‘traffic’ requirements.
- Progressively introduce secondary cable pulling pits rather than extending and replacing existing cable trenching.
- Upgrade security fencing commensurate with the degree of assessed security risk.

Please refer to the following documents for further information:

- Environmental Management
- Health and Safety Management
- Civil Infrastructure
- Infrastructure Security

7.15 Infrastructure Security

The state and federal governments have designated selected electricity transmission sites as ‘Critical Infrastructure’.

The SP AusNet Integrated Response and Contingency System (SPIRACS) contains the framework for preventative and responsive measures to infrastructure security threats. It has classified credible threats as:

- Safety – untrained persons in the vicinity of energy containing equipment
- Malicious – motivated by revenge, fame, association or challenge
- Criminal – profit driven, includes theft, fraud, sabotage or extortion
- Terrorism – use or threat of force or violence to influence government or public through fear or intimidation

The main drivers of investment in security controls at more than 100 terminal stations, remote communication installations, depots and offices are to:

- Ensure that only authorised and trained people have access to key assets
- Identify, respond and minimise the impact of security events
- Prevent loss of assets or functionality for the community and customers

Security risks have been quantified using a purpose built Infrastructure Security Risk Assessment Tool (ISRAT), which integrates the principles of AS/NZS 4360, National Guidelines for the Prevention of Unauthorised Access to Electricity Infrastructure[50] within REALM[51], an objective risk assessment methodology.

The Terminal Station & Communication Site Physical Security Policy[52] provides the context and rationale supporting the progressive improvement, introduction and integration of security measures

[50] National Guidelines for Prevention of Unauthorised Access to Electricity Infrastructure – ENA DOC 015-2006
[51] 30-2650 Risk Assessment Methodology
[52] Terminal Station & Communication Site Physical Security Policy – SP AusNet 2006

including, fencing, electronic access controls, intrusion detectors, closed circuit television cameras, security lighting, building exterior hardening and remote alarm monitoring in the Network Operations Centre. Improvements include security event investigation and reporting, control measure audits and network and site-specific contingency plans.

Management strategies are centred on:

- Commensurate with the assessed risk of unauthorised access, upgrade existing security control measures and introduce new controls to deter, delay, detect, respond and mitigate unauthorised access intrusions.
- Facilitate remote alarm verification and response by NOC and external security resources.
- Integrate security controls using WAN communications and CARDAX management system.

For further information refer to the detailed plant strategy, Infrastructure Security.

8 Appendix – Foundation Documents

The following list of documents details the support material for the AMS. Each title listed is a hyperlink to the relevant Foundation document.

8.1 Business Environment Assessment

Business Environment Assessment

8.2 Process and System Strategies

Asset Management Information Systems
Asset Replacement and Refurbishment
Capital Expenditure Prioritisation
Condition Monitoring
Environmental Management
Health and Safety Management
Knowledge and Record Management
Network Performance Monitoring
Operations Management
Plant and Equipment Maintenance
Process and Configuration Management
Program Delivery
Risk Management
Skills and Competencies

8.3 Plant Strategies

Asset Data Gathering Networks
Auxiliary Power Supplies
Capacitor Banks
Circuit Breakers
Civil Infrastructure
Communications Systems
Control and Monitoring - SCADA

[Control and Monitoring - General]
[Diesel Generators]
[Disconnectors and Earth Switches]
[Earth Grids]
[Fire Detection and Suppression]
[Gas Insulated Switch Gear]
[Infrastructure Security]
[Instrument Transformers]
[Line Easements]
[Power Cables]
[Power Transformers and Oil-filled Reactors]
[Protection Systems]
[Revenue Metering]
[Secondary Cabling]
[Static VAR Compensators]
[Station Air Systems]
[Surge Diverters]
[Synchronous Condensers]
[Transmission Lines]